NUCLEAR REGULATORY COMMISSION

ADVISORY COMMITTEE ON REACTOR SAFEGUARDS

IN THE MATTER OF:

SUBCOMMITTEE ON WASTE MANAGEMENT

Place - Richland, Washington

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UNITED STATES NUCLEAR REGULATORY COMMISSION'S
ADVISORY COMMITTEE ON REACTOR SAFEGUARDS

April 19, 1979

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UNITED STATES OF AMERICA

NUCLEAR REGULATORY COMMISSION

Advisory Committee on Reactor Safeguards

Subcommittee on Waste Management

Thunderbird Room
Hanford House
Richland, Washington

Thursday, April 19, 1979

The meeting of the Subcommittee was reconvened, pursuant to adjournment, at 8:00 a.m., Dr. Dade W. Moeller, presiding.

Present:

Dr. Dade W. Moeller

Dr. Stephen Lawroski

Mr. William Mathis

Dr. J. Carson Mark

Designated Federal Employee:

Mr. Ragnwald Muller

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P R O C E E D I N G S

DR. MOELLER: The meeting will now come to order.

This is a continuation of the meeting of the Advisory Committee on Reactor Safeguards, Subcommittee on Waste Management. As we mentioned yesterday afternoon, the meeting is to review certain aspects of the updated Nuclear Regulatory Commission's waste management program that we did yesterday afternoon, and then to be briefed on, one, recent developments in solidification and vitrification research and development underway here at Richland; two, to review DOE studies of high-level waste disposal in both bedded salt and non-salt media; and three, to review certain activities of the State of New Mexico in connection with the proposed WIPP facility.

The meeting is being conducted in accordance with the provisions of the Federal Advisory Committee Act and the Government in the Sunshine Act. Mr. Ragnwald Muller is the Designated Federal Employee for this meeting, standing at my far right. And any speakers who have copies of materials which should go into the minutes of this meeting, or into the transcript or record, please be sure that Mr. Muller receives those.

The rules for participation in today's meeting were announced as part of the notice of the meeting published in the Federal Register on March 23, 1979. A transcript of the meeting is being kept, so we ask that all of you identify yourselves and speak clearly and loudly enough, or use a microphone, so that everyone here can hear what is being said and so particularly that the Reporter can have an accurate transcript of the meeting.

We will now proceed with the meeting, and I will call upon Raul Deju who will be discussing the Basalt current Program with us.

Mr. Deju.

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MR. DEJU: Thank you, Mr. Chairman.

I wonder if I could have the lights out?

Would you show the first slide, please?

(Slide.)

I would like to give you a little glimpse of the Basalt Program as we're presently conducting it here at Hanford. This is part of the evaluation of non-salt media from the standpoint of the feasibility of constructing a repository.

(Slide.)

What I am going to try to do today is to give you a very short glimpse of the technical status of the program with an idea as to some of the things that we have accomplished and some of the things that we still have a lot of work to do on.

(Slide.)

A basic program element is to assess the feasibility as to building a nuclear waste repository in a non-salt media such as basalt, and to compile the information needed for that feasibility assessment as well as the information needed for the preliminary concepts, the preliminary design of such a repository.

(Slide.)

This is part of the over-all Department of Energy Waste Isolation Program which also encompasses the Office of Nuclear Waste Isolation, the WIPP Project, the NTS Project. The Basalt Project is one of those programs.

(Slide.)

The program at present involves 110 subcontractors involving approximately 25 percent of our budget at universities, approximately 40 percent of our budget at National Laboratories, and the remaining of our budget with private companies and other contractors.

(Slide.)

The area of study that we're looking at is the Columbia Plateau which encompasses parts of eastern Washington, Idaho, and Oregon. The Plateau itself covers approximately 100,000 cubic miles of basalt.

(Slide.)

One of the areas within the Columbia Plateau is the Hanford Reservation which I'm showing here for reference in our later discussions.

(Slide.)

In reference to the previous diagram I bring to your attention the fact that the Handord Reservation sits in the middle of the Pasco Basin which is structurally one of the deepest basalt provinces within the Columbia Plateau. The depth of the over-all basalt sequence in the Columbia Plateau in the Pasco Basin portion of it is now estimated at approximately six to eight kilometers.

(Slide.)

Within the Hanford Reservation I call your attention to the location of Gable Mountain, which is in the north portion of the Reservation. That is a basalt outcrop within the Hanford Reservation which is the site of our near-surface test facility.

The near-surface test facility, as you will see a little later on, is part of our feasibility study and is a facility designed to test the behavior of basalt under heat stresses and the behavior of basalts subject to the emplacement of spent fuel cannisters.

(Slide.)

The program at this point in time is in the research and development phase. I will comment on the various areas of research that we have at present. The program, if feasibility is proven, would then move to the licensing and public acceptance phase into the construction mode. It will be several years before the research and development phase is completed.

(Slide.)

The areas of study at present cover the seven areas listed on that slide. We have a heavy emphasis in the early part of the program covering the geosciences, the hydrology, and the engineered barriers issues that have been raised by committees such as the National Academy of Sciences and others.

We also have a heavy emphasis on demonstration and that is what the near-surface test facility or NSTF facility program is designed for.

We also have some on-going work on testing of engineering properties and on utilizing a systems analysis approach integrating all of the information obtained from the above on-going programs.

The repository effort is a low-level effort involved primarily in the preconceptual design of what a repository would be like.

(Slide.)

Under geosciences we have approximately an expenditure of six million dollars during the present year. The effort is taking us to complete a rather detailed identification of the basalt flows based on field data and on information from the laboratories. The U. S. Geological Survey is very heavily involved in the geo-aspects of the program.

(Slide.)

The main factors that we're looking at as we're attempting to take the Columbia Plateau and, from the standpoint of the total Plateau, examine its stratigraphy and its structure, assess its geologic stability, evaluate the tectonic setting, and examine those properties that are going to be significant to making a decision whether it is feasible or not to build a repository.

(Slide.)

At this point in time we have completed mapping the area that's cross-hatched, the area in orange. The area in green is being completed at present. We expect in September of this year to have completed our preliminary geologic report of the Columbia Plateau which will cover definitive maps of the whole area and which will be put out for public and peer review, and will discuss not only the structural and stratigraphic relations but also the tectonics and the seismicity of the Plateau.

This report is being done in cooperation with a number of subcontractors involved with the U. S. Geological Survey.

(Slide.)

At this point in time, most of the reconnaissance mapping of the basalt and the late Cenozoic sediments that overlies the basalt has been completed. We only have approximately 8,000 square miles to complete.

The western half of the Pasco Basin, where emphasis is being placed because of its structural significance, has been completely mapped, and the eastern part of the Pasco Basin is about 80 percent mapped.

The stratigraphy of the Pasco Basin and the stratigraphy of the Columbia Plateau have both been issued by the U. S. Geological Survey and Rockwell Hanford.

Geophysical surveys have been conducted. We just recently completed 70 miles of seismic reflection work and we have completed a number of aeromagnetic and magnetotelluric tests which have shown that such geophysical techniques, although with some difficulty, can be used for structural mapping of basalt at the best three or four thousand feet.

The geophysical tests are significant because they allow us to study the subsurface with a minimum number of drill holes.

We have issued a number of bibliographies covering all of the geotechnical literature published on the Columbia Plateau in the last 50 years.

(Slide.)

THose literatures cover both the States of

Washington, Oregon and Idaho.

I don't want want to leave the impression that we've got it all done. We've got a long way to go. We have to complete the mapping with special emphasis on trying to understand the complexity of any of the prominent structures and with a much more detailed mapping of those areas which appear to be attractive repository targets.

One issue that is still unresolved that we're spending quite a bit of effort in is what are the underground seismic criteria that need to take place or need to be used for a repository. How do we evaluate those, and how do we assess the tectonics of the Basin? And those are the areas we're concentrating on at this point in time.

(Slide.)

Another important area of study is the hydrology. At the present, this year's hydrology program is investing approximately five million dollars in the hydrologic effort. And again this effort takes us both from the field and into the laboratory and into the computer modeling realm.

(Slide.)

We have a number of drill holes that we're using for the field portion of the study. Within the Pasco Basin we have 13 holes which we're using. These are deep holes that penetrate through a number of deep basalt sequences.

THe deepest of those is on the southwestern portion of that slide, RSH-1, which penetrates to 10,600 feet beneath the land surface. We also have a number of holes from which we have extracted data which are not shown on that slide: there's approximately 240 holes that penetrate the deep basalts within the Columbia Plateau outside the Pasco Basin.

Those holes, unfortunately, in many cases are open throughout the entire section and do not give an ideal bore hole for testing and analysis. However, data can be obtained from many such holes.

(Slide.)

The main emphasis of the program is in identifying the regional and local hydrologic setting. By October of this year we will be issuing our hydrologic integration report which includes the coverage of the hydrology of both the Pasco Basin and the Columbia Plateau, and the status report as to where we stand in this program.

The reason for issuing that report at that point in time is to have adequate peer review on the information base that's available.

(Slide.)

A number of the hydrologic properties have been measured such as porosity, hydraulic conductivity, gradients, and essentially a number of the points that need to be made is that the hydraulic conductivity of the basalts were generally very low; the potential gradient is

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relatively flat; and in a number of the holes that we've tested within the Pasco Basin, the majority of the holes show a vertical potential gradient downward for the deep basalts which is consistent with the direction of the paleoslope of those basalts.

(Slide.)

We have just recently completed the development of the models that we're going to be using for the long-term hydrologic evaluation, and completed the first phase of sensitivity analyses of this model.

Also the first phase of the hydrologic measurement program, the program aimed at measuring the base line properties has been completed with the completion of 53 drilled-down and pumping tests last year.

WE have a preliminary integration report on the hydrologic data for the Pasco Basin which was recently completed.

And again, just as in the geotechnical area, major bibliographies covering the data available for the Plateau, with written data as well as well data, has been issued.

(Slide.)

We have again a number of areas where we're stressing work in the next three years. We want to complete an assessment utilizing existing models of the regional and local hydrologic systems.

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We want to continue a more detailed measurement of some of the basic hydrologic problems with emphasis on potential repository areas. And we also want to discuss and evaluate the extent to which fracture flow modeling is needed to characterize the basalt flow system.

(Slide.)

Another area of study is the engineered barriers program, where we're looking at the barriers that are needed for containment of the waste. These are barriers such as overpack and the waste form itself.

We are also interested as part of the engineered barriers program in assessing the extent of interactions that take place as a result of the basalt and the waste being placed in contact with one another in the presence or absence of a number of barriers. This work is primarily being done at Battelle Northwest Laboratories,at the Lawrence Berkley Laboratories and at Pennsylvania State University.

(Slide.)

The work involves both the theoretical aspects of modeling the reactions between the basalt and the various waste forms as well as laboratory experimentation where these materials are emplaced in pressure vessels and subjected to repository conditions, or I should say postulated repository conditions.

(Slide.)

At this point in time we have conducted quite a large number of what I will refer to as interaction experiments, experiments under a variety of conditions. All of these, by the way, have been reported in the literature. And we have identified a number of reaction products. All of the products that we have identified are stable minerals.

We have also with the Lawrence Berkley Laboratory been involved in the development of models to analyze the interactions and the analysis of the types of interactions that are projected. We also have here at PNL and in our Rockwell Laboratories we have been analyzing the potential transport of radio-contaminants and determining some of the baseline properties that would be needed as inputs to transport codes so that one could assess the potential transport from a repository from a chemical standpoint.

(Slide.)

All of the data that I've reported on my previous slide is also in the public domain. Our annual report that was issued at the end of the last calendar year contains a listing of all the documentation that we issued during 1978. And that document is available to the Committee and has been made available to the public.

We have a number of issues requiring resolution in the engineered barriers area, and these are rather critical. We want to assess how effective each of these barriers is, how effective a type of overpack is, and how much of these barriers do we need, what are the additional reaction products that we have not determined. We need to look some more into this waste-basalt interaction; complete the determination of transport parameters; and a very important part of our multiple barriers work is borehole plugging effort. And we feel that it's necessary to have a demonstration of this technique in basalt which is quite different from a salt medium.

(Slide.)

In addition to the research and development areas that I've discussed above, I'd like to talk a little bit about our facility demonstration. Our near surface test facility, which is located on the northern flank of Gable Mountain within the Hanford Reservation in a basalt outcrop of the Pomona basalt, which is approximately a 150 foot thick basalt flow, is presently under construction.

This is a two-fold facility. It will have a heater test area and a limited spent fuel area. At the bottom center of that picture you see the aerial view of the three tunnels that lead into the near surface test facility.

(Slide.)

The facility sketch looks as shown on this slide. Basically on the lower portion of the slide you have the entrance to the extensometer room. This is an instrumentatio area where the instruments that will monitor the heaters will be located.

To give you an idea of the completion, and I will show you some pictures of NSTF in a second, the lower tunnel is complete at this point in time, as is the extensometer room.

The extensometer room is a 23 foot tall room in an unsupported condition. There are no supports in that entire room.

The heater test room is presently 90 percent complete from one angle. It's coming actually from the center tunnel.

The computer room, monitoring both the heaters and the nuclear waste tests, will be located outside the facility.

Tunnel number two, which is the center tunnel, is also complete at this time. And we're presently tunnelling in the heater test area.

The tunnel number three -- tunnel number one, which is your top tunnel, leads to a nuclear waste area, and that tunnel is approximately 90 percent complete.

So the basic entrance tunnels, which are about -- they range between 600 and 700 feet, are all complete. The extensometer room is complete. And we're presently working on both the heater test area and the nuclear waste test area from tunnel number two, or the central tunnel.

We expect to have the facility completed on schedule, as you'll see on the next slide.

(Slide.)

The objective of the facility is to develop a multipurpose facility for in situ testing of basalt, and to use this information as a basis for both the qualification process that has to take place as part of the feasibility study and as a basis to give us design parameters.

In addition, we feel that the demonstration aspect of it is very important, and we're looking for a demonstration of placement, storage, and retrieval of a limited number, less than 20 canisters of nuclear waste, in an underground basalt environment, as well as a demonstration of the waste monitoring capability in such an environment.

(Slide.)

As I indicated in the previous slide, we have two phases to this test. Phase 1 referred to the heater portion of the test, and phase 2 refers to the nuclear waste portion of the test. The heater portion, the design is essentially complete.

The design, of course, covers not only the tunnels, but the entire facility, the heaters and so on.

The tunnel construction is 70 percent complete. All the construction will be completed by December of '79.

That's not just the tunnel construction, that's the entire facility.

Phase 2 covers the spent fuel portion of the test, and the conceptual design is very well underway. All the design will be complete by December of '79. The tunnel is again 70 percent complete now. And all of the construction will be completed a year after the phase 1 completion.

(Slide.)

These are some pictures of some of the tunnels. This happens to be the central tunnel on the previous sketch that you saw. And that picture was taken about 500 feet into the tunnel.

You see the tunnel is actually coated with a flash coat of shockfree, approximately one and a half to two inches of shockfree, and that is the only support on the entire column.

(Slide.)

Here you see at the end of the tunnel number three, which is the bottom tunnel, the tunnel leading to the heater test area. The miners are at the end of the tunnel, and they're in the process of building a raise to connect this to the heater test area.

(Slide.)

This is a picture of the extensometer room, as I pointed out, 23 foot high. This will be the room where the exte someters will be emplaced to monitor the heater test areas.

(Slide.)

This is a portion of the small tunnel, or tunnel number three, which is leading toward the raise. And again it gives you an idea of the dryness of this facility.

(Slide.)

In the engineering testing area we're designing the tests that go into these tunnels, as well as trying to analyze basic properties utilizing cores from drill holes that we have here at Hanford, so that we can obtain properties from the materials at depth.

We're also utilizing cores from outside the Hanford Reservation as obtained from the Army Corps of Engineers and other agencies that have been drilling in the Columbia Plateau.

(Slide.)

A number of standard techniques are being used to determine basic properties of basalt. We've recently reported a collection of the data on the basic physical, thermal, and engineering properties of basalt.

(Slide.)

We've also designed a number of tests under the engineering testing program to go into the near surface test facility. We have a full scale heater test which will look primarily at the temperature and stress fields in the vicinity of simulated waste canisters, simulated by full-sized heaters, very similar to the STRIPA tests that I'm sure Dr. Witherspoo will be talking later on.

We've also utilized computer models to determine the validity of these tests utilizing computer models available from the University of Minnesota Laboratories.

(Slide.)

We have a number of heaters that are going to be used for a time scaled heater test. This will be looking primarily at the regional temperature and displacement fields around the array, and we will be trying to simulate during the operation, during the three years operating on the test we'll be looking at approximately 30 years of simulated operation.

(Slide.)

We also have a number of physical determinations, as I pointed out, that have been completed. We are doing some more under a variety of conditions. And we've also completed design and fabrication of the test articles and monitoring equipment for the heaters and the spent fuel tests are well underway. The design and fabrication is approximately 50 percent complete.

(Slide.)

We have a number of issues that are still to be done. We want to pay special emphasis to understanding the variations in the basalt thermal conductivity as a result of waste emplacement. So we'll be running some experiments at much higher temperatures and much higher pressures.

We want to check the validity of a number of computer mine models by running some additional sensitivity analyses. And we'll want to obtain a better definition of many of the engineering design parameters as a result of the engineering testing and the near surface test facility tests.

(Slide.)

All of this information from both the near surface test facility effort as well as from the research and development of the geosciences and hydrology and the engineered barriers area, is information of a very specialized and complex nature. And we have a systems organization that is responsible for integrating this information, assessing whether this information meets the criteria, the requirements for qualification or disqualification of a potential target site.

The systems integration organization is responsible for the basalt qualification or disqualification. They are also responsible for the repository siting activities. They're responsible for assessing overall feasibility. The licensing activities are under this organization, as well as being sure that all the pieces of the program are appropriately streamlined so that they're all aimed at the basic goal that I started this presentation with, namely to assess the feasibility of utilizing basalt as a waste repository.

(Slide.)

One of the main activities this year within the systems organization is in the area of site selection. We want to take the plateau and examine within the plateau what are the areas that appear to be likely to meet requirements for a site for a repository.

In light of this we start by developing criteria and the decision analysis theory that is required to make the screening process viable. That part of the program has been completed, and we have completed our preliminary development of site screening guidelines.

Once those guidelines are assembled and once all the data available on the plateau is assembled and cataloged, we will screen the data. Out of this screening process we will result with a number of candidate sites which will then be ranked with ranking guidelines that were identified in step number one, and those sites would be subjected to further evaluation.

This is the basic site screening process that we have ongoing now with the existing data base to help us by the end of this fiscal year, namely by October of '79, to have a better idea of those areas within the Columbia Plateau that appear to meet the siting requirements for basalt repositories.

When I talk about siting requirements for basalt repositories, at present we don't have a formalized criteria from the NRC as to what the siting criteria are. However, the National Academy of Sciences panel has come up with a number of geologic criteria, and those are being used primarily as a baseline for this kind of information.

(Slide.)

As part of our systems integration effort we have completed the development of preliminary siting criteria. We've identified the key research areas which basically form the basis of planning our program. We've developed some tentative formats for licensing applications and environmental reports which we proposed.

And we have developed the demonstration plans that are being used in other portions of the program, namely the demonstration plans for basalt qualification. We prepared guidelines for the preconceptual design effort, and completed development of preliminary models of what a repository would be like. I'm talking about thermal mechanical models of the repository.

(Slide.)

There are a number of issues that have still got a long way to go. One is the repository siting area. At the present we're looking at the end of 1981 before the preliminary siting is completed.

The licensing arena, which again would depend upon whether or not feasibility is established. We want to emphasize the use of systems analysis for data integration. And this is of course a continuing activity, as well as the latter one. Our systems integration activity will continue to analyze data coming from other portions of the program to examine how it fits in our overall scheme of feasibility.

(Slide.)

One final point that I want to stress is that I mentioned earlier that all of this was aimed at feasibility. In order to assess feasibility one has to have a concept. And at present we're completing the preconceptual design stage of what a basalt repository would look like.

This is a very rough artist's concept of the repository with lots of liberties. The preconceptual design would give a much cleaner basis on which to base our assessment of feasibility. We are also at present in the selection process of an architect-engineer for the completion of the conceptual design phase of the repository in basalt.

All in all we have issued during the last two years approximately 150 research papers on various areas of the program that cover in more detail specific technical issues.

We have held one annual meeting, which was held last November, where the public was invited and approximately 400 persons attended, here in Richland, in fact in this room, discussions on the various technical aspects of the program, not only by our Rockwell staff, but our subcontractors.

We've moved a long way in many of these areas. We still have a long road to go.

Thank you.

DR. MOELLER: Thank you, Mr. Deju. That was an excellent presentation and a fine way to begin the day.

One question I had right at the beginning is that you have obviously gone a long way in the development of your plan. And I assume that you have established certain criteria that you probably feel you would be able to meet. In other words, in terms of minimizing the movement of the radioactive materials and so forth.

I wonder if you considered writing those down and submitting them to the Nuclear Regulatory Commission to see if they would be acceptable to the Commission. You know, this could be a two-way street instead of waiting until they set down criteria and provide them to you. Maybe you could tell them what you believe now you're able to meet.

MR. DEJU: The National Academy of Science -- and I don't see Frank Parker -- yes, he's back there -- I'm going to probably misname your committee, the Committee on

Waste Management, and what else?

DR. F. L. PARKER: Geological Site Criteria.

MR. DEJU: Okay, the Geological Site Criteria, the committee that my colleague in the back so well put the name of, has come up with a document which spells out the basic siting criteria.

Now what was done is we've elaborated on those siting criteria by trying to identify if one takes out that very general criteria, what is the kind of information that one would need to gether in order to determine whether that criteria was met or not.

At present we have prepared that in draft form. We are reviewing that with the other waste isolation contractors, namely the Office of Nuclear Waste Isolation, Nevada Operations, and the WIPP site. And we expect to have a resolution so that all of those criteria for all these sites are in a uniform fashion.

And I'm sure that the Department of Energy, as soon as we complete that task, will be most happy to transmit that to the NRC.

DR. MOELLER: Shaler Philbrick, do you have questions or comments?

DR. PHILBRICK: Yes, I've got some in various degrees of magnitude.

As you go through the study of the basalt in the

Columbia Plateau, do you find that the upper layers are conformable with the lowar layers?

MR. DEJU: Again, as in geology, I'm always hesitent to make generalizations. But basically the Columbia River basalts, through basalts, the lower layers, the grand rock basalt, for example, covers most of the entire plateau. Now that lower layer of the grand rock is the most extensive basalts that we have found in the Columbia Plateau. It covers almost from the Idaho border to the Cascades.

They're relatively flat, and there's a thickness. The upper layers that we find, the Saddle Mountain basalt and so on, are much smaller in extent. Some of the upper layers, some of the upper flows only exist in small basins, such as the Pasco basin.

The bulk of the deformation in the basalts took place during Saddle Mountain time approximately nine million years ago.

DR. PHILBRICK: So then what I read you in saying is that the layers are structurally conformable, but not equal in distribution.

DR. DEJU: That is correct.

DR. PHILBRICK: Okay.

Now when you speak of rotary holes you're speaking of non-coring holes?

MR. DEJU: No. We have a number of holes in the reservation. We have a number of the holes that we have drilled by rotary techniques.

However, during portions of that drilling we stopped the rotary drilling and we cored.

DR. PHILBRICK: So then you would have rotary drilling as distinct from coring.

MR. DEJU: Yes. The coring is when we totally core from top to bottom.

DR. PHILBRICK: Okay.

Now you speak of the flow of water being essentially down, which is what I thought it always was. Is this underground?

MR. DEJU: This is underground.

DR. PHILBRICK: Right.

Where is it going?

MR. DEJU: Well, I would imagine that the drainage system of -- and let me try to simplify this thing for you.

When you look at a basin such as the Pasco basin I would expect the upper aquifers, the unconfined system would drain within the basin and clearly to the Columbia River as the lowermost point of the drainage. The lower aquifers have a much more complex system, and they also have a much lower content of water that they carry.

The travel times are much greater. They ultimately will drain to either an upper aquifer at a discharge site, or to the Columbia River at a lower point.

DR. PHILBRICK: Do you have any idea where the discharge locations are?

MR. DEJU: Our report which we issued in March, which summarizes the hydrology as we understand it today, puts into the recharge of -- the discharge, I'm sorry, of the lowermost aquifers to be either through interconnection with upper aquifers or discharging to below the Lake Waula pool elevation for approximately 50 miles from the center of the Pasco basin.

DR. PHILBRICK: Now you say that they may be intermixing by water rising from the lower aquifer to the upper aquifer.

Do you have any basis for that in terms of age dating of the water or anything else that would tell you that?

MR. DEJU: The waters that we have dated within the Pasco basin -- and we are at a preliminary stage in that -- they show ages of the order of 30,000 years. The waters in the unconfined aquifers, the young waters are less than 500 years.

DR. PHILBRICK: Do you find anywhere that the younger aquifers -- that's the upper ones -- are older in any direction coming about the mixing of the older waters below with the younger waters above, so that you can determine which direction the flow is taking place?

MR. DEJU: We have run a number of tests on a number of holes and we find that the -- and again I want to be very cautious as to how I answer your question. There is so little in the way the permeability is so low in the deep aquifers that I really shouldn't use the word "aquifer" in reference to that.

But the waters that we find at depth are invariably considerably older, not only by carbon dating, but by a number of other techniques, oxygenizing, and all the other techniques that we use; they're always older than the ones above. And the difference is always in the order of 500 years going to a 30- or 40,000 year range, which is again the limit of detection in many of these techniques.

As far as the head differences, again we see the same pattern. If you look at the heads in the unconfined aquifer you find flow upward. As you get below the basalt again you find the flow turns downward. This is consistent with the direction of the Paleo slope of the basalt and we postulate that the general or the regional flow system flows from east to west rather than from west to east.

DR. PHILBRICK: Thank you.

Let me ask you another couple of questions, if I may.

What is the yield of wells in the lower depths?

MR. DEJU: The yield of wells depends on where you're at. And let me try to give you a generalized rundown of all the basins. If you look at the unconfined aquifer and you put an average, say eight to ten inch water hole in the unconfined aquifer, if you penetrate it in a portion where you have the glacial alluvial material that was carried during the Spokane floods, you will find yields of as much as 500 gallons per minute.

DR. PHILBRICK: This is not on a basalt?

MR. DEJU: No, I'm going down the section to make it a little clearer.

DR. PHILBRICK: Okay.

MR. DEJU: In that same aquifer, however, if you put the well -- and I'm talking about depths of the order of 50 feet -- if you put the well a little bit deeper in an area where the glacial alluvial material is not present, your yield probably will not exceed 50 gallons per minute of that same well.

As you go down into the basalts and you go through the first basalt sequence in some portions of the Columbia Plateau, primarily in areas where you have brecciated basalts, you will find in the upper 500 feet of the basalt some aquifers that have yields of 100 to 200 gallons a minute from very large wells.

As you get below 500 feet in the basalts and you get into formations which yield water, the maximum thicknesses that you find water bearing strata are of the order of a few feet and the maximum yields that you find are of a few gallons per minute.

To give you an idea, below 2000 feet the maximum yield that we have found was 12 gallons per minute.

DR. PHILBRICK: Do you have any wells close enough that you can get the drawdown relationships at that depth? Do you get interference or not?

MR. DEJU: We have a number of holes. Notice on your handout you will see that a number of our holes are drilled pairs, and those are 50 feet apart.

DR. PHILBRICK: And they affect each other?

MR. DEJU: Very very little, only in the upper section.

DR. PHILBRICK: If you were down at your proposed repository depth, which I don't remember that you stated?

MR. DEJU: Well, the proposed repository depth would be somewhere below 2000 feet for the basalts.

DR. PHILBRICK: Have you got any indication down there that you could get any quantity of water from the basalt, not from interbed, but from the rock itself?

MR. DEJU: The rock itself, our opinion is it would be reasonably dry.

DR. PHILBRICK: By that, what do you mean?

MR. DEJU: By that I mean it will have basically less than two percent moisture content and essentially if you were to drill a hole into the entabliture of a basalt flow, that portion of the hole would be dry.

DR. PHILBRICK: By that you mean --

MR. DEJU: A simple portion of the --

DR. PHILBRICK: Now when you made your rock tests were you testing --

MR. DEJU: When we were doing rock testing we have tested both dry and wet cores.

DR. PHILBRICK: Do you get a difference in strength?

MR. DEJU: No, sir.

DR. PHILBRICK: So that if you had a repository which had been open for a good many years there would be no change in the physical character of the rock merely because the repository had been opened and dry?

MR. DEJU: Well I don't think we can totally make that generalization.

DR. PHILBRICK: Why can't you?

MR. DEJU: I think that additional modeling would have to be needed. I think that aside from the openings -- and all that needs to be taken into account.

DR. PHILBRICK: Supposing you had a couple of inches of Sakrete, or whatever. Would you expect any change in the physical behavior of the rock forming the tunnel?

MR. DEJU: Not really.

DR. PHILBRICK: Do you have any reason to believe that the construction of a repository that you diagramed on the board for the storage of nuclear waste, high level waste, spent fuel or whatnot, is not perfectly feasible?

MR. DEJU: Well, at this point in time, as I indicated, we're in a feasibility mode. My opinion is that most of the techniques that would be used in building a repository are existing techniques. We certainly know how to mine mines at depth. There are a number of mines in existence today, one that was actually built in 1872 in Canada which is in terrain similar to the basalts here, a little bit older, quite a bit older, that are dry. And this particular one that I'm thinking of is at 7000 feet.

There are a number of other mines in this country that are also dry at great depths that are larger than a potential repository. I don't see why feasibility in crystalline rock, basalt being one of them, cannot be done through to a particular site.

DR. PHILBRICK: And you're approaching this from the standpoint that you're going to get a positive answer yes before you finish the job?

MR. DEJU: Well, any job that you approach you always approach it on a positive angle, but with a willingness and an open mind to prove that a condition cannot be satisfied. And then you have to come up with a negative answer.

DR. PHILBRICK: Have you seen anything so far that suggested a negative answer is in view?

MR. DEJU: No, sir.

DR. PHILBRICK: Thank you.

That's all I have.

DR. MOELLER: Are there other questions?

Herb Parker and then Carson Mark.

MR. H. M. PARKER: Referring to your comments on site selection, I presume you meant that to range over this basaltic region of the Columbia Plateau, is that correct?

MR. DEJU: The site selection process is looking at the entire Columbia Plateau, as well as the Pasco Basin.

Now we have a peculiar situation here. The basalts are the thickest in the Pasco Basin, which is the saucer shaped structural basin right in the middle of the Columbia Plateau. And it is where most of the data exists.

So we're running the program in parallel in order not -- obviously there is more data on the Pasco Basin than on the rest of the entire plateau simply because there are more drill holes that existed here to start with and more studies that were done.

So we're doing the site selection both for the Pasco basin and for the Columbia Plateau so as not to bias the data. However, the study, the criteria and the methodology are identical for both portions.

MR. H. M. PARKER: Just going by eye from the map you gave us, about 50 percent of that area is in the State of Oregon, which is state that has a very distinguished record of not wanting other people's high level waste.

Are you seriously considering areas outside the reservation on an equal basis with areas inside it, for example?

MR. DEJU: Okay. Let me answer that two-fold.

Number one, the study, as I indicated, on the geologic map that I showed you, covers Oregon and Idaho. There's a very good reason for it. From a geologic standpoint and from a hydrologic standpoint, you want to understand the whole system.

If I want to look at the geology of the plateau, one of the best ways to understand it is to map the outcrop areas to look at the surrounding basins, and to examine in detail all that information. That is a basic reason why Oregon becomes important from a geologic standpoint.

However, understand that the basalts are relatively thin in that area. You're looking at the edge of the basin. We are placing the bulk of the emphasis on the Pasco basin where the basalts are thick.

So hopefully that answers your question. We're looking outside the Pasco basin primarily to understand the regional geology. But the main emphasis is on the Pasco basin.

MR. H. M. PARKER: And the site selection is almost inevitably within the Hanford Reservation.

MR. DEJU: Well, the site selection will be based upon the technical criteria. If that shows that the Hanford Reservation is the likely place to put it, then it should be.

But I think we have to be reasonable about the whole thing. And if the site selection criteria were proved that Hanford was totally unacceptable, then we will so state.

DR. MOELLER: Carson Mark. And then Martin Steindler and then Don Orth.

DR. MARK: Assuming that you conclude that you could use some site here at 2000-plus feet, and assuming also that a salt dome or bedded salt, or whatever people are looking at right now, should meet some criteria, what would you guess would be the relative cost of establishing a repository of the same size in one medium or the other?

MR. DEJU: Okay.

The cost of building a repository, of course, is subject to all kinds of assumptions, from what is our policy as to what nuclear waste we're going to emplace here, spent fuel or what have you, that's certainly an important factor that's going to bear on the cost.

So rather than try to get into cost figures, I'm going to try to give you an idea of the relative --

DR. MARK: That's all I was asking.

MR. DEJU: -- costs.

As far as basalts are concerned, it was a study done for the environmental impact statement that compared it to costs of other media. When you look at crystalline rock the cost of tunneling is higher than for salt. The costs that we presently estimate probably would not be more than 25 percent different from the costs of the salt dome repository. But there's a lot of work that needs to be done before those numbers --

DR. MARK: I accept that. But it's not a factor of ten; it's a factor of less than one and a half.

MR. DEJU: Right. I don't think it's a significant factor when you look at the total costs of a project. You have to look at the overall design and all kinds of factors before you really know.

DR. MARK: There is, I presume, another important difference. You could guarantee retrievability for a long time, as compared to what salt people could offer.

MR. DEJU: There are advantages and disadvantages in both of them. And certainly they are different. From a bore hole plugging standpoint they are certainly quite different. From a retrievability standpoint, they have different behavior.

DR. MARK: You mentioned that your heat tests will in some instances be overtests. You put in a higher temperature than any likely stories would impose.

You did not mention tests in which you are using the water with a proper pH and mineral content that you would expect to find and asking about leaching features of that kind of water.

I presume those are in fact even laboratory tests.

MR. DEJU: Yes. As part of our laboratory tests at Pennsylvania State University we are taking waters with the exact compositions that we find at depths, trying to simulate those waters, and reacting those in the laboratory and laboratory vessels.

We find that our control of that kind of work in the laboratory is much better than in situ.

DR. MARK: The last question:

I have the sort of vague notion that the Columbia Plateau is very low in seismic activity. You did not mention, let's say, a microseismic net or anything of that sort which is getting current data on such points.

MR. DEJU: Yes, we have a microseismic net that in fact has been operational for years. It's operated by the University of Washington. The seismicity here is extremely low, as you mentioned, and we are expanding that net to have a much wider coverage of the entire plateau this year.

DR. MARK: Is it possible to say that there are no known faults in this basalt flow region affecting the basalt?

MR. DEJU: Well, again, that's one of those geologic generalizations that I don't --

DR. MARK: I used the word "known".

MR. DEJU: I'll make the following statement:

I think associated with any fold you always find some minor faulting. And I would say if you look on this earth, any mountain or any hill you look at, you're going to find some minor faulting.

Let me put it in more exacting terms:

Within the Columbia Plateau in other areas of the plateau outside the Pasco basin, yes, there is some known faulting. I'm talking about 100 miles away from here. There are some major faults in the Cascades, certainly not major in the sense of the San Andreas, but within the Pasco Basin we do not know of any continuous fault that would affect the basalt.

We have recently been looking at a very interesting study, looking at the recent sediments and examining their age, and any deformation that would be found in the recent sediments. And work by ourselves and the USGS in the past year has moved the age of the recent sediments, the sediment over the basalt, from the previously estimated age of one million years to 3.5 million years.

So even the overlying sediment is older than initially suspected, which is very relevant ' the field of deformation, since we do not find any evidence of deformation in the overlying sediments.

DR. MARK: Thank you.

DR. MOELLER: Martin Steindler and then Don Orth.

DR. STEINDLER: Do you anticipate being able to extrapolate the near surface test results on both heat and whatever else you're planning on to depth without any major difficulty?

MR. DEJU: Well, that is obviously one of the problems that one has in any endeavor is to extrapolate, say, laboratory to bendscale and bendscale to prototype and so on. And it's the same kind of problem one has in extrapolating from the near surface test facility.

Now let me tell you how we're approaching that.

The near surface test facility, we're looking at heat, we're looking at stress behavior, we're looking at demonstrations. We will accomplish those things to some extent. The Pomona basalt, which is where the facility is located, was selected because it is reasonably similar to some of the deep basalt flows in physical and chemical properties, as well as being one of the thick surface exposures, 150 foot thick flow.

So in that context there are sufficient similarities. And the areas where, of course, you don't have similarities is the fact that you're not going to have 2000 feet of overburden on top of that facility, and the facility is above the water table, above the regional water table.

Now in extrapolating those two items we have to depend on two things:

First, in gathering the data at depth through cores; and secondly, in utilizing models to examine. First we will run the models at NSTF prior to turning that first heater on. So we will know, we will have a measure of how good the models are.

Secondly, we will use the same models with some of the predictions at NSTF with some of the core data with simulated depth reference conditions. And we will have to do the best we can on that.

DR. STEINDLER: Okay.

What is the current size of your effort, total size.

MR. DEJU: Dollar-wise?

DR. STEINDLER: Right.

MR. DEJU: The expenditures for this year are approximately in the $30 million range.

DR. STEINDLER: Okay.

The original objective of the program continues to be the demonstration of feasibility. How will you know when you're there?

MR. DEJU: Okay.

The objective of feasibility -- and as I pointed out in my remarks on the integration of all this effort --we have geotechnical, we have R&D information, and demonstration information that needs to be put together. We started by putting in siting recommendations. In other words, what are the requirements that are going to be needed? When are we going to know that we've met those requirements?

So what we did is we took the National Academy of Sciences statements, like I'll use one as an example -- and forgive me, Frank, for paraphrasing. But a very simple one is that you want to look for a site where erosion is not expected to either get rid of all the cover on top of the repository or the geologic processes are not expected to bring that repository back to the surface.

Well, once we have written a criteria like that and identified the type of data that we're going to gather and the type of programs that we're going to gather to make a yes-no decision on it, we've identified those, we have those ongoing. We have a target date and a schedule that says Okay, by this date we will have all the data to evaluate that criteria.

We can do that evaluation, and it's a role of our systems organization to by September of 1981 come up with the assessment as to whether or not those siting requirements are met. So that's the approach we're taking.

DR. STEINDLER: So unless you have some externally imposed criteria that significantly conflicts with the ones you're currently using, you're going to be internally consistent and thereby determine feasibility. Is that right?

MR. DEJU: That is correct. That's the intent.

DR. STEINDLER: Okay.

Has any significant area of your program, or the methodology been discussed at all with the NRC people?

MR. DEJU: We hold periodic meetings with the NRC through the Department of Energy at headquarters in Washington. In fact, we have briefings with the NRC on a biweekly basis. And key members of my staff are periodically briefing the NRC. We just had one on site explorations.

It's my understanding we're having one on siting criteria later on this month. By the way, the Office of Nuclear Waste Isolation and other members of the waste isolation community also make presentations at those meetings.

MR. STEINDLER: Thank you.

DR. MOELLER: Our speaker is on a tight schedule, so we'll have two more sets of questions and then close it out.

Don Orth and Dick Foster.

DR. ORTH: In the 1960s the granite bedrock below the Savannah River Plant was investigated for a period of time. There were a lot of measurements of the movement of water in the rock, the direction of flow, all hopefully contributing to an analysis of how long it would take to emerge and where it would emerge. We've already touched on a little bit of this with Dr. Philbrick.

But, anyway, the Savannah River work included such things as injecting tritium tracer water into various holes and measuring the dispersion and how long it would take to get out of other holes and such things.

Are you planning that kind of an approach, again with that key point being will you know where it's going to come out and when it's going to come out?

MR. DEJU: For recharge and discharge, as all of us in the hydrology profession know, it's a pretty hard subject to say By God, the water is coming out of here and it's coming in here, yes. And of course, techniques have been more refined since that time.

DR. ORTH: Certainly.

MR. DEJU: The electronics techniques that we're using now for monitoring pressures at depth are much improved and our accuracy of permeabilities and a lot of these techniques are much better. So, yes, those detailed tests -- in fact we have a contract that should be on board in a few weeks and mobilizing at this point in time who will be bringing staff on board to conduct a couple of hundred tests in the various holes we have here. And there are additional holes that are planned to specially answer the question as to where the potential discharge areas are.

DR. MOELLER: We'll close out with Richard Foster.

DR. FOSTER: I just have one quick question.

If memory serves me correctly, that very deep hole, that 10,000 foot hole up on Rattlesnake was put there by the oil companies exploring for petroleum.

Do you think that in the future there ought to be any revival of that interest to look for petroleum in this basin again?

MR. DEJU: Well, let me add that that particular hole at 10,600 feet was indeed put in by Standard Oil Company. It was also a dry hole. There are a number of other holes in the Pasco Basin which have penetrated the basalts. There are some works that we completed primarily to look at what is potentially beneath the basalts. And, of course, as in most geophysical techniques, they do have certain elements of which -- witchcraft is not like having a drill hole -- where you can look at the area where you're drilling and you can take a sample or so. But the geophysical techniques show that the basalts in the Pasco Basin, as I indicated, extend some eight kilometers or more beneath the plant surface. Drilling the basalts to eight kilometers is a lot of drilling.

So I would say if you're going to put in some gas or oil, it probably would be staying clear out of the Pasco Basin. There is some drilling that has gone on on the edges of the Columbia Plateau. They have found some small gas, but no economically recoverable amounts of gas.

In the '40s there were some gas wells that were put in in the Yakima area. Most of those wells just were not economical.

DR. MOELLER: Well, thank you very much, Mr. Deju.

Let the record show that Mr. Deju is from the Energy Systems Group of the Rockwell Hanford operations.

Thank you again.

Moving on with our schedule this morning, we've heard, then, on the basalt studies. The next logical step is to hear a similar comparable report on the work in salt. And for that presentation we have W. Weart from Sandia Laboratory who will be discussing the WIPP facility.

Mr. Weart.

Mr. Weart, your item on the agenda is scheduled for one hour. If you can restrict your presentation to no more than a half hour, that would give us time for questions.

MR. WEART: I'll try to show every other viewgraph.

DR. MOELLER: Thank you.

And we will take a break at the end of this presentation.

MR. WEART: I'd like first of all to express Don

Schueler's apologies for not being here. He's the Department of Energy project manager for WIPP. He is not here because there was suddenly a press conference called at Albequerque to release the WIPP draft environmental impact statement. And consequently he was unable to come.

(Slide.)

The Waste Isolation Pilot Plan, or WIPP, as I will be referring to it throughout the discussion, is to provide a demonstration of radioactive waste disposal in bedded salt. The waste types that the WIPP was intended to accommodate as a repository are defense transuranic wastes, both those which are low enough radiation that they can be handled with contact methods and those which require remote handling.

According to the definition of two hundred mr per hour contact is the dividing line.

The facility is also intended for use as an underground laboratory, if you will, to conduct in situ experiments with high level waste forms. And it has also been proposed that the Waste Isolation Pilot might be used to demonstrate the disposal of up to 1000 spent fuel elements.

All of the wastes that we're talking about will be retrievable. For the transuranic wastes, for periods of five to ten years, for the spent fuel, periods of twenty to twenty-five years, and the experiments themselves, the high level waste experiments will be retrieved and recovered upon conclusion of the experiments.

(Slide.)

The schedule that now exists for the WIPP is shown here. Important points that I'd like to show are that we are in the process of coming to the completion of Title 1. We do not have approval yet to initiate Title Two design. That decision is being pursued by headquarters at the moment.

If all aspects of the Waste Isolation Pilot Program should proceed according to the most optimistic schedule, construction could start here in 1981. There's about a four year construction period. We would not be in a position to accept radioactive waste at the WIPP in the most ideal situations until 1936.

(Slide.)

There is still a considerable discussion on whether or not the Waste Isolation Pilot Plant will be licensed. The Department of Energy position is that the WIPP should be a licensed facility. That has not been resolved, and there is considerable discussion between the administrative and legislative departments back in Washington at the moment.

The concept for the WIPP is to use two different horizons within the bedded salt. The lower horizon at a depth of about twenty-six hundred feet, which is very pure mixed salt, would be used for spent fuel and high level waste experiments. The upper horizon at twenty-one hundred feet below the surface would be used for the TRU with contact handled repositories.

The location is in the extreme southeast New Mexico, about twenty-six miles from Carlsbad, almost due east. The nearest town of significance is Nuami, New Mexico, shown at this point.

(Slide.)

For those of you who have not been through southeast New Mexico, this is what the terrain looks like. The rainfall is about 13 inches a year on the average. There is fairly loose sand at the surface covering the first ten to twenty meters. Scrub vegetation holds that sand in place over most of the area, but in some places it is mobile and moving about.

The drilling operation you see here is drill hole ERDA 9, which is in the exact center of the area that's being examined. The population density is very low. I think there is something like 13 permanent residents within ten miles of the site.

(Slide.)

As seen from the ground, a little closer view. You see the mesquite sage, rabbit brush, that covers the area.

(Slide.)

The environmental studies that have been conducted in the last four years for the area have not shown any endangered species, either wildlife or flora. The area is used for grazing. There is a modest amount of dove hunting.

And I will discuss in a little bit the underground utilizations that are potential in the area for natural resources.

One of the questions that someone expressed an interest in is what do we plan to do with the salt that's mined from the repository, how is it planned to be disposed of. We've looked at a number of options, and we have in fact been contacted by some salt mining companies who are interested in purchasing the salt from the lower horizen. However, our present plans are to store the salt in a tailings pile on the surface for the operational life of the facility.

Upon decommissioning much of that salt will be used for a final backfilling. We think that the optimum method for disposing of the remainder of the salt then is to transfer it to the very large brine lakes and salt tailing piles that exist in the area.

(Slide.)

This is a picture of one of the salt mining operations. You can see down here in this lower corner just a portion of one of the very large tailings disposal areas which cover many tens of acres. The amount of salt that we would add to those existing areas is a fraction of one percent.

I'm going to skip over some of these slides in the interest of time.

(Slide.)

But I did want you to know that the five major areas which we've divided our site selection criteria into are these: geology, seismology, tectonic stability, geochemical compatibility, and the economic and social compatibility. Each of those areas, then, contains a number of factors.

(Slide.)

I'll just show this one sheet where we show those that relate to geology, and we have looked at all of these factors to see whether or not in these areas there are elements of the geologic factors, for instance, which would perhaps preclude against the location of a repository in this location which might lead to its jeopardy or breachment of integrity in the long run, or whether the factors appear to be desirable.

Now it's difficult to put quantitative limits on many of these things because they all interact as a system. And one can accept certain hydrologic characteristics, for instance, in one of the aquifers depending upon what one has for some of the other factors involved. So one can upon attainment of the siting parameters that can put these all into the scenarios can calculate what kind of consequence one might expect should these various things lead to a breach of the repository.

(Slide.)

The various techniques that we've used to look at the WIPP site as far as the geotechnical aspects, are shown here. We've found several of the geophysical techniques to be useful.

Perhaps the most useful for our particular program turned out to be seismic reflection and electrical resistivity. We made extensive use of seismic reflection to look for subsurface structural features. And we have found electrical resistivity to be very useful in looking for dissolution features at the top of the salt formation.

The other geophysical techniques have had more limited application. But we have acquired data from aeromagnetics because we do have at least one instance of an igneous dike in the Delaware Basin. That's about eleven miles from the site and it shows up very well. And aeromagnetics was used to look for further such instances, none of which were found, incidentally.

We have been monitoring the seismicity for about five years now. And it's a relatively low seismic area. There is activity on the central basin platform which is about 60 miles to the east of the WIPP site. A study there has been trying to determine whether or not the activity mpb4- which has maximum magnitudes in the order of 3.5 to 4, Richter magnitude, whether that activity could be correlated with water flooding activities in the oil fields there.

41 The indication from that program is that that is the case. It's not yet conclusive. We hope to be able to wind that program up in the next year.

I might add that the nearest capable fault that we've been able to find in the region is about 60 to 65 miles west on the west side of the Guadalupe Mountains. We found no indications of recent faulting closer than that.

(Slide.)

The geologic section in the area of interest is shown here. Salt beds, of course, are not pure halite. There are many inner beds, and toward the top of the section they are more frequent. They consist of polyhalite and anhydrite.

The area shown as showing the most promise for the key area waste horizen is here at about twenty-one hundred feet depth, and for a high level waste horizen, relatively short halite at around twenty-six to fifty feet below the surface.

We do have an interval of about 30 feet with no clay and anhydrite stringers. Polyhalite is very uncommon in these deeper halite zones.

(Slide.)

The areas that we find to be of most significance, having done all these regional geologic studies through the acceptability of the WIPP site, are these three general categories: The hydrology and dissolutioning features associated with the hydrology, salt stability and flow structures that exist within the salt, and the presence of natural resources within the region.

I'll discuss each of these briefly.

(Slide.)

We know that the salt is being dissolved toward the edge of the basin in the neighborhood of the Pecos River. The site area, the center of it shown by ERDA 9, in this location, as we go to the west of the center of the site, we find that salt which occurs in the Rustler Formation is gradually being dissolved. And by the time we reach this location the salt is absent in the Rustler Formation and dissolutioning is starting to attack the top of the Salado Formation.

In siting the WIPP site the U.S. Geological Survey did a number of geomorphological studies;for the most part. some studies of the salt below the Pecos River to determine the rate at which this solution front at the top of the Salado was moving eastward toward the site.

DR. MOELLER: Could we have a question at this point?

DR. PHILBRICK: Is that dark line the top of the solution front?

MR. WEART: It indicates the top of salt, wherever it occurs. At this point there has been no dissolution of salt in this section at all.

As you come this way you see the first salt that you encounter is increasingly deeper, indicating it has been dissolved by groundwater. And by the time you get to this location there is no salt left in the Rustler.

DR. PHILBRICK: Any indication of when this occurred?

MR. WEART: It's probably continuing today. We think that it's been an active process over several million years. The studies that have been done by the U.S. Geological Survey indicate that over the last half million years, when we could get a fairly good handle on release, that the progress of this solution front, and in particular the point at which it's attacking the Salado, is moving at the rate of about six to eight miles per million years towards the east in the horizontal sense.

The vertical rate at which that solution proceeds downward in the section once it has reached the top of the Salado is on the order of 300 to 500 feet per million years.

DR. PHILBRICK: Now where would the repository be in that section?

MR. WEART: The repository in this section is below the bottom of the viewgraph. It's quite a ways down.

If one takes those dissolution rates that the USGS determined -- and they are average rates of the last half-million years, but they're what we call, what I call, at least, maximum averages. In other words, they use very conservative assumptions about the period of time over which dissolution occurs. The repository horizens would not be breached for several millions of years.

DR. PHILBRICK: Thank you.

(Slide.)

MR. WEART: There is also a question about deep dissolutioning because south of Texas there's dissolutioning going on at the bottom of the evaporate section. One of our consultants has suggested that this could pose a problem for the WIPP site, and he was particularly concerned because there were some Halite beds that do occur to the north of the Delaware Basin in the area of the site shown here by ERDA 9 which do not occur to the south.

So he suggested that we core in an area where those beds were known to be to see whether or not their absence was due to deep dissolution. ERDA 10 was for that purpose, and did not find dissolutioning or any past dissolutioning evidence, in fact. Rather, the indication is that the absence of that Halite unit was due to depositional reasons and not dissolution.

One of the nice things about working in salt, even though its solubility is considered by many to be a drawback, it does leave a nice track record to pin down whether dissolutioning is or has gone on in the past.

(Slide.)

There's a lot of talk nowadays about breccia pipes and whether or not they represent hazards to a repository. We are fortunate in one sense in southeast New Mexico in that we have a breccia pipe that has been mined into a potash line. And so we can get a look at it at least at the level of the McNutt formation which contains the potash mineralization.

None of these so-called breccia pipes has ever been drilled to depth. We have a program about to start to do that.

One of the things that we have done is we've run over known features of this type which we think form due to dissolutioning, removed rough salt at depth with eventual collapse of the overlying material into that void. We have run both seismic reflection and resistivity over known features of this sort, and they both provide very characteristic obvious identification of signatures. So we've applied those techniques over the entire 30 square miles of the WIPP site and find no indication that any of these exist.

We do feel, however, that we need to have a better understanding why these features form, their genesis, what caused them to form where they did, did they form in a discrete period of the geologic past, so that we can make a better prediction of whether or not there is a likelihood that these might form even in the distant future at the WIPP site.

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We know that they do occur in salt basins throughout the United States. Wherever they occur there is extensive deep dissolution, a one-to-one correlation as far as we know. We have avoided deep dissolutioning in the WIPP region and therefore we hope we've also avoided these, both for the present and the future.

The program to pin down the genesis of these features is being conducted jointly by Sandia and the USGS, and we hope to have a report out which will be an interim report in just a couple of months. The final analysis of this program, if indeed we can ever come up with a definitive conclusion as to a genesis, is probably about two years away.

The studies so far have shown that almost no breccia pipes in the basin have been active within the last million years.

(Slide.)

I wanted to say a few words about salt flow and structures. Many of you are probably aware that we drilled a site originally selected back in the early 1970s. When that site was drilled we found underground structures so severe, dips of up to 80 degrees, fractured Hydrite near bedded salt which contained enough fracture porosity that the high pressure brine pocket had accumulated. We felt this was not a tenable area in which to develop a repository, so we renewed our site selection.

But these kinds of features were later found to be associated with proximity, a belt about five miles in width in front of the underground Capitan Reef, presumably due to over the last 40 or 50 million years, deformation of the salt and a very slight dip as it abutted against the Capitan Reef.

In our search for a new site, then, we had to impose one additional criteria to those that have been used before, and that was to stay out of this deformation belt.

Now the seismic program has indicated that these beds over the WIPP are quite flat, dips of less than a degree. But we have found indications in this area to the north of the withdrawal area and right in this region of some general anticlines.

Now they were much more subdued than the feature found in the previous site, but we felt that this should be drilled into the anhydrite to see if the anhydrite did contain a potential for brine pockets. We've done that, and we did not find any evidence of anhydrite fractures. The structures are too general, apparently, to cause that.

Because we find associated with these anticlines sometimes slump features in basalt or foliage structures which can be interpreted as faults in seismic records, we wanted to determine whether or not the faulting or slumping seen in the deep salt beds in this region could indeed be faulting, tectonic faulting, which would extend up into the more recent sediments. And so a series of drill holes were drilled in this area in the one mile mark in the center of the region to determine whether or not there was in fact any faulting in the salt beds which was later than Permean Age. And those showed that indeed there was not, to the best of our ability to detect it, at least.

One other thing that I use this viewgraph for is to show you what the resource problem is in the area. There have been no drill holes drilled through the salt within this border here, which is a buffer zone around the three square miles that will eventually be mined for underground disposal.

We do, however, have four drill holes drilled for petroleum purposes out here in the shaded zone, all of which were dry holes. There is production of gas from a drill hole out here in the southwest corner just outside the region, and it is a very good gas line.

The studies that have been done by our petroleum consultants indicate that there is indeed a good potential for natural gas in this area, as you might expect, anywhere in the Delaware Basin, anywhere in the Permean basin. In fact, there is a potential for hydrocarbon resources. The amount of that is not large, according to our consultants, in terms of the natural energy picture, something like twenty-three billion cubic feet, within this inner zone which, for the moment at least, is off limits to vertical drilling that would go all the way to the salt.

We do allow drilling for oil and gas in this outer region providing it's done in such a way that the holes may be easily plugged upon completion of their useful life.

DR. LAWROSKI: How deep are those?

MR. WEART: The gas in the area is from the Morrow and the Toka, which is at depths of 10- to 15,000 feet.

The oil in this area may occur anywhere from 4000 feet on down. But the potential for oil in this area is very low.

DR. LAWROSKI: Will it be less of a problem should they find gas if and when they were to drill deeper, such as has been done in Oklahoma?

MR. WEART: We in fact have told several of the companies who have leases in the area that if they would like to explore their lease, they may do so by drilling vertically down through the salt outside the buffer zone, then deviating below the salt to tap the area of their lease.

Most of the area, in fact, can be tapped by this method. Unfortunately the resource of principal interest is natural gas and not oil. Were it oil we would be more worried about large extraction of oil causing subsidence, seismic events, possibly even water flooding that they might want to do.

With gas at this depth there was very little concern for subsidence due to extraction. And we see no evidence of seismic activity associated with the very large amount of gas which in fact has been extracted from this one well.

So we think that eventually the gas, the hydrocarbon resource that is within the WIPP site can be extracted without jeopardizing the integrity of the site. We do have one program, however, which we want to implement before allowing drilling within this one mile buffer within the vertical sense. And that is the borehole plugging program.

DR. MOELLER: Dr. Lawroski has another question.

DR. LAWROSKI: Sometime ago, if my memory serves me right, it was reported that there had been found hydrogen sulfide in some of the -- during some of the drillings. This was some years ago. And as I recall, it was viewed as being disconcerting.

What has been the resolution if indeed it did turn out to be true that there was?

MR. WEART: Yes, that hydrogen sulfide was dissolved in brine in this anticlinal structure. It was drilled up here to the north of the present location. It was the original site which was located in that deformation belt. And we know, since running into that, that we have found that there are other encounters with artesian brine pockets in the Castile formation, which is the evaporate formation just below the Salado where the repository would be placed.

These artesian brines are generally associated with anticlinal structures. Occasionally there are pockets of brine encountered which are not at geo-pressures which are not artesian, which are not obviously associated with the structures.

One of the plans that we have is to more fully define that reservoir that was tapped several years ago. And that is the program that we will initiate next year. We try and learn whether or not that is indeed an isolated pocket and not connected with any dynamic situation.

The age dating that has been done on it would indicate that it has been isolated for at least 800,000 years.

The other resource which we have in the area is potash. There are two potash minerals, potassium chloride solite and limonite, which is the potassium magnesium sulfate mineral, and it does occur extensively in southeast New Mexico in the McNutt formation which lies several hundred feet above the repository horizen. The area in fact I think produces 85 percent of this country's potash, domestic potash.

The studies that have been done would indicate that within this central three square miles there is virtually no potash mineralization either for reserve or resource categories. There is, however, an area up here to the northeast which lies principally in this outer shaded zone which is of sufficient grade and thickness and impurity content that it could probably be produced by a potash company according to our consultants in the U.S. Bureau of Mines.

Now as with oil and gas, we do allow mechanical mining for potash in the shaded zone, very much like we allow drilling, if it's done according to certain specs. We do not allow solution mining. Fortunately that's not an issue, because the principal mineral here is limonite, a sulfate mineral, and it's not very soluble. So solution recovery is not one of the things that we're concerned with.

We have a program underway in conjunction with the United States Geological Survey and the Bureau of Mines to look at the effect of subsidence on the overlying aquifers and aquatards to determine whether or not mining in this inner zone would in any way jeopardize future integrity of the site should that be allowed. It also has a secondary purpose, and that is that in spite of the fact that we will backfill the repository with fresh salt, it has a high porosity so there will be some subsidence associated with the collapse of the rooms in the repository themselves over a long period of time.

DR. LAWROSKI: How much water is needed in connection with mechanical mining for various reasons?

MR. WEART: They use very little, just enough to keep some dust control.

DR. LAWROSKI: How about cooling of equipment or anything?

MR. WEART: They do use some, depending on the technique. Some of the mines use mechanical liners, others use drilling glass. But they use very little water underground in salt mines because salt is so easy to drill.

Fortunately the overlying aquifers that we do have to deal with are not very productive. We've drilled a couple dozen hydrologic test holes to get the hydrologic parameters for these overlying aquifers in the Rustler. And we find that the true principal aquifers are carbonates, called the Magenta and Culebra Dolomite. The productions of these in fact are so low that we still have some drill holes that have been open for two years still recoverying these to do their static tests.

We do get production to the west of the site, a greater amount to the east, virtually none we can measure. Rates of anywhere from four gallons per day to four gallons per 400 days, very tight.

So in one respect we're very fortunate as far as the hydrologic system goes. And in fact when we get to the point where we calculate failure scenarios, the breaches of the repository that would cause isotopes to get into these overlying aquifers would eventually find their way to the Pecos River about 15 miles away, but at a very low rate.

In fact, one of the things that we have done that will be reported in the draft environmental impact statement is a series of failure scenarios which have been calculated to see what the consequences of those failures would be.

(Slide.)

One of the most likely to occur we feel will be a breach of the repository by man himself through drilling, perhaps of hydrocarbons in future exploration even without any potential resources in the area. I think one cannot rule out some type of future possible penetration by man.

If in this particular scenario that should occur and connect the aquifers up here in the Rustler with the aquifers below the evaporates and establish a circulating flow of water through the two repository horizons, we can dissolve the salt, and with it the waste. At this particular point in time we don't know what the waste form for the waste in WIPP will be. We have made some very conservative assumptions, however.

For instance, in the calculation I'm about to show you, we assumed that the waste would dissolve at the same rate as the salt. Essentially no credit for waste form. We have also, within the various hydrologic regions between here and Pecos, assumed the maximum of a measure of set parameters for hydrolite conductivity and transpecifics. Doing that, we can then calculate when some of these isotopes will start to show up, in what quantities.

And again assuming that we have a hypothetical man living on the Pecos River ingesting as many of the isotopes as occur in twenty liters of water every day for 50 years, in spite of the fact that in a week it would kill him because it's so salient, we can calculate at least what the anticipated dose would be under those very conservative conditions.

For the TRU repository condition it starts to show up at the Pecos River and this man would start to ingest it in about 35,000 years.

Now a good portion of that is due to the retardation due to ion absorption. The transit time for just water or the isotopes which are not retarded I think is on the order of 1500 to 3000 years.

The thing to point out perhaps on this is that while these isotopes start to level off and reach a steady state at about 100,000 years, they're still well below -- a couple of orders of magnitudes below -- the radiation which occurs from naturally occurring radiation in rocks and in the sediment in the area or almost five orders of magnitude below that produced by cosmic rays, and so a relatively benign effect.

The interesting thing is that plutonium never shows up at all during the period of this calculation due to its large absorption affinity in the aquifers.

I very briefly am going to indicate what another part of our program is, and that's the experimental program which is separate and distinct in many ways. However it's clearly an interaction with the earth sciences. But you look at the effects which will occur when you put salt and waste into contact.

The areas that we've identified that seem to hold the greatest concern for people and which we require additional technical resolution on are in the areas of thermal effects, salt stability, and in the brine waste migration area. The near field waste-rock interaction even with TRU waste, there is a phenomenon which we are concerned about, and that is generation of gas from the organics in the TRU waste should that waste come in its present form and not be incinerated or slagged. And finally a host of rock mechanics issues that have to deal not so much with long term stability as they do with short term operational stability of the facility.

(Slide.)

In a TRU waste program we have several ways in which the gas can generated from the organics of TRU waste, and I've shown on this viewgraph the various mechanisms, radiolytic, thermal, chemical, bacterial, helping us quantify those various phenomena.

One of the things we are concerned about, of course, is if this phenomenon is of sufficient magnitude after the mine is decommissioned and sealed and low permeability is reestablished, it could cause reinflation of the mine, possibly even hydrofracture, and that kind of thing.

(Slide.)

Studies to date have shown that the potential for gas generation is greatest for bacterial decomposition. This is the range of values. We've assumed the value of this level, this rate, to do some consequence studies for what it would mean to the mine, and find indeed that the permeability is so low that we will achieve pressures greater than the status of this gas generation.

(Slide.)

As part of this program, we do have a permeability study going on. We've done a lot of work nearly concluded, of course, in the laboratory. We've had some problems, of course, because we do disturb the medium. You do open up microcracks and it becomes more permeable.

We're also doing some in situ experiments with the bore holes that we have in the basalt.

(Slide.)

The laboratory studies show that while the permeability may be relatively high on a core that is taken out of the ground, shown here in microdarcies, that by applying steady pressure it will reveal these microcracks and over a period of many days you eventually get back to what we think is probably an in situ condition, anywhere from 100 to a tenth of a microdarcy.

The drill holes that we've recently tested, which goes through the entire Salado salt section, was packed off and tested recently. And it shows an average permeability over the entire salt section of about a tenth of a microdarcy. That encompasses many things besides salt, of course. It encompasses polyhalites, anhydrites, in some places.

(Slide.)

We have some programs on high level waste interactions. The ones which I would like to mention specifically are the two at the bottom, nuclide migration and brine migration. We have done quite a few studies on this because in the past it's been assumed that there would be a fair amount of credit given to the canister or the waste form. But we do need this kind of information for input to our definition of source term for these various failure scenarios.

More recently we've come to believe that it may not be that difficult to provide a considerable measure of protection by the canister.

(Slide.)

Some of the metallurgical studies done at Sandia in fact would show that for some materials, like ticode, an alloy, that you can get very good corrosion properties sufficient to provide several hundred years of protection for the canister.

Now WIPP, of course, is not primarily a high level waste repository. And so these studies have been limited mostly to what kind of sleeves should we put into the WIPP to provide protection for the spent fuel over a twenty-five year retrieval period. But studies have shown that it might be quite practical to talk about materials which would provide protection for several hundred years, a period of time when the thermal pulse is large, when mechanical interactions of the waste exposed to brine are rapid, and there could be a significant advantage by providing the protection over a period of time.

One of the areas that's been very much on people's minds lately with regard to salt is the brine migration issue. We have conducted a number of small scale laboratory experiments at Sandia to look at brine migration, and have found that indeed the brine migration that we observe is present and does flow toward the heat source. More recently we have tried to give information on some larger specimens such as this one meter block of salt.

(Slide.)

We place a heater into the center of that. We jacket it and control the boundary conditions thermally with water jackets, so that we know the precise temperature gradients.

We've also done experiments on small samples.

(Slide.)

The kind of results that one may expect is when you heat the sample you start to evolve water gradually decreasing in rate. You change the heater power, you suddenly have another jump in water evolution. And then, as we've noted, all the way back to salt walls. When you turn the heat off you get a very large spike of water rushing in in a very short period of time.

These were done on small one kilogram blocks in autoclaves. The salt block experiment on the meter size specimen I showed has just been concluded. We don't have the data in hand yet. But initial results indicate that the rate at which water flows into the heater cavity is much faster than would be expected by the anticline model. So we're looking into that.

The way that the WIPP engineering program has been structured is to assume that all that brine that's there within the region of the thermal instruments would eventually migrate towards the heat source, and the design of the facility, the placement of holes, then, has been engineered to prevent that from coming into contact with the waste by providing sumps. We're looking at materials which will tie it up chemically. That looks very promising.

So we think that there are several engineering approaches, manmade barriers, if you will, to accommodate the brine question should it occur at its maximum magnitude.

340 Some of the other programs that we have, the bore hole points program, many of the experiments oriented toward getting data to help you engineer and operate such a facility are now in the process of being planned for an area that we have negotiated with one of the potash mines. We will shortly be starting some in situ experiments on a rather large scale in one of the potash mines in New Mexico.

Now the experiment in this in situ dedicated area facility is fairly close to the WIPP site. In fact, this is the outline of the WIPP site. The mine in which it will be conducted is shown over here. The similarity -- In fact we'll be operating at depths at 1100 feet as opposed to repository depths of twenty-one hundred feet or greater. But we are able to find relatively similar salt chemistries. They are starting, we hope, in about June.

(Slide.)

Many of the brine questions, rock stability, thermal stability, can only be fully resolved in an underground situation. The one drawback to such a facility is that we will not be allowed to introduce any radioactivity. So the thermal effects will be simulated. And there may be some radialysis effects which could be synergistic with the thermal effects which we can only get a handle on in the laboratory studies at this time.

The layout is shown here. We have a much better view of that in the handout. The schedule that we envision for these in situ experiments, we hope to start very soon excavating the area required. These experiments would run for several years. They would start to phase out when we have the WIPP facility itself available, which starts out here in the '83 time frame.

As we continue to build up the experiments of the WIPP facility itself, the experiments in the potash mines are phased out. But even after WIPP is available, we anticipate many of those will run for several years to get some of the information on long term effects that we would like to acquire.

I'll stop there. I skipped over a great many viewgraphs, but you have them in your handout. And I'm ready for questions.

DR. MOELLER: Thank you very much.

We'll begin with Carson Mark.

DR. MARK: Mr. Chairman, on the program there has been listed a Mr. Neill from the State of New Mexico. Is he going to be giving us a presentation today?

DR. MOELLER: Yes, he will immediately follow this presentation.

DR. MARK: And from him, then, we will hear about the non-technical but social aspects of WIPP, I suppose.

DR. MOELLER: Well, he may cover some technical things. He will present the viewpoint of the state.

DR. MARK: Then I will reserve questions.

DR. MOELLER: Mr. Healy.

MR. HEALY: I'd like to comment first on the endangered species thing. I do believe that there are several physicists several hundred miles away at Albequerque that may well expire of apoplexy before this is over.

(Laughter.)

I'd like to know a little bit about the history of these beds, and the character of them. How long have they been around, how were they formed, and they are inter-bedded, they're not solid blocks of salt, are they?

MR. WEART: That's correct. The Castile and Salado formations were deposited principally between two hundred and thirty and two hundred million years ago. Since that time they have been elevated and submerged below sea level at least three times. They, however, have suffered this change in elevation over very broad gradual areas, so that the beds in the Delaware basin for the most part are quite wide.

They have in certain areas suffered more extreme deformation due, we think, to the fact that about 40 million years ago when the last episode of the southern Rockies elevated areas to the west, Guadaloupe Mountains, the area was given a general tilt of about a degree. And where the beds abutted against the Capitan Reef, for instance, they seem to flow and crumple.

Now one of the desirable things about basalt, of course, is that even with this extensive deformation they don't show brittle fracture, they do show flow. The brittle anhydrite beds which may exist within them do show brittle fracture, and it was within one of these beds that brine reservoirs and the hydrogen sulfide accumulated.

MR. HEALY: All right.

One other -- one or two others, if I may.

Why are you putting in the retrievable for the TRU

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waste for five to ten years? What do you hope to learn about that for the long term?

MR. WEART: It's extremely difficult in fact to expect to learn very much at all about the interaction of the TRU and the closing horizon over that period of time. The effects that we would expect might be of concern if we have organics would take a considerably longer period of time to start to interact with the basalt in the surrounding environment.

In order to try and speed things up to accelerate the process in the experimental facility we will put degraded waste directly into contact with basalt; in some areas we will intentionally introduce brine and put the waste directly into the brine and salt and observe the phenomena that occurs . In the TRU repository itself I would be very surprised to see any direct interactions between the TRU and basalt.

There is one area that we may be able to get a handle on and that is to intentionally cause uranium to fail more rapidly and collapse on TRU containers and see what effect that collapse in the application of 1,000 psi does in fact have on containers and the waste within it.

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MR. HEALY: That would hardly be considered retrievable, though, would it, without a very massive effort? It's not what I would consider an essential placing for retrievability.

MR. WEART: That's why those kinds of experiments are done in an experimental area.

MR. HEALY: Okay. Good.

Just one other point. This resources question as you know is a very hot one, and I don't think, in my mind, that it's a sufficient question to say that it is only a small part of the national energy resources because a hundred years from now it may be the national energy resources for that type of material.

Would you consider at all any plan of making sure that these resources are depleted as far as they could be before you moved out?

MR. WEART: Well, that would be up to the petroleum-producing companies. We feel that we do have some regulations within the Department of Energy right at the moment which would let these people explore for those resources that they're sufficiently interested in with the use of deviated drilling techniques.

MR. HEALY: But the real concern I think with the waste management -- I don't subscribe to it particularly myself -- is that we will eventually lose track of the site and then somebody will rediscover that these resources are there, you know, 10,000 years from now, and drill through. And I think one could aid this problem if the resources were

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deliberately depleted before you abandoned the site.

MR. WEART: Well, I had some trouble with that argument because if one forgets that the repository is there you're also likely to have forgotten that resources were then produced from the area.

MR. HEALY: I did not originate this argument, and I do not necessarily subscribe to it, but it's the type of argument that I think you're going to have to face at some point.

MR. WEART: Well, I do agree with you that the most likely penetration, at least at this repository and I think any well-sited repository, is going to be by man's penetration, by drilling,by exploration, and therefore, I think one needs to look at the consequences of that should it happen.

I showed you one of those scenarios that fits up with what, in my view, is a rather benign consequence. There are some, however, that are not quite so benign but which may stretch the imagination a little.

For instance, one scenario is suppose that 100 years from now, 100 years from the time the waste has been at the repository, a hole is drilled which penetrates right through a spent fuel cannister and that some curious geologist is looking at a three-foot section of core and spends an average of an hour one meter from that core because it's so intriguing to him, and he gets an exposure then of 90 rem.

Now that exposure is pretty severe for that guy but it is limited to just one or two people. It does not endanger a large element of the population.

DR. PHILBRICK: A very important element of the population.

(Laughter.)

MR. WEART: Such an exposure in the same scenario in 200 years would give you something like 8-1/2 rem exposure. So maintaining administrative control for a period of 200 as opposed to 100 years greatly helps in reducing the consequence of that particular scenario.

I would like to think that this country will be stable enough to provide that kind of control.

DR. MOELLER: Dr. Lawroski?

DR. LAWROSKI: With the current standards of safety, performing excavations and drilling, can you guess how risky is the job or providing the volume required down there for storage?

MR. WEART: Well, we have a pretty good handle on that because of the extensive potash operations. In fact, those particular mining operations are probably much more risky just from the standpoint of construction and operation because they endeavor, and in some cases do retrieve, up to 90 percent of the potash. And it is somewhat disturbing to be in an area where you can almost see the ceiling coming down on your head, but they have an excellent safety record, far safer than coal mining, uranium mining, and any hard rock mining. They have a very safe record for potash mines.

One of the reasons of course is that when salt fillers do fail they don't fail catastrophically.

DR. LAWROSKI: Okay. Because the mining industry as a whole has the reputation of being rather risky.

MR. WEART: They do kill a few people in potash mining.

DR. LAWROSKI: But this particular type of mining is a lot different from the average experience at coal mining and other large scale --

MR. WEART: I couldn't hear it.

DR. MOELLER: Frank Parker and then Martin Steindler.

MR. PARKER: One of the big problems that's been raised concerns brine migration. I was wondering whether or not you were studying or planned to study any procedures that would allow you to produce that brine migration either by reducing the heat differences or the spacing, or other procedures of that sort?

MR. WEART: One of the problems with all the brine migration studies to date has been that they have used very high thermal gradients, very high, so that's about all that could be observed in a reasonable period of time.

There is some considerable doubt in fact as to

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whether or not any appreciable brine migration will occur with with the pressures we will have and with the thermal gradients that we will have, which are only about a tenth of those that have been used in experiments.

The experiments in the Mississippi Chemical Potash Mine, the Duvall Mine, will be used to try to get a better handle on what actually does occur under realistic conditions.

However, there are two programs going on, both at Sandia and the USGS, to develop backfill or overpack materials which will prevent the brine from ever coming in contact with the waste form, and there are some very promising materials there to accomplish that end. There are also some high temperature results that can be used.

Perhaps one of the simplest things, at least forthwith where we're talking a relatively small number of spent fuel elements would be to provide a sleeve or an overpack made of this brine-resistant alloy which would resist the brine and isolate from the waste form simply from its presence.

DR. MOELLER: Okay. Martin Steindler.

MR. STEINDLER: Where are you at this point regarding the feasibility determination of this whole operation and how did you get there?

MR. WEART: In December we sent a report to the Department of Energy. It was called the "Geological Characterization Report for the Waste Isolation Pilot Plant."

It was transmitted with a cover letter which outlined all of the site selection criteria and factors that have been applied to our investigation.

And we indicated to the Department of Energy when we transmitted that that we felt that all of the factors had been well satisfied with the exception of the conflict with natural resources, and then proceeded to identify the magnitude of that conflict.

That report did not go into the failure scenarios and the consequence of, say, trying to recover those. But the Draft Environmental Impact Statement which has just been released does do that.

There will be public hearings on that statement in June. And as a part of the NEPA process, I expect the determination will be made by government and by the people and by the state, in fact, whether or not that is an acceptable area for a repository. In other words, I think the final feasibility will be determined through the NEPA process.

We have implicitly said they feel it's an acceptable site to pursue for the next stage of development by the very fact that they released an impact statement before the hearings.

MR. STEINDLER: Have you, in the course of your planning, had interaction with NRC up both in the planning stage and in the discussion of results?

MR. WEART: We have had relatively little interaction with NRC, although we have participated in these information briefings which Paul Deju mentioned earlier.

The reason, of course, is that there is a great deal of controversy about whether or not WIPP is to be licensed, and consequently, it's a little more difficult because we don't know what kind of interaction we should be having with NRC.

MR. STEINDLER: It's a good indication that the current position of DOE is that the facility should be licensed.

MR. WEART: Yes.

MR. STEINDLER: And on that basis, you still do not feel it is necessary to set up some kind of a formal mechanism for information exchange and programmatic input?

MR. WEART: Well the Congress saw fit in passing the appropriations for the Defense Waste Management Program to prohibit any activities which relate to spent fuel disposal in WIPP for the licensing of the WIPP facility. And so it would be in some violation of that Congressional mandate to pursue anything in that regard.

MR. STEINDLER: What is the current size of the program, current budget?

MR. WEART: This year our operational budget is about $16 million.

DR. MOELLER: Don Orth and then Shaler Philbrick.

MR. ORTH: Are you having any continuing studies on the fundamentals of this brine migration-temperature relation? A couple of weeks ago I heard some discussions of it and I'm making the same points that you made, that many of the experiments were unrealistic in terms of the temperature differences. But they also included some discussions of the fact that the brine came into the holes after the experiments were discontinued and the temperature was turned off, not while they had temperature.

MR. WEART: Yes, to answer both parts of your question, we do have a fairly large continuing effort. In fact, that's one of our prime categories for experiments at the moment, both in the laboratory on small samples, looking at migration of occlusions and single crystals under electrostatic pressure and one meter sized salt blocks.

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And just as soon as we get into the potash mines we'll be doing the full scale realistic experiments there. We believe the reason for this when the heaters are turned off is due to the thermal shock opening up a microfraction and allowing water which has accumulated near the boundary to suddenly flood in. It comes in very rapidly, almost instantaneously, as the surface cools down.

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DR. ORTH: One of the reasons for the particular interest at the meeting I was talking about is that you would not be exposed to brine and hot waste at the same time.

MR. WEART: Well, we think there are a lot of unknowns about the mechanism of brine migration. We are suspicious, as I said, because of the rates at which we see the anticline model. That is the governing model.

We hope very soon to get some confirmation on this point.

DR. MOELLER: We'll close this topic out with questions from Shaler Philbrick.

DR. PHILBRICK: You spoke of a dike. Has that been used underground?

MR. WEART: Yes it has.

DR. PHILBRICK: What is the effect of that dike on salt?

MR. WEART: The dike is a limonite, which is a basic igneous material, very dark.

DR. PHILBRICK: A peridotite type of thing?

MR. WEART: Well, it's a finer grain than that. Chemically it's very close.

The area where it's been seen is at a couple of potash mines. The dike where it's been seen is on the order of 10 to 30 feet wide wherever it was encountered. It does contain fractures which are filed with halite and polyhalite.

DR. PHILBRICK: Are the fractures equivalent to the type of cooling fractures you get in basalt?

MR. WEART: Right.

DR. PHILBRICK: Okay.

MR. WEART: The boundary between the dike and the halite does show thermal effects.

DR. PHILBRICK: For how far?

MR. WEART: Well, we're not sure yet; just observations and gross microscopic examination probably we'll confine to about a 10 or 20 foot region.

But we've taken a suite of samples which are being examined to try and better quantify just what has happened, recrystalization, mobilization of some of the minerals and chemicals.

DR. PHILBRICK: Then you're on top of that, then?

MR. WEART: Well, we hope so.

DR. PHILBRICK: Have you got any idea what the temperature was?

MR. WEART: I've heard that number, but I'm afraid if I were to quote you one it might be wrong.

DR. PHILBRICK: Will it be ascertained?

MR. WEART: Yes.

DR. PHILBRICK: All right.

Now you spoke of a capable --

MR. WEART: The interesting thing is that one does see evidence of extensive dissolution on the borders.

DR. PHILBRICK: Okay.

You spoke of a capable fault. Is that within a reasonable distance of the site?

MR. WEART: It's about 60, 65 miles west of the site.

DR. PHILBRICK: Now collapse from present mechanical mining; did you say in the potash mines that they're taking out 90 percent at the present time?

MR. WEART: That's about the maximum.

DR. PHILBRICK: What is the standup time on retreat? When you've completely backed out from the face --

MR. WEART: They mine all the way out, and then as they retreat their rock propellers --

DR. PHILBRICK: Right.

MR. WEART: And in these mines where they're getting 90 percent extraction, we have actually instrumented some of those pillars prior to the mining to get some failure data. Now as to whether or not our codes can predict this kind of thing, those things you expect to fail over a period of decades, when we can no longer get into the area.

DR. PHILBRICK: How far up has the fracturing gone in the overlying rock?

MR. WEART: Well, the subsidence, of course, goes all the way to the surface. It goes to the surface fairly rapidly.

Now we do have some mines in which they mine at two levels. Customarily they go along and they mine at the lower level, and then after subsidence they will come along and they will mine the upper level. When you go into that upper level you see no evidence of fracturing. The salt deforms, but it does not appear to fracture.

So there is some evidence that in areas that are separated by only 100 feet of salt, with subsidence on the order of four feet, you don't see any fracturing in salt.

DR. PHILBRICK: But the upper bed, when it is extracted to 90 percent, then fractures to the surface?

MR. WEART: Yes.

We have asked all the mine operators whether they'd ever seen a problem with water inflow to their mines, because some of these mines in our area the potash horizen has quite a thick cover of salt between the nearest mine and the nearest aquifer. But in some areas to the west they may mine at within 50 feet of the aquifers.

In one of those mines there is some indication of seepage of water, very slow, into the mine. The deeper ones never see it.

DR. PHILBRICK: Now how long have these mines been pulling up pillars to that extent?

MR. WEART: Well, mining began there in the 1930s and most of the early mines did not get this kind of recovery.

But they have seen subsidence.

DR. PHILBRICK: All right.

You speak of natural resources. What is the life expectency of the potash deposit in that territory?

MR. WEART: Well, you get a lot of answers, depending on who you ask that question of. The potash operators that we've talked to say that we have enough potash under lease that we would not be interested in this area if at all for at least 30 years.

DR. PHILBRICK: Well, he's just talking finance.

MR. WEART: That's economics, yes.

DR. PHILBRICK: But in terms of production at the present time, assuming we hold equal demand places, have we got 200 years of potash, 300, 500, 1000, or what?

MR. WEART: I really don't know the answer to that question, because it depends a great deal upon future economics. The resource down there is still quite large. Today they're only mining potash in southeastern New Mexico because of the tarrifs and taxation policy. They cannot compete with some of the other deposits.

DR. PHILBRICK: Will you address this idea in your report?

MR. WEART: It is discussed in the EIS, yes.

DR. PHILBRICK: Okay.

Now what's your feeling about the overall feasibility of waste disposal in bedded salt in the southwest in the Delaware Basin?

MR. WEART: Technically I think it's very good. I think that there are questions related to the resources, and I believe in the long run they won't deal with the amount of resource but rather with this other question that was raised, about the attractive nusance aspect, or attractive to future generations.

So the increased probability that man will drill into or through repositories, that really is the issue. That one I think may be of greater probability than for something in the Pasco Basin, for instance, the possibility of man's breaching it. But I don't think for any repository anywhere in the United States that one could provide 100 percent guarantee that it would not be drilled into some time in the future.

DR. PHILBRICK: By this society.

MR. WEART: By this one or any one.

DR. PHILBRICK: In the future societies, wipe this out and start over, when do you think society will develop, in terms of hundreds of years, thousands of years, capability of drilling to the depths you're talking about?

MR. WEART: Well, if I just go back and look at what they were able to do in European countries as far as mining rather than drilling, they were able to mine to depths like these before we knew anything about radioactivity.

DR. PHILBRICK: Were they going down as far as 2000 feet?

MR. WEART: Yes.

DR. PHILBRICK: Now when did they start to get to that depth? With the invention of gunpowder?

MR. WEART: I don't really know just when. But I know that some of the deep mines in salts in Europe were in existence in the mid-1880s.

DR. PHILBRICK: Okay.

If that is the time, then 200 years from the present the initial excavation for water in the Mesopotamia area at the maximum depths that we know of were around 300 feet, back 2000 or 3000 b.c. So 5000 years can elapse with a new society before they can get to this depth.

I think this thing ought to be stated when you consider drilling into resources, if we wash out the society we're in now and start a new one.

MR. WEART: If I might respond just briefly to that, one of the things that we do have in our program that we have not addressed at the present time is what you might call risk analysis. We've done a consequence analysis where we assume these things happen. And I agree with you that many of the things we assume will happen are extremely unlikely. And if we could get a good quantification of that then we could develop the associated risk.

DR. PHILBRICK: Do you state in your report that it appears that these things are unlikely, or do you lay them out and say This is a thing without probability?

MR. WEART: I hope in there our answers are properly qualified.

DR. PHILBRICK: Tnank you.

DR. MOELLER: Thank you very much, Mr. Weart.

We're at the halfway point in terms of time, so we'll take ten minutes.

(Recess.)

DR. MOELLER: Could we resume, please? The meeting will resume.

The next item scheduled on our agenda is a presentation by the Director of the New Mexico State Environmental Evaluation Group, which is looking over the facility. That person is Mr. Robert Neill.

Bob, the floor is yours.

MR. NEILL: Thank you, Mr. Chairman.

It's a pleasure to be here this morning and to see so many of the people I've worked with in the past in the business of protection of the health from unnecessary radiation. Alex Grendon and Jack Healy, on doses from color TV sets, Dick Foster has been the chairman of our advisory committee on environmental radiation, Herb Parker, the chairman of the Bureau's advisory committee on setting regulatory performance standards, and, of course, yourself.

The years have certainly gone by. And I was amazed at the report that to date we've spent a total of over one billion dollars in the area of radioactive waste disposal.

Earlier today the comment was raised on the endangered species issue, and I haven't had the heart to tell anyone yet that on the work on the Pecos River we pulled out four snail darters.

(Laughter.)

Let me tell you a little bit about what's happening on the state level in New Mexico on the proposed WIPP project. Needless to say, I'm not hear to speak for all interests in the state, but will try to provide a perspective on the sample of the evaluation group.

On the WIPP project, which as you know is slated at the present in FY '80, to be about $55 million total, which is five percent of the proposed budget for the coming fiscal year on waste disposal management. The purpose of our group, which is part of the New Mexico Health and Environmental Department, is to conduct an independent evaluation of the health and safety of the potential radiation exposure to people and environmental degradation for the proposed WIPP project.

As you'll note, those words are somewhat akin to the charter of the Advisory Committee on Reactor Safeguards. Now how will it be done?

Our staff will be in the business of reviewing reports by both the Department of Energy and other federal agencies and other groups both pro- and anti-WIPP. Our budget, under contract to the Department of Energy, is for $350,000 per year for six years, and that level is about less than one percent of the total budget.

We will provide feedback in the form of reports to the Department of Energy, the Secretary of Health and the Environment Department, the legislature, governor, and, of course, the public. Since I came on board in November we have been successful in getting the services of an environmental engineer, Dick Schnell, who has previously been with the Environmental Protection Agency, a geohydrologist, named Gelhart, from the University of New Mexico Tech, who was available at the time, and I've been using a number of health physicists in consultive capacity.

Today our efforts have amounted to about one man-year, both for in-house staff as well as a third of a man-year in the use of consultants.

Now the output of the group will be used by the state in exercising the current option that has been offered by the Department of Energy. And in our business we will generate radiation dosage estimates which will be of use by the various bodies of concern.

Now since millirem figures aren't terribly helpful at times to both the general public as well as the professional community, we will also develop some estimates of absolute risks from this, and for the individual that wishes to make such a comparison, we'll include tables of other radiation doses to the environment and other risks, as well as other societal risks that we're exposed to.

One of the things that we will probably not do will be to compare these risks to what a real accident would be.

We will try to differentiate between both voluntary risks where an individual will accept a certain exposure, a comparison to those which are involuntary on society.

In generating those dosage estimates, as you know, Mr. Weart covered earlier that the repository is scheduled to have 100 percent of the military stored wastes located as well as ten percent of the ten year old spent fuel which we currently have in the US from commercial power sources, as well as 17 producing high level wastes.

We'll look at transportation accidents and possible doses incurred there. We'll go to the breach and leach type calculations described earlier today. We'll look at issues, as earlier mentioned, where there will be contamination of natural gas.

We'll look at the issue of wells being sunk as to whether or not -- what the potential radiation exposure would be from there. We'll try to go through and check some arithmetic of various calculations that were described by Sandia, et al. We will also probably take the WISAP program from their computer modeling, as well as other reports.

We'll look at some of the transportation problems associated with those retrieved high level wastes when the experiments are concluded. And we'll look at some of the calculations and their reasonableness.

Let me tell you a little bit about some of the legislation that was passed in New Mexico during the session this past year, where two bills relating to the WIPP were discussed.

The first, known as the Concurrence Act, provides for the definition of concurrence by eight members of the legislature in which they'll spend a year to sit down and define exactly what is meant and how one would exercise this option of concurrence provided by DOE, based on parts of the Environmental Evaluation Group, but it would be based on a vote by the legislature, a signature of the governor, a vote by the people.

The issues here are quite obviously very important because both the secretary and the deputy secretary of energy have stated that the state will participate in the process of the assessment and evaluation of WIPP. And I think that any time a bureaucrat, whether it's in Washington or Santa Fe or elsewhere, says that while they clearly have the responsibility and the authority to take an action and they want to share those authorities and share those responsibilities in the process with the people that are affected, I think that's a commendable act and I think they should be really praised for that.

Another feature of the concurrence act is to establish a three man task force with the secretary of health and environment department, the secretary of energy and minerals department, and the highway administrator. Their role would be to coordinate the state activities relative to the proposed action.

The second act establishes the transportation act, that one of the problems that's come up recently in New Mexico is the various jurisdictions have been establishing regulations regarding the transport of radioactive materials, and it was considered appropriate to have one body establish standards which would be applicable throughout the state, rather than having many various regulations in effect.

Once again, I'm very proud of the actions, I think, of the legislature. I think maybe they will serve as a model for the other states.

Perhaps the Department of Transportation has considered issuing regulations comprising all of the efforts. The state legislature in my own judgment really deserves high marks in considering these issues and taking the position that the

WIPP repository is entitled to a fair hearing. That is to say, it shouldn't be approved before the facts are in, nor should it be disproved without benefit of all of the information.

In fact, when one reviews the regulations by 22 other states which ban the repositories, some of them are not very well defined. Clearly, I think this is cause for giving the legislature high marks.

Now what are some of the problems that happened in New Mexico? And it's presumptious of me or anyone to try to siccinctly summarize the issues, but I'll try to identify some of them for consideration here.

The first relates to that standards and criteria not currently available for waste repositories as we know, that EPA will establish their criteria for guidance of federal agencies. NRC is establishing a system to develop regulations for those who wish a license. But it will take several years for these things to come into effect. And in the meantime the plan, as scheduled, is to proceed with WIPP.

I'll give you an example that just came in this morning. I think it's interesting. And I'd like to solicit the Committee's views on this.

Hanford this morning stated that in their selection of the criteria which the sites would meet, they pointed out they are using the National Academy of Sciences reports as a basis for those criteria which should be considered. Sandia later pointed out that they had used in effect some of the criteria which they had established as well as using some of the recommendations of a group from the Oak Ridge Laboratories.

Now the issue, or one of the points that's being raised, is while these sets seem certainly reasonable and adequate, we have recently recommended to the Department of Energy that groups such as the Advisory Committee on Reactor Safeguards and perhaps the National Academy of Sciences group, as well as some of the applicable federal agencies, take a look at these criteria and either concur that they are reasonable and adequate, or make suggestions for extending and increasing or changing some of them.

And I think this is an important concept and an important issue to proceed with in the absence of some of the final standards that we're going to have.

One other issue of that concept is that which has been mentioned earlier today. It's whether the NRC will license the facility and what the implications of it are. I might perhaps try to put it in terms that are even more specific to you all, but in your role on the Advisory Committee, to assess the health and safety implications of a proposed nuclear reactor facility or some other facility, if WIPP is not licensed, that means the NRC will not develop or generate their safety evaluation reports, nor the environmental statements. And whether or not this would complicate your job and make it more difficult to try to provide an assessment in the absence of those reports, that's one of the specific points.

The state may well request an equivalent type of review procedure to be established if NRC is not authorized by the Congress to get the licensing effort for it.

Another concern which crops up constantly there is while the technological community may state that the technology exists to get on with the job of establishing and have the answers with R&D on these repositories, people note that the budget for waste management has in the past year been a half million dollars, and the present budget is requesting an increase to one billion dollars.

Sometimes it's rather difficult for people to view these seemingly inconsistent positions, and there is some apprehension as to whether or not we have all of the information required at this time.

One other area of concern, as the investment in the WIPP project proceeds, the issue is whether the threshold will rise proportionately. This is one that I think is a real concern, and one which cannot be ignored.

Now the job that we have taken on in this context with the Department of Energy is an endeavor to get out the facts of a potential radiation exposure and put them in a format which is comprehensible and understandable by the public. This is an area that so many of us have been involved with through the decades with varying degrees of success.

One format that we have suggested to the Department of Energy which was really an obvious one is embodied in the ICRP, looking at the benefits and risks associated with this potential radiation exposure. And it's a matter of taking the specific source, but it's not military wastes but rather the spent fuel rods, and placing in columns the benefits or advantages and the disadvantages or risks associated with it by the population that's affected or by the group, a compilation of risks and defining them.

Now the job of the environmental evaluation group is to look at one aspect on the risk side, namely the potential radiation exposure, and what that entails. There are other boxes built in.

Earlier today the discussion was made on the potential human resources that may be lost due to the facilities. One estimate by a federal agency suggested we may lose a million dollars in potash, in recoverable potash in that area. Money can assess the magnitude of that. Include other factors, such as tax revenues lost as a result, and in the other column come up with a tabulation of tax revenues gained or jobs produced in the area,that if X people will work in the Carlsbad area over Y years. That certainly belongs on the positive side, the economic benefit. And on the negative side, one can point out at the end of that period when the plant is taken down, X people will be laid off, after a period of years. And we'll try to tackle it and assess the magnitude of it.

What we're suggesting is certainly not a unique concept. We like to talk about benefits and risks, and it's not as simple as the benefits and risks from, say, smoke detectors, where you can calculate the benefit very readily and the risks very readily.

But we're suggesting this format in this framework which will be helpful to the governor and the legislature and to the public, for better recognizing and understanding what the issues are and not focussing exclusively on the benefits associated with it or the risks.

In that regard I would certainly like to solicit any suggestions from the committee-- You've been in this type of business for a long, long time -- as to how we might better endeavor to get this material out in an assembleable format so that the State of New Mexico, in this specific instance, can exercise its option as intelligently and as reasonably as possible.

With that, Mr. Chairman, I'd like to stop right now and try to respond to any questions. And we welcome any suggestions by the committee members.

DR. MOELLER: Well, thank you very much, Bob.

Do we have comments or questions for Mr. Neill?

Okay, Jack Healy and then Carson Mark, and then several others.

MR. HEALY: Bob, in order to carry out this procedure that you're talking about of the risk benefit, we have run into a problem that is a bit troublesome to me. And this s that in order to do a good job of it, you have to have all of the details of the construction and the site.

In other words, you have to have it in final design and ready to go before you can do such a risk evaluation.

How would you plan to handle that one?

MR. NEILL: There are two ways, Jack. I think the way that you're describing is clearly the proper way to do it. However one model that I certainly admire is Justice Parker's summary on the Windscale Project of fuel reprocessing. And in there he devoted one page to a list of 30-word sentences of the 25 reasons why that project should proceed, and on the other page he had succinctly the objections. And I thought that that type of approach was very helpful in providing a perspective of people in viewing the issues.

Then one of the other problems I think you are alluding to is that many of these things are in dissimilar units, to try and compare health effects, dollars, and the ability to maintain a strong military posture doesn't lend itself well to being able to put these things in similar units and sum them up and see if the sum of the one column exceeds the other.

But I truely believe that in every endeavor, whether it's personal or sociatal, we have to do this kind of thing in reaching decisions. And I'm not adverse to leaving it in that form.

Your point is well taken, but I'm thinking more of the Justice Parker type of approach.

MR. HEALY: In other words, you would not really expect to have a final design, but would take the type of approach that was taken earlier in nuclear energy, and that is -- in many cases, anyway -- and that is we'd see how insurmountable problems proceed with the design at this time and we're confident that this design can be made.

Is that right?

MR. NEILL: I think that the dosage estimates, whether one, say, goes the EPA, you know, in the general sense, they can believe that we can design a repository such that there would be less than -- I believe the figure was .1 effect per year. This is a type of calculation.

And I think that perhaps if one puts it in that context that the public and people can say Well, let's take a look at that risk, let's compare it to some other risks and decide whether or not this is acceptable or unacceptable.

MR. HEALY: Okay.

I referred earlier to endangered species, and I think you know who I mean. Do you think that you'll have any luck with that approach with that particular group of people? Or are you aiming more at the legislature?

MR. NEILL: Well, we don't know how the legislature will define "concurrence", but I certainly view our work of trying to lay it out to either -- to show the legislature, the governor, and the people in this state, regardless of whether they're either pro or anti, the position of our group is neither pro- nor anti-WIPP. This is a very important issue.

And we have endeavored to be absolutely neutral in this regard. And we're not proponents of it nor opponents.

MR. HEALY: You're certainly in the hot seat, and I wish you a lot of luck.

DR. MOELLER: Carson Mark.

DR. MARK: I'd like to say that I think Mr. Neill has described the situation emminently reasonable in those terms. It's just the job that's going to have to be done if the people of New Mexico are to reach any kind of a defensible position on that.

There is a lot of feeling involved which has to be presented with facts.

It's perhaps a little too early to ask you to answer this. Sandia has made some estimates of the magnitude of possible physical effects and events, and of course their work is still tentative, as we've just heard. And your group has not done that work on these exact problems for terribly long.

I was wondering, though, if you could say whether you find already that the estimates of the magnitude of undesirable events as perceived by the Sandia people are at all similar to the estimates that you would find acceptable?

MR. NEILL: I don't know. One of the reasons Don Schueler isn't here is that that report at Sandia is being released yesterday or this morning, and we'll look at those calculations.

At this time I have no way of commenting on this.

DR. MARK: I was afraid that that might be the case. Thank you.

DR. MOELLER: Okay. Let's see. Alex Grendon and Martin Steindler.

MR. GRENDON: At a glance, it's evident that the benefits are largely national in scope, and the costs environmentally speaking are local. Let us say, then, that New Mexico says We don't want to be the ones who pay local costs for national benefit.

If New Mexico were to say that, then probably any other state would say the same thing. Don't you then foresee that this would ultimately result in becomming a federal exclusion area, just as atomic energy started out to be initially? Are you going to present that viewpoint in your report?

MR. NEILL: I don't know, Alex. And I think that that is the heart of the issue.

For example, one could argue this way: It is beyond the scope of my group's effort, namely to look only at potential radiation exposure. But in order to be able to provide an input back to the state, we feel it's going to be necessary to look at the total benefits and total risks.

Let's take the military wastes. One would say that yes, there is a greater risk to that population associated with this. One might take the position that the defense of the country could be equitably distributed against the population. If there is a higher risk, that's the way it ought to be done.

Now let's take the other one of commercial spent fuel. If one goes through this benefit-risk analysis and takes the entity of the nuclear power industry, there are a number of discrete advantages in locating ten percent of the ten year old spent fuel there. It solves a very crucial problem. There are a whole host of advantages they have.

I'm not aware of any of the disadvantages to that organizational entity located there. So in that box it might be zero. And when one looks at the population at risk, one sees disadvantages that the risks, albeit very small, are not quite zero.

Perhaps this type of analysis would focus attention on any potential imbalances of these various groups to better decide whether or not some mechanism should be established to provide discrete benefits to that group. That will be a political decision, I'm sure, as to whether or not there should be compensation roads or what have you.

DR. MOELLER: Okay.

Martin Steindler.

DR. STEINDLER: You indicated several times that the scope of your group's activity will be an independent evaluation of exposure, and that those are the limits of your activities. Yet the discussion that at least has elicited the most response so far has dealt not with exposure but with the peripheral aspect of it, ultimately resulting in what you I guess assume to be a risk-benefit analysis.

I assume, then, that this technical discussion that you are going to prepare is far from limited to exposure analysis. Is that a reasonable assumption?

MR. NEILL: Well, in reviewing, for example, the geological characterization report on the WIPP site, obviously one would look at the solution mechanism described earlier today to see whether that possibly breached the integrity of the repository.

So from that standpoint, yes, we will look at the other issues. But the benefit-risk, which could be a concept and certainly we don't know, in this case it is more complicated than a benefit-risk type of analysis for smoke detectors.

One can look at that potential radiation exposure and calculate that if every home had one one could save 4000 lives per year. And as MacDonald Ren in a recent paper had, with those types of doses and exposures, it could result in possibly .07 cumulative deaths per year from that exposure. One looks at the benefits and risks from that type of thing and it's rather simple to do the analysis.

But there are so many other factors involved in this endeavor that while we're doing the one box on radiation exposure in order to assess benefits and risks, there are many other boxes to be filled in, both by the Department of Energy and by other elements of the State of New Mexico.

DR. STEINDLER: Okay.

Let me make my comment a little clearer. You've already addressed at least one question, and that is you're going to try to classify risks in terms of voluntary and involuntary. You have, I believe, by the act, moved out of the area of technology and into the area of politics.

You can, I believe, structure the ground rules for your analysis to come up with any answer you like. It's a fairly well established technique which has been used with great skill, I might add, and some useful life by a number of different groups. So I think it ought to be made fairly clear at the outset that the analysis that we're likely to go through will at least be in two parts. One is there's no doubt that you're going to have to engage yourself in an analysis of the technical data that is generated by others in a review of the basic assumptions that are used to arrive at manipulative data, either by computer programs or whatever else.

But in order to satisfy the final output you're going to have to provide some independent input in the non-technical area, and I don't think you really should disclaim either implicitly or explicitly the inclusion of sociatal and political information to come up with whatever the final result is.

The second point I think I would make is that you have taken as a given that a risk-benefit analysis is,one,desirable and, two, possible in a meaningful way. I have yet to hear a convincing argument that, number one, it is possible in a meaningful way to arrive at sensible risk-benefit outputs, and, two, it is not at all clear that it is the only or the best way at arriving at a decisionmaking tool which I presume is the final bottom line of your whole endeavor.

And I think it would be of interest to at least examine before you get too far down the line whether or not it is necessarily true that a risk-benefit in the numerical methodology that you've outlined so far is even possible to give you meaningful answers to the kind of questions you're asking without requiring some predetermined set of ground rules, which I think stacks the case.

Again, I'm sure we can find in the literature,various kinds of literature, risk-benefit analyses so couched that the answer is predetermined largely by what the ground rules are before you start.

The final comment I guess I would make is that I have to agree with Alex's -- I guess it was Alex's comment, down at the bottom of the table -- that there is evident now and growing at what I consider to be an interesting rate, a movement throughout the country that in effect says Don't dump it here. And it doesn't make any difference whether we're talking about spent fuel or land fill or hazardous chemicals, it makes no difference. The attitude is basically the same.

If you extrapolate that, and unfortunately there are sufficient data to make that extrapolation viable, if you extrapolate that then the potash mining in your state will extract out of your state at some tax for the 49 states, a necessary component of society. And you will be asked to pay a tax to, for example, Michigan, that exports iron. And pretty soon, instead of having 50 states, you're going to have 50 countries.

The result of that kind of a situation I think is disasterous. And so while you're embarking on a politically very important mission, you may well be setting a set of ground rules for other missions of that kind that you ought to examine with the greatest of care, not in a technical area, but in the sociatal and political area before you get too far down the line and find yourself in an irreversible situation.

That's not really a question, I guess it's a long winded comment.

MR. NEILL: And a very good one too.

DR. MOELLER: Okay, Don Orth.

DR. ORTH: A rather general comment or question.

Other states also have to worry about federal activities. So do you exchange information with any kind of comparable organization, with any other states?

MR. NEILL: For 15 years there's been an association of radiological health programs where you have the chief rad health man in every state and he gets together once a year together with officials of the Bureau of Radiological Health and the regulatory commissions and, more recently, the Department of Energy. Such a session is scheduled in the first week in May in Oklahoma City.

There have also been established a number of task forces in the area where they're generating some model codes in different areas. This has been a pretty effective area in being able to trade off information, concerns, solutions with each other.

DR. ORTH: Well, we've heard discussions of the activities of those groups with respect to such things as emergency planning, for example, but that's a little bit different category from worrying about the political problems of dealing with the federal activities.

MR. NEILL: They have worked in emergency planning and in fact there's a session scheduled for that next month.

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DR. MOELLER: Any other questions?

Richard Foster?

MR. FOSTER: I have a short comment and then a question or two, Bob.

First off, I would also like to compliment you on a very good focus on some of the real-life problems that people living out there are having to face.

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One of those things which you brought up was this lack of existing environmental numerical limits at this point or equivalent criteria which the whole sequence of events can be built on.

This is one we discussed at some length in a different context yesterday. I think here you have brought out another vital need for having these things and also stated in the kinds of units which people like the Governor and the State of New Mexico can understand.

Those of us who are in the technical community here who have worked with radioactive materials for a fair part of our careers, I think, feel like we can at least make some sorts of value judgments for ourselves, perhaps for our families, relative to the slowness of migration through some particular barrier, the low-level of some radiation which is received as exposure.

But I would really sympathize with you and your group who have to take some criteria which were expressed in terms of some formula for a rate of migration through a barrier and go to the people of New Mexico and say Here, this is the kind of evidence which is being presented as WIPP being able to meet what is right and proper.

I would doubt that for those people who don't have the familiarity, that they would be able to pull that off. So consequently, I think this is another reason why the country here has got to emphasize getting out those kinds of units.

And if EPA is not going to come out in a timely fashion, I think your suggestion of some interim review group taking a look at those, some interim review group who has some standing that will, in fact, help the public.

So much for the speech. A couple of small questions that I have:

You mentioned that your group would be taking a look at doses or even risks which might be coming out of WIPP. Do you intend that to be a review of the work of others or will you start with an independent development of that pretty much from scratch?

MR. NEILL: Both, Dick. (A), we'll be looking at other people's reports and,within the limits of the sources, available, would generate some of our own estimates.

Obviously, these computer-type programs that we're into now are not entered into lightly nor cheaply. And if we find at any time that we are unable to do the job that we are scheduled to do, the Department of Energy has said Hey come back in here. And so, if this does tend to be a problem, I have no doubt that the resources will be available.

MR. FOSTER: Are you into that enough at this time to know whether, from a non-inadvertent event, there is going to be the drinking water of the Pecos River or whatever that is likely to be the chief exposure pathway?

MR. NEILL: No, our report doesn't do that.

MR. FOSTER: Thank you.

MR. NEILL: I wanted to mention, too, on the earlier point, that Richard Holland is here, who is the liaison officer on our group. And Richard has the responsibility of being that interface, to be able to explain these things to the public, so any questions of that sort should be directed to Richard.

DR. MOELLER: Okay. We have two final questions. Herbert Parker and then Alex Grendon.

MR. H.M. PARKER: Dave, do we have time for one non-technical question?

DR. MOELLER: Go ahead.

MR. H.M. PARKER: Bob, in your question, you mentioned we had worked together before, and at that time I developed a very high regard for your striving accuracy and precision.

This morning at one state you said certain actions in New Mexico could well serve as a model for the other 50 states. As an ex-Englishman, I find it very hard to keep up with the United States, could you tell me the name of the

51st state, please?

(Laughter.)

MR. NEILL: Before I came out here, I was living in the District of Columbia.

(Laughter.)

DR. MOELLER: Alex Grendon.

MR. GRENDON: I hope your report will point out the time scale of any risks that might be few -- that in the near future when the present politicians may get their votes, the risks are by general agreement far smaller than those risks that are contemplated in distant times when somebody may have gotten what is there and so forth.

MR. NEILL: This issue on the risks, I think, is so important and I think we intend to get it out of the way.

And if I may be allowed, Mr. Chairman, one quick example that today we have 55,000 people a year killed on the nation's highways, who has accepted this level? Has the President accepted it? Has the Congress? Have the states?

The fact is that every person in this room accepts that level because none of us have taken any actions to change it. If we really were concerned about the accident rate, we would probably remove one out of three driver's licenses. And you know, out of 50 of us, there may be 17 or so being pulled out.

And this concept of the acceptability of risk is one that we all live with on a daily basis. And I think we can agb5 try to put these in such a format that people would say That's reasonable and acceptable or I don't want it, that is not acceptable.

DR. MOELLER: Thank you very much, Bob.

We'll move on now to the next item on our agenda which is a presentation by the Lawrence Livermore Lab on their tests, their field tests of spent fuel placements in granitic rock at the Nevada test site. Mr. L. Ramspott will make that presentation.

STATEMENT OF L. RAMSPOTT OF SANDIA LABORATORIES

(Slide.)

5.160 MR. RAMSPOTT: The project that I'm discussing today is part of the Nevada nuclear waste storage investigations. It is one small part of it and I'll set it in some context later. I'm specifically going to talk about the spent fuel tests in the granitic rocks. We actually have several other field tests, but this is what I'm going to talk about.

(Slide.)

The Nevada test site is located in Southern Nevada, about 75 miles northwest of Las Vegas, as you can see on the map. Principally, the test site is for testing of nuclear explosives and has been used numerous times in the past for other non-weapon related testing.

(Slide.)

The overall Nevada nuclear waste storage investigations, agb6 there are several objectives. The first is to evaluate the major geologic formations on NTS to see if they're suitable for a repository for high-level waste.

This is the significant part of the program -- have some $19 million in this program, we have in this program this year about $8 million on that.

The other part is to provide research and development support to the National Waste Management Program. And what I'm talking about to you today falls in that category. This is a generic test.

(Slide.)

Of the field tests in the granitic rock at NTS, the first one, heater test number one, is a series of thermal measurements, permeability measurements which were made during Fiscal Year 1978. There were no rock mechanics tests conducted during those tests but we were able to get thermal properties, thermal parameters of the rock. 205

Those parameters went into the environment of the spent fuel assemblies, which is the test storage of spent fuel assemblies which is going to start in the spring of 1980. The target date is April, 1980.

Finally, the rock mechanics test facility is the proposed project to complement measurements from the spent fuel test.

(Slide.)

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There are several important points here. The spent fuel test is a generic test. The Climax Granite in which the test is being carried out is not currently considered to be a viable repository location. This is not a technical judgment which has yet been made but a judgment in terms of resource use.

The Climax Granite is close to the weapons testing area and has been excluded because of that reason. It's a generic test in which we're taking actual fuel assemblies from operating nuclear reactors. We're retrieving them at a possible depository depth in granite.

What we're doing is we're using 11 canisters of spent fuel, six electrically heated simulator cannisters, of which I'll speak more later, and 20 auxiliary electrical heaters. Doing that, by using those, we're simulating the early and close-in history of a repository.

At the same time we're looking at the effects on granite, this time only granite, of heat alone plus the effects of heat plus radiation.

Now one could achieve some of the same information by providing, as pointed out here in the third point, some laboratory tests, computer simulations, and field tests of various sorts, without actually putting spent fuel in the ground. The benefit that we feel from doing this is that if you wait some 20 or 30 years so that you can carry out what used to be called, three or four years ago, a bulk test during the actual construction phase of a repository, there might be some unexpected synergistic effect, one that's unexpected, unpredicted. It wouldn't be revealed until that time.

So by actually placing the fuel in a very early time we are carrying out a generic test of that and therefore, guarding against the unexpected effects which might take place. I believe that Beranini of the California Energy Commission has pointed out the desirability of doing this on several occasions.

Another thing that we get is an experience base in hydrogen handling.

DR. MARK: Excuse me. Is Beranini aware of what you're just telling us now?

MR. RAMSPOTT: He was at the meeting in Tucson when a talk was made about the over-all Nevada program, so I assume that he is aware of it. I haven't personally informed him.

(Slide.)

We have had some practical considerations as well as purely technical objectives influencing the test design. The first one-- Of course all of these are trying to keep the costs low and therefore, minimize the capital investment by having not hot cell at the storage site. I'll go through that a little bit later.

One way to handle this would be to set up a hot cell above the line. We do not have that.

Another thing is that John Carr is going to talk later about the spent fuel handling packaging program in canister design and some work that's going on at the site, in which spent fuel assemblies are being stored, alluvium stored in various types of surface storage. So what he did was use exactly the same canister design with a different shield plug at the top, and we're able to effect cost savings there.

Of course one of the design tests is to keep the radiation levels low; that goes without saying. We wanted to keep the fuel cladding temperature below the allowable maximum values for integrity of the cladding.

We wanted to have public accessibility. That ties back to keeping the radiation levels low. We don't want to have to monitor people and keep them away from certain areas as they walk through the facility.

We also wanted the earliest feasible schedule. In order to do that we wanted to use off-the-shelf technology, and we did not want to attempt to design a prototype of any kind of a repository.

(Slide.)

Basically here is what we're doing, acquiring the fuel assemblies and shipping them to NTS. The fuel will be encapsulated in canisters at the E-MAD facility, about which you will hear more later from John Carr. We transport it over the roads to the Climax site and lower it to the 1400-foot level below the surface.

We are going to transfer it via railcare and emplace it in the storage hole which is steel-lined. We'll talk more about that later.

Then we will have auxiliary heaters for repository simulation, and we go through a whole series of other things, monitoring it and eventually retrieving it and returning it to E-MAD.

(Slide.)

This is an outline of the Nevada test site. The E-MAD facility is down at the southwest corner where the fuel will be received and encapsulated and then transported over federally controlled roads throughout this area up to Climax Stock which is which is up in the northern part of the test site here.

DR. MOELLER: How are they transported to the site? In regular casks?

MR. RAMSPOTT: To the E-MAD facility?

DR. MOELLER: Yes.

MR. RAMSPOTT: They're transported in a DOT-licensed ordinary surface transporter.

DR. MOELLER: Thank you.

(Slide.)

MR. RAMSPOTT: This is a very schematic representation of what we're going to do. We will have a cask which travels horizontally, a flatbed, but which can be erected during transfer operations. Because this is a very large hot bay, the fuel, the canister of fuel, will simply be lifted up and inserted into the top of this cask.

It would then be laid down and driven out of the hot bay on 50 miles north to the Climax site. At the site, the cask will be erected and lowered into a recess for radiation shielding. This recess is over a hole, a 30-inch diameter hole, a 19-inch ID casing where the fuel can be lowered 1400 feet under. It will enter a railcar cask, a separate cask underground. Again, this cask is capable of being elevated or lowered in order to keep down exposures.

Once it is in this cask it will then be transported along this grid and stored.

(Slide.)

I'm skipping over a lot of this because the principal thing I'd like to talk about are some of the technical concepts.

This is a picture of the E-MAD hot bay facility which I think John will tell you more about later, so I'll just point out that there's a man there for scale.

(Slide.)

This is a picture of a convoy there at the test site. I think you can see something about the country there. This is over totally federally-controlled roads inside the reservation.

(Slide.)

This is a picture of the facility, the surface facility. This is a mine head frame. This has been here since about 1962 when the facility was constructed to support nuclear weapons testing.

This is the active testing area down here in the mountain range which you can't see very well. It's about 75 miles away.

(Slide.)

This one is the layout of the test. The area that you see over here, the dashed area, is previously existing workings. The heater test Number 1, which I talked about, is in this area. This is where we got the information earlier, the thermal information which gives the test design.

All of the area of the solid lines which you see here has been or is going to be in line for this test. The orientation of it was chosen to be parallel to the particular principal fractures in the rock. At this time, all of the mining you see here is complete except for some mining in this electronics instrumentation alcove.

In fact, today and tomorrow, this central storage drift down here is being cleaned up. We're having a crew of some eight geologists in over the weekend to do geologic mapping so that next week we can begin to prepare this for a concrete floor to be underneath the rails. So essentially mining of this area is complete.

I will very quickly point out the canister access hole through which the material is lowered is here. The shaft station is here. These are heater drifts on either side of the storage, and this general configuration I'll come back to several times.

(Slide.)

This is a picture during the operation of drilling the access holes, a different orientation from what you saw earlier. This is the head frame of the mine. This is the drill rig which was set up to drill that 30-inch access hole. And you can see a geophysical logging truck. The hole had been completed at this time and we're putting geophysical logs into the hole at this time.

The picture was taken at about 5:00 a.m., which is why it has the unusual lighting that you see here.

(Slide.)

This is in one of the existing heater drifts. I believe it's the north heater drift but I'm not certain. And what we see here is a crew of people who were installing some instrumentation during a prefuel insertion phase of the study that I'm going to get into a little later in the talk.

This is basically what the mine looks like at the present time. The support here is rock bolts. Essentially, just as a general matter, rock bolts and wire mesh are used for any underground activity at the test site.

(Slide.)

Okay. I hinted at this earlier.

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There are two main experiments in the technical experiments in the spent fuel tests at Climax Granite. The first is the radiation effect experiment in which we're going to compare the effect on granite of heat alone, which we're going to get from electrical simulators the same size and shape as the spent fuel canisters.

We're going to compare that with the combined effect of heat and radiation which comes from the canisters of spent fuel. You can see the distribution simulators are shown by the open circles of spent fuel and black dots, and then the heaters are shown and the outer drifts are shown here.

So in this area which is shaded green, and I think the shading is not visible in the handouts which you have, unfortunately, but in this area here which is shaded green here and here, there is a distribution of spent fuel and simulators in which we hope to address the question of the differential effects, and we're going to address it in two ways.

One way is we're going to monitor the thermal fields around all of those locations and see if there's any difference in effect on degradation of the ability to dissipate heat or whatever effect one might see. The radiation has a different mechanism for getting heat into the rock and the infrared radiation that's coming from the heat, also, so we will be monitoring that fairly closely.

And the second one is the repository simulation experiment, and there we're looking-- We'll take this module which you see in yellow and use that to compare what goes on here, use that to simulate a module in an essentially infinite repository and just use this as one element of a nearly infinite repository.

Now in a repository itself this would be a half width over to the next drift, so in the calculations I'll show you in a little bit, the next drift where the fuel would be over here, and over here, and this here and here is essentially a half width for the next line of storage.

(Slide.)

The hypothetical repository then is a large array of parallel drifts based on 15-meter centers with canisters three meters apart. We chose this three-meter spacing of canisters not for any reason of our worry about the ability of rock to dissipate heat but just because in the handling of the spent fuel we wanted to have a little bit of space, and we have a lot of instrumentation down there.

We have just concerns that if we start getting the fuel very close together we might be stumbling over ourselves from a technical standpoint, so that's the only reason for the three-meter spacing. We could get them a little closer together.

The test simulations is a 15 x 15 module of that repository array that I showed you on the previous slide. The design parameter then is the temperature history of the rock wall adjacent to the center canisters at both the repository and the test array.

Essentially what we did was we calculated that location, both for a calculation which simulated this repository and also one that calculated specifically the layout of the test. And the thermal parameters were the ones which we arrived at from the <u>in situ</u> experiments done earlier.

(Slide.)

The results that we got from that during the design, the temperature-time curves for the repository calculation and the spent fuel test calculation agree within one percent in the first seven and a half years. What you see here is the rock temperature rise in Kelvin versus time out of reactor years.

We plan to put about two and a half year old fuel in the ground. I'll get into some of the ramifications of that in a minute.

Putting in two and a half year old fuel, doing calculations now, not data but calculations for both of those, you'll see that we have this much here from the repository calculation and the test layout we have.

(Slide.)

Now for the test layout, this shows some of the

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components that go to produce that curve. The heat from the auxiliary heaters is used. We can take a single canister, only a single canister, and place that. This would be the temperature-time history.

That 17-canister array along the storage thing has this, and then heat from auxiliary heaters, and that gives that curve which you saw on the previous Vugraph. This is how we're carrying out the simulation.

DR. MOELLER: Could you repeat what the auxiliary heaters do, the contribution there at the bottom which raises the total?

(Slide.)

MR. RAMSPOTT: In a repository itself, if it were laid out in this manner, there would be another drift over here that would have the same layout of three-meter, ten-foot spacing, and essentially these are closer in and they're turned on with the power history which simulates not only this drift but the next, the next, and the next, up to-- Well, we've done the calculation with 6,000 cans, 10,000, and then we did an analytic solution for infinite.

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MR. PHILBRICK: That's 1750 watts over the full height of the hole. That's not a point.

MR. RAMSPOTT: That's not a point.

MR. PHILBRICK: It's distributed over the whole thing.

MR. RAMSPOTT: Some of the original calculations done were done with point sources, but then we did line sources with 3D finite difference heat transfer calculations and then compared them. So I believe these were done with line sources.

MR. PHILBRICK: How many watts is an ordinary flat-iron?

MR. RAMSPOTT: I don't know. 1,000 watts is very typical for a heater in a bathroom, or something like that.

MR. PHILBRICK: And you're spreading that over 20 feet in depth?

MR. RAMSPOTT: The active part of the fuel element is something less than 15 feet.

MR. PHILBRICK: So then you're spreading it over 15 feet.

MR. RAMSPOTT: Right.

MR. PHILBRICK: So you might have something a little more than 100 watts per foot.

MR. RAMSPOTT: Yes. The over-all-- It's not 1750. Actually those are--

MR. PHILBRICK: 1730.

MR. RAMSPOTT: Yes. The auxiliary heaters are 1730. We have 2 kilowatts for the canisters themselves. That's what threw me. The auxiliary heaters we're talking about are 1750 watts. It's 2 kilowatts for the spent fuel.

MR. PHILBRICK: You have 2 kilowatts over 15 feet.

MR. RAMSPOTT: Right.

MR. PHILBRICK: Isn't this kind of an esoteric idea? I mean, hell, if you had 20,000 kilowatts in there that would be one thing, but you're messing around with this kind of stuff and you're talking about granite.

Why do you go through the routine?

MR. RAMSPOTT: There have been tests which have been conducted in Britain where much higher thermal inputs, something like I believe it was 20 kilowatts--

Paul, do you happen to recall that? What was the input in the British tests that caused the decrepitation?

MR. WITHERSPOON: 18 kilowatts.

MR. RAMSPOTT: There have been tests run at 18 kilowatts which raised the rock temperature to on the order of 350 degrees Centigrade which caused decrepitation of the rock wall and the falling in of the rock material.

VOICE: For how far out?

MR. RAMSPOTT: The test was terminated because the heater shorted out.

So there is this question of thermal decrepitation of the rock, and when that happens, one gets a medium which has a lower thermal conductivity. The thermal conductivity of this rock is about 3 watts Kelvin. The thermal conductivity of the sand is about half a watt per meter. So there's a possible degradation downward, a factor of six perhaps, or maybe not that great.

What I'm trying to say is I don't think it's entirely esoteric. And the other thing is that we don't know whether there will be an additional effect from radiation.

MR. STEINDLER: Could you identify where you're measuring the temperatures?

MR. RAMSPOTT: Well, --

MR. STEINDLER: For example, those that are shown on the plot just prior to putting that figure back on. You indicate a temperature rise maximum of about85 degrees Kelvin.

MR. RAMSPOTT: This?

(Slide.)

This particular one is a calculation. It's predicting the midpoint of the element, the rock wall adjacent to the midpoint of the fuel element.

MR. STEINDLER: This is immediately adjacent to the element so that the interface between the fuel element canister and the rock-- Is that right?

MR. RAMSPOTT: There is an air gap, but it is the rock surface, calculations for the rock surface.

MR. STEINDLER: At the edge of the air gap?

MR. RAMSPOTT: Right.

DR. MOELLER: Go ahead.

(Slide.)

MR. RAMSPOTT: Part of the experimental design that we're looking at here, the rock next to that center canister in the large repository, this time-temperature history varies with the age of the waste. We did the calculation for two and a half year old, five and ten year old waste. And this is the calculation which is carried out to about a hundred years.

And I don't have it on the Vugraph but the difference between our spent fuel test array and the-- Excuse me. I was going to say if one takes an infinite repository versus the one we have, there is only about a 5 percent difference out to this point, only because it deviated in about 50 years, so it's dominated by the close-in effects for the first 50 years.

Basically you can see it's quite a different curve here, so that if we put in ten year old fuel the temperature never gets quite as high and we don't have this very rapid rise. We reach a peak temperature here in about ten months with very young fuel, and five year old fuel you can see doesn't go as high, and then ten year old fuel.

What we're attempting to do here is put the most severe case possible on the rocks.

(Slide.)

There is a situation that depending on the final test schedule, we get different curves, and this is the difference just between the two and a half year old and the three year old fuel. To stress to rock to the maximum amount it is necessary to get the youngest fuel in there possible. We can't get any younger fuel because everything's together in the test fuel schedule, and we can't dry ship a licensed canister of younger aged than what would be required for the fuel cycle.

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This is essentially the layout that we have.

(Slide.)

There are some other technical issues that we're looking at regarded as somewhat secondary to the two ones we were talking about.

We are going to do a quantitative study on the effects of ventilation of heat distribution during the test duration, and the reason for that is that our calculations have shown that as much as 36 percent of the heat input would be removed by a rather low level of ventilation, quite low. As a matter of fact the level of ventilation is some 50 times lower than what we would have to have if we were doing heavy construction. So the amount of heat removed by mine ventilation is very significant at these low heat levels.

We are of course concerned with the definition of the site geology including measuring the _in situ_ state of stress of the rock and a number of other types of stress measurements. We have something I'll speak to in a moment, rock mechanics mined by experiment. I won't say anything more about it now.

We are going to put some test chips in the rock environment and also in the high radiation environment later on in the canister. We are going to do qualitative evaluation of the effects of storage on the spent fuel assemblies and canisters and I think this was put in the sense of purely a backup because it is going to be a rather extensive program carried out by John Williams. John Carr may speak on that, whether or not they are going to do testing. It's quite a bit more extensive than anything we would do. It's a qualitative study.

It's possible that we can do backfill studies. And I think I have to make one thing clear:

One of the groundrules was that this material had to be retrievable because we knew of the fact that there might be falling in or flaking in of the rock. What we have done is we're emplacing the fuel inside the steel liner. The hole will be lined, and then the fuel will be inside that.

So there will be the assembly and the canister and then an air gap, a steel liner, an air gap, and the rock.

And a question came up at various times during the design, why not just put some backfill in the experiment? And we felt that we were already, with only those 12 assemblies, somewhat loose on statistics as far as showing the difference between the electrical simulators and the spent fuel, and if we took half of those and made various backfill configurations, then we would be even worse off.

So what we're considering is the possibility of running the tests for several years, depending upon the results, then retrieve the fuel and store it back in E-MAD temporarily, take the liners out and get samples of the bore hole walls and then reconfigure it with the backfill, and then go on with the tests with the backfill in place, so that we can look at the effects on the backfill as well as on the granite itself. That has not currently been considered.

(Slide.)

We had an experiment called the mine-by experiment. We're carrying that out in conjunction with Terratech. And at two locations down the drift, here and here, after we had mined out this heater drift and that one, but before any mining took place of the canister storage, we drilled a number of holes and placed a lot of stress instrumentation and displacement instrumentation in these locations.

Now this is a high enough drift. It's some 20 feet high. And it has to be mined in two passes. And so we were able to watch the mine-by at one pass and then watch the mine-by at another pass.

(Slide.)

Very quickly, let me show you the kind of instrumentation at one of those locations.

You have a number of extensometer anchors all through here and various convergence heads which were in place after the first bench was put through and they are now in place. They are there for permanent measurements. So this was a whole series of measurements that were made.

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(Slide.)

Running through this very quickly, what we have is a finite element calculation predicting the displacement after complete excavation of the tunnel.

Along this ridge you'll see the very light lines which you'll see there, the original grid. The dark solid lines are the displacement lines. You can see the displacement scale. It's about a millimeter, and you'll see there's about a millimeter rise in the floor at that point. So these are the kinds of displacements that we're looking for, attempting to measure this mine-by experiment.

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Now after we do that calculation we set the grid back to zero, and one can go through a calculation to show the displacement from thermal load after a year. And now we look at the scale and it's two millimeters and you can again see the kinds of displacements we're going to get on the floor and the ceiling and over here. It's quite a different displacement pattern.

You'll see that the magnitude of the displacements from the thermal load seems to be greater than what is predicted by the code for the actual mining itself. And we started that mine-by experiment late in February. The mining is completed. Most of the data are available. We have not produced that data at this time but we know that we have it.

We are continuing to take certain key measurements but we should be able to quantitatively compare the mining in this location with the calculations that we have and then be able to have data on the effect of the mining versus the effect of heat.

(Slide.)

And just very quickly, this one last Vugraph is the type of calculations we've been making, 3D finite difference transfer calculations showing the effects of ventilation, showing the temperature history versus time at a number of locations.

This is the air in the drift itself which you can see is tracking along here, and this is the temperature on the steel shield plug at the top of the canister which is about 85 degrees.

So essentially, Mr. Chairman, that's it.

DR. MOELLER: Thank you, Mr. Ramspott. A couple of quick questions.

What capacity would you have, or could you have here for spent fuel if everything works out? In other words, could you have the capacity for the 70 operating commercial plants in the U. S.?

MR. RAMSPOTT: Well, I think I need to stress that this is a generic test and--

DR. MOELLER: So you're really not looking for that at the present time?

MR. RAMSPOTT: Because of the interaction with the use of the site test program and a number of other issues we have made, that strictly is a generic site.

DR. MOELLER: Okay.

Do we have questions?

Jack Healy.

MR. HEALY: All of the temperature measurements you have indicated have been measured at one point at the surface of the rock. Do you have any plans to measure the differential temperature between the surface and at some great depth in order to try to assess the thermal stresses on the rock?

MR. RAMSPOTT: Right. I didn't show a Vugraph, but we're going to have six thermocouples actually on the assembly itself. We are going to have thermocouples on the steel liner. We will not have thermocouples directly on the rock surface but we're drilling a couple of holes in the rock around each drill hole, and then we'll have a series of thermocouples just in the general field. So we'll have somewhere between 350 and 300 thermocouple channels to test.

MR. HEALY: And you will continue to have your stress gauges there during the time of the tests so that you can measure this level?

MR. RAMSPOTT: Right.

DR. MOELLER: Frank Parker.

DR. PARKER: What sort of effects would you expect in the granite that would make it unacceptable? Water cooling temperature, or what?

MR. RAMSPOTT: Well, if there really were a serious problem with this interpretation, if one got into what might be called a thermal runaway situation, I think that might be a problem. I don't know whether it would make it unacceptable; it would be a problem that one would have to look at very carefully.

DR. PARKER: Are you going to look at different thermal densities?

MR. RAMSPOTT: Not in this test. Calculationally we can. Once we are able to calibrate the codes we'll be able to look at a variety of thermal densities.

DR. PARKER: Then you could control decrepitation if that's the serious problem by that factor?

MR. RAMSPOTT: Well, I also don't have that Vugraph, but the very great majority of the heat right on the bore hole wall comes from a single canister or heater within that hole and so, particularly at early times, almost all of the heat comes there, so it is very difficult to control the temperature of the bore hole wall during the first year by spreading out the density because you are not getting very much contribution.

DR. PARKER: You use more aged wastes.

MR. RAMSPOTT: Well, that's very true. We're using very young wastes. But I was thinking in terms of density and placement of the canisters.

DR. MOELLER: Martin Steindler.

MR. STEINDLER: To what extent has NRC participated in looking at your experimental design and the kind of work you are planning on doing in the future?

MR. RAMSPOTT: Well, there have been several briefings of either NRC people or NRC contractors by the DOE office and we've conducted tours underground. But there has been no-- I think this is the first formal presentation to any body.

DR. MOELLER: Don Orth.

DR. ORTH: What did you mean when you said thermal runaway, and what are the effects of decrepitation?

MR. RAMSPOTT: Thermal runaway is the postulated case where, instead of constant dissipation of heat outward maintaining equilibrium temperature, some effect takes place in the rock such as decrepitation which greatly lowers the thermal conductivity of the rock surrounding the bore hole, so that then the temperature shoots up in the assembly or heater or whatever it is that's back in the hole.

That's what I meant by thermal runaway and that would be the effect of decrepitation of rock.

We're at temperatures here which are significantly below I think the maximum allowable temperatures, probably by several hundred degrees C. And all of the calculations turn out to be reasonable so I think we still have quite a bit of room for degradation of the heat dissipating ability of the rock.

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DR. ORTH: I still have a small problem. The thermal runaway is bad because it gives you decrepitation which gives you thermal runaway.

MR. RANSPOTT: No, no. Decrepitation gives you the thermal runaway, and the thermal runaway is bad because it elevates the temperature of what you're storing, and then there is a whole series of postulated things if you're storing spent fuel. Maybe you split the Zircaloy cladding, and so forth.

DR. ORTH: Okay. It hasn't really been well thought out then, what are the evil effects of having that get hot at that point.

MR. RAMSPOTT: Well, I guess in the context of this experiment, right. Over-all in the scientific community, there has been a good bit of effort in that area.

DR. MOELLER: We will close this presentation with questions from Shaler Philbrick.

DR. PHILBRICK: You have a liner in the hole which is essentially a casing.

MR. RAMSPOTT: There's a standoff. There's at least an inch of standoff. And it's not cemented around the annulus. If you want to regard it as an uncemented casing, right.

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DR. PHILBRICK: You have a metallic medium between the canister and the rock.

MR. RAMSPOTT: Right.

DR. PHILBRICK: What's that for? So that you can retrieve?

MR. RAMSPOTT: So that we can retrieve; right.

DR. PHILBRICK: Now what's going to happen to the heat that's generated by the canister and hits the casing?

MR. RAMSPOTT: It will be reradiated on the rock.

DR. PHILBRICK: Reradiated into the rock.

MR. RAMSPOTT: It's just one step.

DR. PHILBRICK: Where does this decrepitation take place?

MR. RAMSPOTT: It takes place in the rock.

DR. PHILBRICK: What is the actual effect? Is that material going to spall out and get up against the casing?

MR. RAMSPOTT: Right. That's the postulated event.

DR. PHILBRICK: Then are you going to pull the canister and pull the casing?

MR. RAMSPOTT: We will pull the canister. How easy it will be to pull the casing I don't know.

DR. PHILBRICK: You don't know about that.

MR. RAMSPOTT: No. This is the reason why we have the casing there. It's because if you wedge the rock in against the canister and casing--

DR. PHILBRICK: I'm with you on that.

MR. RAMSPOTT: I should point out at the time of insertion of this fuel, the surface dose rate is 65,000 r per hour, so that we can't jiggle things around in a typical oil field fashion.

DR. PHILBRICK: You can't get in there and push it around with your hands.

MR. RAMSPOTT: Right.

DR. PHILBRICK: How far apart are these things now?

MR. RAMSPOTT: They're ten feet. Center to center, they're ten feet apart.

DR. PHILBRICK: Do you think each will affect the other?

MR. RAMSPOTT: After a certain period of time, somewhere toward the end of the first year, they're beginning to see the effects of canisters farther down the way, yes.

DR. PHILBRICK: They do.

MR. RAMSPOTT: In fact, the very, very initial heat gets there in a few months from the closest canister, and the small contribution rises. Radiation-wise, we don't expect any interaction.

DR. PHILBRICK: Is the last question the one which says why can't we go to lunch?

DR. MOELLER: Well, thank you very much.

The last presentation prior to our lunch break will be on the subject of the two-year field tests in granite that are being conducted in Sweden at the Stripa site. This presentation will be by P. Witherspoon of the Lawrence Berkeley Laboratory.

MR. WITHERSPOON: Mr. Chairman, can your Committee hear me if we do not use the microphone?

I have about a 30-minute presentation, Mr. Chairman. I don't wish to delay the luncheon of this distinguished Committee.

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DR. MOELLER: Well, the schedule called for a total of 30 minutes. Whatever you can do to shorten it will be appreciated.

(Slide.)

MR. WITHERSPOON: This is a project between the governments of Sweden and the United States, with the Department of Energy providing funding for the Lawrence Berkeley Laboratory to operate a test facility in Sweden at a place called Stripa with these program objectives in mind.

We have now accumulated about two years of data, field data, that I would like to summarize for you very briefly. One main point, to try to get at design parameters for a waste repository, to develop instrumentation obviously is a considerable concern as one gets into the large-scale field test facilities, to collect data for predictive models and, of course, to promote an international exchange would be very desirable.

(Slide.)

The location is in south central Sweden in an iron ore mine that's been in operation in the shallow levels for 400 years. The most important part of the mining operation has been since World War II down to depths of about 400 meters.

(Slide.)

The LBL program is outlined here, consisting of heater experiments to simulate the effect of radioactive waste, the energy from radioactive waste on a crystalline rock.

In addition, fracture hydrology assessment is another important part of trying to understand the way in which fluids can move through discontinuities in a granite rock mass.

(Slide.)

The underground rooms are at the 330-meter level, and an assemblage of rooms off this main added at approximately 100 meters deep where a granite rock mass joins the iron ore body that is essentially in the lower part of this slide going back for about a mile. All of this was newly mined by the Swedes immediately before the experiment began.

The tunnels are about 5 meters in diameter. The total length is about 100 meters. The location of the U. S. experiments are shown, indicated here: a full-scale experiment, a time-scaled experiment, a computer room because there's some 800 channels of information to be stored, digested, and displayed on a TV screen on command.

(Slide.)

The full-scale experiment consists of two canisters. We were told by the Office of Waste Isolation to use a canister 12 inches in diameter, 10 feet long, with 5 kilowatts in this one on the left and 3.6 kilowatts for the canister on the right. They are separated by 22 meters so that over the two-year period in which we were to observe heat effects, no interaction would take place.

The instrumentation is from a horizontal direction from an extensometer drift and from the floor of the full-scale heater drift; thermocouples extensometers, stress gauges, a number of methods of measuring the behavior of a fractured crystalline rock under a thermal load.

(Slide.)

The heaters were designed and constructed by the Lawrence Berkeley Laboratory, tested up to 500 degrees Centigrade over a period of six months. This is one of the heaters about to be emplaced in a 16-inch hole with a 12-inch canister, leaving 2 inches of an air gap for transmission by radiant heat.

The instrument shed's in the back. The heads of extensometers were placed in a vertical mode here. This work was done by Teritech who calibrated the extensometers and placed them in this vertical mode, as well as in the horizontal modes you can't see because of the location of the room.

One of our main concerns is the prediction of the thermal field, how well can we predict thermal history? We will look at a plane through the midpoint of this canister underground after 190 days and compare predicted temperatures, based on laboratory measurements of thermal conductivity, resistivity and conductivity, with the actual measurements scattered throughout this rock mass by virtue of thermocouples placed in three dimensions around the canister.

(Slide.)

This is the result, 190 days with temperatures plotted in degrees Centigrade. This is meters, out to 4 meters, and from the center of the axis, plus 4, minus 4 in the Y direction. Dashed lines represent computed results. The squares represent measured results in the same plane.

Note that between 35 degrees and 50 degrees, 37, 37, 38. Note that between 25 and 35, the same thing, 27, 27, and 27.

You can move into the center at the heater, very close. And the net conclusion is one can predict the thermal shield.

At a point a half a meter away from the axis of this heater, in other words at a point right near this 147 degrees, this is simply the history of the thermocouple as measured by the solid line.

(Slide.)

As predicted by the dashed line, some thermocouple difficulties had to be overcome and thereafter you will note that there is rather good agreement in predicted and measured.

(Slide.)

Turning to another experiment on the other side of

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that tunnel which we call a time-scale experiment, we have emplaced eight small heaters ten meters below the floor. This distance is ten meters. The heater is one meter long. It operates at one kilowatt.

And by virtue of the laws of scaling, we have been able to set this array of heaters up so that the temperature fields do mesh in the same time period and enable us to predict what would be accomplished in the full-scale heater experiment over a much longer period of time. The scaling factor is essentially one to ten.

So we can observe temperatures in the full-scale for two years. Data collected in this time-scaledroom would enable us to predict effects over 20 years. These are scaled with the three-meter directions in the short spacing, seven-meter directions in this longer spacing, representing rows of canisters about ten meters spaced along the length of it and adits approximately 20 meters apart.

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(Slide.)

Results after we looked just briefly at the time-scaledheater room: This is a view that shows the granite walls. Notice no supports are needed here. This is very tough rock. This is about five meters across.

These small chimneys here are to condense water that was found in the heater holes well below the water level. We must be able to handle water in the fractures that, as I'll show you in a moment, are all over this granite rock.

Again, some extensometer heads are shown on the floor.

(Slide.)

Just to give you one idea of the temperature results that essentially are the same as those obtained in the full-scale experiment, this is a plot of temperatures over distance at the midplane of all eight heaters, both computed and measured. This distance is about 22 meters in this direction and about 8 meters in this direction. The computed are shown by the dashed lines, the measured in the same plane between 30 degrees and 25 degrees, again a remarkable uniformity, 27, 27, 27, 27.

You can look through these results and those of the full scale and despite the discontinuities in this rock system, the temperature field can be predicted.

(Slide.)

Turning now to another important effect, and that is the displacement, the movement of this rock subjected to this thermal stress. Here we cannot at the moment predict the thermal mechanical effects, the reason being that as the rock mass heats up and expands, the fractures that enclose that rock block tend to close.

Our first approach to this was to simply assume an intact rock and from that we predicted displacements at this particular location outside the full scale heater of .3 meters above the midplane of the heater to .3 meters below. Over that span of 6 meters we predicted up to 1-1/2 millimeters of displacement whereas the actual displacement over 180 days as shown here is a little less than 1/2 millimeter.

If you take the ratio of measured to predicted, you get the curve shown on the right-hand slide that shows a very non-linear behavior by virtue of the fact that the discontinuities are closing up as the rock mass expands and therefore, the behavior of such a system depends very greatly on the knowledge of the fracture geometry and the stage of stress of those fractures before you begin those tests.

Notice that we get up to about 35 percent of the predicted value and after that it would appear, if we understood how to initially understand this initial movement, we could predict the whole picture.

(Slide.)

The reason for this then is the discontinuity, and we have embarked on a very comprehensive plan of mapping the existence of these discontinuities in three dimensions. This is simply the first effect in the floor of the time-scaled heater room where every discontinuity has been mapped on the floor.

Later studies showed us, as indicated in the lower diagram, that there were certain of these fractures that were the controlling features of this discontinuous rock mass.

(Slide.)

With all of the holes drilled down on the floor it is possible to project the discontinuities at the surface down into the rock mass itself, and then one can make a kinomatic study of why the fracture had difficulty moving against a curved surface, since they are not linear features, they are curved, and moves more easily along a curved surface.

So detailed fracture mapping is necessary in order to understand the kinomatic behavior of discontinuous rock mass subjected to a thermal load. That we think will lead to an understanding of how this kind of a system behaves with heat.

(Slide.)

The problem with interpretation has been mentioned. We have already performed an experiment with the 5-kilowatt heater that demonstrates what will happen when the stresses on the rock wall exceed the compressive strength of the rock.

This is the 5-kilowatt heater, 12 inches in diameter in the 16-inch borehole. At Day 7, the skin temperature of the heater is about 190 degrees Centigrade. The borescope shown by the circle can be run up and down the 2-inch annulus between the heater and the rock wall so that we could examine decrepitation during the consequent rise in temperature of the system. Not much was observed at Day 7.

At Day 97, the canister temperature was 320 degrees Centigrade. Some evidence of very small flakes, about the size of the end of your finger, about a millimeter in thickness falling off down into the annulus around this heater.

At Day 204 we turned on a series of peripheral heaters located .9 meters from the axis of this large, full-scale heater. At .9 of a meter we had an array of eight heaters, each operating at one kilowatt. Within a few days, the borescope was encountering debris in the annulus. The temperature of the cannister was now 365 degrees skin temperature. The heater wall was estimated to be about 30, 40 degrees less.

A few days later at Day 232 there was so much debris in the annulus that the borescope could not be run to the bottom. Examination of the walls showed definite decrepitation taking place along preexisting cracks. Large flakes of granite had dropped off, and an examination of the stress indicated that we had exceeded the compressive strength of this rock at about a temperature of 300 to 310 degrees Centigrade on the rock wall.

DR. PHILBRICK: What's the compressive stress there?

MR. WITHERSPOON: About 210 megapasquales. Multiply that by -- what? -- 14, would be 145, which would give it -- what? -- 200 times 145, about 39, 40 thousand --

DR. PHILBRICK: Psi?

MR. WITHERSPOON: -- psi.

DR. PHILBRICK: Okay. Thank you.

(Slide.)

MR. WITHERSPOON: Now we're not the first.

Dr. Ramspott mentioned just very briefly an experiment run by Harwell and Cornwall in a granite system in a quarry. An 18-kilowatt heater was emplaced in an 8-inch hole and after just slightly over 100 days at 18 kilowatts the heater failed, but just before it failed the measured temperatures on the heater wall versus predicted on the heater wall began to deviate at 300 degrees Centigrade.

When they pulled the heater out after it failed, the 8-inch hole had gone to 9 inches in size, and a large amount of debris was found below the heater hole which extended a good bit below this particular heater. Those fragments are about the size of a dime, usually a millimeter in size on down to sand grain size.

So this would appear to be further evidence that decrepitation will take place at temperatures around 300 or 320 degrees Centigrade, but it technically means that the stress induced by the heat has exceeded the compressive strength of the wall on the heater wall.

(Slide.)

Another question that we're very much concerned with is what size core samples can be brought back to the laboratory when one feels that laboratory measurements will provide additional information to supplement what you're gaining in the field. It is customary to bring back samples from two inches to six inches in diameter. That's what most everybody likes to work with.

We have been examining, using this equipment at the University of California, samples up to 36 inches in diameter, six feet high. It weighs about four tons. By placing a fracture across the horizontal part of this at the middle, we can enclose it in this device and place a stress across it and examine the fracture permeability subject to stress, normal stress, across a horizontal fracture.

What we find is, briefly, we do not get the same results for the large core as opposed to a small core with exactly the same rock and the same test conditions.

DR. PHILBRICK: Which way does it go?

MR. WITHERSPOON: And it's non-conservative, meaning the small core gives us an indication of a smaller permeability than we could get for exactly the same conditions in the large core, so it is a non-conservative result.

This suggests to us -- and this is a preliminary finding there, we have not scrubbed this out -- that further work needs to be done to decide what is the right sized core. When indeed you want to come to the laboratory, is there a size effect and if there is, what's the best sized core to bring to the laboratory?

DR. PARKER: Is that also true for your temperature predictions?

MR. WITHERSPOON: No, temperatures can be predicted, we're fairly confident of that, simply by knowing the thermal diffusivity and thermal conductivity of the rock and the boundary conditions that will prevail in any underground repository.

(Slide.)

Because of that we've asked our Swedish friends to mine out a core for us. They can drill and blast and come out with perfect samples. This one has been bolted together with these steel ties. It is now in Berkeley where we intend to study the granite with a core that is one meter in diameter, about two meters high.

(Slide.)

Turning now to the other question of fracture hydrology which is a very tough problem, tough because we know we're working with a fractured rock, we need to know the geometry of these fractures which means coring a number of wells from the surface down to the elevation of the tunnel in order to obtain fracture geometry.

In the same boreholes we're making tests to get a fracture aperture. This work is still in process, and so I can't give you the results. We intend to combine these measurements into a permeability tensor that will give us the permeability in X, Y, and Z directions that would then be needed for mathematical model predictions.

But I can show you some results of our supporting activities that will be compared to the results of these fracture mapping experiments.

(Slide.)

The total location of the underground openings relative to these oriented boreholes; 52 degrees from the horizontal in this direction, 45 degrees from this, and a third borehole to be drilled later this year, have enabled us to get data to characterize the fracture geometry. There are three near vertical sets and one near horizontal set, so four families of joints exist in this fractured granite.

And again, remember the mine is an iron ore body called Leptite in Swedish. It exists back this way and our granite exists from this way out to the north. At various point levels in this mine we have been gathering water samples for geochemistry and age dating. We have looked at surface waters; we have looked at shallow well waters; we have looked at waters at the 330 meter depths. And there is one borehole that extends from 410 to 700 meters depth in the mine itself.

(Slide.)

Just one example of the results, one of a great many results that have been accumulated is given on this slide which shows the oxygen 18 on the vertical axis and the chloride content on the horizontal axis. Many more measurements have been made, but this will show you immediately that there is a distinct difference in oxygen 18 content of shallow waters as compared to those in the deeper parts of the mine.

There is also a distinct difference in the chloride content. No tritium has been found in these deeper waters. Carbon 14 dates at the 330 meter level gives us 25,000 years. Helium content as a dissolved gas in the waters confirms that the lower ones are probably older than would be obtained by carbon 14 at the 330 meter level.

Another new ratio that we're looking at is the uranium-234/238 ratio, not yet perfected. Much more work needs to be done, but the results also confirm that the deep waters are significantly different than the shallow waters, entered the rock mass when the climate was distinctly colder than at the present time.

And this then would seem to be a tool if used over a wide area, and the answers always come out greater than 25,000, greater than 100,000 years, begins to give you some confidence as to the velocity of movement in a fractured rock mass of this kind.

(Slide.)

Let me turn then to the last experiment that we are undertaking. This is in the last segment of that main tunnel that I showed before. Our time-scaled drift is here. The computer is here. The last 30 meters of that room has just recently been sealed off by this impermeable wall. Ventilating systems are now being installed so that mine air brought in at this point can be heated up to a prescribed temperature. The rock is about 10 degrees Centigrade.

We will heat this air up to 20 or 30 or perhaps 40 degrees Centigrade, diffuse it over the entire room in order to pick up what we perceive to be a very small seepage, and pick it up by evaporation. And by measuring the humidity in, the humidity out, the mass flow rate, we can compute the amount of water that will evaporate into that moving air system in this enclosed section of the mine.

Boreholes have been drilled out 30 to 40 meters in all directions at different locations in the end of this room in order to give us the pressure field. So if this experiment will succeed we will have the rate of movement of fractured rock mass into a bore hole 5 meters in diameter and 30 meters long, and we will know the pressure field in all directions away from the sides of this rock mass.

From that we can compute a permeability, and that will be an independent measurement from the ones made with all of the fractured geometry, pressure tests, and all that kind of activity.

(Slide.)

What have we learned from Stripa?

First of all, the heat transfer in these fractured rocks does not seem to be a problem. It's predictable. It is simply by conduction. Despite the water that exists in the fractures, the thermal field can be predicted.

The thermally-induced rock movements is another problem. This is non-linear; as I told you, it's non-linear. At the moment it is not yet predictable because it depends upon a knowledge, an exact knowledge, of a fracture system that fails in the rocks.

For the development of instruments I mentioned the problems we had with stress determinations, but we are continuing to work on these. Somewhat more work is needed in order to attempt to measure stress as opposed to displacement. They are two different kinds of problems.

Decrepitation certainly takes place when you exceed the compressive strength of the rock. It would appear that temperatures around 300 degrees Centigrade is the critical problem.

Laboratory measurements we think may depend on core size. This needs further study.

Accurate fracture mapping seems to us to be very important because of thermal-mechanical effects on the one hand and the need to know the groundwater movement over a total flow system.

This tool of using geochemistry and isotope hydrology would appear to be a very effective tool that needs to be used a great deal more.

And finally the problem of converting the micromeasurements that one can make in boreholes over into the global value for permeability of the total flow system is a problem that requires a good bit more work. Our ventilation experiment will be sampling a system of the order of several hundred thousand cubic meters. We think this is a first step in that direction.

(Slide.)

So it is our view that this cooperative project in Sweden has enabled us to get at the program objectives rather effectively. I might mention that the Swedes now plan to continue this work, since we will tend to taper down, with a backfill experiment in that ventilation room that I just described. It is a beautiful setup for a full-scale backfill experiment using the Swedish mix which, as you know, is 85 percent quartz, 15 percent bentonite. We want to participate in that.

The European community is getting very interested in this Stripa project. A meeting will be held in May, next month, wherein they are going to consider whether or not they want to take European Common Market money to a non-Common Market country, Sweden, and take advantage of all the work that's been done here.

The project at the moment will cost the United States $10 million at the end of this year, which is the third fiscal year. The Swedes have put in about $6 million.

And, Mr. Chairman, I believe I should allow your Committee to eat lunch. I apologize for keeping you from your lunch.

DR. MOELLER: Thank you. It was an excellent presentation, and most interesting.

Don Orth.

DR. ORTH: Last year we heard from the USGS that they considered that some years of research would be needed just to identify the items that needed to be measured in mines, much less the additional years needed to make measurements. You have made a lot of measurements and have identified many items.

Do you think you've identified essentially everything that needs to be measured to determine whether a site is good?

MR. WITHERSPOON: I shouldn't be so bold as to agree and give you a positive answer to that question. I do think we have identified the key, and that is the discontinuities.

If you want to talk about crystalline rock or shale, any of the crystalline rocks with fractures will constitute the flow patterns and then those fractures must be studied. In that regard, we have approached it from two standpoints. The heater effects, I think we know how to get the answers for that. Fracture hydrology needs more work.

And if the scientific community will agree with me that those two components represent the main problems in identifying velocity and direction of movement in the crystalling rock mass, then we have indeed focused on the key subject for storage in the crystalline rock.

DR. MOELLER: Other questions?

Frank Parker, and then Herb Parker.

DR. FRANK PARKER: Do you have any explanation for what one would guess would be the counterintuitive behavior of the different sizes of the cores and the permeability? One would think the smaller core would have greater fracture because greater relief than the larger, and yet you say you find the opposite to be true.

MR. WITHERSPOON: We think that when you're talking about fracture as it closes under stress, there is, when the size is too small, a non-representative sample of the opposing faces that are closing in such a way that the sample does not represent what will be encountered when the opposing faces are large enough.

Now how large is large enough is yet to be determined, but it would appear from this idea that as a sample gets too small, the asperities that will attach and the open spaces through which flow occurs are not properly sampled when the sample is too small.

DR. FRANK PARKER: Have you made any calculations of what the consequences are of this non-conservatism in the actual safety of such a repository?

MR. WITHERSPOON: The results that we got from this -- these are the first, preliminary results -- indicated that the magnitude of the permeability for the small samples was ten times smaller than that obtained with the large core. So at the moment we are off by a factor of ten.

DR. FRANK PARKER: But assuming you follow the Swedish system with casters and overpacks and multi-burial long-term containment, would it make any difference in their system?

(Slide.)

MR. WITHERSPOON: Rates of movement will depend upon the permeability. These lower curves are for the small core and this larger curve, this upper curve, is for the large core. And you would like to be able to predict velocity, surely, better than something of this order.

DR. FRANK PARKER: Taking into account the total system that the KBS has indicated they might do, would it make any difference in the dose to the population even with this enhanced permeability?

MR. WITHERSPOON: I think it will lead to a higher prediction of dose, and probably you know that the Swedes assume 400 years would be required for their fuel to reach the surface. As I indicated, from our studies of their own granite system at 330 meter depth, we get ages of the waters that are in excess of 25,000 years. I do not understand why they chose 400 years, and it is on that basis that they then arrived at dosage that would occur at the surface or even plants and animals that would

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be taken by the local population.

DR. MOELLER: Herb Parker.

MR. HERB PARKER: This may be an idiot question, sir, because I don't understand rock mechanics. But supposing for each intended bore hole you first put in electrical heating to bring the rock wall above the temperature that it is going to get from the natural radioactive decay later, and then switched to your permanent disposal.

Would that canister have a kind of a more comfortable and predictable wall environment from then on?

MR. WITHERSPOON: The canister might. But if you wanted to heat up the rock and then put in another source of heat, you are going to drive the system to even higher temperatures, meaning more decrepitation; assuming that you don't worry about the question of retrievability, you'll drive it to a higher temperature, bringing more decrepitation in.

I would assume one might wish to design systems to stay below the decrepitation temperature which means apparently below 300 degrees Centigrade, rather than to go above that point, but that's a matter that goes to this question of retrievability.

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DR. MOELLER: Shaler Philbrick.

DR. PHILBRICK: You are talking about frequency at spacing of discontinuity.

MR. WITHERSPOON: Yes, sir.

DR. PHILBRICK: Did you have in the borings any indication of what's known as a rock quality designation, if I remember the term?

MR. WITHERSPOON: The RQD?

DR. PHILBRICK: Yes.

MR. WITHERSPOON: Yes, we have loads and loads of curves that showed the RQD as a function of depth, from the surface of the borehole down to the bottom of the borehole.

DR. PHILBRICK: What did it do in relation to what you were talking about?

MR. WITHERSPOON: It gives us a general idea of where the fractures are predominant. The method that is usually used is a little bit crude, and we've tried to refine the RQD to show us fractions of a shorter interval from which you can develop profiles that begin to give us an idea of those zones that are more fractured than other zones.

The RQD is a first step, but it appears to be a little too crude.

DR. PHILBRICK: What did it show in the areas in which you were making these tests? Do you remember what the numbers were?

MR. WITHERSPOON: The percentages?

DR. PHILBRICK: Yes.

MR. WITHERSPOON: Oh, the percentages get up to -- Let's see -- if I can recall the profiles, about 50, I believe it is; something like that.

DR. PHILBRICK: Now let's get to the numbers. What was the spacing then between the fractures.

MR. WITHERSPOON: They are approximately one-half meter, on the average. We also had statistics as to their length. We've made length determinations; we've made spacing determinations. We've looked at orientations. There's a whole raft of data.

I should have mentioned--

DR. PHILBRICK: So then the biggest piece you could get out of the rock if you could get in there and take it apart without breaking it up would be something of the size of a half a meter, about so big?

MR. WITHERSPOON: About a foot cubed to a half meter cubed.

DR. PHILBRICK: So then if you could find a granite which had much wider spacing you'd be a whole lot better off, wouldn't you?

MR. WITHERSPOON: Yes, sir, absolutely.

DR. PHILBRICK: So then the size of the rock QD, whatever you want to call it, is going to be the first approximation of what you've got. Did you have any flow structure in this rock?

MR. WITHERSPOON: There are a few dikes located in this--

DR. PHILBRICK: I mean as far as linear elements?

MR. WITHERSPOON: Fracture zones?

DR. PHILBRICK: No, I'm not talking about that. I'm talking about flow structure at the mass prior to fracturing; then it was intruded.

MR. WITHERSPOON: I don't recall any measurements on that.

DR. PHILBRICK: Will this be discussed in the Stripa report?

MR. WITHERSPOON: Yes. I should have mentioned there's a whole series of reports.

Bill, if we could hand it to the Committee, we have for you our program summary and a list of the first 13 reports already released. We will be very happy to provide this Committee, Mr. Chairman, or anyone else, with all of the rest of the reports. There's a whole series of these in the press.

DR. PHILBRICK: Coming down now to the final question, if you were examining a geologic material, you would be concerned with the structure of the material with respect to the size of the particle that would be available in the rock as being intact rock.

MR. WITHERSPOON: You're contrasting grain size now--

DR. PHILBRICK: No, I'm talking about the mass, the rock itself, the pieces that are put together to make the rock mass.

MR. WITHERSPOON: Right.

DR. PHILBRICK: The bigger the piece, the better the location--

MR. WITHERSPOON: Exactly, exactly.

DR. PHILBRICK: Now are you in that sense saying that we can't play games in shale because the stuff is infinitely closely spaced?

MR. WITHERSPOON: I think in shale my experience in underground gas storage is such that the fractures in shale will tend to be major fractures, they will tend to be much farther apart.

DR. PHILBRICK: I'm talking about bedding.

MR. WITHERSPOON: Bedding planes in shale?

DR. PHILBRICK: Yes. THey're the weakest zones.

MR. WITHERSPOON: Right. Well, I don't believe the people who are thinking about storing in shale expect to raise the temperature of that shale up very high because we all know other things are going to take place with the clays that are an inherent part of the shale matrix. You're going to degrade your clay minerals at 100 to 150 degrees Centigrade, so you have to be careful about raising the temperature of the shale as opposed to raising the temperature of a crystalline rock such as granite.

DR. PHILBRICK: Thank you.

DR. MOELLER: Have you learned anything in these experiments in terms of monitoring?

MR. WITHERSPOON: Yes, sir. The use of thermocouples obviously has enabled us to show how well we can predict the thermal field. That does not seem to be a problem.

We are finding that better instrumentation is needed in order to predict the stress, and an idea that I have, as a personal opinion, is that during the construction of a repository, one has an opportunity for emplacing many monitoring methods and at the same time, at the surface of the land, one could try to attempt to develop geophysical methods of monitoring.

When the repository is finally closed and the subsurface methods have deteriorated, I would hope that the surface methods have been calibrated and they can go on indefinitely. But this is just an idea that is sort of in the evolution stage.

DR. MOELLER: That would be a very important contribution.

Alex Grendon.

MR. GRENDON: Do you have a number for the specific heat of this granite?

MR. WITHERSPOON: Yes. It will be in the report. I can't regurgitate it for you right now.

We were surprised how closely we could predict the temperatures using this laboratory-measured conductivity.

Do you remember the thermal measurement of the thermal diffusivity?

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MR. PRATT: Thermal conductivity ranges from like 3.2 and 2.6 watts per cubic degree C. over a temperature range of ambient to 250 degrees.

DR. MOELLER: Can you give us your name for the record?

MR. PRATT: My name is Howard Pratt.

DR. MOELLER: Alex, you have--

MR. GRENDON: It's the specific heat of the rock.

MR. WITHERSPOON: Oh, the specific heat. That's roughly 2.5 calories per gram per degrees C.

Is that about it? It's roughly 2-1/2 times that of water.

DR. MOELLER: Well, let me thank you, Mr. Witherspoon, for the excellent presentation and good discussion that followed it.

We will now recess for lunch, and we're going to reconvene at 1:40.

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(Whereupon, at 12:55 p.m., the meeting of the Subcommittee was recessed to reconvene at 1:40 p.m. the same day.)

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AFTERNOON SESSION

(1:40 p.m.)

DR. MOELLER: The meeting will come to order.

This is the resumption of the meeting by the ACRS Environmental -- or excuse me, Waste Management Subcommittee.

The first presentation for this afternoon is by a representative of the Office of Nuclear Waste Isolation, and that presentation will be by J. Carr.

Welcome here, Mr. Carr, and we look forward to hearing what you have to say.

Perhaps at the beginning you might provide us with a clear indication of your total subject matter. As we have it, you're going to talk about surface storage of spent fuel, is that correct?

MR. CARR: Yes, sir, that and the packaging of waste.

DR. MOELLER: And we note that you have or are scheduled, as you allowed it, a total time of 30 minutes.

MR. CARR: Yes, sir.

DR. MOELLER: If you can restrict your talk to less than that, we'll have time for questions.

MR. CARR: I certainly will.

(Slide.)

What I'd like to talk to you about this morning are the fuel element surface tests, or as we call them, the dry surface storage demonstration and spent fuel packaging.

(Slide.)

The objective of the surface tests, the dry surface storage demonstration is to demonstrate the dry surface storage concepts and the design, fabrication, packaging, and performance of spent fuel under near geologic conditions.

(Slide.)

The dry surface storage demonstration is located adjacent to the E-MAD building at the Nevada Test Site. The E-MAD building is a holdover facility for the old rocket program days.

As you can see, there are the surface storage casks located here and the various dry wells with the tracks for the transporter leading to them.

(Slide.)

Some of the major features of the test are the two dry storage modes, the sealed storage cask and the drywell. I'll describe these a little more in a few moments.

We are emplacing two types of fuel, both PWR and BWR in various packaging numbers. We are performing non-destructive pre-examination assemblies. We've shown the report number to give further information on this.

Some of the tests that we are doing are sip testing for pin failures, visual examination and recording of the fuel assembly member, the dimensional measurements, the bow, length, and flat-flat measurements, the fuel assembly weight, profilometry, the diameter and ovality, the eddy-current examination of surface perturbations, the gamma scanning and the gamma and neutron flux.

(Slide.)

As I stated, we are looking at two types of storage configurations, the first being the sealed storage cask arrangement. It is a large reinforced concrete structure on the surface containing a single cannister containing a single PWR fuel assembly. The cask is instrumented with string gauges, and there are a total of two of these casks at the test site.

(Slide.)

The second storage arrangement is what we call the drywell storage arrangement. Here we see where a steel liner is emplaced in the ground, an assembly is placed in it, and the appropriate concrete shield plug and drywell protective cover. Also you can see on the right some of the details of the package which is being used for the dry surface storage demonstrations.

It consists primarily of a stainless steel container with appropriate head caps and buttressed types of sealed closures.

(Slide.)

Some of the other major features that we have going with the program are, of course, the package and ground temperatures and surface storage cask strain measurements.

We have ongoing in one of the drywells a materials interaction test where we have placed seven test capsules in the container to test for compatibility, structural behavior, and chemical transformation of a number of geologic samples of various minerals and materials such as stainless steel and various other potential cannister materials.

As I described, the spent fuel package is a whole fuel assembly, the stainless steel container, and helium filled primarily for leak detection at the time of encapsulation rather than heat transfer benefits that might be derived from it.

(Slide.)

The status of the demonstration at the present time, the first PWR package was emplaced in a sealed storage cask back on December 8th this past year. We have reached canister steadystate temperature. This is running approximately 185 degrees Fahrenheit. The surface radiation, the maximum reading obtained when measured over the entire surface of the cask is a value of 1.3 mrem per hour.

We then placed two PWR packages in dry wells during the month of January. We're still not quite -- they have not quite yet reached steady state temperature. At the present time, during the past week, we are approaching 235 degree Fahrenheit cannister temperature readings. Radiation measurements taken at the ground surface indicate background radiation only.

DR. LAWROSKI: What's the heat generation at some particular rate?

MR. CARR: The normal five year old fuel, one kw on the PWRs. The BWR is also going to be around five.

(Slide.)

We talked about the E-MAD facility. Here's an overhead shot of it showing the large cold bay region, the large hot bay, the entrance into the bay, the dry surface storage demonstration that I just described is over in this area right in here.

(Slide.)

Here is a diagram of the interior of the E-MAD facility showing the entrance doorway over here, and the various elements that we have installed. The scenario that we would go through in doing an encapsulation of a spent fuel assembly, the large hot bay doors are opened, the truck transporter would enter into the building, the doors would be closed, the cask is then elevated, lifted, and transported over to the cask door platform where the lid is taken off. We then go into an evacuated hot cell environment where the cask -- the fuel assembly is lifted out of the cask and taken over to the weld pit where the cannister is already setting, put the fuel assembly into the container, put the threaded lid onto the container, perform our welding operation around the lip, essentially evacuate the container, fill it with helium, and then add our vacuum bell on top of the container to perform our leak test on the container and from there go to one of three places.

One, in the case of the dry surface platform demonstration, we would then proceed to put the package into the transfer pit. We would then open the doors in the case of the steel surface storage tank, back a truck containing the cask into the building, close off the doors, open the transfer pit, lift out the package, drop it into the container, open the doors and take the cask around to its storage platform.

In the case of the dry surface storage demonstration using the drywells, there is a train transporter which I'll show you in a moment. You would come in, pick up the fuel package and move it out of the hot cell.

In the case of the climax test that Larry referred to this morning, there will be the truck transporter where you transport the assembly from the building to the climax test site. It will also back in there, again be loaded in the vertical position, lowered to a horizontal, and then out of the building to the mine cell.

(Slide.)

As I say, here's the objective. It's to maintain that as a facility to supply waste packages to all the NWTS waste demonstrations and experiments. The presently identified packaging needs, as you can see here in the dry surface storage demonstration, the climax spent fuel test, the basalt test, a salt test facility, we also see the WIPP experimental area which we talked about this morning, and perhaps the WIPP or large ISF demonstration that might occur.

These are the approximate package numbers now being talked about and the date when the encapsulation and the start of delivery would take place.

(Slide.)

I've described some of the major features. We have presently existing the hot bay, cask work, weld pit, survey pit, transfer pit, we also have a lag storage pit which allows us to store up to 24 packages in any E-MAD building for various periods of time. It sort of acts as a flywheel and takes some of the slack out of the packaging versus the delivery portion of the cycle.

Some of the features that we have planned or are in progress is the capability to do non-destructive characterization at the E-MAD facility primarily for the post-characterization of these packages after demonstration. We are presently planning to install a calorimeter so that we can get a precise measurement of the thermal output for the various fuel assemblies. We will install a decontamination facility which will allow us to clean the surface of these packages in some of the various demonstrations, i.e., basalt and climax don't have a hot cell environment at the time we are performing this.

We also are installing a fuel temperature test rig. What this allows us to do is to impose various heat resistences, if you will, to the outside of the container or package and allow us to go in and measure actual fuel pin temperatures, so that we can tie the container temperature, the exterior container temperature, back to the fuel pin temperature, and then allow us to tie the fuel pin temperature from the various laboratory tests to the degradation mechanisms which are being tested.

(Slide.)

I just have here a series of quick shots.

Here we see the cask removed from the truck into the hot bay. Right here is the well station.

(Slide.)

Here we see the actual fuel assembly being lowered into the fuel cannister at the weld station.

(Slide.)

This gives you a little better detail of the cannister design that is used in the dry surface storage demonstration. This will be used for the climax test.

(Slide.)

Here we have a shot of the actual package container with the shield plug on top being lowered to the transfer pit.

(Slide.)

Here we have the train transporter. This is used to emplace the packages into the drywells and it's entering into the E-MAD building. This is the transfer pit here, with a fuel assembly right there.

(Slide.)

Here we have a shot of the train transporter over the drywell. It is going to emplace the package into the drywell.

(Slide.)

Here is just a diagram showing some of the details of the transfer shield of that train transporter.

(Slide.)

The last one I have is a shot that shows you a schematic of the hot bay lag storage where we store 24 of these packages for various periods of time.

Thank you.

DR. MOELLER: Thank you, Mr. Carr.

Do we have questions for Mr. Carr?

DR. STEINDLER: Is DOE planning to actually store fuel in a dry surface storage facility? Is that why you're doing these experiments?

MR. CARR: No, the primary emphasis I think on the dry surface storage has gone down to the -- how should I say this? -- the selection of the AFR pool type storage. We are primarily interested in the dry surface storage for the performance of spent fuel under those conditions.

In other words, we've had an assembly under what we called near geologic storage conditions since December. We'll have had an operating history of practically a year and a half prior to any other type of demonstration. The fuel doesn't know that it's not down in the repository as long as the container maintains its integrity. It's only concerned primarily with its temperature.

So this presents us an early opportunity to obtain that kind of data.

Secondly, it has also provided us the opportunity to effect our packaging techniques at the E-MAD facility.

Thirdly, the dry surface storage is a viable alternative storage method and we are considering it for instance in these various demonstrations, the climax, basalt, salt test facility. Eventually they will come to an end. The next question is Well, what then, what do you do with the packages in the meantime if you don't have the repository in operation.

I'm pretty sure the reactor manufacturers and vendors don't want it back. So we've been looking at this for a number of these reasons.

But the primary emphasis on dry cell storage has gone down in the past, particularly with the emphasis on disposal of spent fuel.

DR. MOELLER: Do we have other questions?

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(No response.)

DR. MOELLER: There being none, we thank you very much for your presentation.

The next item on our agenda will be a discussion of the NWTS current state activities by Mr. Kehnemuyi.

This is important to us in terms of finding sites where the various techniques and procedures that have been described to us can be utilized.

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This presentation will be made by M. Kehnemuyi.

MR. KEHNEMUYI: In my presentation I am going to try to tie together the current state activities at NWTS. You have heard parts of it, and I hope that this first slide I'm going to put on will kind of tie the program together. And then I will go into a summary type of discussion of the site selection process in salt and non-salt media. And then I would like to take a few minutes to talk about our assumed licensing process. I call it "assumed" because we certainly, as a representative of the applicant which is DOE, cannot dictate the licensing process, but we can suggest that determination of what the licensing process will be like, which of course is NRC's decision.

The organization of the National Waste Storage Program comes under the office of the Assistant Secretary of Energy Technology at the Department of Energy, under which is the Office of Nuclear Waste Management. The activities are carried out primarily by three field offices, the Richland Operations, the Albuquerque Operations, and the Nevada Operations.

Under the Richland Operations is the activity of Battelle, which is my organization. Battelle is located in Columbus, and we have a new division created in Battelle to handle this project. Battelle took over this project from Union Carbide last year, in 1978, July 1.

You heard this morning of the activities at the Hanford site, which is the characterization of the basalt formations from Raoul Deju, and you also heard the WIPP activities which comes under the Albuquerque Operations activities, and you heard a little bit about the Nevada test site activities earlier.

The function of Battelle's Office of Nuclear Waste Isolation is to create a uniform activity in the site selection and eventually the depository licensing of construction activities. Basically we develop and integrate all technology that is necessary to back this operation. We identify potential sites and you heard from John Carr about this part of the spent fuel handling packaging program.

The activities are done through sor slightly more than 50 contractors and consisting of about like 150 activities or subtasks.

(Slide.)

The on-going programs summarized on this map of the United States consist of four regions for salt: the Salina Basin, particularly activities in the States of New York and Ohio. At the moment though we have no field activities going on in that region. The domes, the interior domes in the States of Texas, Louisiana, and Mississippi. The Permian Basin activities, which, by the way, contains also WIPP as you heard about earlier today. The Permian Basin activities, particularly in west Texas. The Paradox Basin activities, which is primarily in the State of Utah.

And of course you heard about the Hanford Reservation activities today, and the Nevada Test Site operations.

The type of salts are bedded salts in the Salina Basin. The domes are of course domes, as the name implies. The Permian Basin is also bedded. And the Paradox Basin has anticlines but also is primarily in bedded formations.

(Slide.)

In addition to these activities we have initiated a program to look at crystalline formations in the United States. This is at the moment at its infancy, looking at the map in general to determine where we ought to continue looking at.

(Slide.)

We have also initiated a program to look at argillaceous formations in the United States, and this is also just starting.

Now in addition to these, we propose to make a study to find a closed hydrological system. If I may explain this thing-- I am not a geologist so I'm going to explain this thing in a non-geologist's term.

The approach so far in the program has been to find and determine where the best most rock is. Certainly that approach is good in itself and therefore, the other activities are continuing in that way.

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However, there is one other approach to the problem which is to find a hydrologic basin someplace where there is hardly any or very little movement of water. So we are going to make a survey to find out whether such places exist.

We feel that all this work, integrated together, will eventually satisfy or be in the vein of doing the NEPA Act requests and placing it in the licensing arena.

(Slide.)

The activity in the salt domes are about the furthest in the operations involved with salt. This is not designed for the purpose of building the first repository in a dome, but it is the way things have evolved in the past, and that's where we are.

We have identified eight domes at the moment. Two of them happen to be in Texas. The other two are in Louisiana-- I'm sorry, there are three in Texas, there are two in Louisiana, and three in the State of Mississippi.

(Slide.)

The screening process in numbers went something like this. This, by the way, kind of precedes Battelle's involvement with the project. Union Carbide had been doing this work. This work was done under their operations.

There were 500 onshore and offshore domes identified in the literature, 263 of which were onshore domes. There were-- Yesterday and today there was quite a bit of discussion about criteria. There were indeed some criteria set such as if a dome is extremely deep and mining and arriving there would be a problem, or the closure of the salt would be too rapid because of the depth, those domes were eliminated. And there were domes that were unavailable because they were being used for other purposes and/or there was no access to the surface.

So counting those, the screening process eliminated 148 and 79, and eventually identified potentially acceptable domes numbering 36 total.

These were a total of the coastal and interior domes. The geologists then determined that the coastal domes were not as stable. It wasn't the stability; it was the fact that the growth of the dome had not completely settled in the coastal dome and it would be difficulty to prove that compared to the interior dome.

So therefore, through the screening process, seven domes in Texas and eight domes in Louisiana and 14 domes in Mississippi were identified. This was done through a USGS study in 1973.

(Slide.)

Now in addition to that study of the 263 onshore domes, the dome size, the repository depth and the available cover above the dome itself, and whether the dome was being utilized by others or not was studied in 1975 by the Office of Waste Isolation of Union Carbide, and a consulting firm studied the 29 interior domes and determined that 25 -- studies on 25 should be continued.

And Louisiana State University through '75 - '76 and 1978 made a study and determined that of the 19, two would be of interest because of size or availability.

And in Texas, the Texas Bureau of Economic Geology made a study -- this is all, by the way, literature studies -- of 20 domes and determined that three would be of interest.

And in Mississippi, the Geologic Project Manager of the program made a study and determined that out of the 77 domes they looked at, three would be of interest to continue with, constituting the eight domes that I mentioned.

The program is now continuing on the eight domes. We have found one dome to have-- There was some solution mining activity in one, so we are losing some interest in that dome. So we are just about down to seven to study at the moment.

(Slide.)

Listing these eight domes just to give you a feeling for what we're looking for, we are looking for a depth to the top of the dome not particularly less than maybe six or seven hundred feet, and the depth to be not more than maybe 3,000 feet, and an areal size at the anticipated horizon for the repository of about 1700 acres.

So with this, one can eliminate the size of domes one has looked at, and we came up with this list of domes that we're going to study through site explorations.

Now unlike the other projects, looking at the country and exploring for sites does not have the luxury of always having accessibility to the sites. The permit process of gaining access to drill at a site is indeed a horrendous thing in itself. It is not the fact that it is a technical problem, it is really a political and sometimes social/economic consideration.

We have recently obtained access to Cypress Creek dome in Mississippi, and the drilling started there about 30 days ago. We are going to drill 500 feet into the dome itself, and we will be doing some hydrologic test holes in that area.

We hope to enter the area at the Richton dome and do some activities there.

And in 1978, there has been some activity down at the Vacherie and Rayburns domes, and there will be more site activity, drilling, at those domes to qualify.

(Slide.)

Just to tie the total program to a schedule, I have to kind of apologize for the somewhat complexity of a very easy subject such a schedule, but here it is. I think we ought to concentrate on the black triangles because they tell the story.

We expect that in our site selection, both geologic and environmental activities, not only geologic, we will be able to, if a dome or more domes quality -- of course there is always the case that none of them would qualify. But if one or more domes qualify, we expect to be able to identify one or more domes in March of 1981.

The bedded salts either in the Permian or the Paradox Basin we expect to be able to identify a site location or more than one site location, or zero, in 1982, March of 1982.

The Hanford basalt site location, as Dr. Deju mentioned this morning, would be in September of 1981.

And a site in the Nevada Test Site would be identified by September of 1983.

We do not expect to be able to identify sites in crystalling rocks or argillaceous rocks or the geologic basins, if that is a possibility that I've mentioned, until March of 1984. The fact for that is that activities in that area have not been as rigorous as the activities in looking for sites in salt.

Now tying this thing to the interagency review group's recommendations which have four strategies, strategy one would be to make a decision when the first salt site is available to proceed with a repository. That would be as early as '81.

And strategy two would be the choice between the two media which would be basalt and the salt, which would be in September of 1981.

And of course strategy three would be after various formations have been looked at, including what we term the other regions and other geologies. That decision would not be made until March of 1984.

Just to indicate to you a scale of when a repository, a first repository could be available under these circumstances if the decision were made in March of 1984, we estimate that including the licensing process, construction and preoperational tests, it could require nine years after that for the repository to be available to receive nuclear waste.

The duration would vary with the media. We estimate that salt would be nine years, and maybe other, harder rocks might be as long as a total of 11 years.

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DR. MOELLER: Don Orth has a question at this point.

DR. ORTH: On that chart we have little black marks to identify when the geologic site would be identified as suitable for the depository. We haven't heard much about how you're going to decide whether it's suitable as a repository inasmuch as the screening process already eliminated those that weren't of the right size, the right depth for utilization.

So how do you decide whether they're suitable?

MR. KEHNEMUYI: Well, the site exploration activities, the geologic activities, will be the leading thing to the decision whether the salt is acceptable for the waste that we find in that location, whether the bed is deep enough, and all of these activities which are related to the site, really, and the hydrologic considerations around the site.

Now in addition to that there will be environmental studies that will be carried on, and certainly the site must qualify for those. With that, a qualification report would be put out for each of the sites.

Now for that reason I mentioned that we do not know whether we're going to end up with one, zero, or more sites. That is the--

I should mention one other thing. The purpose is not to find the best site defined in those terms. Obviously one is looking for the best containment but, however, number one, there could be many sites that could be qualified as safe and maybe one not as good as the other. And this falls very nicely in the regional concept mentioned of locating the repositories mentioned in the Interagency Review Report.

Certainly each of the sites must qualify. The safety must be demonstrated of the sites.

(Slide.)

I'm going to now jump to what I call the assumed licensing process.

Going back to the dates I mentioned a minute ago, if one were to wait for a strategy three decision or even for a strategy one decision to proceed with a repository, a PSAR could be prepared in a period of like 12 months after the site is qualified.

At the very earliest, if strategy one were used, this would not happen until about January, 1982, or March of 1982.

The Office of Nuclear Waste Isolation, when we came on board, we felt very strongly that because of the *de novo* nature of this program that there should be some interface and discussion going on between the applicant, DOE, and the regulator, NRC, and of course others. But I'm going to touch the NRC first.

We felt that if we did indeed wait to submit a formal application in January or March of 1982, that would be too late. The criteria have to be developed. There has to be an understanding of what the applicant is doing, and what the regulators are thinking. So we have kind of devised a method of having conversations with NRC, meaningful conversations with NRC.

We plan to do this thing in two parts. Before a formal license is submitted, the first group of meetings are called information exchange meetings. We have already started these meetings. We have already had two of them. One of them was the kick-off meeting, explaining what we'd like to discuss with them, and the second meeting which was held last week was on, in general, geologic explorations of what we're doing.

We plan to have other meetings with them, hopefully one in May, followed by another one in June.

The Office of Nuclear Waste Isolation has prepared a criteria document that's in draft form. We would like to discuss that with the Nuclear Regulatory Commission at a very early date, and we hope that that will happen either in June or very early July.

Following that, that document will be circulated for comment to the outside world.

Going back to this process, before a formal licensing application is made, the Office of Nuclear Waste Isolation is now preparing a document which we have named Preliminary Information Report, which is this second item. This Information Report will be somewhat of the format of a PSAR, and will contain some discussions that are normally contained in an ER. And it will not be a specific, located site.

However, we have selected an example site which is not one of the eight domes or any of the sites that we're looking at, and we're going to prepare the Preliminary Information Report describing the site, the accident analyses that we've run, and describing a conceptual design of a repository.

We feel that such a document will open up the meaningful discussions between the regulator and the applicant at a very early stage of the adequacy of the accident analyses and approaches to the problem. We have scheduled that this

Preliminary Information Report will be ready for submittal from us, the contractor of the Department of Energy, to the Department of Energy around March of 1980, and we hope that very shortly thereafter, that document would be handed to the Nuclear Regulatory Commission for their review.

We are hoping that the Advisory Committee on Reactor Safeguards will also review this document and we hope that as a result of that review, we will end up with an ACRS letter which might list the concerns of the Committee. We feel that this is a very important step before a formal application on a selected site is prepared.

That completes my talk.

DR. MOELLER: Thank you very much, Mr. Kehnemuyi.

Do we have questions?

Let's see, Jack Healy and then Martin Steindler.

MR. HEALY: In your program I did not see anything about either tuff or shale as a storing medium. How would they fit in with what you're planning?

MR. KEHNEMUYI: Yes, they do. The activities at the Nevada Test Site include consideration of tuff as a medium, and I think I did put up a Vugraph which shows that we're going to look at the clays also in general. But as I said, that's in its infancy and we are just looking at the map.

The approach we're talking, by the way, is that not all these considerations are done in the vein of doing a study for an alternative medium. It's being done to really comply with the NEPA process, which is you look at all of them and pick two and decide which of them you will select.

DR. MOELLER: Martin Steindler.

DR. STEINDLER: You indicated it will take something on the order of nine years to pick out a repository of salt. What is the length of time that the commercial groups, industies, take to drill out a salt mine?

MR. KEHNEMUYI: Actually, our estimate for the construction period is not exactly nine years. Nine years is composed of, in the front end, two and a half years of the licensing process. We have allowed for that, for the construction authorization.

And then we have allowed five years for development at the shaft, and approximately 15 percent of the underground work for the mine. The estimate was made in line with those who have developed salt mines, and it is in accordance with that kind of activity. It takes about three years to dig one of the shafts, actually.

DR. MOELLER: Steve Lqwroski.

DR. LAWROSKI: At one point you mentioned you didn't know whether there would be one, zero, or more sites. Could you elaborate a little bit more on the zero?

MR. KEHNEMUYI: Well, it was a qualification process, as we have named it. If indeed one finds anomalies where one could not place the waste, then one would end up with zero sites completely, like the salt bed thicknesses aren't enough, or the salt is not homogeneous through that bed, or any of these factors that would make the thing impossible.

DR. MOELLER: Frank Parker.

DR. FRANK PARKER: Is ONWI doing anything to try to reconcile the differences in the various groups such as the USGS and, say, Sandia or other laboratories?

MR. KEHNEMUYI: Yes. It's an on-going program. The migration question was discussed in depth here. We have on-going at the moment some activities at Avery Island at a salt mine in Louisiana. Some people claim that that is not the answer to the whole question because the water is there and they are injecting water into the bed. But we plan to do other tests in a salt test facility on ground migration.

And the answer to your question is Yes. Through actual testing all of these questions will have to be resolved, and they will be resolved before one proceeds with a repository.

DR. MOELLER: Any further questions?

(No response.)

Well, thank you very much for this overview.

We will move on to the next item on our agenda which is a discussion of progress on nuclear waste solidification. That presentation will be made by Peter Lakey of the Pacific Northwest Labs.

Mr. Lakey, we have allocated an hour for your presentation.

MR. LAKEY: I'll have to change your agenda. I'm filling in for Al. Actually, the presentation would take two parts. I'll start with the glass characterization by John Mendel.

(Slide.)

Just to bring you in a little bit on the background, we do support a cycle on waste immobilization at Battelle. This slide here shows the tasks involved.

Yesterday you were out in the 300 area and you visited the laboratories in which the development work was done, mainly on the development of the solidification process, and those tasks then are the three on the right over there. I believe Jack Macro gave you a presentation on those tasks. Today the discussions will center more on the waste form, the two tasks, number two and number three, product development and characterization, and alternative forms of development and characterization.

I'm sure if Al were here he'd give you a lot more detail, but the only comment I might make in regard to this topic today is that we've heard a lot about the repositories and you know, if you're aware of the continuing emphasis on the repositories, this is sort of, over the past few years, introducing a new discipline, a new discipline in the work, that of the ceramicist and the geochemist, and I think this is a much-needed endeavor.

I know I've worked on the head end of this solidification process for many years, and I've never been able to justify that we have a good product, and now we need to get down into the respository and affirm the final tail end of this process is a good one. So these topics then today are pretty appropriate.

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With that I'd like to introduce our first speaker, John Mendel. John is a senior scientist at the Chem Tech Department. He has been out here several years, working in this area, and just recently he presented a summary of the work at John Glenn's Subcommittee on Energy, Nuclear Proliferation, in Washington.

John, are you ready?

MR. MENDEL: The topic of the testimony that was given to John Glenn's Committee is very pertinent to what is going on today.

(Slide.)

They were interested in glass waste forms and in the behavior in the salt mines, and my testimony was characterized as being quite optimistic.

I would like to, in the interest of time-- Maybe could we go about three slides down, to the one that talks about temperature?

(Slide.)

One of the reasons that I feel we can be optimistic about our waste disposal and move ahead with it is that this temperature thing and the hydrothermal reactions and so forth that so much has been made of in the last two or three years are really based on concerning a maximum efficiency design, as shown on the dotted upper line.

Now this is just what it says. It's a maximum efficiency design. We designed the repository to hold as much waste as possible. Therefore, we do have the possibility of high temperatures shown, but at least in the first generation repositories, we're not going to be able to achieve those temperatures because we won't have the kinds of wastes that would give you those temperatures.

And even if you go out to a few generations from now when you do have waste perhaps, you still have the option of not operating your repository at the high temperatures. You don't have to operate it as a maximum efficiency design. So in reality, the temperatures for many years to come in the first generation or the first few generations repositories could be below the temperatures shown by the darker line.

There is one other aspect of the temperature that is shown on the next Vugraph.

(Slide.)

I think it is also not being brought out in some of these. When you select one of these high temperatures and say that is the temperature in the repository, that is the temperature in a dry repository on the wall of the canister and the surface of the glass of the canister.

As shown here, here's a temperature profile and at the wall of the canister in the dry repository, the maximum efficiency design,immediately the temperature could be up in the range of 300 degrees Centigrade and that's similar to the temperatures used in the hydrothermal tests. But if water intruded into the repository so you could have the hydrothermal conditions, that gap, which is called the crushed salt in this slide, would no longer be dry. It would contain water. The thermal conductivity is much higher and the result would be that the temperature at the surface would drop perhaps down to close to 200 degrees, up almost by half.

So this is another factor that is not being taken into account in some of these hydrothermal temperature examples.

(Slide.)

Now one of the effects of temperature of course is the hydrothermal questions. Another question concerning the behavior of glass at high temperatures is devitrification, and I just want to show this one slide to illustrate devitrification behavior of a couple of waste glasses, 72-68 and 76-68 in this case.

This figure shows the leach rate after the glass has been stored at various temperatures. The storage temperatures are shown along the bottom. In each case the glass was stored for two months at the temperature and cooled, and the leach rate determined at 25 degrees Centigrade.

So these are the leach rates under various conditions and you can see the effect of devitrification which occurs and the temperature range in which it occurs, about 550 and 850 and 900 degrees Centigrade, is to increase the leach rate of the glass no more than a factor of 10. And this is the maximum effect that has been observed in devitrification of the glasses.

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This slide also shows another important thing I think. Here we have two different waste glasses and their leach rate is at least a factor of 10 difference. The difference between the glass formulations has resulted in as much difference in leach rate as the fact that they might be devitrified. And of course you can see that devitrification does not occur below around 500, 550 degrees Centigrade, so it does not occur at the storage temperatures in a repository.

We have, in one of the documents that is included with the material that was given to you, a much more detailed examination of devitrification behavior and an estimation of how the rates of devitrification slow down as you decrease the temperature.

Next slide, please.

(Slide.)

Okay. This is a leach rate at 25 degrees Centigrade, and I think that's the leach rate that should be emphasized because, as I said, the higher temperatures only last for a short time and it's possible to design these things so you don't really have high temperatures. And so although you can't assure that the water is not going to intrude into the repository at some time, it in most probability would be after the temperature has reached ambient repository temperature.

So we have done a lot of leach testing at 25 degrees Centigrade. The actual ambient temperature might be something like 40 degrees. And I think the results are best shown as a band, as shown here, and as you saw in the previous slide there is some difference in the leaching of various glass formulations. But I think it's fair to say that at least 90, 95 percent of all the waste glass that you can find in the literature falls within this band shown on this slide.

The other thing that should be pointed out is the leaching of waste glass is incongruent, and I tried to show that on this slide by showing the cesium and strontium up toward the top of this gray area, and going down to the more non-leachable constituents such as cerium and curium, which are shown toward the bottom.

DR. MOELLER: Now this is for deionized water. If you had a water that was doing the leaching that had stable

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strontium or stable cesium in it, would that in any way enhance the leaching of radioactive strontium or cesium?

MR. MENDEL: All indications are it would inhibit leaching.

DR. MOELLER: It would inhibit it. Thank you.

(Slide.)

MR. MENDEL: This is another way of showing the data that I showed on the previous slide, where it's presented as cumulative penetration or, you might say, depth of depletion if you would prefer to assume it in that manner, as a function of time and not as a log.

You can plot most of the data this way and get fairly straight lines with a slope of something between 1.0 and .5. If the slope were 1.0, it would be a corrosion type mechanism; with a slope of .5 it would be a diffusion type mechanism. The maximum we see usually, as I said, is a slope somewhere in between.

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So this is data obtained by the standard techniques like the RGA procedure where you change water frequently enough so that you try to do away with any surface reaction.

#8

May I have the next slide, please?

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(Slide.)

If you don't change the water of what we call the dynamic leach test, but just simply sample water and see how much has been leached into the water and leave it static, after a while the cumulative penetration -- this is probably the same as the previous figure -- begins to decrease or fall below the curve that's obtained by the dynamic system.

In other words, if you're not removing the water but just leaving the water there, or you might say even with a slope low, the leaching decreases as shown here.

c10

You can make a calculation based on that previous figure that might say one percent of the activity would be leached from the place in 1000 years. That would be with a continually replenished water supply.

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This indicates if water is not flowing, then instead of one percent being released in 1000 years it would be considerably below that. We don't have the models to say just how much below it. But certainly the data indicates that it would be significantly less.

Next slide, please.

(Slide.)

We have one in situ experiment that sort of bears out this idea that the leach rate might actually be quite low in a real situation where you allow things to equilibrate. This is a Canadian experiment where they buried some waste glass at

Chock River in 1960 and have been monitoring that scenario test since.

In this figure I show both some laboratory test results of standard leach tests of the glass that they buried and then the leach rates that they calculate from analysis of the groundwater around the glass. You can see after about nine years that they conclude that the leach rate has leveled off and become constant at a very low level, much lower than anything that has been made in the laboratory tests.

DR. F. L. PARKER: What would have been the effect of lithostatic pressure on all these tests?

MR. MENDEL: There's n o indication that lithostatic pressure has any effect up to several thousand psi.

DR. MOELLER: In this test, now, the Canadian work was done with whatever groundwater was there?

MR. MENDEL: Yes.

DR. MOELLER: And the glass was not -- it was exposed directly to the groundwater?

MR. MENDEL: Yes. They made the glass in ceramic crucibles and actually chipped the crucible off so that it was bare glass on all sides.

DR. MOELLER: Thank you.

(Slide.)

MR. MENDEL: Okay.

So I think, you know, that we have a fairly good handle on what the leach behavior might be at ambient repository conditions.

This figure shows the effect of temperature. Leaching is just like any other chemical reaction: the rate increases with temperature, and it increases quite rapidly.

There are two curves here, one for tests made in deionized water, one for tests made in salt brine. And these results are based on weight loss. The curves are quite parallel. And the one for salt brine is lower than for deionized water.

The matrix of the glass is really less affected by salt brine than it is by deionized water. But as you'll see in the next slide:

(Slide.)

Some of the constituents and the ones that we would be most concerned with in the early period of time and the only time that we could have the high temperatures turn out to be more soluble in the salt brine than in distilled water. So the bulk of the glass is less affected by the salt and you'll find more of the cesium, strontium, in salt brine than you would in distilled water.

And these tests were carried out at 350 degrees Centigrade.

Now I think it's interesting to look at the values over on the right where the test was made with placing glass in contact with crushed basalt in water. And here we have again this saturation or whatever phenomenon it is where you have more ions in solution and it inhibits the leaching of the glass.

So this is a log scale, you see, so that it's really a rather dramatic decrease in the amount of cesium and strontium that are found in the presence of basalt versus salt brine.

(Slide.)

Here is some more hydrothermal data at 350 degrees Centigrade, and here I'm trying to compare a lot of things. As you realize it's only been in the last two to three years that the hydrothermal experiments were being made. So we don't have enough data to draw the gray line, the gray broad bands and so on that we can at room temperature. We have to look at individual pieces of data.

Here we're comparing glass and supercalcine. We're comparing data obtained at two different laboratories. So you have to bear that in mind. But I think it shows several things:

One, if you look at, say, the cesium behavior across the top line you can see that some experiments were three days, seven days, 28 days. If you compare the shorter time with the longer time for the glass you see not much difference. If you compare the shorter time with the longer time for supercalcine you see not much difference. You're reaching a saturation situation much more rapidly at this high temperature than the two or three years t requires for the 25 degrees on that previous slide I showed you.

Another thing I think this slide shows quite well is that there is not that much difference between glass and supercalcine at these temperatures. The leach behavior of the supercalcine and the glass are comparable.

(Slide.)

This is just a little bit of data from a report that is going to be presented at the Cincinnati meeting. It's very recent data from Germany. Again it shows the rapid approach to saturation in the hydrothermal situation. So unless you are continually replenishing water you're going to lose your sort of steadystate situation quite rapidly.

This slide also compares glass and the glass ceramic. They've been investigating glass ceramics on weapons fc several years. As you can see the upper line is the glass, the lower line is the same glass that has been thermally treated to glass ceramics. And basically there's no difference in th leach behavior.

(Slide.)

That's all I planned to say about the leaching, the hydrothermal leaching. I wanted to say one other thing since the topic was glass characterization, and I think this is quite impressive.

We have spiked waste glass with curium 244 and to accelerate the alpha dose in the glass we have -- this is a photograph of a sample of glass that has the equivalent of half a million years of alpha dose. And we've run many tests on this glass with stored energy, density change, leach rate, and so forth. And really the only thing that has happened to the glass is it has saturated with a small amount of stored energy, around 30 calories per gram, and a density change of about one percent.

Now we've done these experiments with several different glass formulations. Depending on the glass formulation the density change may be positive or it may be negative. But we have never seen density of about more than one percent.

So glass is a very radiation stable material, quite thermally stable, as I showed in that one figure where the only thermal effect is above 500 degrees Centigrade and only a small effect on the leach rate.

So basically for a first generation situation we feel that glass is a satisfactory waste form.

That's all I have to say.

DR. MOELLER: Thank you.

Mr. Lakey, did you have other speakers, or is that your presentation?

MR. LAKEY: It might be appropriate to ask John questions now if you have any more for him.

DR. MOELLER: Okay.

Do we have additional questions for Mr. Mendel?

First Jack Healy.

MR. HEALY: According to the studies done by EPA in their formulation of the criteria, the primary elements of concern are things like technecium. I wondered whether you had looked at the leaching characteristics in the glass for these materials that are not as well held up by ion exchange before they get out into the biosphere?

MR. MENDEL: We are looking at the leaching of technecium in several simulated groundwaters, and none of the data has been published yet. We have some, and we'll be getting more.

DR. MOELLER: Can you tell us roughly what it shows?

MR. MENDEL: Roughly it shows that the leaching of technecium is not much different than some of the more leachable ions.

DR. MOELLER: Thank you.

Other questions for Mr. Mendel?

Alex Grendon.

MR. GRENDON: You showed some leaching experiments with two months' devitrification with two months' storage. Has there been any determination if that is as much devitrification as you will get, or will longer storage increase it?

MR. MENDEL: We have -- the approach to devitrification depends on the temperature, and we have reached saturation and devitrification at 700 degrees, 750. We have data for all these temperatures. And even at two months at 700 degrees you have reached a saturation devitrification.

Now when you get below about 700 degrees, then it takes longer to reach the equilibrium.

MR. GRENDON: That's the point I was driving at. But when you showed there was no appreciable devitrification at lower temperatures, I was wondering if it had been stored long enough to show up any that might occur.

MR. MENDEL: We have looked at the pseudo-activation coefficient of devitrification based on the data that we have above 700 degrees Centigrade, where we know that we've demonstrated that it has reached saturation and have curves which are -- I left one copy of the document that showed the rate that you would anticipate for complete devitrification and at the temperatures that you would find any repositories. It's millions and millions of years.

MR. GRENDON: So that progress in devitrification does go on beyond that two months?

MR. MENDEL: At temperatures below about 750 degrees, yes, it continues.

MR. GRENDON: Okay.

I have another question. I was puzzled because you showed less leaching in brine at 25 degrees than in deionized water. But you showed more extraction of cesium and strontium at 350 degrees. And I didn't quite get whether this meant that there was more leaching in general or just more leaching of these particular chemical constituents.

MR. MENDEL: Basically those chemical constituents -- well, the reactions are extremely complex because you're having chemical recombination occurring.

MR. GRENDON: What I was concerned with was the reversal from brine being less effective in the one case and more effective in the other.

MR. MENDEL: No, the -- the one curve was based on weight loss which showed that the weight loss was less in salt brine. But the extraction and the maintaining the ions in solution, there are certain ions that we measured, cesium and strontium, which were of particular interest. There were more of those particular ions in solution in the salt.

And maybe I'm not following your question.

MR. GRENDON: Well, as I say, I thought there was a reversal of the effectiveness of brine when you went up in temperature, and I didn't understand what was going on there.

Now if it is the fact that these others don't remain in solution, then I could understand that, the difference in the result. Is that what it is?

MR. MENDEL: Yes. There are further reactions that occur in chemical recombinations that occur in the absence of salt brine that evidently ties up with some of the cesium and strontium.

DR. MOELLER: Any other questions?

(No response.)

DR. MOELLER: Well, thank you.

Mr. Lakey, then I guess your next topic is the alternative waste form.

MR. LAKEY: As you know, there is quite a bit of interest in alternatives to glass, and my topic will be covered by Dr. John Rusin.

John is a Ph.D. Engineer in our Material Department.

DR. RUSIN: Well, the original objectives of the alternative waste forms program was to provide a backup or second generation process.

(Slide.)

Also to produce a waste form which has improved inertness and lower dispersability.

(Slide.)

The program was initiated in 1973 primarily in contact with Penn State University. The work was underway in '74. The development of the crystalline supercalcine, also at Gulf General Atomic the development of PYCN sic carbine coating technology.

Later in '75 this coating technology was transferred to Battelle Columbus. Metal matrix, encapsulation work initiated in 1976.

Next slide please.

(Slide.)

In 1977 the program resulted in four one liter samples of selected multibarrier projects. In '78 the program of comprehensive waste materials characterization study was initiated.

(Slide.)

As I mentioned, the result of the multibarrier study was the production of four one liter waste forms, as illustrated here. These are examples of the various concepts of uncoated and coated supercalcine and crystalline product and glass or insulated waste glass marbles, all these in a metal matrix.

(Slide.)

What is the multibarrier concept? The concept is based upon providing barriers between the solid inner waste core and the environment. These barriers are either coatings or a metal matrix.

(Slide.)

One of the inner waste cores is supercalcine, a crystalline product. The concept is to modify the nuclear waste with additives to form an assemblage of tailor made crystalline phases. Typical compositions there are SPC-2 and SPC-4, the high level waste oxides. There is very little change there, just a slight change in the additives.

The additives are silicate, calcium silicate and strontium. The silicate is added to the waste stream. The other components are nitrates.

(Slide.)

The supercalcine is formed in a spray calciner, typical of the way you form ordinary calcine. At this phase the powder is porous. It is produced directly from the high level waste stream.

(Slide.)

The powder is consolidated into spheres using in this case a depelletizer. This is a commercially available apparatus. Its 16 inch unit will handle the output capacity of a full scale straight calciner as used in PNL.

(Slide.)

The next stage in the development of the sintered cores is to heat treat the cores. The first part of this is to consolidate, through sintering shown here, bulk density versus temperature for the two temperatures.

The second composition, SPC-4, at higher temperatures there is an increase in density and it also gives an example of the SPC-2. It reached its ultimate density at 1100, a much lower temperature.

(Slide.)

The primary reason for heat treatment is to convert the enormous calcine into the crystalline phases. Shown on the right are the various structures of the host phases and the supercalcine, and on the left, the waste ions that are included in these phases.

(Slide.)

This is an example now of the sintered supercalcine cores as produced by dispelletization. It is 49 millimeter at the lower right-hand corner at 500 X. You can see the sort of salt and pepper regions, and these are the various crystalline phases within the supercalcine.

Also, in the upper right-hand corner, the cross-section of the cores, showing that there is porosity. This is typical of the process. And toward the outer layer it is much denser because of the process and the snowball effect of forming these cores.

(Slide.)

At that stage these cores could be directly encapsulated in metal matrix. In order to do that a coating should be utilized, either a glass coating, or as shown here, a chemical vapor deposited coating of carbon and aluminum oxide. The hylitic carbon has excellent resistence. The aluminum oxide in this case is primarily added as an oxidation barrier for the hylitic carbon, but also the aluminum has a very high leach resistence.

(Slide.)

The final stage in the multibarrier concept is to encapsulate the inner cores, which may be either supercalcine or glass marbles. Three techniques were studied: gravity sintering -- this is just taking the powder and vibrating it into the cannister with the waste core and sintering, getting very little shrinkage, but getting sufficient strength from the sintering process -- conventional casting, just using normal pressure testing plus using assistance of a vacuum.

(Slide.)

In summary, the four multibarrier type concepts that were demonstrated in a one liter fashion were, first, a glass marble made from a 72-68 type glass. This was encapsulated in a lead tin matrix at 400 degrees Celsius. The last three are supercalcine, the first two without a coating and with a glaze coating, and a vacuum cast, aluminum 12 silicon matrix. And finally, the most complex but possibly the most durable product, the duplex coated with piolithic carbon and aluminum oxide on a supercalcine core in a gravity sintered copper matrix.

(Slide.)

From the studies on the development of the multibarrier concept several recommendations were made. The first two were scaled up demonstrations, the first on encapsulation of the glass marbles in a lead alloy. By vacuum casting here we find that just ordinary pressure testing is sufficient.

The second recommendation is a scale-up of demonstration of encapsulization of an uncoated supercalcine alloy. Also further work needs to be done to demonstrate the process feasibility of these alternative concepts, and also a simple characterization and evaluation of alternative waste forms must be made on a comparative basis.

(Slide.)

One of these recommendations is presently being carried out at our labs. This is the high level waste glass marble process, using the existing spray calciner and continuous filter, plus a marble machine which was developed in the last year. This machine is based upon a patented process by Corning Glassworks.

Presently the matrix encapsulation stage is being added to this process. In 1980 this will be demonstrated on a total integrated process.

(Slide.)

Here is a shot of the marble machine. The glass stream here is pouring from the ceramic melter onto a rotating track. The next slide should give you a birds eye view of the holes.

(Slide.)

This is a vibratory casting technique and it can handle the output capacity of the ceramic melter as shown in the next slide.

(Slide.)

This is a four hour demonstration run. A total of 170 kilograms of marbles were produced. The average production rate was 35 kilograms per hour, but toward the end of the run the output of the furnace was jacked up to its maximum and outputs of 80 kilograms per hour were reached.

(Slide.)

The next stage in the development of the multibarrier waste form characterization. This lists some of the tests that were used in the characterization. Primarily the impact strength, the leachability, also the stored energy due to radiation damage, the density and microstructural analysis.

In the handout I've included several figures and tables on the characterization of the multibarrier waste products. I will not go through those for time right now.

(Slide.)

But I'll list some of the conclusions of those figures and tables.

First, in the case of volatility, that the waste loss of supercalcine ranges between .01 and 1.6 weight percent. The temperature range of 1000 to 1200 Centigrade. This is from three to 30 times less than that of a typical waste glass, depending upon the temperature and the composition.

Secondly, that in impact resistence, glass marbles in a cast lead alloy offer up to an order of magnitude improvement. The chemical vapor deposited coated supercalcine in sintered stainless steel matrix offered up to two orders of magnitude improvement in impact resistence.

The glass in the PYCAL203 coatings provide effective inner leaching barriers. And finally, that after an equivalent alpha exposure of 200 years supercalcine ceramics have maintained their physical integrity, that is they haven't fallen apart, but they show crystalline phase instability.

I will show two viewgraphs on this.

(Slide.)

The first one here illustrates the loss of the appetite phase. This is one of the post phases for the waste ion. It contains the rare earth ions from the waste.

As we see after six months, this is approximately 100 years of alpha exposure. The appetite peak has decreased. After one year it has decreased to zero intensity.

(Slide.)

Another problem or possible potential problem with crystalline waste forms is transmutation. Pulocite is one of the things containing cesium. Cesium decays to barium. There is an exchange. We are presently investigating this by taking cesium-133, natural cesium, neutron irradiating it to cesium-134. This is done at Oak Ridge. And then we let this decay back to 134-barium.

We have presently finished our neutron irradiation. Samples have been removed from the reactor, and now we're waiting for the decay, which will be over 200 days, to get the barium. At that time we will look at the properties of the supercalcine.

DR. MOELLER: We have a question. Don Orth.

DR. ORTH: Can we assume that since you're focusing on cesium and strontium as major products in this specific case that these are applicable to that stuff that you've separated, the separated capsule, and not just general waste, which does not have macro amounts of these things in it?

DR. RUSIN: I'm sorry, the separated?

DR. ORTH: Strontium and cesium from Hanford.

DR. RUSIN: This work, the concept was initiated on reprocessed waste at that time. Presently we're looking at, again, the cesium and strontium because this is a transmutation.

As far as other things, I'm not that familiar with Defense wastes. Perhaps Tom can comment.

MR. CHACOLIC: The intent here is to look at supercalcine, which is a crystalline form proposed for the accommodation of some of these species of highly stable crystalline media.

Tom Chacolic from PNL.

If I understand the question properly, why are we looking at cesium when this would not be a problem in Defense waste?

DR. ORTH: No.

The problem is that the total amount of cesium, radioactive cesium and strontium in the final waste forms with commercial wastes is still a pretty small amount. I'm just considering the physical chemistry.

A transmutation over a long period of time with a tiny amount of waste may not be much of an effect that we're looking at. However it would be worth looking at if you were actually looking at the separated cesium and strontium from the Hanford Defense wastes.

MR. CHACOLIC: That's right, except in the supercalcine concept the intent is to try to incorporate these attitudes to allow all of the cesium to be incorporated or consolidated within these discrete phases. Therefore the interest is in the stability of the pollucite and what happens under the conditions.

(Slide.)

DR. RUSIN: Up to now I've discussed the multibarrier concept. As I pointed out,this work was initiated in 1972.

I'd like to say in 1978 the multibarrier concept came to completion at that time. The one liter demonstrations were finished at that time and characterized.

There is a comparative study of existing waste forms and process scale-ups of the multibarrier concepts.

(Slide.)

The comparative study program recognizes the fact that there are several waste forms available, as shown here, from straight calcine to pelletized calcine, a supercalcine additive, the synthetic minerals. There is a matrix glass ceramics, a long list.

(Slide.)

Recently the Savannah River operations office summarized some of the properties of these high level waste forms, and here I have several waste forms in the development status, some of the properties, leachability, the high resistence or volatility. The intent of the program at PNL is to provide a systemmatic investigation of these waste forms and quantify these properties to put some numbers in these boxes.

(Slide.)

This will be achieved by looking at some representative waste forms in the various categories. So here you have glass, the glass ceramics, the sintered ceramics, the synthetic minerals, which include the supercalcine, hot pressed ceramics, and also hot isostatic pressed ceramics, concrete waste forms, and then metal matrix forms.

As indicated here, some of these samples will include mercurium 244 to look at the effect of radiation damage.

(Slide.)

These waste forms will be characterized by the following tests, the impact leachability volatility, the bulk properties, the microstructure phase analysis and radiation effects on the above properties in addition to stored energy in metamitazation.

(Slide.)

One of the synthetic minerals that we're presently fabricating is the synrock B composition which includes the three phases of holandite, zirconolite, and poroscite. This differs from supercalcite in that only three phases are used, and the phases provide the majority of the waste forms.

The waste is added up to ten percent, although it is proposed that 30 percent waste be contained in the synrock in the simulation. Shown here are some of the ions that fit into the various simulations. Also you see that in the case of sodium and a few others that they've been going to one or two phases.

The next viewgraph, please.

(Slide.)

Here is an example of the phases alone, the holandite, poroscite and zirconolite. These were formed under cold pressing and fired at 1300 for two hours. The synrock B mix contains an equal portion of each one of these three phases and at the bottom taking the synrock B mix and adding ten weight percent of PW4B type calcide at 7500 psi.

As a conclusion I'd like to say that our current objective of the program have not changed that much, and that we are primarily still concerned with providing a backup for a second generation process. Our approach to this now is to evaluate existing waste forms on a comparative basis and to assess the process feasibility by scale up demonstration of promising candidates. But also to still develop new candidate waste forms for this comparative evaluation to ensure that we're not overlooking any candidate.

Thank you.

MR. MENDEL: That completes our presentation, unless there are questions for John.

DR. MOELLER: Thank you.

Do we have questions?

Frank Parker.

DR. F. L. PARKER: Have you made any rough estimates of the different costs of the different alternative waste forms?

DR. RUSIN: We are presently looking at the cost problem. To date what we have evaluated is just the raw materials going into the process and the complexity. We have established flow charts for each one of these systems and are presently going out to outside contractors to look at the cost of the operation.

This will be completed at the end of this calendar year.

DR. MOELLER: Other questions?

Don Orth.

DR. ORTH: On the slide it had a 1979 date, and you just repeated yourself, you expect to complete evaluating these dozen or two dozen forms against a dozen or so different properties all within this year?

DR. RUSIN: No. The study will be completed in Fiscal Year '80, which would be by September of 1980, as far as the waste form properties. The cost studies that we're talking about, that is looking at only four processes, not the complete process listed here.

DR. MOELLER: Any other questions?

(No response.)

DR. MOELLER: Well, thank you very much. That was a well prepared and well delivered presentation.

We're now at the point where we can take a break. So we will declare a 15 minute recess.

:9

(Recess.)

DR. MOELLER: We're ready to resume the meeting. The meeting will come to order.

The next item on our agenda this afternoon is a presentation on decommissioning and decontamination, specifically related to the Hanford site. This presentation will be made by Jerry Landon of DOE, and it's scheduled for 45 minutes.

If you can allow within that time at least one-third to one-half the time for questions, we would appreciate it, Mr. Landon.

MR. LANDON: I'm Jerry Landon. This will actually be presented by three people on three different topics. The first part of this will be presented by Ralph Wahlen of United Nuclear Corporation -- UNC Nuclear Industries, excuse me, on D&D projects on the 100 reactor areas.

The second part will be by Art Graves with Rockwell-Hanford operations, the D&D projects and the chemical process in the 200 areas. And Ray King of PNL will be presenting general R&D that's directed toward D&D projects both at Hanford or generically available for other sites. And Ralph Wahlen will start out.

DR. MOELLER: Will these be roughly equal in length, about ten minutes each?

MR. LANDON: Yes, sir.

DR. MOELLER: Thank you.

MR. WAHLEN: The Department of Energy is supporting two programs in the 100 area for disposition of the retired facilities, and one of the programs is called the Site Cleanup. And the objectives of this Site Cleanup program is to eliminate the -- can you hear all right?

VOICE: No.

MR. WAHLEN: The purpose of this Site Clean up program is to eliminate the potential hazards along the river and to eliminate the buildings that are no longer in use out there. And an example of the work that's been done on the site clean up program will be seen on the next three slides.

(Slide.)

This is a photograph of the river pump house.After the facility was shut down the equipment was sold on public sale. The highest bidders removed the equipment and the building was demolished, and the shoreline was restored to its normal configuration.

(Slide.)

The next slides shows an aerial view of 100F area.

(Slide.)

There have been a number of buildings that have been removed from this area. During operation there were 51 buildings in the area. Since this photograph was taken, this building here of the Power Supply System has been removed, the storage basin where we stored the raw water of the river has been backfilled, the river pump house has been removed, the high tank is gone, there are three buildings over here in the corner that belong to Battelle Northwest that are for their biological studies, and those three buildings -- two of those buildings are gone and the third one is programmed for removal later this year.

The remainder of the buildings are all contaminated and they will be taken out under the D&D program. The D&D program was authorized to begin planning for the decommissioning of one reactor facility in 1977.

(Slide.)

The program on the deactivation is primarily in the planning stage. The site characterization study has been complete. The facility site description is complete. The environmental assessment has been made and documented in a rough draft form. The quality assurance plan is complete. The management plan is 50 percent complete. And the disposition plan is divided into six categories.

(Slide.)

The site preparation, the reactor decontamination and removal, the reactor block removal, the support and research facilities removal, and these four activity descriptions are completed and identify the procedures that will be used to implement the particular activities.

The stabilization of burial grounds activities description is about 15 percent complete, and that will identify what final disposal will be with the burial grounds, cribs, and trenches.

The project close out is still to be written. And once it is written it will identify the way the facility is left. It will also record the experience of the D&D program.

(Slide.)

The decommissioning schedule looks something like this. We will complete our planning by the end of Fiscal Year '80. In 1981 we will go into the general site preparation, complete the tooling and equipment, and toward the last half of Fiscal Year '81 we will be hiring people to do the D&D work.

At the start of Fiscal Year '82 the D&D work will begin, and will be completed at the end of Fiscal Year '84.

mpb27 The cost of the program looks something like is listed on the bottom. We've been authorized to spend $100,000 this year. We're authorized to spend -- or we've requested $500,000 for Fiscal Year 1980, and $3,200,000 for Fiscal Year '81, $8 million for Fiscal Years '82 and '83, and then it will drop down to $2 million in Fiscal Year '84.

DR. MOELLER: Are these the costs for a single site or a reactor?

MR. WAHLEN: These are the costs for the buildings that were shown in the photograph.

DR. MOELLER: What I'm getting at, this has only been a small part of the total.

(Slide.)

MR. WAHLEN: This is only a small part of the total. It does clean out one area, however.

In this particular area there's the gas system which supplies the inert atmosphere to the reactor during operation, the ventilation stack. At the base of the ventilation stack there's a confinement building. There's the 105 building with 9.118 the reactor in it. And the waste lip station -- liquid waste lip station, and then there's another biological lab over here that has to be removed, and that's the 108 biological cass 10 flws laboratory.

DR. MOELLER: Don Orth.

DR. ORTH: Is anybody worrying about whether those dollars will be all right if, for example, somebody says you can only irradiate the people who are doing the work to a fraction of the normal rates?

(Slide.)

MR. WAHLEN: We'd be concerned about this yes, it would increase the cost. The cost as you see here is based on the current exposure limits.

DR. ORTH: Are you doing a pretty careful job about trying to plan against doses?

MR. WAHLEN: Yes, we are. Most of the handling of equipment will be given to the reactor, and dismantling will be done remotely. The current plans are to have the water -- or the reactor filled with water, so it will all be done under water.

DR. MOELLER: Richard Foster.

DR. FOSTER: In that vein, about how many people do you expect to be actively engaged in the decommissioning work on site?

MR. WAHLEN: Right now we figure the work force will be at around 80 people.

Now one of the main purposes of this particular demonstration is to get a better feel for what the radiation levels are going to be in dismantling the reactor and what the costs are going to be and things like this. We really don't have a good base for calculating this.

Now we did make a survey, a characterization survey earlier in the program and based on this why we feel that we've got a pretty good idea of what the exposure requirements are going to be. We will, however, take more samples as we develop the procedures to do the work.

DR. MOELLER: Well, when was this reactor shut down?

MR. WAHLEN: The reactor was shut down in 1965.

DR. MOELLER: Thank you.

.146 DR. LAWROSKI: What is the planned disposition of the graphite?

MR. WAHLEN: The graphite will be packaged in boxes and the box, then, will be put into -- our current plan is like this:

We will put the graphite in the boxes and the boxes are moved, then, out of the -- the shielded boxes are moved out of the reactor into a railroad car. Now we feel that you can buy these railroad cars that are no longer serviceable for railroad use, and fill these full of the waste and then bury the railroad car and everything.

In other words, you bury the waste with the railroad car.

DR. LAWROSKI: So it's a shallow land burial.

MR. WAHLEN: Yes. There will be some parts of the waste that will have to be handled as Class A waste, and that will be handled in another way.

DR. LAWROSKI: What's the inventory of tritium for a reactor? I'm sorry, not tritium, the carbon-14?

MR. WAHLEN: I don't think I could answer that specifically. I do have a chart here that shows the calculated burden of radioactive material in the reactor.

(Slide.)

It figures out to be about 35,000 curies. Most of this is cobalt-60 and carbon-14.

DR. MOELLER: Jack Healy.

MR. HEALY: I just wanted to ask about the waste, and I think you've answered the question.

DR. MOELLER: Go ahead.

MR. WAHLEN: Okay.

I guess that concludes my presentation.

DR. PHILBRICK: How are you going to bury that railroad car?

MR. WAHLEN: Possibly run a track right into the trench, or lift it with hoisting equipment.

DR. PHILBRICK: That's a pretty good sized load. What are you carrying, something like 75, 80 tons?

MR. WAHLEN: Do you have any idea what it is?

MR. GRAVES: I don't have any idea as to the exact weight. But a lift of that nature is not unique. We could handle that.

The other point that I'd like to make, we're looking at two options for the graphite, one for the low level waste disposal and the other, depending on the carbon-14 content and the final criteria for disposition of carbon-14, we may have to put it into interim waste storage and into a waste repository because of the long half-life.

DR. MOELLER: Thank you.

Well, let's move on to the next phase.

MR. WAHLEN: Okay.

Before you do, I'd just like to apologize. My mouth got so dry I could hardly talk, and I'm sorry for that.

DR. MOELLER: Don't worry.

MR. LANDON: Our next speaker, then, will be Art Graves from the Rockwell-Hanford operation. And with the two contractors we have, one responsible for the 100 areas, the reactor areas, and another for the chemical processing areas, we try to keep it coordinated to really knowledgeable people who are the ones that have the responsibility for speaking to you today on their particular areas.

(Slide.)

MR. GRAVES: I will give you a very brief overview of the D&D program at Rockwell Hanford operations. This program is in its second year. And we have not had the hardware progress that UNC has. We are working on the chemical processing where as UNC is really working with the reactors.

(Slide.)

The generic objectives that we're working toward are to reduce or eliminate the requirement for radiological controls, and these are on facilities that are retired and no longer needed for use or are passive facilities. And the general methods used to accomplish these ends are to decontaminate, which would remove the contamination from the site on which you want it removed, or you can dismantle and remove the contaminated components and put them in a simple location.

Both of these really consolidate the waste from one area into another area that should be easier to administer.

(Slide.)

The major programs that we have going on at Rockwell right now are the long range D&D planning. I'll go on to each of these separately.

Surveillance and maintenance of the retired facilities, development of full-scale size and volume reduction equipment to treat this D&D waste, and then the D&D program itself on retired contaminated structures.

(Slide.)

On the long range planning, the objectives are to develop and maintain a list of contaminated inactive facilities and this includes the characterization of these facilities and input of that data into the national DOE long range plan that presently the environmental control technology has taken a lead on. And also to develop a Rockwell internal long range plan for D&D to supplement the national plan.

Two major accomplishments are listed there, and we'll move on to save time.

(Slide.)

Also this one is in your package of handouts. This merely lists the number and types of facilities that I have programmatic responsibility on. These happen to be the DCQ facilities. There are other facilities that are retired and not on this list.

(Slide.)

On the surveillance and maintenance of contaminated inactive facilities, our objective is to prevent the spread of this radioactive contamination potential, the spread of this contamination from the inactive facilities. These can be structures that have contamination. We're to maintain those so that the contamination is contained pending D&D, to stabilize and reduce the surface areas contaminated on outdoor sites. These can be retired burial grounds, ponds, trenches, these types of things. So we are to stabilize these in the interim.

Now the approach to the long term management will be covered by Chuck Manry. I believe he's coming up later on.

Also we are to maintain the inactive structures prior to D&D. Once again, we have listed our accomplishments too.

(Slide.)

To go into a little more detail on the development of full scale size and volume reduction equipment, the objectives are to develop and demonstrate the technology and systems to size reduction. Now size reduction of the waste is the cut of a large component so they can handle further volume reduction. And we're going to do this with an arc saw, which is a device to use arc erosion to cut up major components such as tanks and piping systems. Also develop and demonstrate the technology and systems for volume reduction.

Now this is the follow on to size reduction, whereby you take the equipment, metallic equipment, charge it into a furnace and melt it down. It's a natural volume reduction for this contaminated waste. We're using a vacuum furnace to contain fumes, and that is in the process where we are developing.

These two, then, in conjunction with each other will give us a size and volume reduction for major metallic components.

The major accomplishments, we have a 16 inch arc saw system that has been fabricated, delivered, installed, and ready for testing, and Joe can show us the next slide on that.

(Slide.)

This is a schematic of an arc saw. The upper center of the picture is a blade. The blade rotates merely for the purpose of reserving the melt. The actual cutting process is arc erosion.

We have a conceptual design where we will use a process that cuts these components into about one cubic foot sizes. At that size they will be easy to put in an 85 gallon drum.

(Slide.)

I have a photograph of the installation in the 200 west area of the arc saw. The large tank square system is the tank that holds the cut-up. Now this is smaller for demonstration purposes and it will be filled with water, and we will start out with underwater cutting.

The orange components there are the drive mechanisms. There is a shared power supply that we will use for a larger arc saw system.

(Slide.)

The next slide is the concept of the vacuum furnace. It will be all completely contained. It will have a water-cooled electrode arc discharge into the charge metal to melt down the 55 gallon drum and its contants. It will be a batch process whereby we can add successive drum· until we have an ingot of the proper size. The ingot then will be removed by welding and then disposal.

(Slide.)

The D&D retired facilities is the next major project we're working on. The objective is to develop planning through the process technology and field procedures for D&D of contaminated facilities or chem process facilities that we're talking about. In this way we can develop processes in a small facility; that will be our demonstration site for the small facilities that we need. Then we will move on to a larger process facility which is the Z Plant. And those procedures that we developed will apply to the Z Plant.

And lastly, to do the D&D to the long range plan.

I'll cover these objectives very briefly.

(Slide.)

On the development objective, the scope is to development management and control documents, and this is to have an organized discipline approach to D&D in general, to develop the decontamination, dismantling of containment and waste handling equipment and processes for the transuranic contaminated facilities. We will evaluate different processes, different ways of treating the waste and trying to zero in on those that are the most economical, and then develop detailed procedures for performing D&D operations that can be applied to any process plan, and also we're working with UNC industries taking parallel paths for generalization procedures.

To date we have prepared control documentation for our programs and have initial procedures in place for doing our first demonstrations.

(Slide.)

Demonstration effort now. The scope is to demonstrate equipment and process technology on this 233S building. This is a small process building. The D&D of that building to unrestricted use, and that's our end point for demonstration purposes, and to standardize these techniques.

(Slide.)

We have a photograph here of the 233S building. You can see the scale of the building with this truck on the side. It's a four-story process hood within that. It contains all the piping. There was a breach of the system about 12 years ago and a fire, and so the internal portions of the facility are quite contaminated.

(Slide.)

Here's the floor plan. We went through the entire building to get a complete photo survey, which is the pre-D&D conditions. It also gives us some physical information to help develop procedures. We did a complete radiological survey and we upgraded all the support facilities necessary to perform the D&D.

We have completed D&D operations. On the far left the airlock has been completed, and in the next two, the cam storage and PR cam storage have been completed. The process was to go in there and remove all of the equipment and hardware from the walls, ceiling, and floor, that weren't required to support the operations, decontaminate to a workable level, and then put a fix on it. We've done that.

We are now in what's known there as a PR load cam room. There's a load output there that's to be completed this year. The load-up has about 23 grams of Pu, and those would be the activities that we will carry out this year.

(Slide.)

The last objective in our program is to D&D the Z Plant, and we have started this by performing a planning and engineering exercise for the Z Plant to D&D. In other words, we want to plan out the front end engineering before any equipment has been made to do that on the Z Plant.

The alternatives that we're looking at are the end points for D&D, and these are four levels of residual contamination, starting at the top from unrestricted use and complete release to the fourth one down which is restricted non-use, similar to entombment.

Now these are the levels we will look at and/or study, and there are two in-between levels that we can look at. We're going to then determine the extent of D&D operations as a result of this analysis performed on the Z Plant and then to a final release and survey.

To date we have completed the study report which kicked off the effort on Z Plant D&D, and that's the one where we came up with a gr ss estimate, unrestricted use of all Z Plant areas of influence of $101- to $50 million. And this is a real scare number. This is a number that probably can really cause you not to proceed with the project.

This, then, said Well we'd better go with the engineering plan and look at our alternatives and come up with a cost-risk-benefit analysis. And now the cost-risk-benefit analysis we will look at different levels of residual radioactivity to be left and make judgments as to which level do you D&D to which portions of the building.

We've completed 60 percent of the characterization, both radiological and physical, that feed into this process and analysis, and we have completed the computer logic for the interim solution on the cost-risk-benefit analysis.

That's a very brief and quick review of what we're doing.

Any questions?

DR. MOELLER: Any questions on this portion?

Yes, Richard Foster.

DR. FOSTER: Are there any plans that your volume reduction equipment might be used for equipment brought in from outside of Hanford?

MR. GRAVES: They could very easily be used that way. We're looking at specifically D&D waste, but we're not limiting our design to that. We are trying to be general enough in the design and have it so that it will take any non-specific geometry equipment and size and volume reduce it. So it should be applicable to all waste management techniques. It should be probably used in our waste management system.

DR FOSTER: Let me perhaps ask the question in a different direction.

Considering D&D operations throughout the country, how many such facilities would be required in order to accomplish the job on an ambient basis?

MR. GRAVES: Well, I would say when we establish repositories, I would guess probably we would require one for each repository and handle that type of waste that comes in. The through-put should be sufficient.

DR. MOELLER: Carson Mark.

DR. MARK: You mentioned the figure of 150 million to restore the Z Plant, I believe, to completely unrestricted use.

What kind of price tags go with some of those?

MR. GRAVES: Well, the objective of the cost-risk-benefit analysis is to allow us to make objective prioritization of different areas of that building, different levels, to be practical for any identified companion occupation for that type of building.

The $100- to $150 million dollars is an outside guess. I believe that is -- number one, it will probably never be reached, number two, I don't think there will be a practical use for that level of money.

We are looking at a quite extensive and useful effort, a third of that quantity, maybe even less.

DR. MOELLER: Don Orth.

DR. ORTH: In that decommissioning of the Z Plant building, are you talking about raising it, plus digging up everything that's underground, and then it might be contaminated in that building so you could plant grass on it, or are you just talking about decontamination of the building?

MR. GRAVES: Well, the reference point is the unrestricted use, and that's what develops $150 million, and that would be the case where if you had to tear down a wall to get to the contamination you would in fact tear it down and you would make a judgment as to whether it would be cheaper to restore that particular wall or raise the building.

So for that type of number in the reference case for our studies, it is complete clean-up and unrestricted use, realizing that is not really a practical end point.

DR. MOELLER: Steve Lawroski.

DR. LAWROSKI: What's the total estimated cost for the 300 odd buildings listed to be D&Ded?

MR. GRAVES: I have not attempted to develop that number.

Jerry, do you know of that?

MR. LANDON: We really don't have a number for that. We're still at the point of learning what costs are by doing these preliminary projects and getting cost data. And I think it would be premature to try to arrive at a total cost figure. We don't know what our end points would be or what our unit points would be, our unit costs would be.

DR. MOELLER: One final question:

You mentioned melting down these large metal objects. The last time the Subcommittee was out here we were given a demonstration of the electrical policy. What do you melt down and when do you use that tactic?

MR. GRAVES: We would be using the electrical polishing and migratory finishing as developed by PNL as a median process before we do the cut-up. And all surfaces that were accessible would go through that process first, and there would be an attempt made to clean those up and maybe release them.

DR. MOELLER: Thank you.

So you have one more presentation, then, in this series?

We are nearing the end of your time, so make it as brief as reasonable.

MR. LANDON: We have a project to do just generic R&D where there's no specific goal for some particular job or building or facility that needs decommissioning, and this type of R&D will be available, then, to application at any site, whether it was Hanford or other government sites or commercial applications. PNL has been responsible for that program at RNL.

MR. CAIN: Our objective in developing a decontamination policy is to provide a base of technology with emphasis on unit cost for the different technologies involved, hoping to contribute to improved reliability of cost estimations for decontamination and decommissioning processes. We're also giving emphasis in our program to processes that could be automated, so that the decontamination activities could be conducted, hopefully remotely, or at least in a mode to reduce exposure to those involved in the decontamination activities.

(Slide.)

Our program is funded by DOE with the information out of the headquarters office of environmental control, with RLD in the field office and as handled in PNL by Dr. Bear's program office, the Environmental Health and Safety Program.

(Slide.)

This year our activities, we have in addition to the project management function, nine technical activities. The technology that we're looking at is a mix of technology developed within the program of commercial technology that is applicable to decontamination programs, and to technology that's being developed in other research programs that can be applied to decontamination projects.

I' briefly outline what's involved in the various tasks and technology assessment area. We're proving with our program an interface to the Rockwell staff and to the United Nuclear staff to identify critical needs and to plan to factor those into our program.

We've giving major emphasis this year to techniques for decontaminating concrete because there are very large volumes of concrete associated with retired facilities. We're looking primarily at two devices. One is a mechanical device which would spall the contaminated concrete surface to reduce the volume of contaminated material that would have to be packaged and buried. The second is a high velocity, high pressure liquid jet that also has the capacity for spalling concrete surfaces.

In our electro-polishing vibratory finishing task we are taking the technology that's been developed in another R&D program and applying it to D&D problems. In this particular task we're using the 233-S facility that Mr. Graves just described as our reference facility, and we're determining how to best apply those two technologies to that particular D&D problem.

We're also developing a very sensitive field survey instrument to permit rapid survey of contaminated field areas, decontaminated field areas, decontaminated structures. We're also looking at a method to stabilize shallow buried wastes looking at a cobblestone barrier modified with herbicides modified in a number of fashions to prevent plant and animal penetration of buried wastes.

We have a low level task this year looking at concrete properties. More specifically, we are taking core samples from selected Hanford facilities and examining the concrete to see what kind of damage may have occurred over the 35 or 40 years that the facilities have been in service.

The dry ice blasting task, again we're here looking at a commercial process that's very commonly used in the aircraft industry, automotive industry, very neat, fast, simple way of cleaning surfaces. We're looking at that process and seeing how we might apply that to D&D activities.

PNL also has an arc saw in this D&D program, using the PNL arc saw which was aquired by a fuel element program. It was inquired to investigate rapid methods of disassembling fuel bundles. We're using the arc saw to complement work that Rockwell and United Nuclear are doing in their arc saw development.

Specifically we're using the PNL arc saw -- we're evaluating it as a rapid way of sectioning pipe, pipe up to 14 inches in diameter. Our arc saw has the capability of traversing a 14 foot length of pipe.

We have also just recently added another task because of the importance of developing a family of fixatives, fixatives that could be applied to components prior to sectioning, fixatives that might be applied to a contaminated surface prior to spalling by our mechanical concrete spalling device, fixatives that could be used in normal pilot operations, actually two, in such operations as changing glovebox panels, prior to sectioning that glovebox, prior to electro-polishing, prior to physically rub and scrub type decontamination activities.

(Slide.)

I have some examples. This is our concrete spalling device being tested in one of the facilities in the 100F area. The white test panel areas are painted so we can see the area that we're clearly spalling and leaving.

With the equipment that we have now, which is a manually operated system, we can spall about 100 square feet of concrete per hour. We can drill and spall. The spalling operation requires the predrilling of a hole to insert an expanding manually hydrolic actuated which applies radio forces in the drill hole and causes the concrete to spall, and we can spall about 100 square feet an hour with that technique.

(Slide.)

We're all familiar with the electro-polishing process. In this program we are not developing the electro-polishing technique; we are looking at ways to apply that technology to D&D problems.

(Slide.)

I'm not so sure how much the vibratory finishing technique has been described to you, however. The vibratory finishing technique again is an example of a common commercial process used to debur metal stampings, used to take flashing off of metal castings. The schematic that's shown on the screen, the tank itself is U shaped, filled with an abrasive media. You insert the objects to be decontaminated, turn on the vibrator. The materials, because of the different density, rotate in the tank at different speeds. Your abrasive media scrapes the surface and the residue from this scraping process comes down through the drain portion; you flush with a liquid, it could be water, it could be a detergent, it could be another solvent selected particularly for the specific application. It's a very neat compact system, very inexpensive system. It lends itself very neatly to portable installations and you can move it directly to a field site and install it in a facility.

(Slide.)

This is an example of material that's been vibratory finished, a section of pipe on your right. The internal surface is heavily scaled. Within a few minutes of vibratory finishing the sample, the pipe on your left, has been cleaned on the inside and outside. The vibratory media can be an abrasive material and the metal components, there's a wide selection.

We're leaning now to a metal type of an abrasive component to minimize the waste, contaminated vibratory material itself.

(Slide.)

This is a photograph of the PNL arc saw. Our arc saw has a 30 inch diameter blade. In your handout there is a schematic that describes the physical features and capacity of the system to give you an idea of the size components that we can handle. Again, this is an example of taking some technology developed in another program, attempting to apply it to D&D activities in a complementary way to the programs at Rockwell.

That concludes the presentation.

DR. MOELLER: Thank you, Mr. Cain.

Do we have questions?

(No response.)

DR. MOELLER: There appear to be none. Thank you for your presentation, as well as those of your colleagues.

We'll move now into the last item in our formal agenda for today, and that's a discussion of the low level waste cleanup here at the Hanford site. This I gather will be a discussion of materials already considered to be waste as contrasted with the buildings and facilities which we've just heard covered.

This presentation will be by C. W. Manry of the Rockwell Hanford operation.

Mr. Manry.

MR. MANRY: Thank you.

I'm standing in for Don Wodrich, who was out of town today and could not be here.

I would like to clarify the subject matter which is low level waste. I would like to do this in relation to Hanford by describing waste management at Hanford very briefly.

Low level waste is considered those facilities or sites where material has been either disposed or is stored and is considered waste. The other two types of waste we can see on this reservation are high level wastes, which are stored in tanks as a result of the chemical process of the fuel, or in water basins.

The engineered facilities, the structures are, we consider, D&D. So what I'm talking about is everything excluding the engineered structures of the D&D which are high level wastes. So we're kind of like the agenda today: We're last, we get everything else which is left over.

(Laughter.)

Can I have a slide, please?

(Slide.)

The Hanford complex, or Hanford site, as it is now called, has operating areas scattered throughout. The 100 areas are the reactor areas, the 200 areas are the chemical processing and waste management areas, the 300 areas are our fuel fabrication and laboratory areas, and the 600 areas are areas within the Hanford site which are formerly used sites and are now no longer in use. They are not in any of the fenced areas I just described.

On your handout -- and I don't have a slide of this -- I did put a list of waste sites by number for the different areas I've just described, so you can see. You will see on that list that there are over 99 percent of the plutonium wastes located on the site or in the 200 areas. This Hanford site was originally thought to be a short term operation. Current industrial practices of the time were used for disposal of waste.

Solid waste was disposed of in shallow land burial. Liquid wastes were disposed of in the ground.

Next slide, please.

(Slide.)

This is a slide showing you the low level waste sources. You will find that it is divided into three types of waste. There are liquid disposal sites which are those sites where liquids were put into the ground as a disposal means, a lot of different types of sites. There's 235 of those sites here on the reservation.

There's 167 of them which contain plutonium. Solid waste disposal sites were some of the sites that were operated in the early days in which both transuranic and fission products were put into there. Since 1970, only low level or non-transuranic waste has been put into shallow land burial as a disposal means.

The last category are solid wastes, solid waste storage sites, which are the 20 year transuranic burial sites and the retrievably stored material in caissons. Those are the three classifications of waste that we deal with.

So when I talk about low level waste I'm talking about fission product and transuranic waste. There is a distinction in some areas as to what's low level and what's not. This is the distinction.

(Slide.)

I would like now to talk about a specific operation in which we went into one of the liquid disposal sites and removed the top 30 centimeters of soil, called the Z-9 cavern.

The history of events leading up to the decisions to mine this facility is included in the report that is now in preparation, and which will be published very shortly. I'll be glad to give you the reference on that if you want it.

I'd like to summarize the operations. They lasted from August 17, 1976, until July 14, 1978. In this period a total of 5,222 cannisters of soil were removed from the site. These cannisters were packaged in 653 55 gallon drums, and those drums were put into the transuranic storage area.

The Z-9 mining operation has a two-fold purpose. One was to simply remove 30 centimeters of soil from the top of the crib; the second was to develop and demonstrate the technology for doing that, and to provide such a demonstration.

The major observations on the site are listed on this slide. Plutonium-bearing soil can be safely removed. We've demonstrated that. Non-destructive assay of soil was not precise and needs development. We have a program undergoing now to look at a small package counter that will allow us to have better reliability.

What we do here is since it was not precise, we limited, administratively limited the amount of material that could be put into a container. So some of the containers did not have a full container, some of them were less than full.

We ran into the radiolytic generation of hydrogen and oxygen and other gases in the soil. We had to go back in putting vents and recombination catalysts in the drums to alleviate that problem. That was successfully done. It was demonstrated that we could handle that now.

Carbon dioxide by a chemical means from the acidic waste that was put into that site and carbonates that are present there does generate carbon dioxide, and this must be treated. We've had to treat this.

Drums, we've demonstrated that we can open drums which have become pressured by the generation of gases and safely and correctly treat these. The mining equipment can be used in any environment. We've demonstrated that the mining equipment, which is basically a clamshell digger, can be operated remotely with minimal maintenance with good operation.

mpb53

Lessons learned in this operation can be applied to the removal of plutonium contaminated soil if such a decision is made in the future.

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The experience we gained here was good. At the same time the decision was made to mine Z-9 we made a decision to look at other plutonium cribs from the standpoint that we needed to take a look at the distribution of plutonium in those cribs from a reactivity assessment standpoint. We needed to judge how far, or how much distribution there was in those.

This led to another project, which was the 216-Z-1A characterization project. We moved over to another crib which had approximately 57 kilograms of plutonium in it. And we looked at characterizing that, remembering that the technology to go into a site and characterize it is still -- well, we think we've got it developed. But at that time it didn't exist that well.

C11

May I have the next slide, please?

(Slide)

This is a cut-away of the 216-Z-1A crib. You can see it serviced the Z plant. It received the waste from the plant. It was constructed by using a herring bone -- vitrified clay pipe that was laid out in a herring bone pattern and backfilled, polyethylene sheathing, and then more backfill.

The waste was introduced into this facility at three different points. We separated it into the A, B and C sections along that herring bone so that we could demonstrate the time periods, or historical periods in which wastes were introduced into that site.

VOICE: How far up does the polyethylene go?

MR. MANRY: I can't give you that exact number, but I can get it for you. I can't get it for you right now.

It lies on-- You've got your herring bone laid down, then that is covered with gravel. There is a backfill of material, sand and gravel material, then the polyethylene sheet is laid on it. So it is flat. And then you've got more backfill on top of that polyethylene sheet.

VOICE: The question is, if the purpose of the polyethylene sheet is to act as a barrier against migration of something, what's to prevent the material from going around the edges of the sheet?

MR. MANRY: The material could fly around the edges of the sheet, but in this arid land of low rainfall not much percolation occurs around it. Now we'll get into the distribution here, and I think you'll see that the polyethylene sheet covers the area that was penetrated. But it was-- At the time the crib was constructed the polyethylene sheet was put down as a barrier against penetration upward and downward.

DR. MOELLER: When was that?

MR. MANRY: Excuse me; let me look that up.

I'm sorry, I don't have that. I will get it for you, though.

DR. MOELLER: Could we have a ballpark? Is it twenty, thirty years ago, or....

MR. MANRY: Oscar, can you give me a number on that? When was Z-1A constructed?

MR. CAIN: It was in the mid-fifties.

MR. MANRY: Twenty years ago.

MR. CAIN: We used it for about eight or nine years.

MR. MANRY: In order to determine the distribution of plutonium in this particular crib wells were drilled. Wells were drilled using a Cable-2 rig--

Let me have the next slide.

(Slide)

--in which core barrels, which were designed specifically to provide control of contamination were used. We designed those here on site.

The white circles are what they call the center wells. And they correspond to the A, B and C sections of the crib facility. The blue dots are the perimeter wells.

MR. GRENDON: What's the meaning of double white circle?

MR. MANRY: We drilled two wells in that spot. What happened was, using a Cable-2 rig, as we started drilling we hit a boulder which we could not get around. So we moved over and sunk another well.

This is the pattern of wells that were drilled.

Next slide.

(Slide)

This is the sediment distribution of the geological cross-section of the crib. I apologize for the picture being dark. But the geological cross-section was used as a map to help determine the distribution by taking the core samples, determine their geological cross-section, the radionuclide content, and we were able to map the distribution in this particular section.

Next slide.

(Slide)

Looking at the crib, which runs north and south, looking at the north-south cross-section taken through the center wells.

The next slide shows the distribution.

(Slide)

You'll note here that there is -- that the orange areas are the highest concentration. You will see some distribution in silt lenses below the major orange area in which are the same concentrations.

The yellow areas-- Can you focus that? Okay.

The orange areas, greater than 10 nanocuries per gram, the yellow areas are .01 to 10 nanocuries per gram.

The distribution, about thirty meters down, which is about thirty meters above the water table, this is the major distribution that we have determined.

DR. MOELLER: Dr. Philbrick?

DR. PHILBRICK: What was the purpose of this? Was it to get the material into the ground, or to hold it up?

MR. MANRY: The purpose of this particular crib was as a disposal site, it's a liquid disposal site, to put it into the ground.

DR. PHILBRICK: Thank you.

MR. MANRY: That was the practice that was carried out at the time.

The next slide shows the proposed distribution mechanisms.

(Slide)

Looking at the data that we've accumulated, looking at past work in the laboratory and field here, we have postulated the distribution mechanisms that occurred in Z-1A. The physical means-- Solid, insoluble plutonium dioxide went into this site as part of the waste train. It was filtered by the soil at the -- near the surface and through flow in the uncontaminated soils. Some of it did penetrate. But most of the plutonium is held at near the top of the crib. By chemical means the acidic soil -- reduction in pH, chemical reaction with the caliches, the carbonates that are present in the soil, produces a chemical change and a precipitation of the plutonium-bearing material.

The silt lenses in the previous slide, a lot of caliche and carbonate are in those silt lenses. And so when you start getting a chemical reaction there you start getting a concentration.

DR. MOELLER: Dr. Lawroski?

DR. LAWROSKI: What was the total volume of waste that was put into the Z-216-A crib?

MR. MANRY: The total volume, the Z-1A, the total volume was about 6 man-liters of waste, acidic waste.

DR. LAWROSKI: That's liters?

MR. MANRY: Yes, liters, measured in liters.

There's an estimated 57 kilograms of plutonium in there.

DR. MOELLER: Don Orth?

DR. ORTH: For both Z-9 and the Z-1A, do you have an estimate of the highest concentration of plutonium in terms of, let's say, grams per cubic foot of soil?

MR. MANRY: We have concentrations in the Z-1A of about 100 nanocuries per gram in the soil. For Z-9 we feel we've removed most of the top 30 centimeters which contained the highest concentration: that has been removed.

Next slide.

(Slide)

The environmental impact of low level waste practices at Hanford was presented in the Environmental Impact Statement of ERDA-1538. It discussed low level waste and made some of the commitments that you see here listed on this slide.

We talk about recovery of plutonium. The practical level of recovery needs to be defined.

In 1978 the Technical Review of the National Research Council on Radioactive Waste Management at Hanford said that, "most soils and sediments containing dispersed radionuclides should be left in place, and not exhumed until a major hazard to the environment is demonstrated. Plutonium is hazardous for so long a time that removal of sediments containing considerable amounts might be desirable."

The Report to the President by the Interagency Review Group recommends that "For buried transuranic waste, DOE should accelerate its environmental and technical analysis of disposal options at all sites and reach a conclusion by mid-1982 on whether the buried material should remain in place or be exhumed."

Today we have a program that's a couple of years old moving in what we call long term transuranic waste management. It includes within its scope the low level and transuranic waste storage disposal sites that were listed on the earlier chart.

We are looking into the methods of pursuing long term solutions.

May I have the next slide.

(Slide)

The strategy is to develop on a parallel path the alternative studies which will look at the technical options, the risks and cost estimates for long term solutions to the low level waste problem.

Concurrently with that, the development of technology aimed at carrying out those alternatives. Obviously you're not going to do your alternative study after you do your technology development. We have a concurrent effort there.

Our technology development today is a low level effort. Our alternative studies today are proceeding. We are aiming toward a -- later this year, having a draft alternative study finished, which we will immediately use and go into a programmatic environmental impact statement.

The programmatic environmental impact statement will discuss the environmental impacts of the long term waste management technology development. It is not a specific environmental impact statement that will lead to a decision to remove any operating or surface facilities. It is a technology development environmental impact statement, a document we are scheduling for about Septembe of next year, 1981, as a draft document.

We anticipate that it will have review, comments, and we will issue that then in final form in 1981, fiscal '81.

Following that, our technology development effort will accelerate, looking at long term solutions based on the guidance that we get from our alternatives environmental impact study. Certain technology development items will need to be demonstrated. We look at demonstration of these selected activities to demonstrate that the removal, or in-place disposal of this material can be safely handled.

Leading from your environmental impact statements of the programmatic and specific nature and the demonstration of technology, we're looking at an implementation phase which probably in the mid-to-maybe-early nineties will commence, following the selection of alternatives, the, of course, approval and funding, and construction and operation of facilities to handle these.

This is our strategy for the long term.

The Z-9 work, the Z-1A work are all part of site characterization efforts that are leading to a definition of information we need for the alternative studies.

We have to define the data base from which we are operating. We're working with other programs in D&D and high level waste to define the interfaces between these programs. We're working to make sure that we've got the real estate at Hanford covered, and that there is no duplication.

We're looking at other sites that are working on technology that can benefit us. And we hope to share our technology with them.

For instance, we're looking at an interface between our D&D activities, an engineered structure which has a pipeline that goes to a disposal site, a crib, for instance. A line of departure has to be defined for what's part of the low level site, what's part of the facility, so that you can adequately cover. It's a big reservation, and it may not sound like a big issue, but it has to be covered. We just want to make sure we get it adequately covered.

Next slide.

(Slide)

Let's look at some of the alternatives we're considering and studying right now.

There's the no-action case that says you just defer all action to the future, don't make a decision today just keep doing what you're doing and let the decision come later. Continue the present practices indefinitely. That's something that has to be considered. With what we're doing today, can we just keep going forever?

There is no attempt made to say which one of these alternatives is the one we will follow. We're evaluating them, we're trying to evaluate all of the alternatives equally, so that we do cover all the possibilities.

The leave option. We can enhance our surveillance and monitoring, keep up with the material by maybe automated means, more manpower, the "how do you keep up with it over long periods of time?"

The thrust here is long term, better ways of making sure thatyou've got the waste under control. A monitoring program that looks at identification of the waste sources and its stability, that gives you a signal if there's an undesirable event happening, so that you can provide response to it.

Long term site stabilization improvements. Some of the D&D discussion earlier was talking about gravel, concrete, a lot of good interim waste management stabilization techniques. Again, the thrust is long term, How do you assure that that barrier that you put in to stabilize that site is going to last for a long period of time.

Storage sites that exist. We have storage and twenty-year retrieval of storage. If, for some reason, that storage site were not to be removed to a federal repository and to be disposed in place, then you would have to convert, you would have to stabilize it. You would have to do something with it.

The retrieval option. The retrieval option is the one that entices a lot of people. You have to look at various levels of transuranic waste cleanup. When you remove plutonium from a site, if you'll remember the cross-section on the Z-1A site, where there was a 10 nanocurie or greater isopleth in the orange area, if you go down to that level you still have plutonium below that. So you have a residual site which you have to stabilize. You have to process that material that you take out of there to meet disposal criteria; which we don't have yet.

We have to provide packaging and transportation to either on-site or off-site repositories. There is no real reason to start a production program to remove any facility until you've got a place to dispose of it on a permanent basis. There will be some demonstrations that are carried out in which we will go into the twenty-year retrievable storage if any transuranic materials are there. But we see no thrust to carrying out an operational program without a repository to put the material in.

I have given you a quick rundown on the current operations, the long term strategy, and, with that, I think I'll cease. --unless you have some questions.

DR. MOELLER: Thank you, Mr. Manry.

DR. LAWROSKI: This is a followup to my question I asked about the volume of the waste, the liquid wastes that went into the Z-1A crib. And this second question I have is one that has probably been asked many times, but I'd like to ask it today again.

Was there consideration given to, and was the AEC requested to provide funds for tanking this waste? If the answer to that is Yes, was the Congress requested for funds?

MR. MANRY: We knew at the time this facility was in operation that was the accepted disposal practice Today that practice is no longer used. All of the wastes that are generated in the plutonium plant go into tank facilities.

DR. LAWROSKI: Was it ever considered to tank them before they were generated, to provide tankage for them in lieu of cribbing them?

MR. MANRY: At the time the facilities were used, no. That was the accepted disposal practice. We start out with a site in which the short term use of the site was thought to be just to get a job done. They used existing industrial practices which said liquid wastes you put into the ground, you put it into underground cribs, ponds or ditches, and let it percolate away. And solid wastes you put in shallow land burial sites.

In 1953 the practice was looked at, data was accumulated, and showed that the Hanford soils were very good, in fact, from a non-exchange of chemical and moisture standpoint, a good retention agent. They started a program of specific retention which said you review the wastes which you are going to put in the ground, and you determine how much waste you can put into a particular site based upon the geology and flow characteristics of the wastes you're putting in there.

The practice was discontinued. We have since stopped that practice. We now put all wastes from our plutonium facilities into tankage.

DR. LAWROSKI: I asked that question because I had had recollection of -- I read or I was told that there were occasions when tankage, perhaps not for this operation, had been requested by the AEC, but organizations in Washington that reviewed this arrived at different answers and did provide funds. I just wanted to be clear.

MR. MANRY: The time that facility was operated, that issue was not raised.

I'll say this: today we transport all liquid wastes from our reactor areas and our laboratory areas and our 300 areas, all that liquid waste is transported into the 200 areas where it is added to the B tanks for the evaporators, and it, in effect, becomes a part, the residue from that operation becomes a part of the high level waste tank inventory. No liquid waste goes to the ground in the 300 and 200 areas.

In the 200 area we still have cooling ponds to which normally cooling water goes to. We maintain these, we monitor them. We have an environmental surveillance program that's looking at maintaining control of these and the safe operation of them. We looking at a reduction of radiation zones. We're removing some of these sites from active service.

DR. LAWROSKI: Thank you.

DR. MOELLER: Carson Mark.

DR. MARK: My question is really almost covered by what has been said. But, to perhaps complete it: you referred to 1953. The waste disposal activity I believe started here in '44 perhaps.

MR. MANRY: Right.

DR. MARK: And this crib disposal of liquid wastes was the standard practice beginning then in the very first days?

MR. MANRY: Yes. They were-- Reversed wells and French drains were some of the first liquid disposal sites. And cribs were used to distribute the waste to the ground. That was standard industrial practice at the time used by a good chemical processing company which was operating here.

DR. LAWROSKI: Was most of this generated when the production program was accelerated around 1952, at the time of the Korean war?

MR. MANRY: All of it is defense wastes that were generated as a result of operations here at Hanford, yes. We do receive some other wastes.

DR. LAWROSKI; But a large fraction of what's in the 216-A, was it not generated as a result of the accelerated production program that was taking place in the early fifties?

MR. MANRY: The waste that's in the Z-1A site is a result of a scrap operation in our Z plant, and the rate of production of which was accelerated at the time.

DR. MOELLER: Do we have other questions?

MR. H.M.PARKER: Just a very brief comment about the sloppy industrial waste practice.

From the very first day that this plant operated all wastes that were released were governed by a policy that if and when they reached the public domain it would be at a level lower than the then-existing tolerance standards, as well as you could determine that with the very limited technology of the times. And that technology, due to the work of Dr. Foster and many others around here, was very rapidly put in place. Which is not quite the same as saying the waste was handled in the conventional chemical waste fashion. That is absolutely not true, as far as I'm concerned.

MR. MANRY: I agree with you. If I implied that it was that, I'm sorry. But you're right.

DR. LAWROSKI: I'm glad to hear that additional information.

MR. H.M.PARKER: May I ask a question?

On your present list of alternatives, under the no-action where you say, the second one is "Continue present practices indefinitely." You're assuming there that Hanford is no longer going to be a major continuing production center; is that correct?

MR. MANRY: I'm assuming that the maintenance and surveillance of the waste sites will continue indefinitely, regardless of what the mission of Hanford is.

MR. H.M.PARKER: You're assuming that it doesn't crank up and start churning out large volumes of waste; is that fair to say?

MR. MANRY: No; I'm saying the waste sites that exist, which are today minimized, are going to be maintained. We've got 392 sites out there. We're not going to walk away and leave them. We're going to either maintain them indefinitely or do something with them.

MR. H.M.PARKER: What happens to them depends on whether you did put large additional volumes of liquid on top of them; isn't that correct? I mean, this is the main driving force to ever bring these wastes into the public domain. If you leave it to our present rainfall, not very much is going to happen within a measurable time; right?

MR. MANRY: That's right. We are evaluating the alternatives. The impact of the scenario of a climatic change will be evaluated.

Today the number of sites that we have in an active capacity, there are about six liquid disposal sites, eight ponds and ditches, all in the 200 areas. None in the other areas. And these sites, we are using them at a minimum rate. The processing improvements have been made to operating plants which these sites service.

With the operating life of the facilities as planned today, these facilities will be shut down and will no longer be used. They'll become inactive. The amount of radionuclides going into the ground today is very minimal.

DR. MOELLER: Alex Grendon has a question.

MR. GRENDON: My question related to Herb Parker's question, which somewhat confused me.

Even if Hanford were engaged in a greatly accelerated production program it would not be discharging very active waste to the ground, would it?

MR. MANRY: No. With our practices today we do not follow the large discharges of liquids into the ground. For new facilities that would be added here the no-liquid-waste-to-the-ground policy I'm sure would be implemented.

What I'm talking about with regard to these 392 sites is a result of thirty-five years of operation. The level of use today of those types of facilities is greatly reduced. But we've still got 392 sites which we provide waste management for. And we continue that. Safety, and looking at the long term options for the technology to do something with these sites.

DR. MOELLER: Do you have means, or do you assert an effort to keep up with what's going on at foreign countries in comparable activities, such as the Federal Republic of Germany?

MR. MANRY: Yes, sir. We have a programmatic team. One member of that team is a representative of our health safety environment organization. He is primarily charged with making sure that all of our members are kept up to speed on events at other places.

Every member of the team is well aware that there is a lot of activity going on at other places, other sites within the Department of Energy. We're very keenly aware of the need to gather as much information in a growing emphasis area such as waste management.

DR. MOELLER: Are there other questions for Mr. Manry?

(No response)

DR. MOELLER: I hear none.

Thank you very much for your presentation.

This brings to a conclusion the formal portion of our program. In closing let me make a few acknowledgements, to acknowledge the excellent cooperation of the DOE staff both at headquarters -- particularly Sheldon Meyers who assisted us there, as well as Alex Purge -- and here in the Richland Operations Office, John Streiber who was of immense help to us in setting up this program and handling the logistics of the meeting.

I would also like to acknowledge the participation of the DOE contractor personnel who have appeared on the program. There are some here from the Richland area and others from Sandia, LLL, LBL, and so forth.

Also we'd like to thank the representatives from the State of New Mexico for coming and appearing.

On behalf of the Subcommittee I would like to say it has been a privilege to visit Richland and to enjoy both your hospitality and your weather.

Last but not least I'd like to thank our Reporter who has stuck by us and taken everything down that's been said.

This will conclude, then, the formal portion of the meeting. We will adjourn and go into executive session, the Subcommittee will. That will be open to the public. You are invited to stay if you desire to hear it.

So, with that, let me declare the meeting adjourned.

(Whereupon, at 5:10 p.m., the Subcommittee was adjourned to Executive session, the transcript of which follows.)

(5:10 p.m.)

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EXECUTIVE SESSION

DR. MOELLER: We've heard a number of presentations. The way the Subcommittee operates is that we do hold an executive session in which I generally poll each consultant and each member of the Subcommittee and ask them for one or two salient points that they've noticed, or observations that they've made during the meeting. Depending on what comes out of those comments we may also request a written statement from each Subcommittee member or Subcommittee consultant.

Let me say that if we do conclude that we desire a written statement, please do not submit more than one or two pages.

Do we have a volunteer to begin with some observations? Or I'll just start at the far end of the table.

All right, Marty, you go first. And then Herb will pick up.

DR. STEINDLER: I would just as soon start because I may have to run out on you, depending on how long this takes.

I've got a couple of kinds of comments. One, I've already made some comments about the NRC high level waste plan. I'm simply-- Let me simply reiterate (1) there is certainly a need for greater speed. I'm very concerned about the schedule.

Too, I think there certainly is a need for much better interaction between DOE programs and the NRC staff, at least as represented by the inquiries we made concerning the involvement of the NRC staff in the DOE program planning process.

Secondly, this is probably not the meeting in which one ought to comment explicitly on DOE programs, but having heard a report from many of them I guess I can't help but make some few remarks.

(1) I hope that the ONWI program becomes better focused fairly quickly. I'm a little concerned that, if it doesn't, the assurance that a repository will actually be available in short order is going to be somewhat weak.

Further, I think there needs to be some systematic and hard assurance that the quality of the data that comes out of those studies, the ONWI program being quite large, the quality of that data has to be, I think, very high in order to stand both the scientific community's scrutiny as well as the public's scrutiny. This may be the most scrutinized bunch of information that the world has ever seen when that first repository finally gets rolling.

I hope the DOE Basic Sciences is listening to this, or has some way of determining what has been said here. I'm afraid they're not. But they certainly ought to be.

Because some of the things that have been brought up in the course of discussion of scientific information clearly points to a lack of fundamental knowledge; and that, I think, is one of the functions that DOE Basic Sciences Division should be looking at much harder than they do I think right at the moment.

I continue to be concerned about how computer modeling is going to be used, and specifically how it's going to be described to the public. Obviously there's no substitute for good data, and certainly not a complicated computer program.

The last discussions we've had on the D&D programs I think need to pay some attention to the separation of such things as actinides in order to be able to dispose of actinides, transuranics, in geologic formations in any kind of a sensible, economic way.

I see a great deal of effort on burial isolation for the near term. I see relatively little effort to concentrate the actinides into a disposable form.

Finally, I would urge that somehow the NRC Waste Management Group begin tomorrow to develop some visible expertise in the area of data analysis that relates to licensing, and that that group begin to evaluate the results of DOE programs. The DOE program is large enough, bordering three-quarters of a billion dollars, in some fashion or another, certainly large enough that such an evaluative NRC activity -- for practice, if you will -- can easily begin, can begin now, and probably could be a very useful training ground for both their own cadre and the whole question of interaction with DOE.

In that connection I would say that the Omree programs are obviously the first priority, or should be the first priority for NRC to look at in detail.

That's all I have.

DR. MOELLER: Well thank you. That's very helpful

I might mention, as a commentary on those remarks, that, No. 1, it could be both disappointing but also stimulating that the Subcommittee can provide a forum for the interchange between NRC and DOE. So it can work two ways. I feel personally that that perhaps is a part of our responsibility. So if we can help them, more power to us.

One other comment. In reviewing DOE programs or offering comments on DOE programs, I think it is well for everyone to understand that when Congress established the Advisory Committee on Reactor Safeguards as, of course, a statutory committee, we were given responsibility to serve in an advisory capacity both to the NRC and the DOE. So we're not in any way going beyond our charge if we offer comments to DOE, whether we are requested specifically or not.

MR. PURGE: Do your procedures allow for comment from us?

DR. MOELLER: Yes, certainly, Alex. Let me give you the microphone.

MR. PURGE: I wanted to comment on Marty's comments. I listened pretty well, and I think that most of your complaints about the NRC/DOE interaction has to do with the WIPP program. And I think -- I hope it was understood that we do have a pretty good program set up now for meetings with NRC on an exchange of information basis. But there's nothing we can do about the formality of the WIPP program. We are forbidden by Congress to spend any money that is aimed at licensing of a facility. And we've had an intention of, ever since this program started seven years ago, of having all phases of that where the public was involved in the outside systems, to go through regulatory review. We had no intentions of licensing, which to us meant public hearings to decide whether or not we're going to do it and when we're going to do it. But we had every intention of having regulatory review from the health and safety standpoint.

The other comment about the Basic Sciences: it's a good point. People have been listening. We received a plan about four weeks ago from the Assistant Secretary for Energy Research. It wasn't very good. We met with them.

It's been revised now, and I think things are starting along the line.

The initial problem was that they focused on technology instead of science. But I think it has been squared away. And there is a major effort being devoted to this now.

MR. H.M.PARKER: Dade, as you know, when we have a Subcommittee meeting in Richland my contribution has to be somewhat one way, because I am still doing some minor consulting work for Battelle and have to disqualify myself from substantial comment on what they're doing. Although I think it would not be wrong for me to say I think some of the work at the American Battelle sounds as though it would be extremely constructive for the national waste management program in the coming years.

And, secondly, since I was here in the early days, we had responsibility for the health and safety, and perhaps I am still too sensitive to the fact, but I think it was done perhaps as well as it could have been in the light of 1944 at that time. And those who look at it now can't know that. I think they were probably in diapers at that time.

We have had thirty-five years of experience, and tremendous advances have been made in the management of wastes since that early time, which now look sloppy. But wb6

it looks sloppy in the light of knowledge of 1979. That I think is a key point for the Committee to keep in mind

And then, moving to a more constructive thing, I would like to just single out two papers that I thought were extremely fascinating. And I don't mean to imply that some others were not about as good. These just happened to strike me as providing pleasure to hear excellent work well presented: in the one case, Dr. Anderson's work, for example, on the seabed disposal: I felt like I could have heard a day's worth of that and still have been learning. And today I thought the account of the Swedish work was extremely well done and very interesting to the objectives of your committee.

Thank you, Mr.Chairman.

DR. MOELLER: Thank you , Herb.

Jack Healy, are you next? Or is Frank next?

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DR.F.L.PARKER: I want to agree with Marty on the time frame. It's very distressing to see it stretch out further and further all the time. And I think all of us on the Subcommittee will eventually have annuities in this whole project.

I also think with regard to the IRG, that these problems have no effect upon the question of utilization of nuclear power; it's just patently false. And we should have had some reaction to that in our discussions.

Moving to another point, I thought that one of the points that Jim Malaro brought up was very good, the licensing procedure on an incremental basis, and there won't be any final decision until they're actually in the site and are experimenting in the ground itself. It seems to me that makes sense. And we've said that before.

DR. MOELLER: Would you say that again?

DR. F.L.PARKER: With the licensing procedure on an incremental basis, it means they've got to get down into the mine, in the repository itself, to look at the property and look at the hydrology and look at the geology in place. It's so important. And I think it had not been looked at as thoroughly in the past, it had not been recognized. And I'm pleased to see that NRC recognizes that that is an important factor and is a part of their program.

I think one area, though, where they have not made clear what they're going to do, and which may be important in the future. If their rules and their criteria become too general so that they apply to all media and all waste forms, then they won't be very helpful to the applicant. It seems to me that they might have to think seriously about how to write different criteria for different waste forms and different media, because the interactions are apt to be very different unless they can totally divorce the waste form from the medium itself.

On the seabed disposal, I agree with Dr.Parker. But it seems to me one area they recognize they have not addressed sufficiently, and which is the key to the whole problem, is the heat generation and its effect on interaction. And it seems to me that that's what really needs to be studied before they spend a good deal of time and effort on other problems. Because if that is not solved then the whole concept, it seems to me, is in great trouble.

Turning to the ONWI presentation -- I wish they would change the name of that, because the acronym is, unfortunately, too true. It's not clear that they have the authority to sell the controversies, the scientific controversies, and it's not clear what is happening over the last few years that they are proceeding to sell us on the scientific controversy. It seems to me it would be very useful to make them very specific and to set up the research to resolve those and resolve them very rapidly.

That's basically all.

DR. MOELLER: Well, Frank, one quick comment. And, of course, one nice thing about doing the summary this way is that the later people -- the first people have said it all, so the later people won't have too much to say.

But one thing the Subcommittee concluded, and which was repeated yesterday, was that there aren't going to be fifty-six of these repositories, so that each needs to be handled, or will need to be handled individually on a case-by-case basis. And you still believe that?

DR. F.L.PARKER: Absolutely true.

DR. MOELLER: How does that, then, impact NRC in setting up criteria? Can you comment on that? Do they still do it in a general way?

DR. F.L.PARKER: I believe that's what I was alluding to, that it doesn't make any sense to talk about how they have a general plan. They need to have specific plans for specific wastes in specific forms.

DR. MOELLER: Specific wastes in specific forms for specific media. Okay. Thank you.

Okay, Jack.

MR. HEALY: Again, I'd like to echo that I'm very happy to be back in Richland. I spent sixteen years here. And I would like to speak further about Herb's comments.

I think it's not only the technology that is changed, it's the attitude of the people. Back when the plant was established we had no real environmental monitoring. As a matter of fact, the Hanford plant was one of the first in the nation to establish an extensive environmental monitoring program for which these waste sites were indeed part of the responsibility.

I'd like to start out first by saying in spite of the fact that I've been to New Mexico, this is the first time that I've heard the presentation of the program. And I was quite please. I am particularly pleased that DOE took the initiative to provide the funding to the State. Because I think it's going to make a big difference in the future, and I think we have some quite capable people working on it.

I would like to make a specific comment on the basalt at Hanford. As I see the program, the major problem may well be political, in that you are right next to one of the major waterways in the country, and one which has a tremendous flow and may well be a resource for the future.

We've had some experience with a situation similar to this in Savannah River. And my understanding is that that was essentially stopped, the bedrock storage, by flooding because the Governor did not care to run the risk. And maybe we can hear more about this one later.

But I do think this is a political problem; namely, no matter what assurances you give people, I'm not certain that the politicians or the people are going to accept them.

I'd like to comment extremely favorably on the acid digestion work, perhaps because this is getting close to something I've always felt; that is, that every gram of plutonium or actinide or other material we don't put in the environment or into a repository is a gram saved. And I must admit I was very doubtful about this work when I first saw it. I never thought it would work. They've done an excellent job. And I hope that the results could be applied to giving us lower recovery limits than our present operating plants.

I'd also like to congratulate DOE Waste Management people on taking the step of getting away from the garbage man complex, and putting the money into the operation at key points that will limit the amount of material which goes to the environment, either repository or elsewhere.

I'd like to comment on the NRC plan and on this great move toward a systems approach. I've finally come to the conclusion, after sitting here listening to the comments from this distinguished committee and the plans presented, that we have two completely different points of view. And I think some time we're going to have to reconcile them.

The older people I believe have largely been raised to consider the scientific judgment as being of considerable importance. And I must admit I am one of those. I can come to a conclusion from seeing a good description of the geology of a site much easier than I can from a computer program. However the younger people seem to be greatly intrigued with computer programs, and they have great difficulty being convinced by a description of the site and its properties. And sometime I guess we're either going to have to get this together or wait until all the older ones die off.

(Laughter)

Thank you.

DR. MOELLER: Thank you.

Herb?

MR. H.M.PARKER: Can I make another comment on what Jack said before we go on?

On this early environmental program, one thing that's overlooked when we say the public was not knowledgeable, is that they were strictly prohibited from making that relationship, and it has been extremely detrimental to the program.

There were times when Jack Healy and I went out on a hundred-mile trip and grabbed a farmer's grain when he wasn't looking to bring it back to sample it for various materials. And that sounds pretty ridiculous now. But there was a desire on the part of the Staff to get public involvement at an early date. And, like Dr.Healy and Dr. Foster, we're among those who tried to get the information out as soon as it was permissible to do it. By that time we'd lost the knack, I think, of talking on good terms with the public, to some extent.

Jack, I don't know whether you feel that way. But I feel that way in retrospect.

Thank you.

DR. MOELLER: It's very helpful that you have this early perspective added to our discussion.

Moving on, let's call on Dick Foster.

DR. FOSTER: I guess the old Hanford-ites are being put together in a bunch here. I'm very happy that I could be included amongst them still at this particular point.

I think many of the reminiscing and historical things, or the philosophies, probably were covered enough, for tonight anyway, by Herb and Jack. I think I'll try to confine my remarks pretty much to things which I would expect perhaps the NRC staff itself, or the NRC as a whole, might focus on, as contrasted with the other particular agencies; that is, except, perhaps, the EPA at this point.

I've been harping on these environmental limits most of the meeting. And I haven't heard anything in the meetings here today that would tend to allay my fears that we are not about to have the kind of limits or criteria which I firmly believe we need in order to give the DOE the kind of guidance it needs on how good is good enough as far as a repository, or the NRC staff its basic building block on what it needs to put in place as far as regulatory criteria laid against the construction concepts in order to demonstrate that what is expected is being reached.

I'm with Marty Steindler about hypothetical models. I just don't think the way I view these things that the hypothetical modeling gets involved at that particular stage of the game. Sure, these things are going to be necessary when it gets into the ALARA type concepts where you get down to the performance of particular kinds of barriers and particular media.

Frank Parker has said that he looks to criteria for a specific criteria, and I think once some of the better ground rules are given then it's going to be how to, in fact, come up with that. But until such a time as we can have an acceptable public limit, or what is good enough, I think the kinds of considerations we're hearing are largely those which are associated with the ALARA type concept.

A second thing that has been mentioned is the possibility of this committee, the ACRS, participating in some way, either in the generation of some of the types of standards, or at least in the review of such standards. Also, the National Academy has been mentioned, and, of course, they have been participating in several ways. I think we're missing a major bet if the National Council on Radiation Protection Measurements is not included into that picture.

Well,we've been focusing here almost entirely on the geologic disposal type of repository. I feel that the NRC staff shouldn't really delay too long on giving some attention to the licensing needs that may be associated with some sort of an intermediate scale facility, since, as I understand the new IRG report, they're tending to back off a little bit on the firm concept of going to salt, and also Senator Glenn's position that the other things ought to be looked at harder. And I'm not at all sure but that the licensing of some intermediate facility may come about sooner than has been in mind during the past few years.

That's it.

DR. MOELLER: Thank you.

Let's go on to Don Orth, then.

DR. ORTH: One item that hasn't been covered yet is the NRC plan document that was passed out that we started with. And I'll quote from it: "It is designed to be a living document and will be revised as the program matures." And it goes on.

Well, I urge the NRC and all the other interested concerned parties, here and elsewhere, to review this plan critically and make any specific suggestions that they can, if it's going to be revised, to be sure that it is as factually correct as possible. Among other reasons, we'd like to avoid having any sections quoted out of context or having any sections held up as an illustration that we don't know what we're doing. And, without spending too much time, I'll just give one very brief mention: that the definitions of what are high level wastes leavea lot to be desired, and they're not very inclusive of what really are high level wastes. And that can be fixed pretty fast.

The other: "We plan to carry out a critical assessment of the DOE program as early as possible to assure that DOE is developing the type of information which will allow NRC to review a later application. Early involvement by NRC will avoid the cost of the delays and could improve the overall quality of the data-gathering process."

That's fine. Then it finishes: "To date NRC has little detailed knowledge of the DOE program." And it's kind of disconcerting to find this in this particular document at this particular point in time.

So that's what I really mean by a critical review. And let's get the document revised, or improved, or what-ever, as fast as possible.

That's it.

DR. MOELLER: Thank you. Those are very helpful comments. And I'm sure the rest of us agree.

Shaler?

DR. PHILBRICK: I want to be sure you have a mike, and that Alex does, too.

I made a fairly clear statement, I thought, yesterday afternoon, about waste disposal and the NRC paper which was furnished before. And I can't get over the basic necessity for getting the job done.

There isn't a question of whether it's IBM or computer data or what the hell ever it is that you want to use. The question is to get the job done. I don't care whether you do it with a bunch of Amazons from Greece or whether you sit down with a lot of numbers and work it out. But the importance of the thing is to get the material underground, out of the environment, not affecting you, me, or your grandchildren or my grandchildren. It's to get the job done. This is the critical thing.

Now how this gets to the people who are in the decision making process, I do not know. But it's my own considered opinion, and I'll bet money on this, that we have a basic problem which has to be solved. And it applies not only to the committee but applies to the whole NRC and the Department of Energy, and applies to the whole United States government. And we cannot sit around and argue about means and methods and whether we should do it one way or another way, once we take the fundamental decision, which is: we don't want it around, we don't want it to come back; we want it to be stable where we put it.

Now if you make that assumption, which is the fundamental assumption which has to be made, and which is an assumption which I've had backup from a good many, very competent men scattered across the country: they happen to be mainly geologists, but there are other people I was talking to. But I don't feel lonely in the position I'm taking.

Now let's just look for a moment at what we've talked about, or what has been talked about since we were here. The Stirpa discussion this morning, whenever it was, was immensely interesting. And it showed many very fundamental things which were not related necessarily to granite or to crystalline rock. It really stated, when you get down through the whole thing, that you should put the waste in a solid continuous medium which is essentially dry. Now you can make the medium out of anything you want to. But those are the characteristics that you have to have.

So if somebody wants to pick granite, then they have to look for certain spacing of fractures. If you have to do something else you have to do something else. But that is a problem of detailed investigation, and it isn't a mathematical investigation. Let's get the rock and look at it.

Now we get to seabed. Seabed disposal is a hidden emplacement. You're blindfolded, you're taking the boom, and you're pinning it on the tail of the donkey. You don't see what you're doing, you don't know what the effect is prior to -- I mean, after emplacement. You can't definitely figure out what the investigation of leakage will be before the emplacement, and it's going to be an unbelievably hard thing to sell to people who can put their feet on the ground and can think about things.

Seabed emplacement is a lovely thing. It's way the hell out there in the water, and nobody sees it, and that sort of stuff. But you don'tknow what you've done.

And this idea of penetrating thirty kilometers with a penetrometer is something I'd like to know more about.

Now let's get to geologic disposal on land. The basic specificat 1 is zero transport by ground water. There are other things that I cited which all add up to the whole thing. But, again, it's you put it there, you know it's there, it's not coming back to bother you. Therefore the critical thing is to have a definitely impervious environment for the repository, completely impervious, non-transporting, nothing is moving out of it. The radiation gets taken care of by depth, the heat gets taken care of by depth, the emotion gets taken care of by depth, the changing climate gets taken care of by depth.

But depth itself does not cover transport by groundwater.

So you go back to what is the value of the salt?

It is that the salt is there. And in the Salina Basin, in some of the bedded salts there is definite indication that the salts have been impervious for four hundred million years. Now you can't beat that as far as indicating that you're not going to get transport. And if the public doesn't want to believe it, the public is dumber than I think they are. I think they're a smart bunch of people. I think they get scared. But I think they're not dumb. And I think the facts are real.

So my feeling about this is that we ought to go away from seabed stuff. We should only get our hands on disposal in areas which are absolutely dry and in which transport by groundwater will not occur.

Now there's a way of doing this thing. I've been extremely interested in seeing people in the geological profession here in Richland. There are two competent people of the right and proper age, of the right and proper experience. I'm willing to see them develop the basalt investigations to the point where the facts are out. I think they're competent, I think they can do it.

I think the NRC -- and they realize this -- to bring up their capability in the geologic area to the point where they will review the work of the DOE, are able to review it on a comparable man-to-man basis. And this will come. This can be either by people who are prominent employees, or by consultants, or what-not. But I think this is so.

My feeling is we're ahead of where we were in October, but not a hell of a lot.

Thank you, sir.

DR. MOELLER: Thank you , Shaler.

Alex?

MR. GRENDON: At the end of this line I have very little more to say. But, as a Californian, I'm very sensitive to one representative of public interest that I think is possibly the most troublesome in the country, and that is California Energy Commission. Because if California goes ahead and shuts down nuclear power for the state, that example would be a deadly one for the rest of the nation.

Now a representative of the California Energy Commission, Barannini, did make a presentation in which I agree in little parts and disagree in large parts. But, nevertheless, he made a presentation on behalf of the California Energy Commission that set certain things going. Some of this effort and research and presenting results of what has been done to date should be more pointedly aimed at public groups like that. That's a public group in a real sense. It should be aimed at satisfying them to the extent possible, because the problem is a political one, not a technical one.

I do not believe there are many in the technical community who think that there are such grevious technical problems that we can't solve them. And we should distinguish between getting a solution for some of the wastes immediately, instead of after fourteen to seventeen years, and not querying whether what you do with that is going to be the long term solution for always. We don't make that distinction clearly. We should get some wastes buried or disposed of in whatever ways we see fit, and I think burying them in these deep geologic repositories is certainly the first way it should be done, and, if necessary, do it by brute force methods.

If, for example, you're concerned that the canister has sufficient containment and won't last more than 'x' number of years, then make it ten times as thick, if you wish, for the initial waste, and make it last long enough to satisfy anybody. In other words, do something within a short enough period of time to satisfy elements of the public that that is a way to dispose of wastes, and that a better way will be developed in the course of time.

That's the principal comment I would make.

DR. MOELLER: Well, thank you very much.

Do we have any other comments from our consultants?

(No response)

DR. MOELLER: Okay. Any comments from Subcommittee wb23

members? Charlie?

MR. MATHIS: I have a few comments.

One: It's quite evident that a lot of progress has been made. And we've heard a lot of interesting and promising options, not the least of which is the seabed kind of thing. And I would encourage that that be promoted somewhat, if for no other reason than the public likes a choice. And this is a far different choice than choosing between salt or basalt. And I think politically it has some merit. And, frankly, I feel that a good share of the problems that remain to be solved are political, and they're going to continue to be that way.

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I still feel that the program as such is not much different than the way it was explained in the report to Congress that the ACRS published in January this year. I don't remember the exact words, but it went something like this, that we felt the programming was somewhat fragmented and was not well organized, it needed more attention and coordination.

I would like to add to that that it seems to me that the schedules we've heard in the last two days in many cases have been quite slow, and for no apparent reason. I think there was one comment made that Well, we have time. I think that's not a very obvious good reason for having a slow moving program.

560 I think all of this adds up to just one thing, and that is that the over-all objectives are lacking, and I think it is pretty obvious to all of us that the decision making potentials are being just held in limbo for lack of a policy, and I don't know what we are going to do about that, but I think that's our big hangup.

That's all I've got.

DR. MOELLER: Steve, do you have any comments additional?

DR. LAWROSKI: Yes.

I heard the reason given why there has been, at least in one report, limited contact between DOE and NRC in regard to the licensing. It's one of the pieces of legislation; I forget what it had to do with. I think it was in connection with one of the budgets a few years ago, I believe, and that's how it came into being.

But notwithstanding that, I think that with some diligence that a way can be found to get better cooperation and an exchange of information that is so badly needed because it has taken so long to get to this day between the DOE and then the NRC.

The DOE has got a large budget to obtain appropriate research and development information, and much of this kind of information is going to be needed by the NRC and it is going to be up to the NRC to work with DOE and vice versa to make the maximum benefit from the derivation of this information as it comes from the laboratories.

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I'm sure that a bit of the spinning of the wheel is the result of so many reorganizations in recent years in both DOE and in NRC, and I know, because I myself read that on the one hand there are Congressmen who say, "NRC, don't you work too closely with DOE because that's going to lead to conflict-of-interest problems." At the same time other Congressmen are saying, "How come you're not getting better informed about each other's work and needs?"

I think part of the problem, too, besides the fact that there have been so many changes of top management, both of the Waste Management Program for DOE and NRC, is that I think in neither organization at the very top of even the first

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couple of layers is there anybody with extensive background experience, so that the situation has been badly compounded with difficulty.

Of course we are getting the legacy here of many years of relatively poor funding in DOE. The greatest attention was always to the development of reactors and safety problems associated with those and therefore, DOE needs for commercial power.

Next in line came funds, considerably limited compared to the reactor development and the separations technology but by golly, it was not until you got into the matter of radioactive waste management, which certainly had to have its appropriate solutions, that you really see a couple of orders of magnitude almost to that extent in the relative funding. It was pitifully low for many years.

I am aware that many things that were done here at Hanford, as Herbert Parker pointed out, were done on the basis of the serious problems of scheduling but nevertheless, as he pointed out, for this site at least there was attention paid by people to try to still see that the wastes were disposed of in a satisfactory manner.

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So it isn't that the public health and safety wasn't given consideration, but perhaps too long a time elapsed, not only at Hanford but elsewhere, getting to better solutions that would have been capable of coping with the change in attitudes that we have seen come about as to the way we store particularly low-level wastes, not only on the part of the public but even on the part of the technical community.

What was perhaps all right at Hanford, because of its climate and the excellent absorption capability of the soil here, may not have been so acceptable at places like in Kentucky, Illinois, and a few other places.

I would just urge again that both DOE and NRC, at least at the upper levels of their management, do whatever they can to expedite the exchange of information and the needs of information between each other. Otherwise, we will continue to hear carping because the amount of money being spent by both organizations is indeed very large.

I would hope that the people who did write these legislations would bear in mind that there has to be an appropriate balance between the NRC's responsibilities, which are such that more than what might seem to be an appropriate amount of contact between it and the DOE, is found to be not only acceptable but encouraged.

DR. MOELLER: Carson?

DR. MARK: I don't have very much to add.

I would like to go back to the matter of the NRC Program Plan document which indeed said it was under continuous review and possibly reformulation. The things that came to mind when I read it may in fact have been my fault rather than the document's fault, but I did feel that it was rather heavily overshadowed by statements made by the IRG. And I don't think that the NRC group should have felt it necessary to say these are the rules and you've got to work within the context of the statements made there, and all the more so in the IRG report. It's likely to come out and look rather different in some respects.

But they should at no time probably regard that as an infallible boundary condition.

I felt also, and this may be an unfair comment, that it was somewhat too heavily cast in the context of storage in salt only. Now it's been said that you can't talk about storage in general, you have to talk about it in particular. But the report should at least cover, as much as possible, of those aspects as might apply either to crystalline rock or to salt or conceivably even to sea bed, and see the things which are common to those and only get to different points when you've got a specific medium to discuss.

I was also a little bit concerned that there didn't seem to be in that Program Plan any allowance for things that might happen in the next year or so such as R&D or experimental emplacement of actual, live fuel is some actual living medium. I was much encouraged that the DOE program does include items of that sort, and perhaps it is not a function of the NRC to license those. Perhaps it is as well that it is not.

I hope that the DOE's plans to get some actual data from real emplacements, even if just one canister in one medium, and to begin to watch it immediately would provide input for NRC in their Program Plan and might allow them to a little bit alleviate the feeling that you can't quite tell when the plans might converge on some actual action.

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DR. MOELLER: Thank you, Carson.

I believe-- Rags, would you agree in the thoroughness of the comments that we have sufficient information?

MR. MULLER: I think so, especially since we have the transcription.

DR. MOELLER: All right.

Well, with that, let me thank Ms. Bloom once again.

Alex, do you have a comment?

MR. PURGE: If I may, I just wanted to say a couple of things quickly.

There was the comment about this choice on sea beds, at least using sea beds so that we have the choice. In the Environmental Impact Statement which is being sent out today we have actually included extraterrestrial disposal and transportation, and the only thing I think we really left out, and even that was covered, was disposal on the ice caps.

We did try to address everything that has been brought up in the past, and we even had the proposal that was made five years ago, to put it in a ten-mile-deep hole, and there were some evaluations made on what that meant.

There was a comment made about the aquifer here and one of the things that we found out in the last ten years is that everybody has his own aquifer and even in Kansas it was found that some of those aquifers there would kill most people but there were a few cattle that were drinking it if they were ready to die, but it was a pressureless aquifer.

I just wanted to comment here that this is the first meeting of this type for a long time where I haven't heard three things brought up.

One is questioning the ten nanocurie per gram number --

(Laughter.)

-- and that other was the 20-year retrievable term that's used and also the OKLA phenomenon.

(Laughter.)

DR. MOELLER: John, did you want to say something?

MR. MARTIN: I don't really have a speech but I just wanted to make a couple of remarks.

As somebody who got appointed three months ago to try to take over the Waste Management Division, this Program Plan is the first step in trying to pull together all of the different NRC offices' points of view.

I was quite surprised when I started to put it together that there didn't seem to be much of an over-all, consistent view in the agency as a whole as to what direction we should be going on some of these things.

We have tried to outline it in this plan, and many of the things in there will seem completely obvious and very simple minded, if they even needed to be written down. But on the other hand when I started putting that together there did not seem to be a very consistent point of view on many of these things which are fairly obvious.

For example, this NRC-DOE interface I found to be just a complete blank. And of the three major things that we were starting out to do in a big way in the next few weeks, that is one of the three major subjects that is being made in that plan, is to find out what DOE is doing and what emphasis we can put on the criteria and standards.

A comment that has come up repeatedly is one that I share myself. I'm quite alarmed that we're not moving along on this. We are not only rallying around that one very strongly in our own shop, we also are doing what we can to build a fire underneath EPA. I want to do what we can there and yet not use that as an excuse for not doing anything within NRC.

I also subscribe to the idea of getting on with the job. We can't study this forever, and I and the Waste Management staff I believe also share this concern about computer models being ends in themselves and serving as a substitute for judgment and conventional engineering practice.

Hopefully, next time we have one of these meetings, rather than expressions of intent and written-down statements of the plan, we can produce a few months of achievements initially.

Thank you.

DR. MOELLER: Thank you.

I think with that, we will declare the meeting adjourned.

(Whereupon, at 6:10 p.m., the meeting of the Subcommittee was adjourned.)

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Rockwell International

Rockwell Hanford Operations
Energy Systems Group
Richland, WA 99352

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Basalt
Waste
Isolation
Program

April 19 , 1979

Basalt Waste Isolation Program

Operated by

Rockwell Hanford Operations

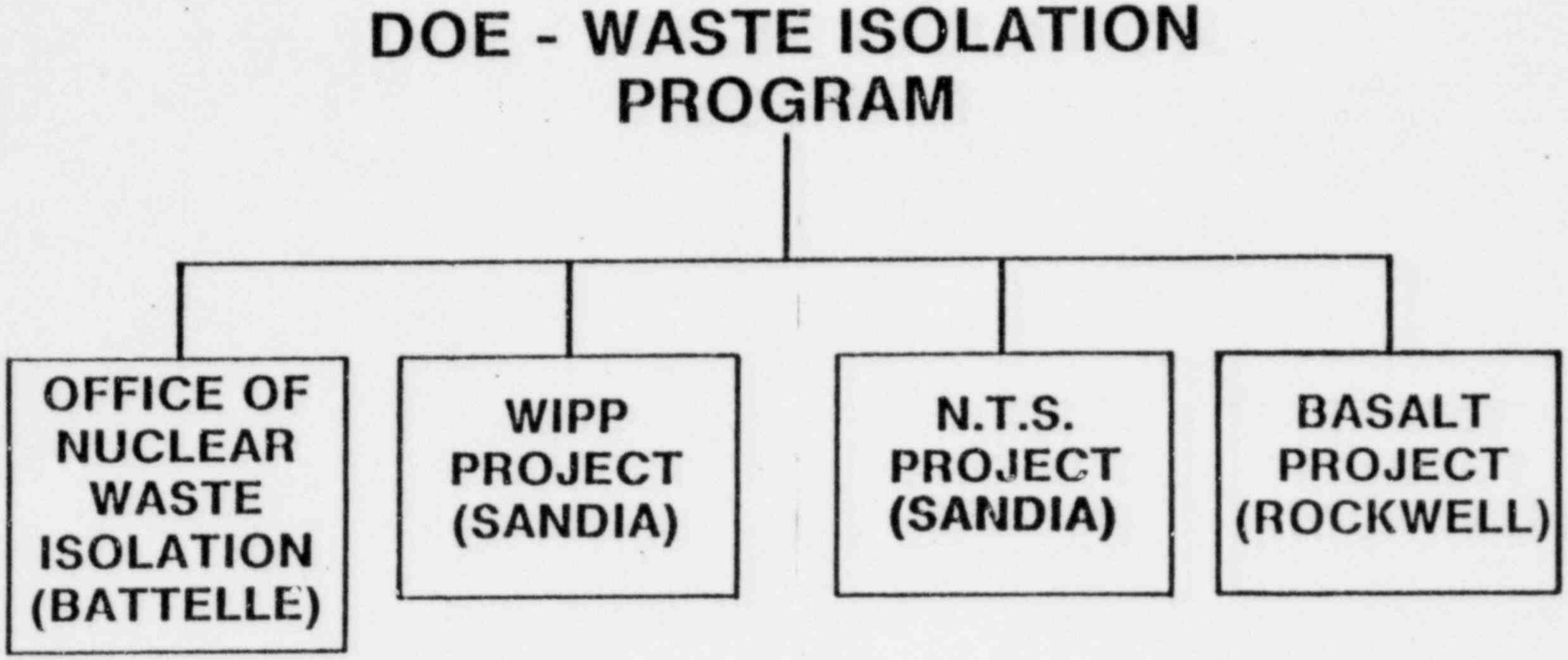
for the

U.S. Department of Energy

Technical Status Report

PROGRAM OBJECTIVE

ASSESS THE FEASIBILITY AND PROVIDE THE TECHNOLOGY NEEDED TO DESIGN AND CONSTRUCT A GEOLOGIC REPOSITORY FOR STORAGE OF RADIOACTIVE WASTE IN BASALT FORMATIONS WITHIN THE COLUMBIA PLATEAU.



DOE - WASTE ISOLATION PROGRAM

- OFFICE OF NUCLEAR WASTE ISOLATION (BATTELLE)
- WIPP PROJECT (SANDIA)
- N.T.S. PROJECT (SANDIA)
- BASALT PROJECT (ROCKWELL)

DEPARTMENT
OF ENERGY

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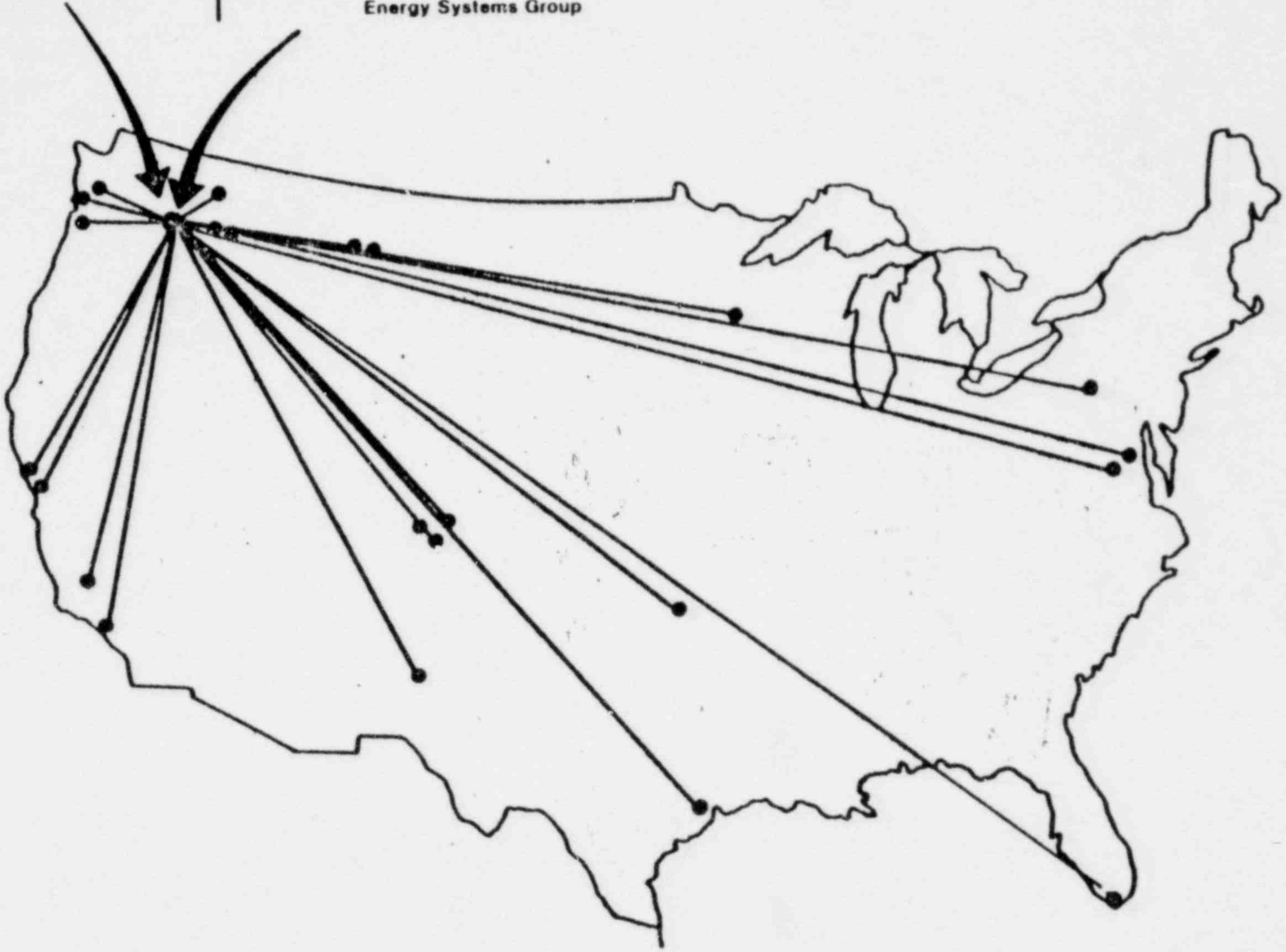
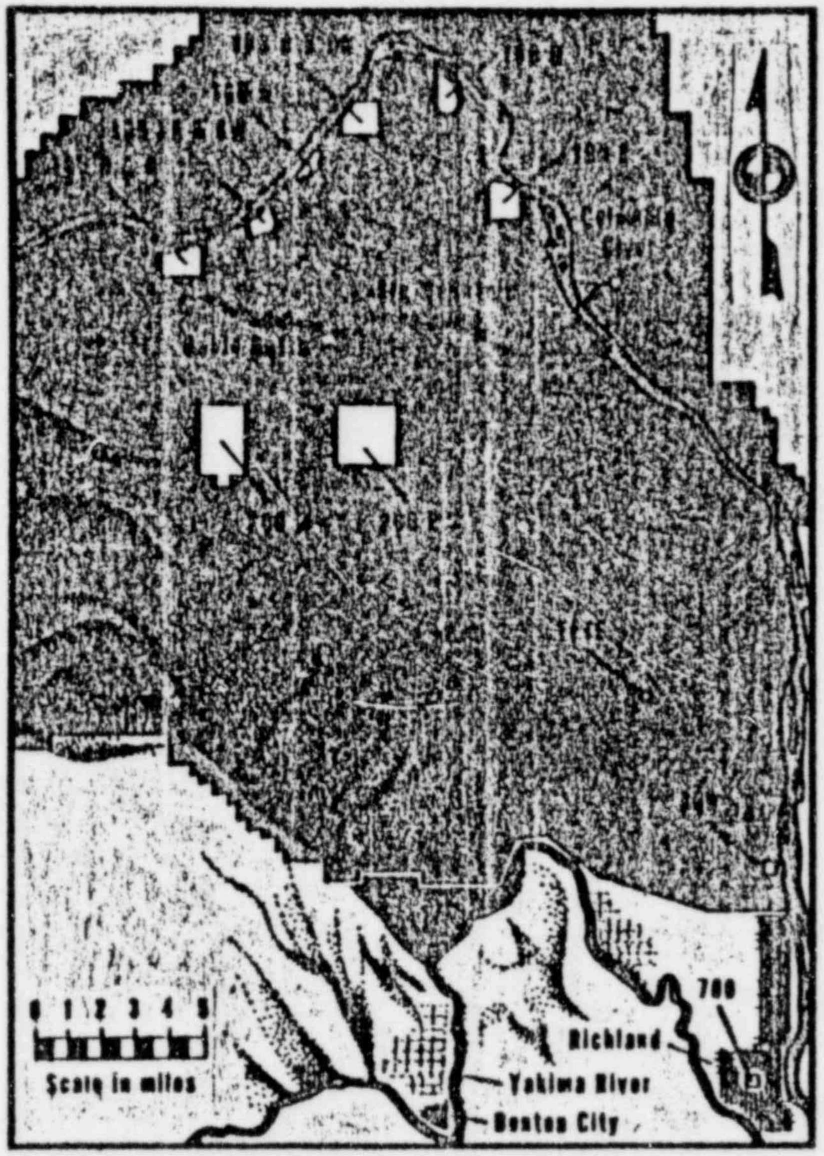


The Columbia Plateau

HANFORD AREA MAP



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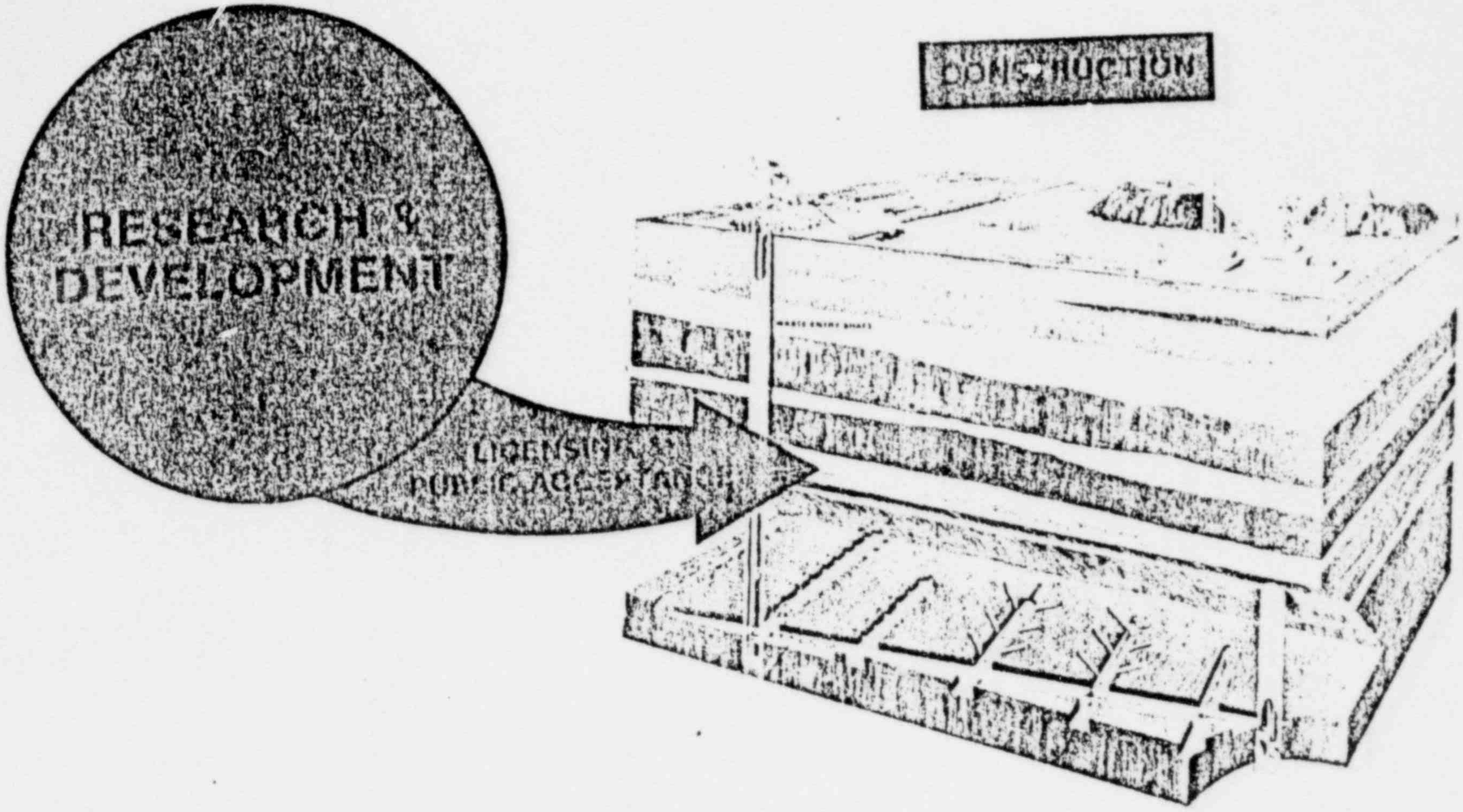
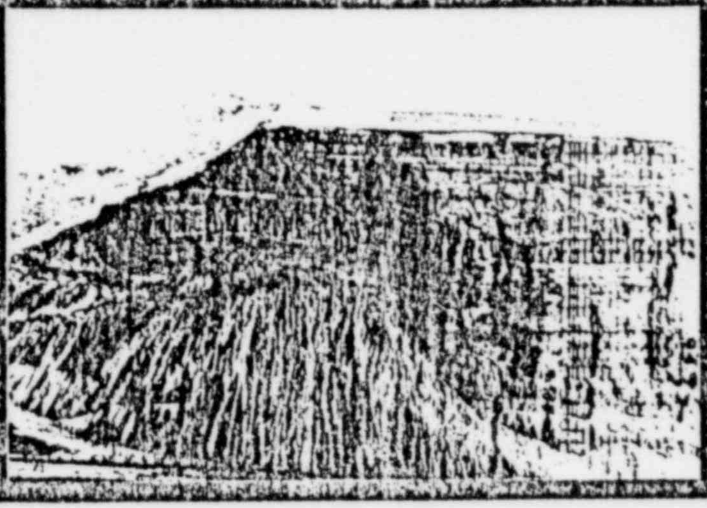


CONSTRUCTION
RESEARCH & DEVELOPMENT
LICENSING & PUBLIC ACCEPTANCE

AREAS OF STUDY

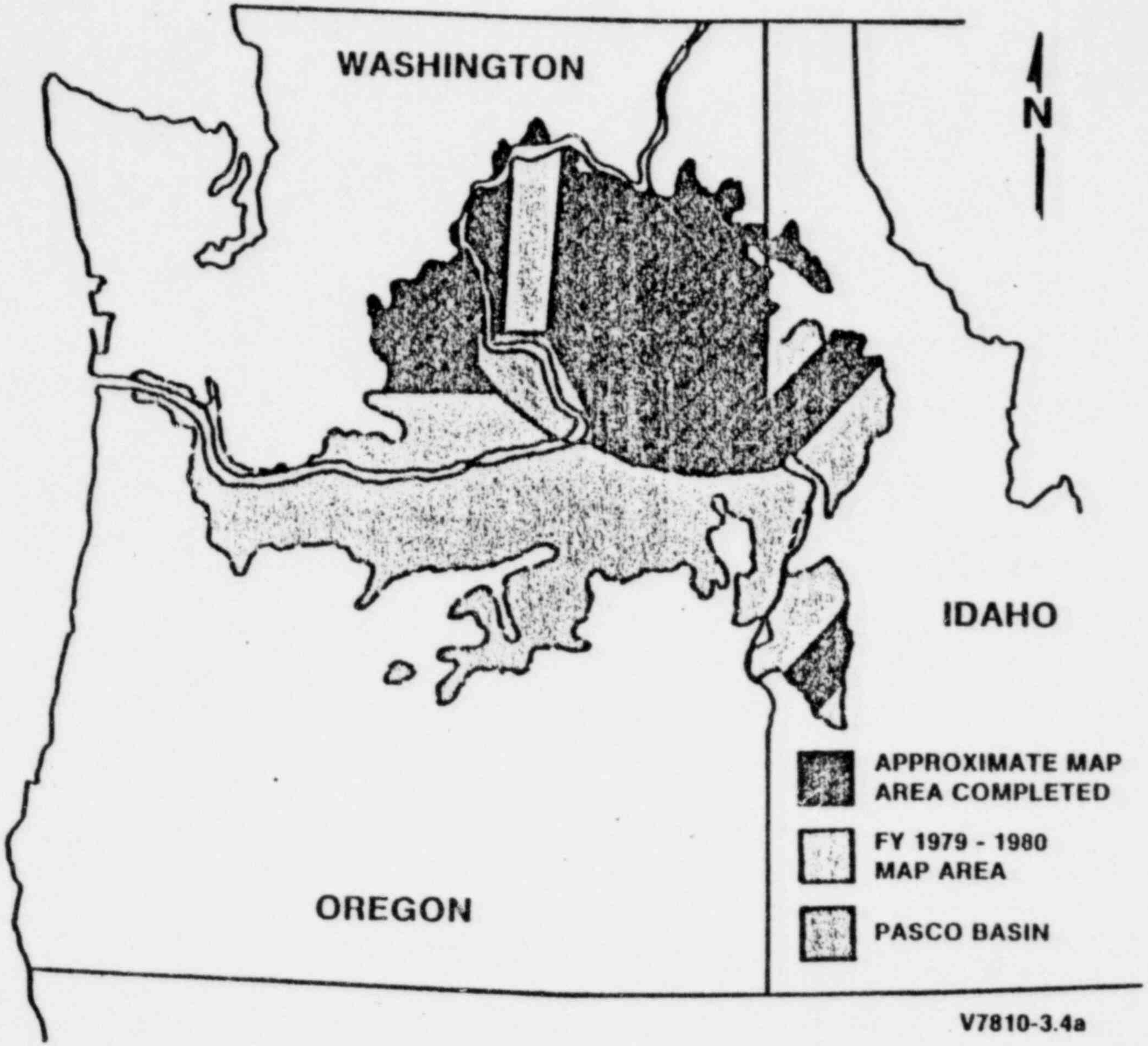
- GEOSCIENCES
- HYDROLOGY
- ENGINEERED BARRIERS
- NSTF DESIGN AND CONSTRUCTION
- ENGINEERING TESTING
- SYSTEMS INTEGRATION
- REPOSITORY

Geosciences



GEOLOGIC FACTORS BEING STUDIED

- VOLUME AND SHAPE
  - STRATIGRAPHY
  - STRUCTURE
- GEOLOGIC STABILITY
  - SEISMICITY
  - TECTONIC SETTING
  - GEOMORPHOLOGY
- LITHOLOGIC PROPERTIES


WASHINGTON
N
IDAHO
OREGON
APPROXIMATE MAP AREA COMPLETED
FY 1979 - 1980 MAP AREA
PASCO BASIN

V7810-3.4a

GEOSCIENCES

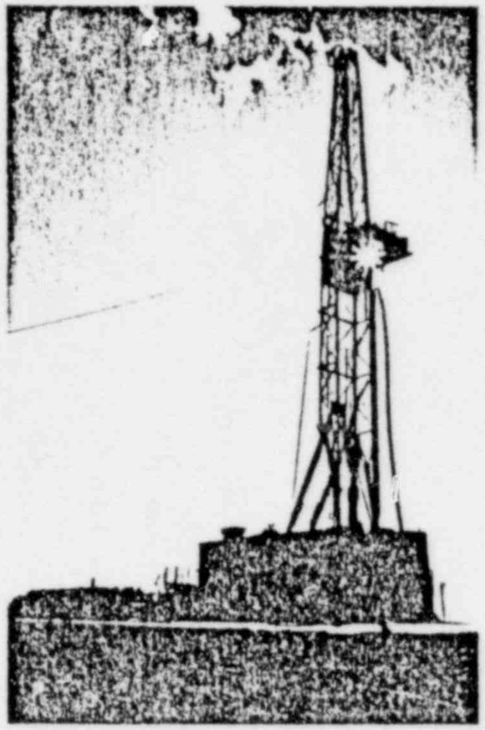
MAJOR ACCOMPLISHMENTS

- MOST OF THE RECONNAISSANCE MAPPING OF BASALT AND LATE CENOZOIC SEDIMENTS COMPLETED
- THE WESTERN HALF OF THE PASCO BASIN WAS MAPPED
- THE STRATIGRAPHY OF THE PASCO BASIN WAS ISSUED
- GEOPHYSICAL SURVEYS SHOWED THAT SEISMIC AND MAGNETOTELLURIC TESTS WILL BE USEFUL IN STRUCTURAL MAPPING OF THE DEEP BASALTS
- MAJOR BIBLIOGRAPHIES WERE ISSUED

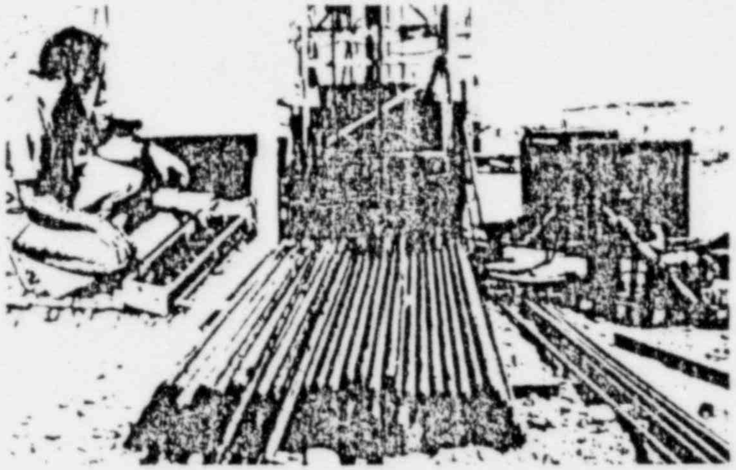
GEOSCIENCES

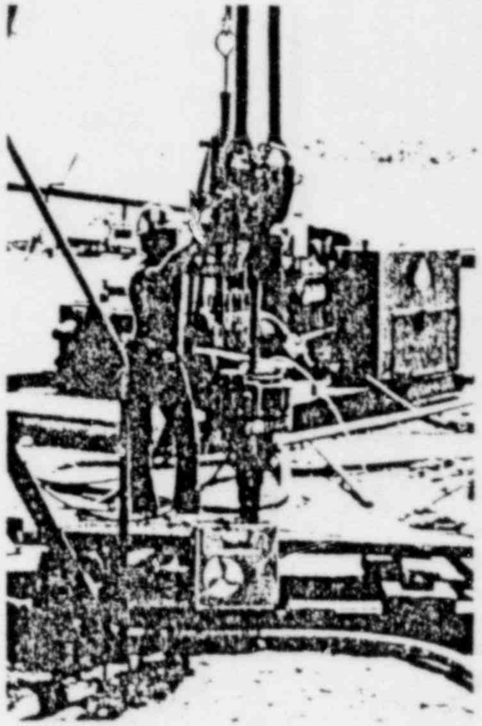
ISSUES REQUIRING RESOLUTION

- MAPPING NEEDS TO BE COMPLETED
- PROMINENT STRUCTURAL FEATURES WILL REQUIRE DETAILED STUDY
- ATTRACTIVE REPOSITORY TARGET AREAS WILL REQUIRE CLOSE EVALUATION
- UNDERGROUND SEISMIC CRITERIA NEED TO BE DEVELOPED

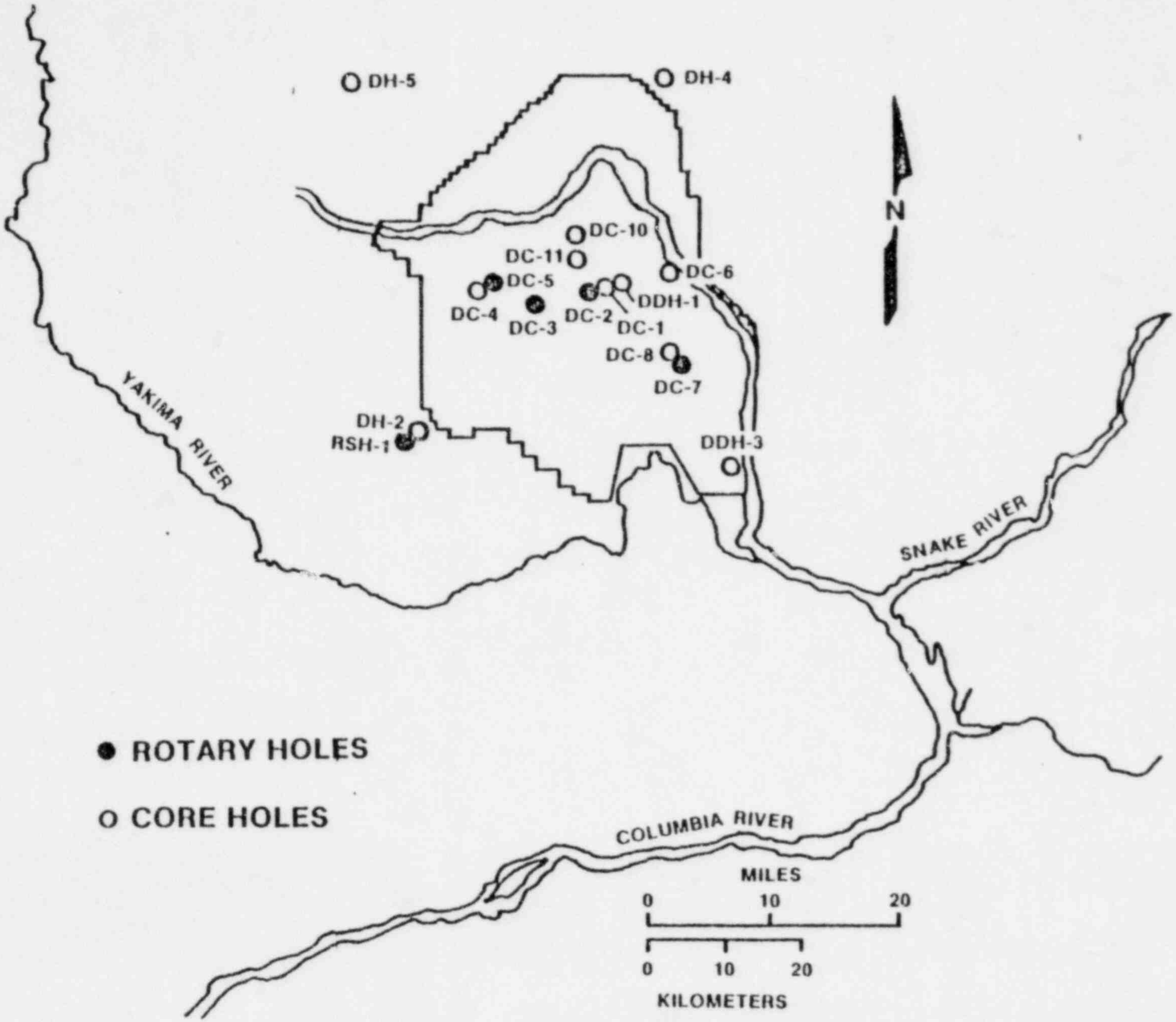


Hydrology





DRILLING LOCATIONS



HYDROLOGIC FACTORS BEING STUDIED

REGIONAL HYDROLOGIC SETTING

- GROUNDWATER FLOW SYSTEMS
- IDENTIFICATION/CHARACTERIZATION
- GEOMETRY
- LITHOLOGY
- RECHARGE/DISCHARGE AREAS
- FLOW RATES/DIRECTIONS
- POTENTIAL DISTRIBUTIONS
- GEOCHEMISTRY

LOCAL HYDROLOGIC SETTING

- FRACTURE FLOW CHARACTERIZATION
- INTRAFLOW AND INTERBED CHARACTERIZATION
- DETAILED BASIN HYDROLOGIC STUDY

BASIC HYDROLOGIC PROPERTIES

POROSITY OF CENTRAL BASALT	.0001 - .10	(LOW IN-SITU MOISTURE)
HYDRAULIC CONDUCTIVITY OF CENTRAL BASALT	10^{-13} -10^{-7} cm/sec	
VERTICAL POTENTIAL GRADIENT	10^{-4} -10^{-1}	(GENERALLY DOWNWARD)
HORIZONTAL POTENTIAL GRADIENT	10^{-5} -10^{-3}	

HYDROLOGY

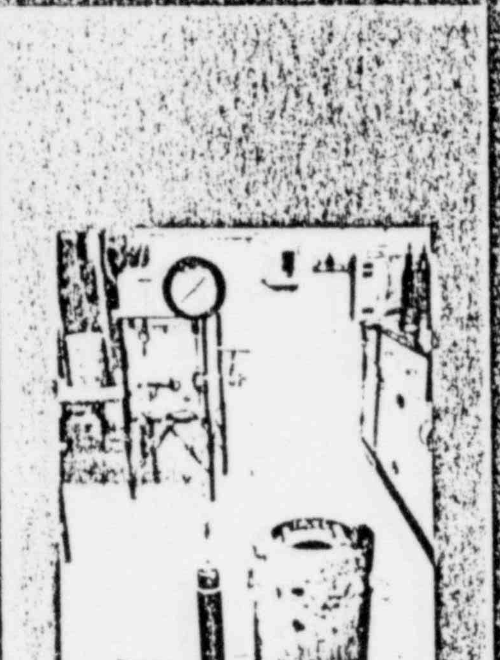
MAJOR ACCOMPLISHMENTS

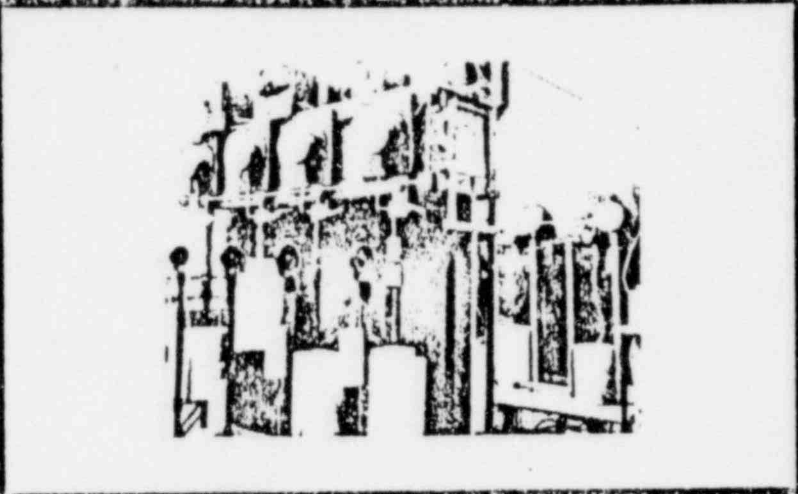
- MODEL DEVELOPMENT WELL UNDERWAY
- MEASUREMENTS OF HYDROLOGIC PROPERTIES HAVE BEEN MADE
- FIELD HYDROLOGIC PROPERTIES OF SELECTED AREAS OF THE COLUMBIA PLATEAU HAVE BEEN DETERMINED
- PRELIMINARY INTEGRATION OF HYDROLOGIC DATA IN THE PASCO BASIN WAS COMPLETED
- MAJOR BIBLIOGRAPHIES WERE ISSUED

HYDROLOGY

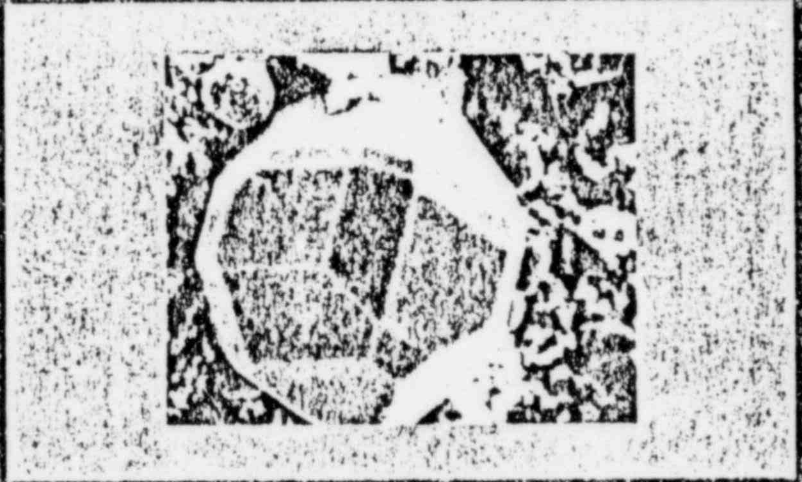
ISSUES REQUIRING RESOLUTION

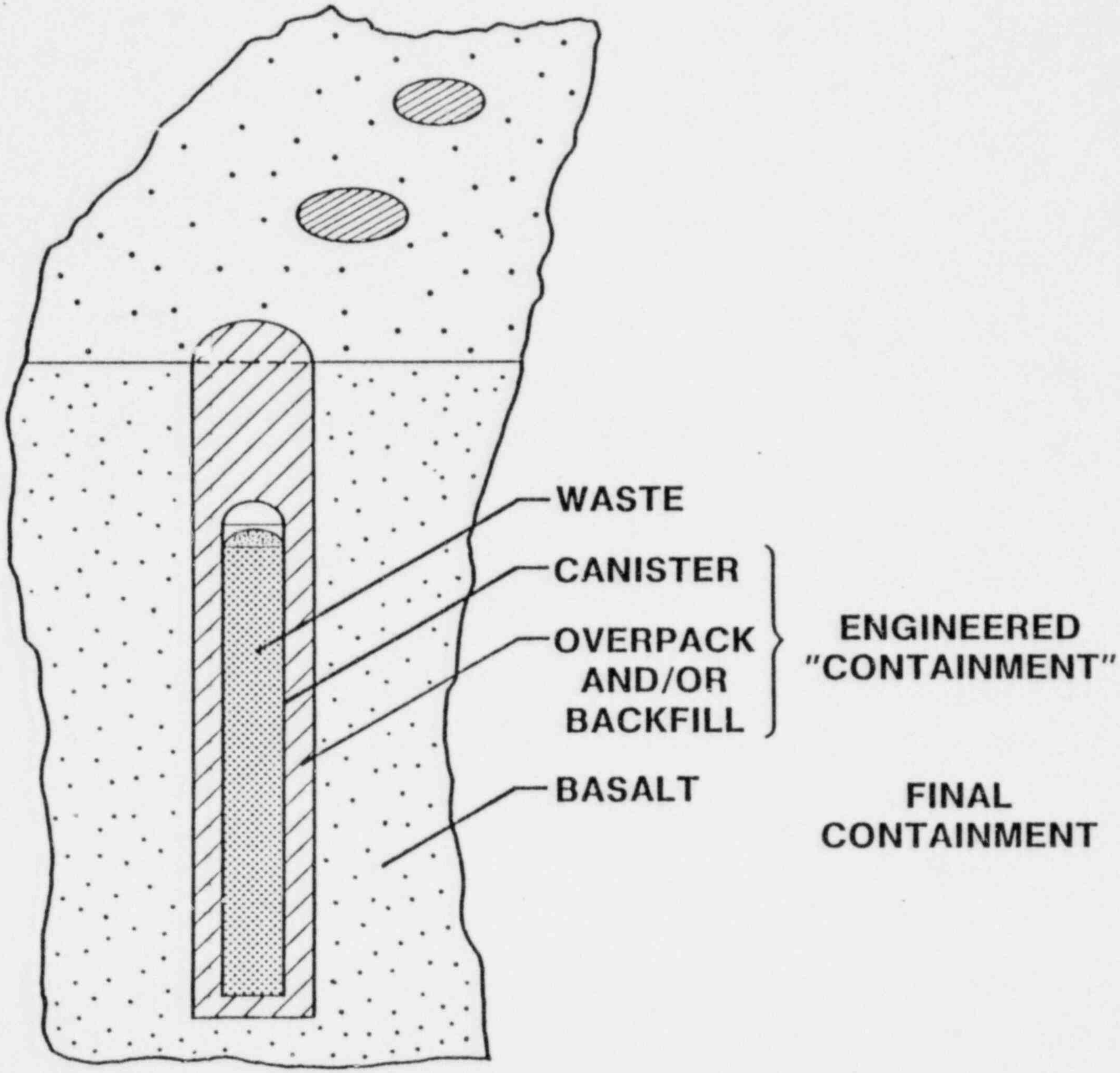
- THE REGIONAL AND LOCAL FLOW SYSTEMS NEED TO BE MODELED
- MORE EXTENSIVE MEASUREMENT OF BASIC HYDROLOGIC PROPERTIES IS REQUIRED ESPECIALLY IN POTENTIAL REPOSITORY AREAS
- THE EXTENT TO WHICH FRACTURE FLOW MODELING IS NEEDED MUST BE DEFINED





Engineered Barriers





WASTE

CANISTER

OVERPACK
AND/OR
BACKFILL

ENGINEERED
"CONTAINMENT"

BASALT

FINAL
CONTAINMENT

ENGINEERED BARRIERS

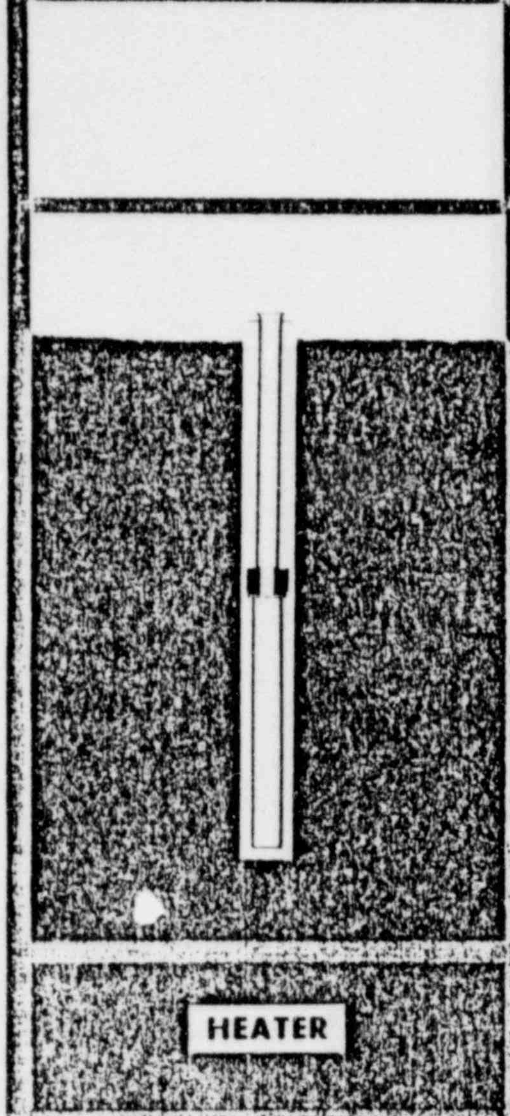
MAJOR ACCOMPLISHMENTS

- HUNDREDS OF WASTE-BASALT INTERACTION EXPERIMENTS PERFORMED. REACTION PRODUCTS IDENTIFIED
- MODELS TO ANALYZE WASTE-BASALT INTERACTIONS WERE DEVELOPED
- ANALYSIS OF TRANSPORT OF RADIOCONTAMINANTS FROM A POSTULATED REPOSITORY ENVIRONMENT WAS INITIATED
- SORPTION RATES OF SOME RADIOCONTAMINANTS WERE MEASURED

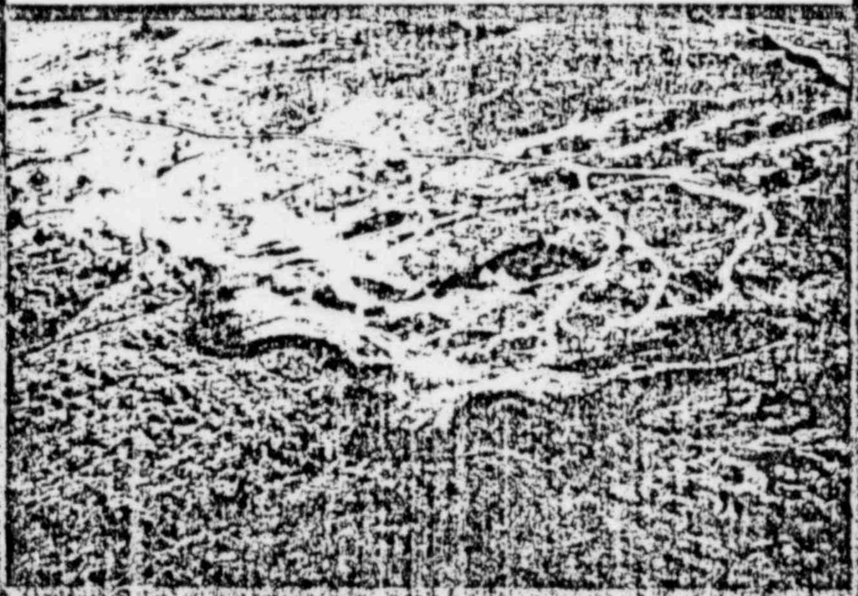
ENGINEERED BARRIERS

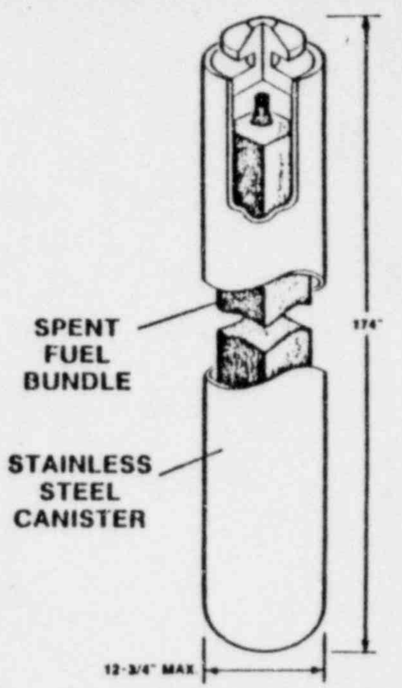
ISSUES REQUIRING RESOLUTION

- EFFECTIVENESS OF EACH BARRIER NEEDS DEFINITION
- REACTION PRODUCTS MUST BE FULLY DEFINED
- TRANSPORT PARAMETERS MUST BE MEASURED
- BOREHOLE PLUGGING DEMONSTRATION IS REQUIRED

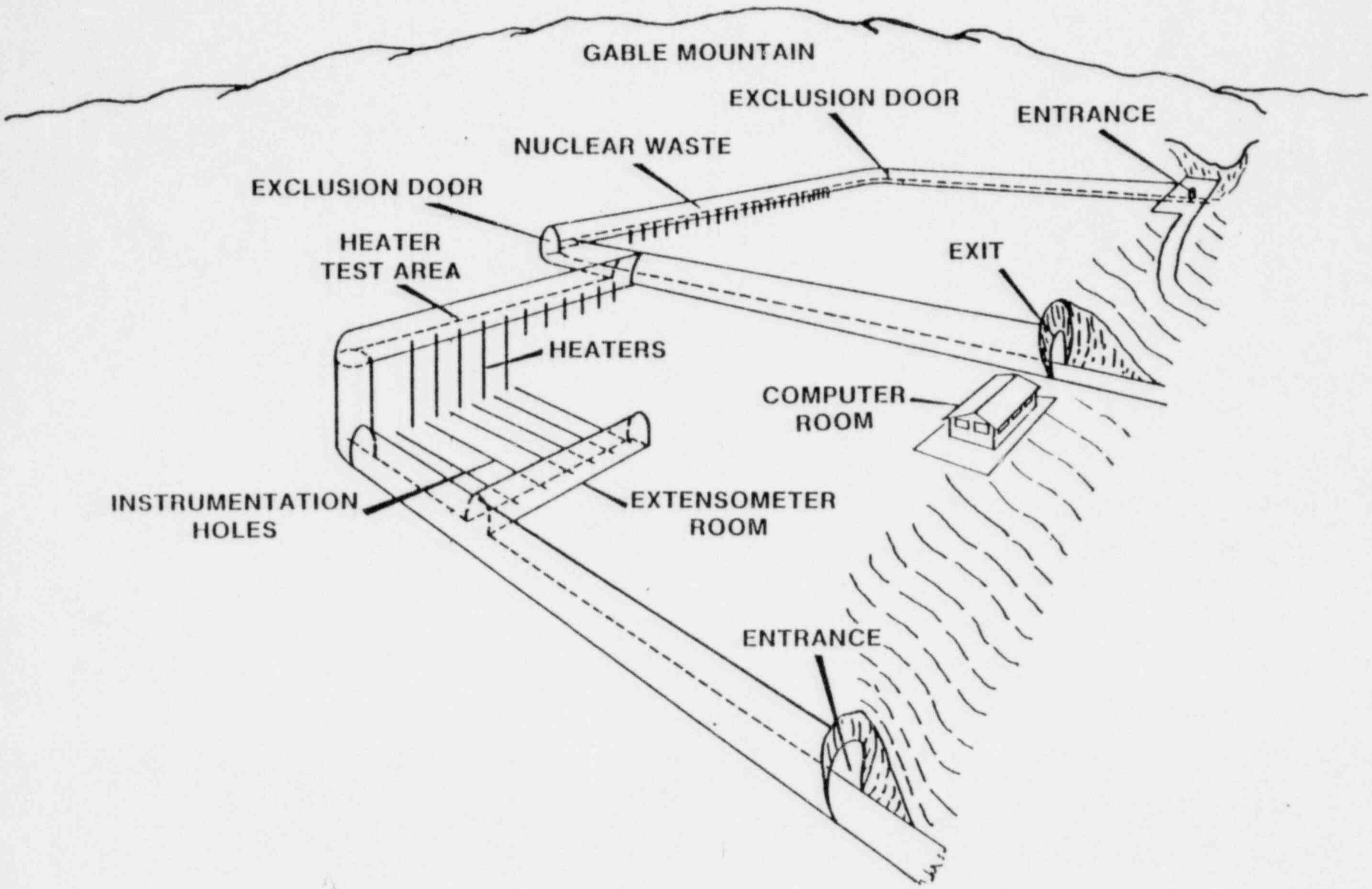


NSTF Design and Construction





NEAR SURFACE TEST FACILITY



OBJECTIVES

NEAR SURFACE TEST FACILITY

- DEVELOP A MULTIPURPOSE FACILITY FOR IN SITU TESTING OF BASALT
- QUALIFICATION OF BASALT AS A REPOSITORY MEDIUM
- BASIS OF DESIGN FOR KEY REPOSITORY ELEMENTS
- DEMONSTRATION OF PLACEMENT, STORAGE AND RETRIEVAL OF WASTE CANISTERS IN AN UNDERGROUND BASALT ENVIRONMENT
- DEMONSTRATION OF WASTE MONITORING CAPABILITY IN AN UNDERGROUND BASALT ENVIRONMENT

NEAR SURFACE TEST FACILITY

STATUS TO DATE

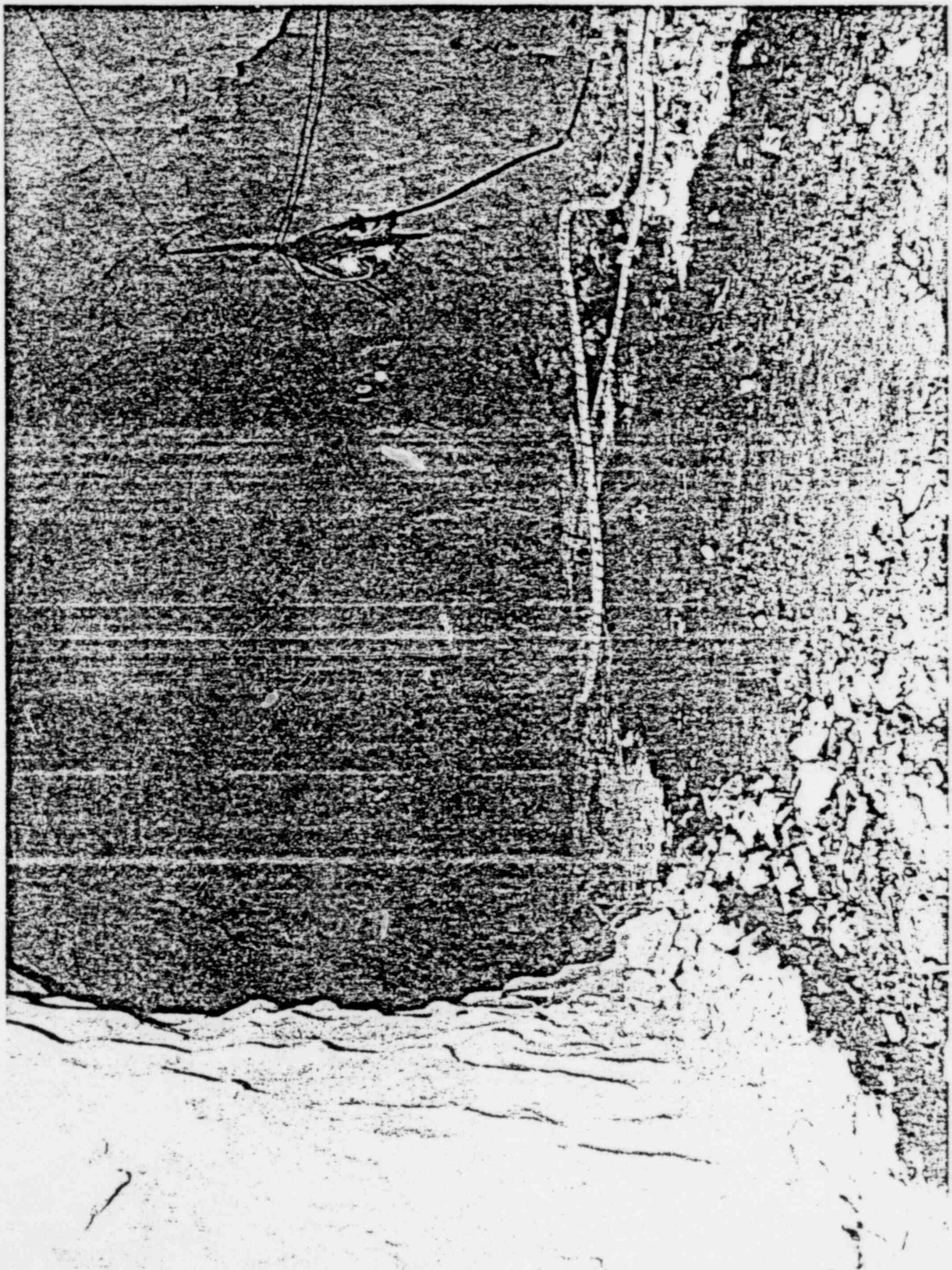
(APRIL 1979)

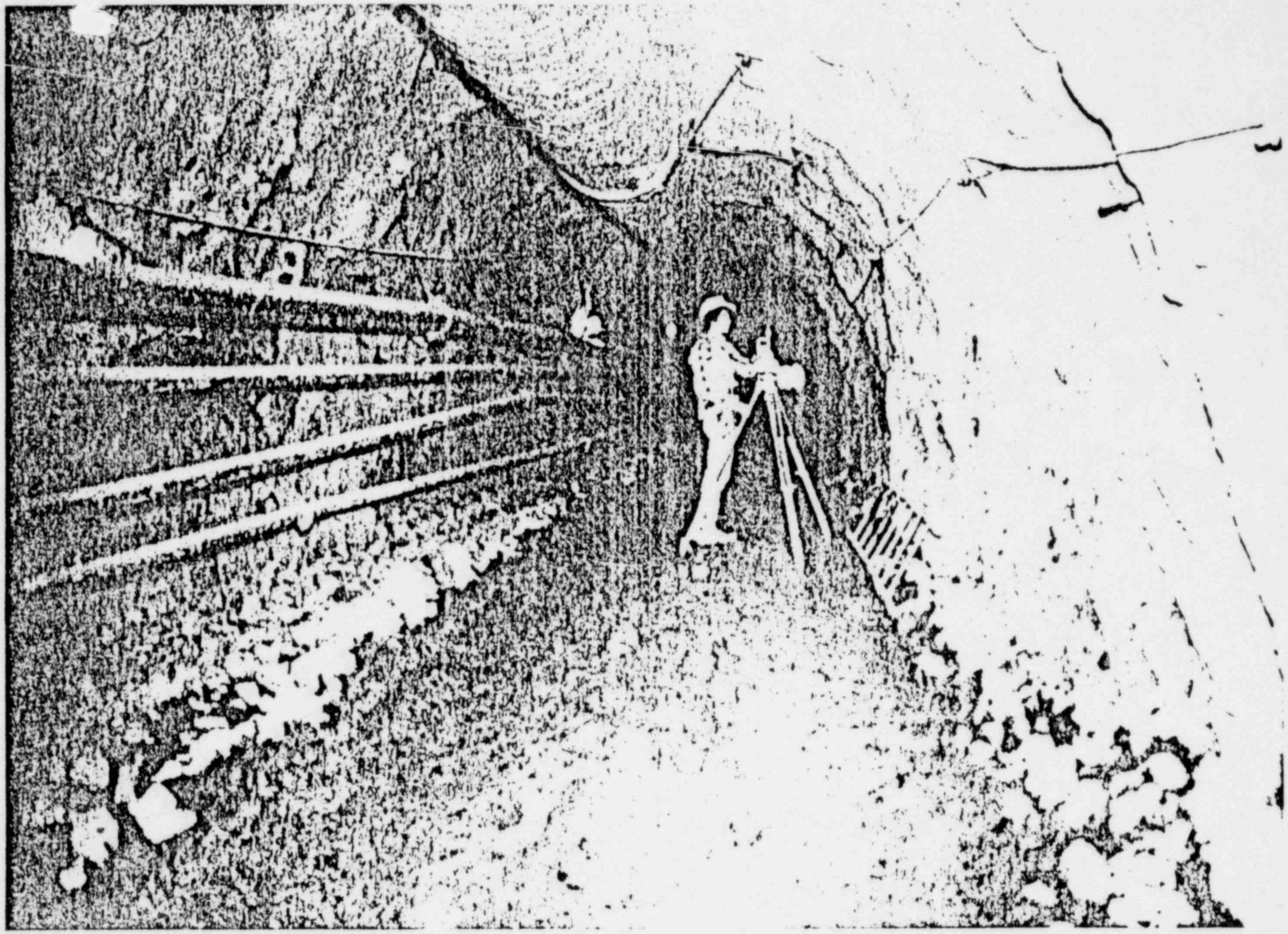
PHASE I

- DESIGN ESSENTIALLY COMPLETE
- TUNNEL CONSTRUCTION 70% COMPLETE
- ALL CONSTRUCTION TO BE COMPLETED BY DEC. 1979.

PHASE II

- CONCEPTUAL DESIGN WELL UNDERWAY
- ALL DESIGN TO BE COMPLETE BY DEC. 1979
- TUNNEL CONSTRUCTION 70% COMPLETE
- ALL CONSTRUCTION TO BE COMPLETED BY DEC. 1980

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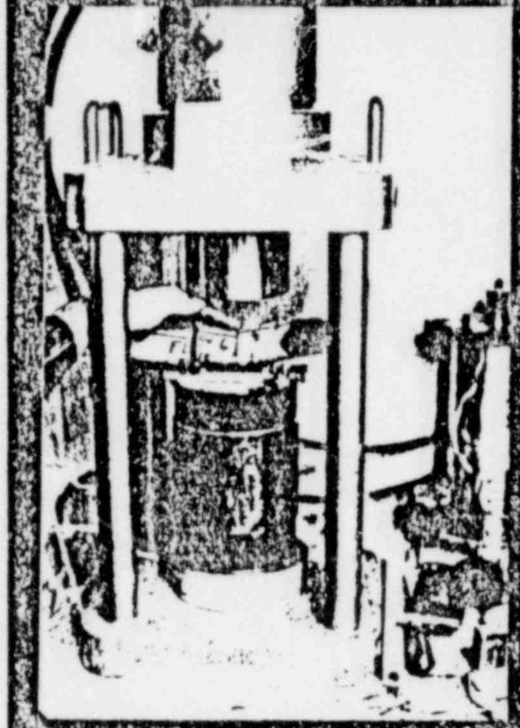
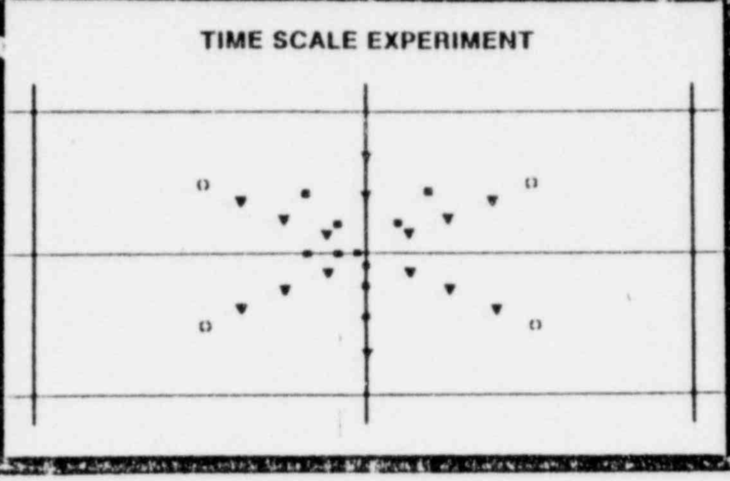
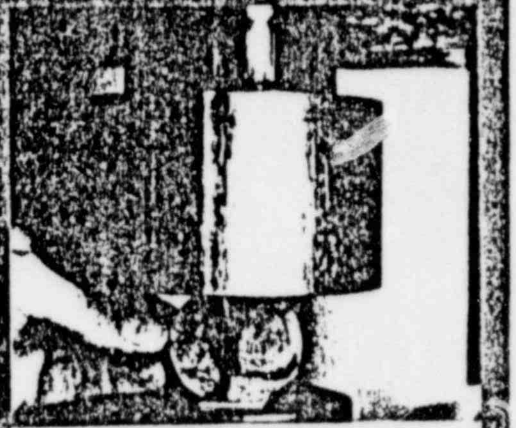
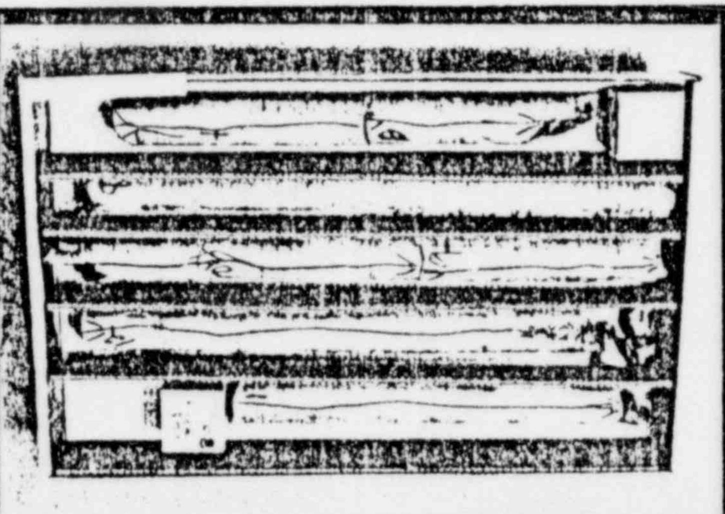
Engineering Testing









BASALT ENGINEERING PROPERTIES

PROPERTY	AVERAGE VALUE		RANGE FOR AVERAGE BASALT
DENSITY	2,820 (176)	Kg/M^3 (LB/FT^3)	2400-3100
TENSILE STRENGTH	20 (3000)	MPa (PSI)	0-23
UNIAXIAL COMPRESSIVE STRENGTH	272 (40,000)	MPa (PSI)	0-400
YOUNG'S MODULUS	68 (10^7)	GPa (PSI)	61-112
POISSON'S RATIO	.25	--	.22-.28
THERMAL CONDUCTIVITY (MEASURED IN THE RANGE OF 0-300°C)	1.37-1.4 (.8-.81)	w/m°k (BTU/HR-FT°F)	1.4-4.3

FULL SCALE HEATER TESTS

- DETERMINE LOCAL TEMPERATURE AND DISPLACEMENT FIELDS AROUND FULL SCALE SIMULATED WASTE CANISTERS
- DETERMINE VALIDITY OF THEORETICAL MODELS

TIME SCALED HEATER TEST

- DETERMINE THE REGIONAL TEMPERATURE AND DISPLACEMENT FIELDS AROUND AN ARRAY OF SIMULATED WASTE CANISTERS
- VALIDATE THEORETICAL MODELS

ENGINEERING TESTING

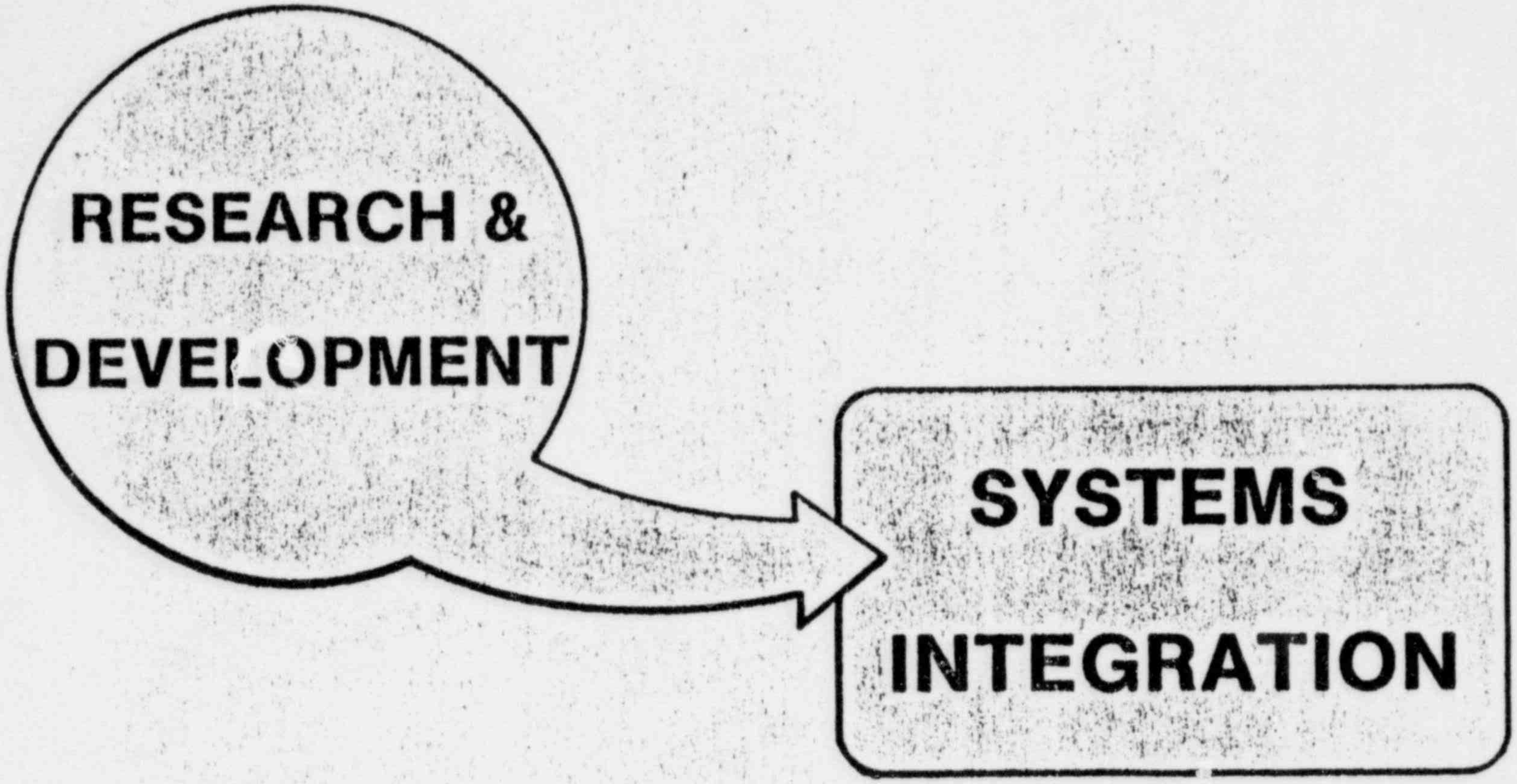
MAJOR ACCOMPLISHMENTS

- PHYSICAL DETERMINATION OF THERMAL AND MECHANICAL PROPERTIES OF HUNDREDS OF BASALT SAMPLES COMPLETED
- DESIGN AND FABRICATION OF TEST ARTICLES AND MONITORING EQUIPMENT FOR HEATER AND SPENT FUEL TEST WELL UNDERWAY

ENGINEERING/TESTING

ISSUES REQUIRING RESOLUTION

- VARIATIONS IN BASALT THERMAL CONDUCTIVITY, THERMAL EXPANSION AND MODULUS OF ELASTICITY AS A RESULT OF WASTE EMPLACEMENT
- CHECK ON THE VALIDITY OF COMPUTER MINE MODELS
- A FULL DEFINITION OF ENGINEERING DESIGN PARAMETERS



RESEARCH &
DEVELOPMENT

SYSTEMS
INTEGRATION

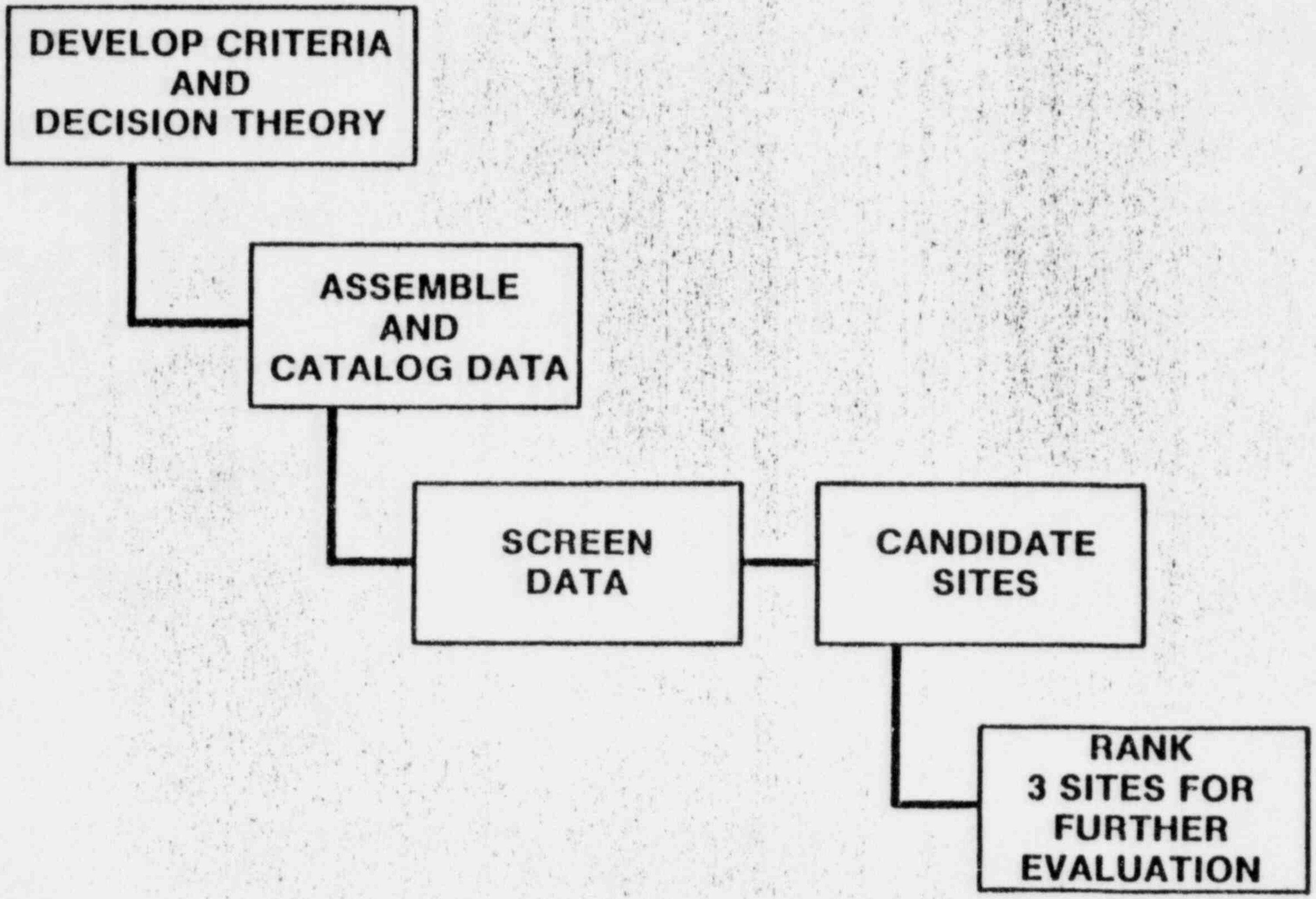
BASALT QUALIFICATION

REPOSITORY SITING

OVERALL FEASIBILITY

LICENSING

SITE SELECTION APPROACH



DEVELOP CRITERIA AND DECISION THEORY

ASSEMBLE AND CATALOG DATA

SCREEN DATA

CANDIDATE SITES

RANK 3 SITES FOR FURTHER EVALUATION

SYSTEMS INTEGRATION

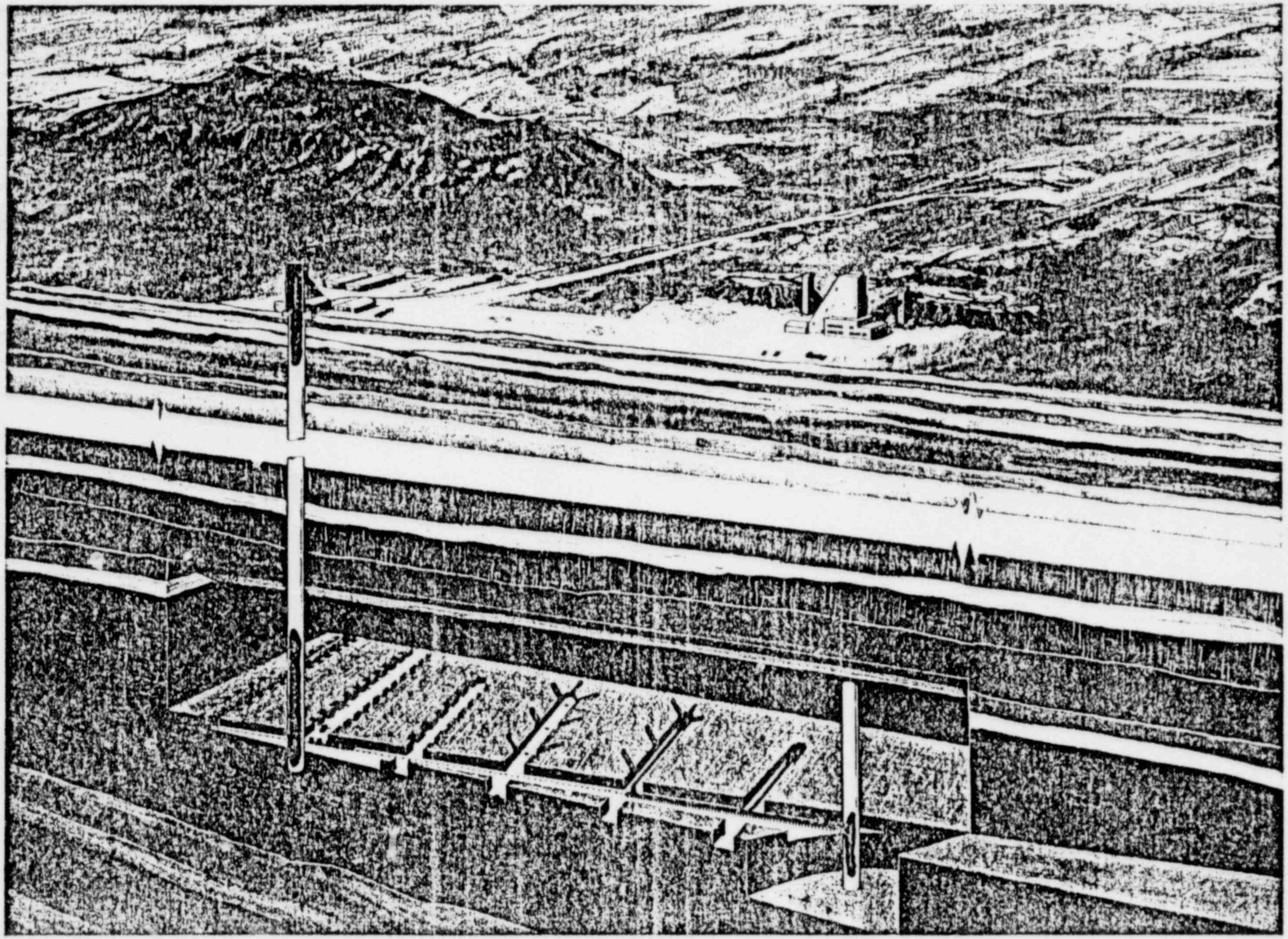
MAJOR ACCOMPLISHMENTS

- PRELIMINARY SITING CRITERIA PROPOSED
- KEY RESEARCH AREAS IDENTIFIED
- FORMAT FOR LICENSING APPLICATION PROPOSED
- FORMAT FOR ENVIRONMENTAL REPORT PROPOSED
- DEMONSTRATION TEST PLANS WRITTEN
- GUIDELINES FOR PRECONCEPTUAL DESIGN PREPARED
- PRELIMINARY REPOSITORY MODELS COMPLETED

SYSTEMS INTEGRATION

ISSUES REQUIRING RESOLUTIONS

- REPOSITORY SITING
- LICENSING
- USE OF SYSTEMS ANALYSIS FOR DATA INTEGRATION
- ANALYSIS OF TEST DATA



WHAT IS THE WIPP ?

- A DEMONSTRATION OF RADIOACTIVE WASTE DISPOSAL IN BEDDED SALT
  (Solid Wastes Mechanically Emplaced in Mined Chambers)

- RADIOACTIVE WASTES ACCOMMODATED :
  - Defense Transuranic – Contact Handling (< 200 mr/hr)
  - Defense Transuranic – Remote Handling (> 200 mr/hr)
  - High Level Waste – For Experiments
  - Spent Fuel (Option) – For Demonstration

- "PILOT PLANT" IMPLIES :
  - Initial Period of Limited Operations
  - Retrievability of all Wastes
  - Decision Required to Commence Full-Scale Disposal Operation

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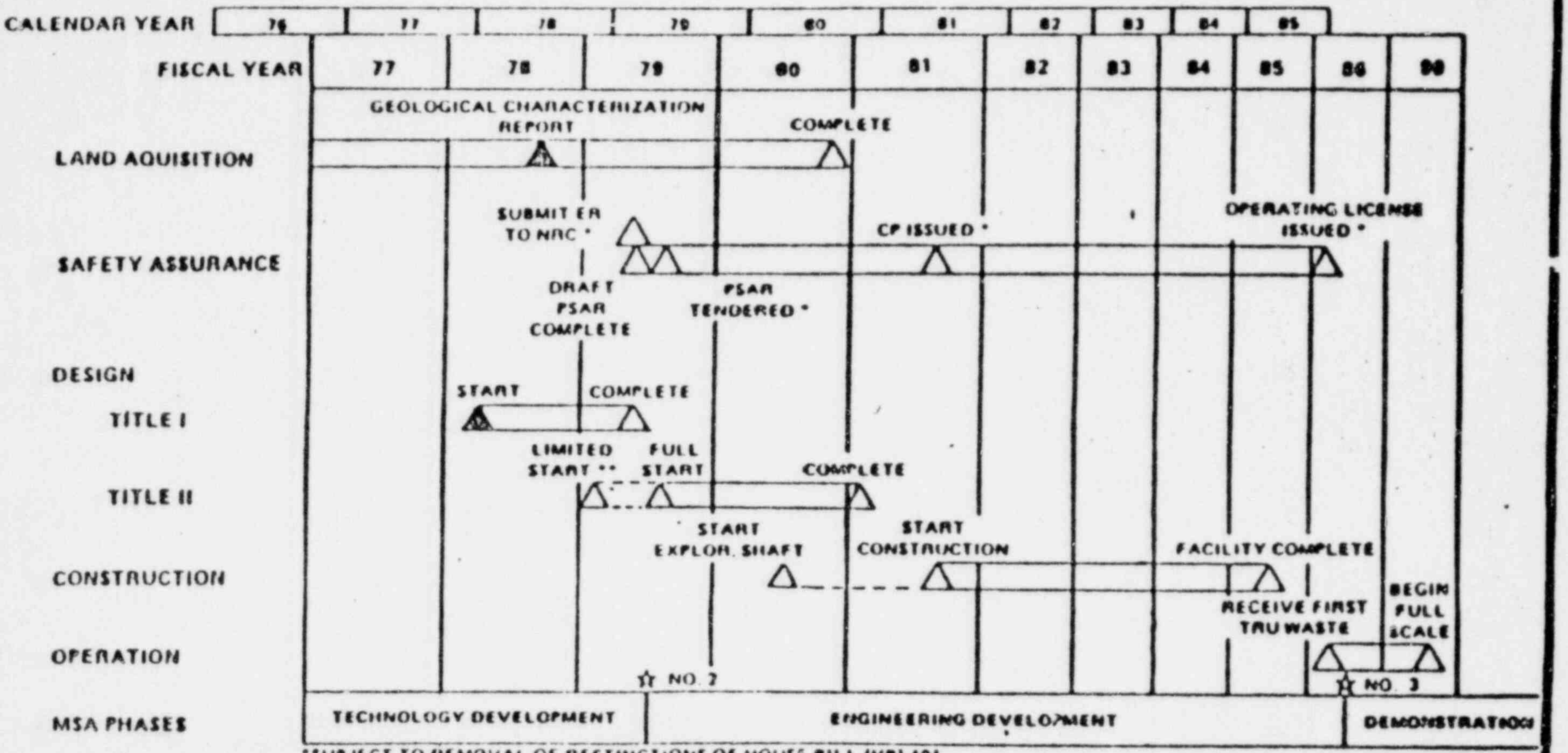
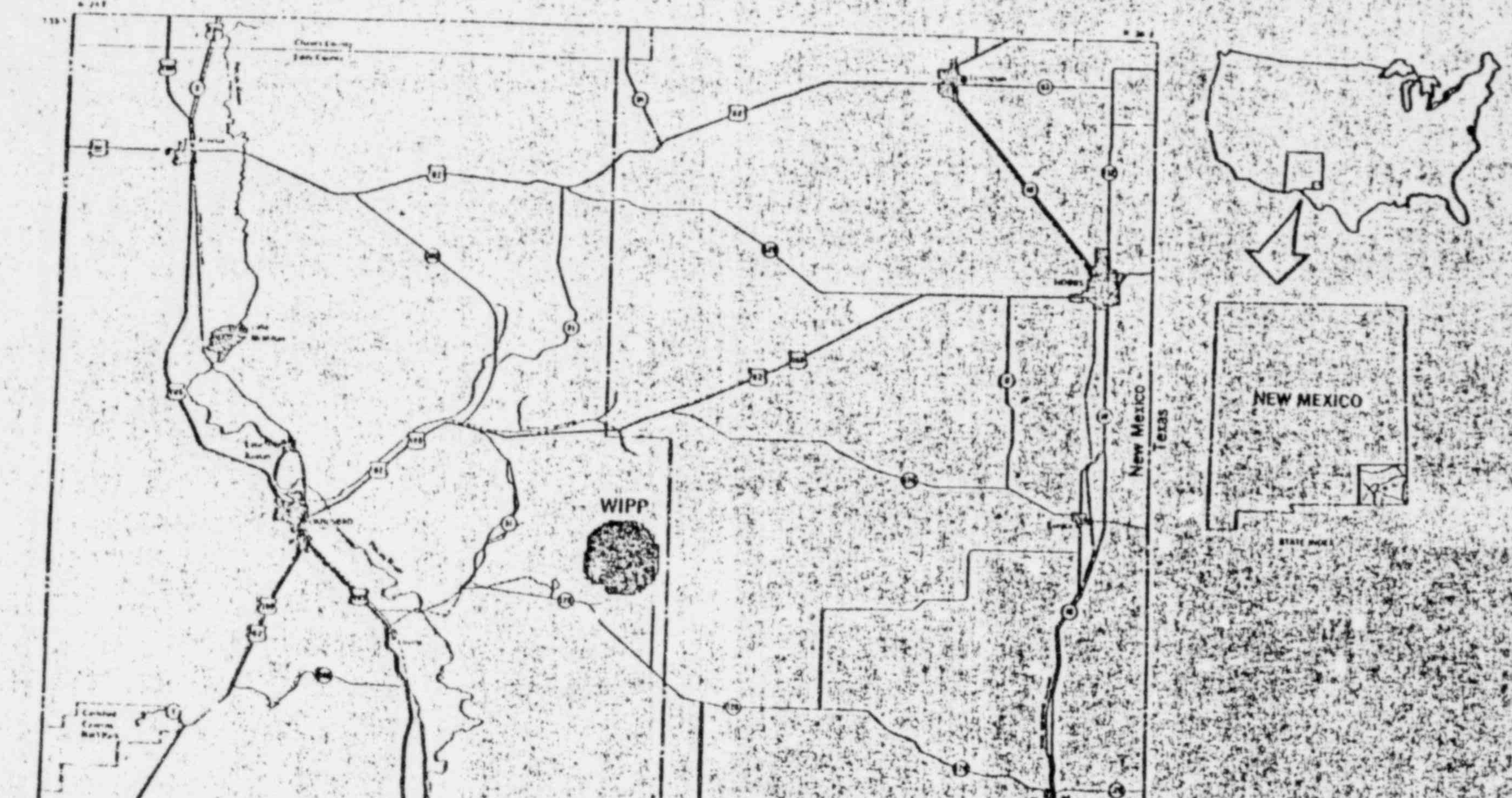
WASTE ISOLATION PILOT PLANT

PROJECT SCHEDULE (SUMMARY)



*SUBJECT TO REMOVAL OF RESTRICTIONS OF HOUSE BILL (HB) 101

**LIMITED TITLE II REQUEST FOR SITE CONFIRMATION SHAFT WORK.



AREA OF W.I.P.P. EVALUATION

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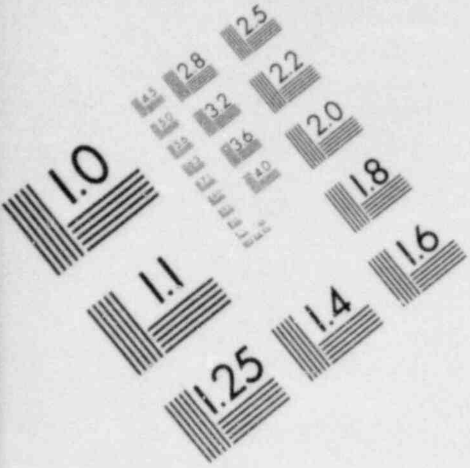


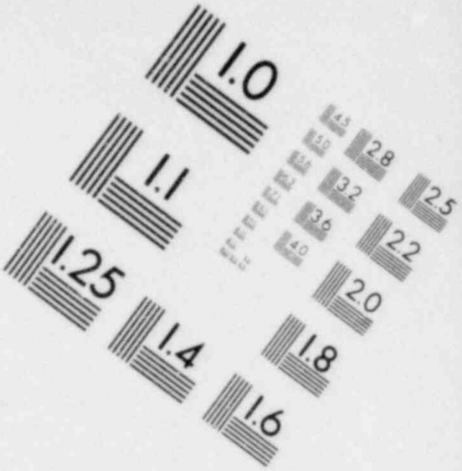
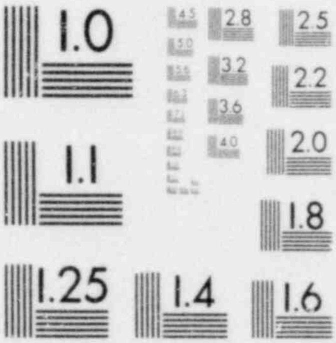
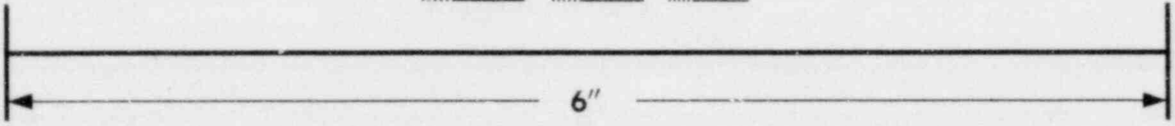
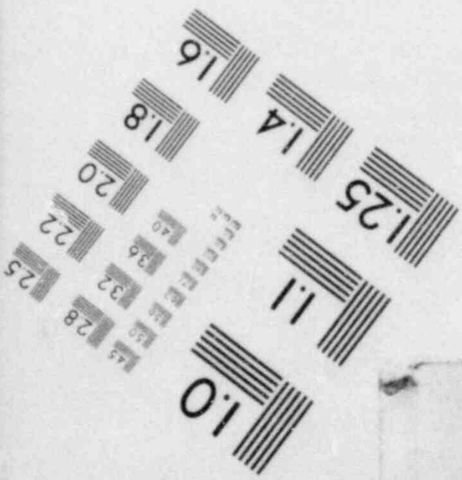


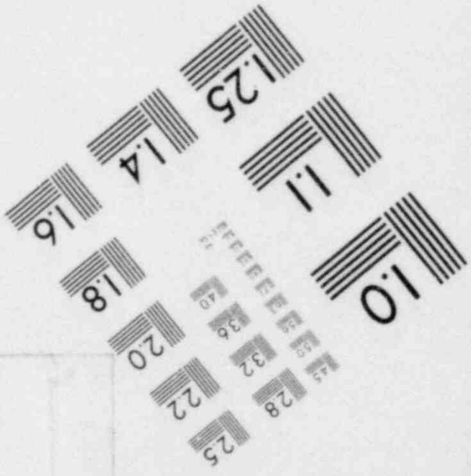
IMAGE EVALUATION
TEST TARGET (MT-3)

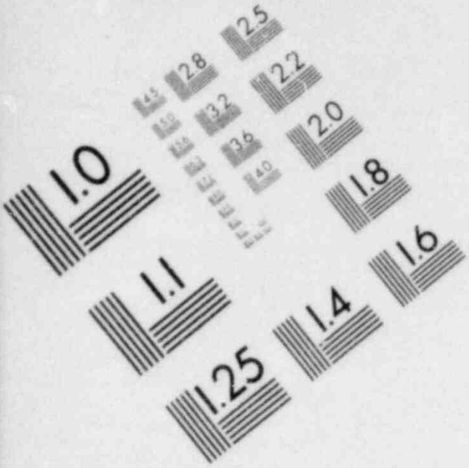




MICROCOPY RESOLUTION TEST CHART







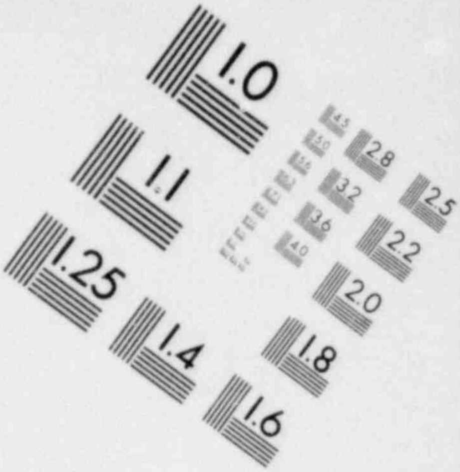
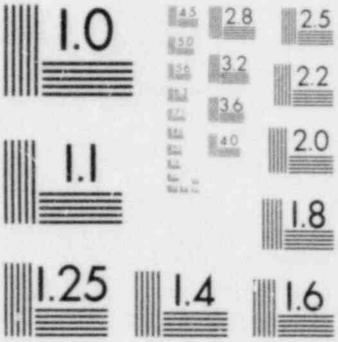
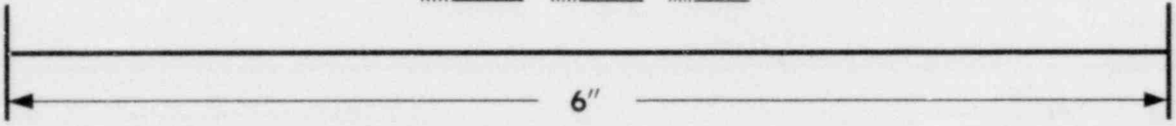
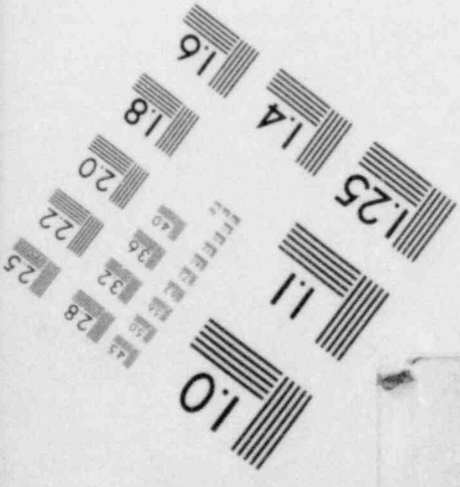


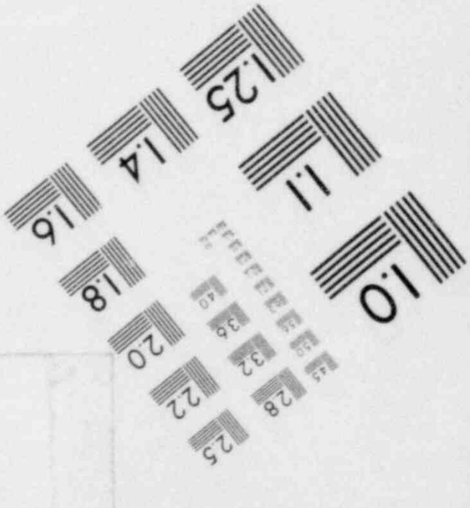
IMAGE EVALUATION
TEST TARGET (MT-3)





MICROCOPY RESOLUTION TEST CHART





WIPP SITE SELECTION CRITERIA

GEOLOGY:	THE GEOLOGY OF THE SITE WILL BE SUCH THAT THE REPOSITORY WILL NOT BE BREACHED BY NATURAL PHENOMENA WHILE THE WASTE IS HAZARDOUS TO MAN. THE GEOLOGY MUST PERMIT SAFE ROOM AND PILLAR EXCAVATION.
HYDROLOGY:	THE HYDROLOGY OF THE SITE MUST PROVIDE A HIGH CONFIDENCE THAT NATURAL DISSOLUTIONING WILL NOT BREACH THE SITE WHILE THE WASTE IS HAZARDOUS TO MAN AND ACCIDENTAL PENETRATIONS WILL NOT RESULT IN UNACCEPTABLE HAZARDS TO MAN.
TECTONIC STABILITY:	NATURAL TECTONIC PROCESSES MUST NOT BREACH THE SITE WHILE WASTES ARE HAZARDOUS TO MAN AND MUST NOT REQUIRE EXTREME OPERATIONAL PRECAUTIONS.
PHYSIO-CHEMICAL COMPATIBILITY:	THE REPOSITORY MEDIA MUST NOT INTERACT WITH THE WASTE IN WAYS WHICH CREATE UNACCEPTABLE OPERATIONAL OR LONG-TERM HAZARDS.
ECONOMIC/SOCIAL COMPATIBILITY:	THE SITE MUST BE OPERABLE AT REASONABLE ECONOMIC COST AND SHOULD NOT CREATE UNACCEPTABLE IMPACT ON NATURAL RESOURCES OR THE ENVIRONMENT.

SITE EVALUATION FACTORS

GEOLOGY

TOPOGRAPHY
DEPTH
THICKNESS
LATERAL EXTENT

LITHOLOGY
STRUCTURE
EROSION
NATURAL RESOURCES

HYDROLOGY

SURFACE WATER
AQUIFERS
HYDROLOGIC TRANSPORT

DISSOLUTION
CLIMATIC FLUCTUATIONS
PENETRATIONS BY MAN

TECTONIC STABILITY

SEISMIC ACTIVITY
FAULTING/FRACTURING
SALT FLOW/ANTICLINES
DIAPIRISM

SUBSIDENCE
REGIONAL STABILITY
IGNEOUS ACTIVITY
GEOTHERMAL GRADIENT

GEOLOGIC SITE EVALUATION PROGRAMS

GEOPHYSICS

- SEISMIC REFLECTION - SUBSURFACE STRUCTURE
- ELECTRICAL RESISTIVITY - SOLUTION FEATURES
- MAGNETICS - AERO & SURFACE - STRUCTURE & INTRUSIONS
- GRAVITY - MAJOR STRUCTURE
- HEAT FLOW - TECTONICS
- SEISMIC MONITORING - LOCAL/REGIONAL STABILITY

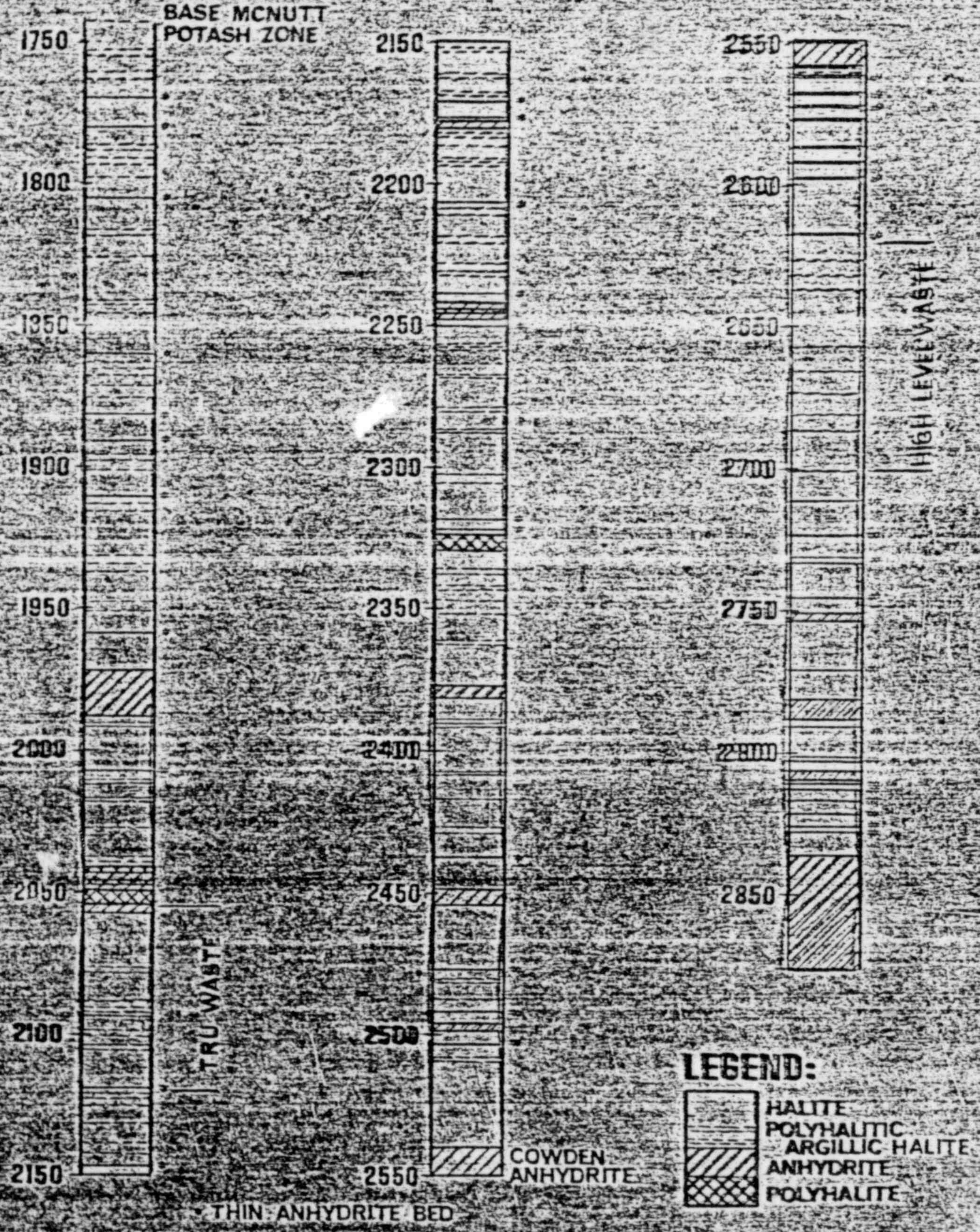
GEOLOGY

- ERTS IMAGERY
- SURFACE MAPPING - STRUCTURE/EVENT DATING/CLIMATOLOGICAL/GROUND TRUTH
- BOREHOLE INVESTIGATIONS - CONFIRMATORY, PHYSICAL PROPERTIES, LOGS & DSTs
- PHYSICAL AND CHEMICAL PROPERTIES - BULK PROPERTIES
- GEOCHEMISTRY - ISOTOPE ANALYSES, FLUID INCLUSIONS, ION EXCHANGE
- RESOURCE ASSESSMENT

HYDROLOGY

- SURFACE - SOIL SAMPLING
- SHALLOW - BOREHOLE TESTING
- DEEP - BOREHOLE TESTING
- HYDROLOGIC MODEL
- HYDROLOGIC TRANSPORT
- DISSOLUTION FEATURES
- SUBSIDENCE STUDIES

ERDA #9 GENERALIZED LITHOLOGIC COLUMN

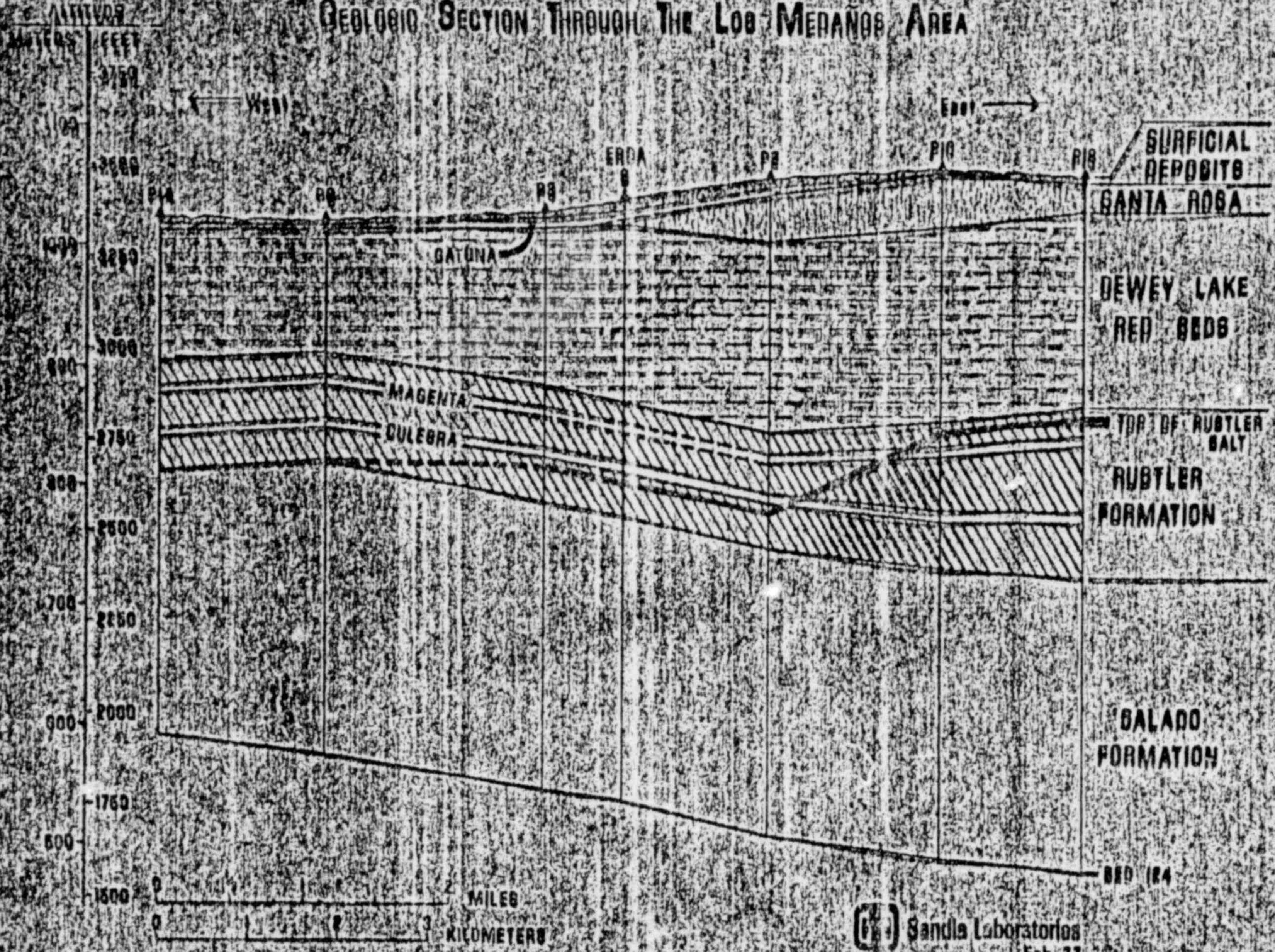


8.3 II
11.47

SITE SELECTION ISSUES

- HYDROLOGY AND DISSOLUTIONING FEATURES
- SALT STABILITY AND FLOW STRUCTURES
- NATURAL RESOURCES

Geologic Section Through The Los Medaños Area



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Feb. 77

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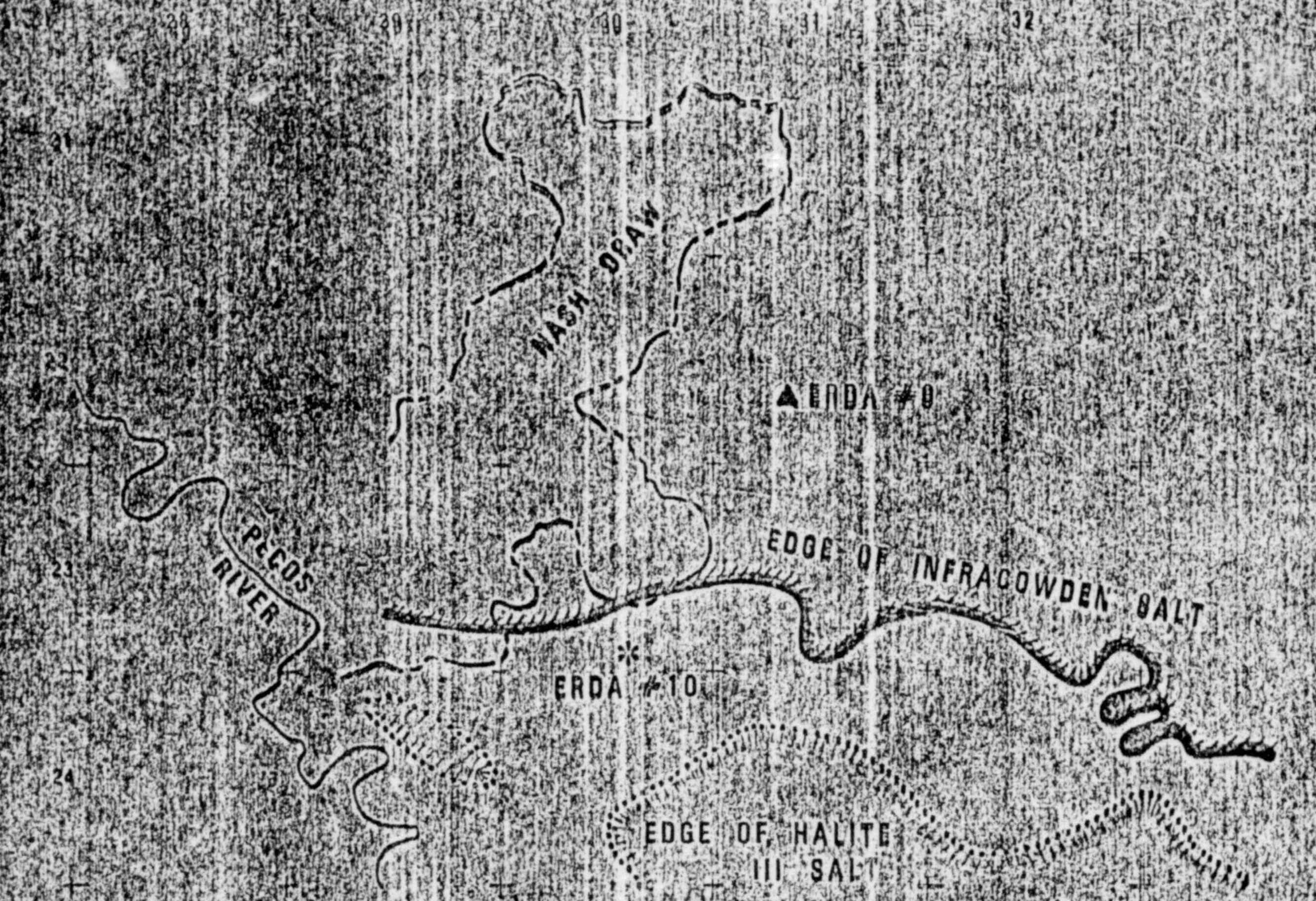
II.D.10

DEEP SALT SOLUTION STUDY



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SEPT. 20, 1977

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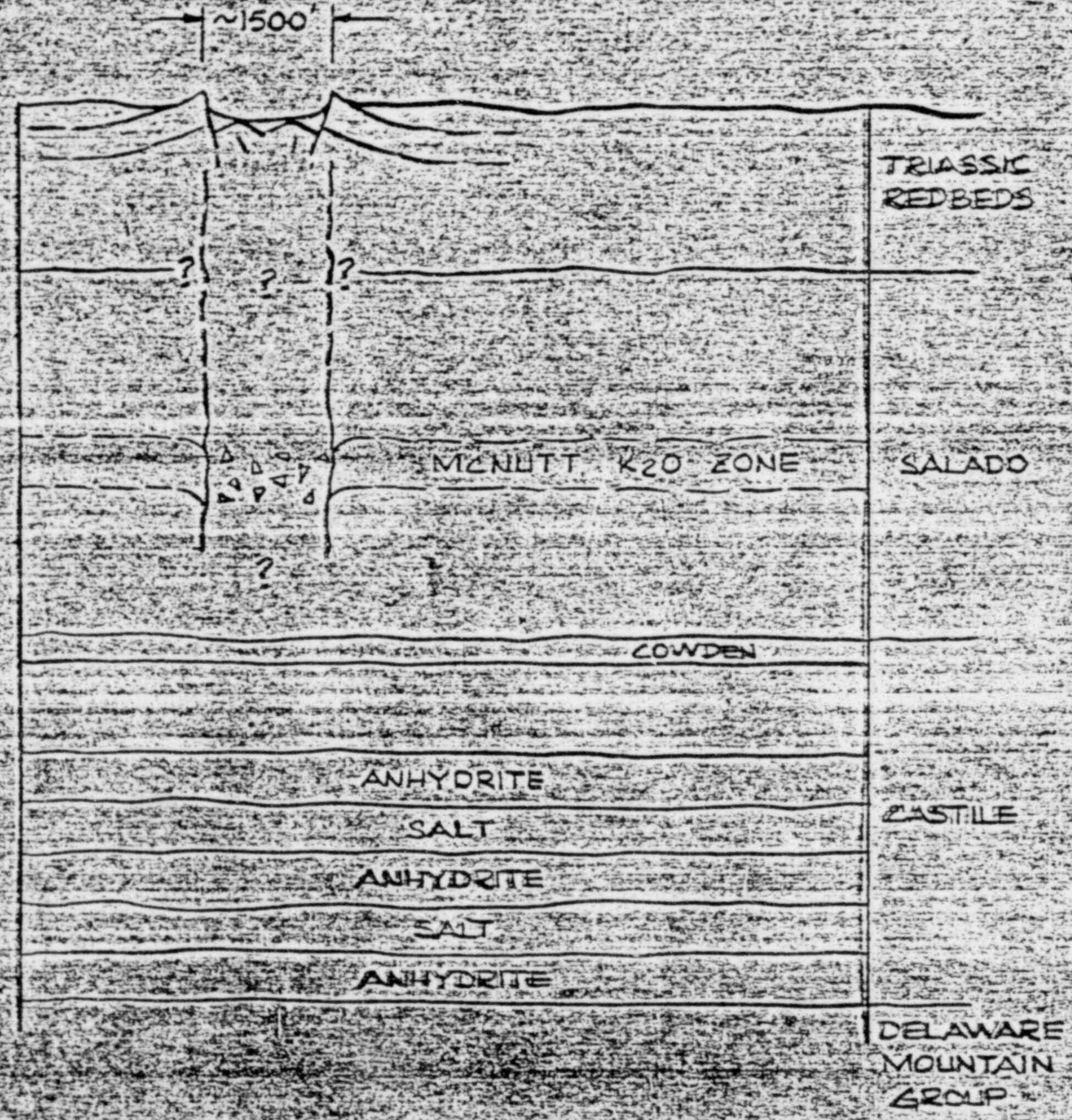
OCT. 20, 1976

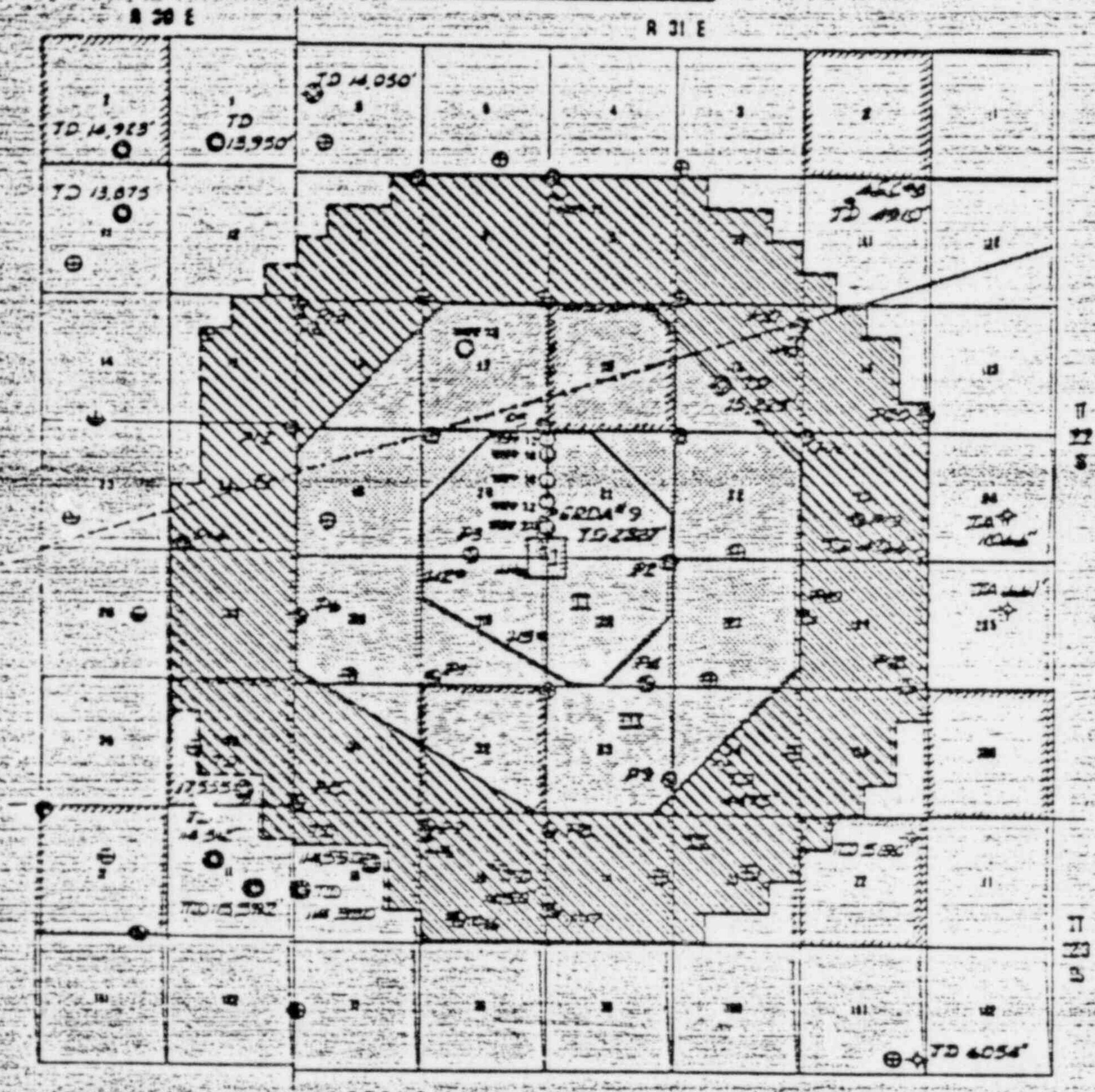


CURRENT DATA ON BRECCIA PIPES

II.D.23
C4/1

WIPP DRILL-HOLE STATUS

MARCH 1979



ZONE	AREA
I	553 acres
II	17,880 ″
III	9,230 ″
IV	10,312 ″
TOTAL	18,960 acres

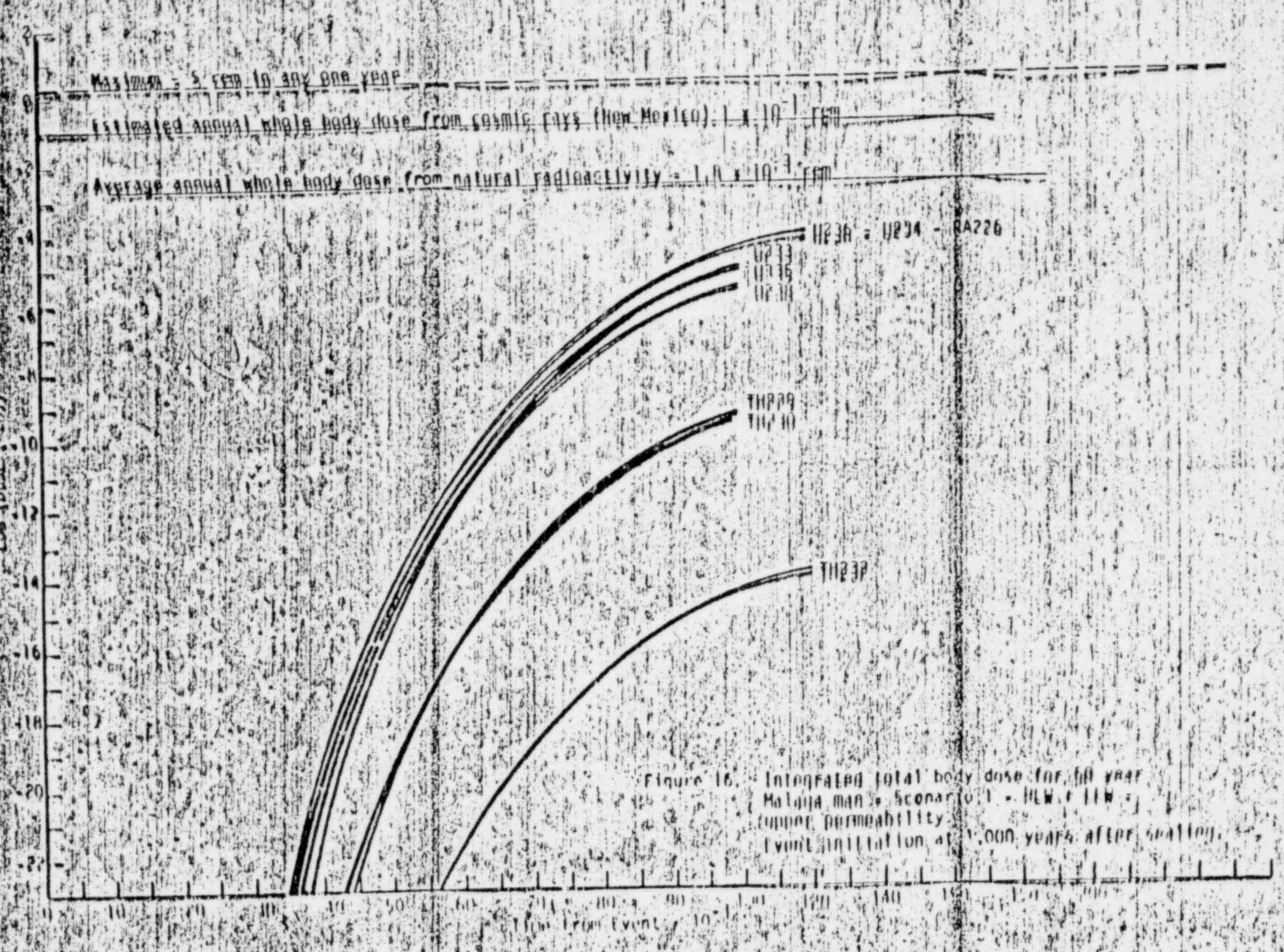
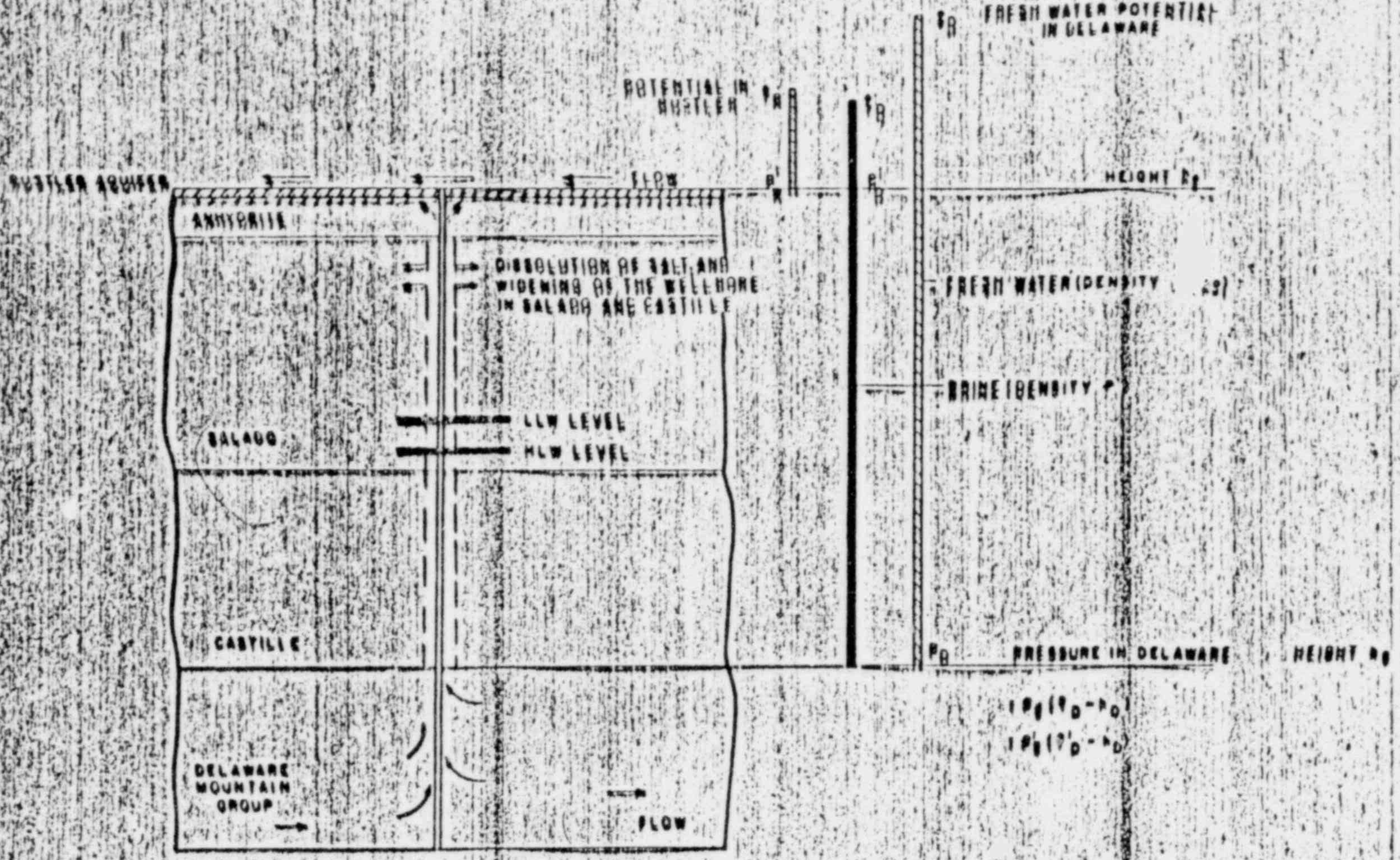


Figure 16. Integrated total body dose for 50 year Malaga man, Scenario 1 - HLW, LLW, upper permeability. Event initiation at 1,000 years after sealing.



PRESSURE IN RUSTLER : $\rho_0 (\phi_R - h_R)$

PRESSURE GRADIENT BETWEEN THE TWO AQUIFERS AT h_R : $P'_D - P_R$

SCHEMATIC REPRESENTATION OF SCENARIO 1

FY79 SITE EVALUATION PROGRAMS

I. CHARACTERIZE THE GROUND WATER SYSTEM

II. EVALUATE DISSOLUTIONING PROCESSES

III. EVALUATE GEOCHEMICAL STABILITY

IV. EVALUATE STRUCTURAL STABILITY

V. DETERMINE CLIMATIC PAST

EXPERIMENTAL PROGRAM - MAJOR ISSUES

- THERMAL EFFECTS
  - SALT STABILITY
  - BRINE/WASTE MIGRATION
- WASTE-ROCK INTERACTION
  - TRU WASTE GAS GENERATION
  - RADIONUCLIDE SORPTION
  - RETRIEVAL ISSUES
- ROCK MECHANICS

EXPERIMENTAL PROGRAM AREAS

I. TRU/CONTAINER INTERACTION AND CHARACTERIZATION

II. HLW/CONTAINER INTERACTION AND CHARACTERIZATION

III. THERMAL/STRUCTURAL INTERACTION

IV. NUCLIDE MIGRATION

V. SALT PERMEABILITY

VI. BRINE MIGRATION

VII. HOLE PLUGGING

VIII. OPERATION AND DESIGN INVESTIGATIONS

IX. INSTRUMENTATION DEVELOPMENT

TRU WASTE CHARACTERIZATION PROGRAMS

WASTE DEGRADATION MECHANISMS
- RADIOLYTIC - LASL, SRL
- THERMAL/CATALYZED PYROLYSIS - LASL, SRL
- CHEMICAL/CORROSION - SLA
- BACTERIAL - UNM, LASL, SCRIPPS

WASTE DEGRADATION PRODUCTS
- GASES (H_2, CO, CO_2, CH_4 . . .)
- WATER VAPOR, LEACHANT
- ORGANIC BYPRODUCTS, CHELATES

LEACHING STUDIES - SLA

CORROSION STUDIES - SLA

COMBUSTIBILITY

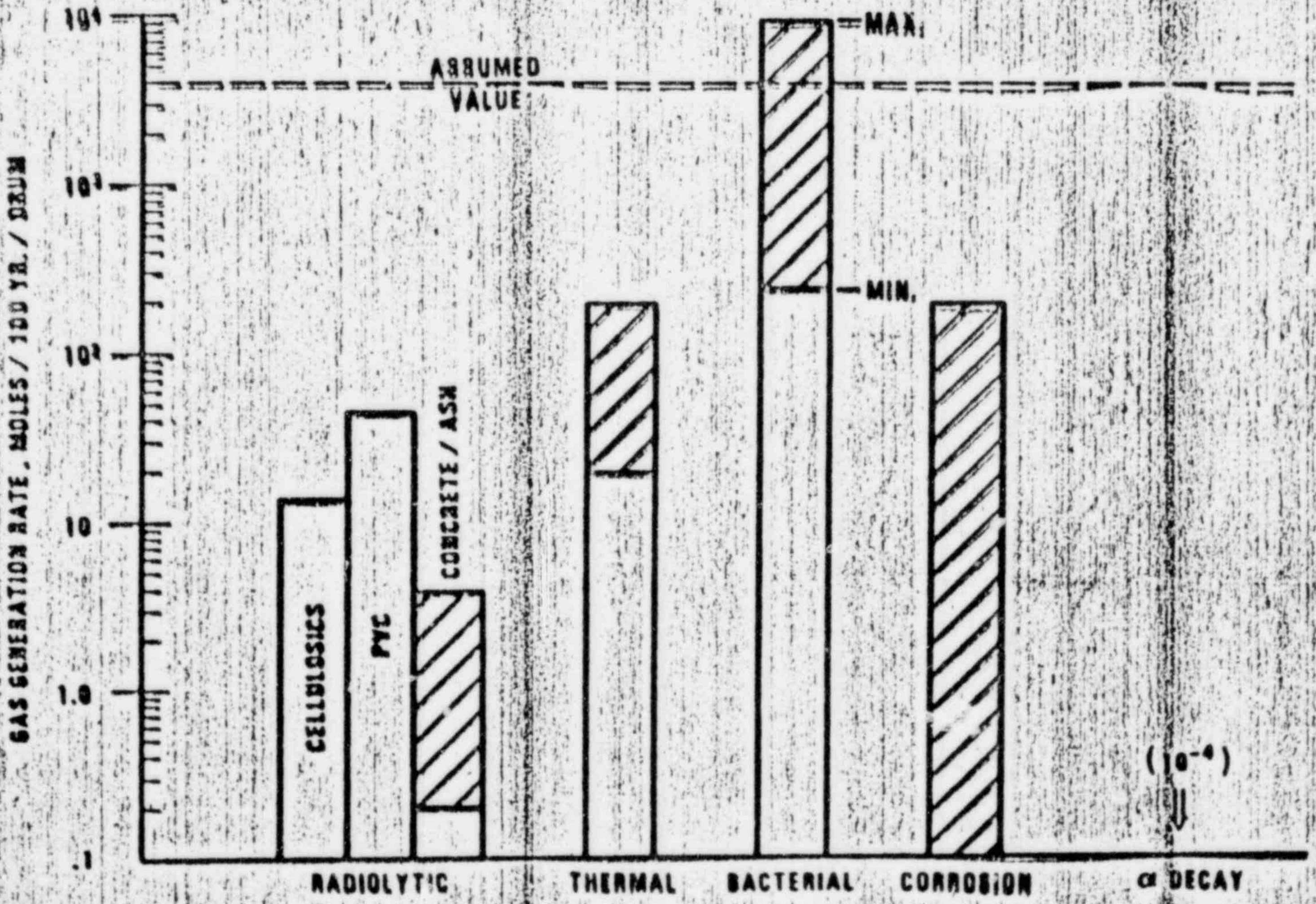
CRITICALITY

RELATED PROGRAM AREAS

THERMAL/STRUCTURAL INTERACTION

PERMEABILITY

NUCLIDE MIGRATION

GAS GENERATION RATE, MOLES / 100 YR. / DRUM
10^4
10^3
10^2
10
1.0
.1
ASSUMED VALUE
MAX.
MIN.
CELLULOSICS
PVC
CONCRETE / ASH
(10^{-4})
RADIOLYTIC
THERMAL
BACTERIAL
CORROSION
α DECAY

PERMEABILITY: PRINCIPAL ACTIVITIES

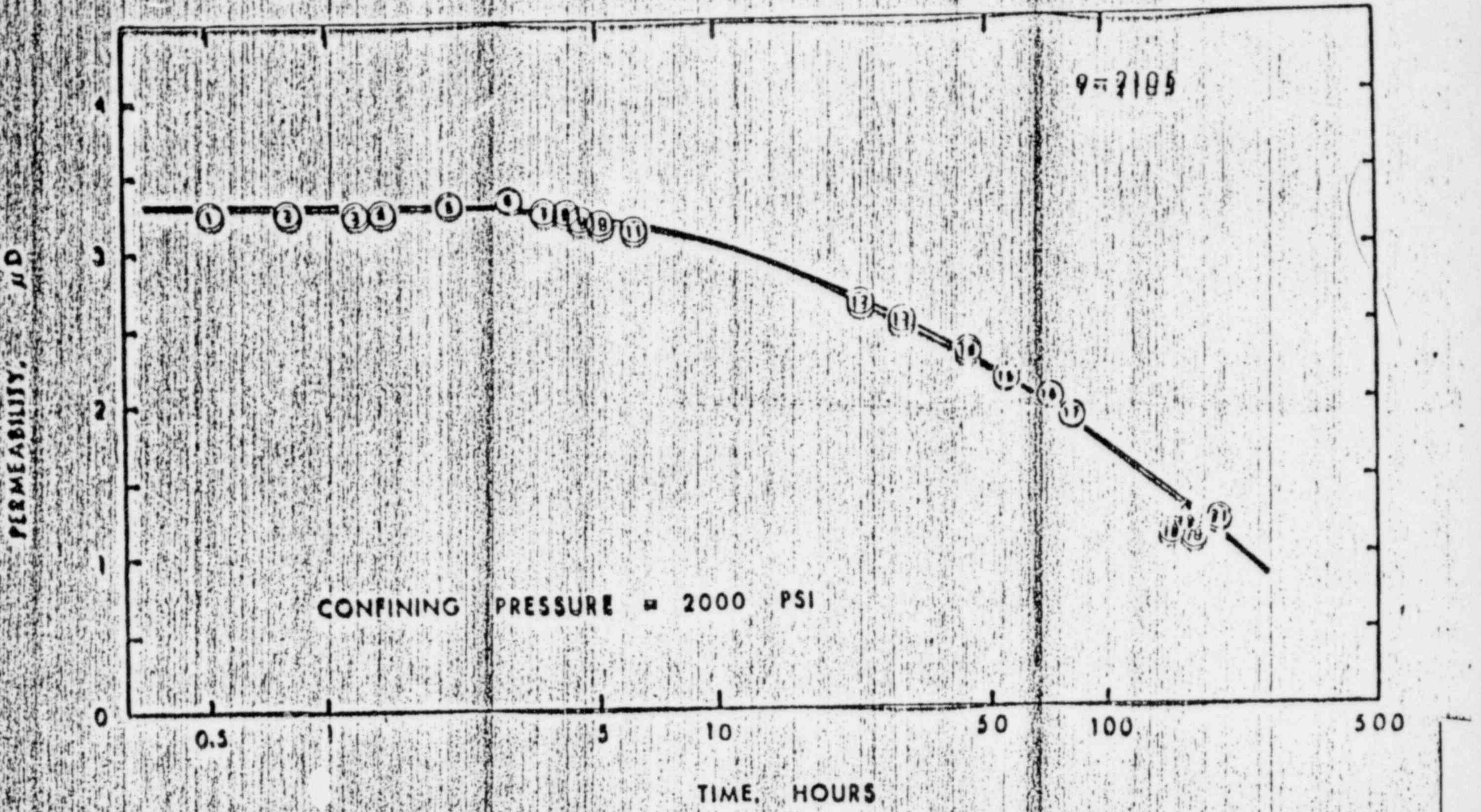
LABORATORY MEASUREMENTS

- SPECIMEN HEALING
- ARGON, HYDROGEN, AND NITROGEN MEASUREMENTS
- DIFFERENTIAL STRESS (DILATENCY) MEASUREMENTS
- INTERFACES (SLA, TERRA TEK)

MODELING

- LABORATORY MEASUREMENTS AS FUNCTION OF P,T
- REPOSITORY INTEGRITY
  - COMPACTION OF BACKFILL
  - HOLE PLUGGING
  - FRACTURING
- INTERFACES (OWI +)

IN-SITU EXPERIMENTS

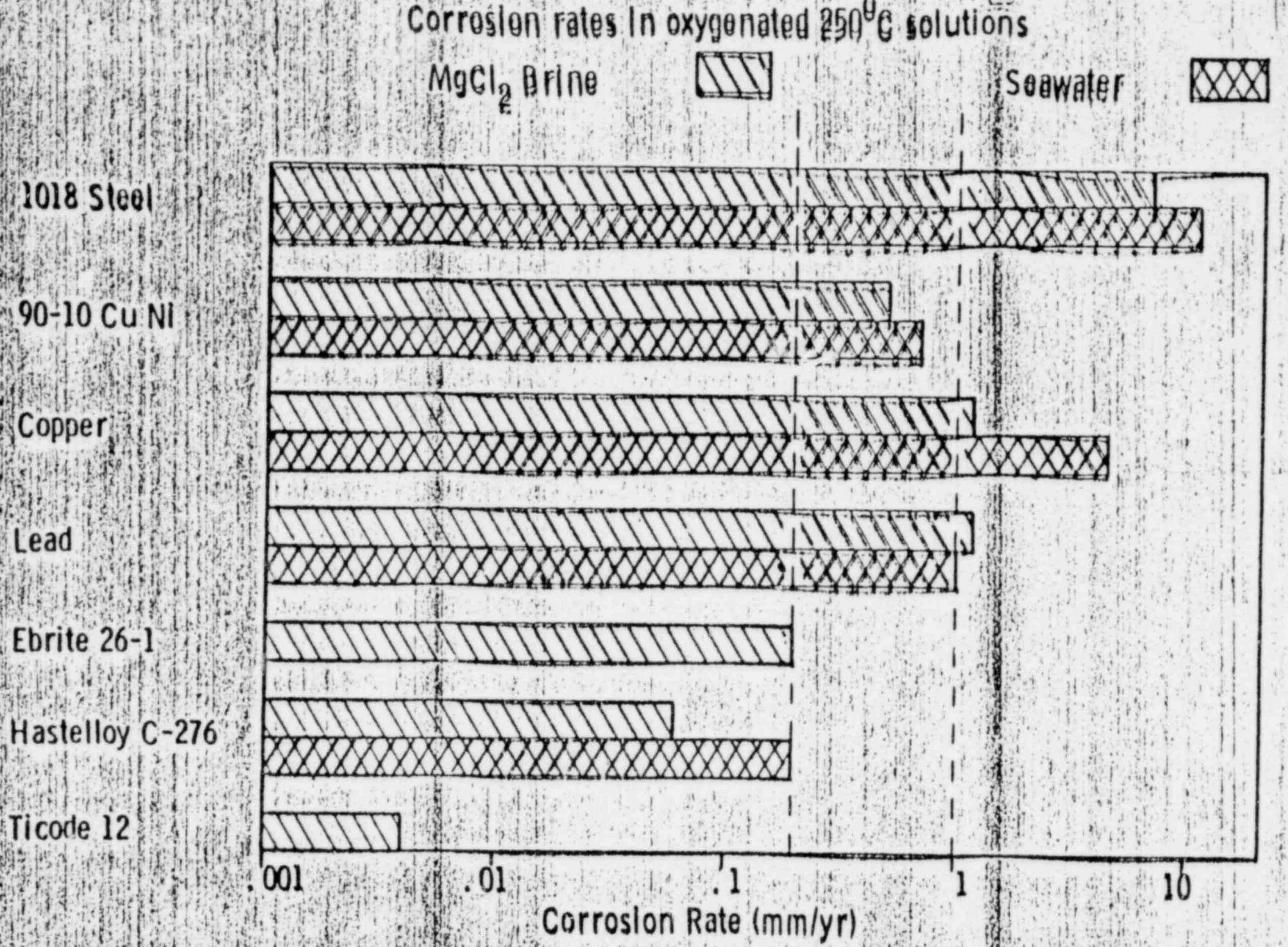

PERMEABILITY, μD
0
1
2
3
4
TIME, HOURS
0.5
1
5
10
50
100
500
CONFINING PRESSURE = 2000 PSI
9-2105
1
2
3
4
5
6
8
11
12
13
14
15
16
17
21

HLW WASTE INTERACTIONS

- HLW BRINE LEACHING
- DRY AND MOIST SALT INTERACTIONS
- METALLURGY – CORROSION TESTS
  - OVERPACKS AND ANTICORROSION COATINGS
- STORED ENERGY STUDY

RELATED PROGRAM AREAS

- THERMAL/STRUCTURAL INTERACTIONS
- NUCLIDE MIGRATION
- BRINE MIGRATION



Corrosion rates in oxygenated 250°C solutions

Table 3

Leaching Data For Zinc Borosilicate Glass Waste Forms

	95°C Leach ($\mu g/cm^2$ day)		Ambient Leach ($\mu g/cm^2$ day)
Element	**SLA**(1)	**BNW**(2)	**BNW**(3)
Cs	1.6	0.27	0.038
Sr	0.69	0.29	0.033
Mo	1.04	0.58	---
Eu	0.015	0.003	1×10^{-4}
La	0.02	0.046	---
Am	—	—	8.8×10^{-4}
Cm	—	—	9.6×10^{-7}
Pu	—	—	7×10^{-3}
Total Weight Loss	88	44	---

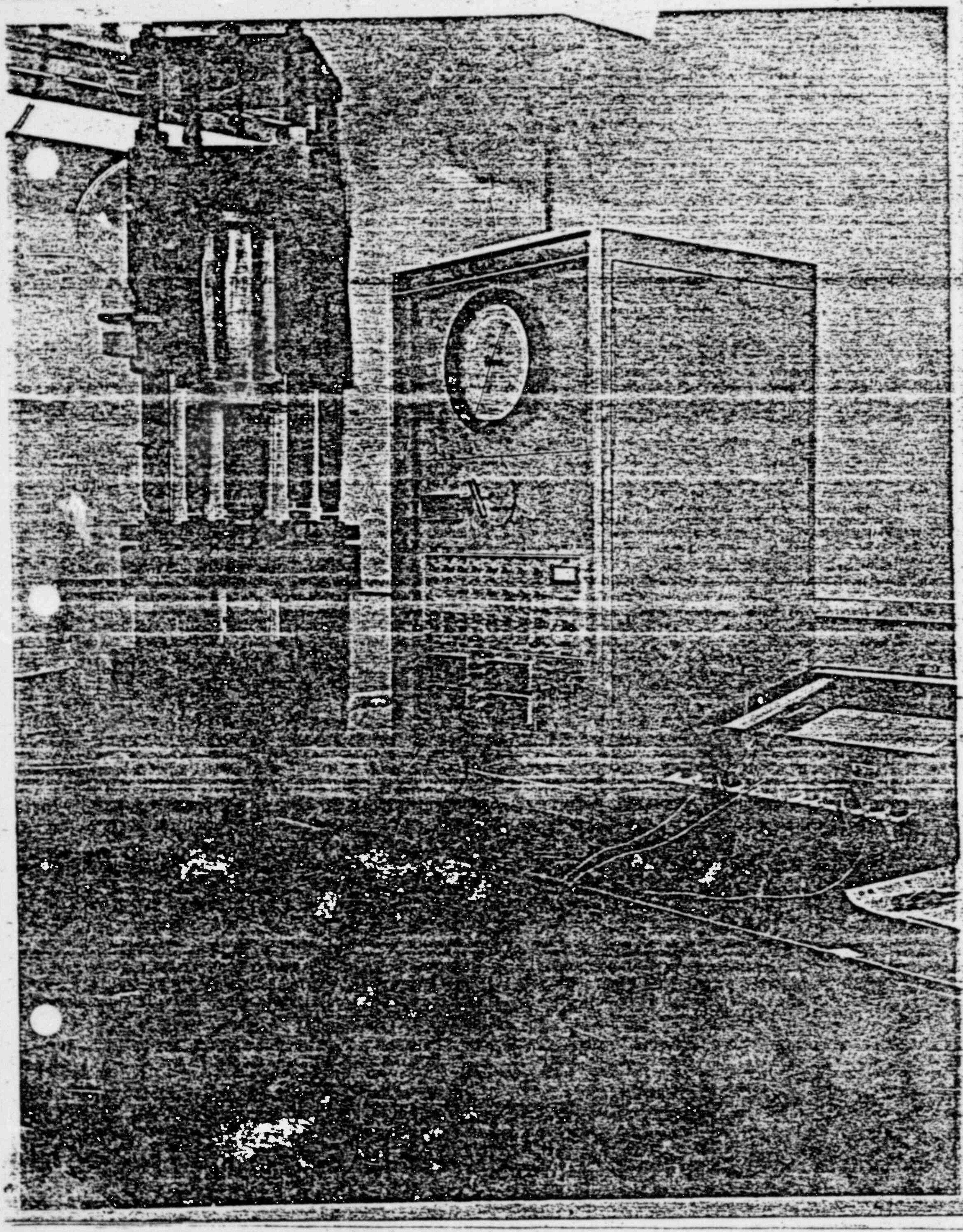
---

(1) Prepared at Sandia using Battelle zinc borosilicate glass frit and a calcined high level waste oxide simulant containing phosphate.

(2) Believed to be of the same composition as the SLA glass waste with the exception that phosphate was not added.

(3) Calculated from data in Battelle document entitled "Batch Kd Measurements of Nuclides to Estimate the Migration Potential at the Proposed Waste Isolation Pilot Plant in New Mexico," by Serne, R. J., Rai, D., Mason, M. J., and Molecke, M. A., PNL-2448/UC-70.

ES NUCLEAR SAFETY FILE



THERMAL/STRUCTURAL INTERACTIONS

MODELING

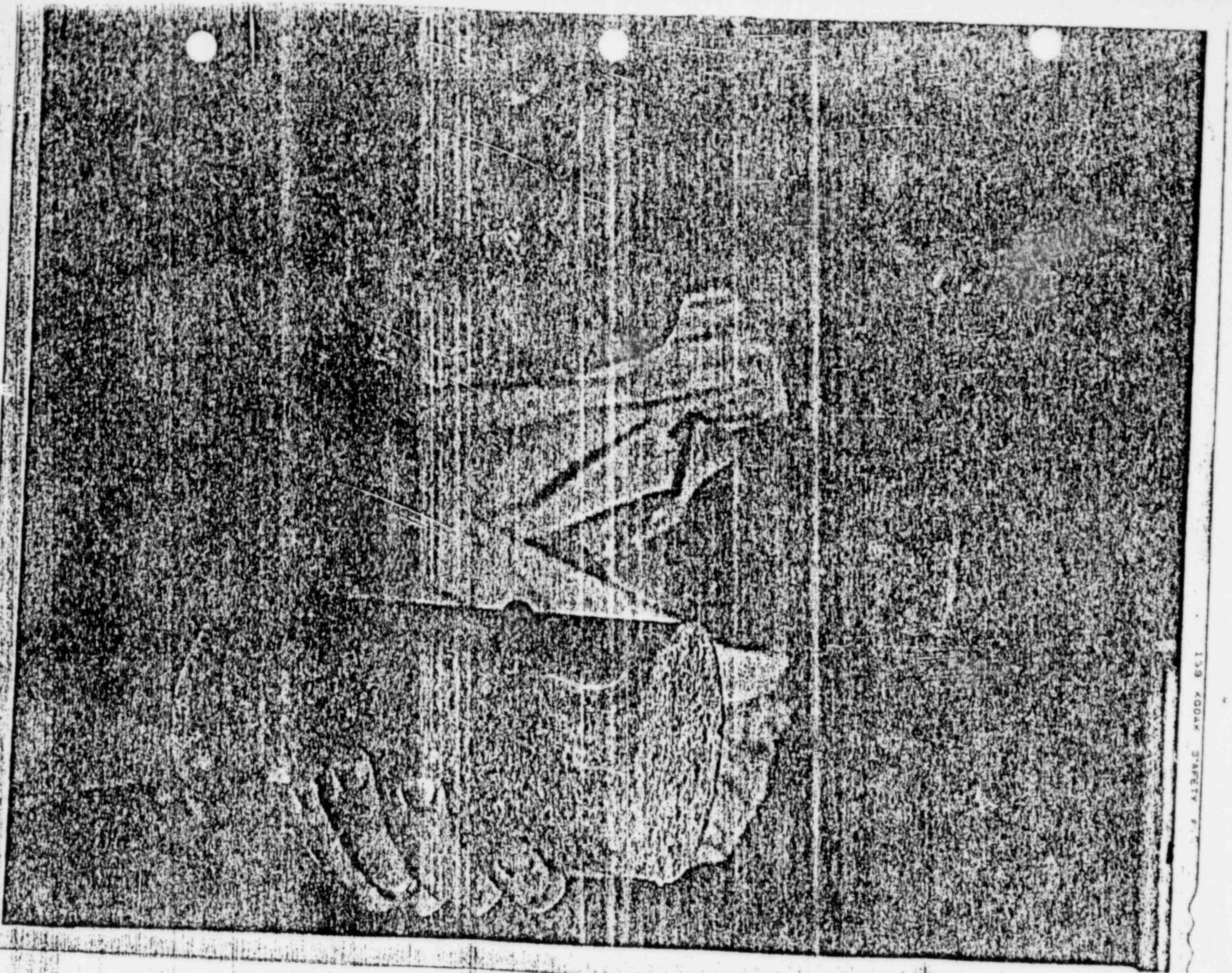
- Constitutive Model Development
- Canister Modeling
- Room Scale Modeling
- Regional Scale Modeling
- Scoping Studies
  - Backfill, Fracture Potential

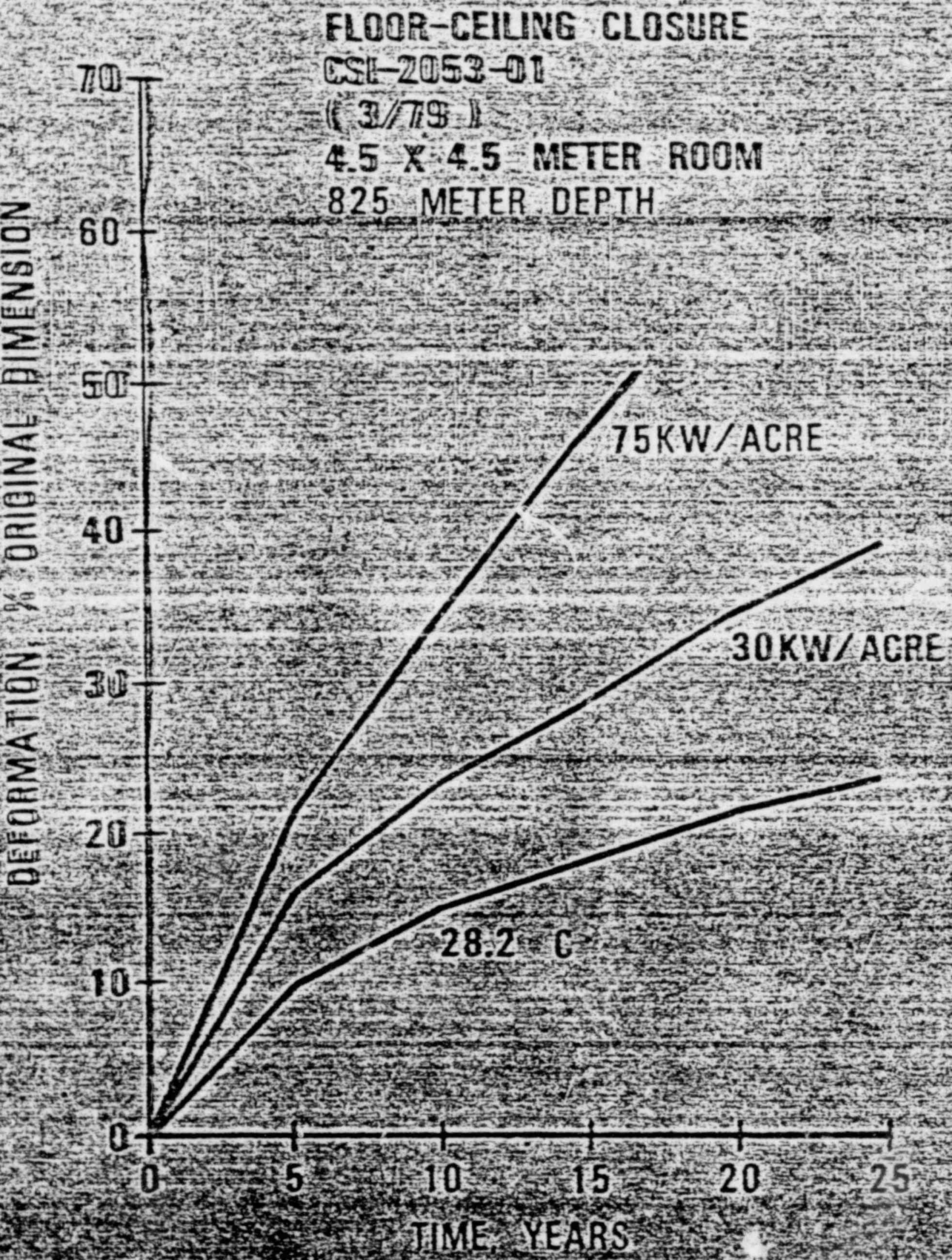
LABORATORY STUDIES

- Thermophysical Properties
- Thermomechanical Properties
  - Rock Salt
  - Non-Rock Salt

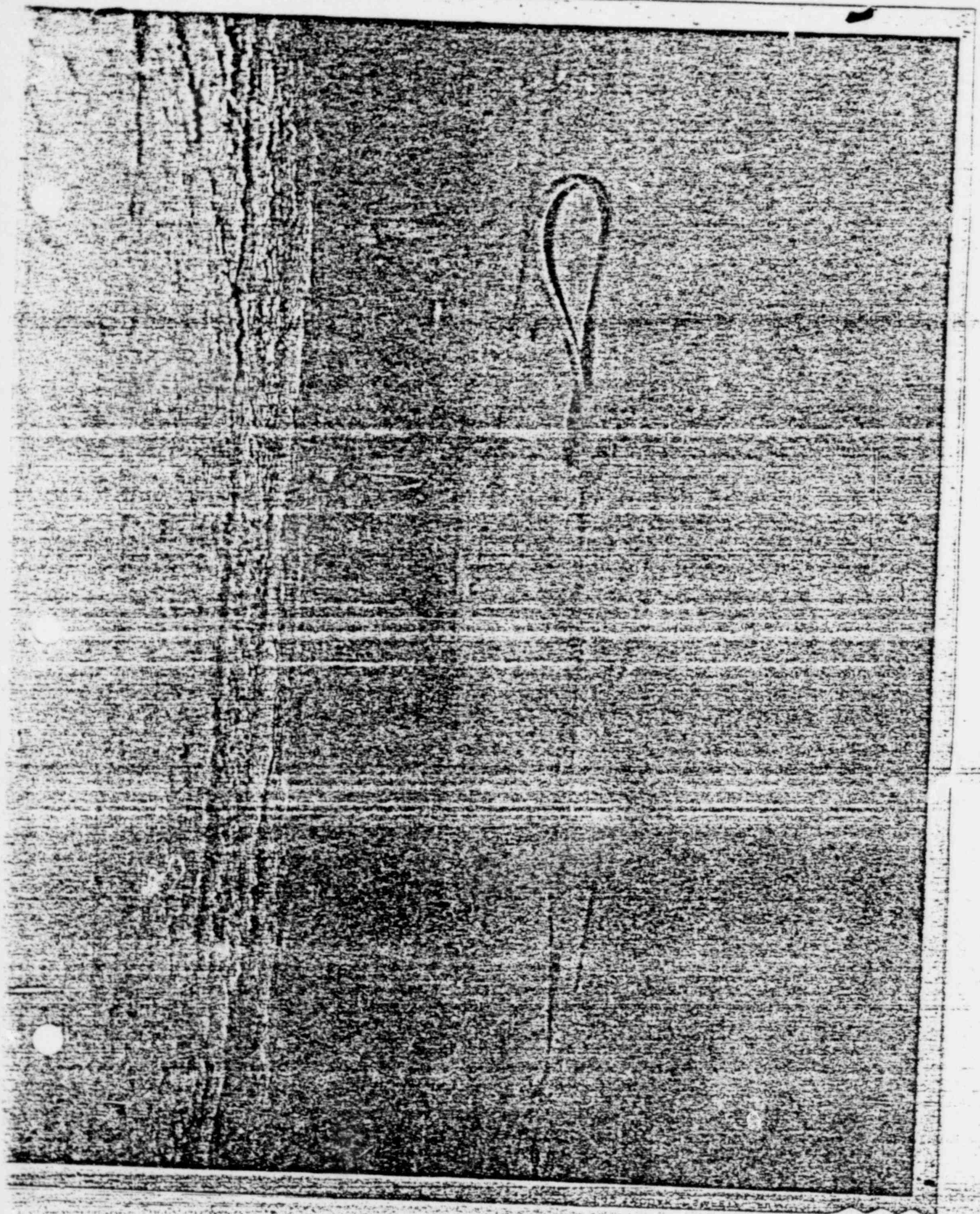
BENCH SCALE AND IN SITU ACTIVITIES

- Salt Block
- Structural Deformation at Ambient Conditions
- Heater Experiments
- Hole Closure
- Heated Room and Pillar
- Fracturing Studies


139 KODAK SAFETY



FLOOR-CEILING CLOSURE
CSI-2053-01
(3/79)
4.5 X 4.5 METER ROOM
825 METER DEPTH



RADIONUCLIDE MIGRATION

- STATIC SORPTION IN BRINE/GROUNDWATER SOLUTIONS
- FLOW THROUGH KINETIC MEASUREMENTS
- IDENTIFICATION OF COMPLEXING AGENTS
- ARTIFICIALLY EMPLACED BARRIERS
- RECONCENTRATION OF FISSILE SPECIES

RELATED PROGRAM AREAS

- TRU CHARACTERIZATION
- HLW CHARACTERIZATION
- BRINE MIGRATION

Table 7

Distribution Coefficients on Samples From the Culebra Dolomite

Fission Product Distribution Coefficients

	pH range	Cs	Sr	I,Tc	Eu,Gd	Ru
Brine A	6.5 - 6.9	< 1	< 1	< 1	> 10^4	25 - 35
Brine B	6.5 - 7.6	1-2	1-2	< 1	> 10^4	540 - 660
Sol'n	7.5 - 8.2	7-10	4-5	< 1	> 10^4	240 - 400

Actinide Distribution Coefficients

	pH range	Pu	Am	Cm
Brine B	6.5 - 7.8	2.1×10^3	2.6×10^3	1.2×10^4
Sol'n C	7.5 - 8.3	7.3×10^3	2.2×10^4	1.1×10^5

Table 8

Distribution Coefficients on Halite From The 2056' Horizon of ERDA #9 Borehole

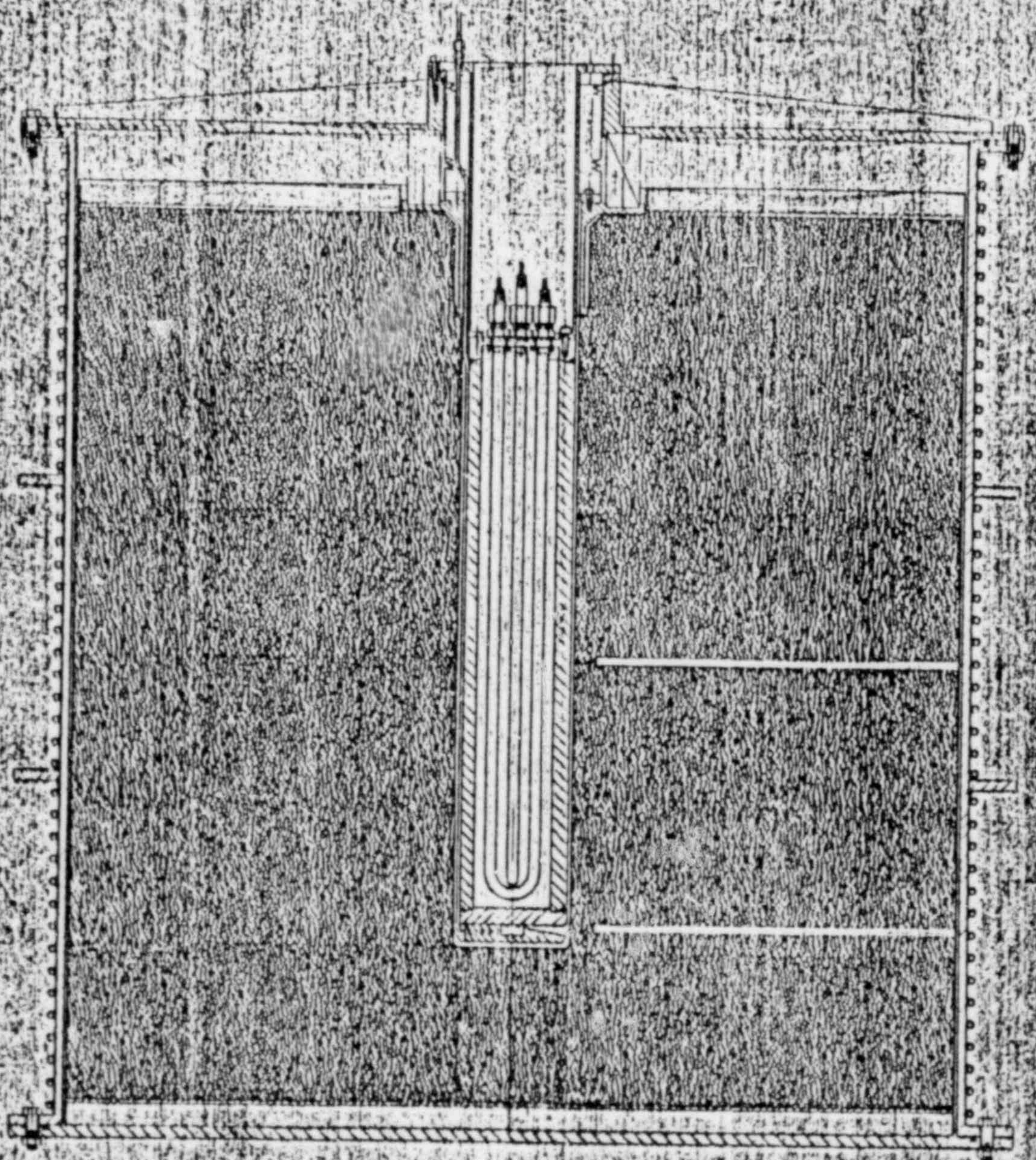
Actinide Distribution Coefficients[1]

pH range	Pu	Am	Cm
7.0 - 7.1	17 (1.0×10^4)	306 (1.8×10^5)	354 (2.1×10^5)

[1] The Kd values in parentheses were calculated from the weight of water insoluble material in the halite. The lower values are based on the total weight of halite taken.

BRINE MIGRATION ACTIVITIES

- Distribution and Analyses of Fluid Inclusions in SENM Salt/(Evaporites) (USGS)
- Microscopic Study of Motion of Fluid Inclusions in Salt/Evaporites (SLA)
- Study of Motion of Water in Salt Under the Influence of a Heat Fluid in a Large Block of Salt Salt Blocks II (V-1) (SLA)
- Study of Water Release Phenomena Which Occurs When Heating of Salt Stops (RE/SPEC)
- Study Effect of Temperature Gradient on Brine Migration (RE/SPEC)
- Temperature Induced Gas Release in Salt (Other Than and Including Water) (SLA)
- In-Situ Activities -- See Thermostructural (Heater) Experiments
- Interfaces
  - External: ONWI, USGS, FRG, ORNL
  - Internal: HLW, Thermostructural, Nuclide Migration, Operations and Design



HEATED SALT BLOCK
GAS FL [illegible] ALYSIS EXPT

OPERATION AND DESIGN ACTIVITIES

Pre-WIPP In-Situ Facility Design and Preparation (SLA, RE/SPEC)

Coring of Hot Salt (RE/SPEC)

Decrepitation of Hot Salt (SLA)

Preliminary Drilling (RE/SPEC)

Simulated Storage of TRU Waste

Simulated TRU Operations Demonstration

Heated Room (Backfill and Simulated Retrieval of HLW) (SLA, RE/SPEC)

Moisture Exchange Through Mine Ventilation System (SLA)

Study of Particulates in Mine (SLA)

Shielding Studies and Evaluation (SLA)

Radiation Background Measurements in a Mine (SLA)

Mine Face Scanning (SLA)

Compaction of Salt (SLA)

Weather Station (SLA)

Interfaces

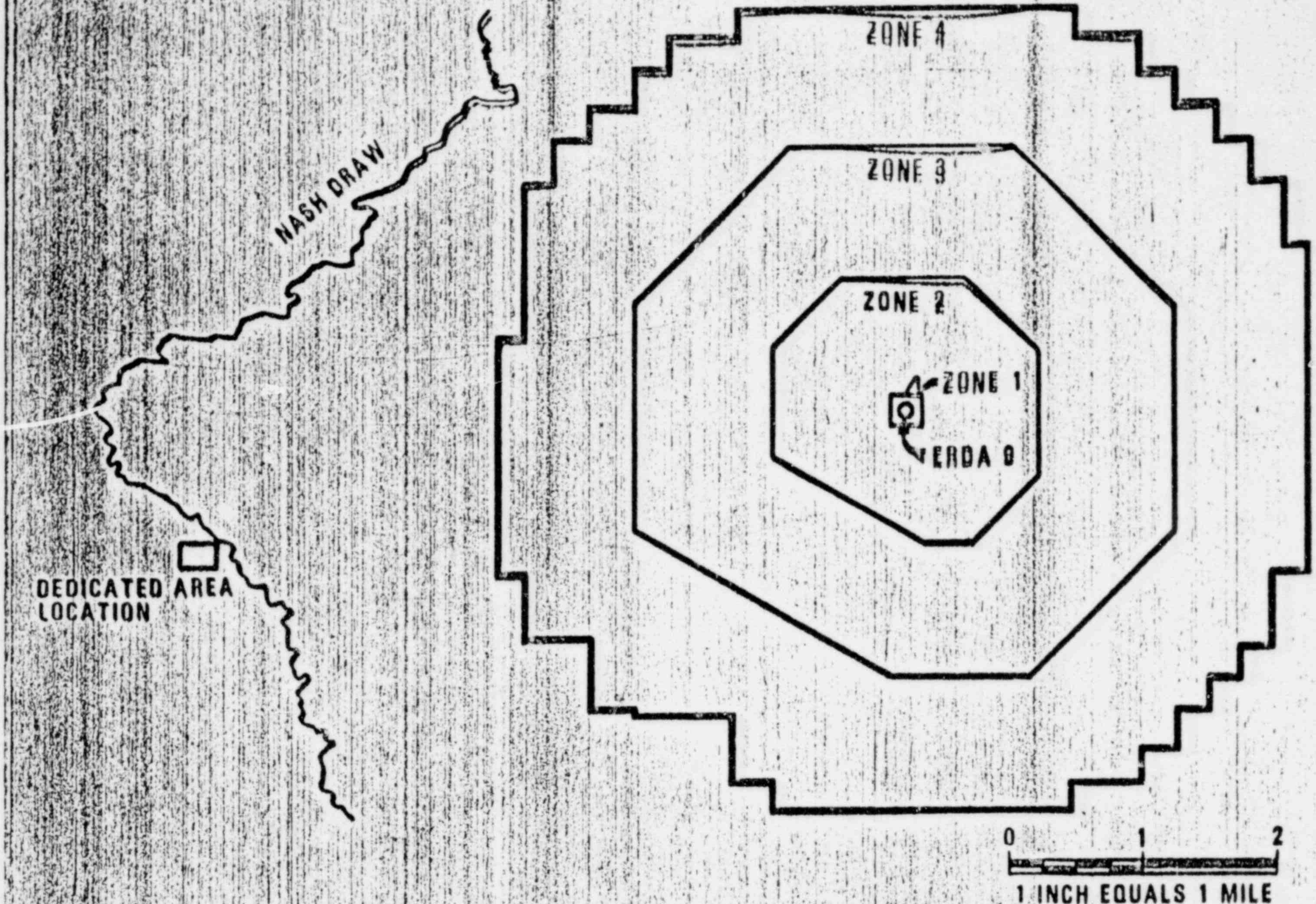
- External: ONWI, FRG, Other
- Internal: TRU, HLW, Thermomechanical, Permeability, Brine Migration

II.H

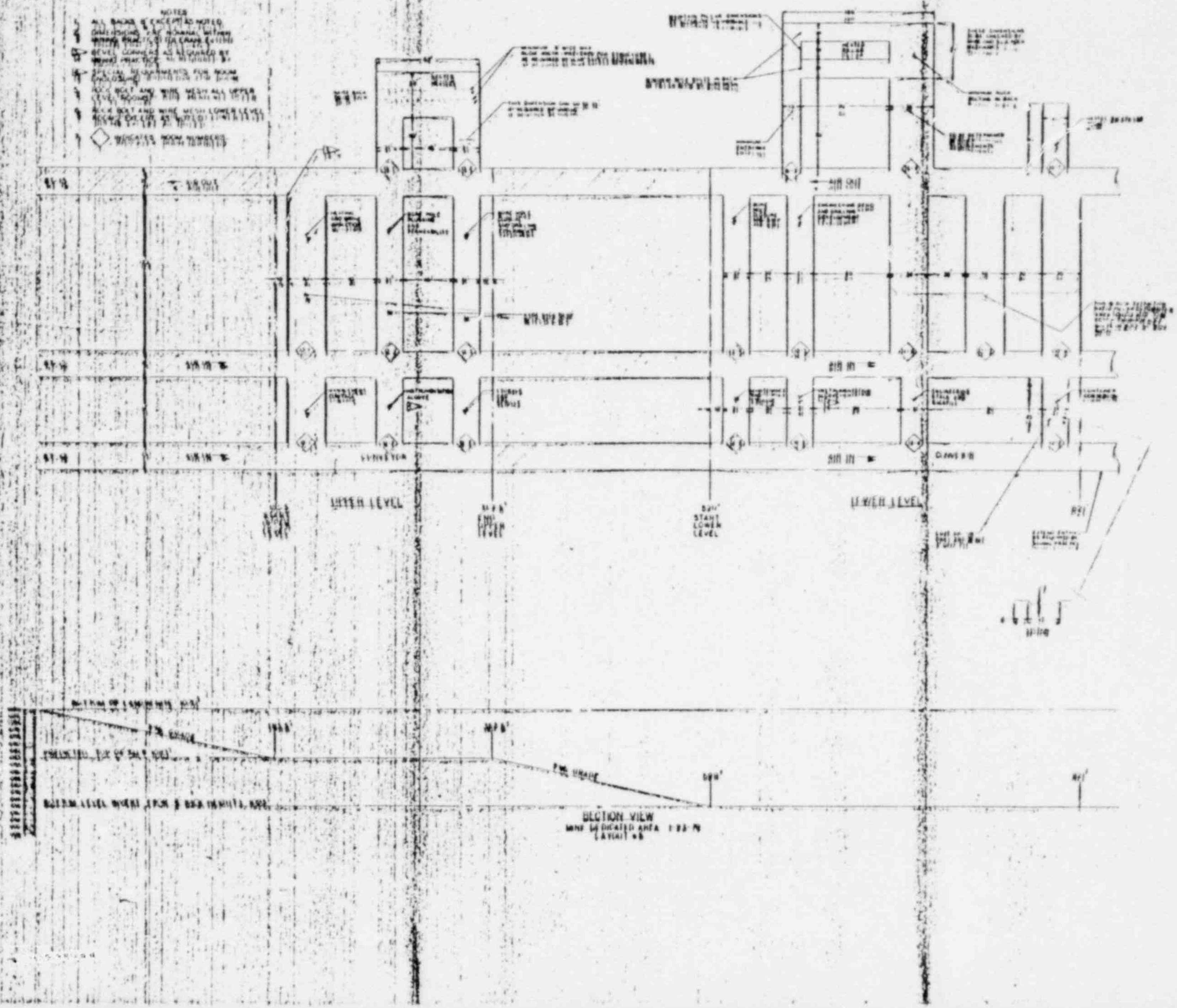
TU

RT

M

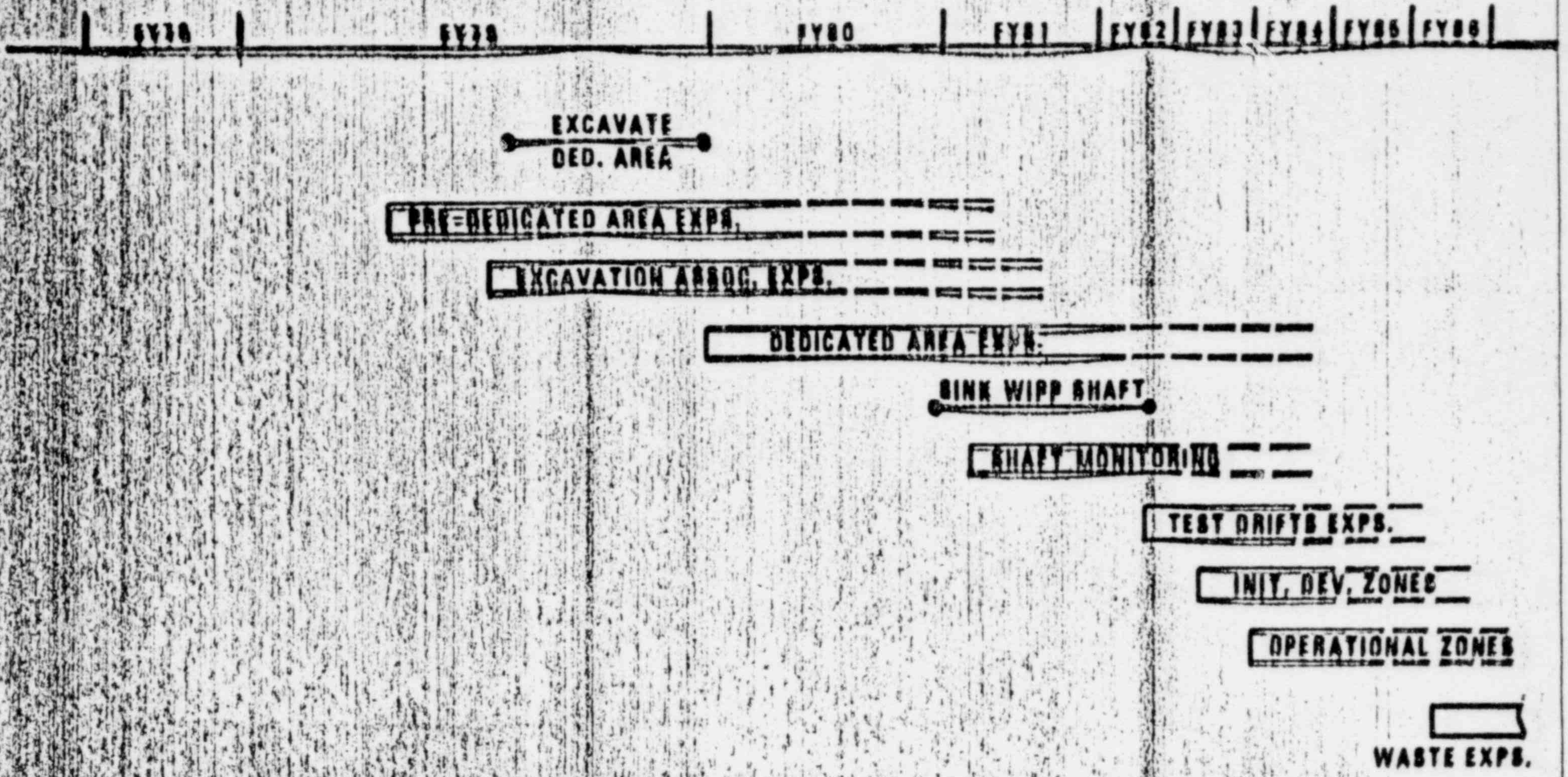


DEDICATED AREA LOCATION


NOTES
1. ALL BACKS ... EXCEPT AS NOTED
2. DIMENSIONS ARE NOMINAL WITHIN MINING PRACTICE ...
3. BEVEL CORNERS AS REQUIRED BY MINING PRACTICE ...
4. SPECIAL REQUIREMENTS FOR ROOM ...
5. ROCK BOLT AND WIRE MESH ALL UPPER LEVEL ROOMS ...
6. ROCK BOLT AND WIRE MESH LOWER LEVEL ROOMS ...
7. ◇ INDICATES ROOM NUMBERS
UPPER LEVEL
END UPPER LEVEL
START LOWER LEVEL
LOWER LEVEL
SECTION VIEW
MINE DEDICATED AREA 1-23-79
LAYOUT #5

171

WIPP
IN-SITU TESTING PROGRAM
SCHEDULE BASIS



19

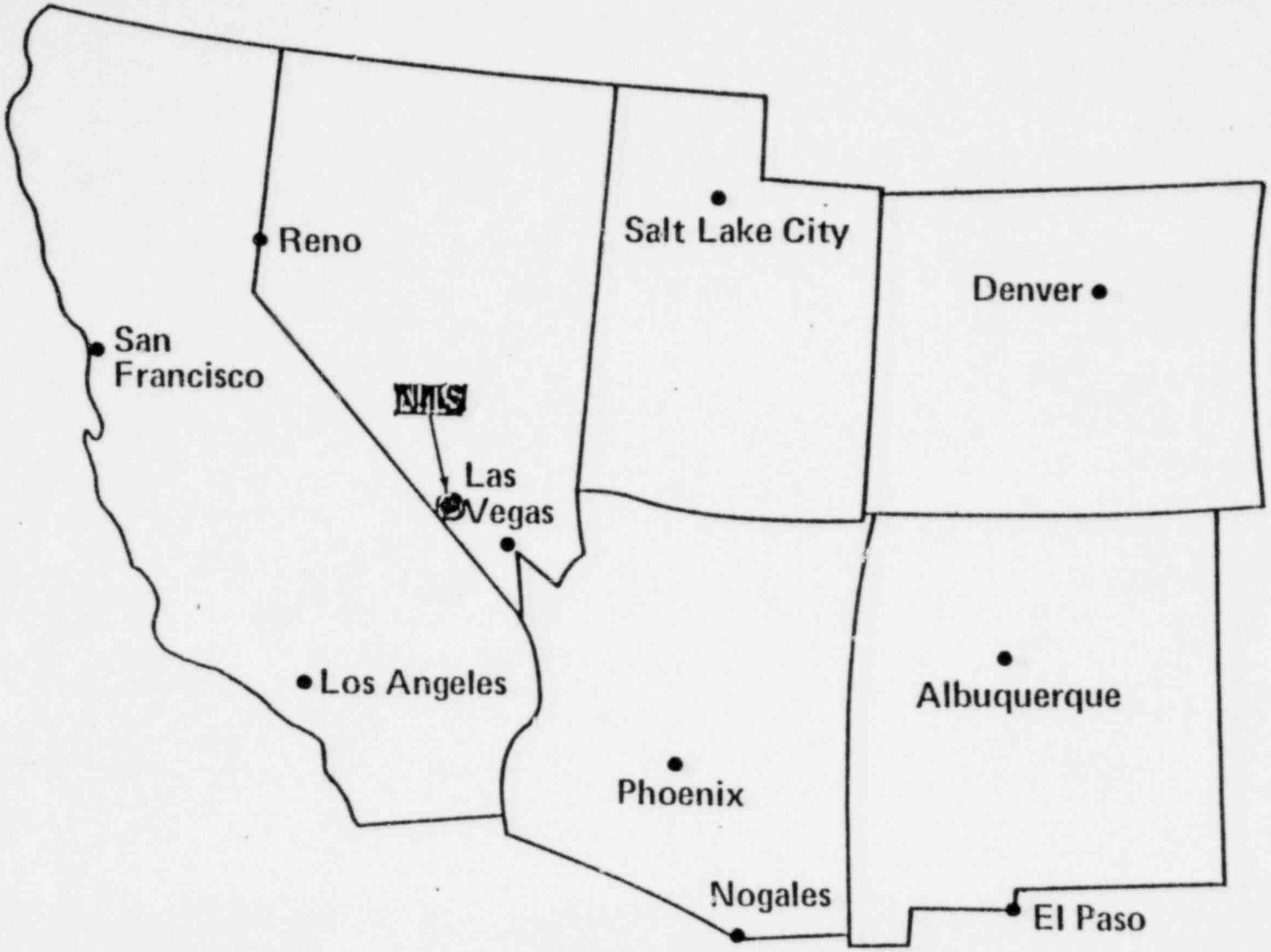
Nevada Nuclear Waste Storage
Investigations:

FIELD TESTS IN GRANITIC ROCK AT NTS

L. D. Ramspott
Lawrence Livermore Laboratory

April 19, 1979

THE NEVADA TEST SITE IS LOCATED IN SOUTHERN NEVADA, ABOUT 120 KM NORTHWEST OF LAS VEGAS



NEVADA NUCLEAR WASTE STORAGE INVESTIGATIONS

OBJECTIVES

- EVALUATE THE MAJOR GEOLOGIC FORMATIONS ON THE NTS TO DETERMINE IF THEY ARE SUITABLE FOR LOCATING A REPOSITORY FOR PERMANENT ISOLATION OF HIGH-LEVEL RADIOACTIVE WASTE.

- PROVIDE RESEARCH AND DEVELOPMENT SUPPORT TO THE NATIONAL WASTE MANAGEMENT PROGRAM IN THE FORM OF TESTS AND TEST FACILITIES WHICH MAY BE UNIQUELY IMPLEMENTED AT THE NTS.

FIELD TESTS IN GRANITIC ROCK AT NTS

- Heater Test #1

  Thermal and permeability measurements during FY 1978

- Spent Fuel Test

  Test storage of spent fuel assemblies to start in spring of 1980

- Rock Mechanics Test Facility

  Proposed project to complement measurements from Spent Fuel Test

THE SPENT FUEL TEST IN THE CLIMAX GRANITE IS A GENERIC TEST IN WHICH SPENT FUEL ASSEMBLIES FROM AN OPERATING COMMERCIAL NUCLEAR REACTOR ARE EMPLACED AND RETRIEVED AT A PLAUSIBLE REPOSITORY DEPTH IN A TYPICAL GRANITE

- The early time, close-in thermal history of a repository is simulated with 11 canisters of spent fuel, 6 electrically heated simulator canisters, and 20 auxiliary electrical heaters

- The effects on granite (and possibly backfill) of heat alone (electrical simulators) may be compared with the effects of heat plus radiation (spent fuel)

- A combination of laboratory tests, computer simulation, and field tests with electrical heaters could lead to similar information, but without two benefits from the spent fuel test
  - Insurance against unexpected synergistic effects being revealed only by a final vault test
  - An experience base in packaging, handling, transport, and storage of spent fuel

PRACTICAL CONSIDERATIONS AS WELL AS PURELY TECHNICAL OBJECTIVES INFLUENCED THE TEST DESIGN

Keep Costs Low

- Minimize capital investment for this experimental facility (no hot cell near the storage site)
- Use existing spent fuel program canister design

Safe Operation

- Design the test to keep radiation levels low
- Design the test to keep fuel cladding temperatures below the allowable maximum

Public Accessibility

- Design the test to operate in a manner facilitating inspection of the hardware and observation of activities by authorized governmental, scientific, and public interest groups

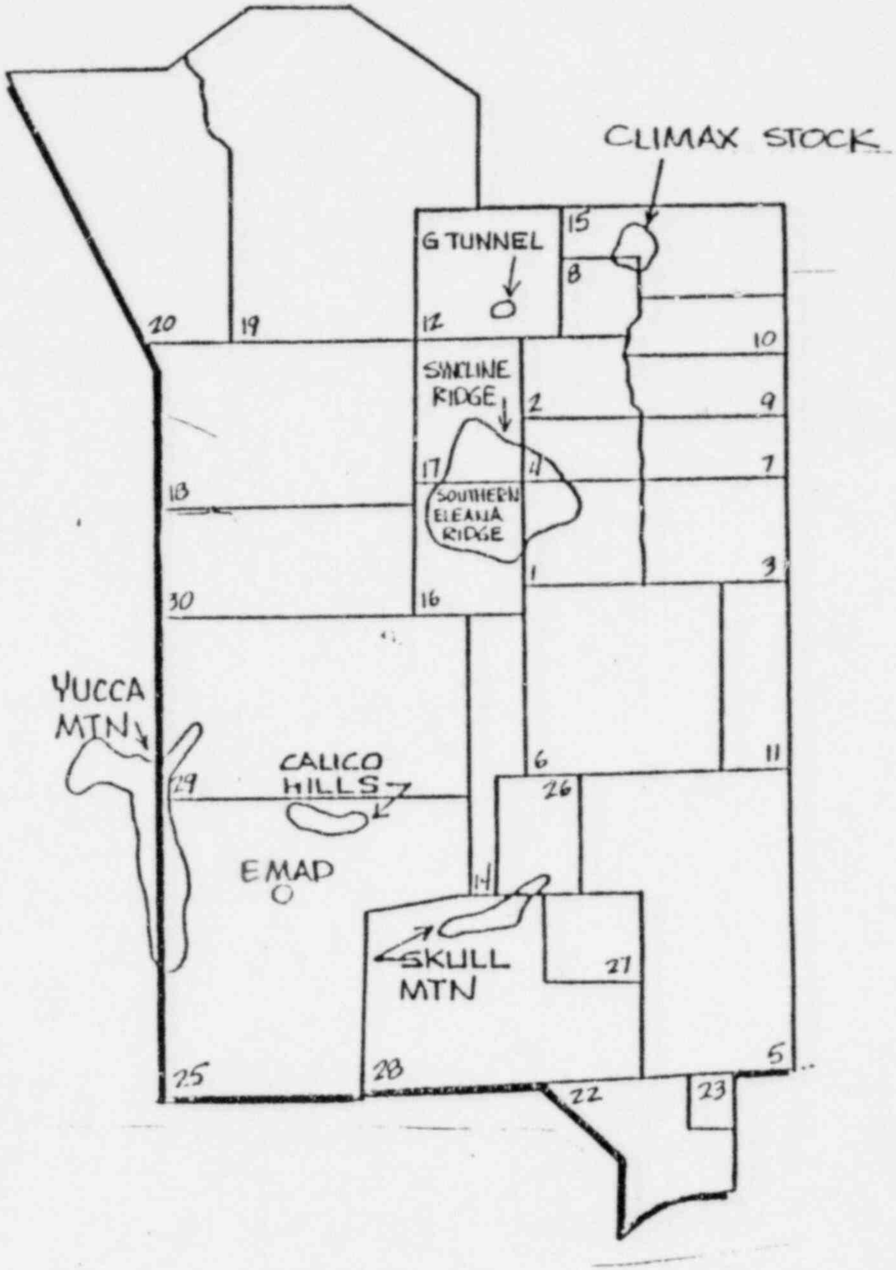
Earliest Feasible Schedule

- Use off-the-shelf technology
- In the above, no attempt was made to design a prototype of a full scale repository

SEQUENCE OF OPERATIONS, SPENT FUEL TEST, CLIMAX GRANITE, NTS

- Acquire fuel assemblies
- Ship fuel to NTS
- Encapsulate fuel in canisters at E-MAD
- Transport to Climax Granite site
- Lower to 1400 ft level
- Transfer via railcar to storage hole
- Emplace in storage hole which is steel-lined
- Energize auxilliary heaters for repository simulation
- Monitor thermal history of fuel and rock
- Monitor radiation and rock mechanics measurements
- Store for up to five years
- Retrieve and return to E-MAD
- Report results periodically

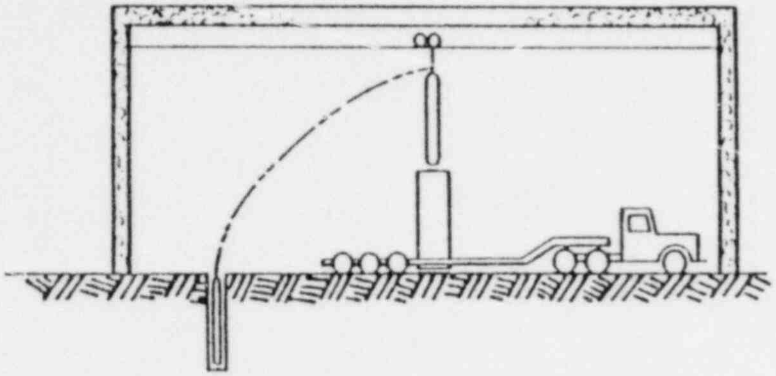
NEVADA NUCLEAR WASTE STORAGE INVESTIGATIONS



CLIMAX GRANITE PROGRAM CANISTER HANDLING

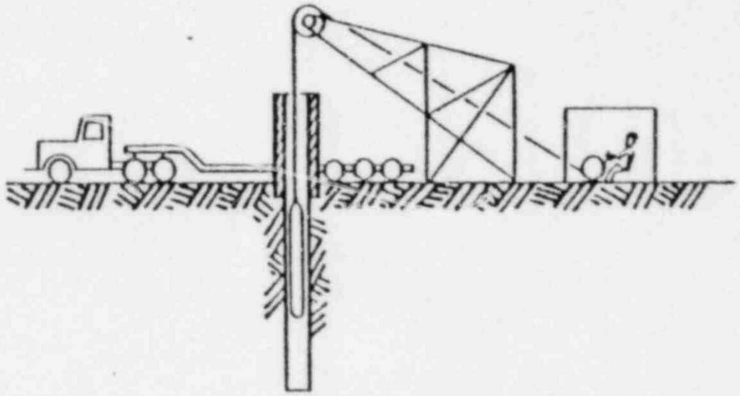
1

Loading cask in E-MAD Hot Bay



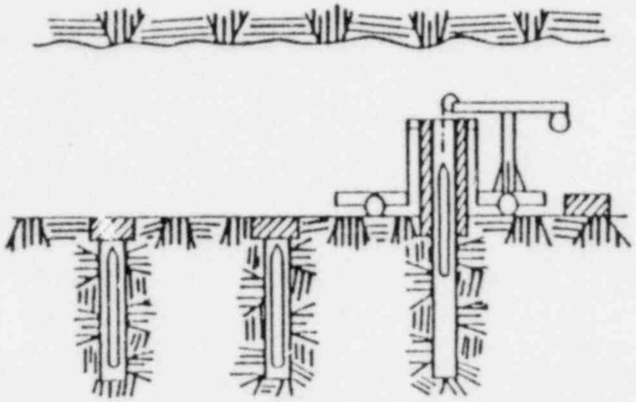
2

Lowering canister in shaft
— Area 15, NTS



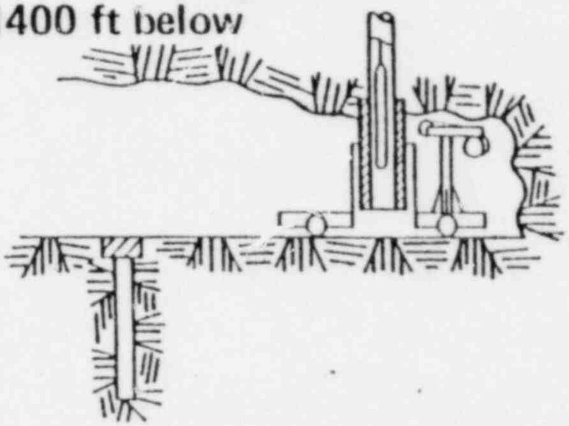
4

Inserting canister into granite

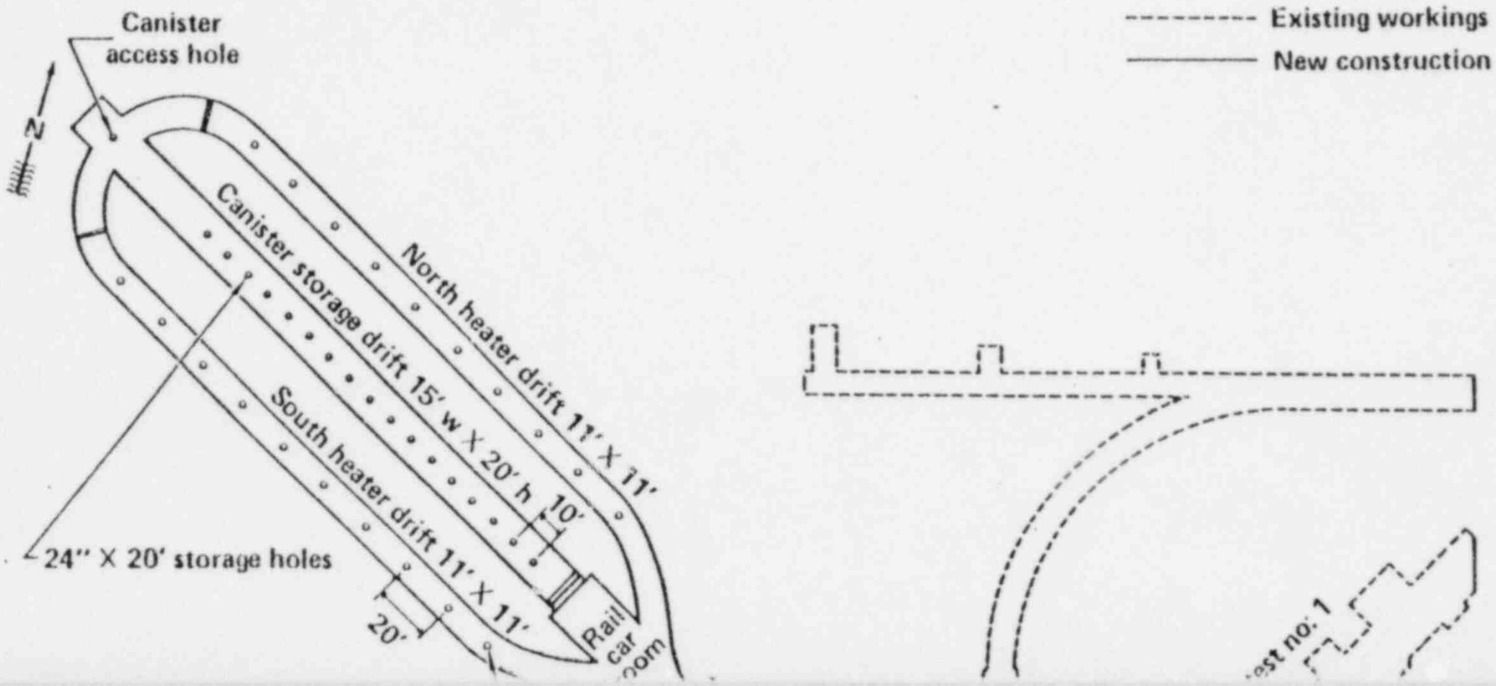


3

Canister entering rail cask
— 1400 ft below

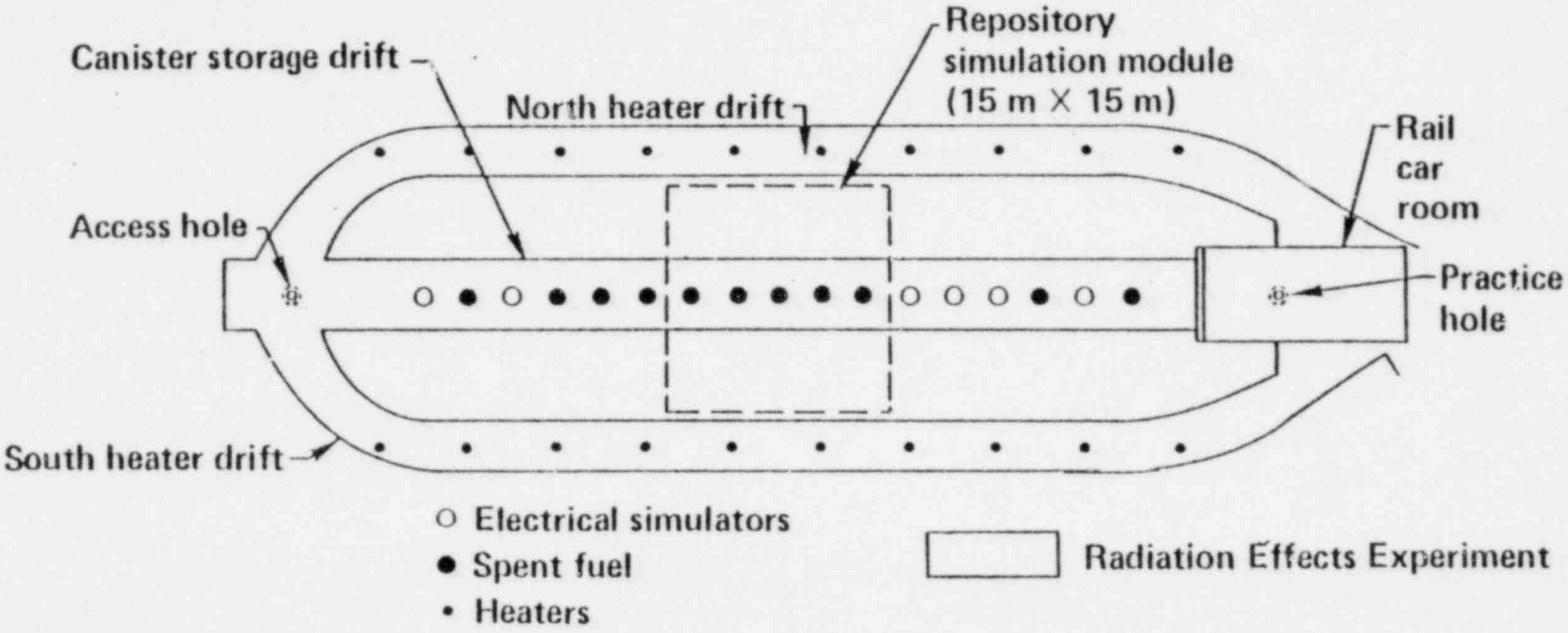


SPENT FUEL TEST LAYOUT IN CLIMAX GRANITE, NTS



THERE ARE TWO MAIN EXPERIMENTS IN THE SPENT FUEL TEST IN THE CLIMAX GRANITE

- Radiation Effects Experiment
  - The effects on granite of heat alone (electrical simulators) are compared with the combined effects of heat and radiation (spent fuel)
- Repository Simulation Experiment
  - The response of a granite repository to waste is investigated in a repository simulation module using a small number of spent fuel elements and electrical heaters



THE EARLY TIME THERMAL HISTORY OF A TYPICAL REPOSITORY ELEMENT IS SIMULATED WITH 11 CANISTERS OF SPENT FUEL, 6 ELECTRICALLY-HEATED SIMULATOR CANISTERS, AND 20 AUXILLIARY ELECTRICAL HEATERS

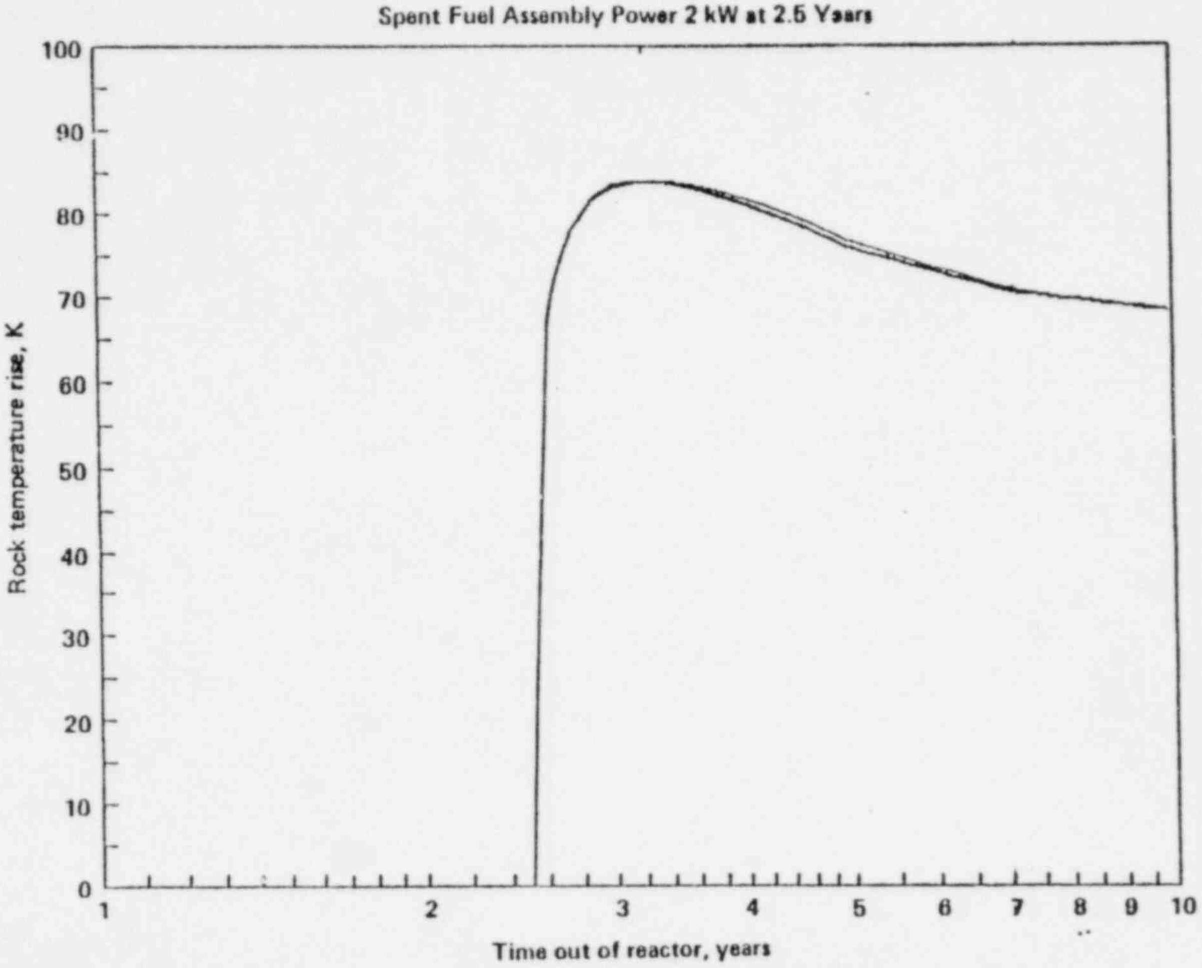
- The hypothetical repository is a large array of parallel drifts spaced on 15 m centers, with canisters 3 m apart

- The spent fuel test simulation is a 15 m X 15 m module of that repository array

- The design parameter is the temperature history of the rock wall adjacent to the center canisters of both the repository and the test array

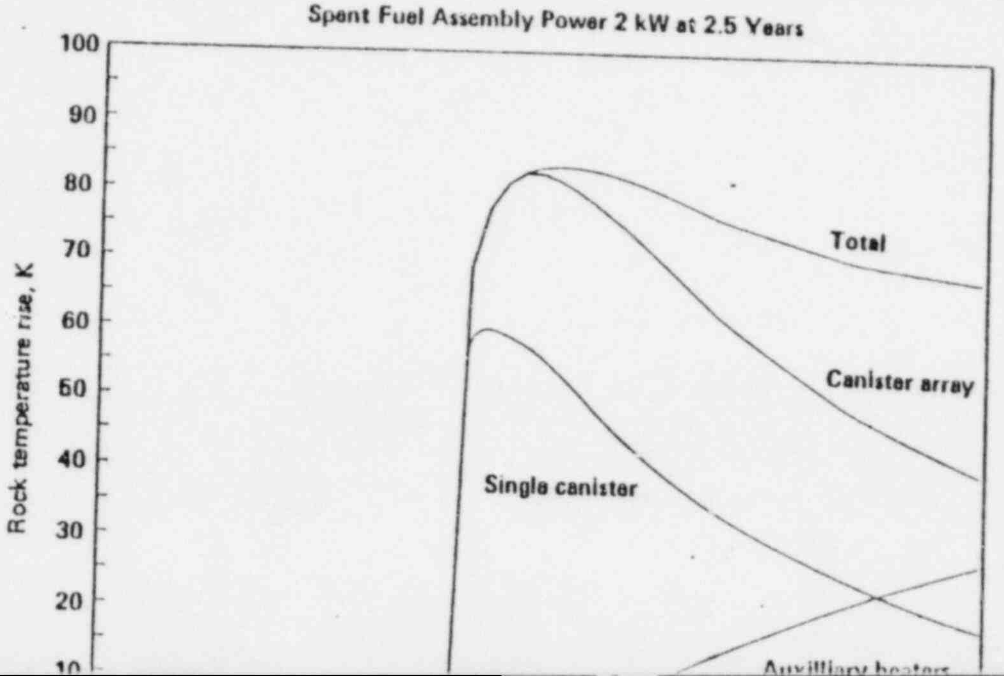
- Thermal parameters from the *in-situ* heater test completed in FY 1978 are used in the calculations

THE TEMPERATURE – TIME CURVES FOR THE REPOSITORY CALCULATION AND THE SPENT FUEL TEST CALCULATION AGREE WITHIN 1% FOR THE FIRST 7½ YEARS

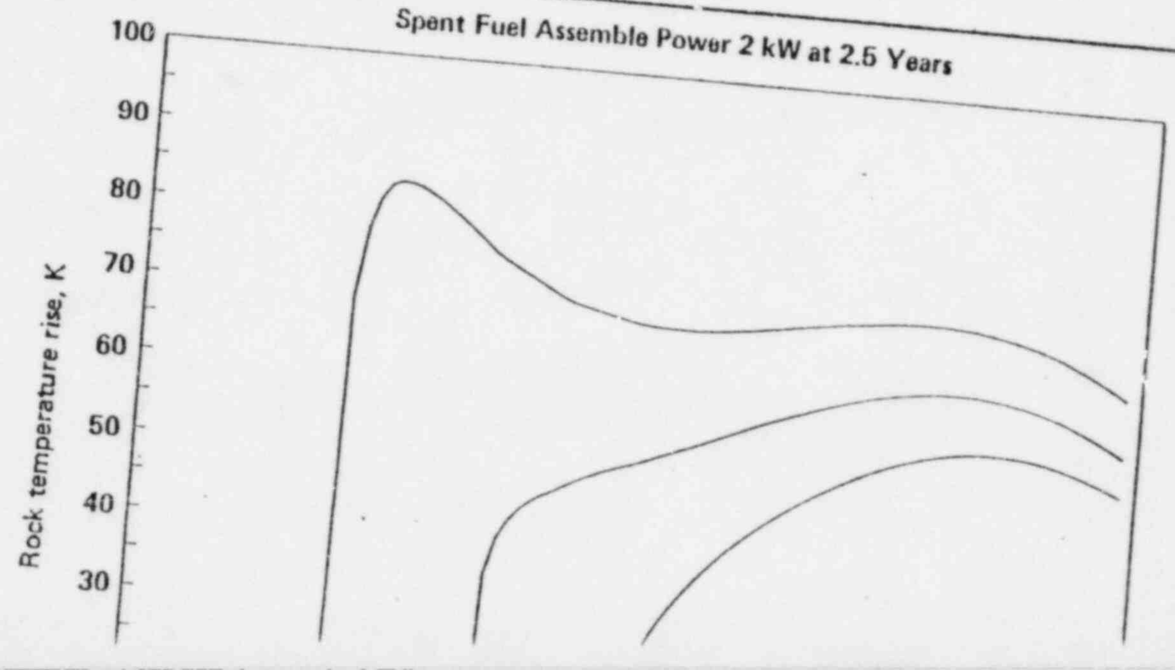


.1,1,5

HEAT FROM AUXILLIARY HEATERS IN AN ADJACENT DRIFT WILL SUPPLEMENT THAT FROM THE CANISTER ARRAY TO GIVE A TOTAL THERMAL HISTORY WHICH SIMULATES A LARGE REPOSITORY



THE ROCK NEXT TO THE CENTER CANISTER IN A LARGE REPOSITORY WILL UNDERGO A TEMPERATURE – TIME HISTORY WHICH VARIES WITH THE AGE OF THE EMPLACED WASTE

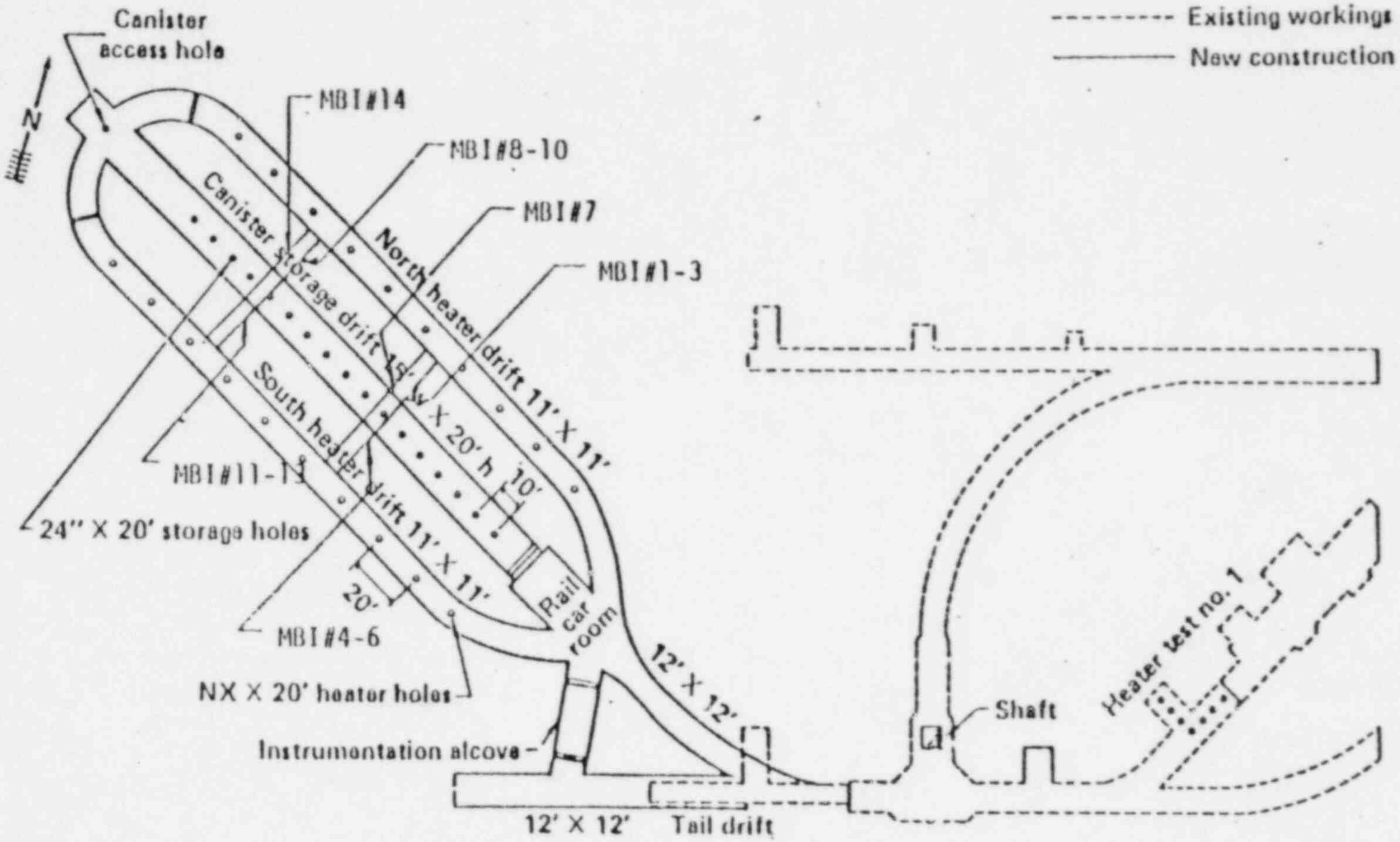

Spent Fuel Assemble Power 2 kW at 2.5 Years

THERE ARE IMPORTANT SECONDARY TECHNICAL MEASUREMENT PROGRAMS IN THE SPENT FUEL TEST - CLIMAX GRANITE

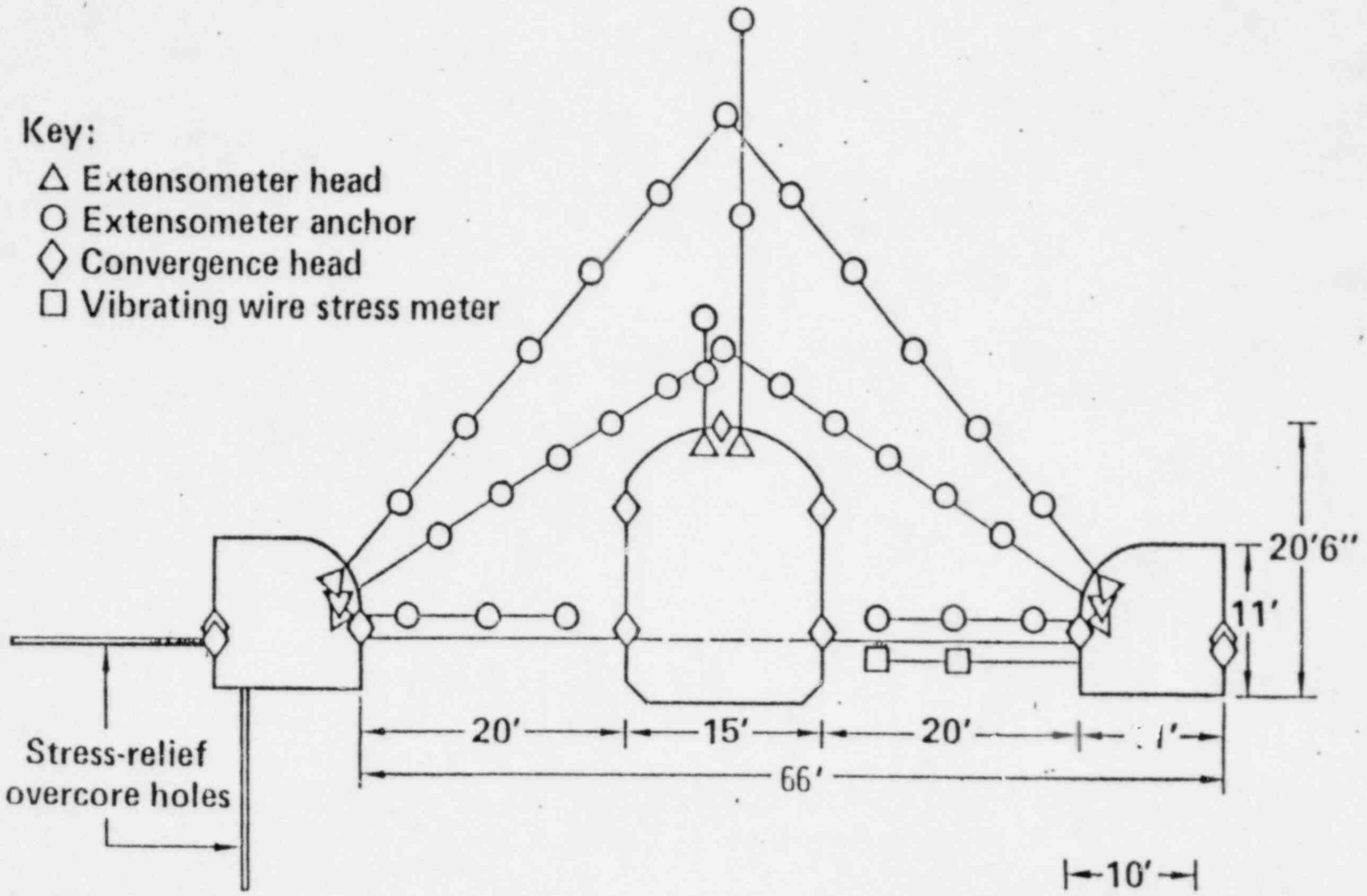
- QUANTITATIVE STUDY OF EFFECTS OF VENTILATION ON HEAT DISTRIBUTION DURING TEST DURATION
- DEFINITION OF SITE GEOLOGY, INCLUDING IN-SITU STATE-OF-STRESS
- ROCK MECHANICS MINE-BY EXPERIMENT
- MEASUREMENT OF TEST CHIPS IN ROCK ENVIRONMENT, AND IN HIGH RADIATION ENVIRONMENT ON/OR IN CANISTER
- QUALITATIVE EVALUATION OF THE EFFECTS OF STORAGE ON THE SPENT FUEL ASSEMBLIES AND CANISTERS
- POSSIBLE BACKFILL STUDIES (NOT CURRENTLY SCOPED OR FUNDED)

2/79

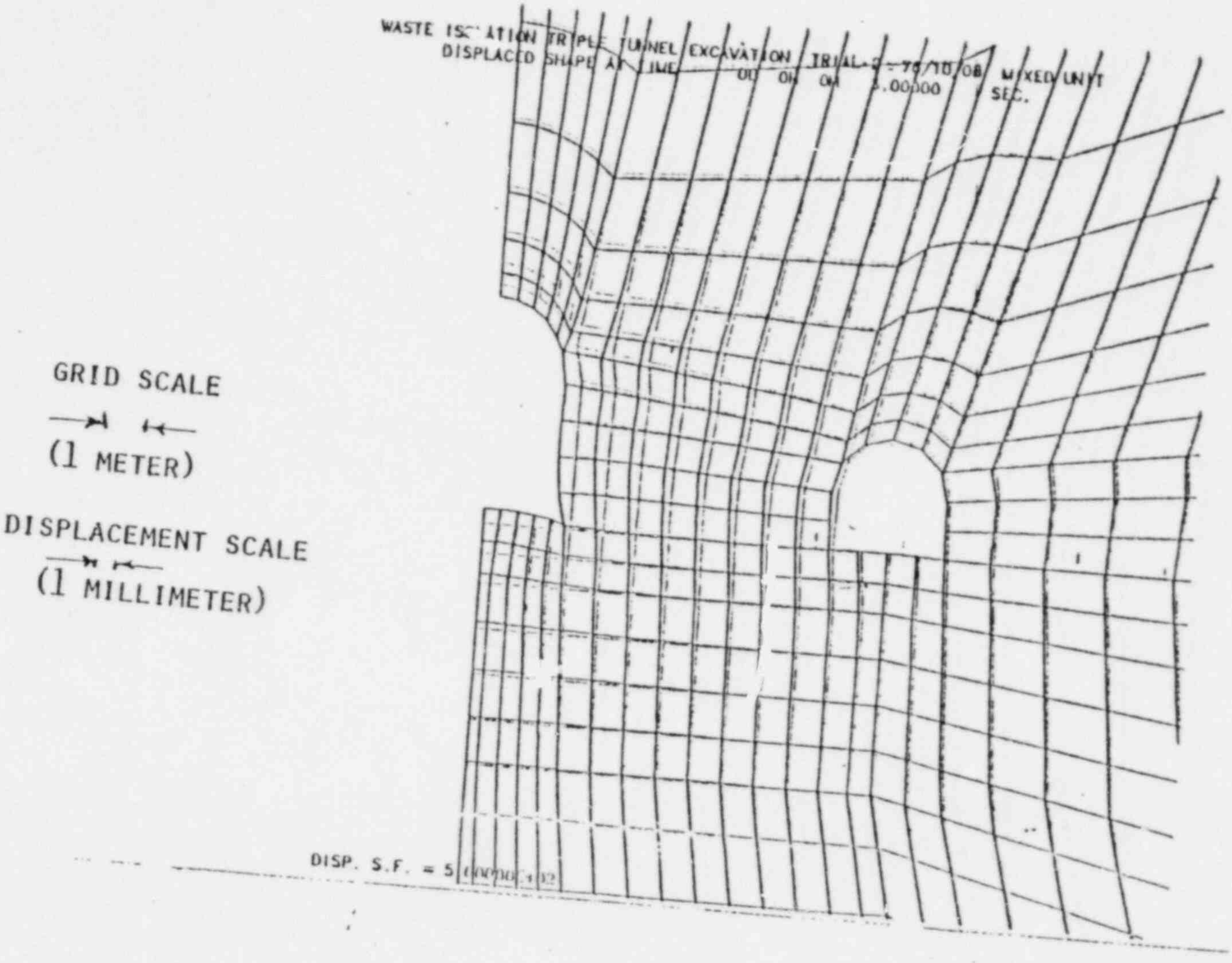
SPENT FUEL TEST LAYOUT IN CLIMAX GRANITE, NTS



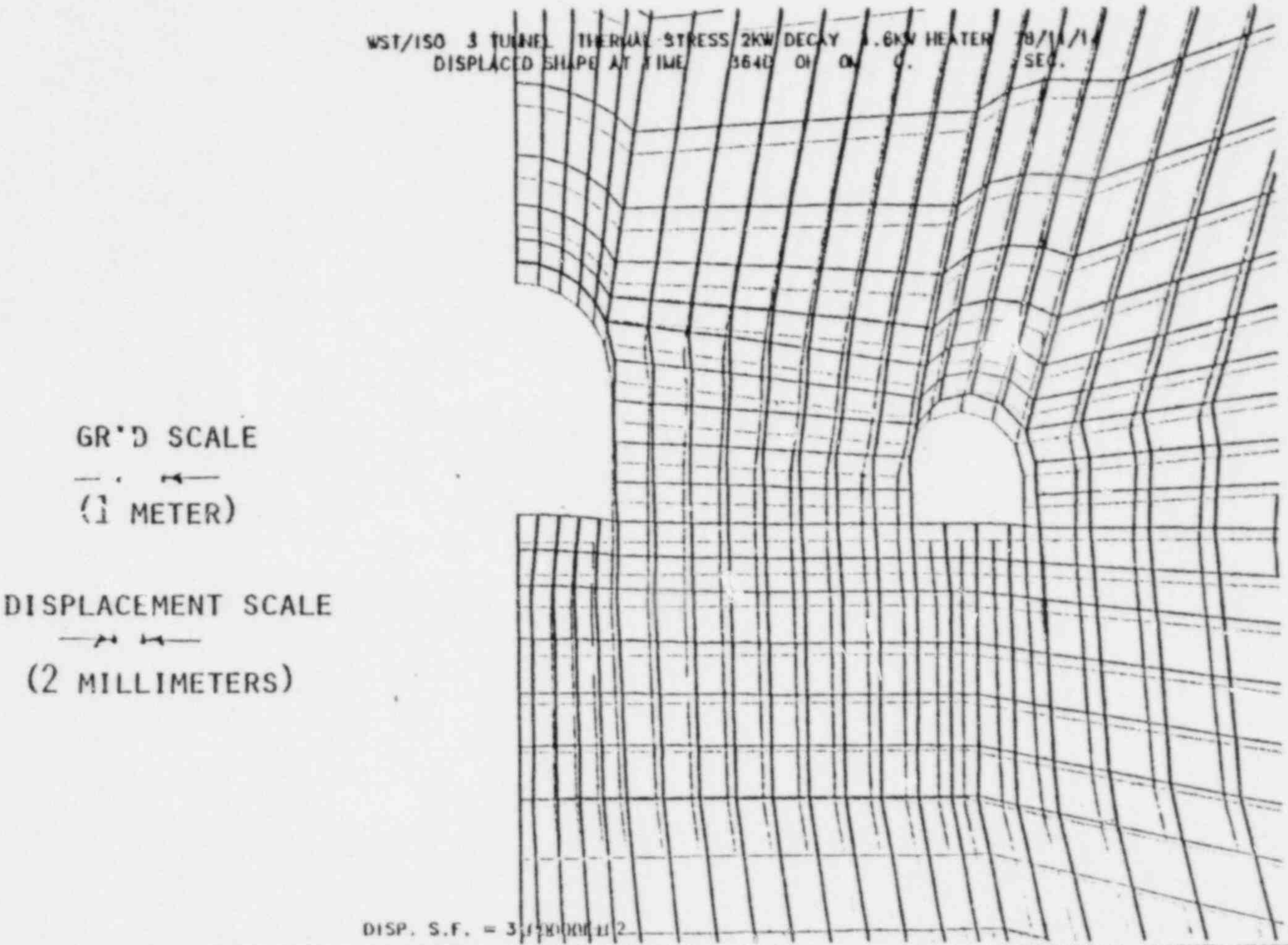
SCHEMATIC OF SPENT FUEL TEST SHOWING RELATIVE LOCATIONS OF MINE-BY INSTRUMENTS

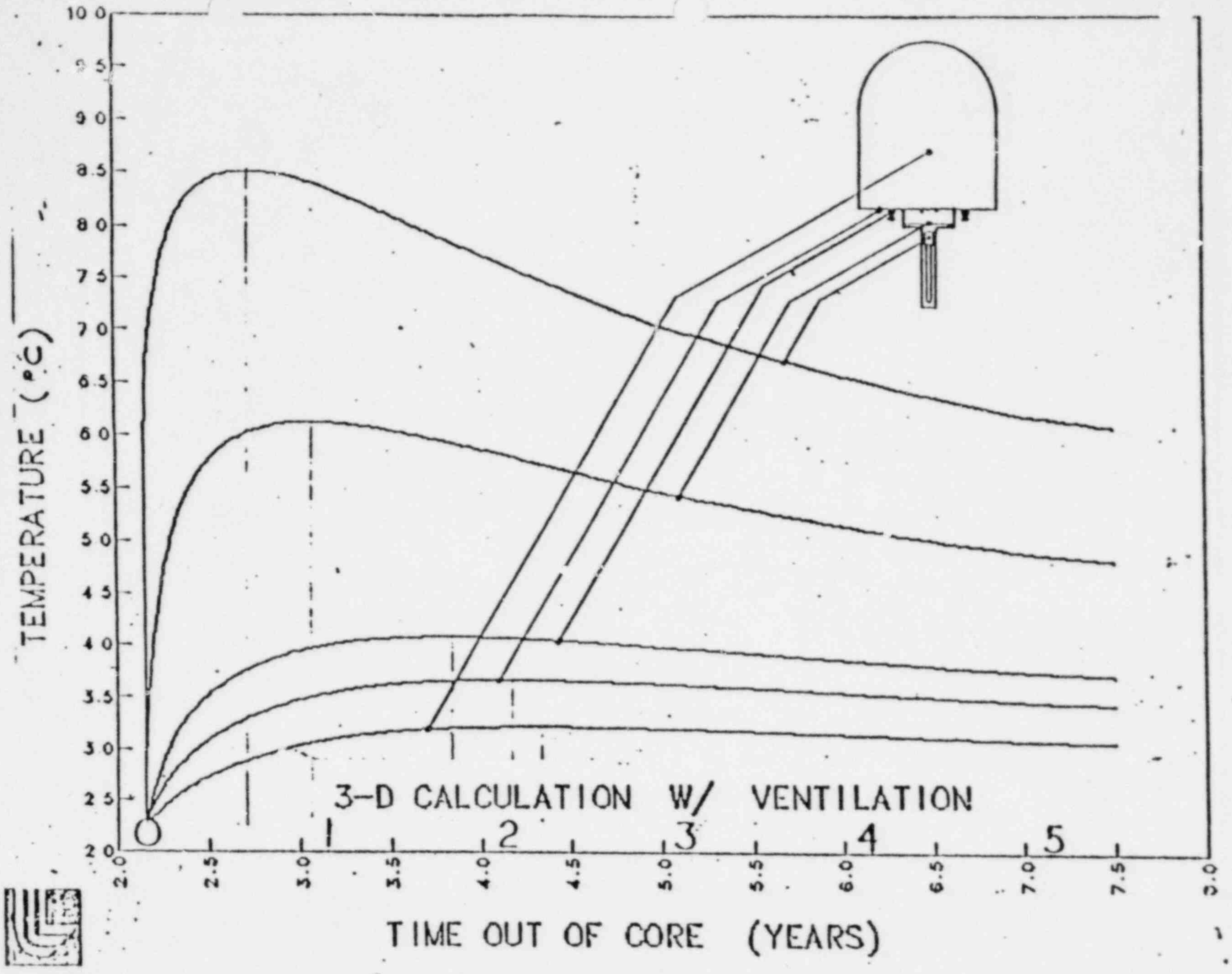


DISPLACEMENT AFTER COMPLETE EXCAVATION OF TUNNEL



DISPLACEMENT FROM THERMAL LOAD AFTER 364 DAYS





TEMPERATURE (°C)
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
2.0
2.5
3.0
3.5
4.0
4.5
5.0
5.5
6.0
6.5
7.0
7.5
8.0
TIME OUT OF CORE (YEARS)
3-D CALCULATION W/ VENTILATION
0
1
2
3
4
5

Ⓚ

SWEDISH-AMERICAN COOPERATIVE PROJECT AT STRIPA

P. A. Witherspoon - LBL Earth Sciences Division

515

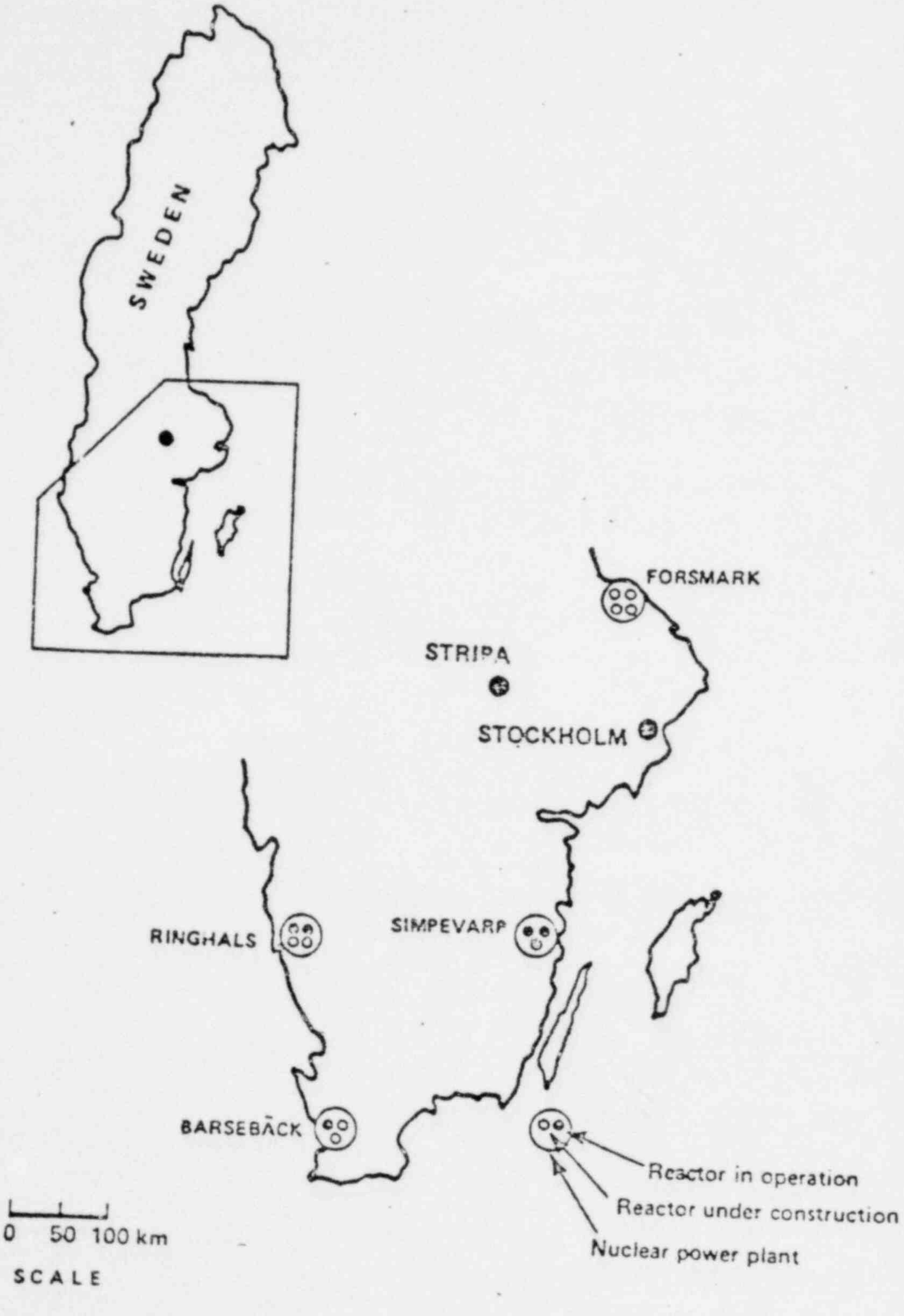
24. Isometric View of Bentilation Room Showing Ductwork and Instrument Panels

25. What Have We Learned From Stripa Project?

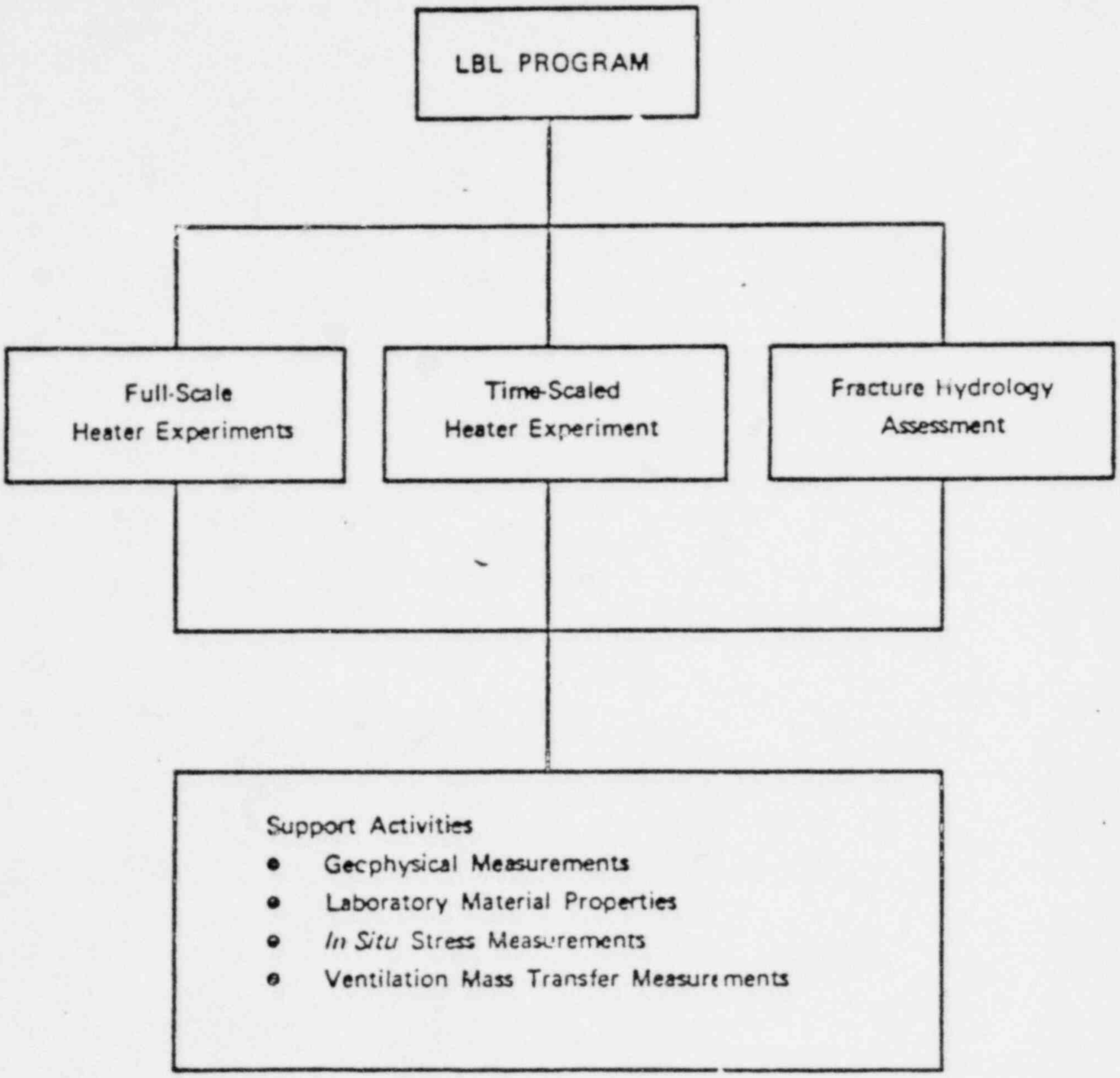
SWEDISH-AMERICAN COOPERATIVE
PROJECT AT STRIPA

PROGRAM OBJECTIVES

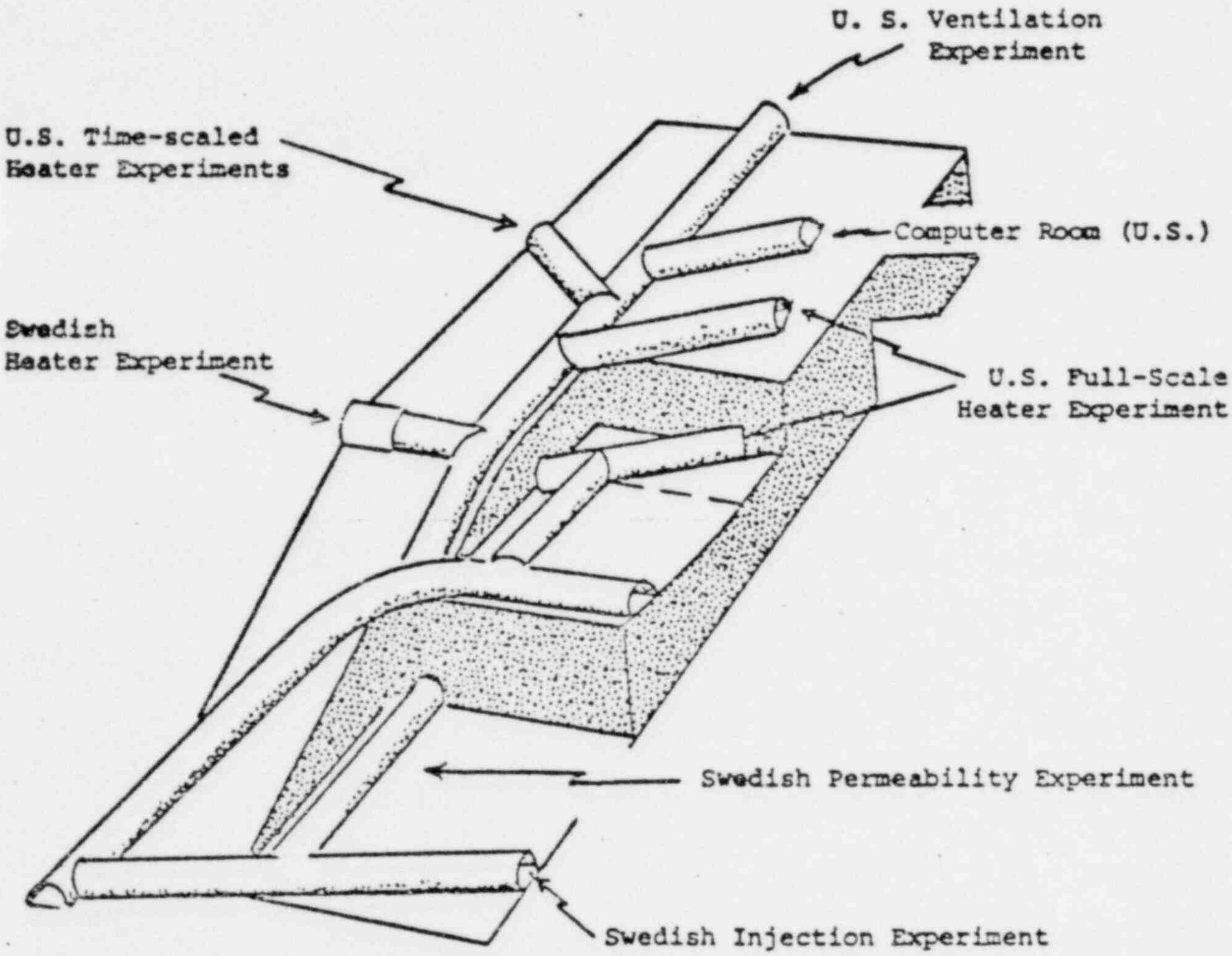
- Establish Design Parameters For Waste Repositories From Large-Scale Field Experiments in Granite
- Develop New Instruments and Techniques for Large-Scale Field Tests
- Collect Data For Development and Validation of Predictive Models
- Promote International Exchange of Information and Ideas



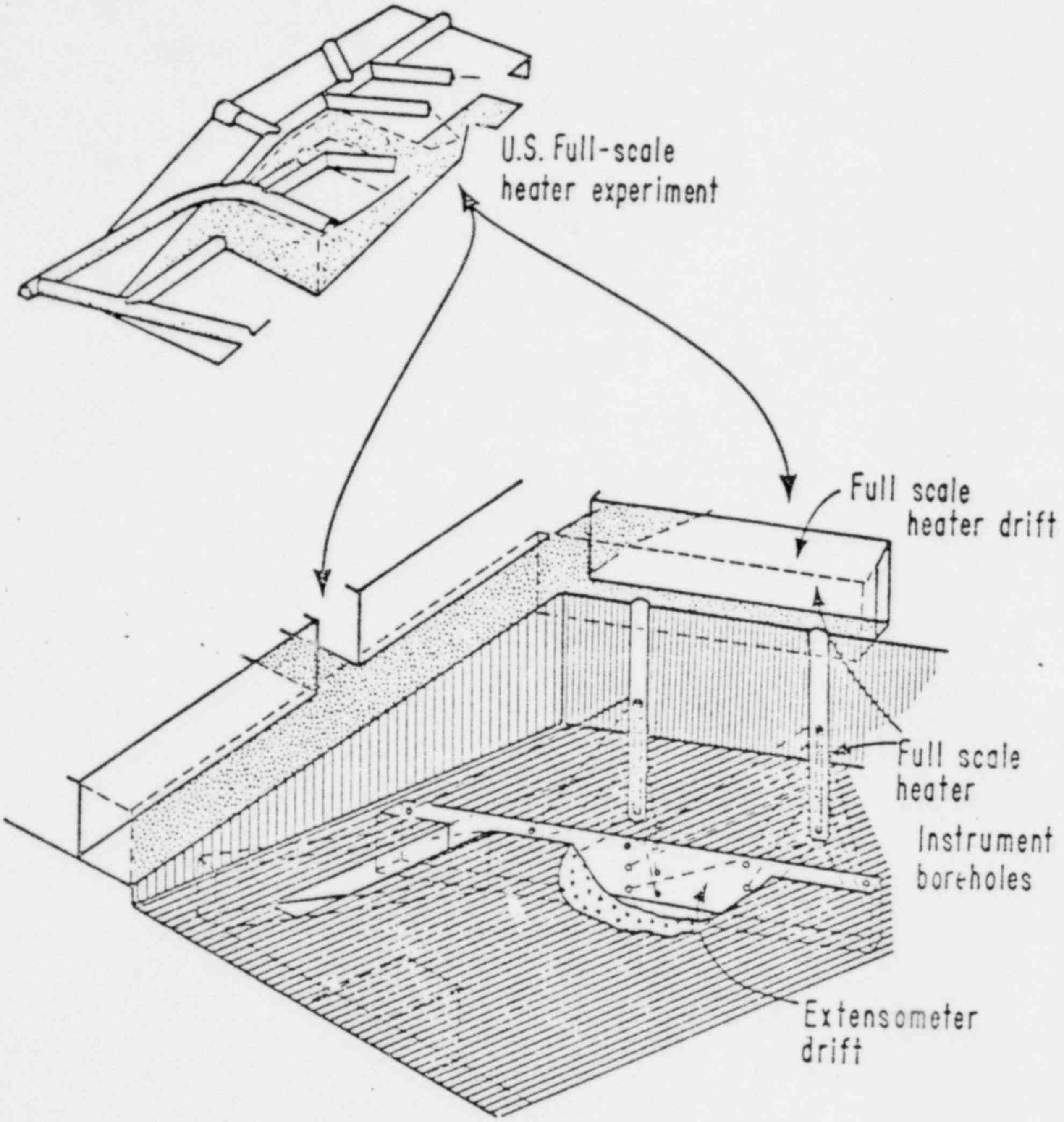
LOCATION OF STRIPA MINE



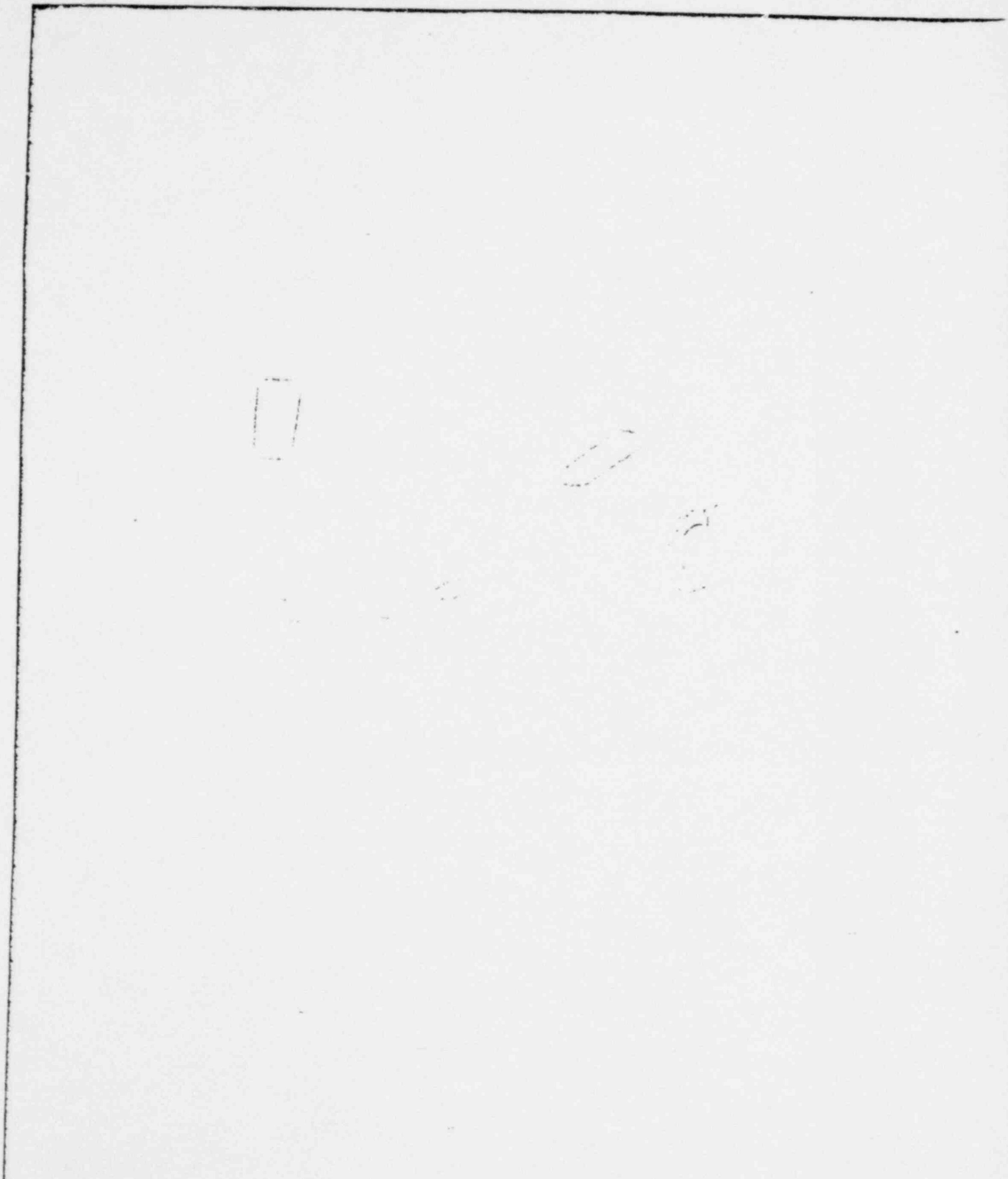
The LBL program of investigations at Stripa.



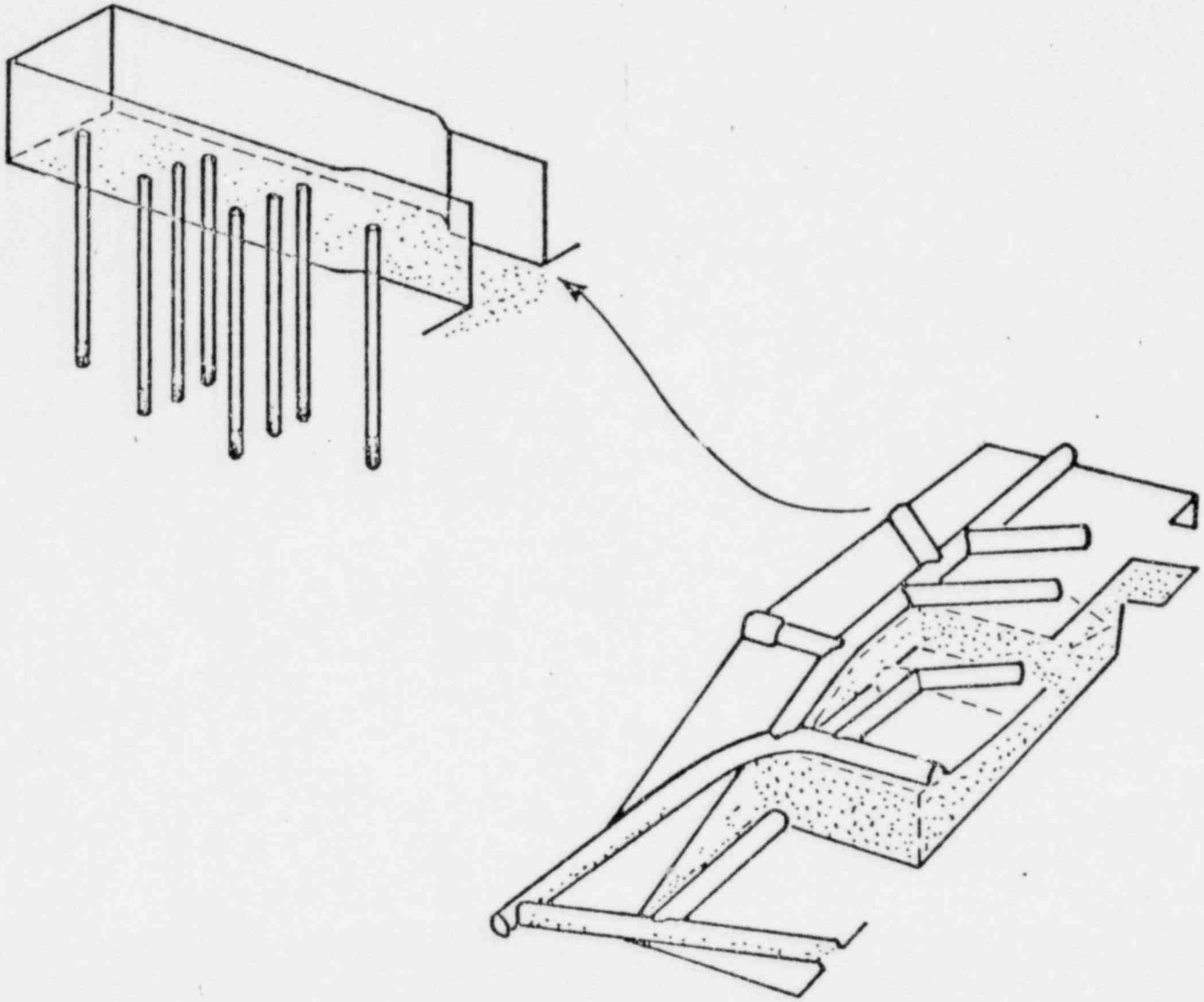
Location of experimental rooms in granite rock mass at Stripa.



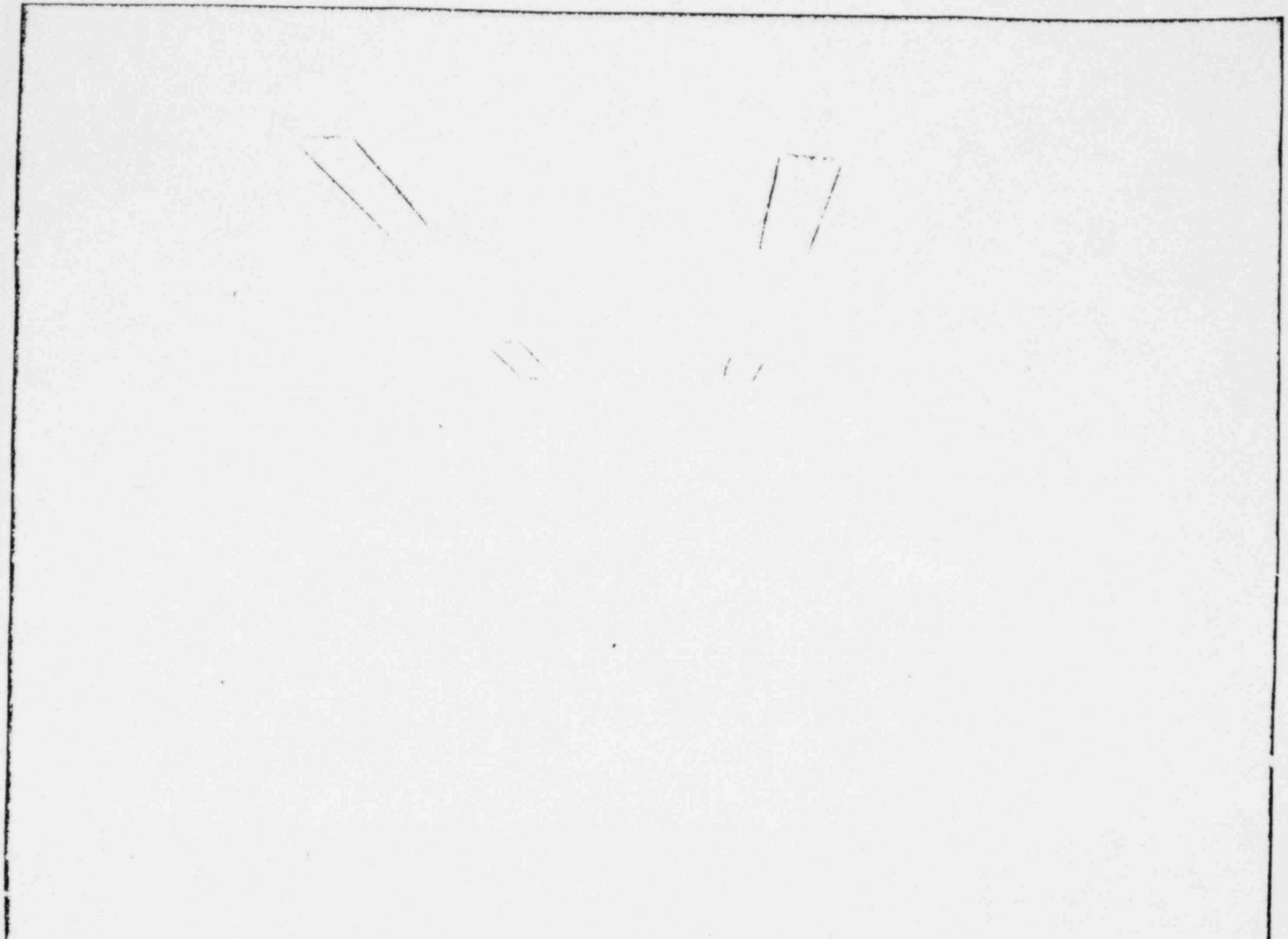
Cutaway Drawing of Full-Scale Heater Experiment



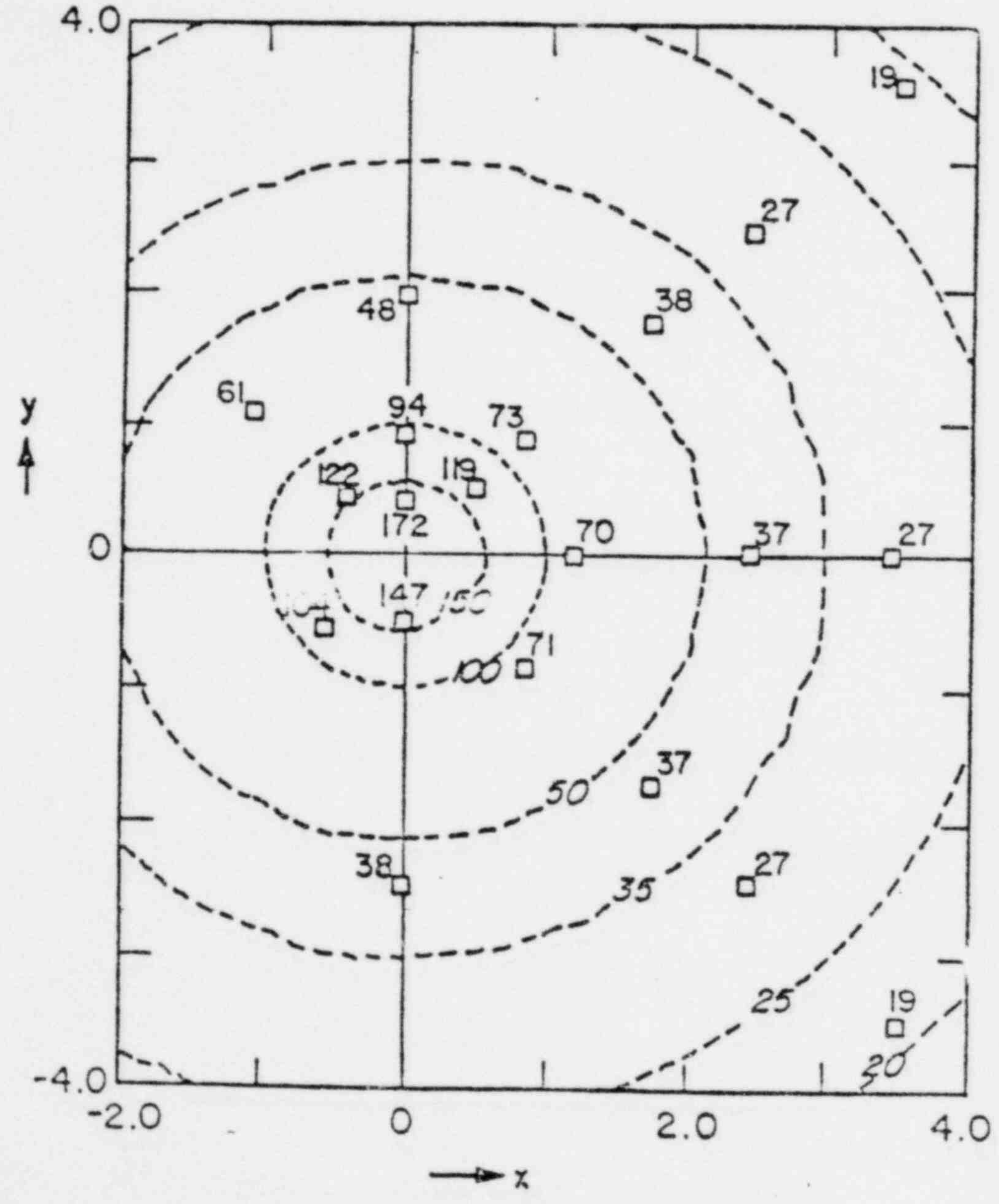
PHOTOGRAPH OF FULL-SCALE HEATER EXPERIMENT



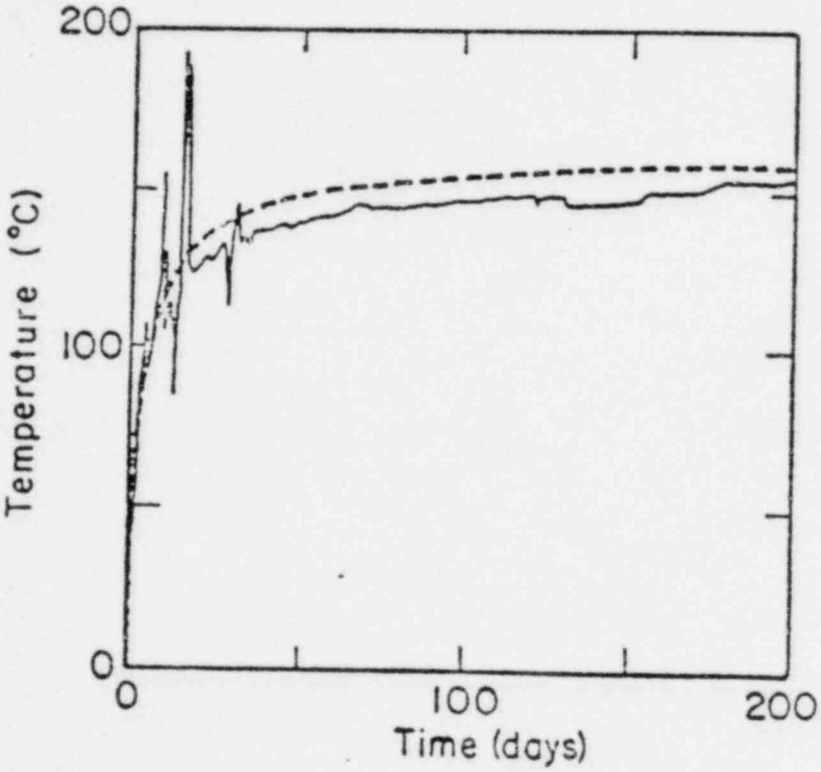
Isometric View of Time-Scaled Heater Experiment



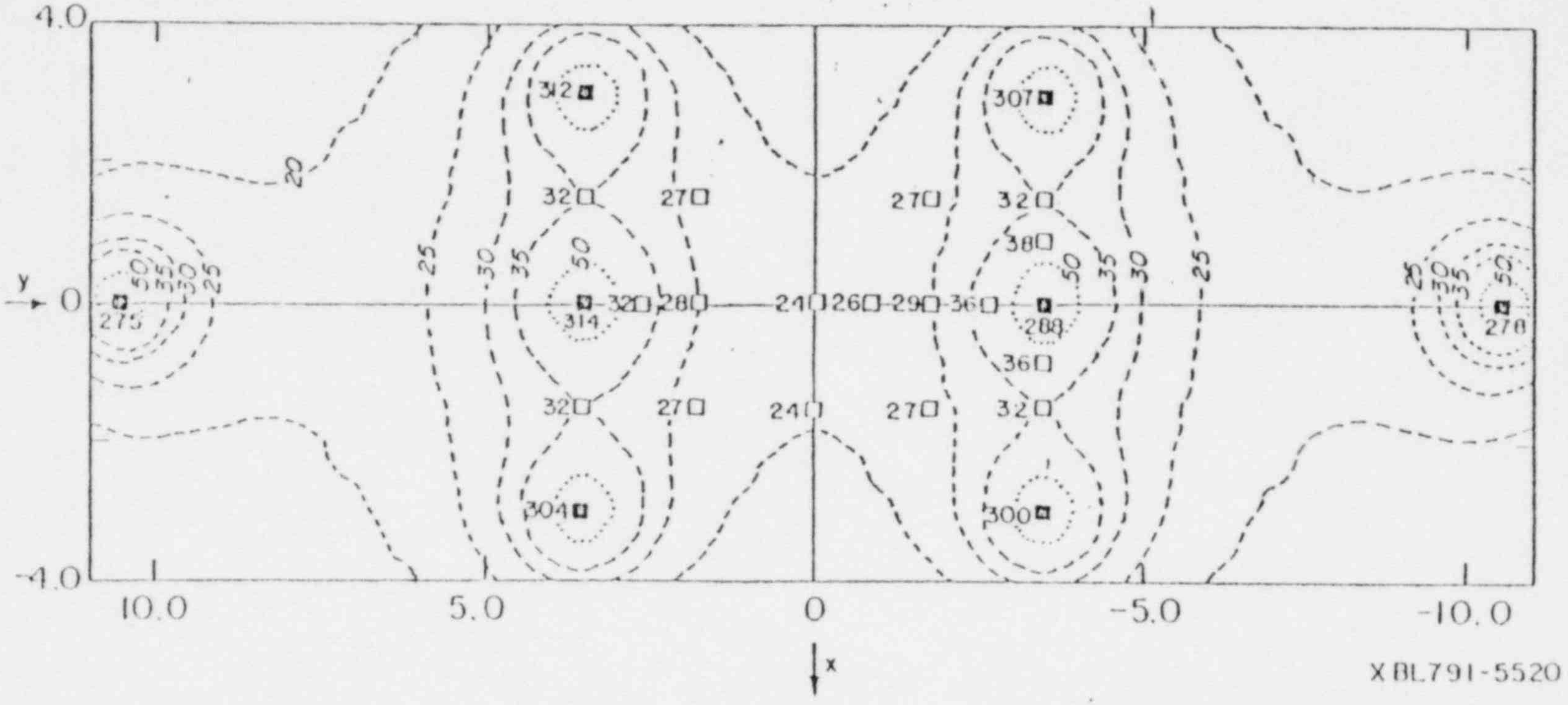
Photograph of Time-Scaled Heater Room



Full-Scale Heater Results - Predicted vs Measured Temperatures, 190 Days After Heating Had Started

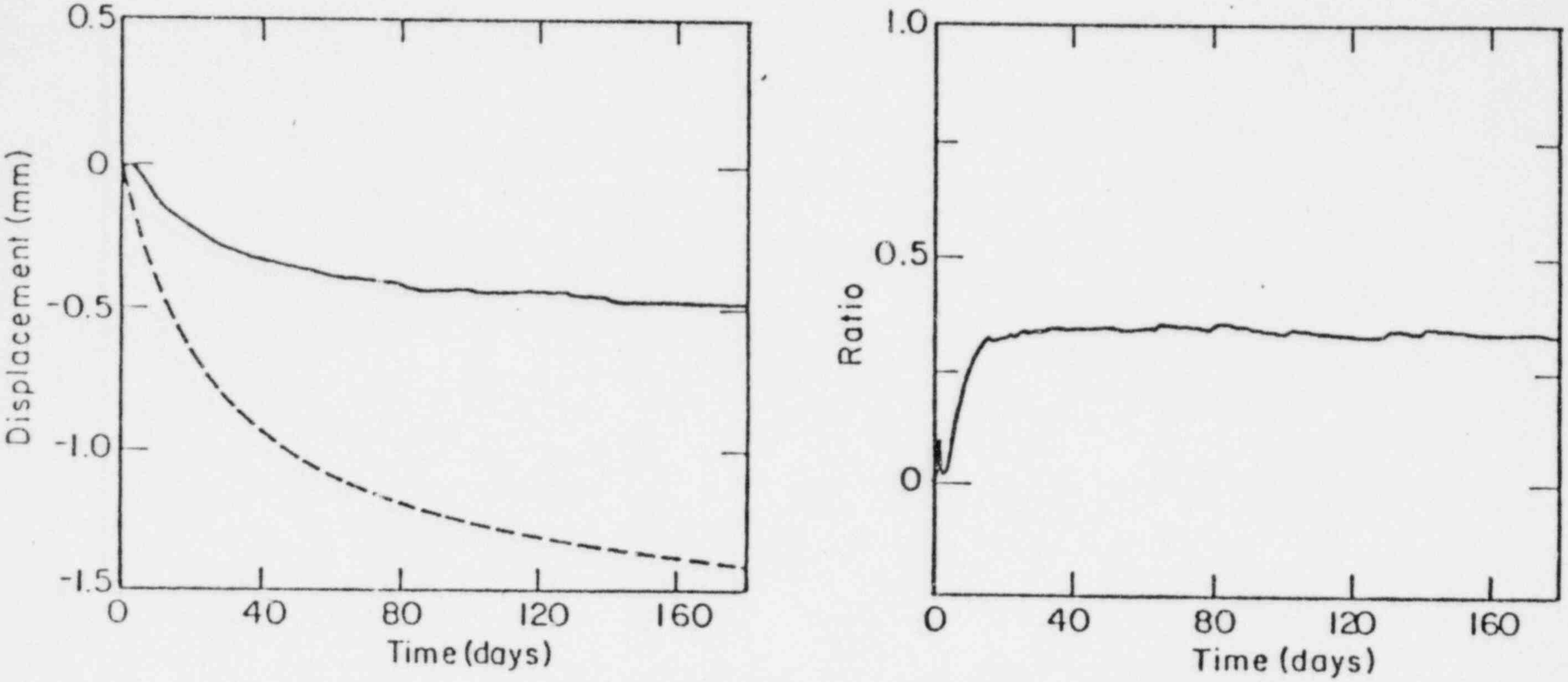


Full-Scale Heater Results - Predicted vs Measured Temperatures at Radius of 0.5 m from 5 kw Heater

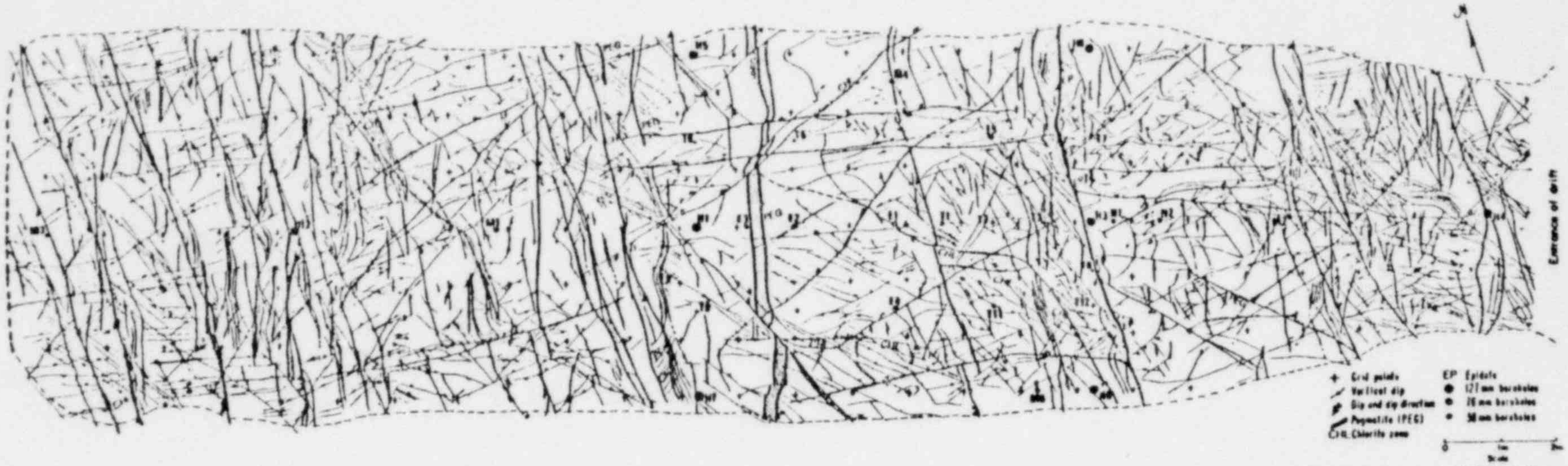


XBL791-5520

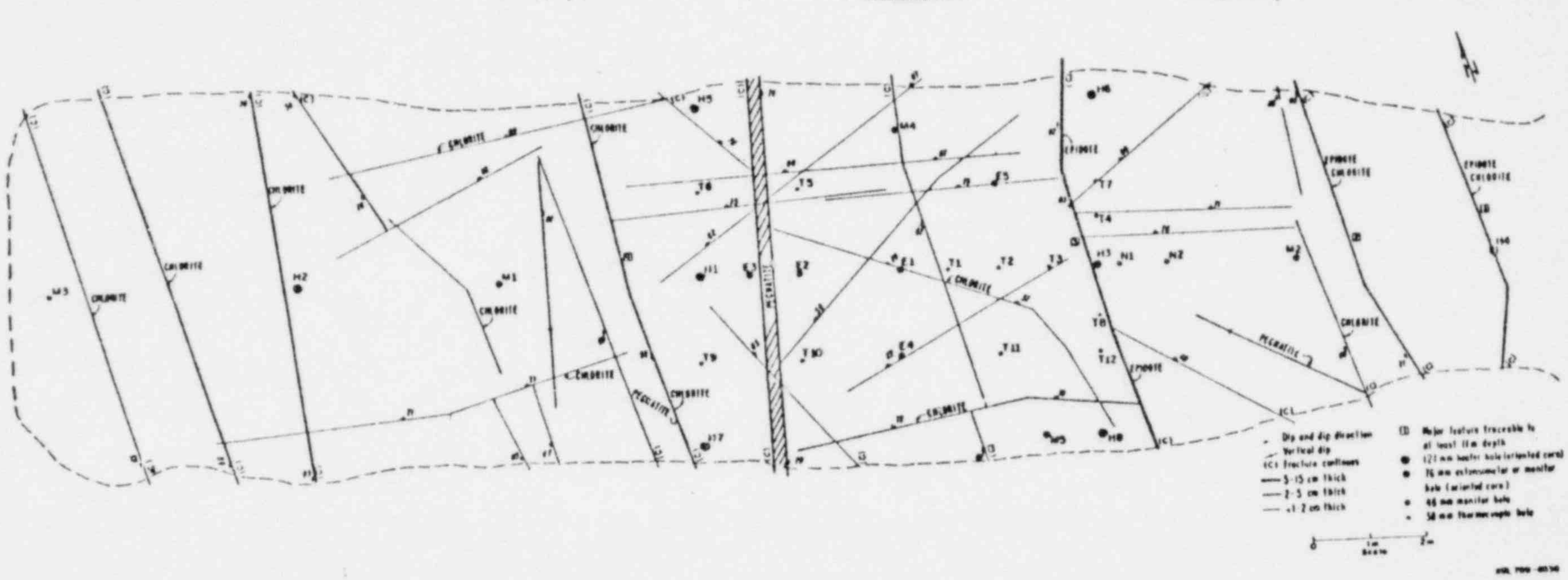
Predicted isotherms and measured temperatures in a horizontal plane through the center of the time-scale heaters 190 days after the start of the experiment. Heater locations are marked in black. (Scales for both x and y axes are given in meters.)



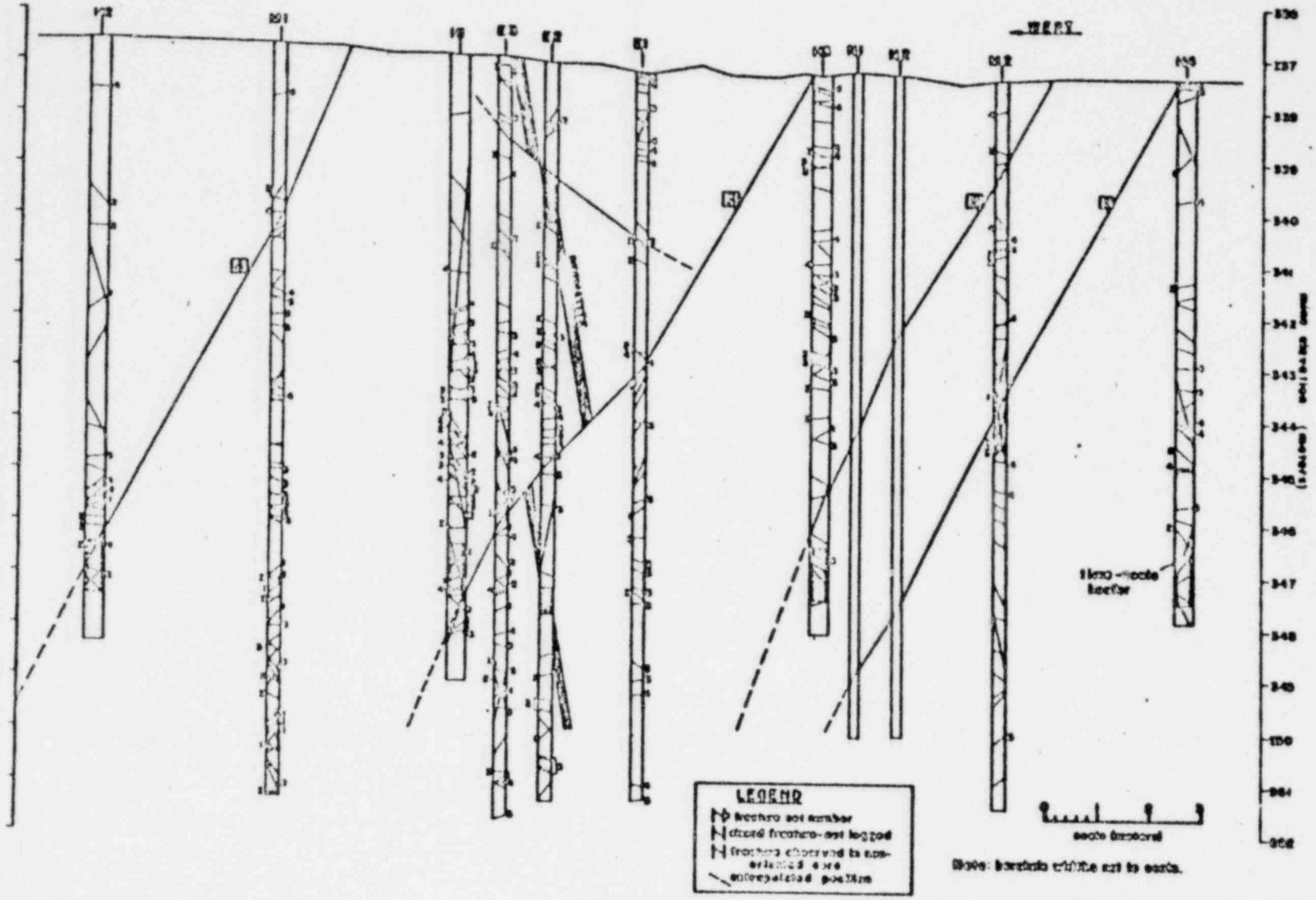
FULL-SCALE HEATER RESULTS - PREDICTED VS MEASURED DISPLACEMENTS BETWEEN ANCHOR POINTS 3 M ABOVE AND 3 M BELOW HEATER MIDPLANE OF 5 KW HEATER



Detailed fracture map TSE drift floor

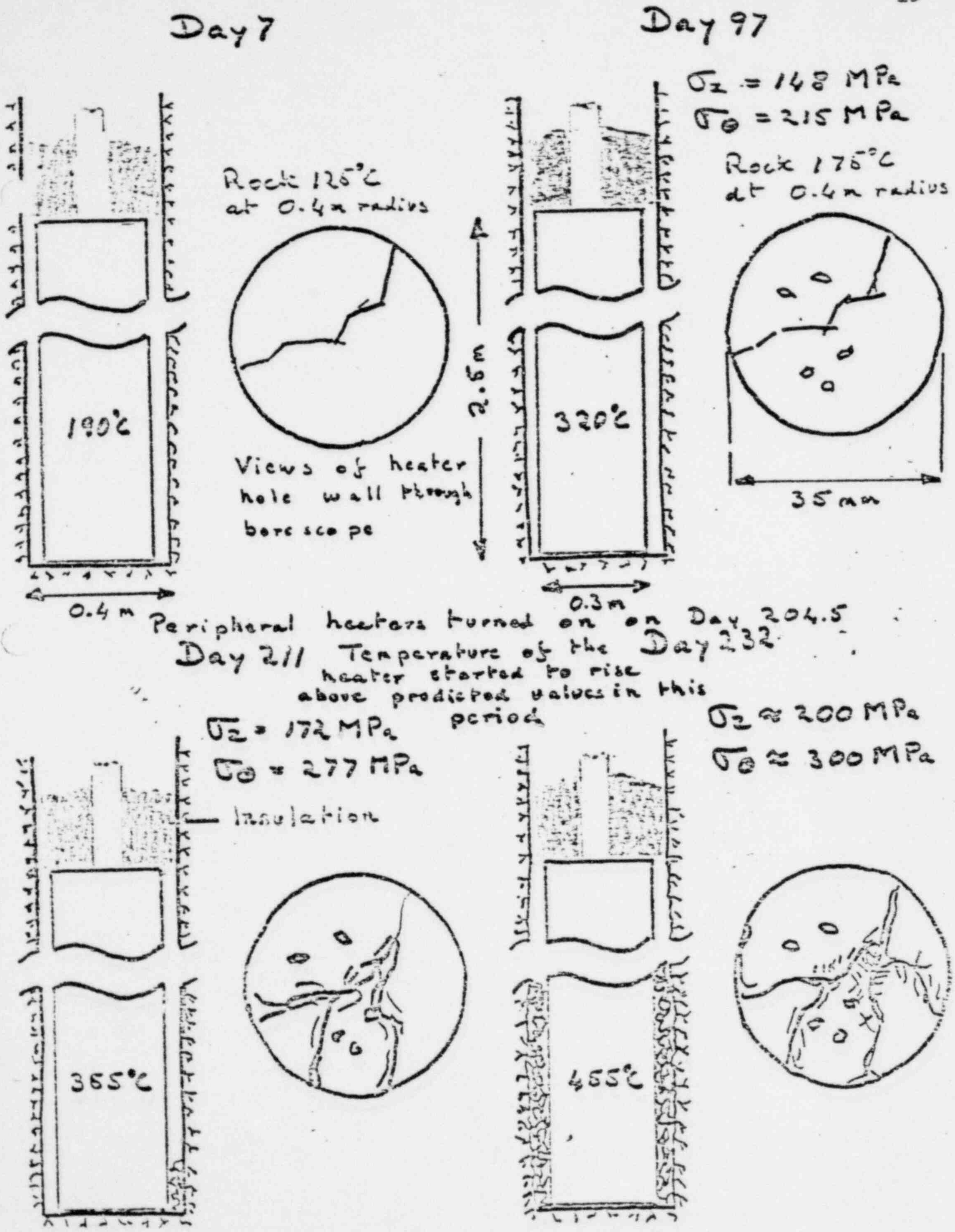


RESULTS OF FRACTURE MAPPING IN TIME-SCALED HEATER ROOM - PLAN VIEW



Results of Fracture Mapping in Time-Scaled

Heater Room - Vertical Section

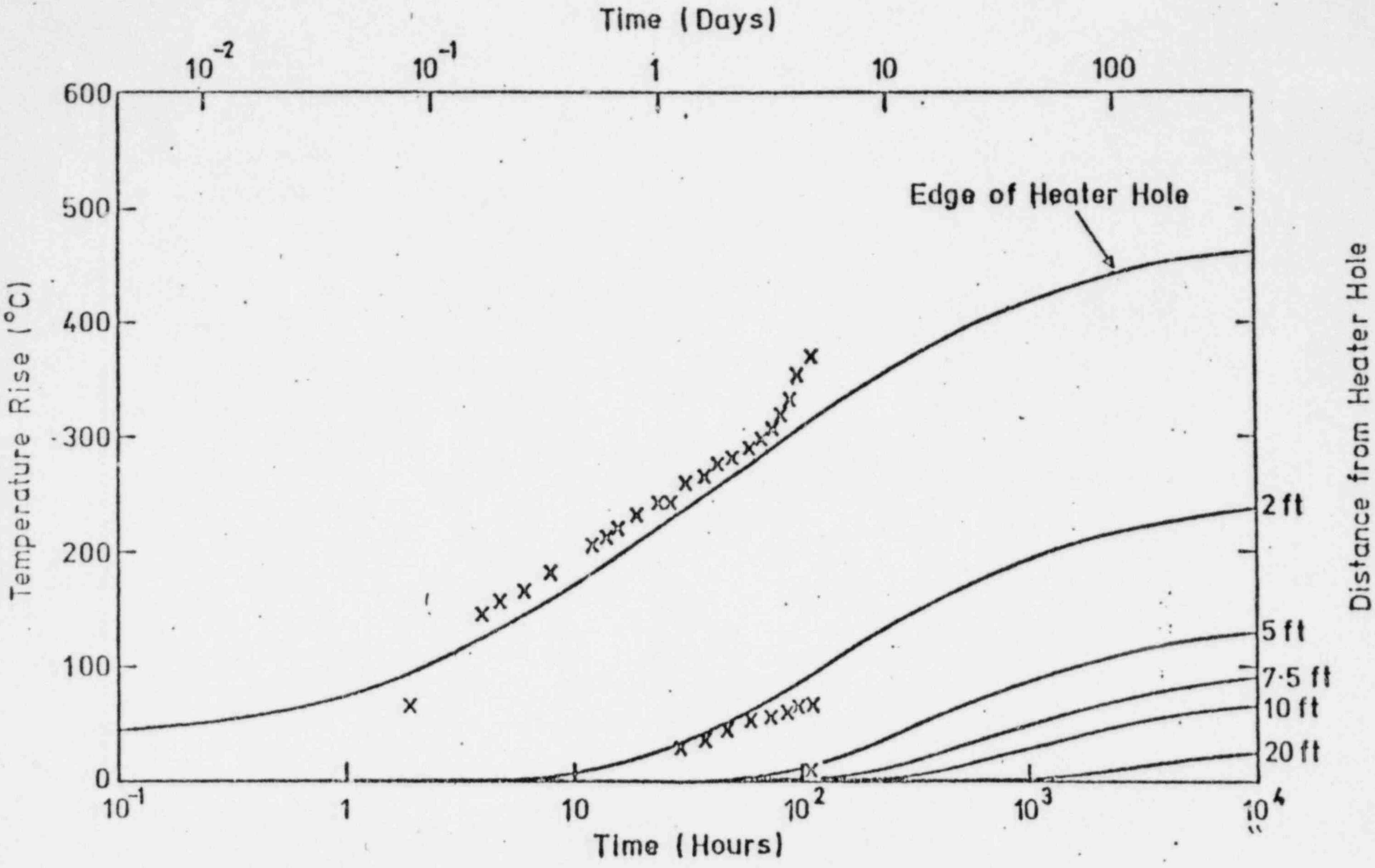


Views of heater hole wall through borescope

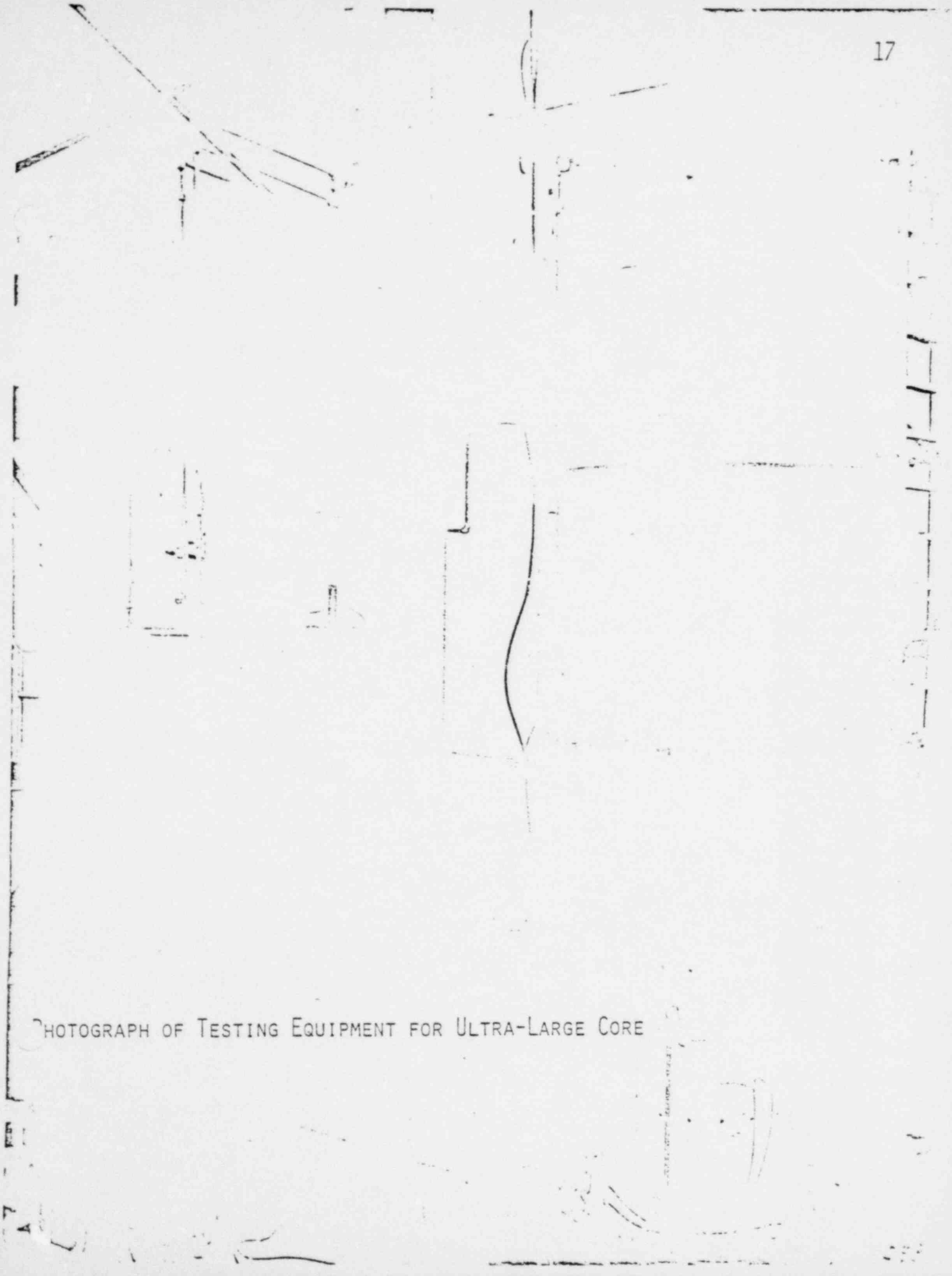
Peripheral heaters turned on on Day 204.5

Day 211 Temperature of the heater started to rise above predicted values in this period Day 232

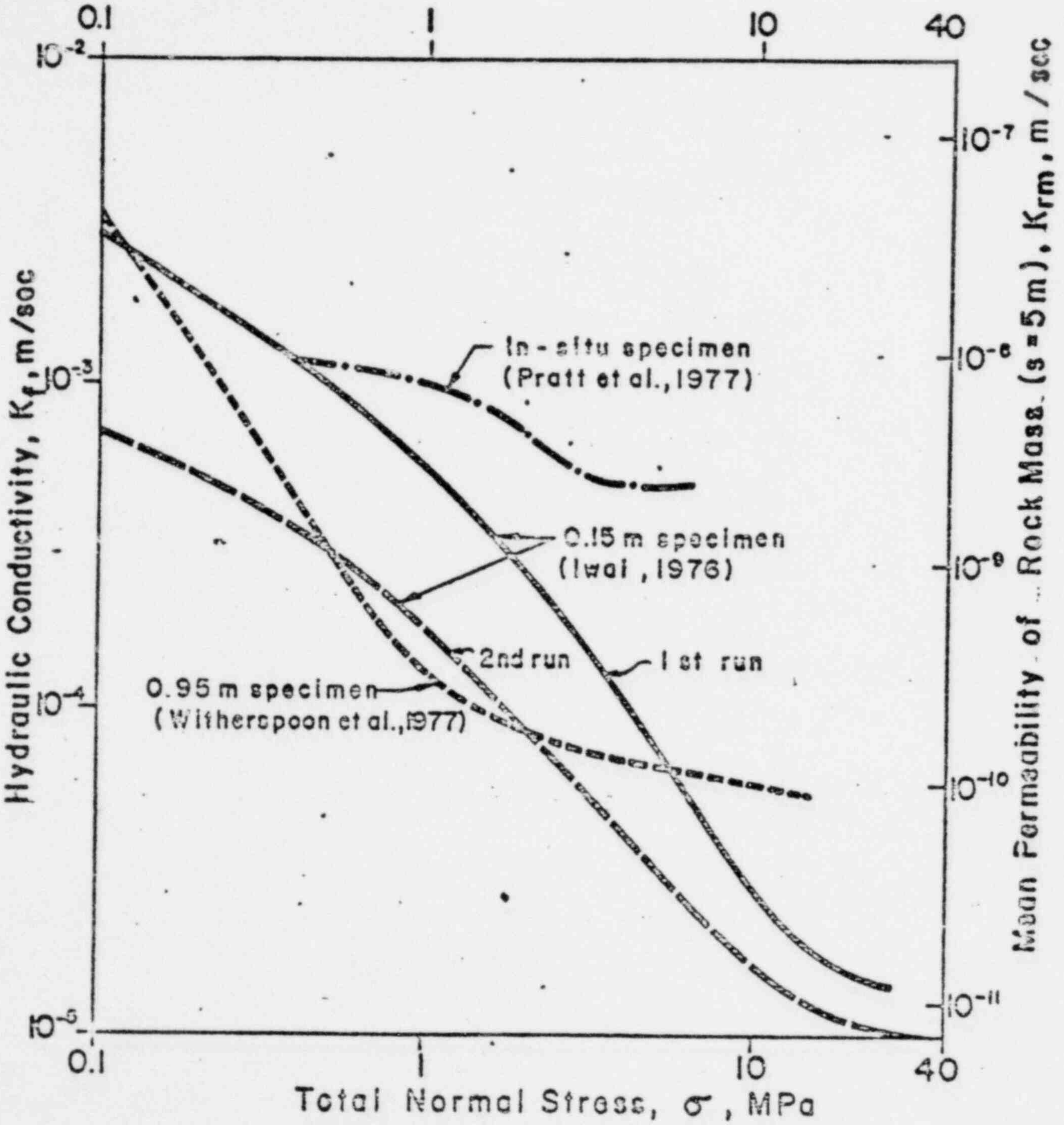
RESULTS OF H-10 HEATER WALL DECREPITATION AT STRIPA



Harwell results of temperature rise vs. time from surface heater tests in Cornwall, England.

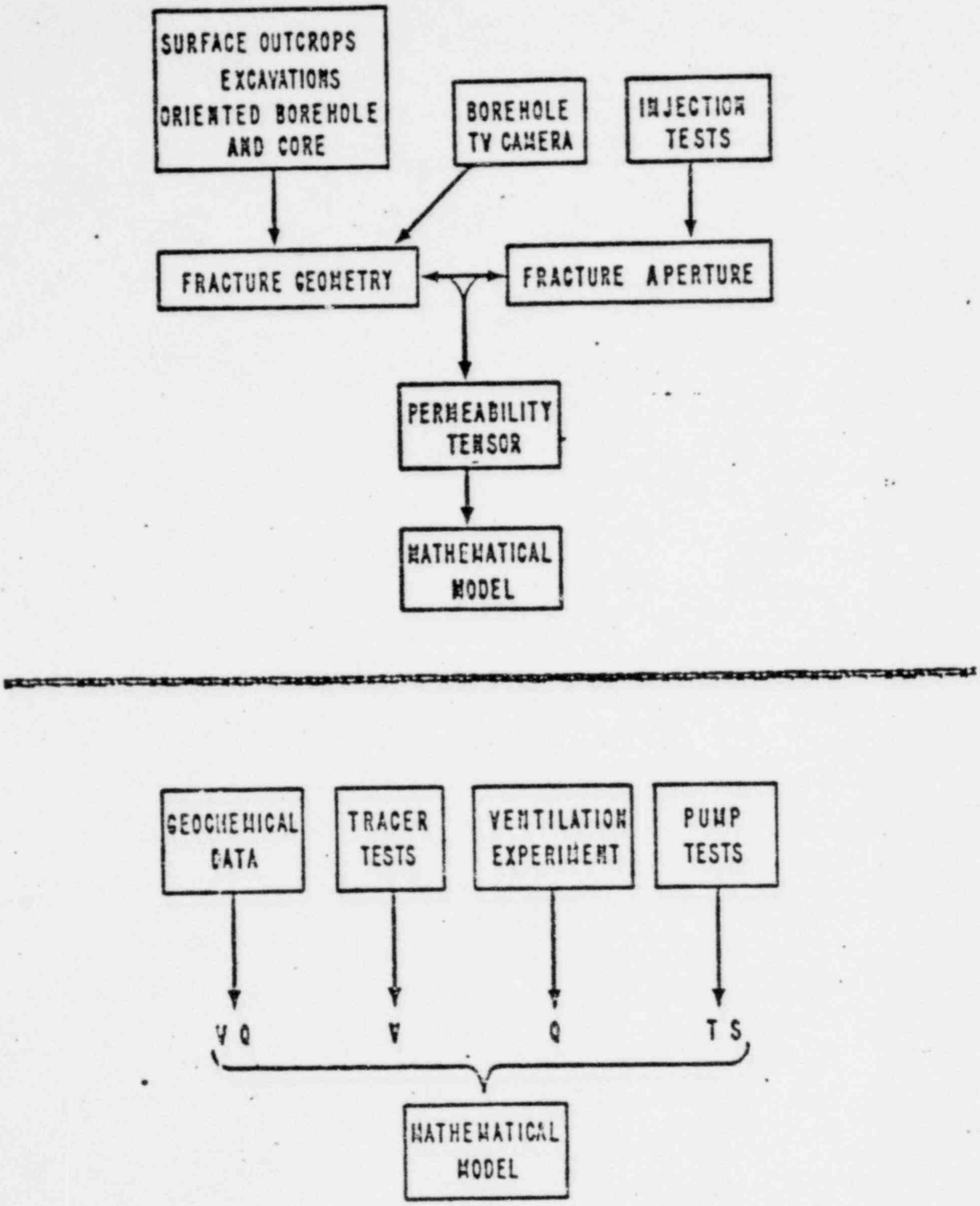


PHOTOGRAPH OF TESTING EQUIPMENT FOR ULTRA-LARGE CORE

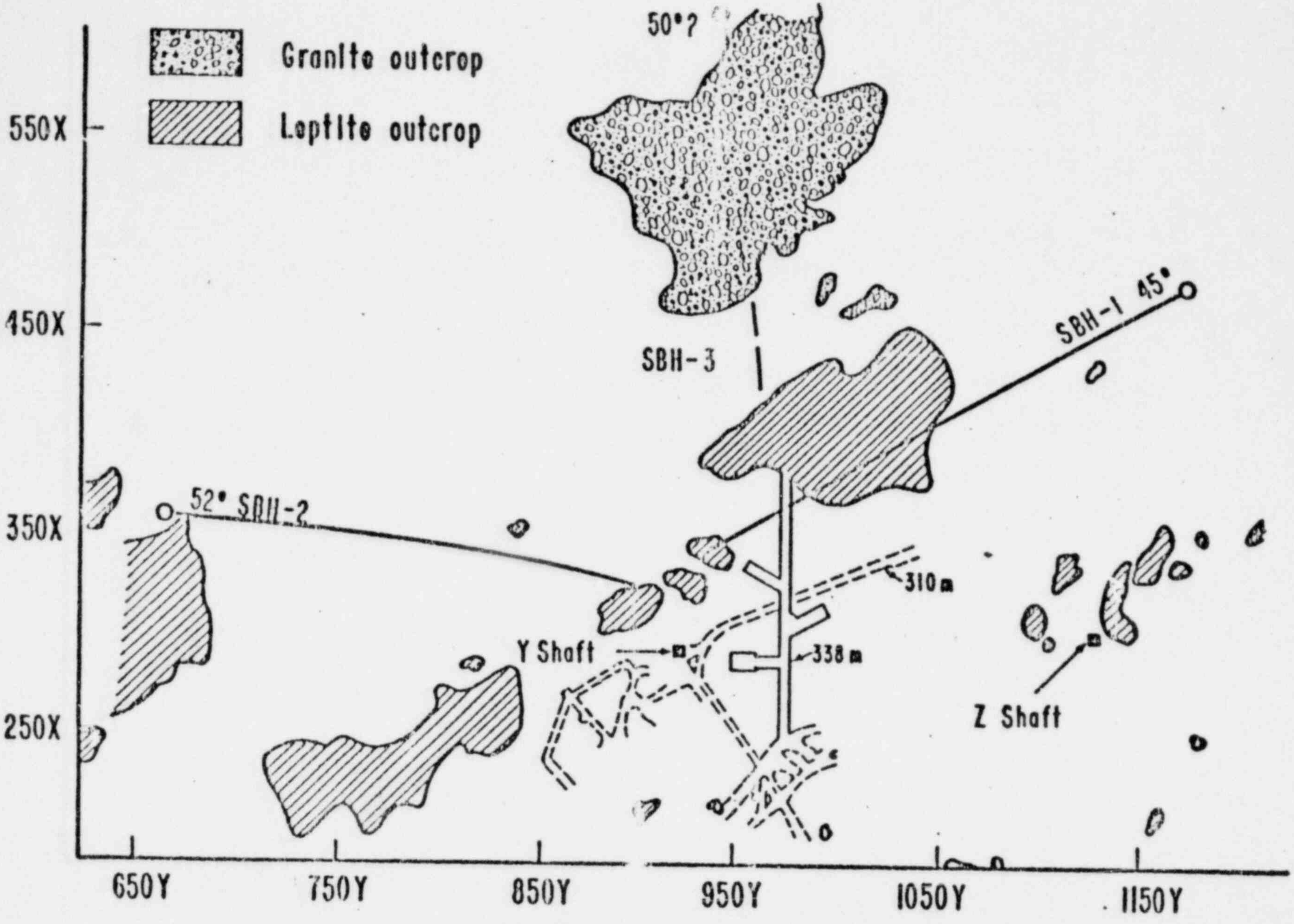

0.1
1
10
40
10^{-2}
10^{-3}
10^{-4}
10^{-5}
10^{-7}
10^{-8}
10^{-9}
10^{-10}
10^{-11}
In-situ specimen
(Pratt et al., 1977)
0.15 m specimen
(Iwai, 1976)
2nd run
1 st run
0.95 m specimen
(Witherspoon et al., 1977)
Hydraulic Conductivity, K_f, m/sec
Mean Permeability of Rock Mass (s = 5 m), K_{rm}, m/sec
0.1
1
10
40
Total Normal Stress, σ, MPa

Photograph of 1-meter core from Stripa Granite

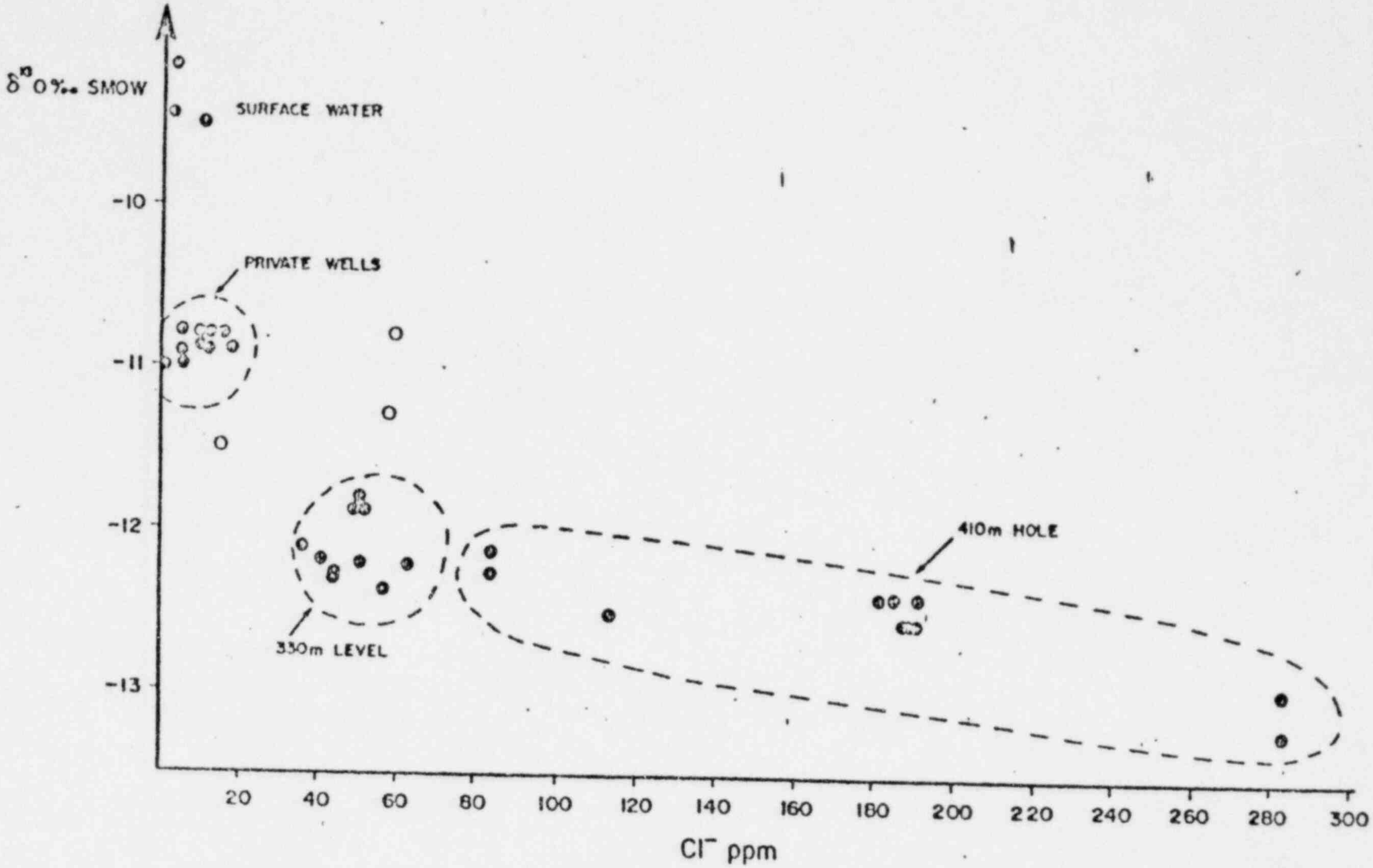
FRACTURE HYDROLOGY STUDIES AT STRIPA



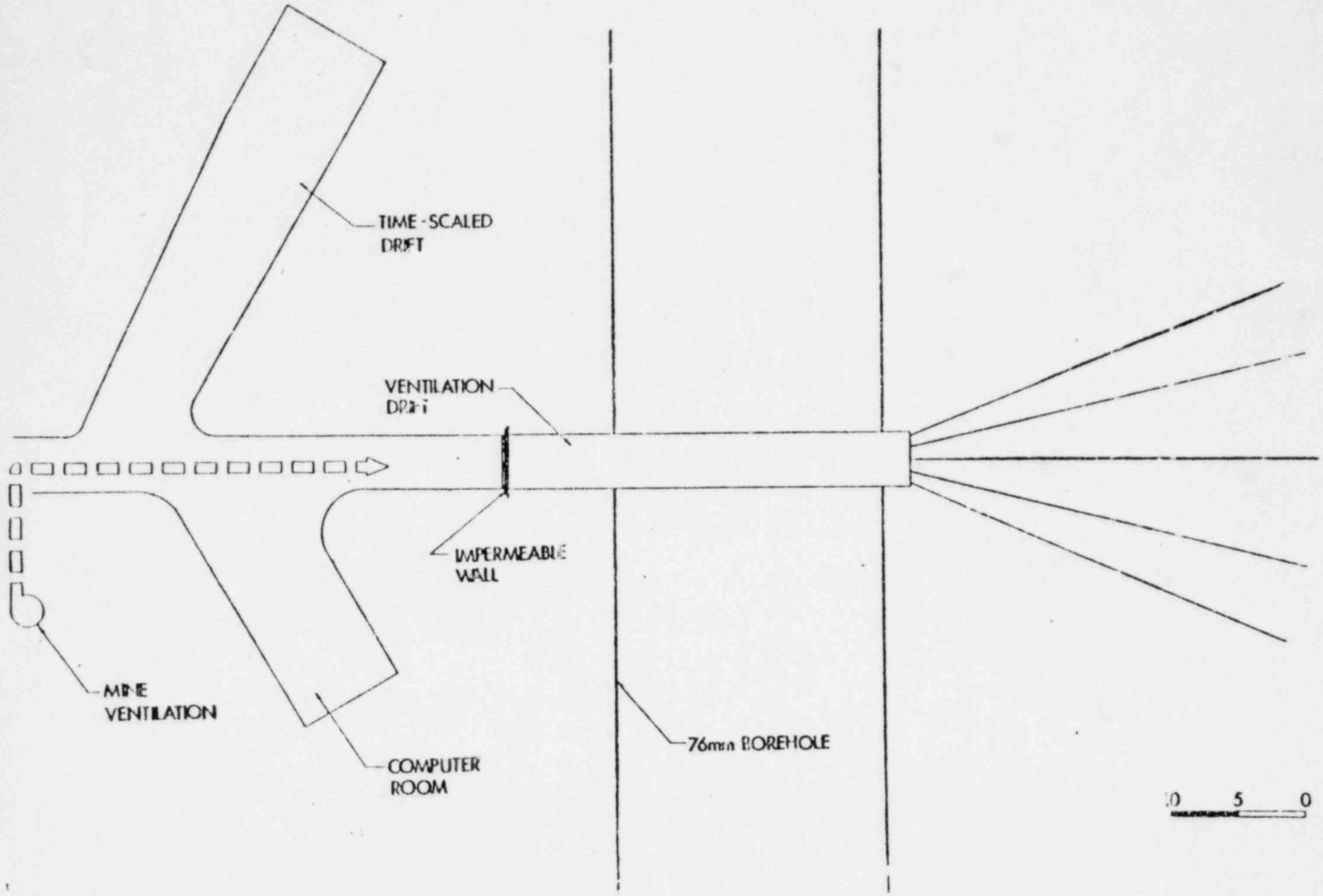
FRACTURE HYDROLOGY PROGRAM OF INVESTIGATIONS AT STRIPA



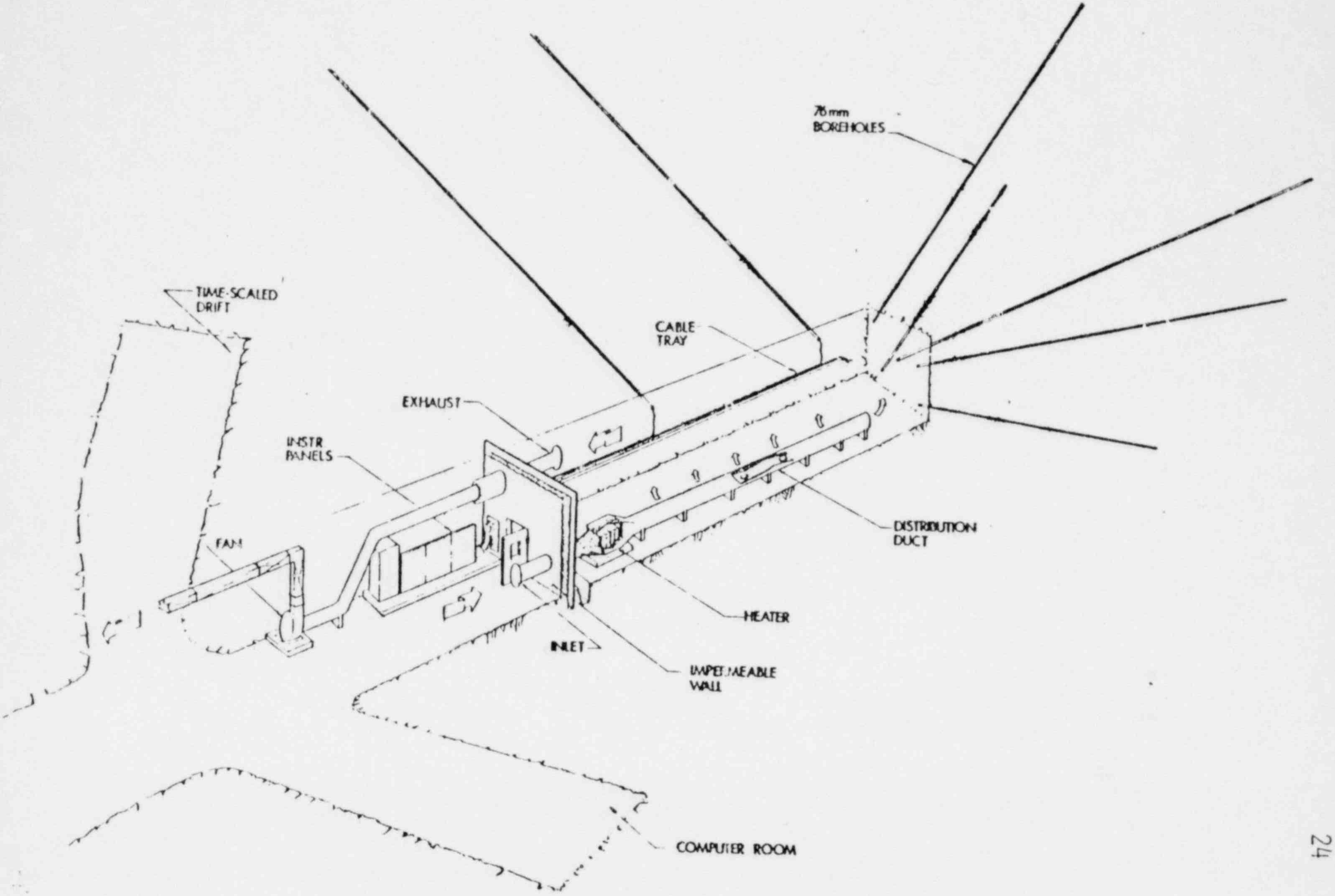
Plan View of Stripa Project Showing Location of Boreholes



A plot of $\delta^{18}O$ versus chloride concentration for waters of the Stripa area. Sample of shallow (private wells), intermediate (330-m-level) and deeper (410-m-level) groundwaters are outlined.



Plan Layout of Ventilation Room Showing Locations of 76 mm Boreholes



Isometric View of Ventilation Room Showing Ductwork and Instrument Panels

WHAT HAVE WE LEARNED FROM STRIPA PROJECT?

1. Heat Transfer in Fractured Rocks -- By Conduction <u>PREDICTABLE</u>
2. Thermally Induced Rock Movements -- Non-Linear <u>NOT YET PREDICTABLE</u>
3. Further Development of Instrumentation Needed for Stress Determination
4. Decrepitation of Granite in Heater Holes When Stress Exceeds Compressive Strength (Approximately 300° C at Stripa)
5. Laboratory Measurement Fracture Permeability May Depend on Core Size
6. Accurate Fracture Mapping Needed to Understand:
   - A. Thermal-Mechanical Rock Response
   - B. Groundwater Movement Over Total Flow System
7. Geochemistry and Isotope Hydrology Results Indicate Deep (>330 m) Underground Waters Very Old - Over 25,000 Years
8. Method Needed to Convert Micromeasurement of Fracture Permeability to Global Value for Total Flow System (Ventilation Experiment -- First Step)

5

FUEL ELEMENT SURFACE TESTS

AND

SPENT FUEL PACKAGING

4/16/79

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Project Management Division
Office of Nuclear Waste Isolation

SURFACE TESTS

DRY SURFACE STORAGE DEMONSTRATION

OBJECTIVE: TO DEMONSTRATE DRY SURFACE CONCEPTS AND THE DESIGN, FABRICATION, PACKAGING, AND PERFORMANCE OF SPENT FUEL UNDER NEAR GEOLOGIC CONDITIONS

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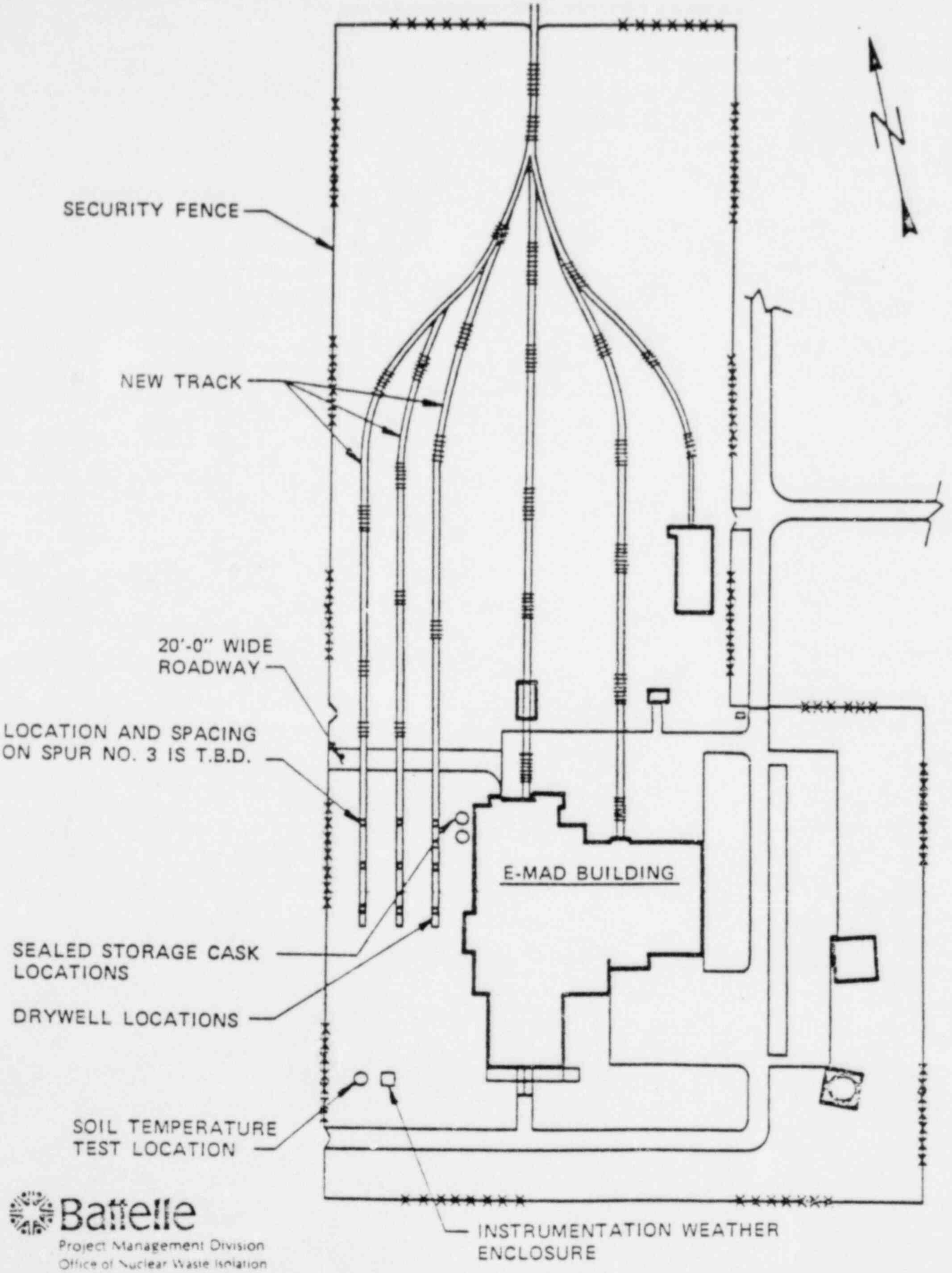
E-MAD STORAGE SITE ARRANGEMENT



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DRY SURFACE STORAGE DEMONSTRATION

MAJOR FEATURES

- TWO DRY STORAGE MODES
  - SEALED STORAGE CASK
  - DRYWELL
- PWR AND BWR SPENT FUEL
  - 4 PWR PACKAGES
  - 1 BWR PACKAGE
- NON-DESTRUCTIVE PRE-EXAMINATION ASSEMBLIES - REPORT TC-1284
  - SIP TESTING FOR PIN FAILURES
  - VISUAL EXAMINATION AND RECORD
  - DIMENSIONAL MEASUREMENTS (BOW, LENGTH, FLAT-FLAT)
  - WEIGHT
  - PROFILOMETRY (DIAMETER AND OVALITY)
  - EDDY-CURRENT EXAMINATION
  - GAMMA SCANNING
  - GAMMA AND NEUTRON FLUX

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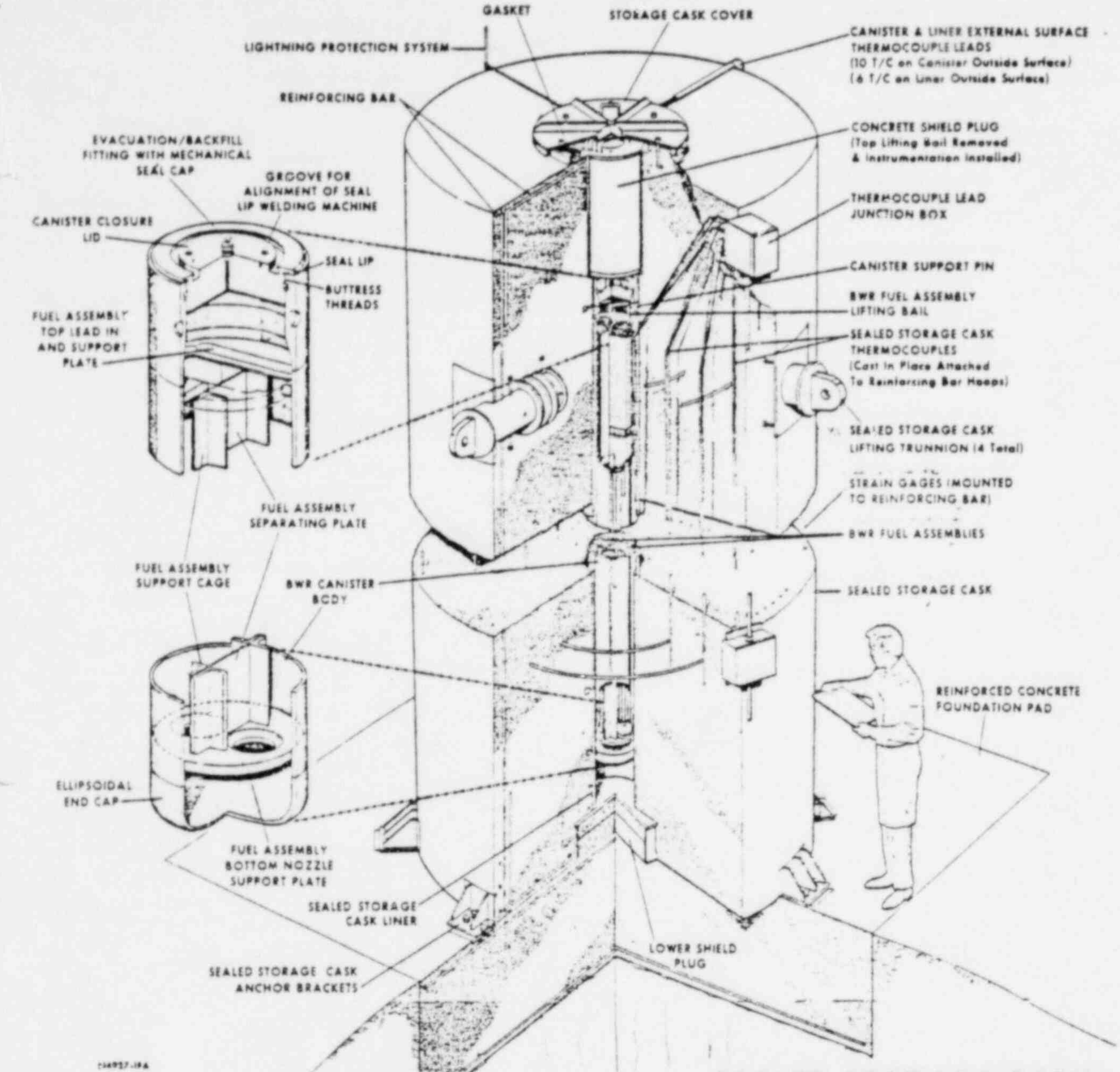

SEALED STORAGE CASK ARRANGEMENT FOR THE CY 1978 SPENT FUEL HANDLING AND PACKAGING PROGRAM DEMONSTRATION

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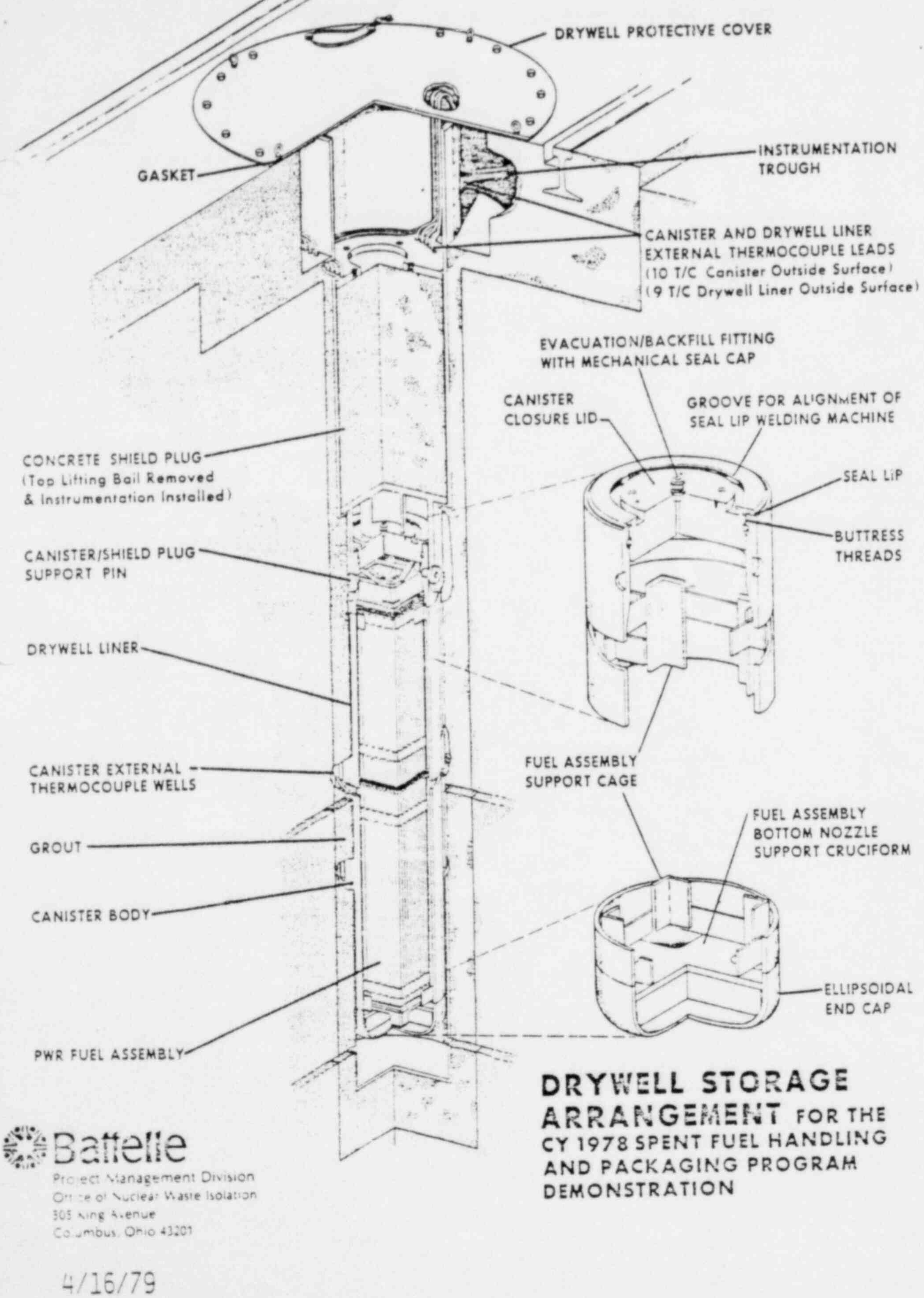

DRYWELL STORAGE ARRANGEMENT FOR THE CY 1978 SPENT FUEL HANDLING AND PACKAGING PROGRAM DEMONSTRATION

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MAJOR FEATURES (CONTINUED)

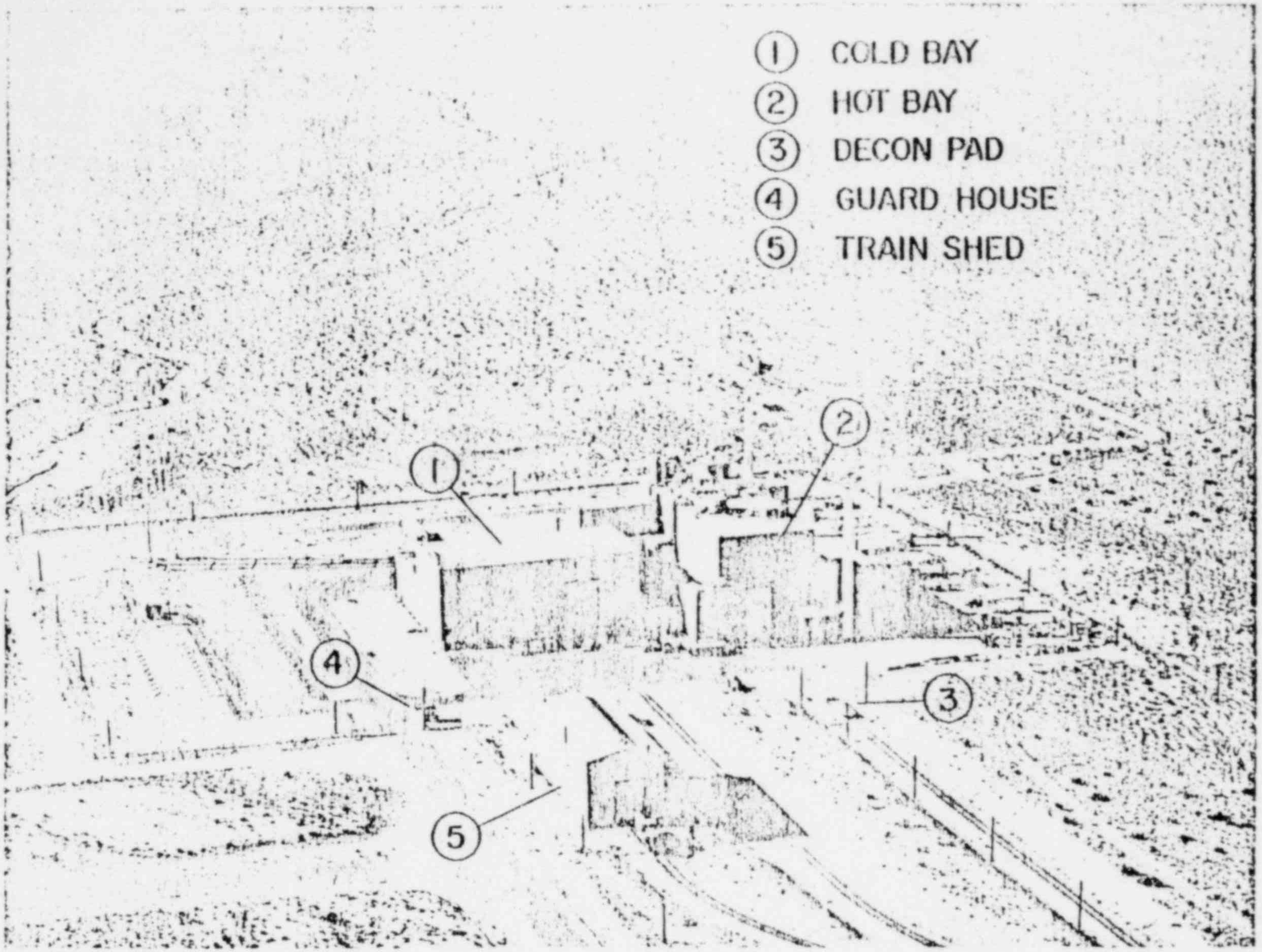
- PACKAGE AND GROUND TEMPERATURES - SSC STRAIN MEASUREMENTS
- MATERIALS INTERACTION TEST - REPORT NUMBERS TC-1226 AND TC-1283
  - 7 TEST CAPSULES TO TEST FOR COMPATIBILITY, STRUCTURAL BEHAVIOR, AND CHEMICAL TRANSFORMATION
  - GEOLOGIC SAMPLES INCLUDE TUFF, GRANITE, BASALT, ARGILLITE
- SPENT FUEL PACKAGE
  - WHOLE FUEL ASSEMBLY
  - STAINLESS STEEL CONTAINER
  - HELIUM FILLED

DRY SURFACE STORAGE DEMONSTRATION

STATUS

- PWR PACKAGE EMPLACED IN SEALED STORAGE CASK - 12/8/78
  - CANISTER TEMPERATURE AT STEADY STATE 185 F
  - SSC SURFACE RADIATION MAX READING OVER ENTIRE SURFACE 1.3 MREM/HR
- TWO PWR PACKAGES PLACED IN DRY WELLS DURING 1/79
  - CANISTER TEMPERATURE AT 235 F NEARING STEADY STATE
  - GROUND SURFACE RADIATION AT BACKGROUND LEVEL
- PROCUREMENT ACTIVITIES STARTED FOR BWR FUEL EXPECTED EMPLACEMENT - 8/79

4/16/79



E-MAD COMPLEX

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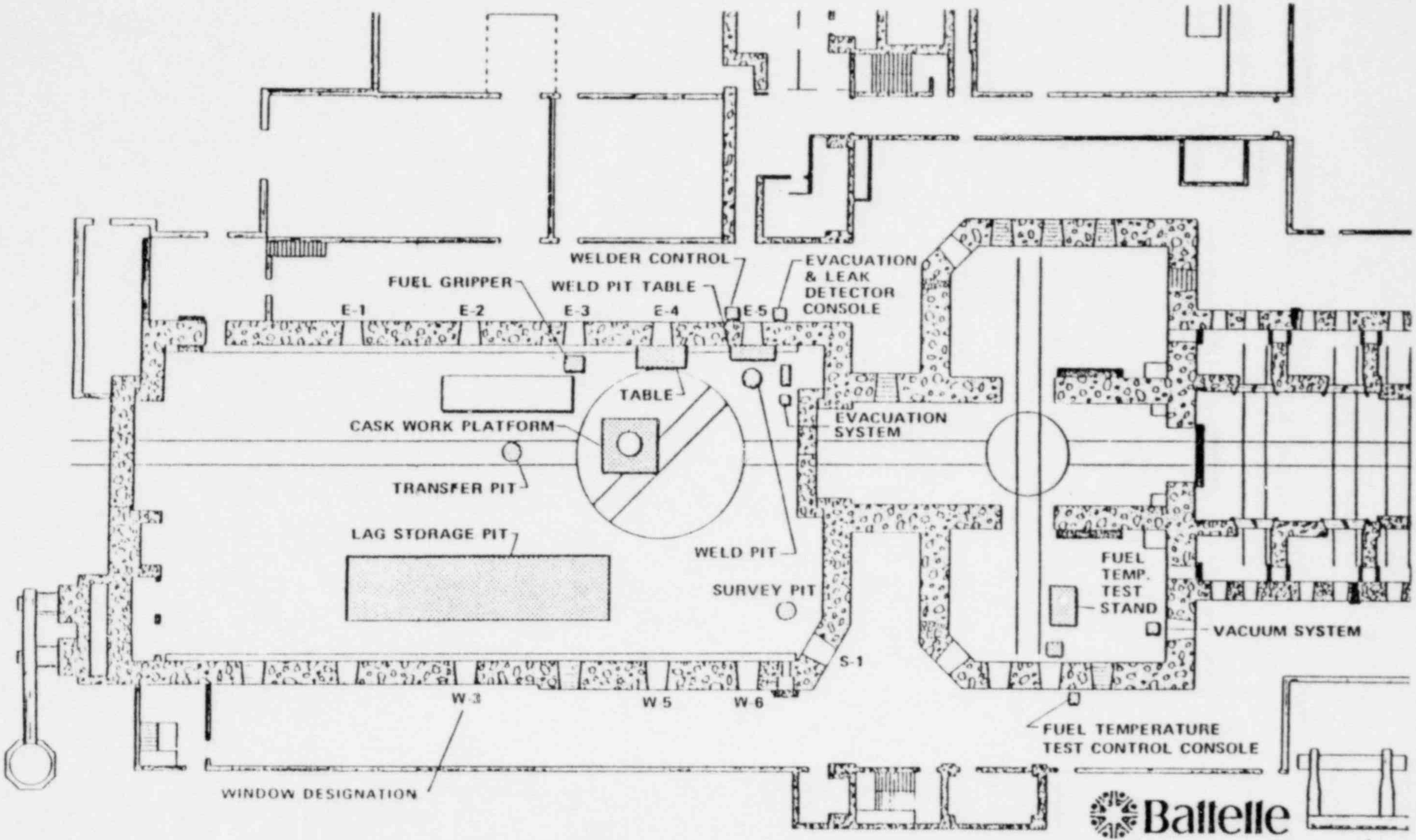
SPENT FUEL HANDLING AND PACKAGING PROGRAM DEMONSTRATION

E-MAD EQUIPMENT LAYOUT



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EMAD PACKAGING FACILITY

OBJECTIVE: TO MAINTAIN EMAD AS A FACILITY TO ENCAPSULATE AND SUPPLY WASTE PACKAGES TO NWTS WASTE DEMONSTRATIONS AND EXPERIMENTS.

IDENTIFIED PACKAGING NEEDS

NWTS PROGRAM	PACKAGE NUMBER	DATE
DRY SURFACE STORAGE	4 PWR 1 BWR	FY79
CLIMAX SFT	13 PWR (2 SPARES)	FY80
BASALT NSTF	20 PWR	FY81
SALT TEST FACILITY	20	FY82/83
WIPP EXPERIMENTAL	20	FY86
WIPP OR ISF DEMONSTRATION	1000	FY86+

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MAJOR FEATURES

PRESENTLY EXISTING

- HOT BAY ACCESS DOORS
- CASK WORK PLATFORM
- WELD PIT
- SURVEY PIT
- TRANSFER PIT
- LAG STORAGE PIT

PLANNED OR IN PROGRESS

- NON-DESTRUCTIVE FUEL ASSEMBLY CHARACTERIZATION
- CALORIMETER
- DECONTAMINATION FACILITY
- FUEL TEMPERATURE TEST RIG

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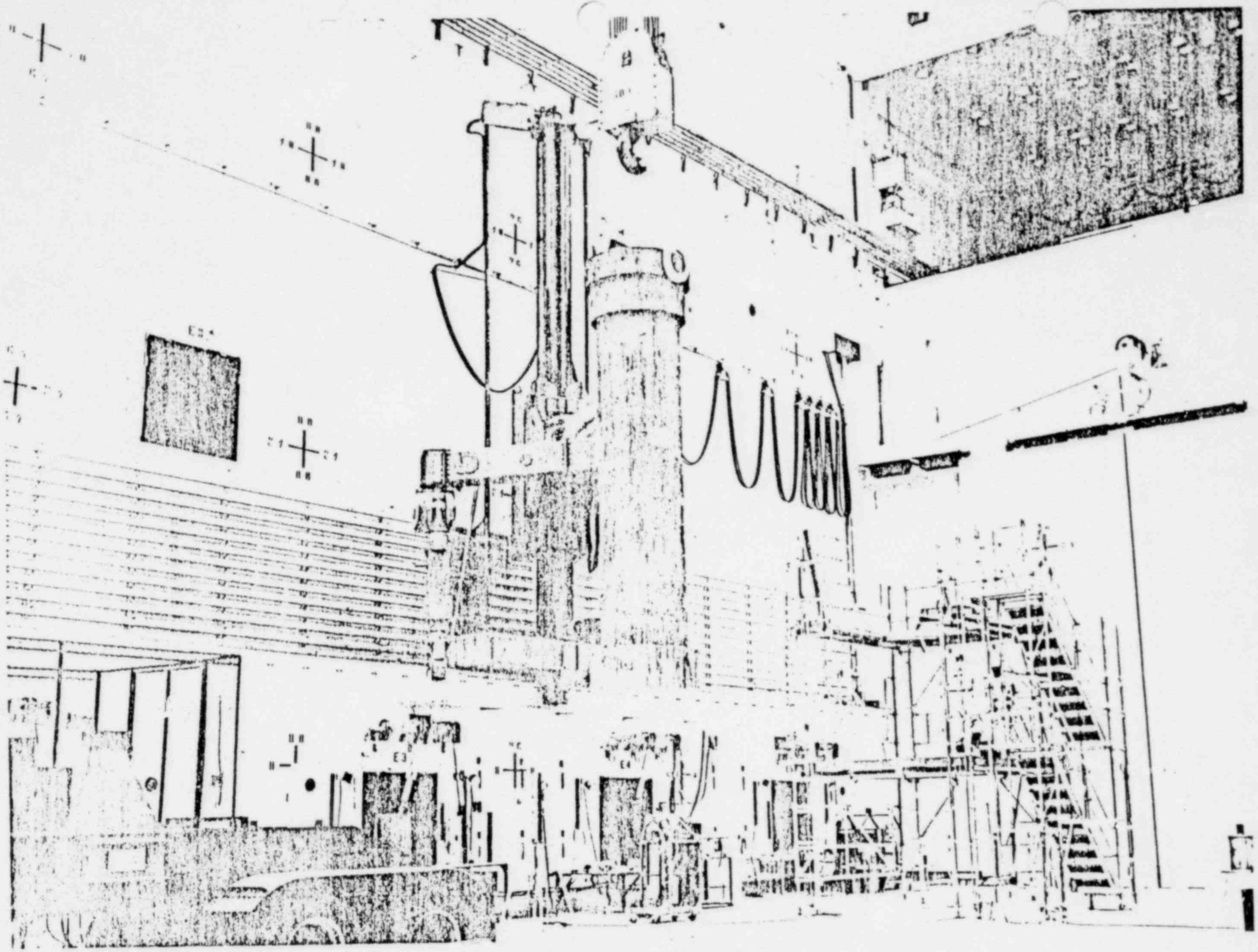
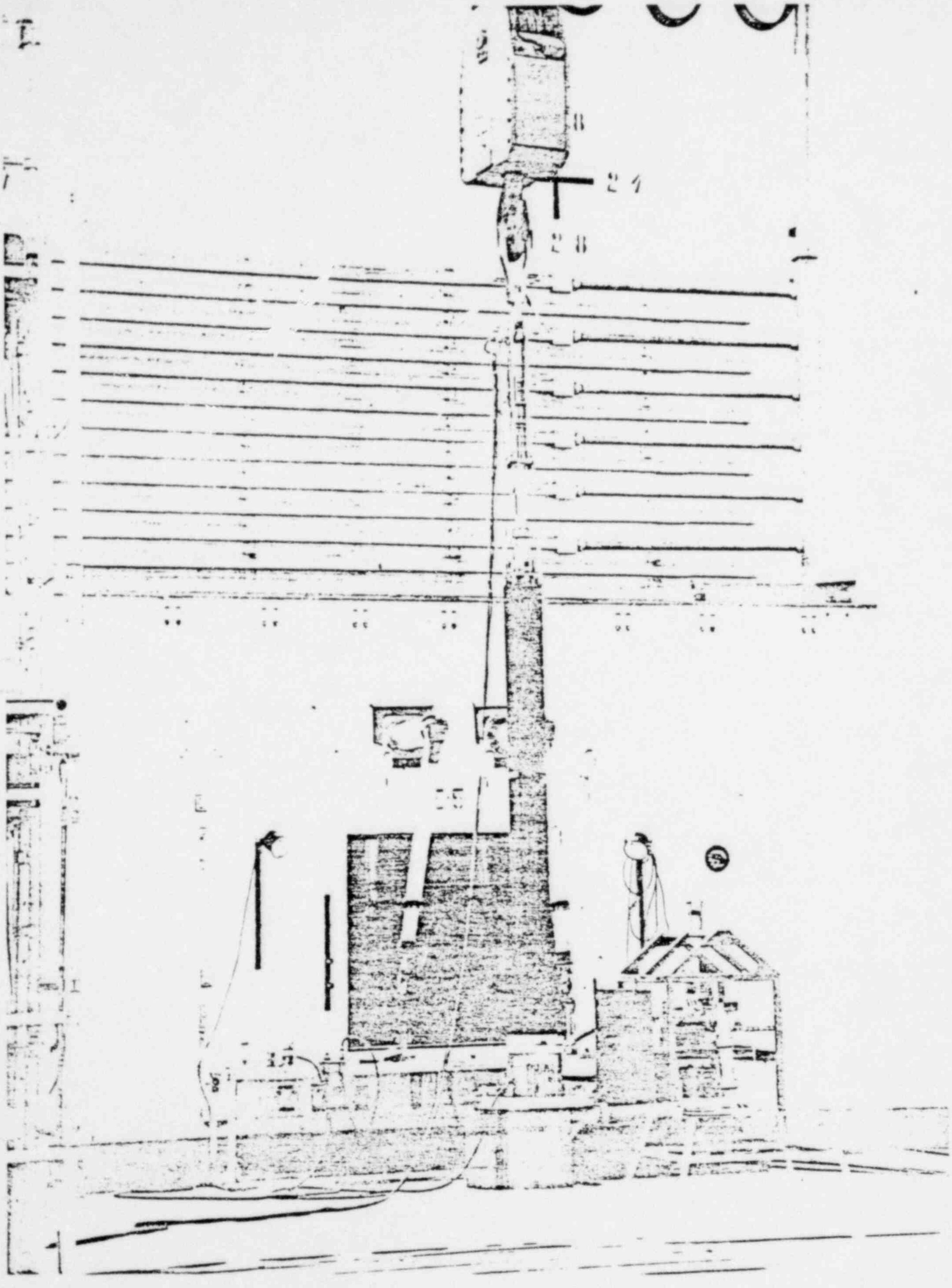
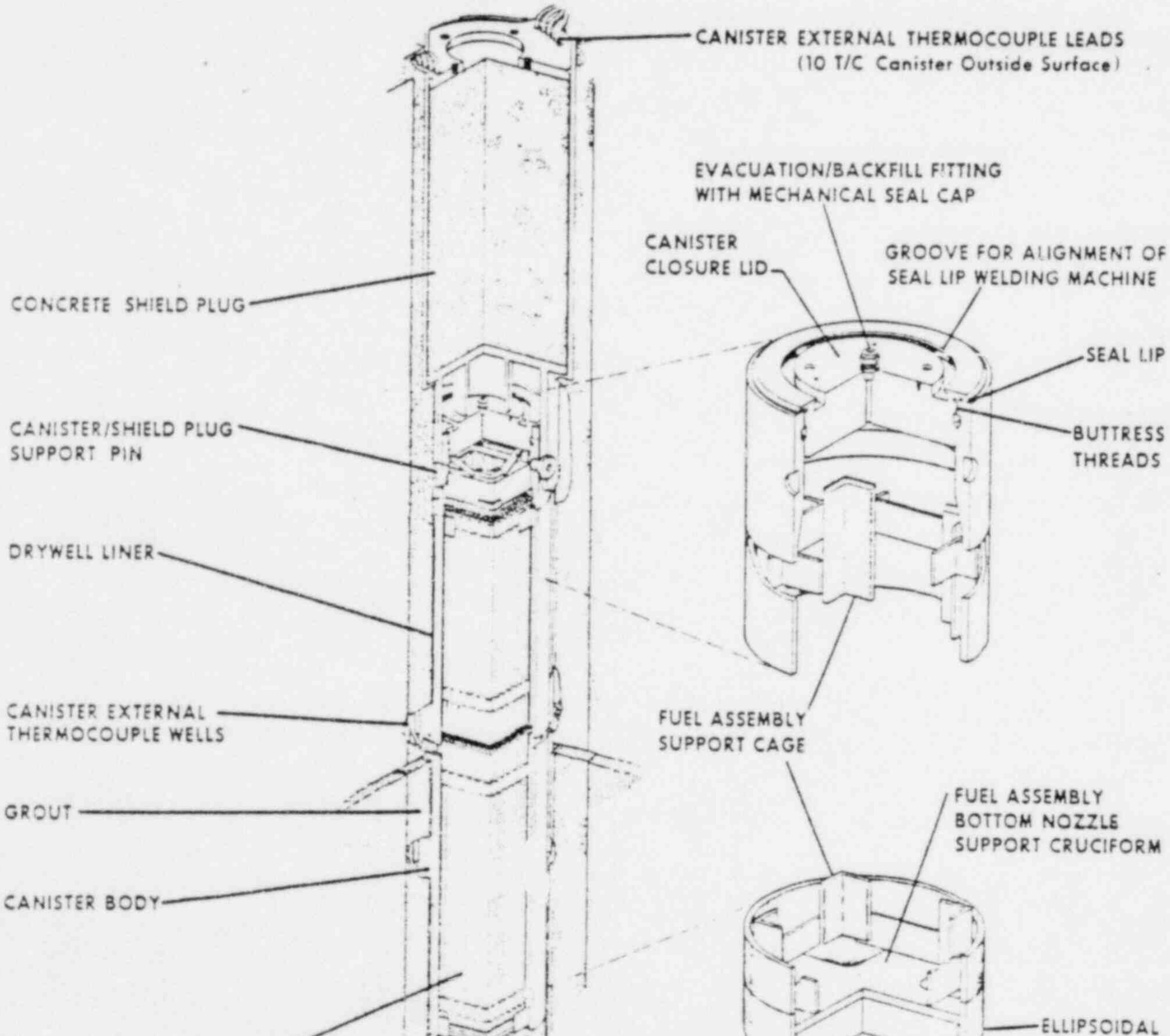


WA 447 CASK MOVING TOWARD WORK STAND INSIDE HOT BAY



WA 455 FUEL ASSEMBLY ENTERING CANISTER IN WELD STATION

CANISTER ARRANGEMENT



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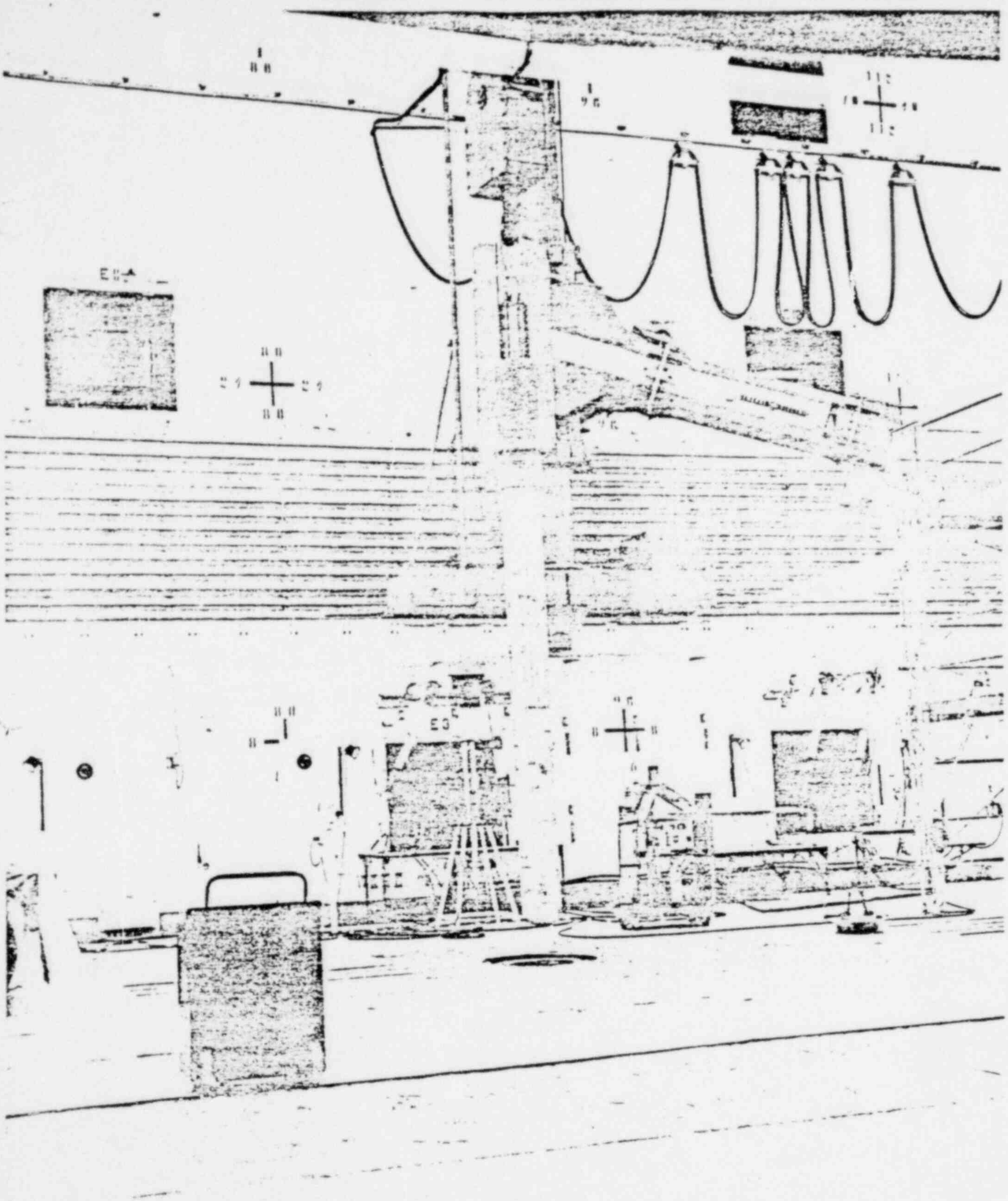
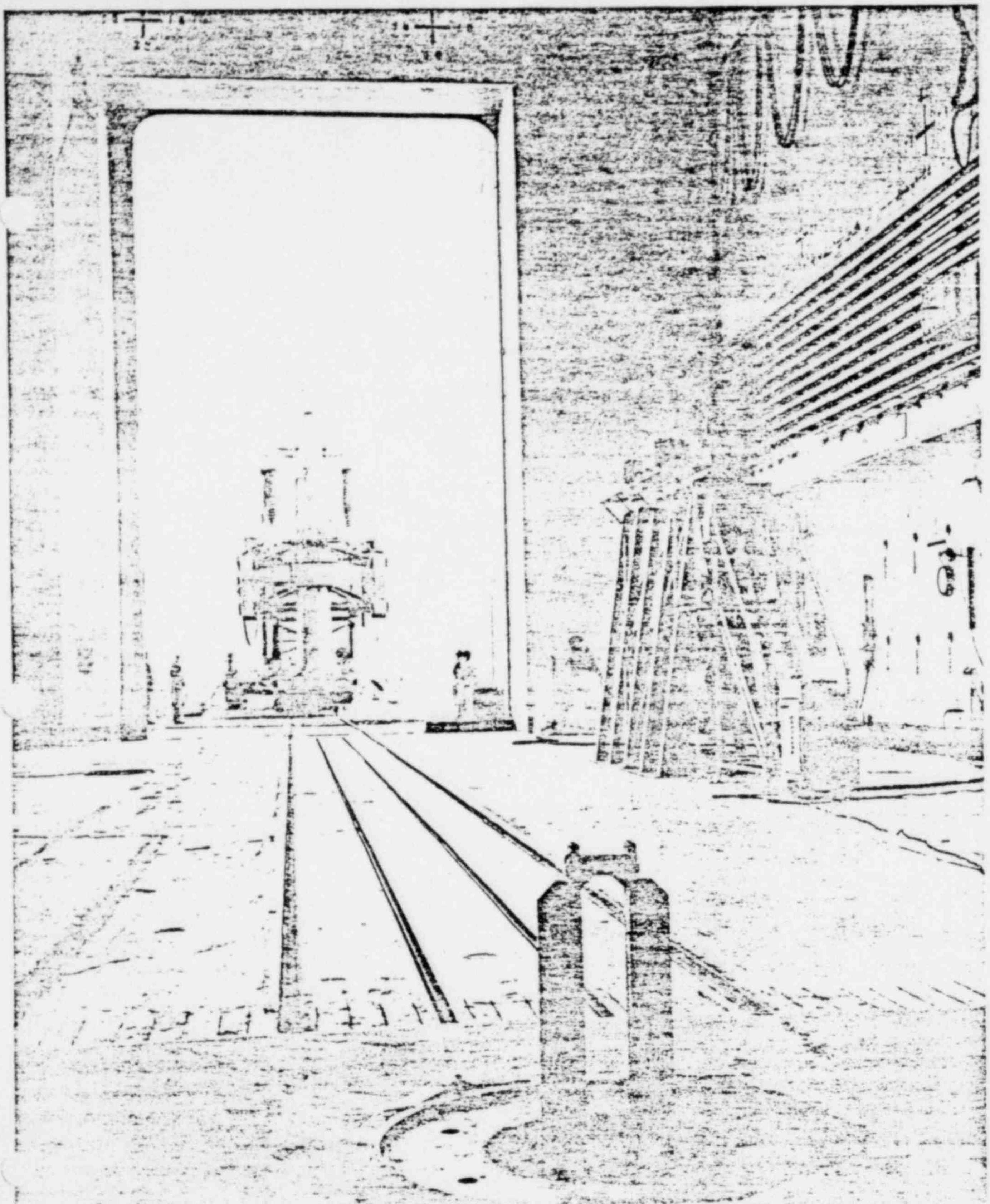
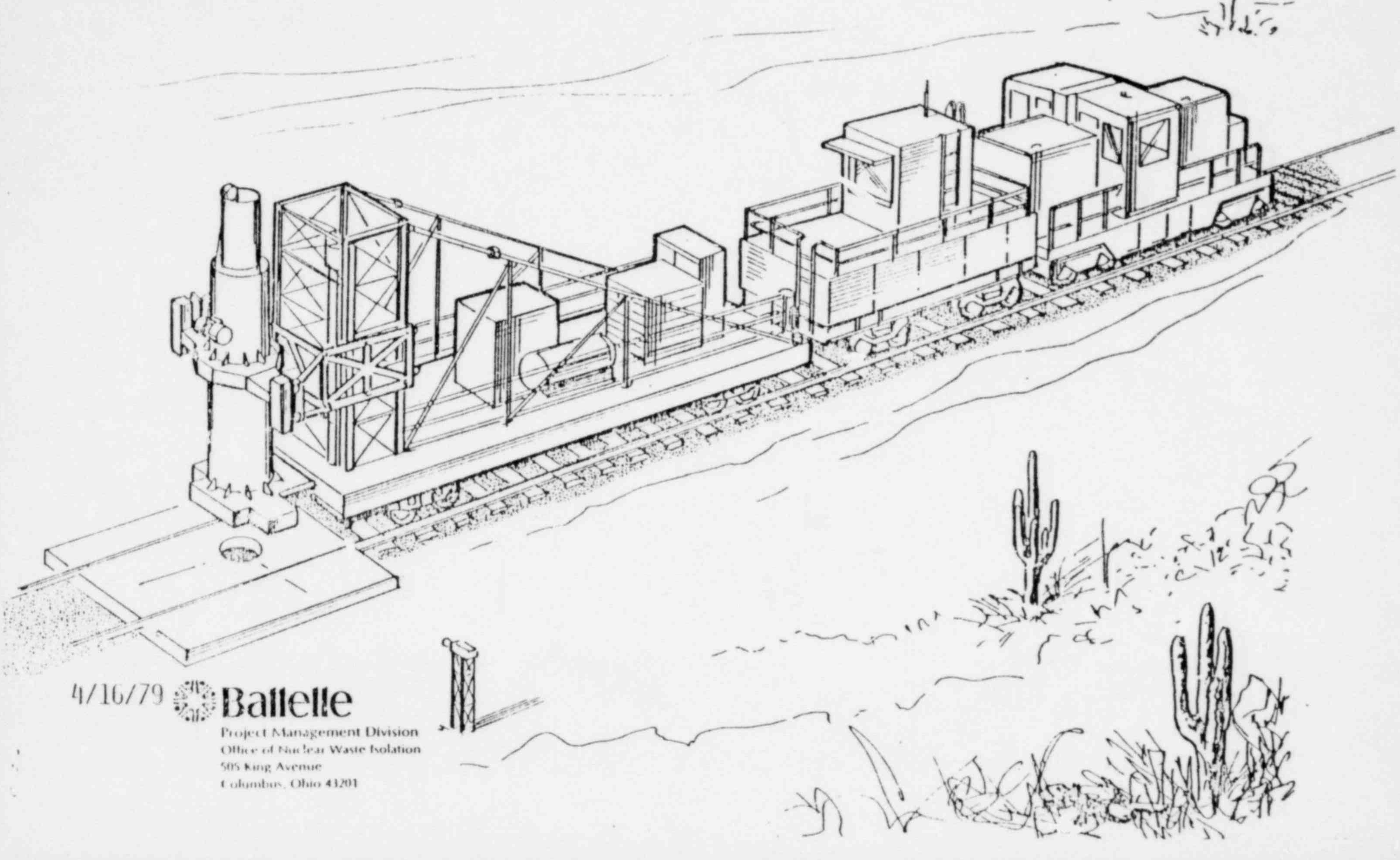


WA 411 CANISTER SUSPENDED OVER TRANSFER PIT



TA 470 EIV/MCC/LS ENTERING HOT BAY

TRANSFER SHIELD, ENGINE INSTALLATION VEHICLE, MANNED CONTROL CAR AND LOCOMOTIVE ARRANGEMENT



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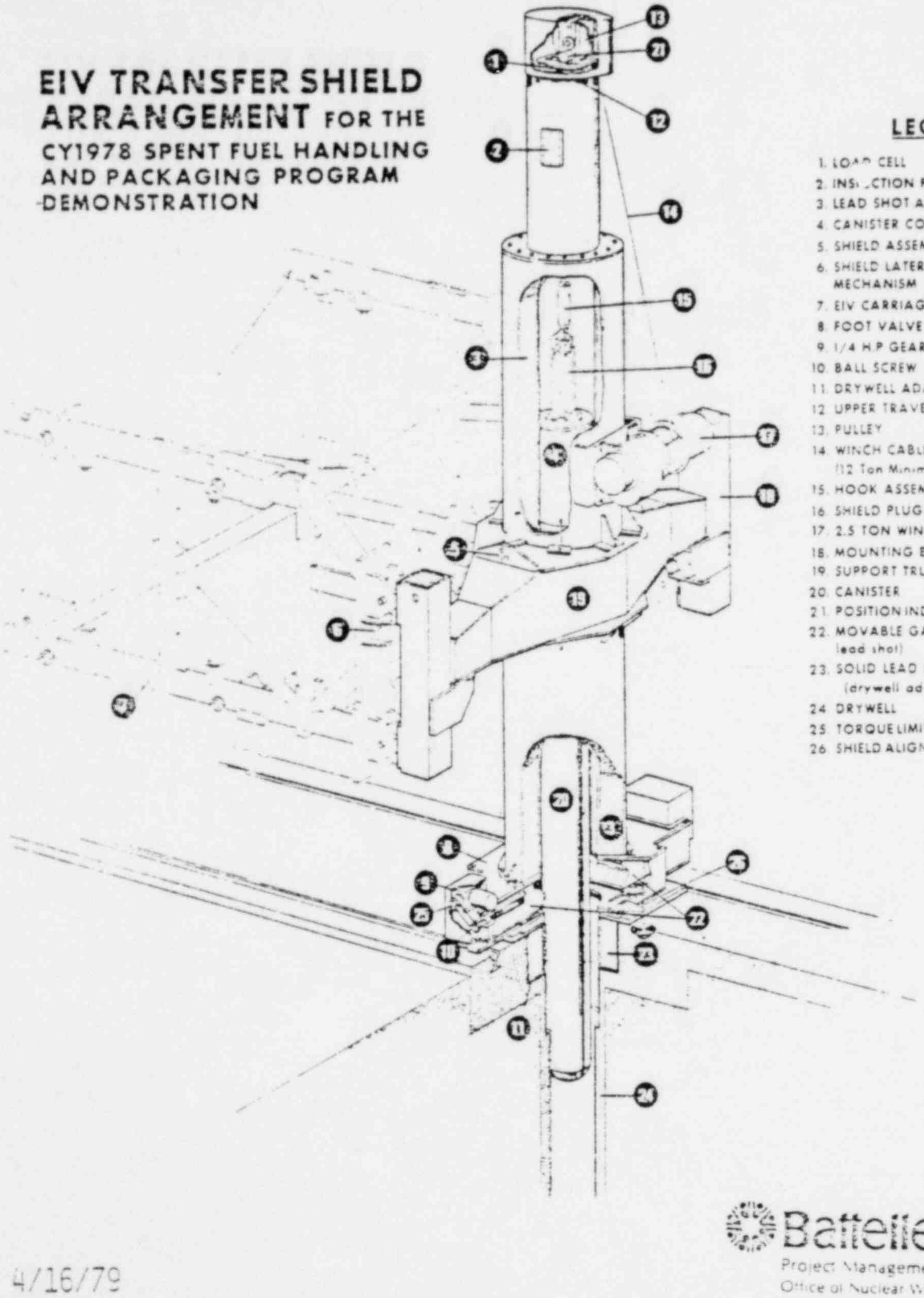
EIV TRANSFER SHIELD ARRANGEMENT FOR THE CY1978 SPENT FUEL HANDLING AND PACKAGING PROGRAM DEMONSTRATION



LEGEND

1. LOAD CELL
2. INSPECTION PORT
3. LEAD SHOT AND OIL
4. CANISTER CONCRETE SHIELD PLUG
5. SHIELD ASSEMBLY LIFTING EYE
6. SHIELD LATERAL ADJUSTMENT MECHANISM
7. EIV CARRIAGE
8. FOOT VALVE ASSEMBLY
9. 1/4 H.P GEAR MOTOR
10. BALL SCREW
11. DRYWELL ADAPTER
12. UPPER TRAVEL LIMIT SWITCH
13. PULLEY
14. WINCH CABLE (12 Ton Minimum Breaking Strength)
15. HOOK ASSEMBLY
16. SHIELD PLUG LIFTING BAIL
17. 2.5 TON WINCH
18. MOUNTING BRACKET
19. SUPPORT TRUSS
20. CANISTER
21. POSITION INDICATOR
22. MOVABLE GATES (filled with lead shot)
23. SOLID LEAD SHIELDING (drywell adapter)
24. DRYWELL
25. TORQUE LIMITER
26. SHIELD ALIGNMENT POINTER

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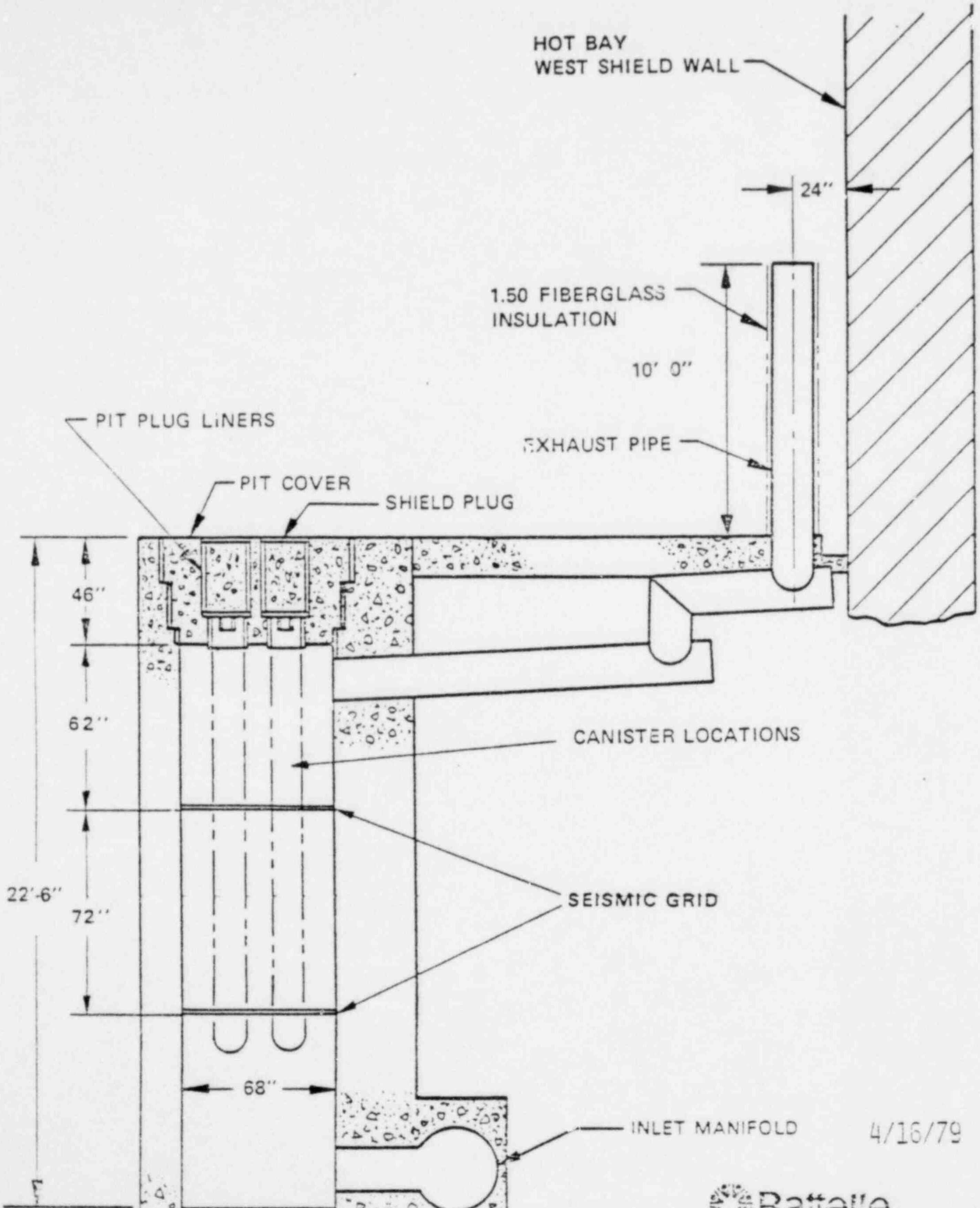
E-MAD HOT BAY LAG STORAGE PIT



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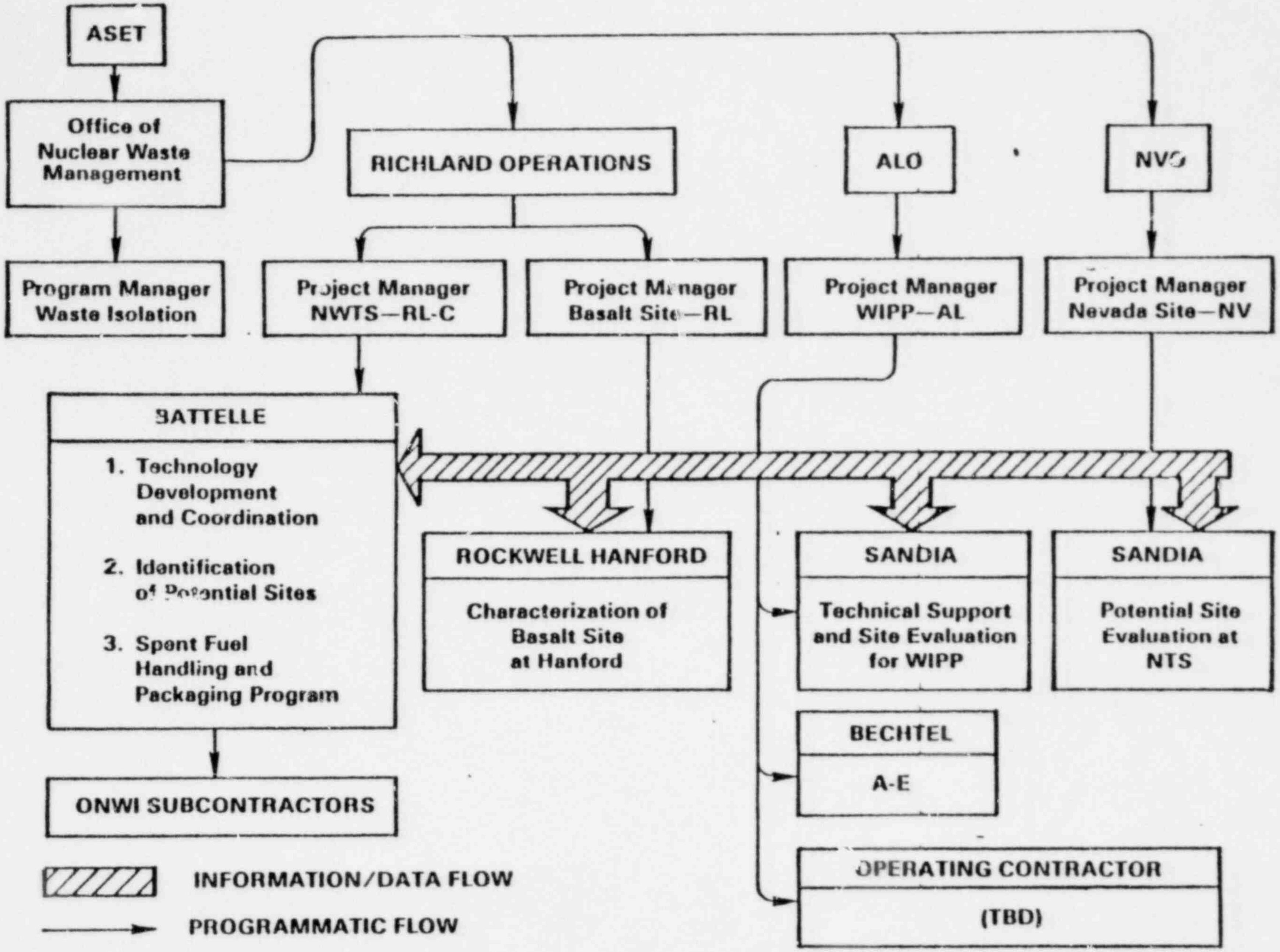
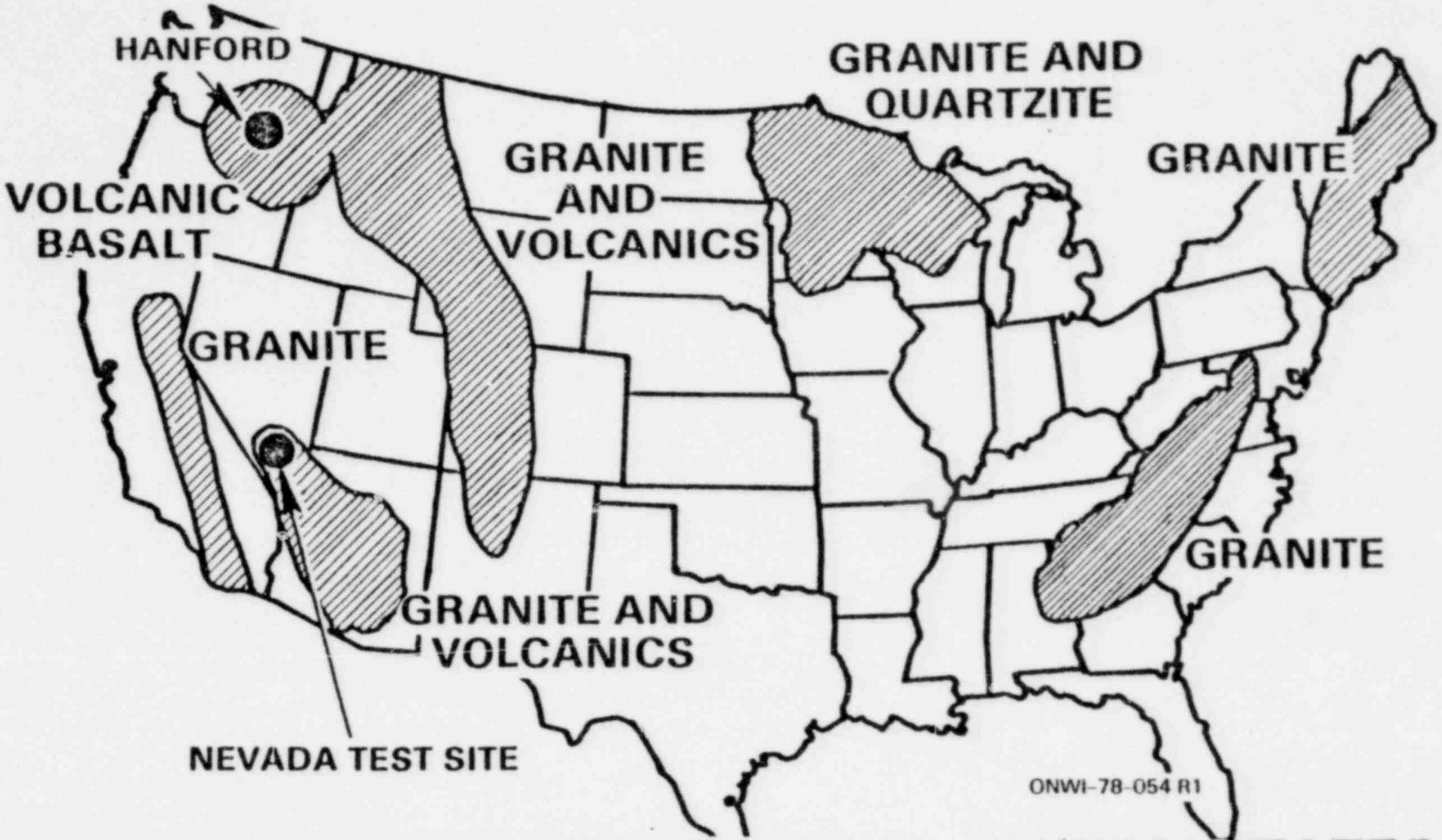


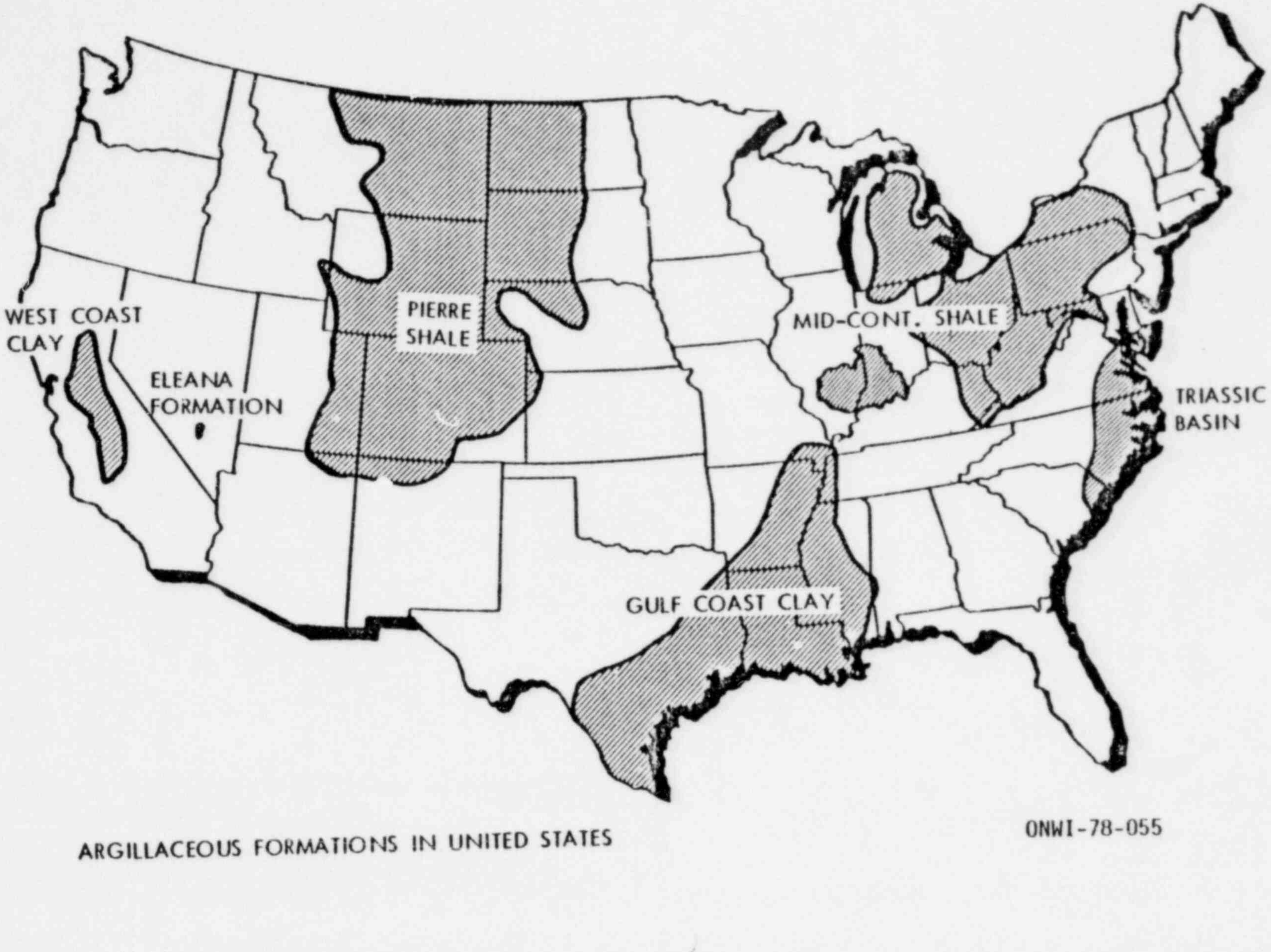
NWTS ORGANIZATION

ONWI-78-041R1
10/2/78

REGIONS BEING INVESTIGATED FOR TERMINAL STORAGE OF RADIOACTIVE WASTES



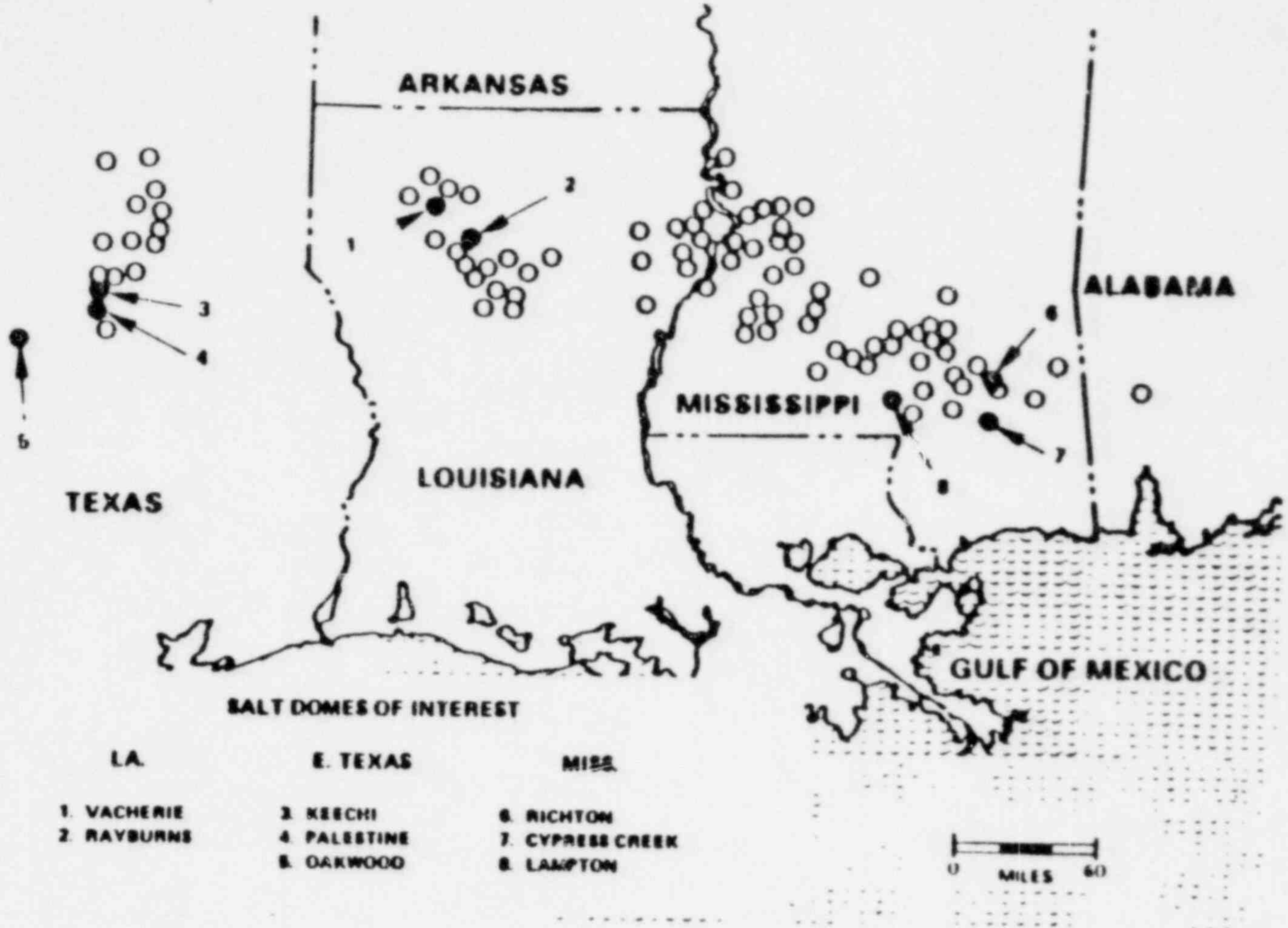
CRYSTALLINE FORMATIONS IN UNITED STATES



ARGILLACEOUS FORMATIONS IN UNITED STATES

ONWI-78-055

INTERIOR PIERCEMENT SALT DOMES OF EAST TEXAS, NORTH LOUISIANA, & MISSISSIPPI



SALT DOMES OF INTEREST

LA.	E. TEXAS	MISS.
1. VACHERIE	3. KEECHI	6. RICHTON
2. RAYBURNS	4. PALESTINE	7. CYPRESS CREEK
	5. OAKWOOD	8. LAMPTON

4-79

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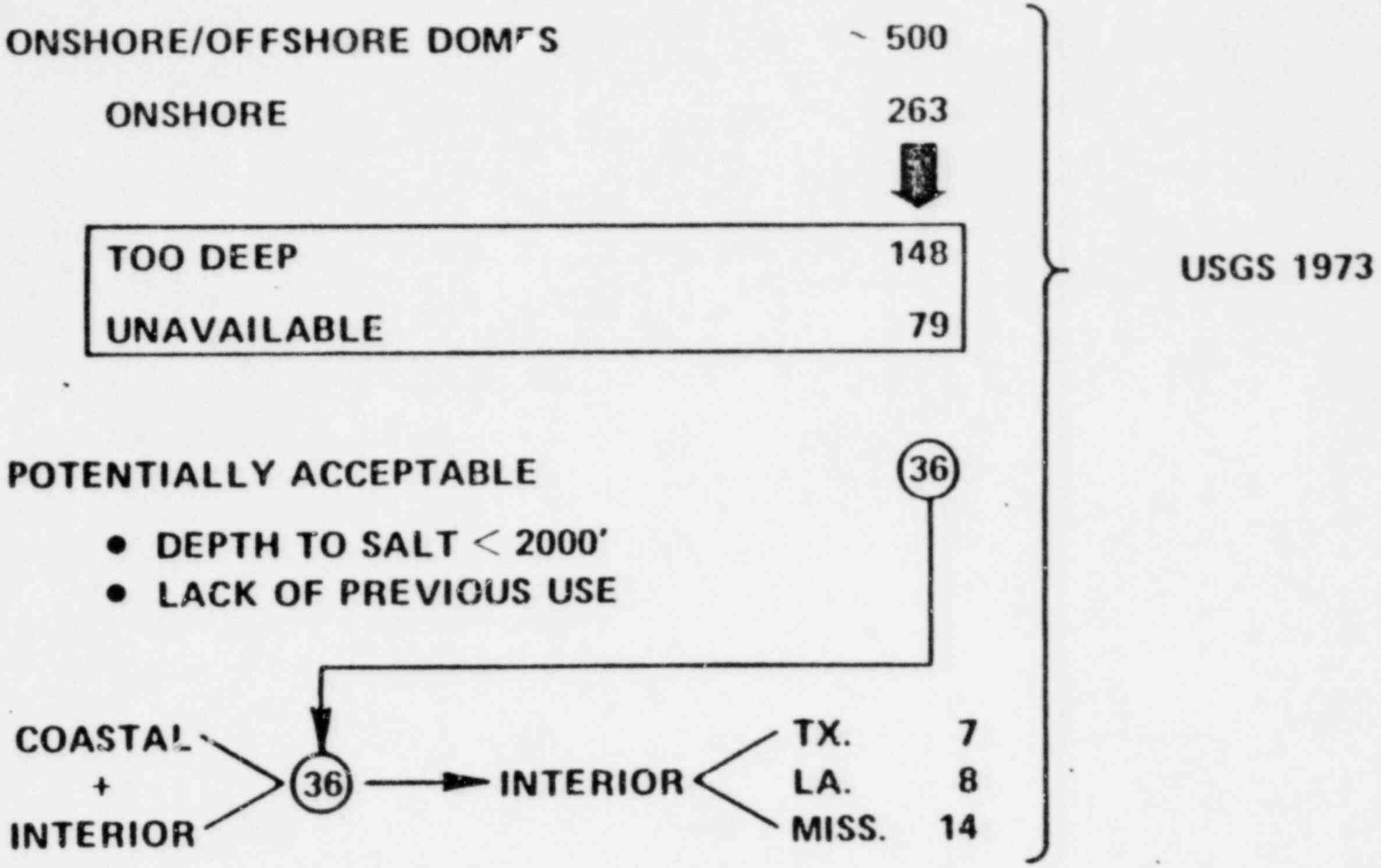
MAJOR STEPS IN SCREENING PROCESS



ONSHORE/OFFSHORE DOMES ~ 500

ONSHORE 263

TOO DEEP	148
UNAVAILABLE	79

USGS 1973

POTENTIALLY ACCEPTABLE ㊱

- DEPTH TO SALT < 2000'
- LACK OF PREVIOUS USE

COASTAL + INTERIOR → ㊱ → INTERIOR

TX.	7
LA.	8
MISS.	14

4-79

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MAJOR STEPS IN SCREENING PROCESS

ONSHORE DOMES

	263 ⟶ 125		
	● DOME SIZE ● REPOSITORY DEPTH/COVER ● DOME UTILIZATION	OWI	1975
INTERIOR DOMES:	29 ⟶ 25	NSAI	1976
(LA)	19 ⟶ 2	LSU	1975 1976 1978
(TX)	20 ⟶ 3	TBEG	1978
(MS)	77 ⟶ 3	GPM	1978
	125 ⟶ 8	GPM/RPM	1979

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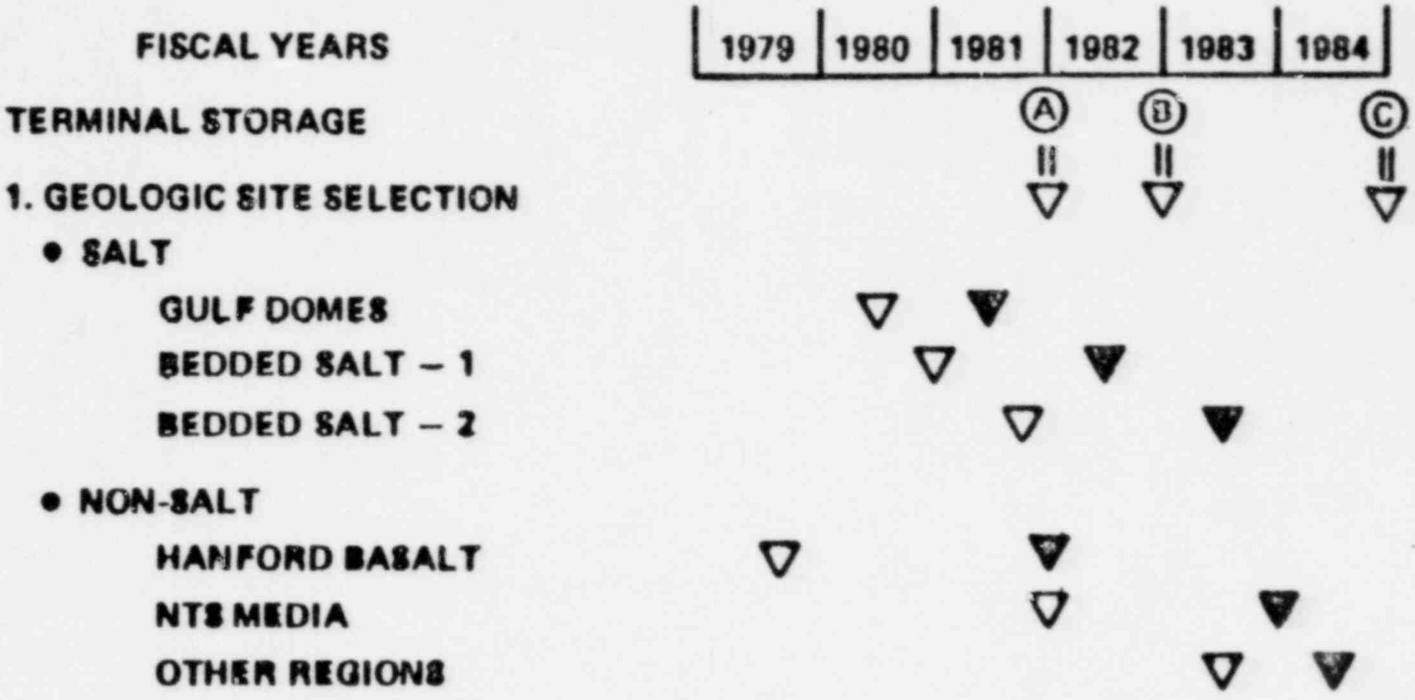
Office luclear Waste Isolation
Battelle

GULF COAST SALT DOMES STUDY

BASIN	DOME	DEPTH TO SALT (FT)	APPROXIMATE AREA OF SALT (Acres) Feet Below Ground Surface 1000	2000	3000
LOUISIANA BASIN					
	Vacherie	777	1620	2400	2860
	Rayburns	130	940	1730	2370
MISSISSIPPI BASIN					
	Richton	720	4025	4500	4275
	Lampton	1650	170	1040	1440
	Cypress Creek	1447 (flank)	2200	2850	3300
EAST-TEXAS BASIN					
	Keechi	400	80	500	1100
	Oakwood	1000	760	1820	2140
	Palestine	100	715	1330	2275

COMMERCIAL WASTE MANAGEMENT PROGRAM
SITING SCHEDULE



FISCAL YEARS | 1979 | 1980 | 1981 | 1982 | 1983 | 1984

TERMINAL STORAGE

1. GEOLOGIC SITE SELECTION

- SALT
  - GULF DOMES
  - BEDDED SALT – 1
  - BEDDED SALT – 2
- NON-SALT
  - HANFORD BASALT
  - NTS MEDIA
  - OTHER REGIONS

▽ MULTIPLE SITE CANDIDATES IDENTIFIED

▼ GEOLOGIC SITE IDENTIFIED AS SUITABLE FOR REPOSITORY

Ⅱ ▽ ALTERNATIVE STRATEGIES FOR INITIAL SITE SELECTION

Ⓐ EARLY SALT AND DOE SITE BASALT OPTIONS

Ⓑ EXPANDED SALT AND DOE SITE NON-SALT OPTIONS

Ⓒ MULTIPLE GEOLOGIC MEDIA OPTIONS

1/8/79

ASSUMED LICENSING PROCESS

- INFORMATION EXCHANGE

  E.G., • WASTE ISOLATION SAFETY ASSESSMENT PROGRAM (WISAP)
  - SITING & ENGINEERING CRITERIA
  - GEOLOGIC EXPLORATION
  - ENVIRONMENTAL SURVEYS
- PRELIMINARY INFORMATION REPORT
- APPLICATION PREPARATION
  - SAR PREPARATION
  - ER PREPARATION
- FORMAL LICENSING

2/6/79

Battelle
Project Management Division

NUCLEAR WASTE SOLIDIFICATION PROGRESS

PREPARED FOR
ACRS-SUBCOMMITTEE ON WASTE MANAGEMENT
AND ENVIRONMENT

APRIL 19, 1979

Prepared by
Pacific Northwest Laboratory Staff
Battelle

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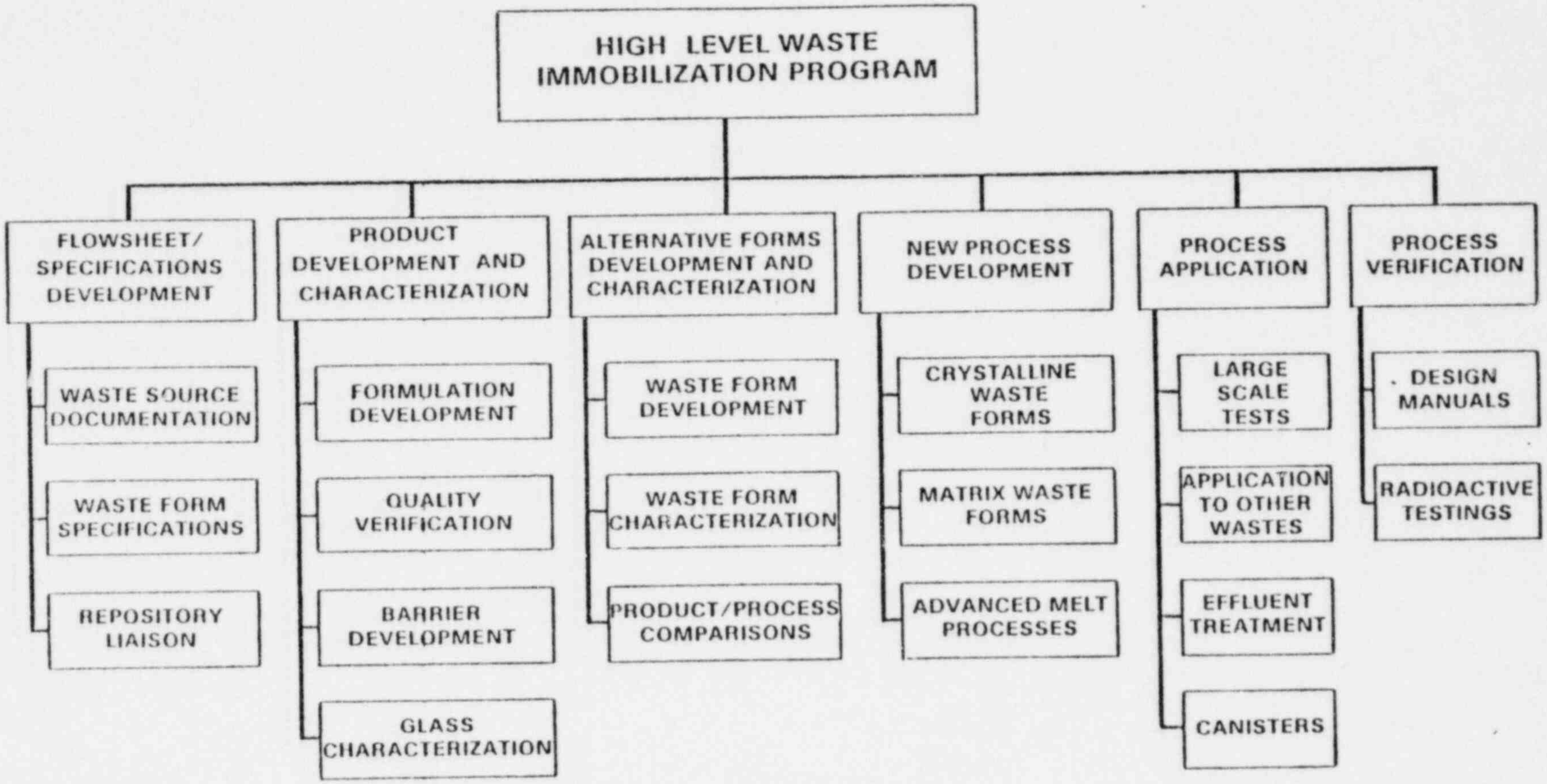
HIGH LEVEL WASTE IMMOBILIZATION PROGRAM
FLOWSHEET/ SPECIFICATIONS DEVELOPMENT
WASTE SOURCE DOCUMENTATION
WASTE FORM SPECIFICATIONS
REPOSITORY LIAISON
PRODUCT DEVELOPMENT AND CHARACTERIZATION
FORMULATION DEVELOPMENT
QUALITY VERIFICATION
BARRIER DEVELOPMENT
GLASS CHARACTERIZATION
ALTERNATIVE FORMS DEVELOPMENT AND CHARACTERIZATION
WASTE FORM DEVELOPMENT
WASTE FORM CHARACTERIZATION
PRODUCT/PROCESS COMPARISONS
NEW PROCESS DEVELOPMENT
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MATRIX WASTE FORMS
ADVANCED MELT PROCESSES
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APPLICATION TO OTHER WASTES
EFFLUENT TREATMENT
CANISTERS
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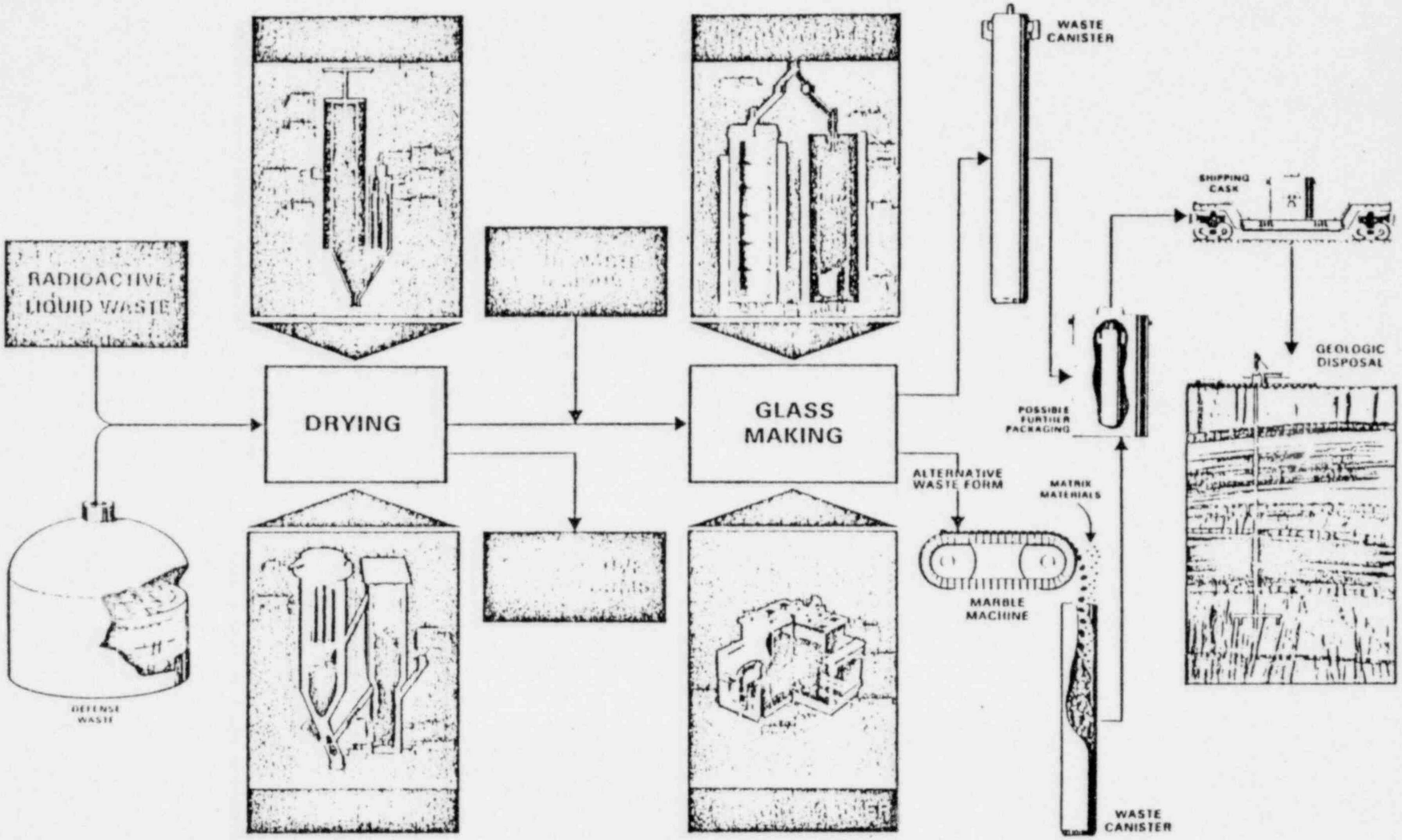
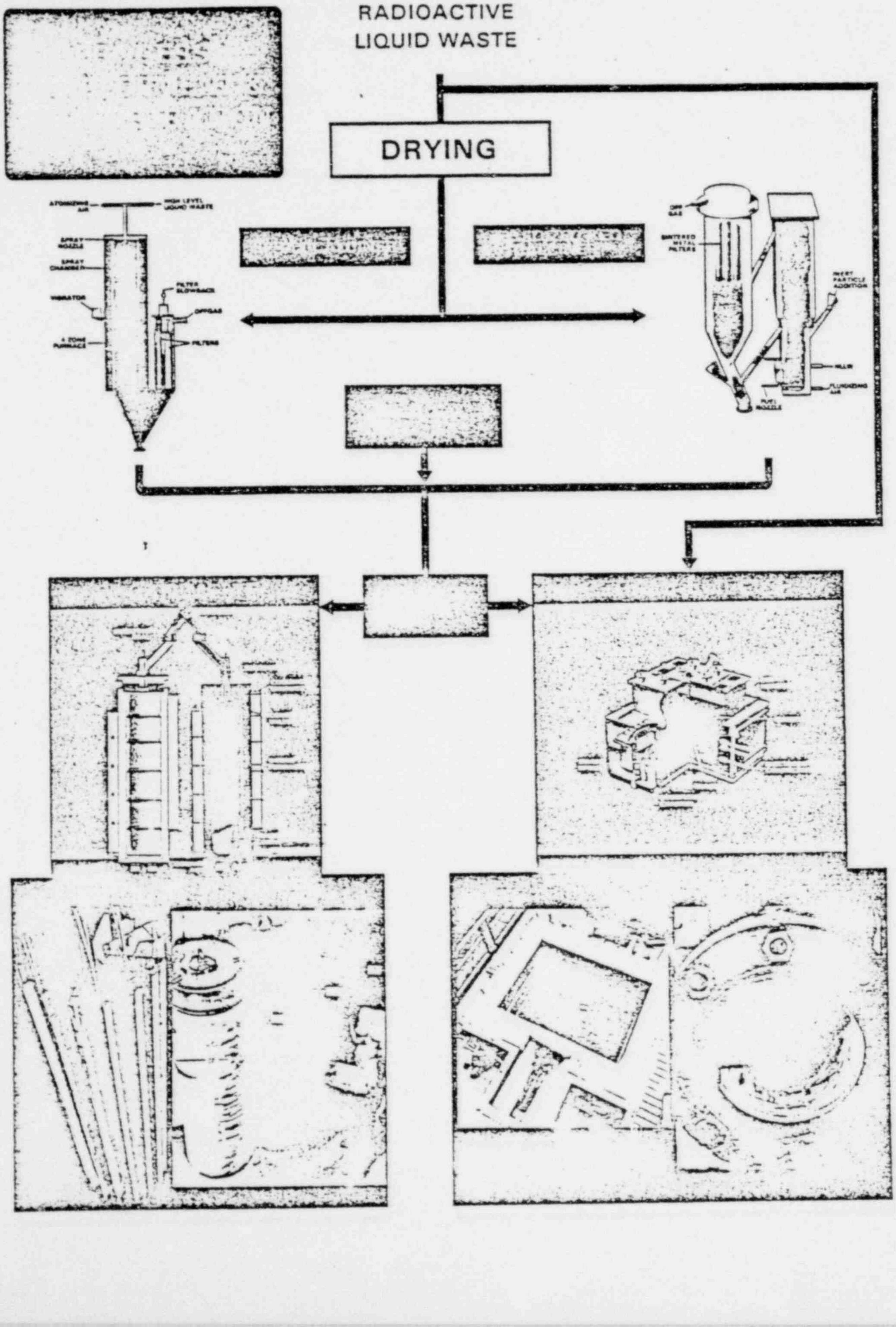
II. STATUS OF PROCESS TECHNOLOGY


WASTE CANISTER
RADIOACTIVE LIQUID WASTE
DRYING
GLASS MAKING
SHIPPING CASK
POSSIBLE FURTHER PACKAGING
GEOLOGIC DISPOSAL
ALTERNATIVE WASTE FORM
MATRIX MATERIALS
MARBLE MACHINE
DEFENSE WASTE
WASTE CANISTER



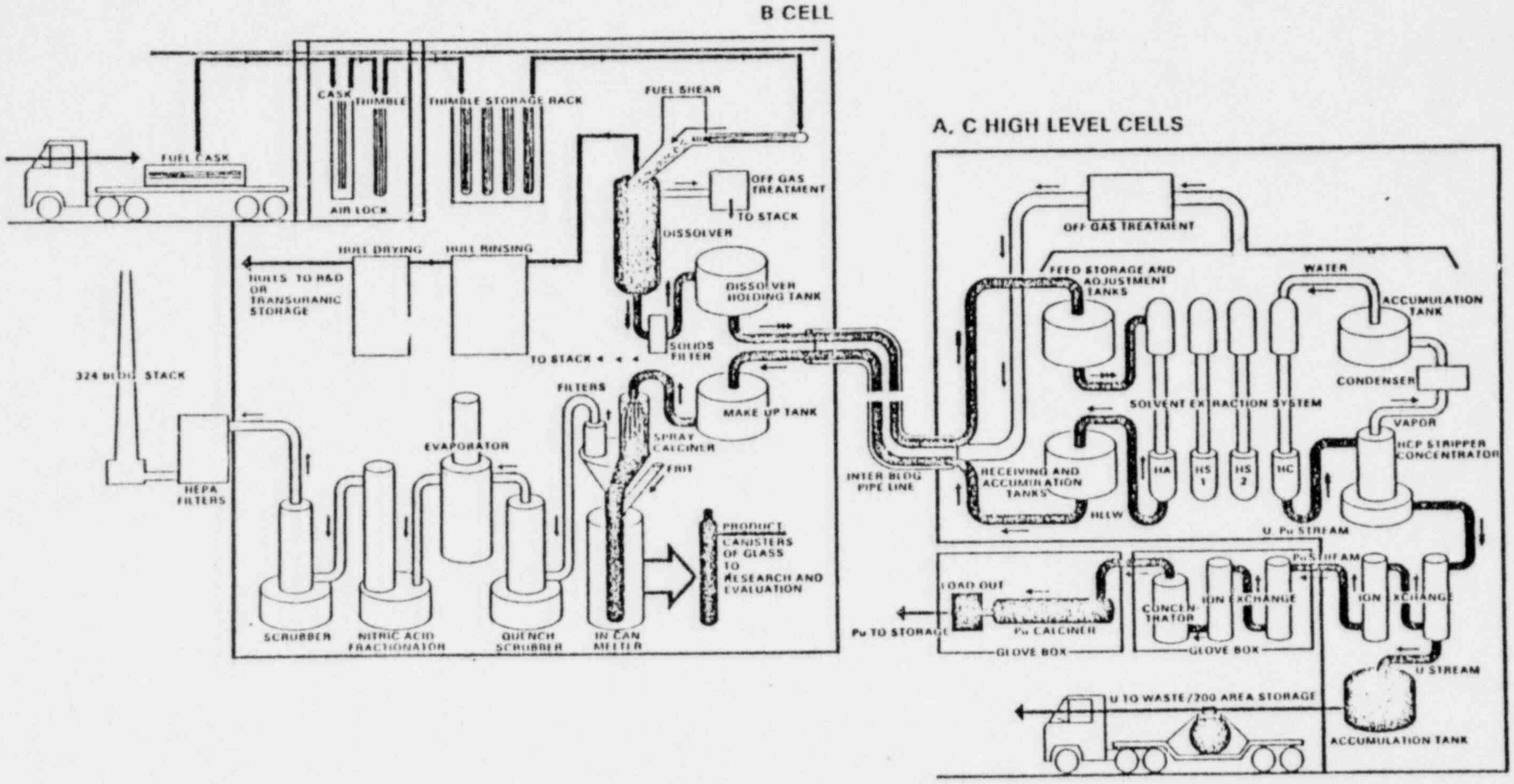
RADIOACTIVE
LIQUID WASTE

DRYING

COMMERCIAL NUCLEAR WASTE VITRIFICATION PROJECT

324 BUILDING

325 A BUILDING



VITRIFICATION OF HIGH-LEVEL LIQUID WASTE FROM LIGHT-WATER REACTOR FUEL

FUEL

POINT BEACH PWR
1.5 MTU PROCESSED
20,400 TO 29,500 MWD/MTU

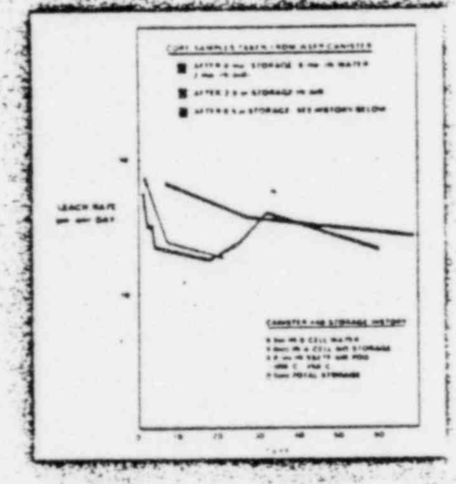
CANISTERS OF GLASS (8' x 8" DIA.)

CAN 1	CAN 2
116 KG GLASS	145 KG GLASS
400 WATTS	1000 WATTS
41 ℓ VOLUME	53 ℓ VOLUME

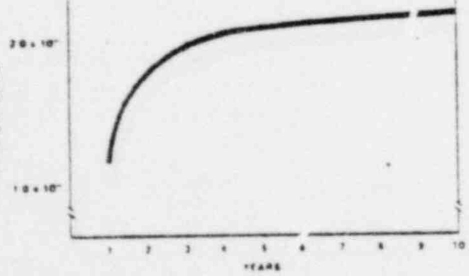
SS-12 CANISTER

WSEP BOROSILICATE GLASS

- DATE FILLED. APRIL 1970 (IN-POT MELTED RUN SS-12)
- CANISTER MATERIAL. 304L STAINLESS STEEL FILL MATERIAL. TYPE 4m WASTE IN BOROSILICATE GLASS VOLUME OF FILL. 54 l
- BULK DENSITY OF FILL. 3.0 kg/l
- FILL HEIGHT. 66 INCHES
- CENTERLINE TEMPERATURE IN AIR. 474 C
- WALL TEMPERATURE IN AIR. 277 C
- INITIAL RADIOACTIVITY. 1.4 MCi
- INITIAL HEAT GENERATION RATE. 90 W/l



INTEGRAL ABSORBED RADIATION IN CANISTER #48



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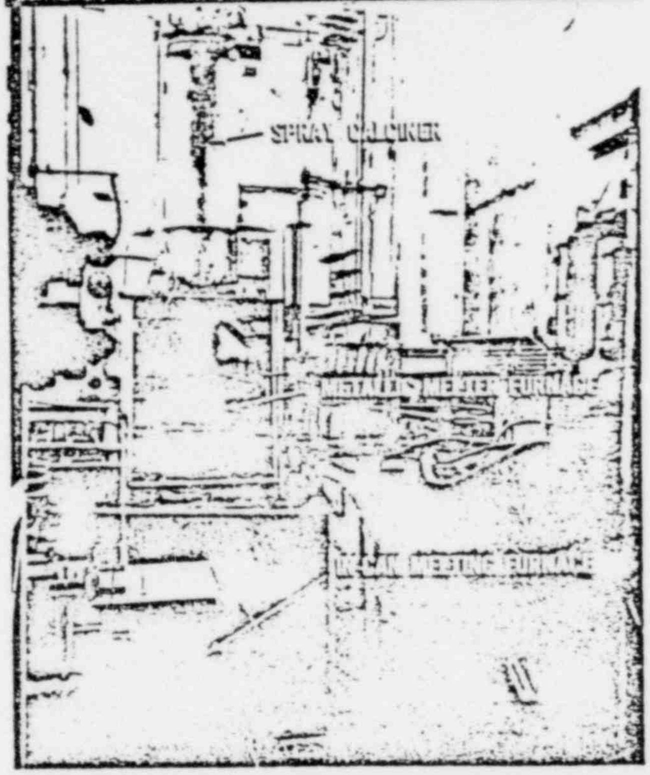
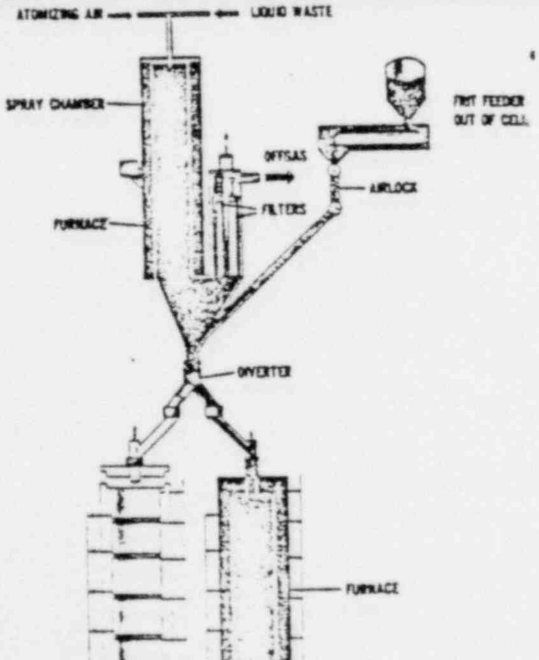

SPRAY CALCINER
METALLIC MELTER FURNACE
IN-CAN MELTING FURNACE

[illegible]


ATOMIZING AIR
LIQUID WASTE
SPRAY CHAMBER
FRIT FEEDER OUT OF CELL
OFFGAS
AIRLOCK
FILTERS
FURNACE
DIVERTER
FURNACE
WASTE CANISTER

III. SENATE SUBCOMMITTEE TESTIMONY

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PNL-SA-7602

NUCLEAR WASTE DISPOSAL

Testimony Prepared for the Subcommittee on Energy,
Nuclear Proliferation and Federal Services
of the United States Senate

March 13, 1979

J. E. Mendel

Pacific Northwest Laboratory
Operated for the U.S. Department of Energy
by Battelle Memorial Institute
under Contract No. EY-76-C-06-1830

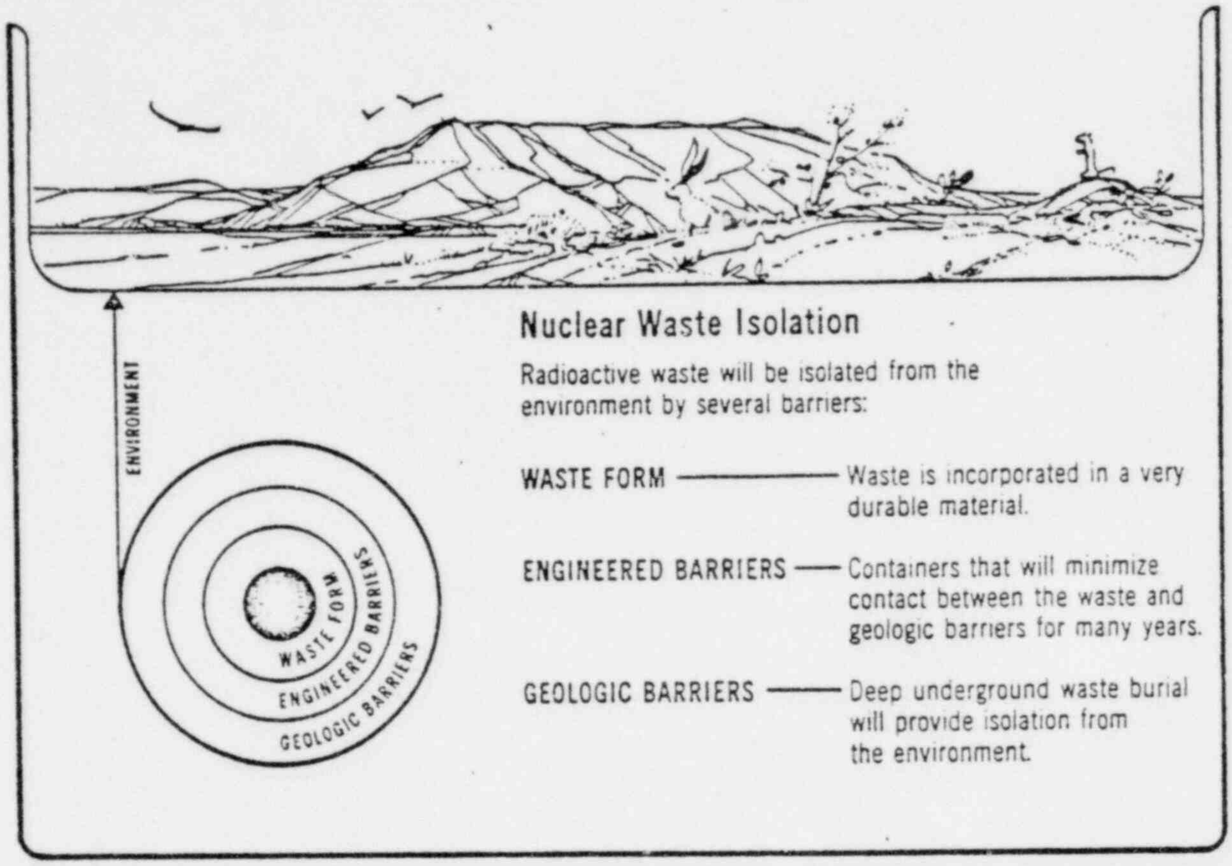
INTRODUCTION

I am concerned about priorities. The recent events in Iran make it clearer than ever that we must develop domestic-based energy options as quickly as possible, including nuclear energy. But questions concerning our ability to dispose of nuclear waste have become one of the stumbling blocks which threaten to slow nuclear energy development. This shouldn't be so. The technology to operate first-generation geologic repositories for nuclear waste in a safe and common sense way is available now, and I will describe it to you this morning.

PERSPECTIVE

The fact that the technology to operate first-generation repositories is available now tends to be obscured by statements made in the press and elsewhere. I am referring to such statements as: synthetic rock is a better waste form than glass; coated particles are a better waste form than synthetic rock; or other geologic formations may be superior to salt as repository locations. The statements have come--and will keep coming--because scientists and engineers are individualists, and they love to solve problems their own ways. I submit that almost all of these suggestions can undoubtedly be made to work. Some may be much more costly than others, some may be much less efficient than others, but most any of them can be predicted to work with confidence because our waste management concept is based upon the flexibility of the multibarrier concept.

The multibarrier concept diagramed for a geologic repository in Figure 1 utilizes a series of barriers, each backing up the other. The system as a whole is more important than is any single barrier. The system allows for a large amount of flexibility, particularly by the use of overpacks and specially designed engineered barriers. The multibarrier concept is described further in Addendum 1, which is attached to the handout you all have. My concern about priorities is that we should not spend too long optimizing the



Nuclear Waste Isolation

Radioactive waste will be isolated from the environment by several barriers:

WASTE FORM — Waste is incorporated in a very durable material.

ENGINEERED BARRIERS — Containers that will minimize contact between the waste and geologic barriers for many years.

GEOLOGIC BARRIERS — Deep underground waste burial will provide isolation from the environment.

FIGURE 1. The Multibarrier Concept Applied to Nuclear Waste Isolation

multibarrier geologic disposal system before implementing it. We must give the public confidence that we can dispose of nuclear waste safely by operating first-generation nuclear repositories as soon as possible, using the technology that has been under development for over a decade. The second, and following generations of repositories, can incorporate some of the technical improvements that have already been suggested if they prove out in testing.

Before going further I should make it clear that by nuclear waste I mean the high-level waste (HLW) that results from reprocessing of spent fuel. I am not talking about the spent fuel itself. Spent fuel is a potential resource--if not now, certainly in the future.

Figure 2 puts the HLW disposal task in perspective. It shows that the radioactivity in a repository of commercial HLW begins to resemble the radioactivity in a similar volume of average uranium ore after 500 to 1000 years. The figure also shows that after 500 years the hazard potential associated with the radioactivity in the repository is actually lower than the chemical hazard potential associated with some naturally-occurring nonradioactive ores. Thus, our major task is to contain the waste for about 500 years. After that, the radioactivity has decayed to levels whose hazard potential resembles that of materials occurring naturally in many regions of our country.

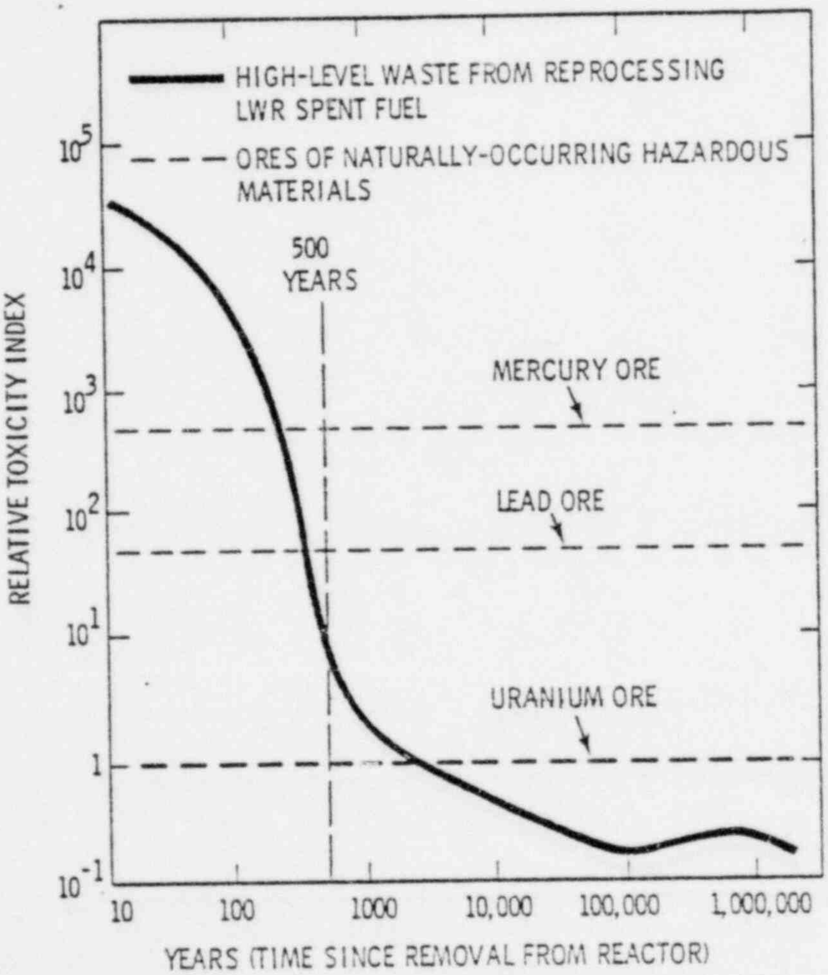


FIGURE 2. Relative Toxicity of Nuclear Waste Over Time, Compared with That of Average Mineral Ores of Toxic Elements (taken from UCRL-52199, p. 6)

Figure 3 puts repository temperatures in perspective. There are two curves in Figure 3, and there could be many more, because repository temperature is a design variable. The repository can be designed so that the temperature does not exceed any set maximum desired. Most of the data on thermal loading of repositories in the literature is based on a "maximum efficiency design" for commercial HLW from the reprocessing of power reactor fuel, in which about forty canisters, each generating about 3.5 kW of heat, are emplaced per acre of repository area. The maximum temperatures that would exist at the wall of a canister in a dry repository under these "maximum efficiency design" conditions are shown by the upper curve in Figure 3. If water intrudes into the repository it will increase the heat transfer at the canister wall and the temperature will be decreased by almost half. But repository temperatures can also be lowered by decreasing the kW of heat per canister and/or the canister loading density. Although it may increase costs, it is a viable design option. Thus, statements that the repository temperatures "will be" certain values are meaningless unless they are placed in context. For instance, the recent Swedish study settled on 70°C (wet) as a conservative maximum repository temperature; the current International Nuclear Fuel Cycle Evaluation (INFCE) study is using 110°C (dry) as the reference repository temperature.

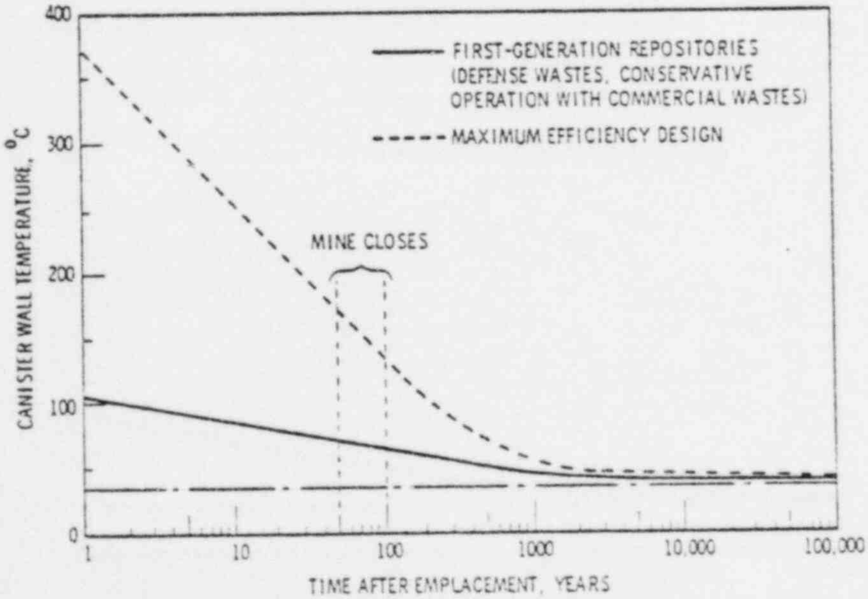


FIGURE 3. HLW Canister Wall Temperatures in a Salt Repository

As we all know, the moratorium on reprocessing spent fuel from power reactors in the U.S. means that we won't have any high-heat-producing HLW for many years. The lower curve in Figure 3 is an estimate of probable maximum temperatures in a repository loaded with defense wastes. This curve is also representative of the temperatures that would be used for the initial conservative operation of a repository for commercial HLW. Such conservative operation is recommended in the IRG report. Figure 3 also illustrates how quickly the temperature decreases in a repository. The message from Figure 3 is that elevated temperature in a repository is both temporary and controllable.

FIRST-GENERATION HLW DISPOSAL

The safe and common sense method of HLW disposal, which can be demonstrated now, is as follows: 1) vitrify the wastes--the technology is available; 2) avoid high temperatures in the repository (there are many ways of doing this); 3) use engineered barriers to protect the waste form for 500 years--until well after ^{90}Sr and ^{137}Cs have decayed to harmless levels (safety evaluations may show that the barriers are unnecessary, but they can be used if necessary); 4) after 500 years use a combination of waste form and geological properties to control the release of long-lived isotopes, so that their hazard is similar to, or less than, that of naturally-occurring hazardous materials. Now I'll discuss each of these four steps in more detail.

WASTE VITRIFICATION

The reference waste form for waste repositories world wide is glass. It is a ready-to-go waste form. It is ready to go because of an early business-like decision made unanimously all over the world to assure that *a* waste form--not necessarily the best waste form, but a suitable first-generation waste form--would be ready when it was needed. The decision has paid off. A nuclear waste glass plant started operating at Marcoule, France, in mid-1978;

design of a potential nuclear waste glass manufacturing facility for the Savannah River Plant defense wastes is underway presently. Last month Congressman Mike McCormack and Congressman James Lloyd visited PNL to witness the first conversion to glass of HLW prepared from commercial spent fuel. The spent fuel was from the Point Beach Nuclear Plant of the Wisconsin Electric Power Company. This demonstration was the culmination of the two-year Nuclear Waste Vitrification Project.

A recent review paper describing waste glass properties, and how they relate to the multibarrier waste management system, is included with my written testimony as an appendix.(a) It describes the very adequate radiation and thermal stability of waste glass in detail. The report also describes the leach behavior of waste glass. Of course, repository locations will be selected to be as dry as possible. Only minor amounts of water may ever enter the repository; nevertheless, it is important to understand what might happen if water is present and if enough of the canister has corroded away to expose some of the waste glass.

Waste glass leach rates are in the range of 1×10^{-4} to 1×10^{-7} grams of glass/cm^2-day at 25°C. It can be calculated that over the long term less than 1% of the activity in waste glass would be dissolved each thousand years if the glass were exposed to flowing water at ambient repository temperatures of about 40°C. Experiments show that even less activity will be dissolved in slow-flowing or stagnant water. For dissolved activity, adsorption and ion exchange in the geologic formations become the principal barrier.

Leaching is a chemical reaction; the rate increases with temperature. The magnitude of the increase has been known for a long time. The leach rate of waste glasses increases a factor of 10 to 100 for each 100°C rise in temperature. Multiply the 1% release previously mentioned by 100 and it becomes apparent that only transient protection is provided by waste glass in flowing water even at 140°C. At higher temperatures the protection is even more transitory. We've already discussed the role of the additional barriers in the

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(a) The Storage and Disposal of Radioactive Waste as Glass in Canisters, (PNL-2764) J. E. Mendel.

system; high-temperature conditions put an additional load on these barriers. The common sense approach to early repository operation is to maintain low temperatures.

METHODS OF ASSURING LOW TEMPERATURES IN THE REPOSITORY

Many methods are available for assuring that low temperatures are maintained in a commercial HLW repository. These include interim surface storage, diluting the amount of waste in the waste form, using smaller-diameter canisters, and spreading the canisters over a wider area in the repository.

ENGINEERED BARRIERS FOR THE FIRST 500 YEARS

Engineered barriers refer to additional layers of protection that can be placed around the canister. The engineered barriers would probably be made of metal, but oxide ceramics, graphite and various adsorbent materials could also be used. An analysis of the necessity for engineered barriers is being initiated by the Office of Nuclear Waste Isolation (ONWI). Risk analyses may show that engineered barriers are unnecessary technologically, but they are certainly feasible in a low- or moderate-temperature repository, and they can be used as a precautionary measure until the risk analyses are completed.

CONTROL OF THE MIGRATION OF RADIOACTIVITY AFTER 500 YEARS

While engineered barriers designed to last 500 years will probably last much longer, there is general agreement that engineered barriers, if used, may ultimately be breached by corrosion or crushing forces in the repository. Then water, if present, can contact the waste glass at the ambient temperature of about 40°C. As shown in Figure 3, the radioactivity in the repository after 500 years starts to resemble the radioactivity in a similar volume of average uranium ore from the Colorado plateau.

Uranium ore bodies have little effect on man because: 1) they are generally deep in the ground, although not nearly as deep as the proposed waste repositories, and 2) the radioisotopes are tightly held in the ore.

Similarly, the radioisotopes will be tightly held in the waste, because of two important factors. First, after 500 years the radioisotopes remaining in the waste are mainly actinides. This is the very same family of elements that are in uranium and thorium ore, so the radioactivity remaining in the waste may be expected to behave similarly to the way it behaves in these ores. These elements do not readily migrate through soil; they are very susceptible to adsorption and ion exchange. Second, at 40°C the leach rate of actinides from waste glass is very low. This assures that activity dissolved and entering the adsorption and ion exchange system is always low, so that the system is not overloaded.

CONCLUSIONS

The foregoing discussions show that if the repository is operated at low temperatures (and we have methods to guarantee the low temperatures), then engineered barriers can be used to reliably contain the waste during the first 500 years, when the major hazard exists. After that, the hazards are relatively low--no greater than from many sources naturally present in nature.

It is most important that establishment of repositories for defense wastes go forward smoothly and that their establishment is not delayed by premature insistence upon optimization. Optimization is of course a desirable goal. But we will be kidding ourselves if we think we can optimize the waste disposal system without the invaluable feedback that can only come from operating experience. (Could we have had such successful Apollo missions without first having Mercury and Gemini?) Thus, the program must be two-pronged. One side includes engineering-scale demonstrations of workable, although not necessarily optimum, systems; the other side includes continued assessment of alternative waste forms and alternative geologic host media. The latter effort need not become overly large. We must guard against getting into a self-perpetuating R & D mode on what is in reality a relatively straightforward task. We must keep our priorities straight. Dr. Margaret M. Maxey has written several cogent articles in this regard. I'd like to close by quoting from one of them:(1)

> By any common sense standards of comparable-hazard analysis and cost-effective health protection, public concerns over uranium fissioning and radwaste disposal, and the expenditure of huge sums of money to reduce already negligible risks even further, have been magnified out of all due proportion.

REFERENCES

1. Dr. Margaret N. Maxey. "Radwaste Management: Ethical Problems and Priorities," p. 69, Waste Management and Fuel Cycles '78, Proceedings of the Symposium on Waste Management at Tucson, Arizona, March 6-8, 1978. Roy G. Post, Editor, Copyright, Arizona Board of Regents, 1978.

ADDENDUM: THE MULTIBARRIER CONCEPT

The multiple barrier concept, sometimes described as defense-in-depth, utilizes a series of barriers, each designed to perform a specific function. Use of multiple barriers is standard in the nuclear industry and has contributed to its outstanding safety record. For a geologic repository the multiple barriers used will consist of: 1) remoteness from the biosphere; 2) specially selected near-field geologic properties, such as dryness and impermeability; 3) specially-designed engineered barriers, including adsorptive backfill materials (optional); 4) an overpack (optional); 5) the canister; and 6) the solidified waste form. It is important to note here that the waste form is only one of a minimum of four barriers in the system. The optional use of overpacks and additional engineered barriers can easily increase the total number of barriers to six or more.

The specific functions the barriers are designed to perform may be defined as follows:

REMOTENESS FROM THE BIOSPHERE

- Remoteness from the biosphere assures that any water that has been in contact with the repository and has become potentially contaminated must travel a lengthy, tortuous and time-consuming path before it reaches locations where man may use the water for any purpose. This path is of value because most radioisotopes are subject to ion exchange and adsorption reactions in rocks and soils, which result in retarded radioisotope migration. Retardation factors, expressed as the ratio of the flow of water to the slower flow of a given dissolved radioisotope, are often 10,000 or more. The extended flowpath also allows radioactivity to decay. Computer modelling shows that remoteness from the biosphere is an excellent barrier--in most cases sufficient to assure safety by itself.

NEAR-FIELD GEOLOGIC PROPERTIES

- The repository will be located within a deep geologic formation selected to have certain desirable properties. Primary among these properties will be dryness and impermeability. Salt formations (proposed for the location of repositories in the U.S. and Germany) and granite formations (proposed for the location of repositories in Sweden and Canada) are examples of formations which are believed to possess the required properties to a sufficient degree. Minor amounts of water may be naturally present in these formations, but rates of recharge of the water will be very low because of impermeability. Other types of geological formations, which possess the properties of dryness, impermeability, and/or other desirable properties, are also under active investigation in the U.S. and elsewhere.

SPECIALLY DESIGNED ENGINEERED BARRIERS (OPTIONAL)

- One type of engineered barrier that is not optional is the mechanical seal that will be placed in repository shafts and boreholes. Additional specially designed engineered barriers can be incorporated into the repository design. An example would be to backfill around each canister of waste with a highly adsorbant clay mixture, which would act as a backup barrier and would hold tightly any radioisotopes released from the primary waste form. The clay mixture could contain sulfides or other materials with a high affinity for technetium, a radioisotope which, when oxidized, has a low retardation factor for migration in most soils. Alternatively, the backfill can contain materials which will swell when contacted with water and thus tend to prevent access of water to the primary waste form, in the event that water does enter the repository. Sleeves or other devices designed so that waste canisters may, if desired, be retrieved from the repository sometime in the future could also be included in the engineered barrier category.

OVERPACK (OPTIONAL)

- Overpacking is another form of engineered barrier; it is placed around the canister and becomes part of the solidified waste capsule. Overpacks are usually considered to be secondary canisters. The primary canisters can be optimized for processing compatibility; overpacks can be optimized to serve as barriers in specific geologic formations. And overpacks can be designed to have a certain lifetime. For instance, the requirement might be to act as a positive barrier until the ^{90}Sr and ^{137}Cs have decayed from the waste.

CANISTER

- The sealed metal container which holds the solidified waste form is called the canister. It forms the primary barrier to dispersion of the radioactivity in the waste during handling, interim surface storage and transportation of the waste. The lifetime of the canister may be limited after the waste is placed in a geologic repository. This is especially true in salt repositories.

SOLIDIFIED WASTE FORMS

- The function of the solidified waste form is to incorporate the high-level liquid waste into an inert form that is compatible with canisterized storage. The waste form must be able to immobilize over 30 different chemical elements, occurring in differing combinations and concentrations, into an inert solid which is as resistant as possible to the effects of heat and radiation and to dissolution in natural waters. The waste form can itself contain additional barriers, in a continuation of the multibarrier concept. The coated particle waste form, under development at PNL since 1975, is an example.

The multibarrier concept results in a multicomponent, interrelated system. The interrelationship is most obvious when the thermal loading of the repository is considered. The maximum temperature allowed will depend not only upon the potential for reactions at the waste form/canister/geologic formation interfaces, but also upon evaluation of the effects of heat on the dehydration, recrystallization, physical strength, and permeability of the geologic formations around the repository. The final maximum temperature value will represent a tradeoff between the adverse effects of heat throughout the system and the potential cost savings that can be achieved by the "maximum efficiency design."

In fact, the design of several components of the multibarrier system may involve tradeoffs. For example, consider barrier No. 1--remoteness from the biosphere (which equates roughly to depth of the repository). Other things being equal, the deeper the repository, the farther any water must travel to reach the surface. A longer migration route allows more time for radioactive decay and for adsorption and ion exchange of radioisotopes with rocks and soil, and thus increases safety. But increased depth raises costs and makes the repository filling operation more difficult. Thus, a compromise depth of two to three thousand feet has been tentatively selected.

Similar tradeoffs are involved in the design of each of the other barriers. The canisters, for instance, are planned to be constructed of 304L or an equivalent grade of stainless steel. Stainless steel canisters are easily fabricated and have favorable characteristics for in-plant processing. However, stainless steel is subject to stress-corrosion cracking, so it is possible that small cracks will appear in the canisters relatively soon after the canisters are placed in geologic repositories. This is certainly to be expected in salt repositories. There are ways of prolonging canister life, but at a cost. Higher chrome-nickel steels or even titanium can be used. And placing the canister in a second sealed container, commonly called an overpack, offers even more flexibility in materials selection.

Tradeoffs are also a factor in the development of waste forms. The major tradeoff for waste forms concerns processing practicability versus product properties. Radioactive processing must be done remotely in heavily shielded facilities. The process must be as simple and reliable as possible. The process must be able to act as a "garbage disposal" for the reprocessing plant. Glass meets the processing requirements and is believed to be a very satisfactory waste form when a systems approach is applied. It has all of the desirable product properties, except possibly one: glass does not provide a very good barrier against dissolution of radioisotopes in the presence of high-temperature solutions. Here the systems approach can be used. Temperature is a design variable--temperature control can be guaranteed. The repository will be designed to be as dry as possible, but here the assurance is less positive. The absence of all water cannot be guaranteed. Therefore, if risk-benefit analyses show the necessity, or even if they don't, an additional engineered barrier can be added which protects the glass completely for at least 500 years.

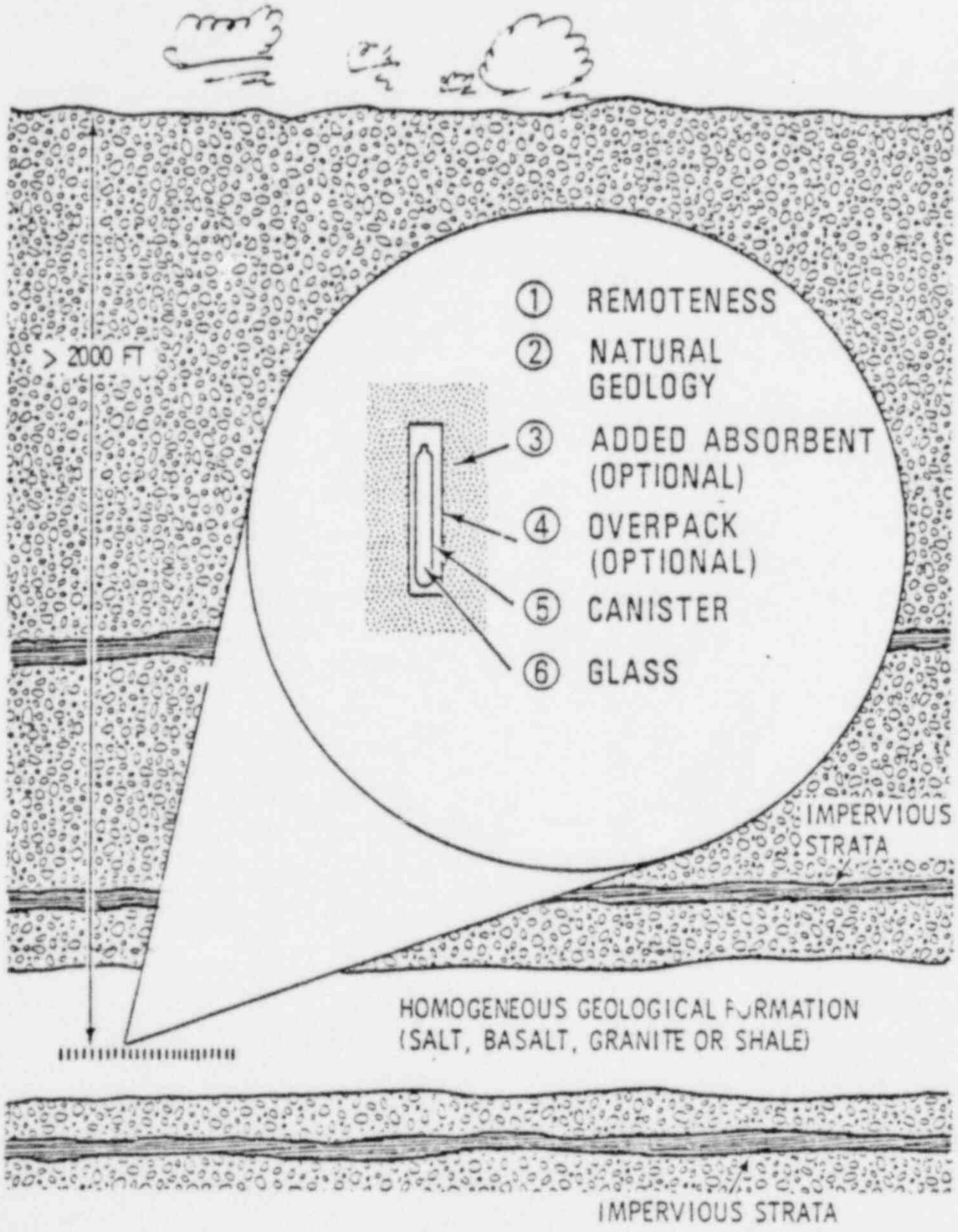
Some of the newer alternative waste forms offer promise of acting as an improved barrier against dissolution of radioactivity in the presence of high-temperature solutions. An example of such an alternative is the PNL-developed coated particle waste form. Such waste forms offer the possibility of reducing the cost of repository operation by operating it more efficiently, but that potential cost reduction will have to be balanced against possible increased processing costs and complexity. It is not apparent that the alternative waste forms offer significant increases in safety over that obtained with waste glass in a properly designed multibarrier system, although that possibility will continue to be examined.

IV. GLASS CHARACTERIZATION

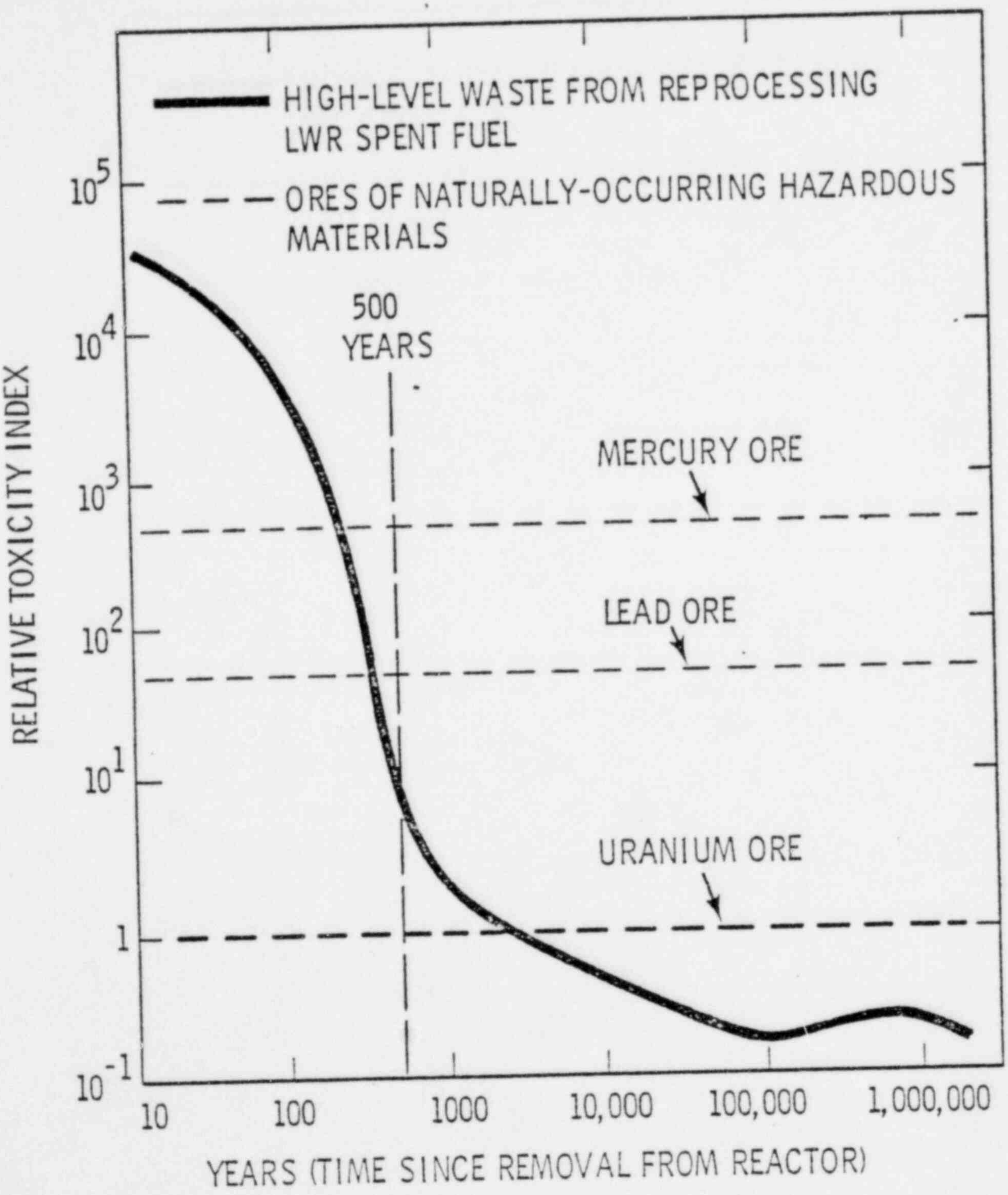
HIGHLIGHTS OF SENATE SUBCOMMITTEE TESTIMONY

- MULTIBARRIER CONCEPT
- RELATIVE HAZARD
- TEMPERATURE IN REPOSITORY

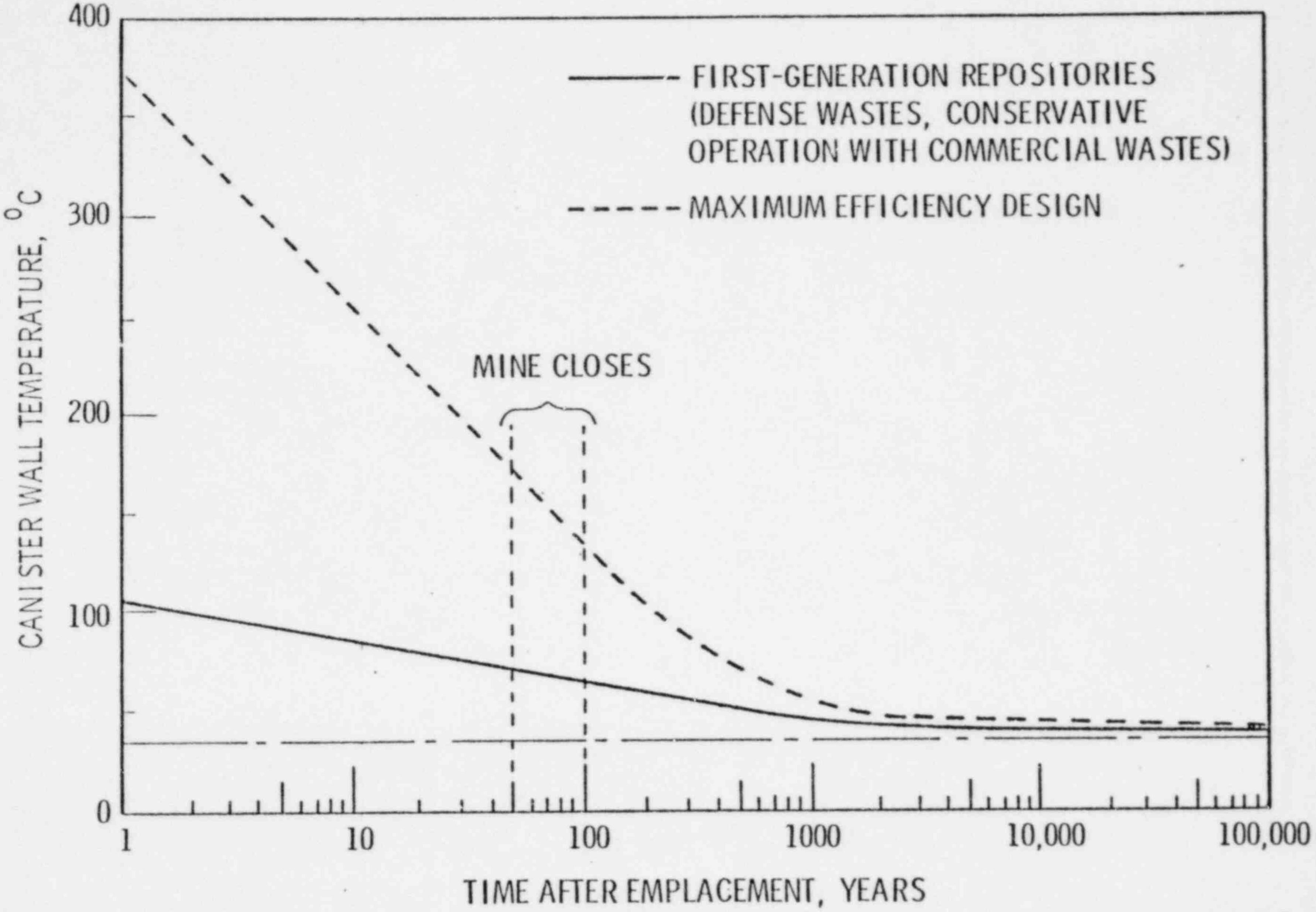
MULTIBARRIER CONCEPT FOR WASTE ISOLATION

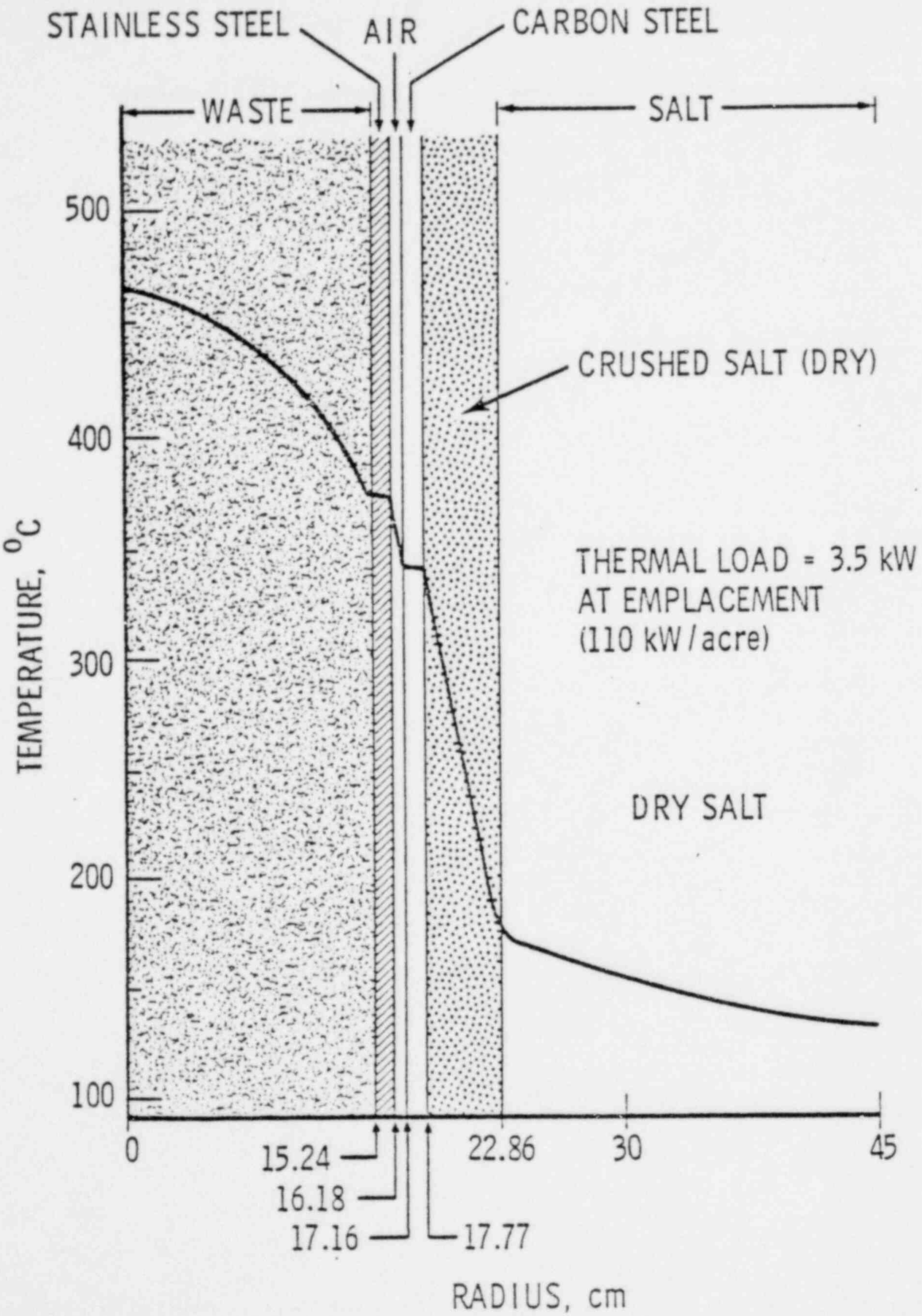


RELATIVE TOXICITY OF NUCLEAR WASTE

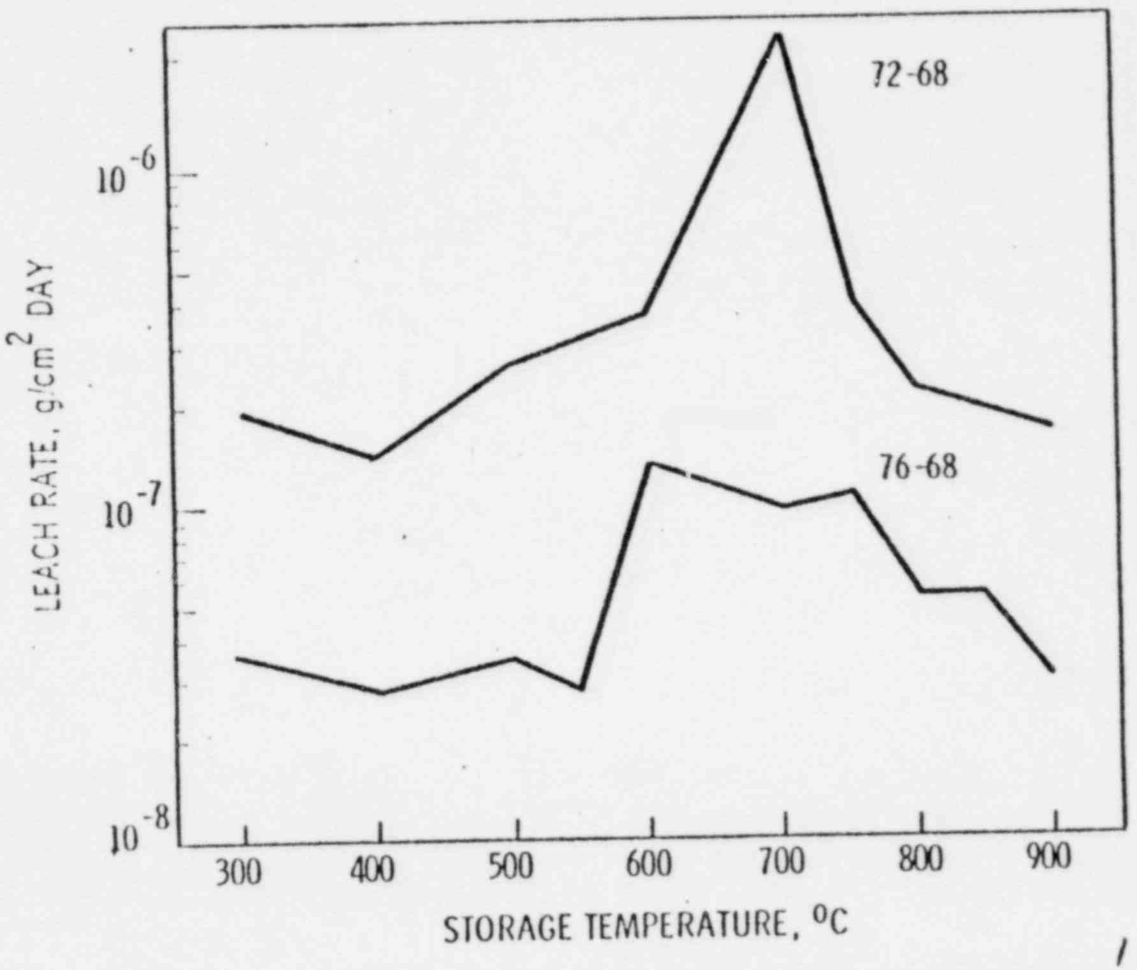


HLW CANISTER WALL TEMPERATURES IN SALT

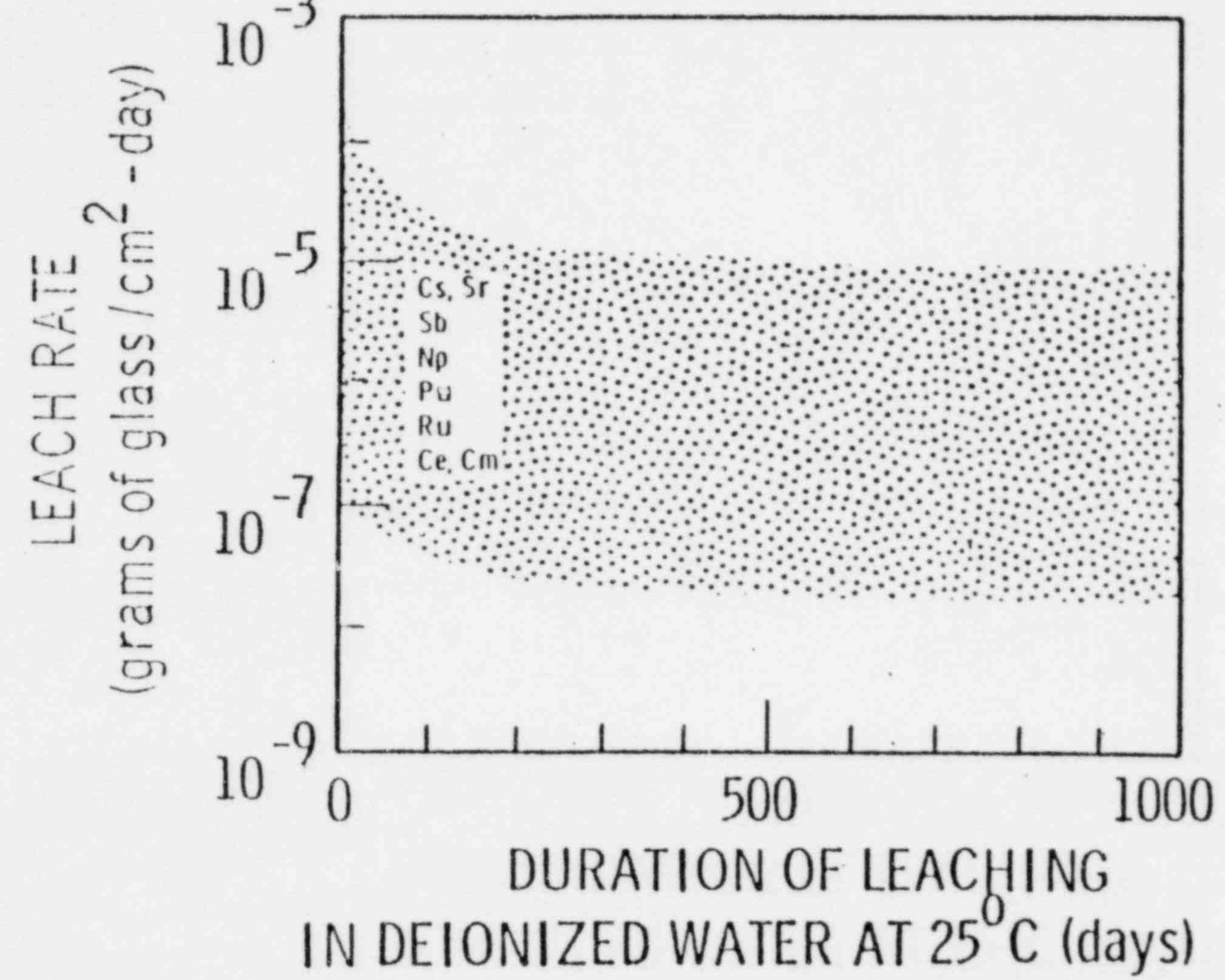



STAINLESS STEEL
AIR
CARBON STEEL
WASTE
SALT
500
400
300
200
100
TEMPERATURE, °C
CRUSHED SALT (DRY)
THERMAL LOAD = 3.5 kW
AT EMPLACEMENT
(110 kW/acre)
DRY SALT
0
15.24
16.18
17.16
17.77
22.86
30
45
RADIUS, cm

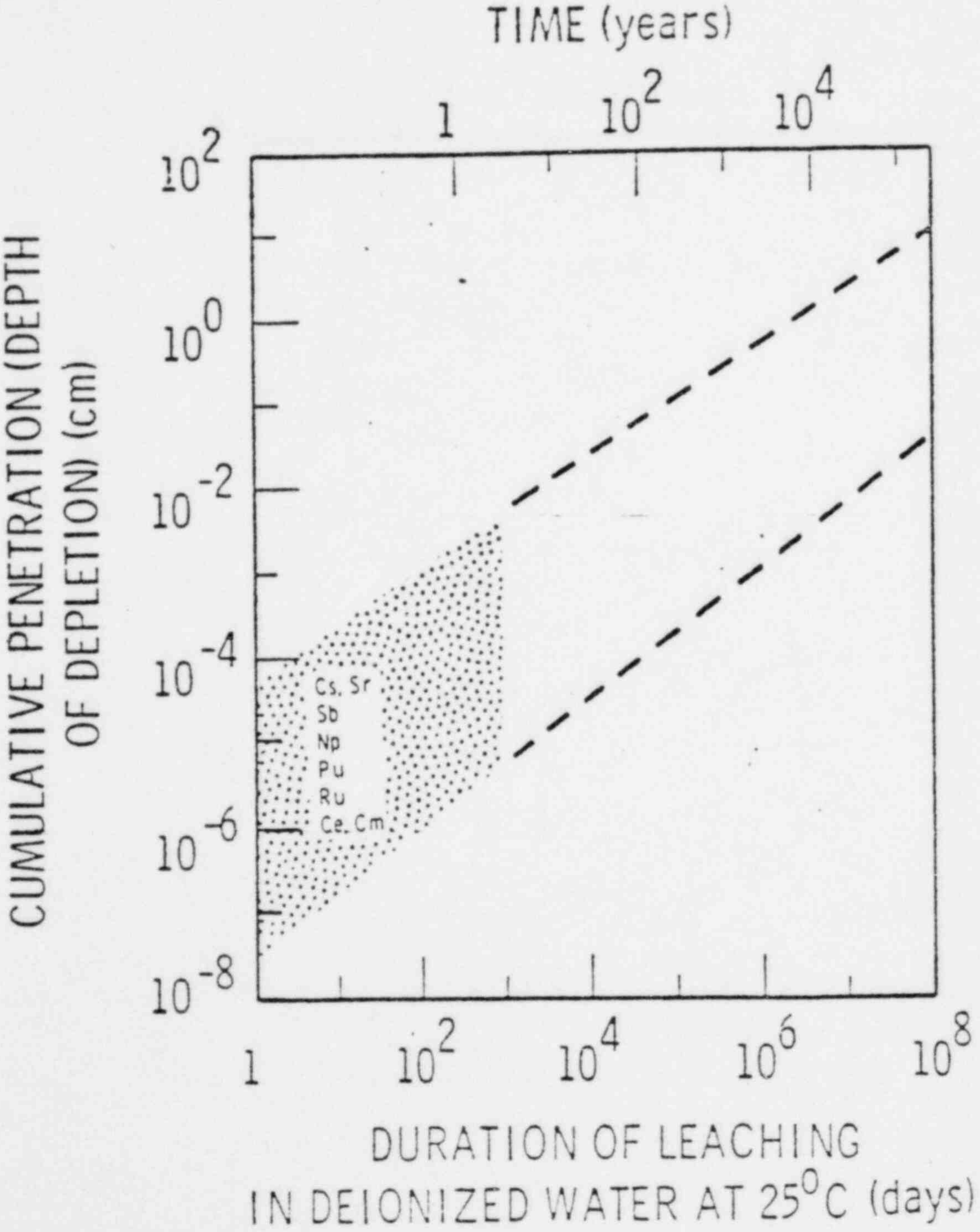
MAXIMUM DEVITRIFICATION EFFECTS IN TYPICAL WASTE GLASSES



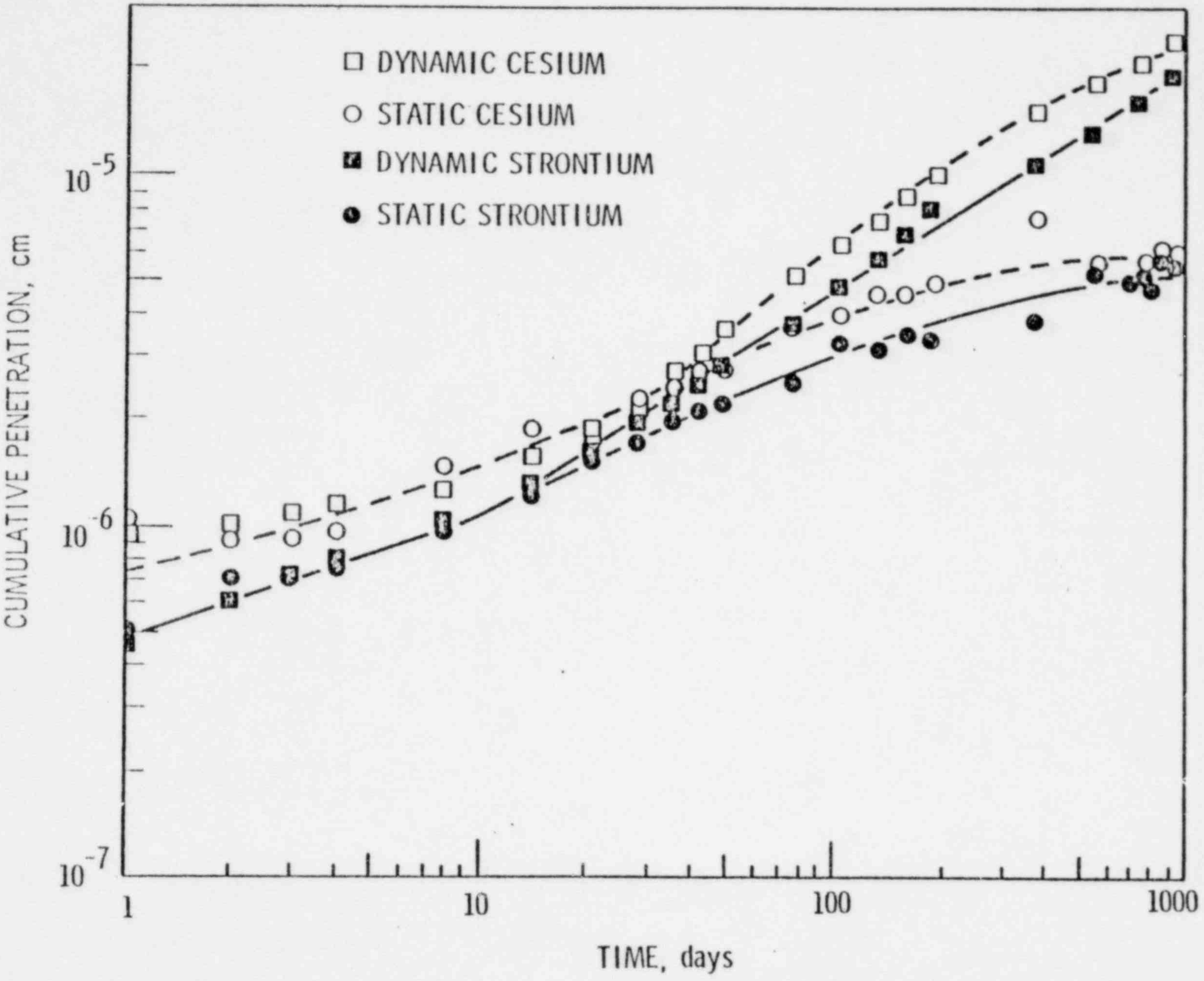
LEACH RATE OF WASTE GLASS



A MORE MEANINGFUL WAY TO EXPRESS LEACH RATES



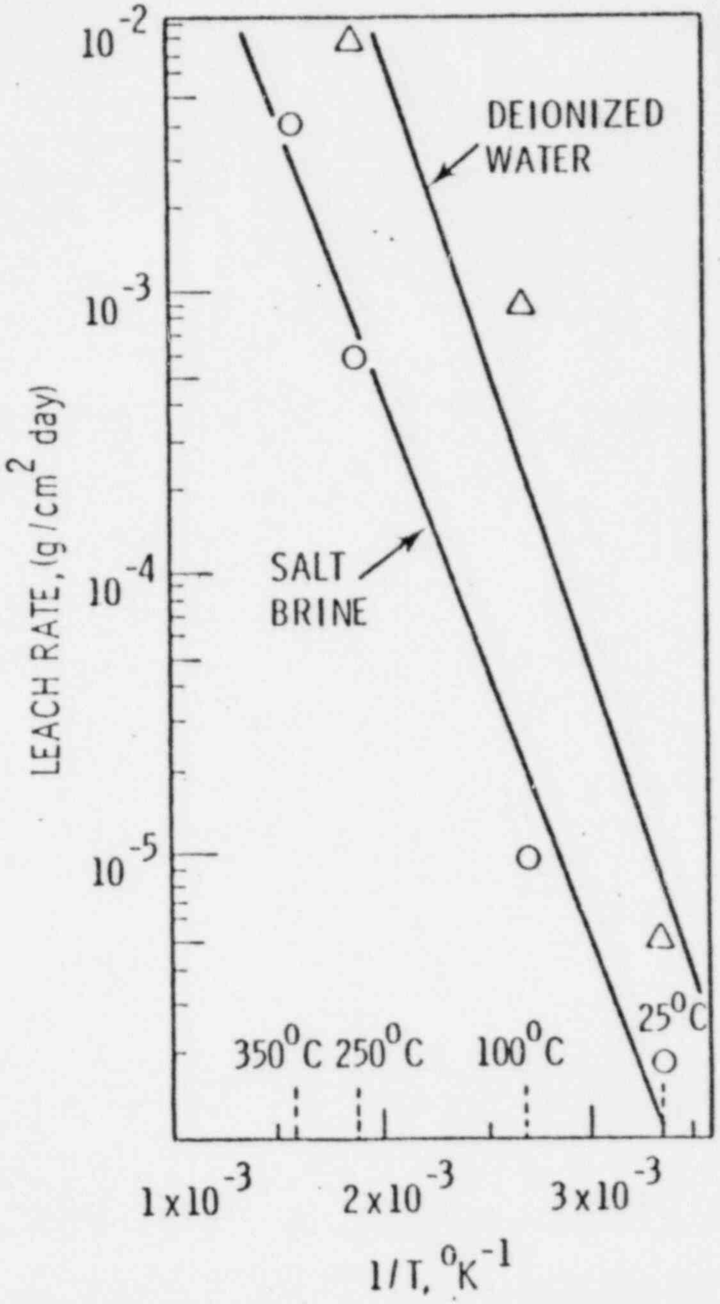
COMPARISON OF STATIC AND DYNAMIC LEACHING



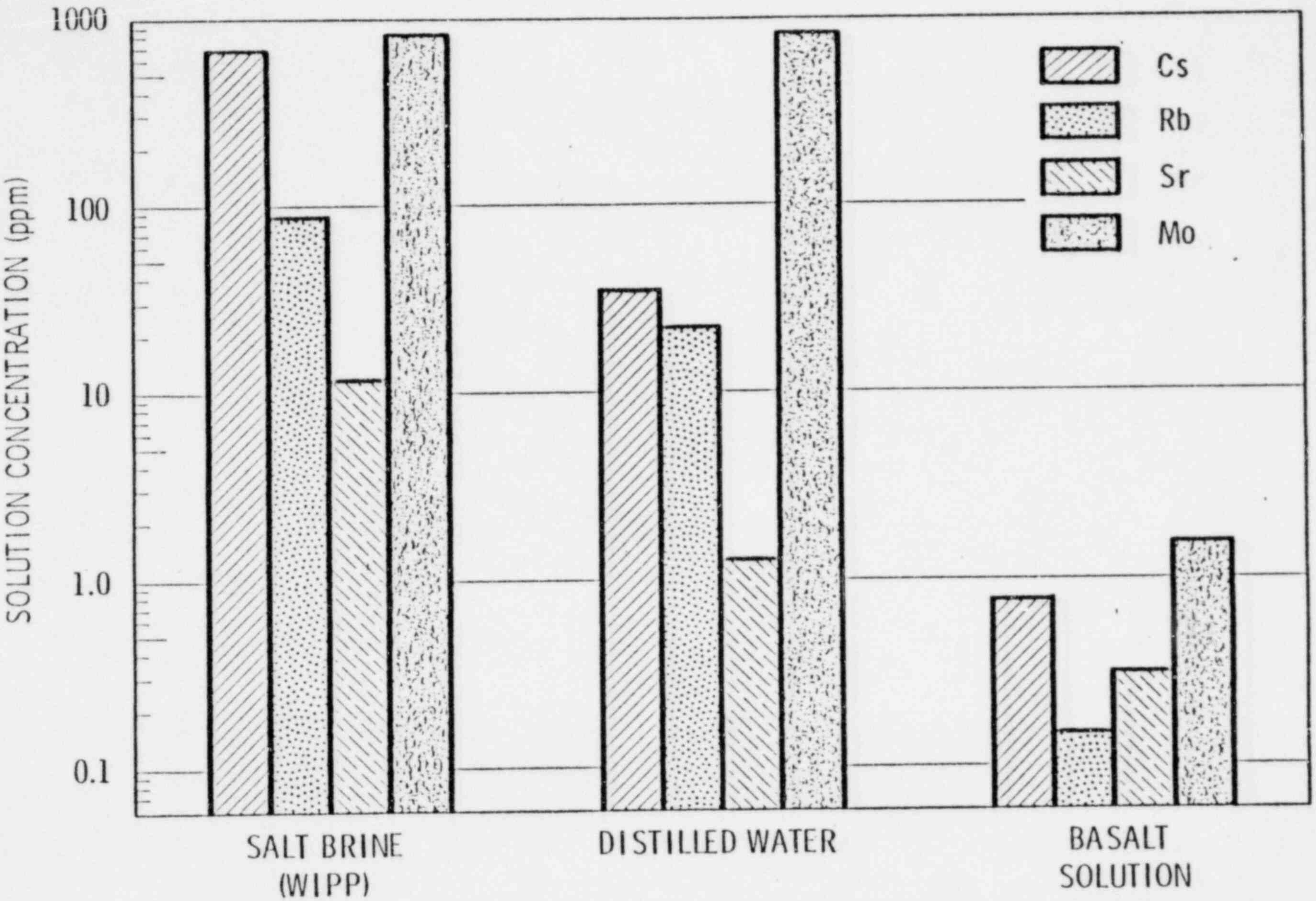
CANADIAN WASTE GLASS LEACHING EXPERIMENT

TIME	LEACH RATE, G/cm^2 - DAY	
1 DAY	1×10^{-5}	LABORATORY TEST RESULTS
10 DAYS	5×10^{-6}	
100 DAYS	4×10^{-7}	
1 YEAR	4×10^{-8}	BURIAL TEST RESULTS
2 YEARS	7×10^{-9}	
3 YEARS	4×10^{-10}	
4 YEARS	3×10^{-10}	
5 YEARS	3×10^{-10}	
6 YEARS	2×10^{-10}	
7 YEARS	8×10^{-11}	
8 YEARS	6×10^{-11}	
9 - 15 YEARS	5×10^{-11}	

LEACH RATE OF WASTE GLASS AS FUNCTION OF TEMPERATURE



CONCENTRATION OF FISSION PRODUCTS IN LEACHATE AFTER TESTING GLASS AT 350°C



LEACHING AT 350°C

	CONCENTRATION IN LEACH LIQUOR, ppm			
	PNL (WIPP-B-BRINE)		PENN STATE (USGS NBT-6a-BRINE)	
ELEMENT	GLASS (76-68) 7 DAYS	SUPERCALCINE (SPC-4) 3 DAYS	GLASS (76-68) 28 DAYS	SUPERCALCINE (SPC-4) 28 DAYS
Cs	640	2000	500	1600
Sr	12	48	160	1300
Rb	86	440	64	470
Si	37	41	---	5.7
Mo	81	33	45	22

RECENT GERMAN LEACH DATA[a]

FINAL WASTE FORM	% WEIGHT LOSS				
	390°K	470°K			
	3 DAYS	3 DAYS	15 DAYS	30 DAYS	60 DAYS
C-31-3EC [b]	0.3	2.3	2.5	2.3	2.3
C-31-3EC [c]	0.8	1.5	1.8	1.5	2.5

[a] W. LUTZE, TO BE PRESENTED AT INTERNATIONAL SYMPOSIUM ON CERAMICS IN NUCLEAR WASTE MANAGEMENT, CINCINNATI

[b] PARENT GLASS

[c] CELSIAN GLASS CERAMIC

V. ALTERNATIVE WASTE FORMS

ALTERNATIVE WASTE FORMS DEVELOPMENT

ORIGINAL OBJECTIVES

- PROVIDE A BACKUP OR SECOND GENERATION PROCESS
- PRODUCE A WASTE FORM WHICH HAS IMPROVED INERTNESS AND LOWER DISPERSIBILITY
- PRODUCE INERT FORMS FROM WASTES NOT READILY COMPATIBLE WITH VITRIFICATION
- INCREASE RELIABILITY THROUGH PROCESS SIMPLIFICATION
- REDUCE THE COST OF SOLIDIFICATION AND/OR STORAGE

BRIEF HISTORY OF ALTERNATIVES WORK AT PNL

1972 CURRENT WASTE PROGRAM STARTED

1973 INITIATED ALTERNATIVES WORK

- MULTIBARRIER CONCEPT
- MICROCRYSTALLINE FORMS
- PSU, CORNING GLASS

1974 WORK UNDERWAY ON

- SUPERCALCINE - PSU
- PyC AND SiC COATING TECHNOLOGY - GGA
- PRESSED CONCRETE - PSU
- HOT PRESSING
- VITREOUS CARBON
- COMPARISON OF ALTERNATIVE MATERIALS

1975

- DISC PELLITIZER WORK FOR CONSOLIDATING CALCINE
- GLASS CERAMICS STUDY
- CVD COATING TECHNOLOGY - BCL
- PLASMA SPRAY COATINGS
- EXTRUSION CERAMICS INVESTIGATED

1976

- METAL MATRIX WORK
  - CASTINGS (Pb, Pb-Sn, etc.)
  - VIBRATORY COMPACTION (Cu, SST, etc.)
- PyC AND Al_2O_3 COATING TECHNOLOGY
- PRESSED AND SINTERED SUPERCALCINE
- GLASS MARBLE INVESTIGATION

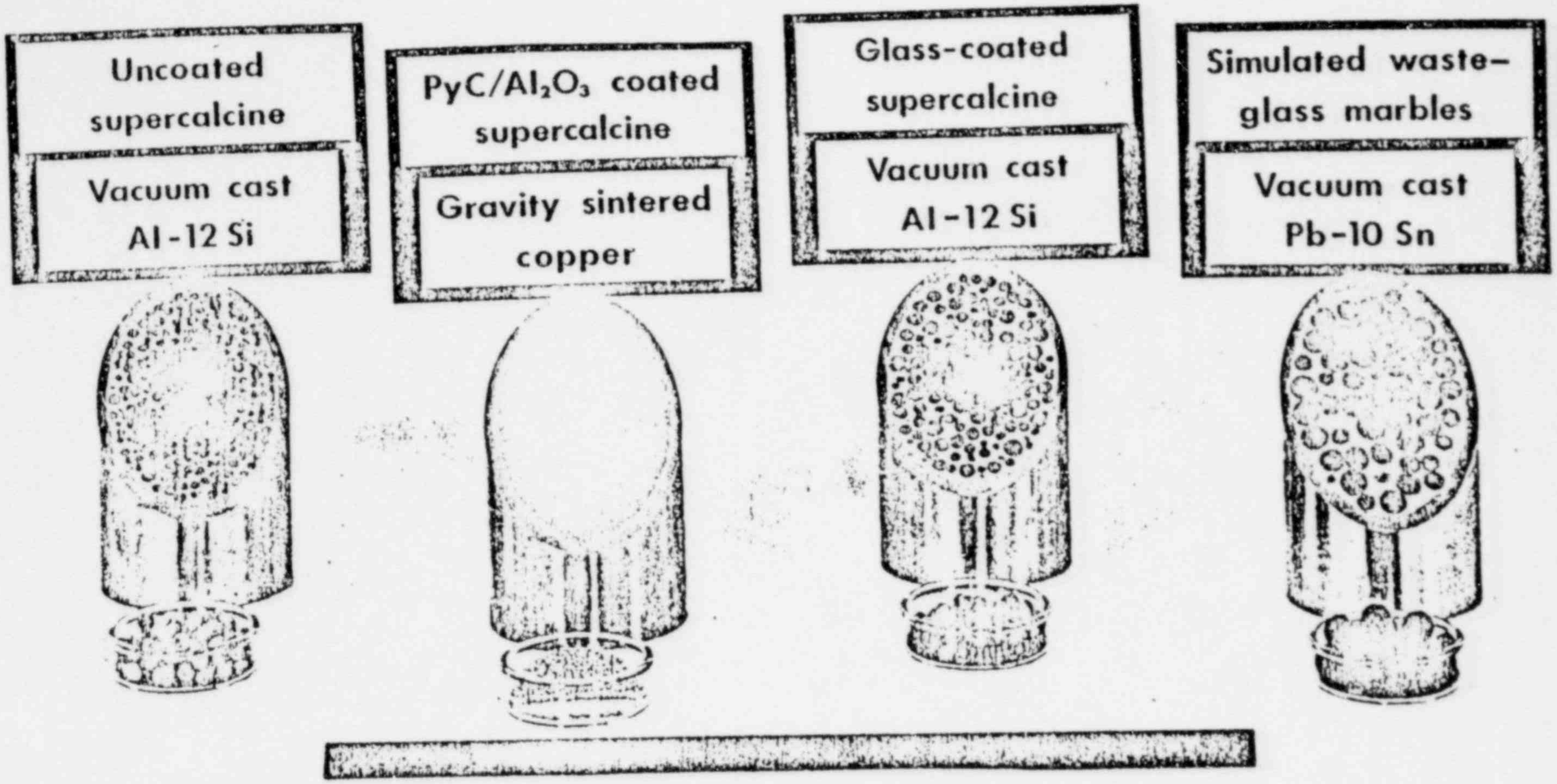
BRIEF HISTORY OF ALTERNATIVES WORK AT PNL (CONT'D)

1977

- MAKE ONE LITER SAMPLES OF SELECT MULTIBARRIER PRODUCTS
- ENGINEERING FEASIBILITY OF ALTERNATIVES PROCESSING
- PRODUCED SUPERCALCINE IN SPRAY CALCINER
- CHARACTERIZED MULTIBARRIER SAMPLES

1978

- ISSUED TWO REPORTS ON MULTIBARRIER WORK
  - (1) SELECTION OF SYSTEM FOR DEVELOPMENT
  - (2) CHARACTERIZATION AND EVALUATION
- ISSUE LITERATURE REVIEW ON CONCRETE AS A WASTE FORM
- BEGAN COMPREHENSIVE WASTE MATERIALS CHARACTERIZATION STUDY
- CONSTRUCTED AND OPERATED MARBLE MACHINE FOR PILOT SCALE OPERATION
- BEGAN PILOT SCALE MATRIX WORK

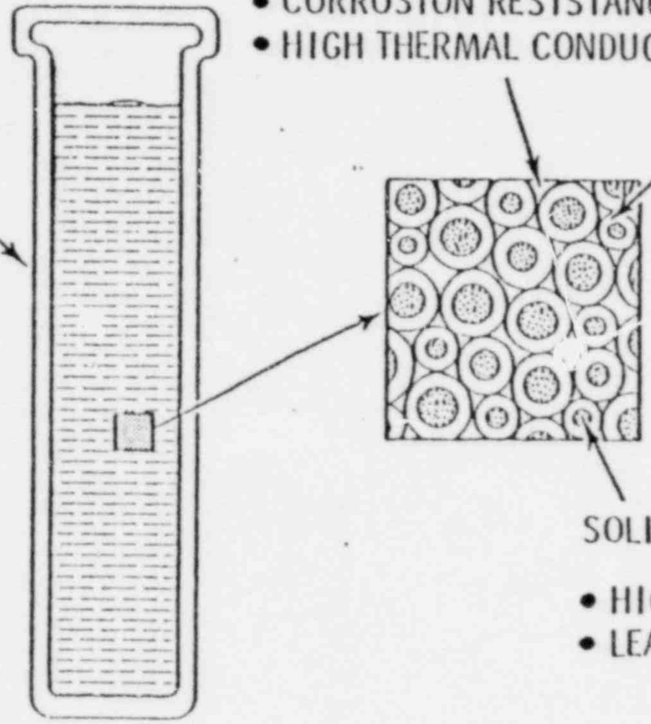

Uncoated supercalcine
Vacuum cast Al-12 Si
PyC/Al₂O₃ coated supercalcine
Gravity sintered copper
Glass-coated supercalcine
Vacuum cast Al-12 Si
Simulated waste-glass marbles
Vacuum cast Pb-10 Sn

MULTIBARRIER WASTE FORM DEVELOPMENT

OBJECTIVE

PRODUCE COMPOSITE WASTE FORMS WITH ENHANCED INERTNESS THROUGH IMPROVEMENTS IN THERMAL STABILITY, MECHANICAL STRENGTH, AND LEACHABILITY BY THE USE OF COATINGS AND METAL MATRICES

MULTIBARRIER CONCEPT FOR ISOLATING HIGH-LEVEL WASTE



STORAGE CANISTER

METAL MATRIX

- IMPACT RESISTANCE
- CORROSION RESISTANCE
- HIGH THERMAL CONDUCTIVITY

IMPERVIOUS COATING

- PyC FOR LEACH RESISTANCE
- Al_2O_3 FOR OXIDATION RESISTANCE

SOLID WASTE INNER CORE

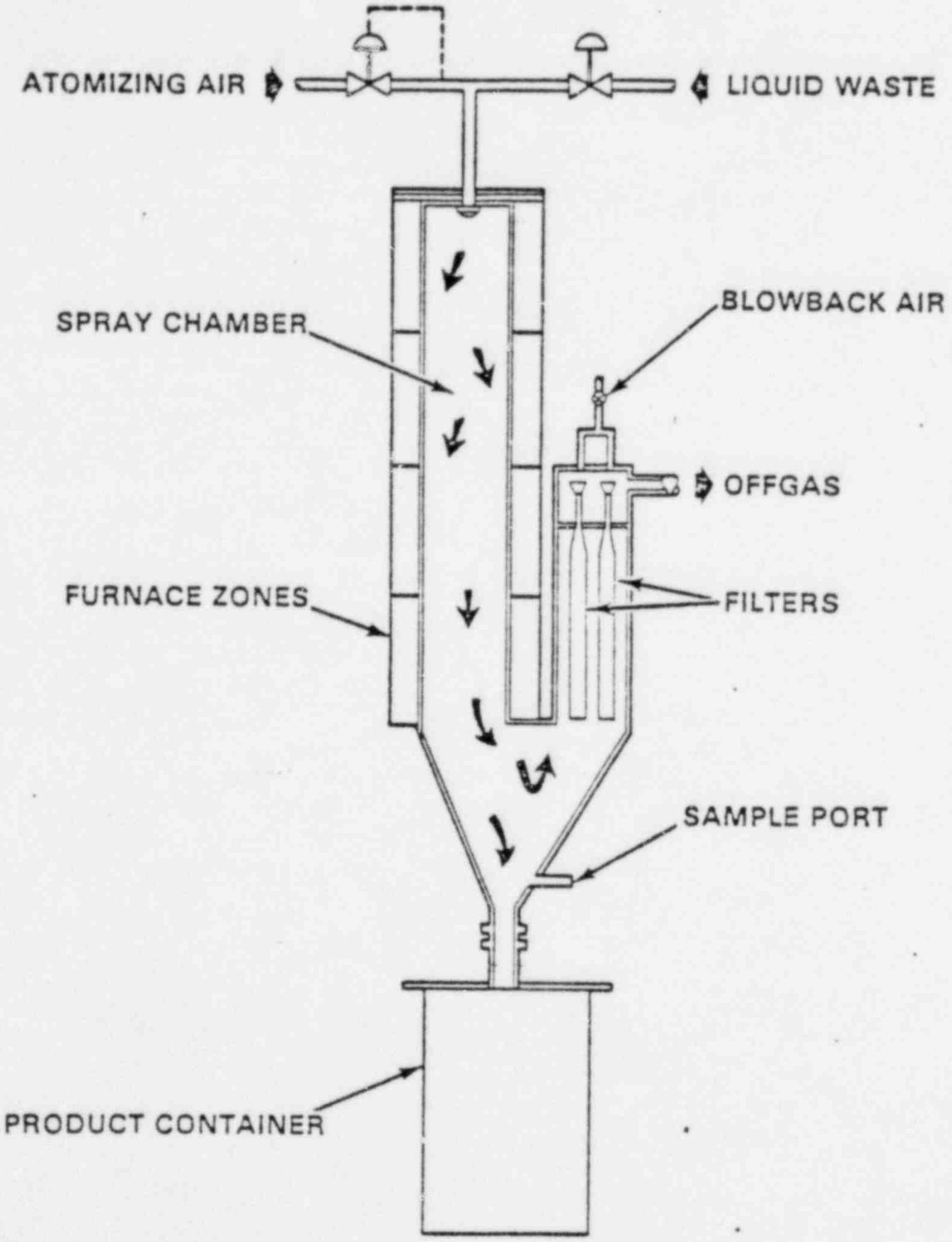
- HIGH THERMAL STABILITY
- LEACH RESISTANCE

SUPERCALCINE

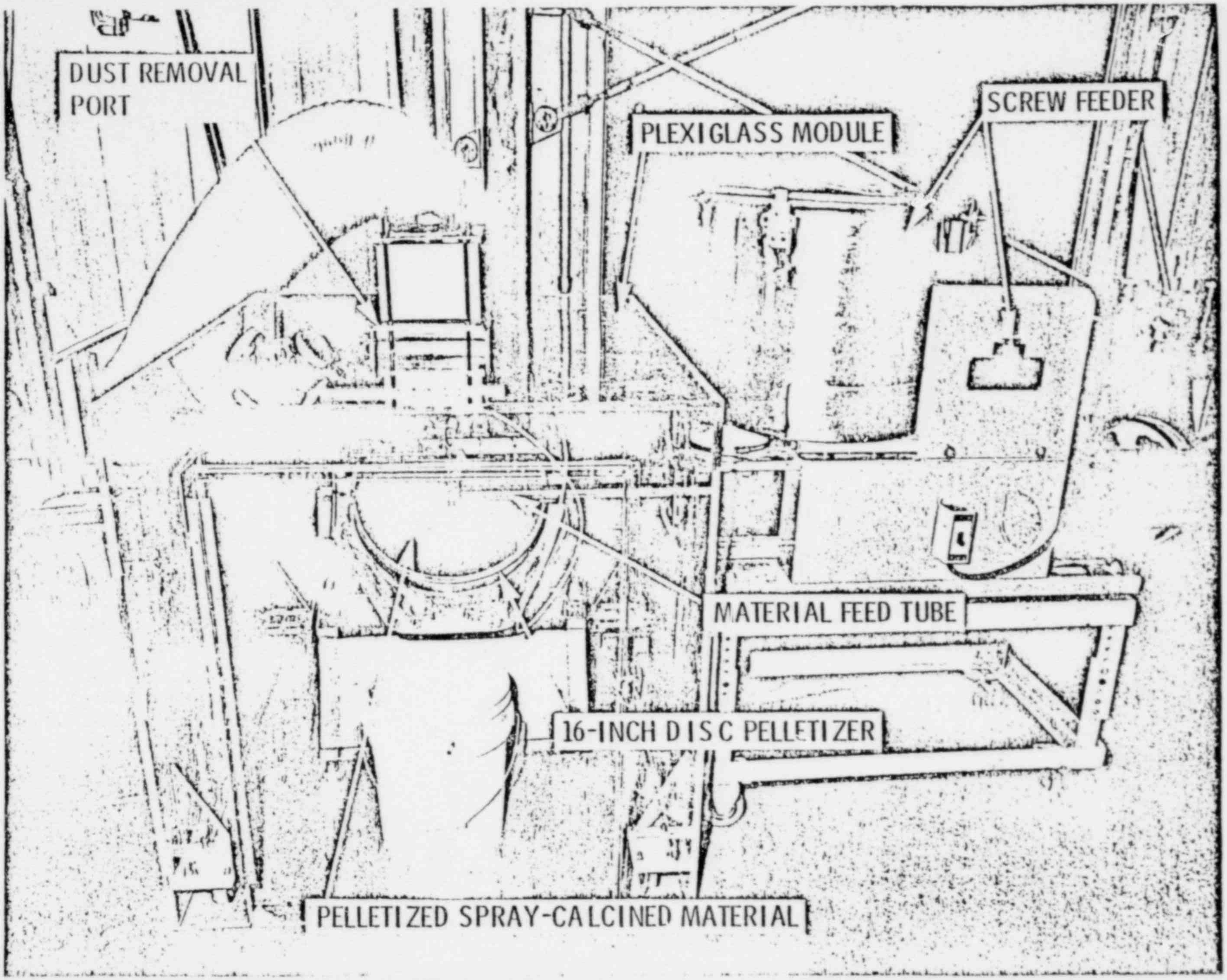
- CONCEPT: "MODIFY NUCLEAR WASTE WITH ADDITIVES TO FORM AN ASSEMBLAGE OF TAILOR-MADE CRYSTALLINE PHASES"
- COMPOSITION:

	SPC-2 (%)	SPC-4 (%)
HIGH LEVEL WASTE OXIDES	77	78
SUPERCALCINE ADDITIVES		
SiO_2	15	14
CaO	4	2
Al_2O_3	3	4
SrO	1	2

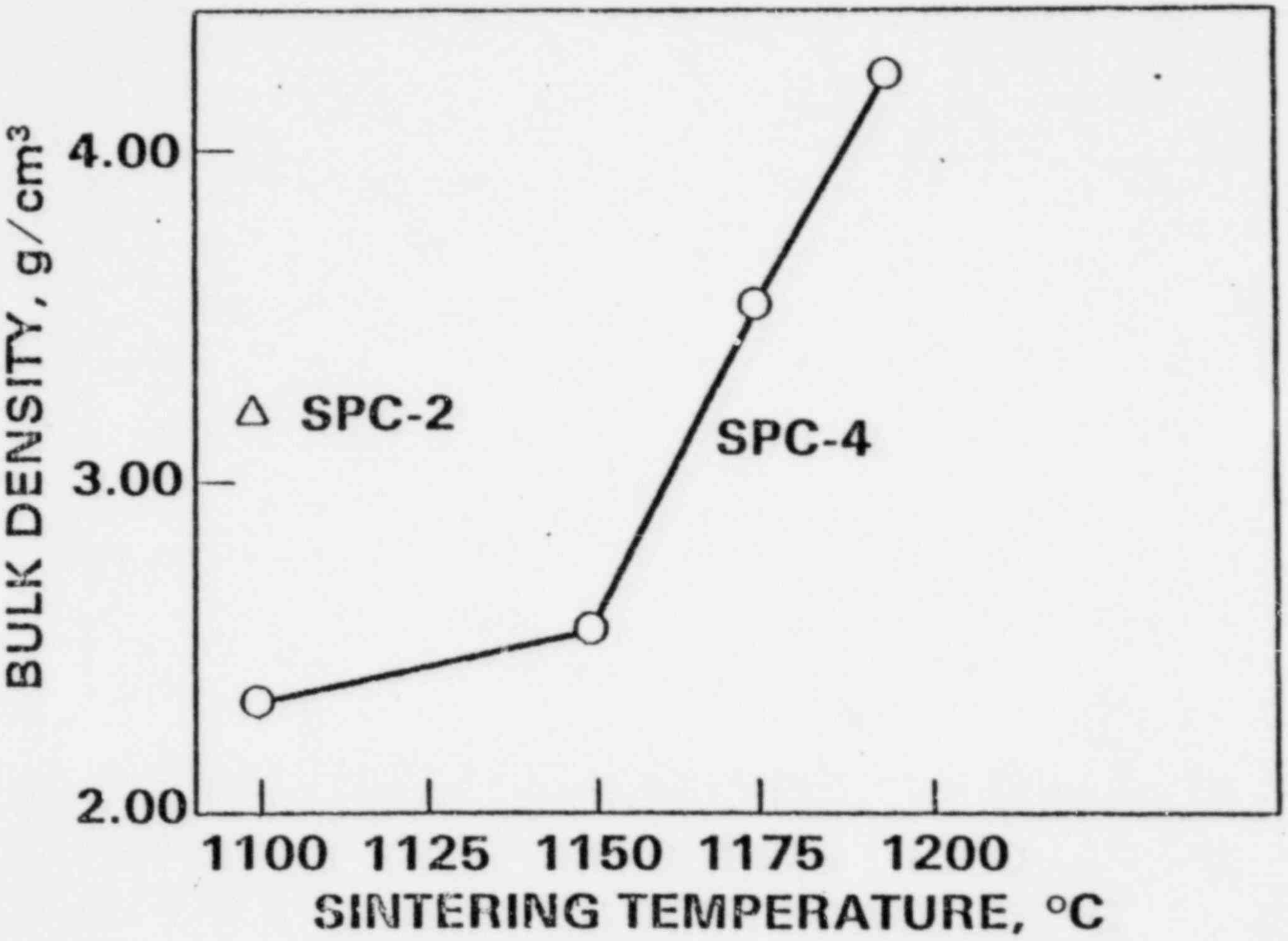
SCHEMATIC DIAGRAM OF PROCESS SPRAY DRYER



LABORATORY-SCALE DISC PELLETIZER SYSTEM



BULK DENSITY VERSUS SINTERING TEMPERATURE FOR SUPERCALCINE



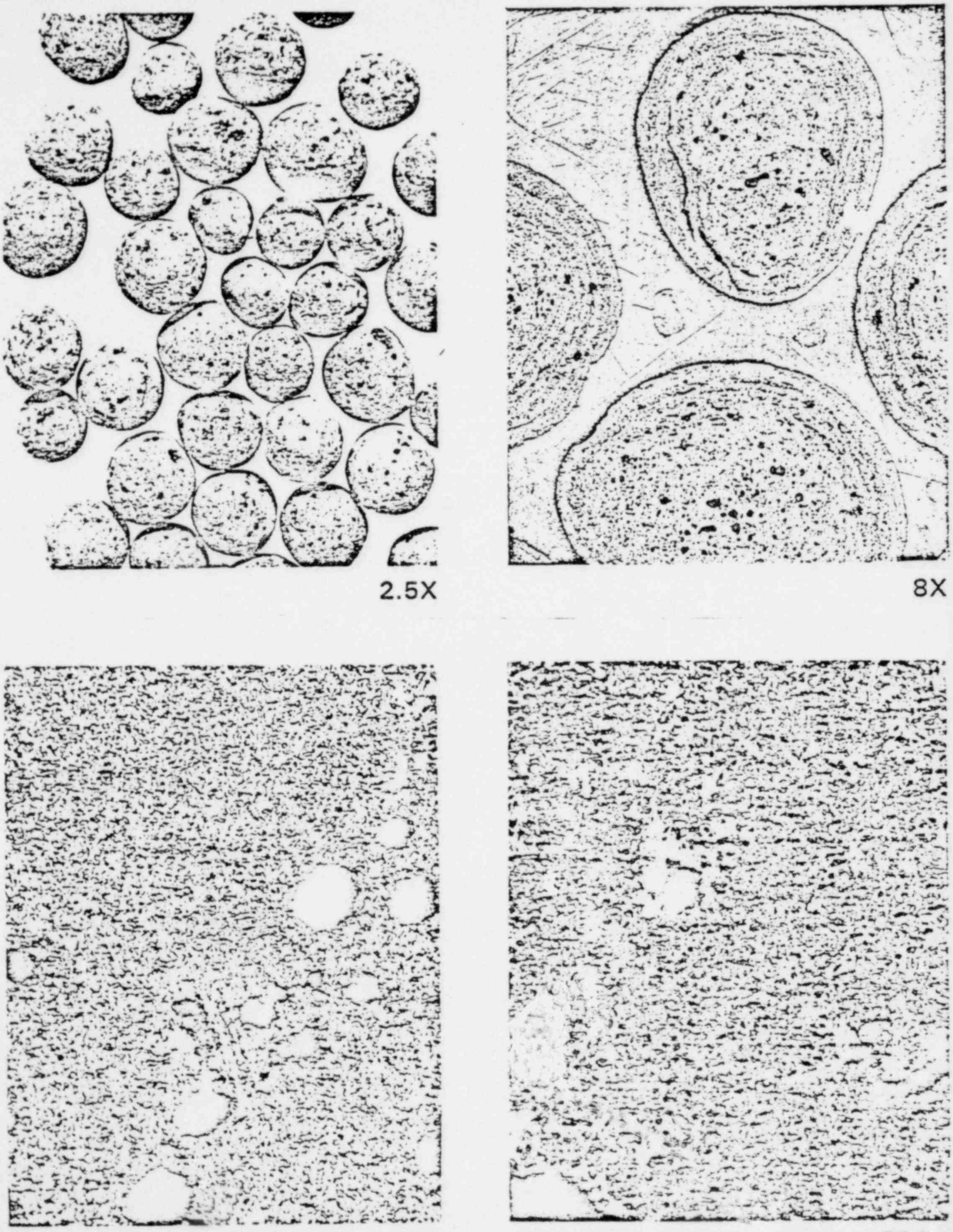
CRYSTAL CHEMICAL ROLES OF WASTE IONS(a)

IONS	NOMINAL COMPOSITION OF SYNTHETIC MINERAL	STRUCTURE
Sr,Ln(b)	$(\underline{Ca},Sr)_2Ln_8(\underline{Si}O_4)_6O_2$(c)	APATITE $[A_{ss}]$
Ln, $[PO_4]$	$LnPO_4$	MONAZITE $[M_{ss}]$
Cs,Rb,Na	$(Cs,Rb,Na)\underline{AlSi_2}O_6$	POLLUCITE $[P]$
Sr,Ba	$(\underline{Ca},Sr,Ba)MoO_4$	SCHEELITE $[S_{ss}]$
U,Ce,Zr	$(U,Ce,Zr\ldots)O_{2+x}$	FLUORITE $[F_{ss}]$
Zr,Ce,U	$(Zr,Ce,U\ldots)O_{2+x}$	TETRAGONAL-FLUORITE $[T_{ss}]$
Fe,Ni,Cr	$(Ni,Fe)(Fe,Cr)_2O_4$ AND $(Fe,Cr)_2O_3$	SPINEL $[SP_{ss}]$ CORUNDUM $[Fe_2O_{3ss}]$
Ru	RuO_2	RUTILE

(a) Te,Pd,Rh,Tc,Pm,Np,Pu,Am,Cm WERE NOT INCLUDED IN THE SIMULATED WASTE.

(b) Ln=La,Pr,Nd,Sm,Eu,Gd,Y.

(c) ADDITIVE IONS ARE UNDERLINED.



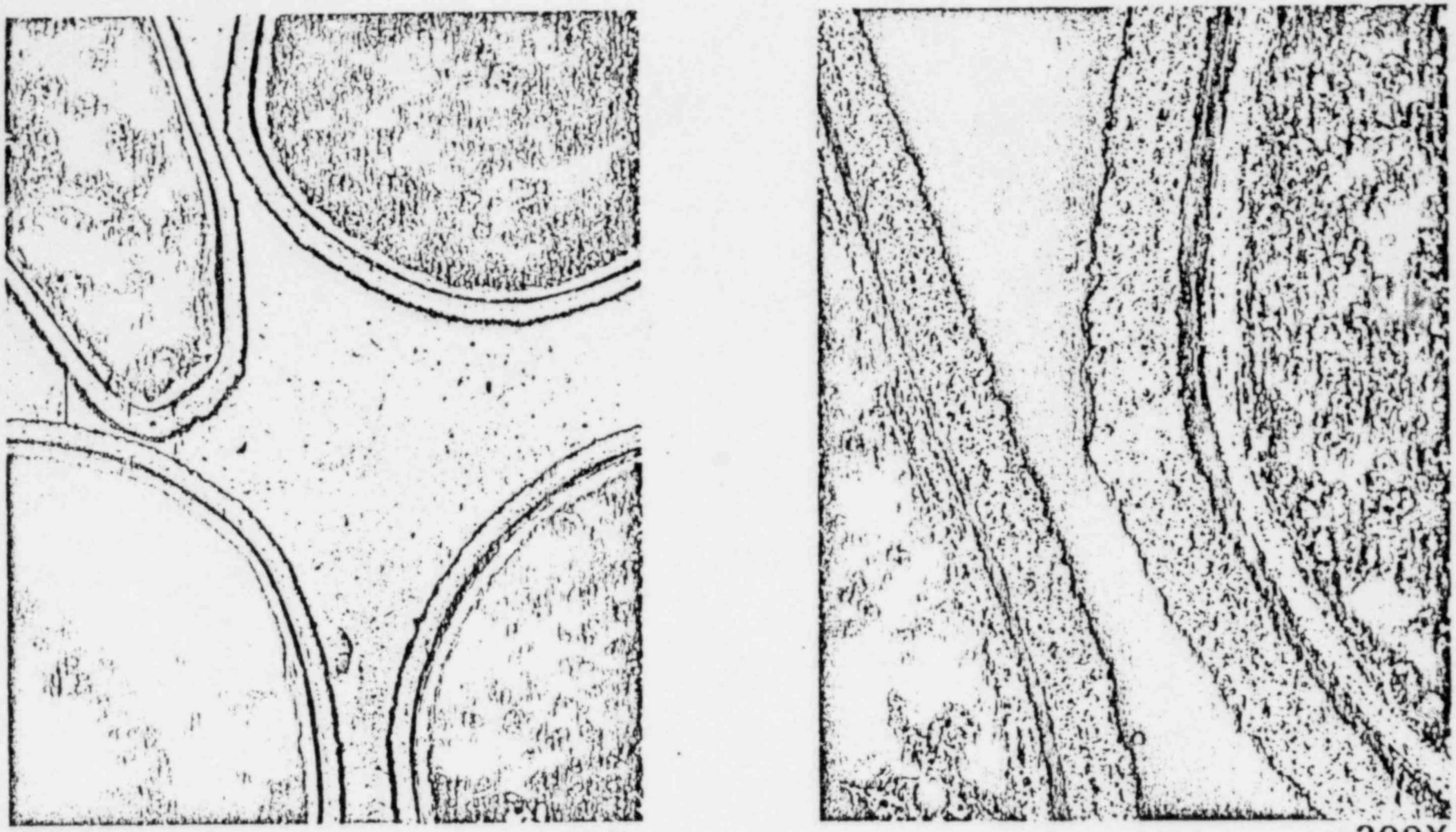
2.5X

8X

200X

500X

SPC-4 4-9mm CORES



50X

200X

CVD COATED SUPERCALCINE

32 μm	PyC
7 μm	POROUS Al_2O_3
49 μm	DENSE Al_2O_3

METAL MATRIX

- GRAVITY SINTERING
- CONVENTIONAL CASTING
- VACUUM CASTING

MULTIBARRIER WASTE FORM DEVELOPMENT
ONE LITER DEMONSTRATION

INNER CORE	COATING	MATRIX	ENCAPSULATION
72-68 GLASS 10 mm MARBLE	NONE	Pb-10Sn	VACUUM CAST, 400°C
SUPERCALCINE 7 mm	NONE	Al-12Si	VACUUM CAST, 650°C
SUPERCALCINE 7 mm	GLASS GLAZE, <1 mm	Al-12Si	VACUUM CAST 650°C
SUPERCALCINE 2 mm	CVD PyC - 40 μm Al_2O_3 - 60 μm	Cu	GRAVITY SINTERED, 900°C - 8 HR

CONCLUSIONS

- MULTIBARRIER CONCEPT SUCCESSFULLY DEMONSTRATED ON 1-LITER SCALE

  —GLASS MARBLES IN PB-SN ALLOY
  —UNCOATED SUPERCALCINE IN AL-SI ALLOY
  —PYC/AL_2O_3 COATED SUPERCALCINE IN Cu

- WASTE MARBLES CAN BE SUCCESSFULLY PRODUCED BY VIBRATORY CASTING

- THE 16INCH PELLETIZER UNIT HAS ENOUGH CAPACITY TO CONVERT THE OUTPUT OF A LARGE PNL SPRAY CALCINER TO SUPERCALCINE OR STANDARD PELLETS

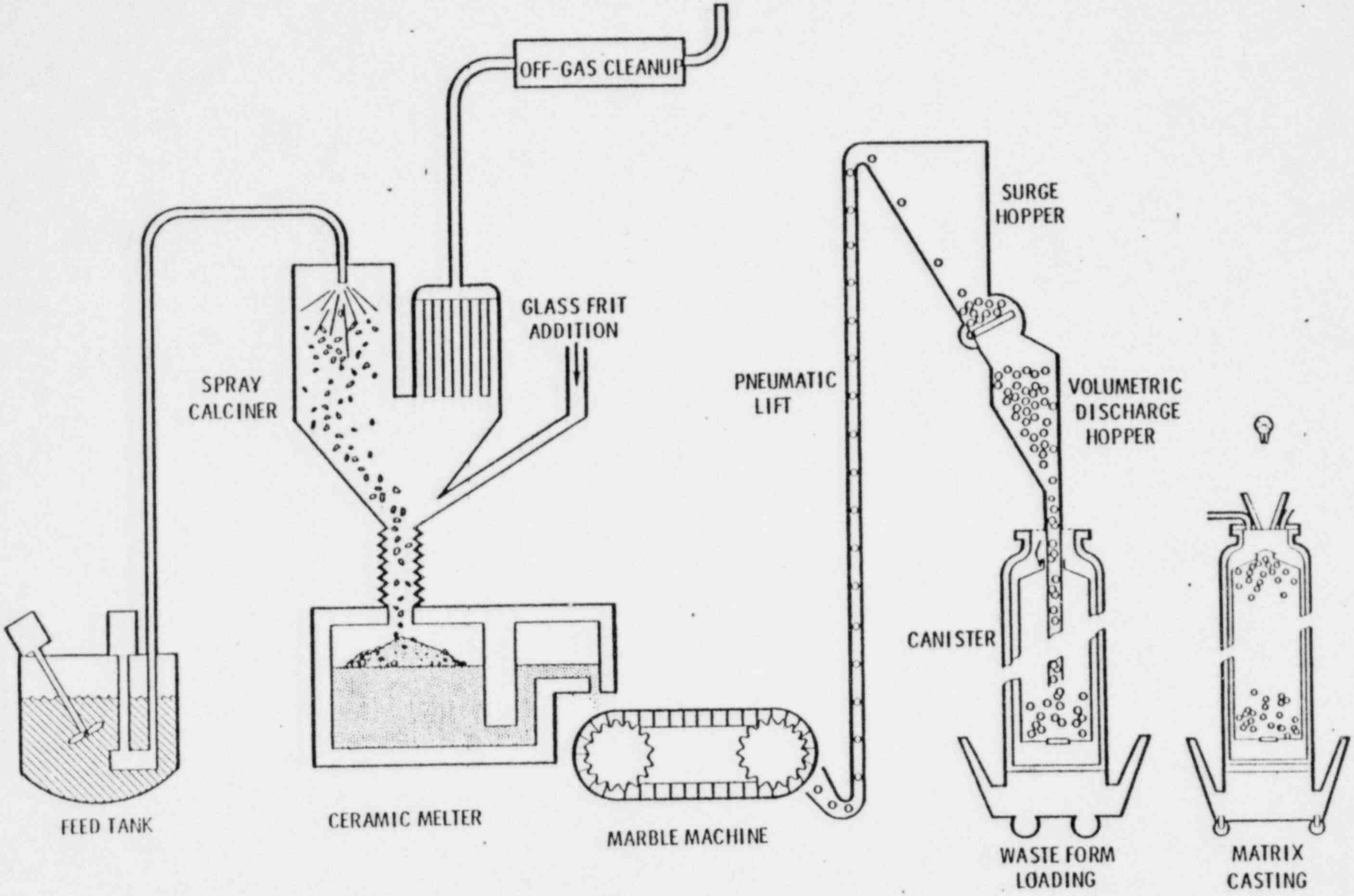
- GRAVITY SINTERING AND VACUUM CASTING ARE BOTH APPLICABLE METAL MATRIX ENCAPSULATION TECHNIQUES

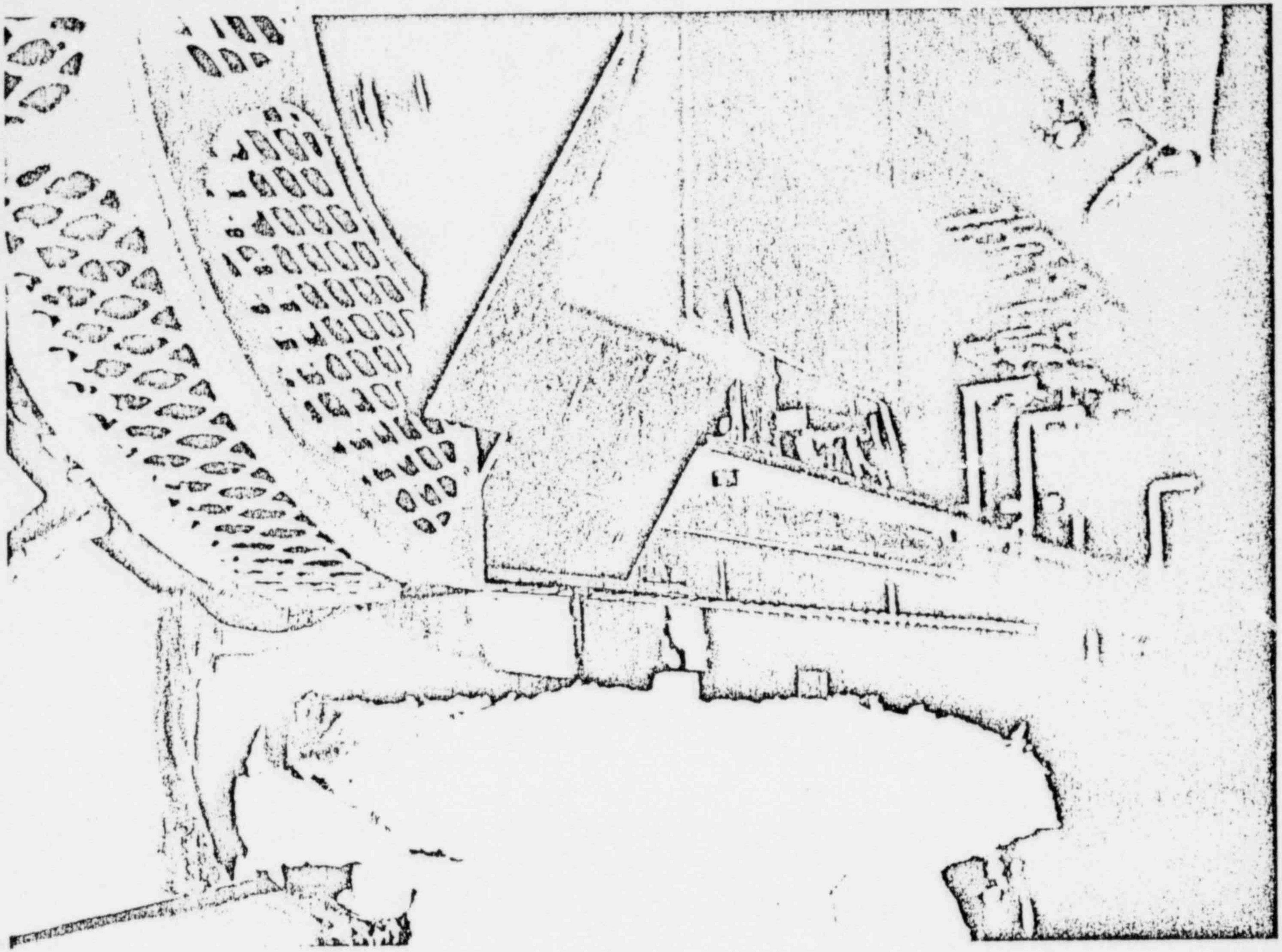
- CONSIDERABLE PROCESS DEVELOPMENT WILL BE REQUIRED FOR APPLICATION OF CVD AND GLASS COATINGS IN A LARGE SCALE OPERATION

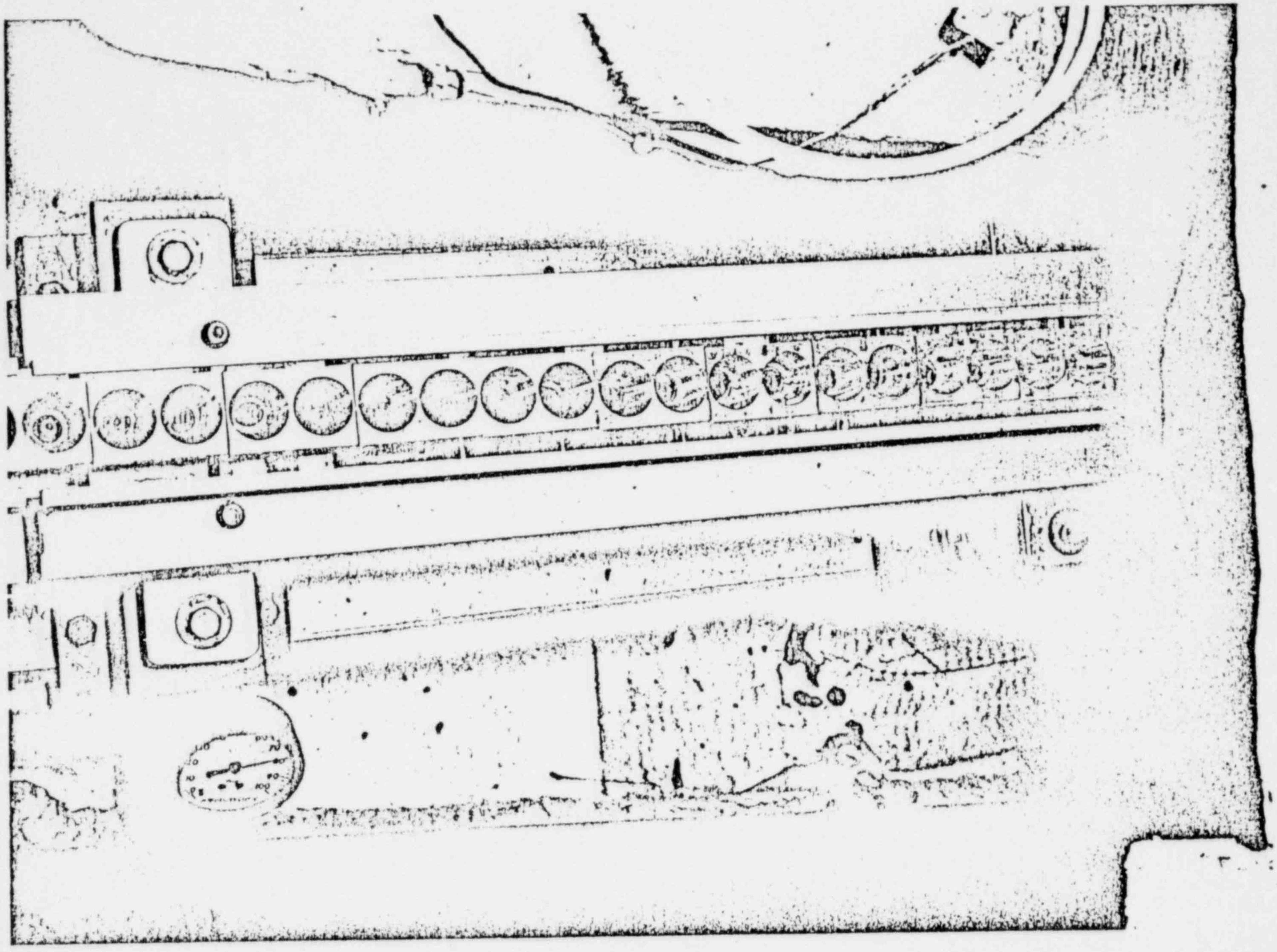
RECOMMENDATIONS FOR FURTHER DEVELOPMENT

- SCALE-UP DEMONSTRATION OF ENCAPSULATION BY VACUUM CASTING OF GLASS MARBLES IN A LEAD ALLOY
- SCALE-UP DEMONSTRATION OF ENCAPSULATION BU VACUUM CASTING OF UNCOATED SUPERCALCINE IN A METAL ALLOY
- DETERMINE PROCESS FEASIBILITY OF REMOTE ADAPTABILITY OF ALTERNATIVE CONCEPTS
- CHARACTERIZE AND EVALUATE ALTERNATIVE WASTE FORMS ON A COMPARATIVE BASIS

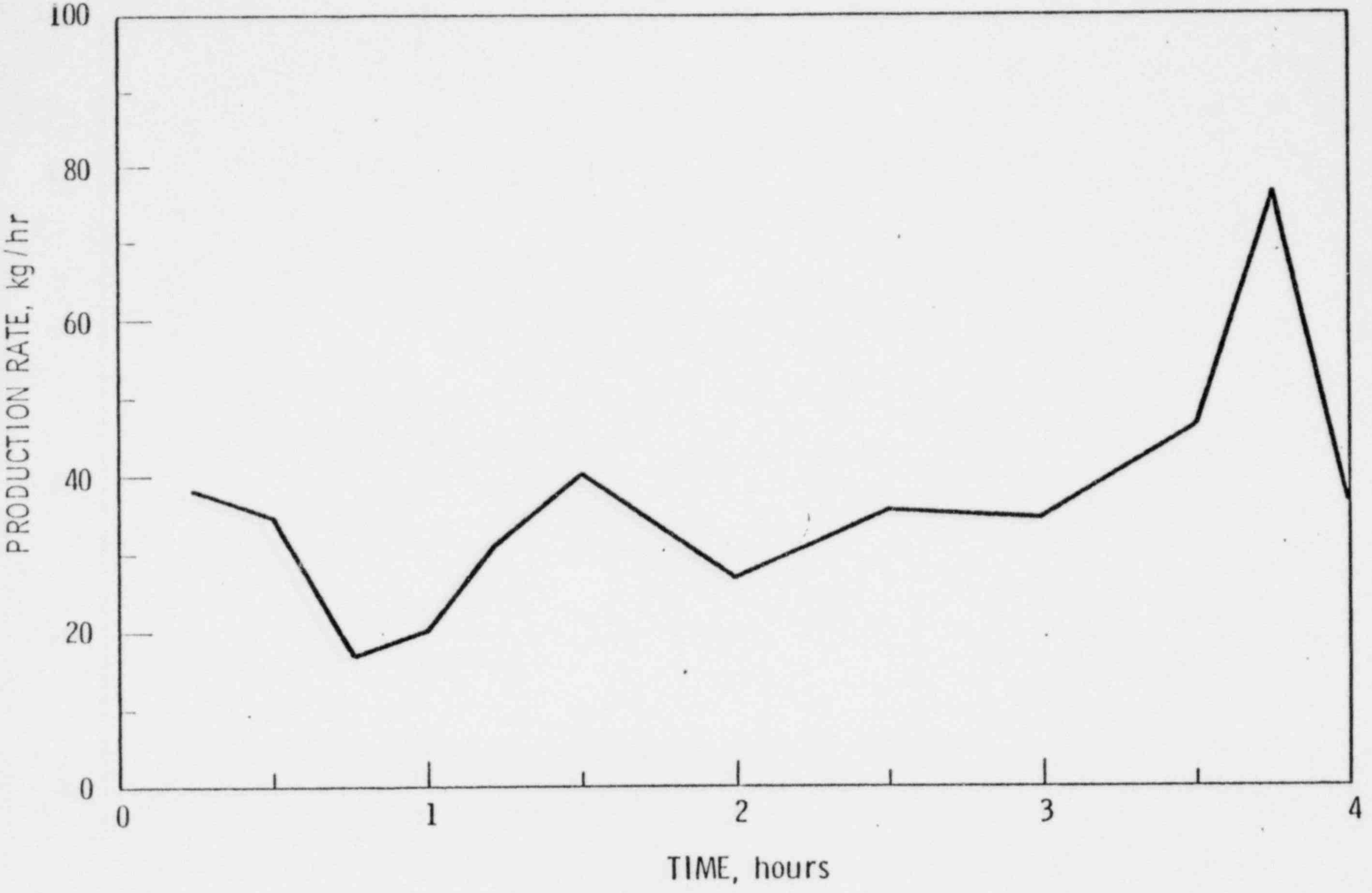
HLLW GLASS MARBLE MAKING PROCESS







MARBLE MACHINE PRODUCTION RATE



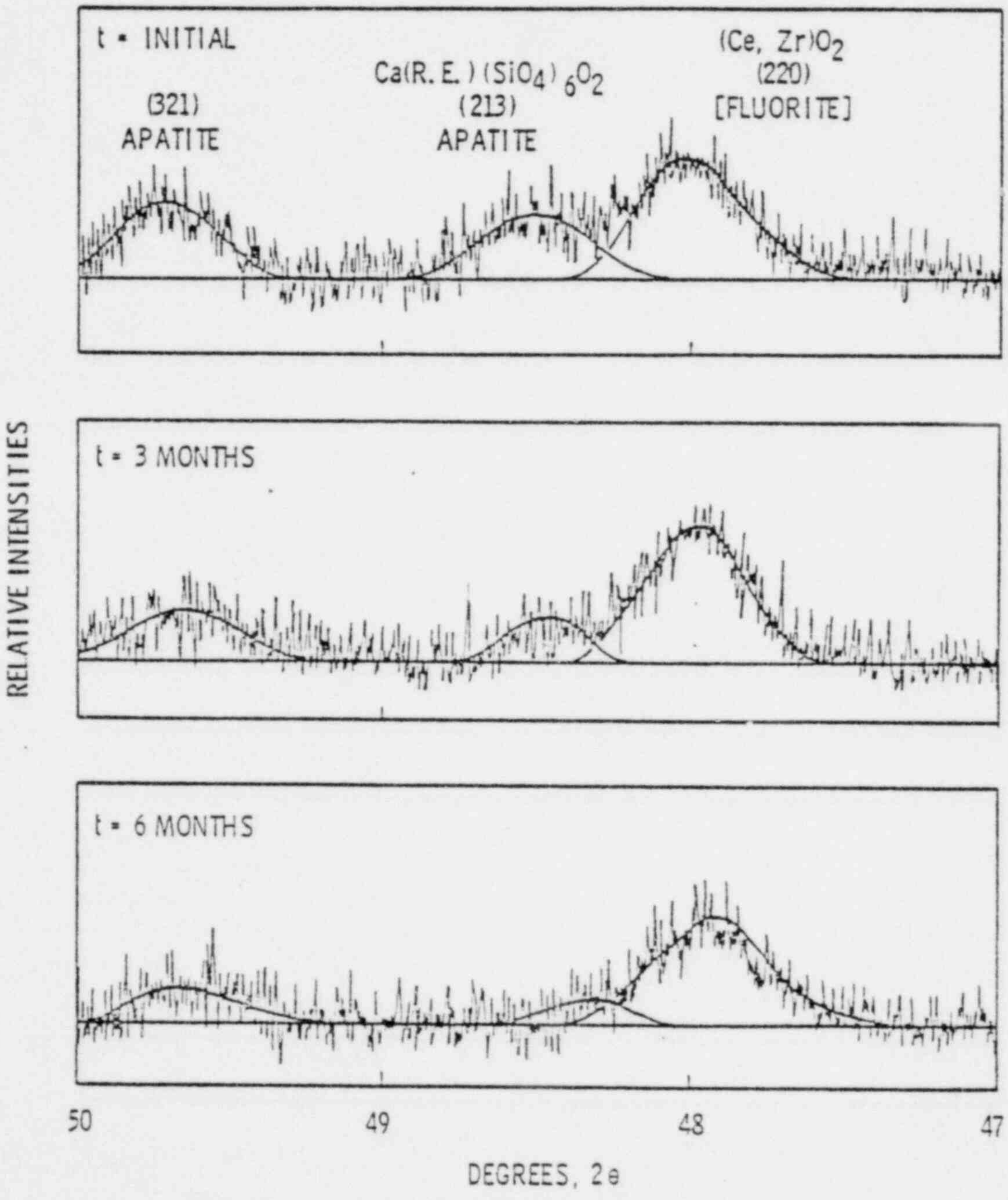
MULTIBARRIER WASTE FORM CHARACTERIZATION

- VOLATILITY
- IMPACT STRENGTH
- LEACHABILITY
- STORED ENERGY
- DENSITY
- RADIATION DAMAGE
- MICROSTRUCTURAL ANALYSIS

MULTIBARRIER WASTE FORMS CHARACTERIZATION SUMMARY

- WEIGHT LOSS OF SUPERCALCINE RANGES BETWEEN 0.01 AND 1.6 wt% FROM 1000°C TO 1200°C
- GLASS MARBLES IN CAST LEAD ALLOY OFFERS AN ORDER OF MAGNITUDE IMPROVEMENT IN IMPACT RESISTANCE AS COMPARED TO GLASS MONOLITH
- CVD COATED SUPERCALCINE IN A SINTERED STAINLESS STEEL MATRIX OFFERS UP TO TWO ORDERS OF MAGNITUDE IMPROVEMENT
- GLASS AND PyC/Al_2O_3 COATINGS PROVIDE EFFECTIVE INERT LEACHING BARRIERS
- AFTER AN EQUIVALENT α-EXPOSURE OF 200 YEARS, SUPERCALCINE CERAMICS HAVE MAINTAINED THEIR INTEGRITY BUT SHOW CRYSTALLINE PHASE INSTABILITY

3 wt% ^{244}Cm DOPED SUPERCALCINE



TRANSMUTATION

POLLUCITE

- $CsASi_2O_6$: $Cs^{+1} \longrightarrow Ba^{+2}$

$${}^{133}Cs + n \longrightarrow {}^{134}Cs$$

$${}^{134}Cs \xrightarrow{\beta^-} {}^{134}Ba$$

SCHEELITE

- $SrMoO_4$: $Sr^{+2} \longrightarrow Y^{+3} \longrightarrow Zr^{+4}$

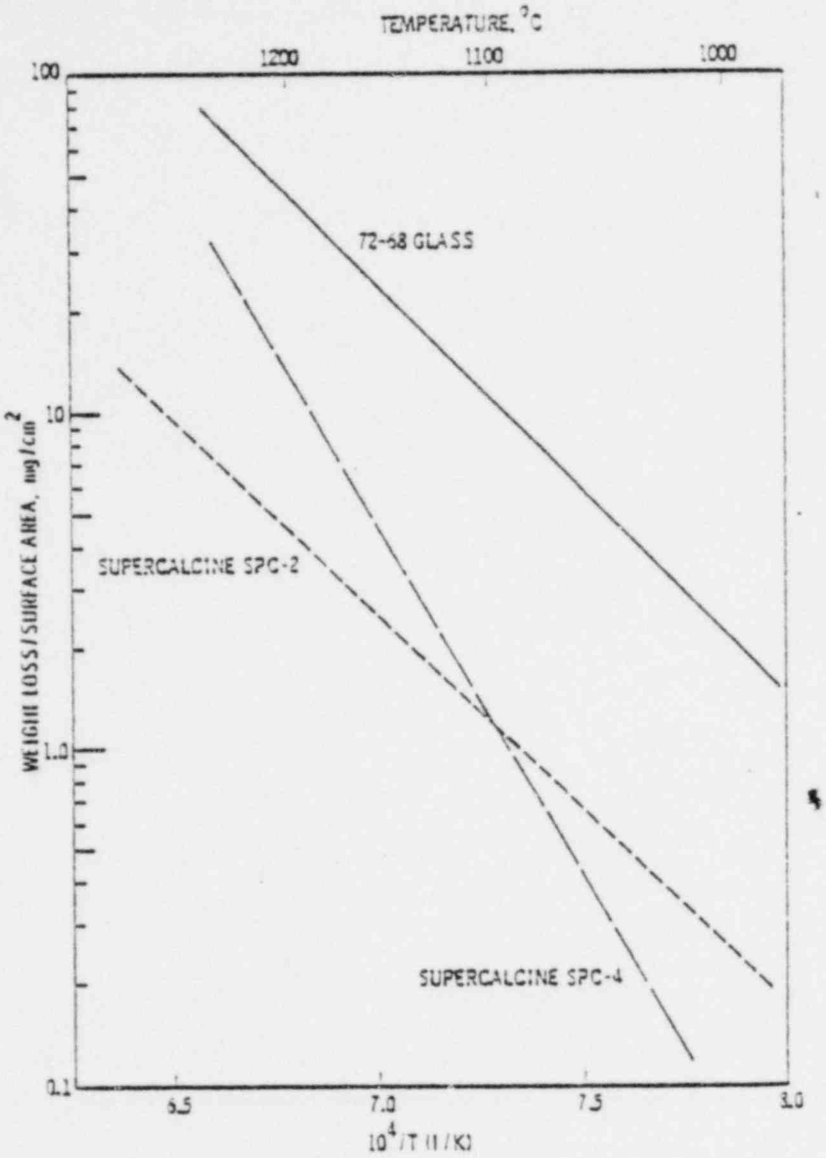
Bulk Properties of Multibarrier Waste Forms

Inner Core	Coating	Matrix	Bulk Density g/cm 3	Thermal Conductivity W/mO K	Maximum Use Temperatures OC
Waste Glass	none	none	3.42	0.84	550
Waste Glass Marble (10mm)	none	Pb-10Sn Vacuum Cast	6.20	8.3	250
Supercalcine Hot Pressed	none	none	4.88	0.91	1200
Supercalcine Pellet (6mm)	Glass(1 mm)	Al-12Si Vacuum Cast	3.40	45.0	550
Supercalcine Pellet (2mm)	PyC (40µm) Al_2O_3(60µm)	Cu Sintered	3.48	24.0	1000

Weight Loss of Supercalcine SPC-4 After 1 hr Sintering at 1200°C

Element	Absolute Weight loss(a), mg	Weight Loss, %
Na	0.52	12.9
Rb	0.91	6.1
Mo	8.23	5.2
Ru	2.53	24.4
Ag	0.16	4.3
Cd	0.39	9.7
Cs	12.29	9.9

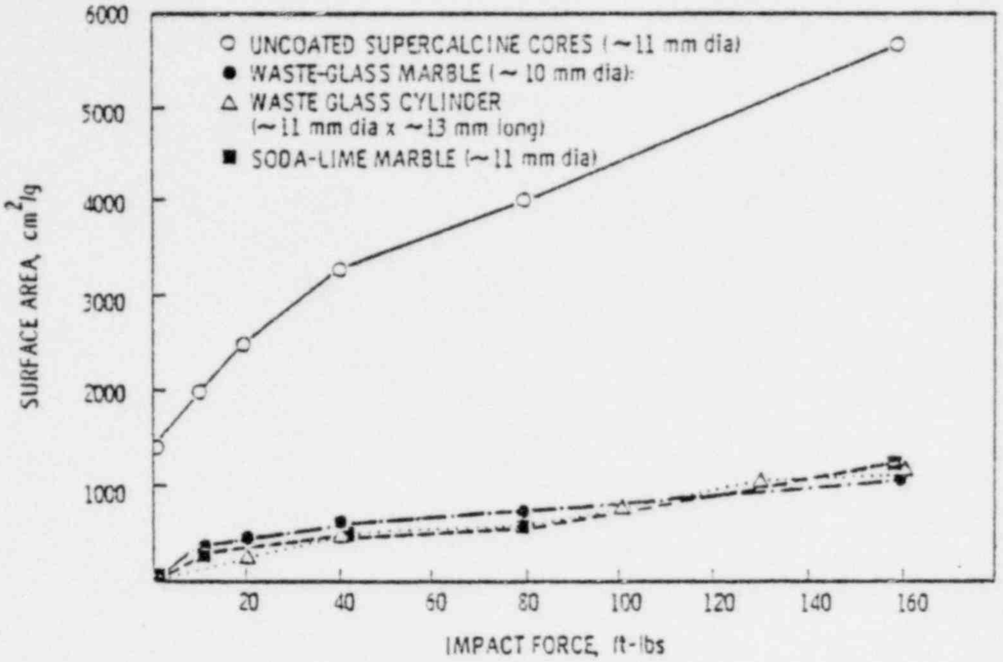
Gross Weight Loss of Waste Forms after 4 hr. in Dry Air



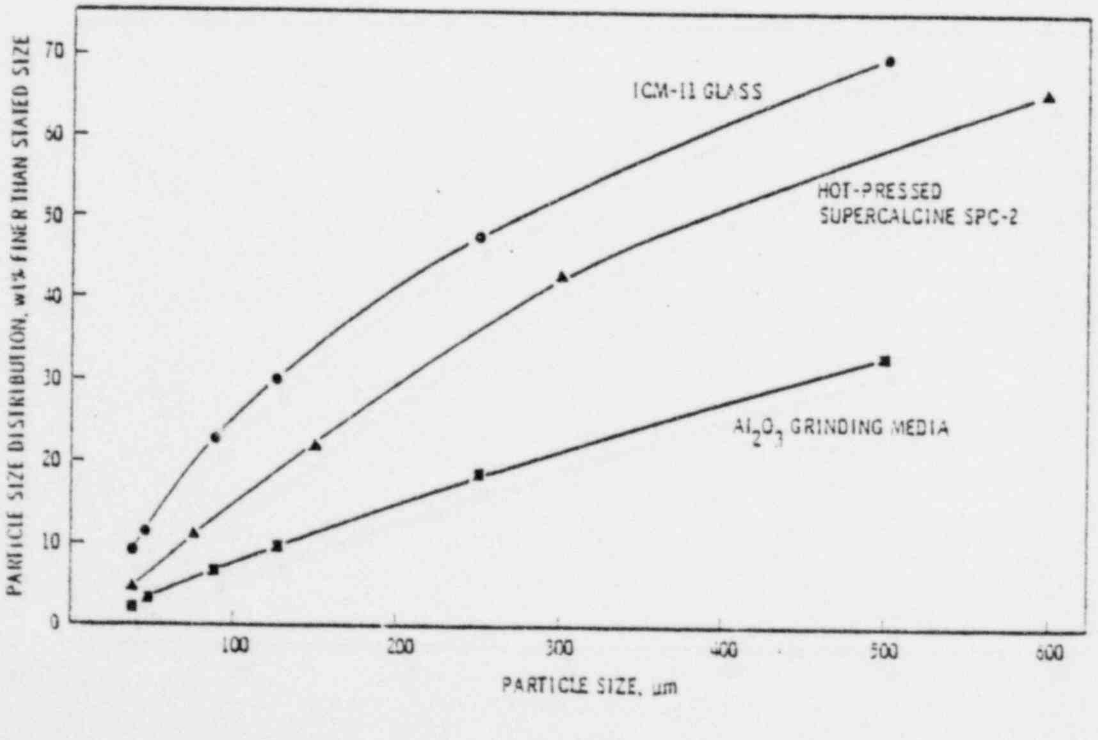
A LEACH RATE COMPARISON OF MATERIALS

Material	99°C Distilled Water g/cm^2-d	250°C Salt Brine, g/cm^2-d
Al_2O_3	1×10^{-6}	2×10^{-4}
Supercalcine	8×10^{-6}	1×10^{-4}
Waste Glass	9×10^{-6}	7×10^{-4}
Granite	1×10^{-5}	6×10^{-4}
Soda-Lime Glass	5×10^{-5}	3×10^{-3}

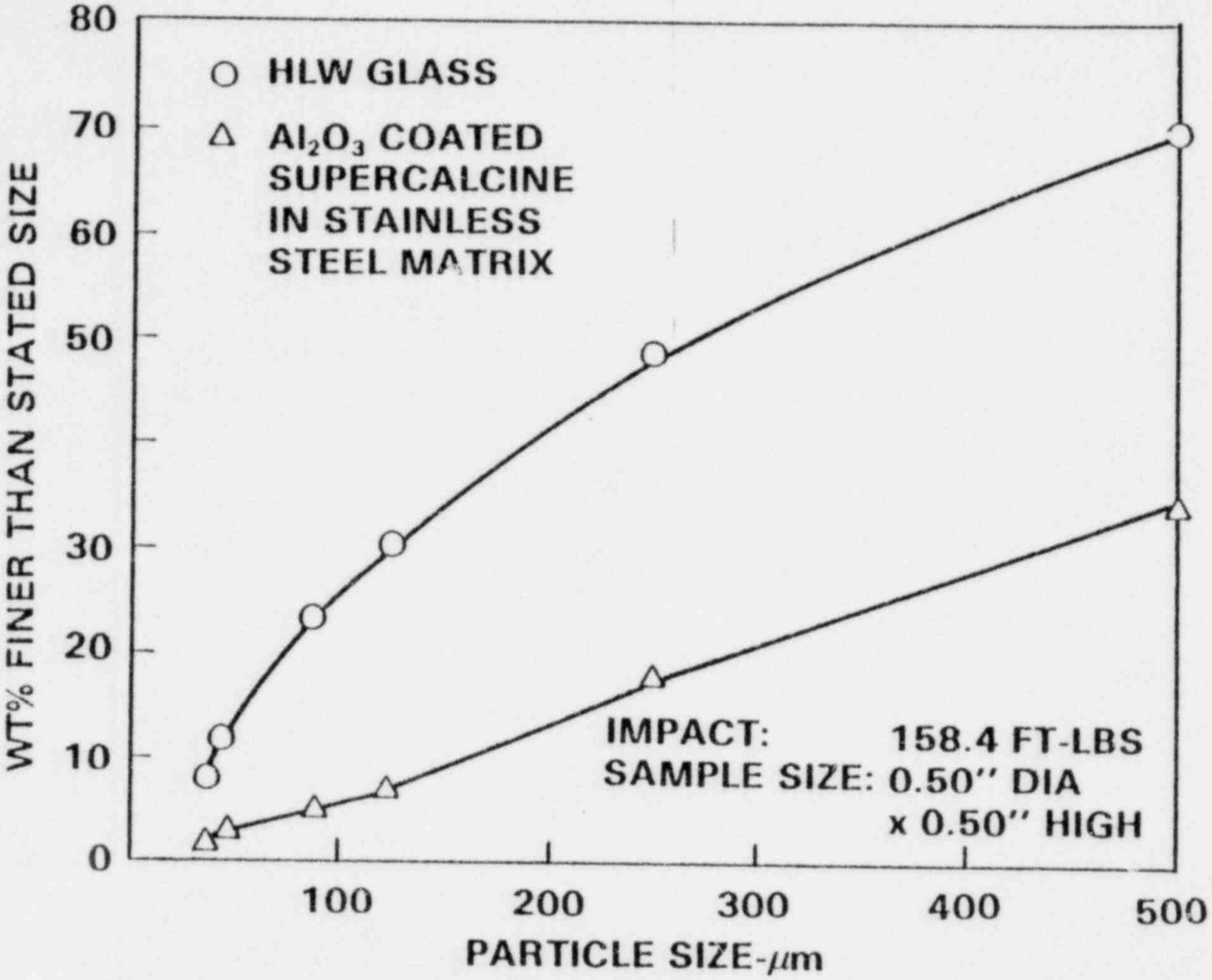
Surface Area of Supercalcine and Other Waste Forms after Impact Tests at Various Forces



Particle Size Distribution of Waste Forms After Impact of 158.4 Ft-lbs.



PARTICLE SIZE DISTRIBUTION OF IMPACTED HLW SAMPLES



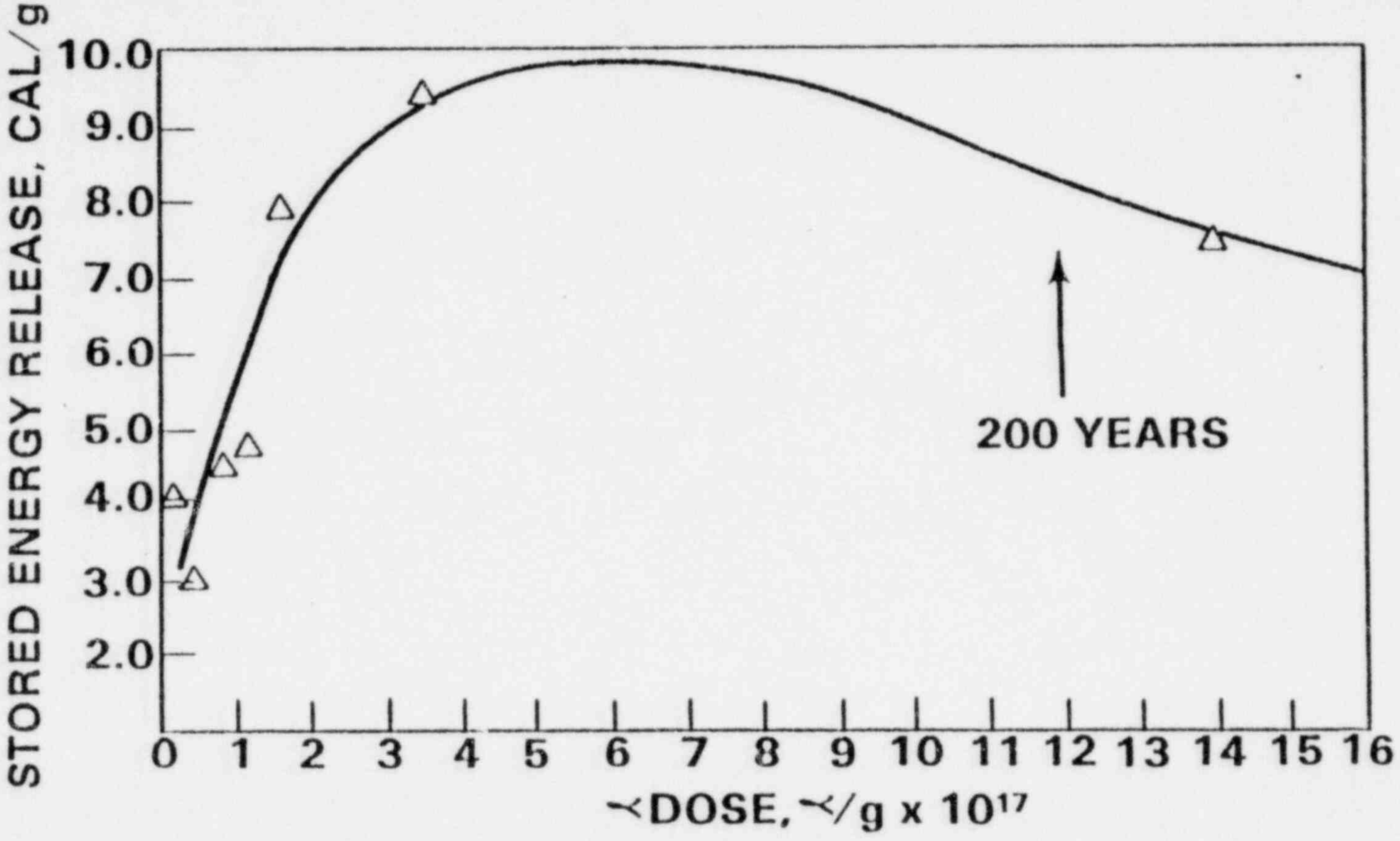
Calculated Nuclear Waste Release after Impact at 158.4 Ft-lb

Material	Sample Size, In.		Coating	Matrix	Vol % Waste	Particle Size After Impact	Nuclear Waste Released
	Diameter	Length				% 37 µm	g/cm^3 x 10-4
Supercalcine Hot Pressed	0.44	0.50	none	none	75%	4.4	1600
Supercalcine(a) Cores	0.50	0.50	PyC/Al_2O_3	410SS	34%	2.0	200
Supercalcine(b) Cores	0.50	0.50	PyC/Al_2O_3	410SS	23%	0.4	28
ICM-11Glass	0.44	0.50	none	none	35%	9.0	1100
ICM-11 Glass	1.25	1.25	none	none	35%	1.0	120
ICM-11 Glass(a)	1.25	1.25	none	Pb-10Sn	21%	0.1	9

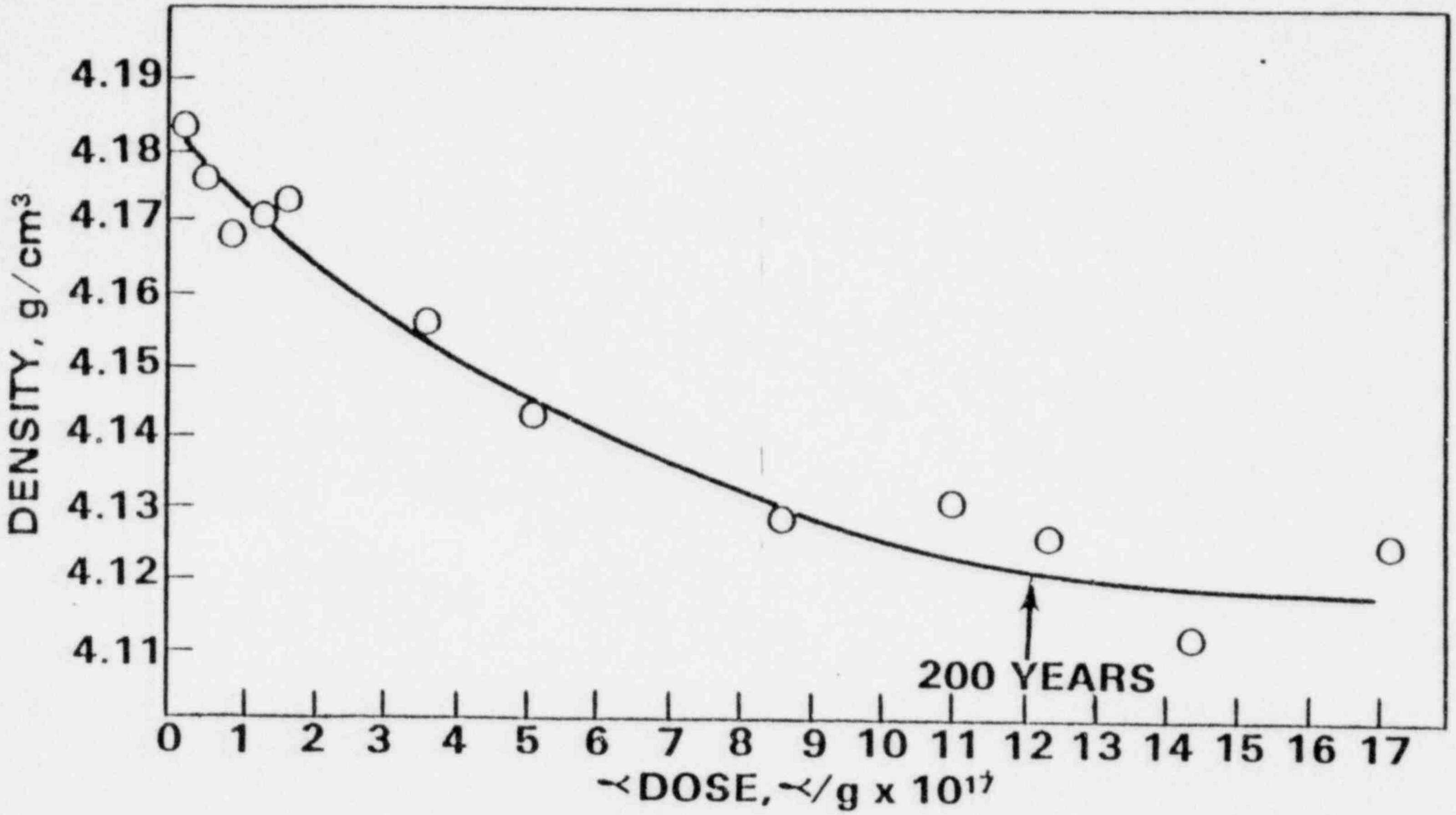
(a)60-Vol % packing

(b)40-Vol % packing

EFFECT OF ALPHA DOSE ON STORED ENERGY OF CURIUM DOPED SUPERCALCINE



EFFECT OF ALPHA DOSE ON DENSITY OF CURIUM DOPED SUPERCALCINE



MULTIBARRIER WASTE FORM DEVELOPMENT
ONE LITER DEMONSTRATION

INNER CORE	COATING	MATRIX	ENCAPSULATION
72-68 GLASS 10 mm MARBLE	NONE	Pb-10Sn	VACUUM CAST, 400°C
SUPERCALCINE 7 mm	NONE	Al-12Si	VACUUM CAST, 650°C
SUPERCALCINE 7 mm	GLASS GLAZE, <1 mm	Al-12Si	VACUUM CAST 650°C
SUPERCALCINE 2 mm	CVD PyC - 40 μm Al_2O_3 - 60 μm	Cu	GRAVITY SINTERED, 900°C - 8 HR

ALTERNATIVE WASTE FORMS DEVELOPMENT

YEAR	PROGRAM GOALS
1972 - 1978	MULTIBARRIER CONCEPT
1979	COMPARATIVE STUDY AND PROCESS SCALE-UP

HLW IMMOBILIZATION FORMS

- CALCINE
- PELLETIZED CALCINE
- SINTERED SUPERCALCINE
- CLAY
- CLAY CERAMIC
- CONCRETE
- PRESSED CONCRETE
- CRYSTALLINE CERAMICS
- GLASS CERAMICS
- CERMET
- GLASS
- METAL MATRIX
  - CALCINE PELLETS
  - SINTERED SUPERCALCINE
- MULTIBARRIER

WASTE FORM FABRICATION

GLASS
- CAST MONOLITHS
- CAST MARBLES

GLASS CERAMICS
- CAST MONOLITHS
- CONTROLLED DEVITRIFICATION

CRYSTALS
- PELLETIZE AND SINTER
- HOT PRESS
- CERAMIC SPONGE

MULTIBARRIER

GLASS, GLASS-CERAMICS, OR CRYSTALS
CONTAINED IN
- CERMETS
- CONCRETE
- COATINGS
- METAL MATRIXES

ALTERNATIVE WASTE FORMS

CATEGORY	EXAMPLES
• SINTERED CERAMIC	SINTERED SUPERCALCINE SINTERED CALCINE (+ ADDITIVES) CERAMIC SPONGE SINTERED TITANATE CRYSTALLINE PRODUCT
• GLASS CERAMICS	CELSIAN GLASS CERAMIC RECRYSTALLIZED FUSION MELTS
• HOT PRESSED CERAMICS	HOT PRESSED CALCINE (+ ADDITIVES) HOT PRESSED SUPERCALCINE HOT ISOSTATIC PRESSED CALCINE (+ ADDITIVES) HOT ISOSTATIC PRESSED SUPERCALCINE HOT PRESSED CONCRETE
• CONCRETE	CEMENT AND CALCINE CEMENT AND SUPERCALCINE CEMENT AND SLUDGE
• METAL MATRIX	GLASS MARBLES IN METAL MATRIX SINTERED SUPERCALCINE CORES IN METAL MATRIX CERMETS

ALTERNATIVE WASTE FORMS COMPARATIVE STUDY

WASTE FORMS

- GLASS*
- GLASS CERAMIC*
- SINTERED CERAMIC
- SYNTHETIC MINERALS
  - SUPERCALCINE*
  - SYNROC
- HOT PRESSED CERAMICS
- HOT ISOSTATIC PRESSED CERAMICS
- CONCRETE*
- METAL MATRIX*

ALTERNATIVE WASTE FORMS COMPARATIVE STUDY

COMPARATIVE TESTS

- IMPACT
- LEACHABILITY
- VOLATILITY
- BULK PROPERTIES
- MICROSTRUCTURE
- PHASE ANALYSIS
- RADIATION EFFECTS
  - STORED ENERGY
  - METAMICTIZATION

SYNTHETIC MINERALS

"SYNROC B"

"HOLLANDITE" ($BaAl_2Ti_6O_{16}$)		ZIRCONOLITE ($CaZrTi_2O_7$)	PEROVSKITE ($CaTiO_3$)
Cs^+	Mo^{4+}	U^{4+}	Sr^{2+}
K^+	Ru^{4+}	Zr^{4+}	(U^{4+})
(Na^+)	Rh^{3+}	Y^{3+}	(Y^{3+})
Ba^{2+}	Fe^{3+}	Gd^{3+}	(Gd^{3+})
Cr^{3+}		La^{3+}	(La^{3+})
Ni^{2+}		Na^+	
Fe^{2+}			

ALTERNATIVE WASTE FORMS DEVELOPMENT

CURRENT OBJECTIVES

- PROVIDE A BACKUP OR SECOND GENERATION PROCESS
- EVALUATE EXISTING WASTE FORMS ON A COMPARATIVE BASIS
- ASSESS PROCESS FEASIBILITY BY SCALED-UP DEMONSTRATION
- DEVELOP NEW CANDIDATE WASTE FORMS FOR COMPARATIVE EVALUATION

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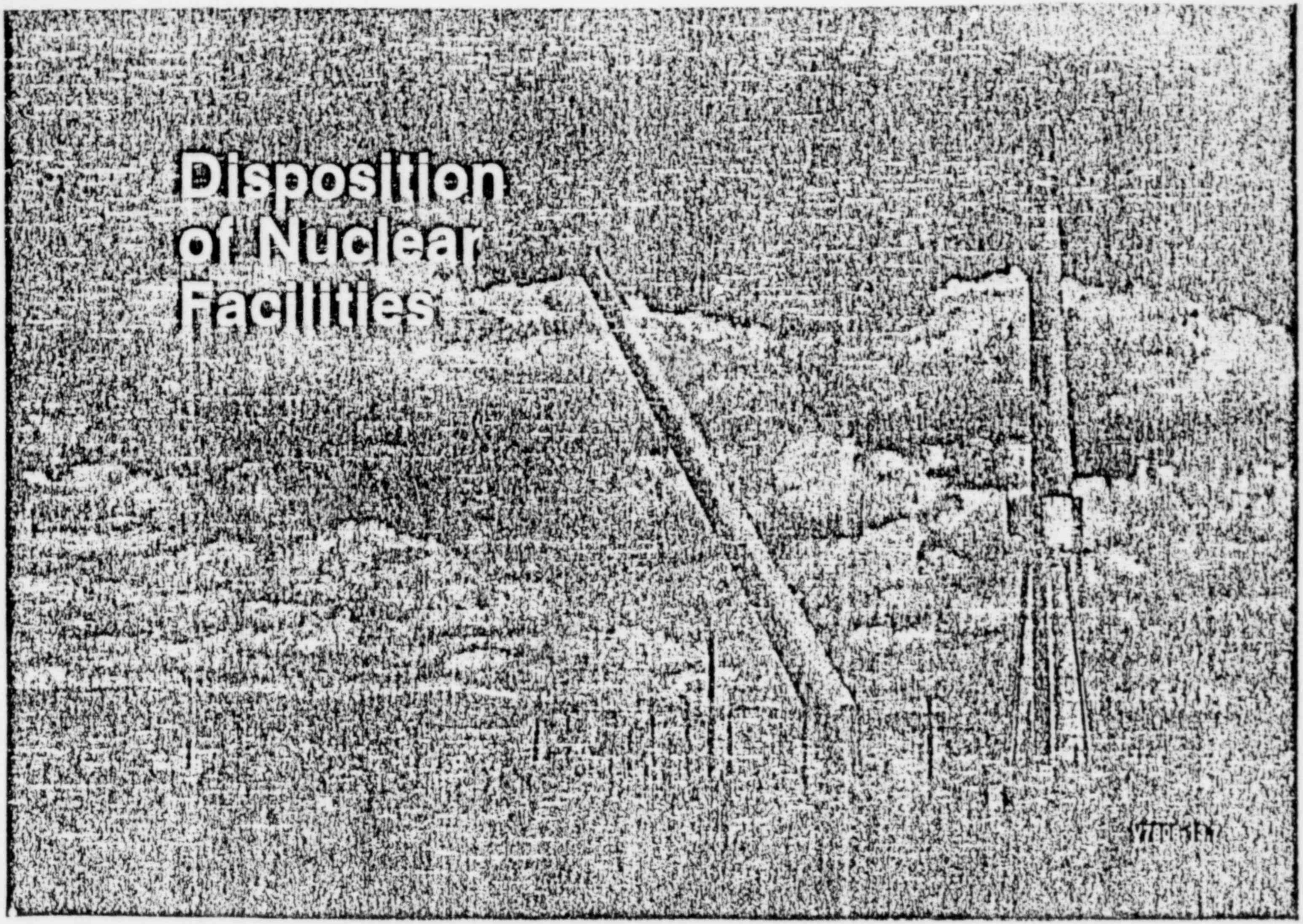
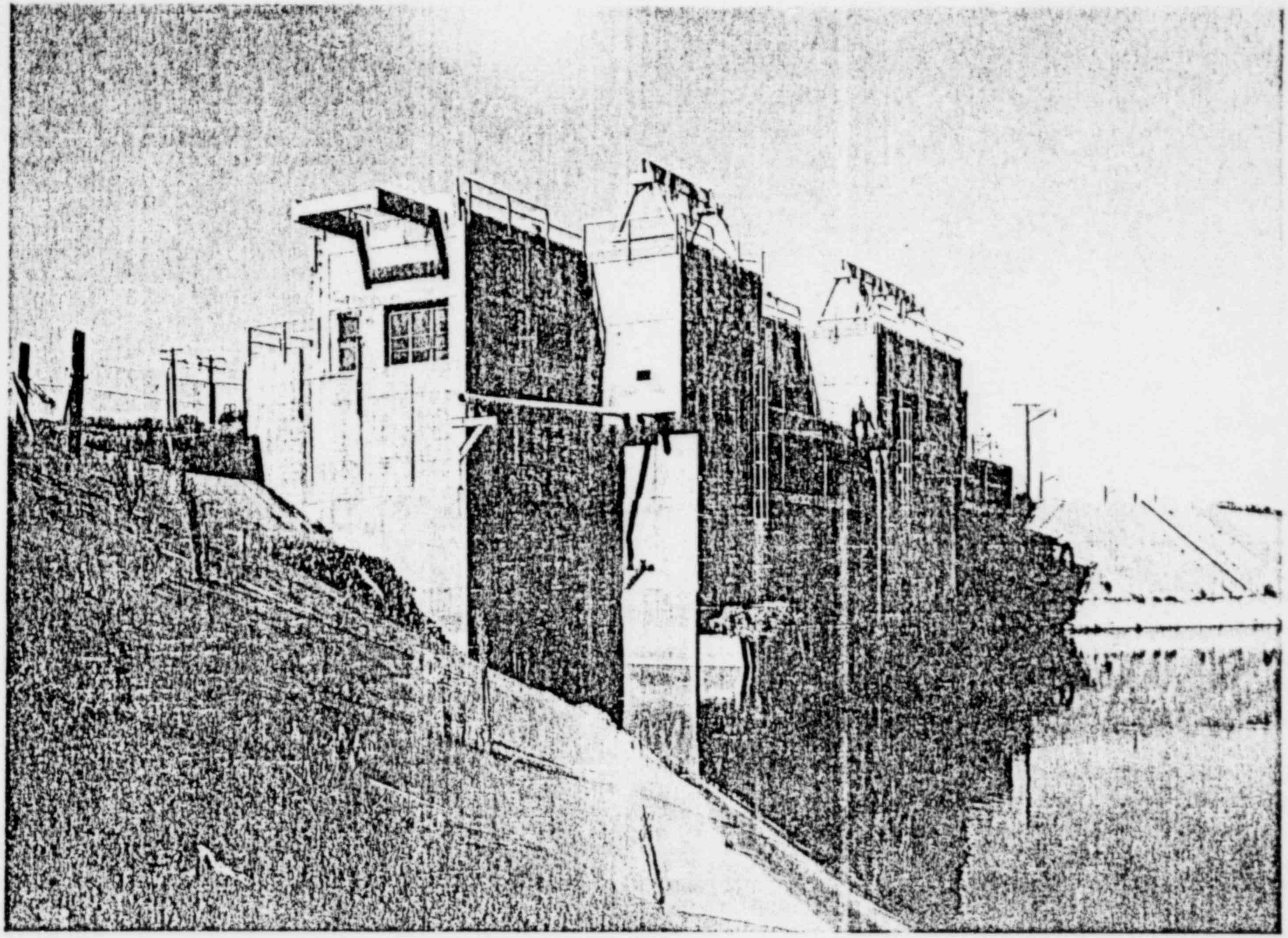
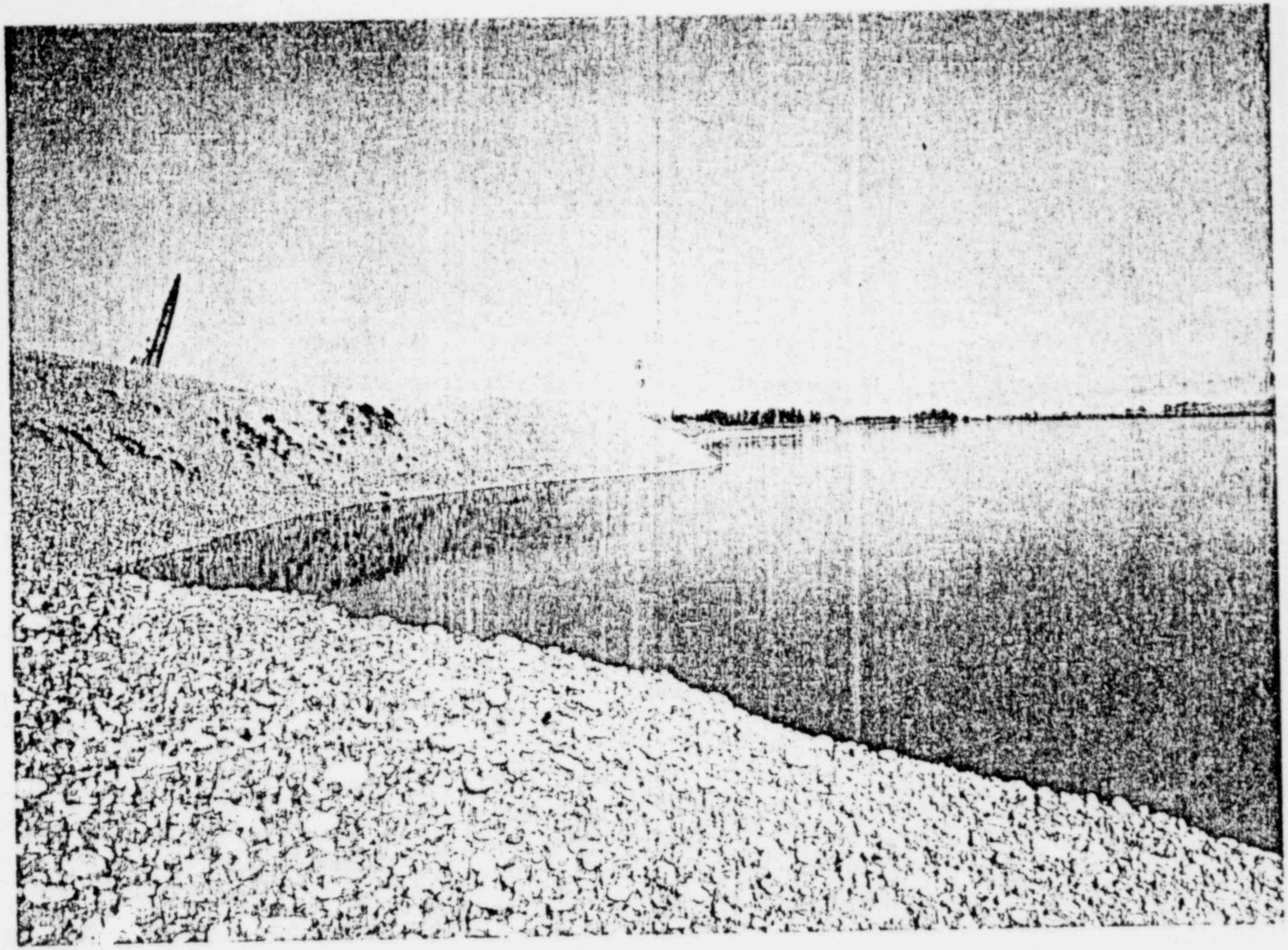
8



Disposition of Nuclear Facilities



VIEWGRAPH NO. 2



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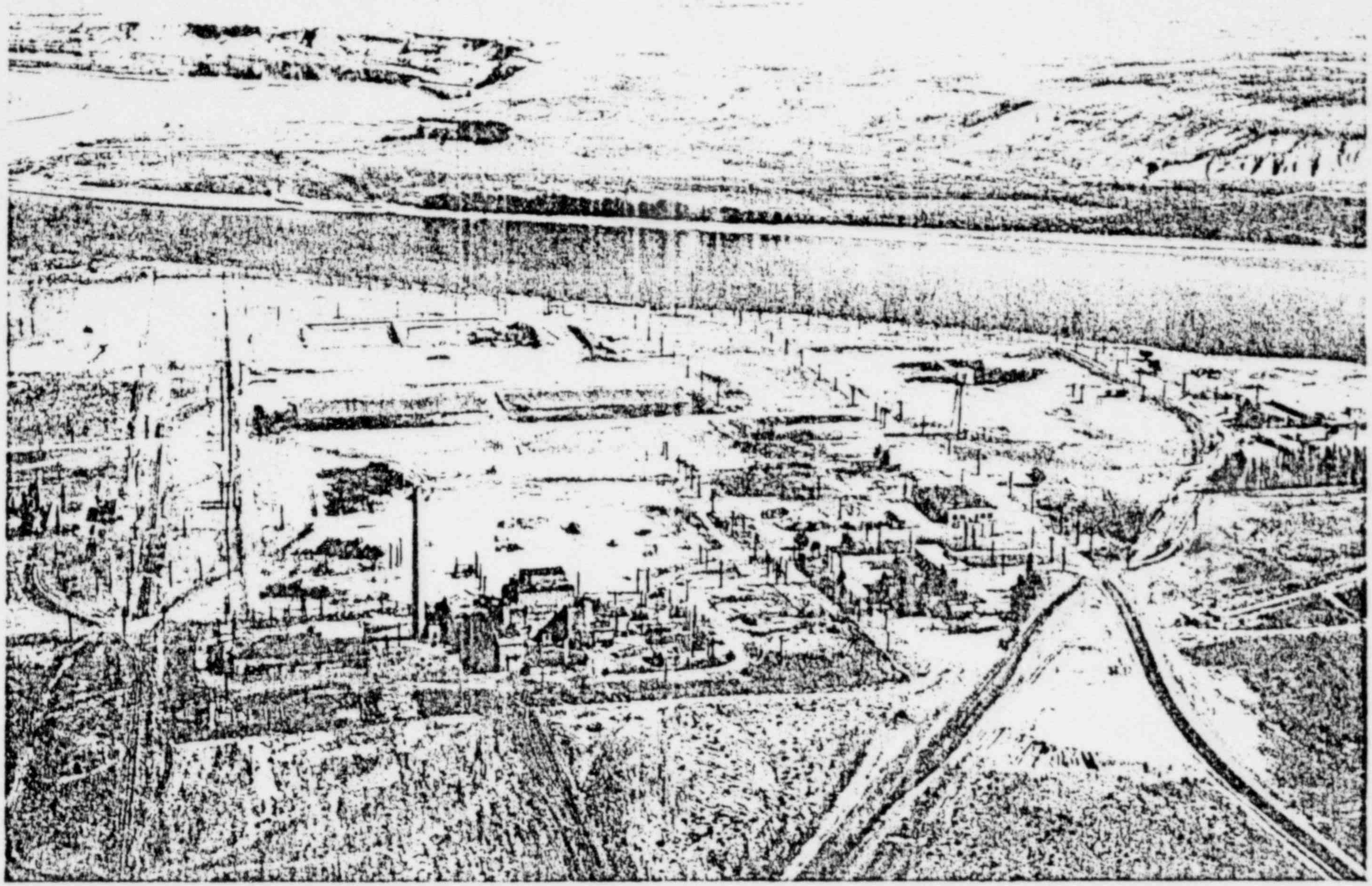


VIEWGRAPH NO. 4

PLANNING SYSTEM

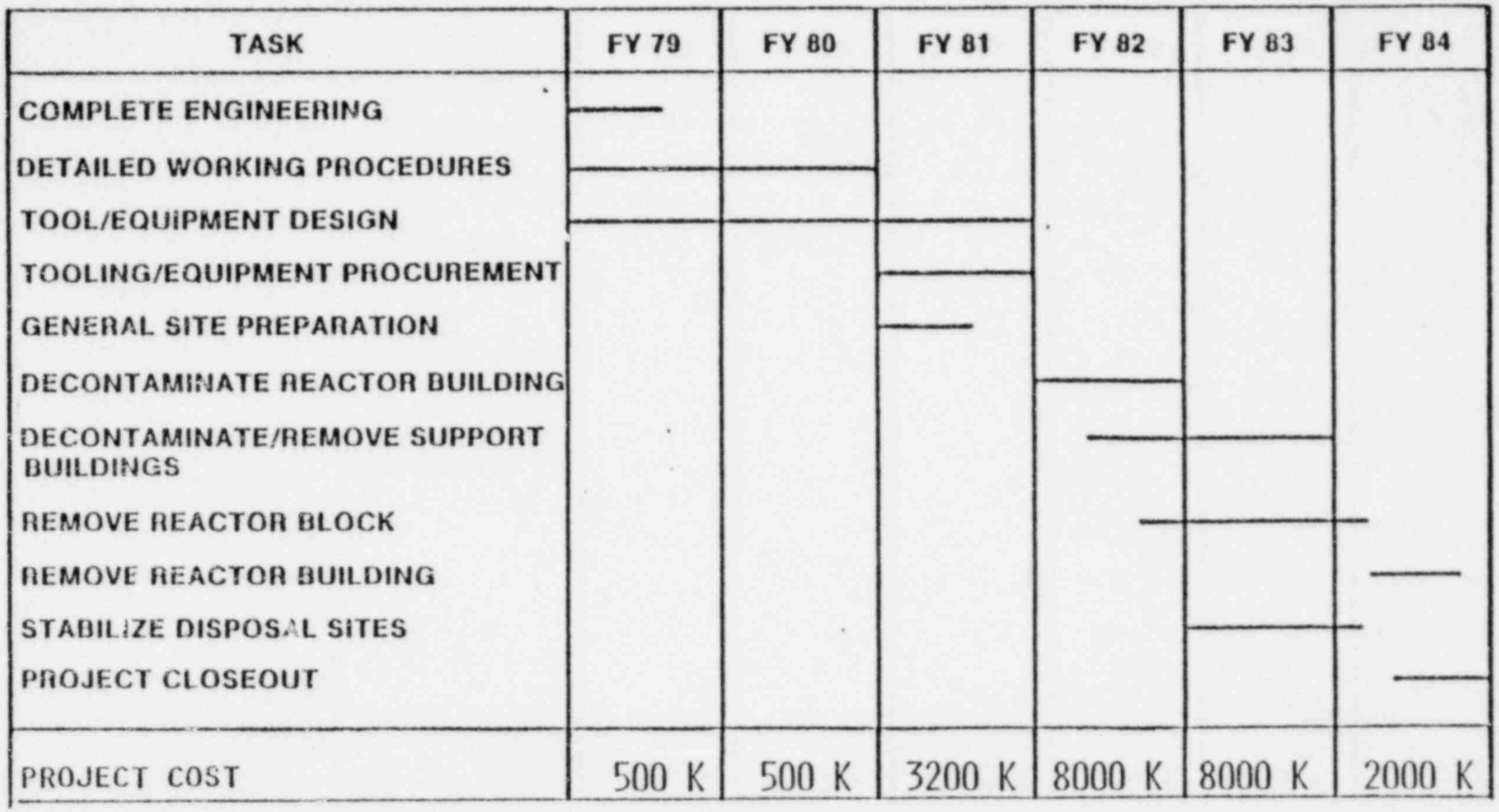
- SITE CHARACTERIZATION
- FACILITY/SITE DESCRIPTION
- ENVIRONMENTAL ASSESSMENT
- QUALITY ASSURANCE PLAN
- MANAGEMENT PLAN
- DISPOSITION PLAN

MAJOR ACTIVITIES

- I SITE PREPARATION
- II REACTOR BUILDING DECONTAMINATION AND REMOVAL
- III REACTOR BLOCK REMOVAL
- IV SUPPORT & RESEARCH FACILITIES REMOVAL
- V STABILIZATION OF BURIAL GROUNDS, CRIBS, TRENCHES
- VI PROJECT CLOSEOUT

VIEWGRAPH NO. 7

DECOMMISSIONING SCHEDULE PRODUCTION REACTOR



TASK	FY 79	FY 80	FY 81	FY 82	FY 83	FY 84
COMPLETE ENGINEERING	—					
DETAILED WORKING PROCEDURES	—	—				
TOOL/EQUIPMENT DESIGN	—	—	—			
TOOLING/EQUIPMENT PROCUREMENT			—			
GENERAL SITE PREPARATION			—			
DECONTAMINATE REACTOR BUILDING				—		
DECONTAMINATE/REMOVE SUPPORT BUILDINGS				—	—	
REMOVE REACTOR BLOCK				—	—	—
REMOVE REACTOR BUILDING						—
STABILIZE DISPOSAL SITES					—	—
PROJECT CLOSEOUT						—
PROJECT COST	500 K	500 K	3200 K	8000 K	8000 K	2000 K

DISPOSITION OF A NUCLEAR REACTOR FACILITY

Presented at ACRS Meeting
April 19, 1979 - Richland, Washington

R. K. Wahlen
UNC Nuclear Industries

The Department of Energy is supporting two programs related to the disposition of retired facilities in the 100 Areas.

For the past several years a Hanford Site Cleanup Program has been funded. The objective of this program is to eliminate potential radiological and industrial safety hazards along the Columbia River and to dispose of the clean (contamination free) unused retired buildings in the general proximity of the Columbia River. An example of this work is shown in Viewgraphs 2 and 3. No. 2 shows the river pumphouse at 100-F before demolition and NO. 3 shows the site where the pumphouse stood.

In Fiscal Year 1977, authorization was given to UNC Nuclear Industries by the Department of Energy to begin planning and implementing the full scale decontamination and decommissioning of a reactor facility. The reactor facility at 100-F Area was selected for this demonstration. The objective of the program is to provide a base for more accurate estimates of exposure, cost and waste volume requirements for disposing of the contaminated portions of the reactor and related facilities. The program will also establish engineering data and demonstrate decommissioning techniques.

Viewgraph No. 4 shows the buildings in 100-F which will be included in the D & D Program.

Viewgraph No. 5 outlines the planning system in use for D & D:

- Site characterization identifies the location, level and type of contamination present in the facilities. This preliminary site characterization study was completed early in FY 1978.

- Facility/Site Descriptions - A description of the facilities to be included in 100-F D & D was completed in FY 1978 and is contained in UNI-1001.

- Environmental Assessment - This assessment has been completed and is documented in UNI-802 Rev. 1. The Environmental Assessment found no conflict with Federal, State or Regional controls or plans.

- Quality Assurance Plan - A plan has been developed and documented in UNI-1006. The plan describes the QA activities to be performed during D & D.

- Management Plan - This plan is approximately 50 percent complete and will define the D & D Operations organization, assign responsibilities and management control.

- Disposition Plan - Is divided into six activity descriptions. Viewgraph No. 6 outlines the major activities.

Major Activities - The activity descriptions are designed to give the sequence of steps required to accomplish the task along with alternate methods of performing the work. Also the descriptions identify equipment needs; show a time schedule for the work; identify industrial and radiological hazards; special tooling; packaging, handling and transportation of waste, and provides cost and manpower requirements.

- The site preparation activity gets the facility ready for the Disposition Plan (ie, water, lights, telephone and other required services - roads, restrooms, offices, lunchrooms, building and facility modification, etc.). This activity description has been completed and issued.

- Reactor Building Decontamination and Removal - Decontaminates and strips the building down to the reactor block. This activity description has been completed and issued.

- Reactor Block Removal - The actual dismantling and disposal of the reactor block is described. The activity description has been completed and issued.

- Support and Research Facilities Removal - This activity description is complete and describes the activity of removing the reactor support buildings and the 108-F Biological Laboratory which was used by Battelle in their animal studies.

- Stabilization of Burial Grounds, Cribs and Trenches - This activity description is 15 percent complete. It will describe the disposition to take place on all contaminated underground facilities.

- Project Closeout - This activity involves the final closeout of the project which will involve radiation survey release documentation, D & D experiences, exposure requirements, costs, etc.

Viewgraph No. 7 shows the proposed schedule of the 100-F D & D Project and the expected cost of the work.

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RKW:skk

ROCKWELL HANFORD OPERATIONS

DECONTAMINATION AND

DECOMMISSIONING PROGRAM

312

4-19-79

DECONTAMINATION AND DECOMMISSIONING (D&D) PROGRAMS

END OBJECTIVES

- REDUCE OR ELIMINATE THE REQUIREMENT FOR RADIOLOGICAL CONTROLS ON FACILITIES THAT ARE NO LONGER NEEDED FOR THE ORIGINAL DESIGNED PURPOSE OR ARE PASSIVE SITES

METHODS

- DECONTAMINATE TO REMOVE RADIOACTIVE CONTAMINATION
- DISMANTLE AND REMOVE CONTAMINATED COMPONENTS AND RADIOACTIVE WASTES TO A CENTRAL CONTROLLED LOCATION
- CONSOLIDATE RADIOACTIVE WASTE TO REDUCE THE SURVEILLANCE REQUIREMENTS

MAJOR PROGRAMS

- LONG-RANGE D&D PLANNING
- SURVEILLANCE AND MAINTENANCE OF INACTIVE CONTAMINATED FACILITIES
- DEVELOPMENT OF FULL-SCALE SIZE AND VOLUME REDUCTION EQUIPMENT TO TREAT D&D WASTE
- D&D OF RETIRED CONTAMINATED FACILITIES

2111 4-19-79

LONG-RANGE D&D PLANNING

OBJECTIVES

- DEVELOP AND MAINTAIN A LIST OF CONTAMINATED INACTIVE FACILITIES
- CHARACTERIZE FACILITIES FOR INPUT TO THE NATIONAL DOE LONG-RANGE D&D PLAN
- DEVELOP A ROCKWELL HANFORD LONG-RANGE D&D PLAN

MAJOR ACCOMPLISHMENTS

- PREPARED A LIST OF 322 ROCKWELL HANFORD CONTAMINATED INACTIVE FACILITIES
- DEVELOPED CHARACTERIZATION DATA FOR THE CONTAMINATED INACTIVE FACILITIES AND TRANSMITTED TO ENERGY SYSTEMS GROUP FOR INPUT TO THE NATIONAL D&D PLAN
- COMPLETED THE ROCKWELL HANFORD LONG-RANGE D&D PLAN DRAFT

ENVIRONMENTAL CONTROL TECHNOLOGY RETIRED FACILITIES

76	BUILDINGS AND STRUCTURES (PLUTONIUM CONCENTRATION BLDG. (233-S), REDOX BLDG., HOT SEMIWORKS, T PLANT, U PLANT, ETC.)
214	LIQUID DISPOSAL SITES (APPROXIMATELY 260 ACRES PONDS, DITCHES AND CRIBS)
32	SOLID WASTE DISPOSAL SITES (B.C. CONTROL ZONE 2,500 ACRES, 200 WEST BURIAL GROUNDS 120 ACRES, 200 EAST BURIAL GROUNDS 70 ACRES)
322	

3116 4-19-79

SURVEILLANCE AND MAINTENANCE OF CONTAMINATED INACTIVE FACILITIES

OBJECTIVES

- PREVENT SPREAD OF CONTAINED RADIOACTIVE CONTAMINATION IN INACTIVE FACILITIES
- STABILIZE AND REDUCE THE SURFACE AREAS OF THE CONTAMINATED INACTIVE OUTDOOR SITES
- MAINTAIN THE CONTAMINATED INACTIVE STRUCTURES PRIOR TO D&D

MAJOR ACCOMPLISHMENTS

- STABILIZED AND REDUCED SURFACE AREA OF A CRIB COMPLEX
- ELIMINATED A NUMBER OF SMALL RADIATION AREAS
- REPAIRED 20,000 SQUARE FEET OF CANYON ROOF USING A RESATURATION PROCESS
- INITIATED SURFACE CLEANUP AND STABILIZATION OF A SOLID WASTE BURIAL GROUND

3117

4-19-79

DEVELOPMENT OF FULL-SCALE SIZE AND VOLUME REDUCTION EQUIPMENT TO PROCESS D&D WASTE

OBJECTIVES

- DEVELOP AND DEMONSTRATE THE TECHNOLOGY AND SYSTEMS TO SIZE-REDUCE LARGE CONTAMINATED EQUIPMENT -- ARC SAW
- DEVELOP AND DEMONSTRATE THE TECHNOLOGY AND SYSTEMS TO VOLUME-REDUCE CONTAMINATED METALLIC EQUIPMENT -- VACUUM FURNACE
- INVESTIGATE RADIONUCLIDE DISPOSITION IN MELT AND SLAG IN LAB-SCALE TESTS

MAJOR ACCOMPLISHMENTS

- 16-INCH ARC SAW SYSTEM FABRICATED, DELIVERED, AND INSTALLED
- VACUUM FURNACE BIDS RECEIVED FOR DESIGN AND FABRICATION
- INDUCTION FURNACE FOR LAB-SCALE METAL MELT TESTS DELIVERED AND INSTALLED

3118

D&D OF RETIRED CONTAMINATED FACILITIES

OBJECTIVES

- DEVELOP PLANNING, EQUIPMENT, PROCESS TECHNOLOGY, AND FIELD PROCEDURES FOR D&D OF ALPHA CONTAMINATED FACILITIES
- DEMONSTRATE THESE OBJECTIVES ON A SMALL PROCESS FACILITY (REDOX PU SEPARATION, 233-S BUILDING, ECT FUNDING SOURCE)
- D&D A MAJOR PROCESS FACILITY (Z PLANT)
- D&D ROCKWELL HANFORD SURPLUS FACILITIES ACCORDING TO THE LONG-RANGE PLAN

DEVELOPMENT

SCOPE

- DEVELOP MANAGEMENT AND CONTROL DOCUMENTS
- DEVELOP DECONTAMINATION, DISMANTLING, CONTAINMENT, AND WASTE HANDLING EQUIPMENT AND PROCESSES FOR TRANSURANIC CONTAMINATED FACILITIES
- DEVELOP DETAILED PROCEDURES FOR PERFORMING D&D OPERATIONS

ACCOMPLISHMENTS

- PREPARED MANAGEMENT AND CONTROL DOCUMENTS FOR D&D PROGRAMS
- PREPARED INITIAL OPERATING PROCEDURES FOR 233-S BUILDING D&D

DEMONSTRATION

SCOPE

- DEMONSTRATE EQUIPMENT AND PROCESSES TECHNOLOGY ON D&D OF 233-S BUILDING
- D&D 233-S BUILDING FOR UNRESTRICTED USE
- STANDARDIZE D&D OPERATIONAL TECHNIQUES

ACCOMPLISHMENTS

- PERFORMED INITIAL CHARACTERIZATION OF 233-S BUILDING
- REACTIVATED SUPPORT UTILITIES
- COMPLETED D&D OPERATIONS IN THE AIRLOCK AND STORAGE ROOMS
- INITIATED D&D OPERATIONS IN THE LOADOUT ROOM

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D&D Z PLANT

SCOPE

- PERFORM PLANNING AND ENGINEERING FOR Z PLANT D&D
- PREPARE COST/RISK/BENEFIT ANALYSIS ON Z PLANT END OBJECTIVES
- DETERMINE EXTENT OF Z PLANT D&D OPERATIONS
- PERFORM Z PLANT D&D OPERATIONS
- PERFORM FINAL Z PLANT RADIATION SURVEY

ACCOMPLISHMENTS

- PREPARED Z PLANT DECOMMISSIONING STUDY REPORT
- PREPARED Z PLANT D&D ENGINEERING PLAN
- PREPARED FUNCTIONAL DESIGN CRITERIA, CONCEPTUAL DESIGN PLAN, AND COST/RISK/ BENEFIT ANALYSIS PLAN
- COMPLETED 60 PERCENT OF Z PLANT RADIOLOGICAL AND PHYSICAL CHARACTERIZATION
- PREPARED COST/RISK/BENEFIT ANALYSIS COMPUTER LOGIC DIAGRAM

4-19-79

10

DECONTAMINATION AND DECOMMISSIONING

D&D OF HANFORD FACILITIES — TECHNOLOGY

OBJECTIVE

CONCEIVE, DEVELOP AND TEST ADVANCED D&D TECHNOLOGY APPLICABLE TO THE HANFORD DECOMMISSIONING EFFORT.

NEED

AN EXTENSIVE, LONG-TERM AND COSTLY EFFORT WILL BE REQUIRED TO DECOMMISSION CONTAMINATED DOE FACILITIES WHICH ARE NO LONGER IN ACTIVE SERVICE OR WHICH WILL BE RETIRED IN FUTURE YEARS. IMPROVED TECHNOLOGY IS REQUIRED TO MINIMIZE THE RISKS AND COSTS OF THE DECOMMISSIONING EFFORT.

PACIFIC
NORTHWEST
LABORATORY

DECONTAMINATION AND DECOMMISSIONING

D&D OF HANFORD FACILITIES — TECHNOLOGY ORGANIZATION CHART

Battelle

OFFICE OF ENVIRONMENTAL COMPLIANCE AND OVERVIEW

ENVIRONMENTAL CONTROL ENGINEERING
DR. W. E. MOTT

D&D LEAD FIELD OFFICE
J. D. WHITE, RL

FIELD OFFICE PROGRAM COORDINATOR
J. L. LANDON, RL

PNL ENVIRONMENT, HEALTH, AND SAFETY RESEARCH PROGRAMS
DR. W. J. BAIR

PNL PROJECT MANAGER
R. R. KING

4/79

PACIFIC
NORTHWEST
LABORATORY

DECONTAMINATION AND DECOMMISSIONING

D&D OF HANFORD FACILITIES — TECHNOLOGY WORK BREAKDOWN STRUCTURE

Battelle

- **PNL PROJECT MANAGER**
R. R. KING
  - 02 TECHNOLOGY ASSESSMENT — H. W. ARROWSMITH/R. P. ALLEN
  - 03 CONCRETE DECONTAMINATION — J. M. HALTER/R. G. SULLIVAN
  - 04 ELECTROPOLISHING AND VIBRATORY FINISHING APPLICATIONS — H. W. ARROWSMITH/R. P. ALLEN
  - 05 SURVEY INSTRUMENT DEVELOPMENT — R. L. BRODZINSKI/K. K. NIELSON
  - 06 BURIAL GROUND STABILIZATION — J. F. CLINE
  - 07 CONCRETE PROPERTIES — G. H. BEEMAN
  - 08 DRY ICE BLASTING — K. R. AMES
  - 09 ARC SAW EVALUATION — G. S. ALLISON/W. B. WEIHERMILLER
  - 10 FIXATIVES — H. W. ARROWSMITH/R. P. ALLEN

4/79

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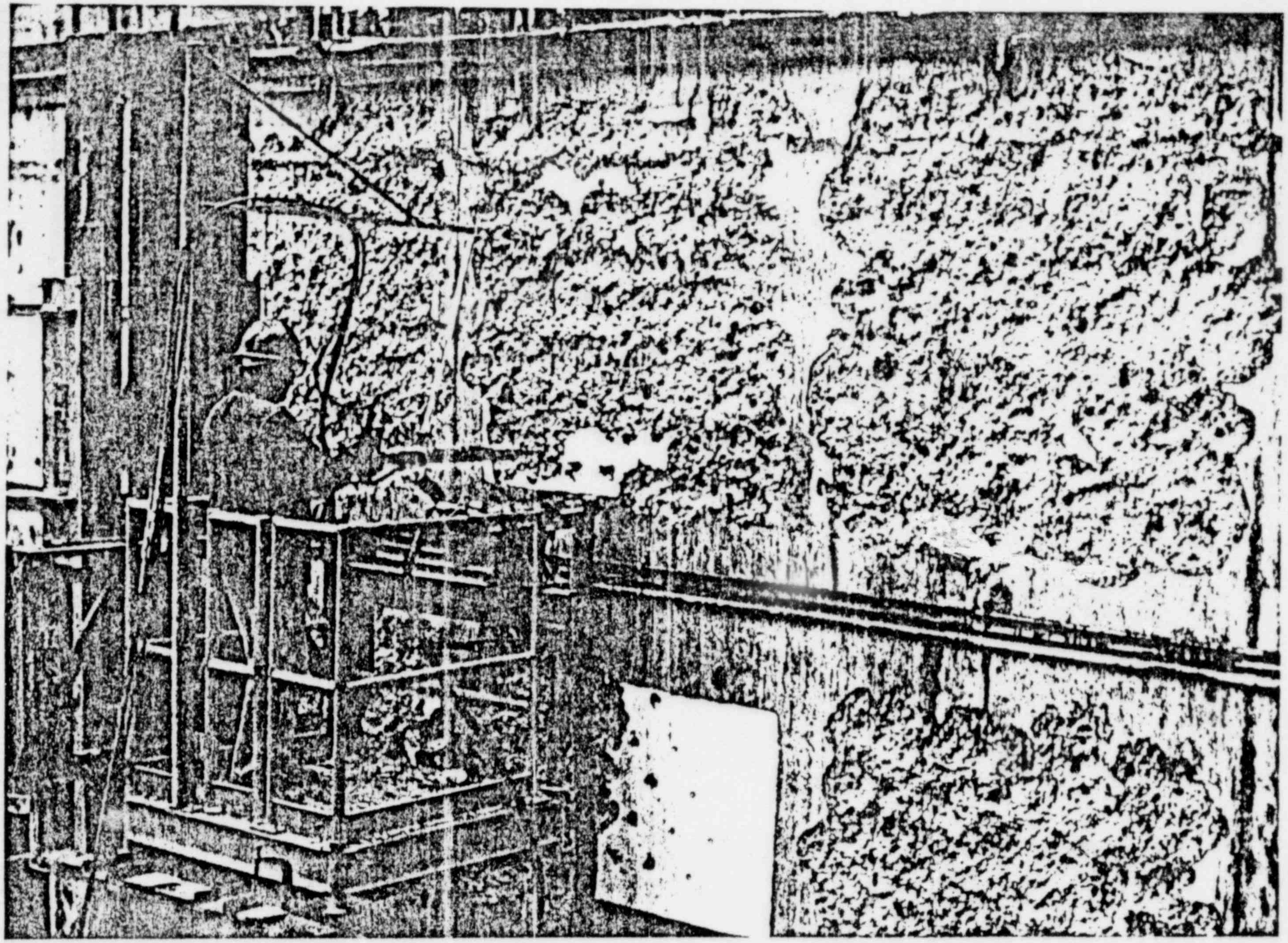
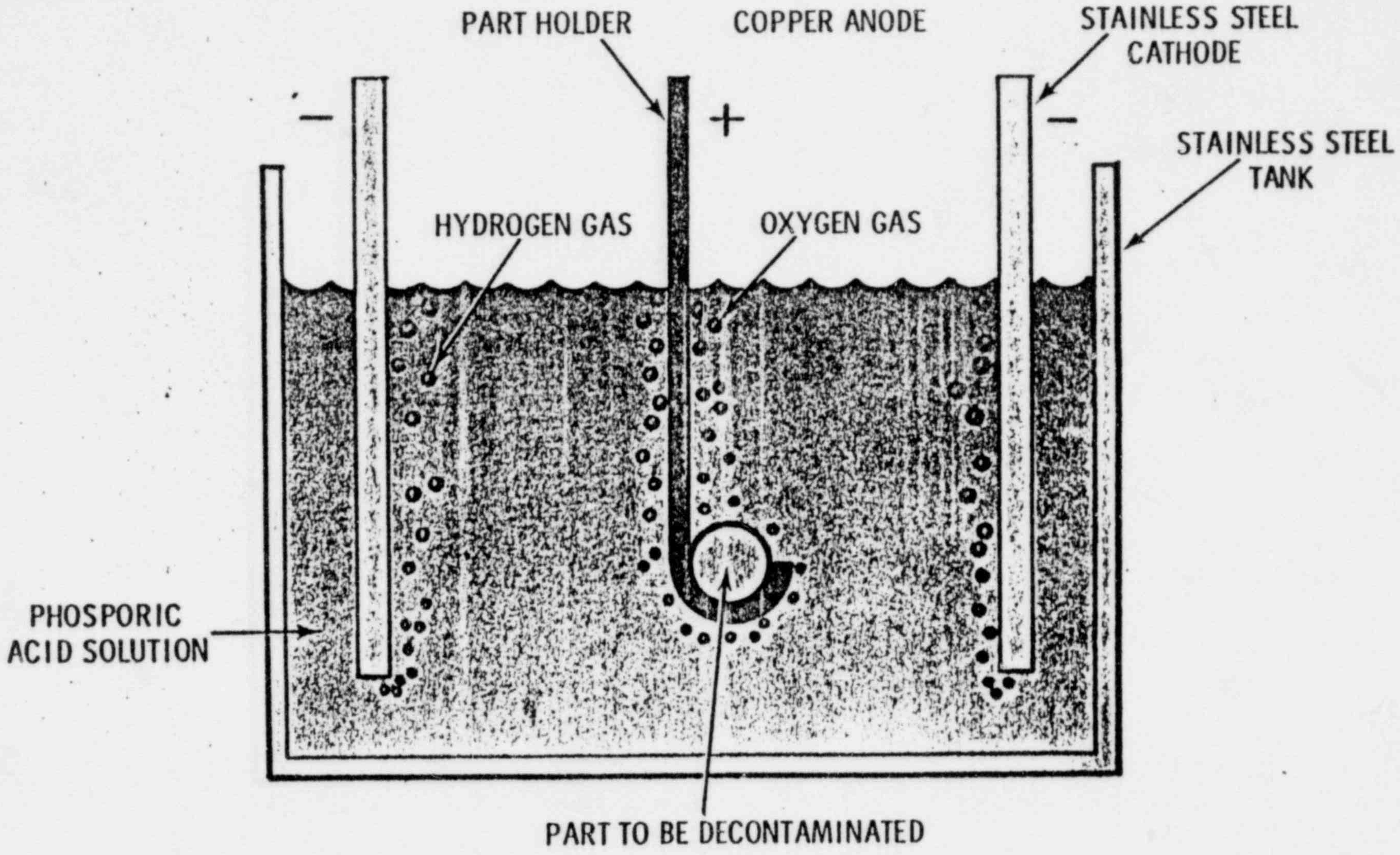
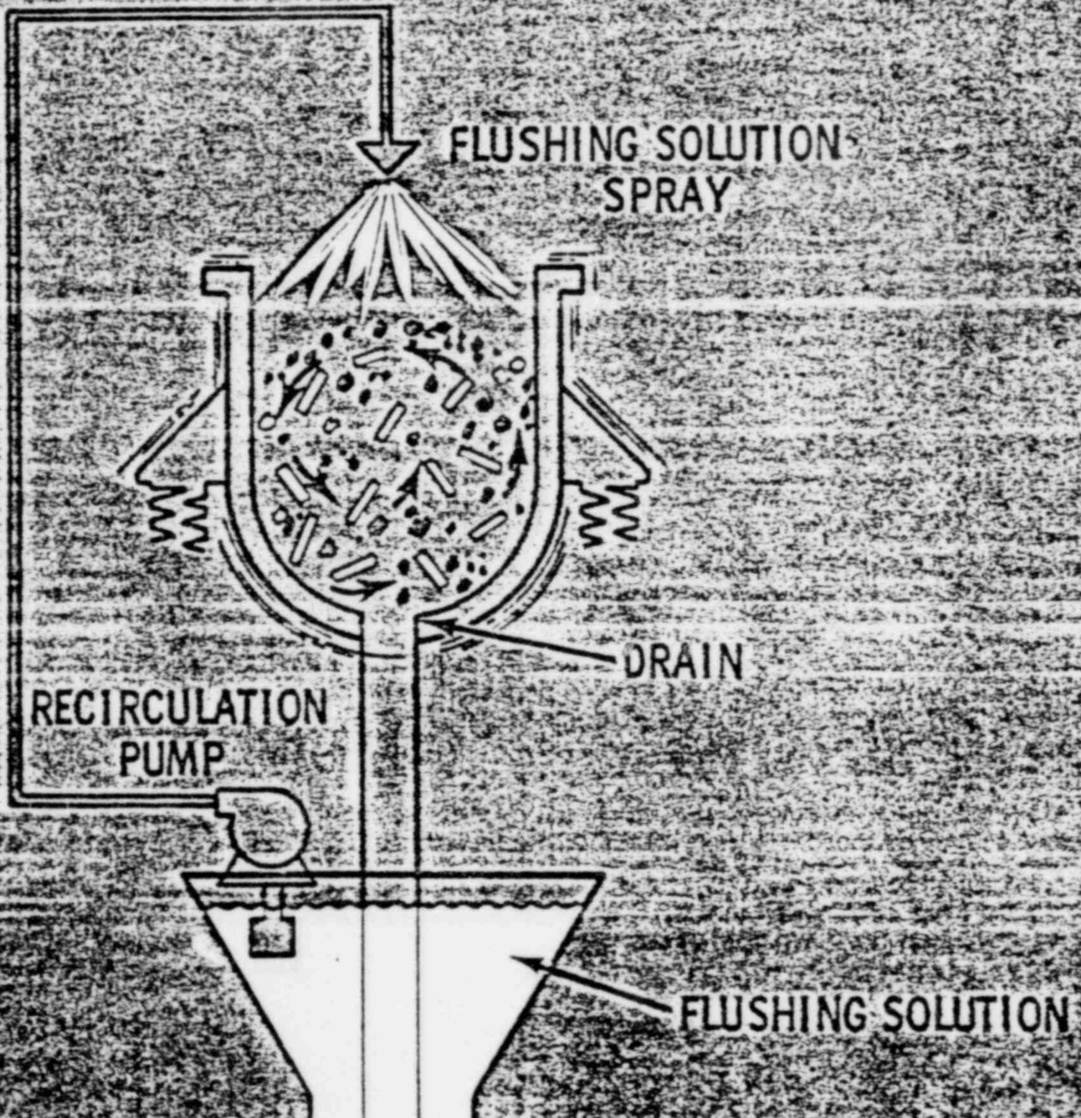
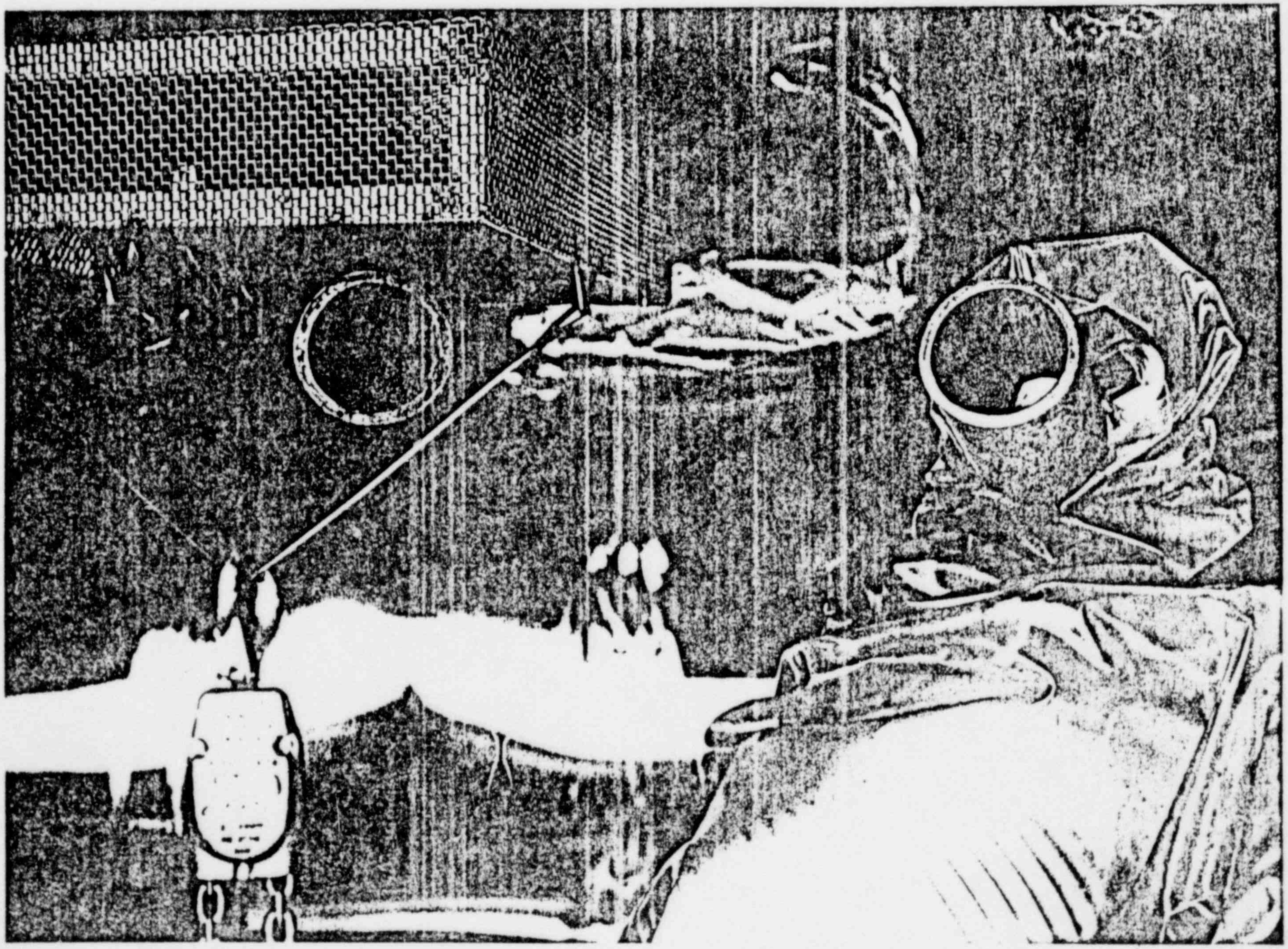


ELECTROLYTIC CELL



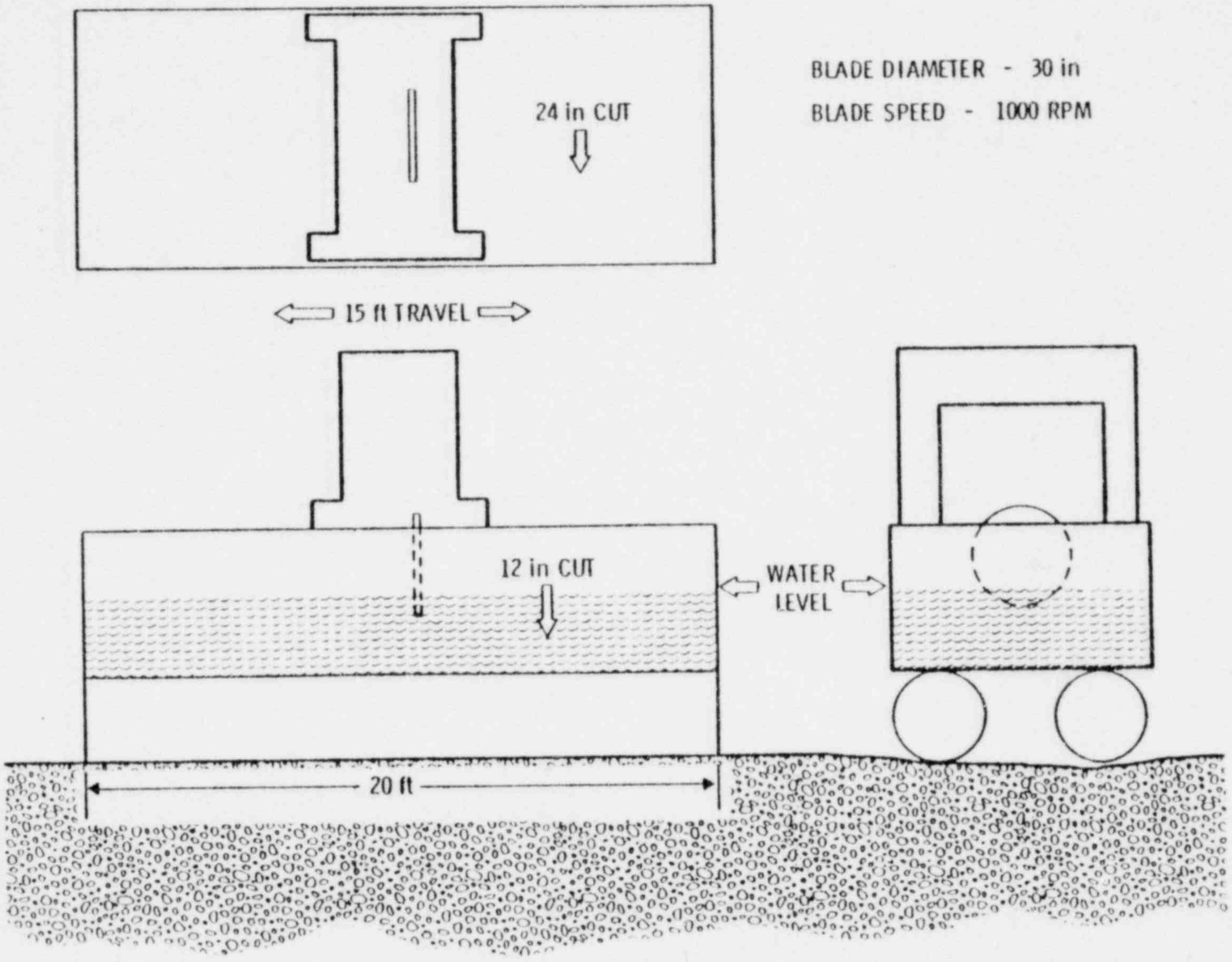
VIBRATORY FINISHING SYSTEM





PNL ARC SAW

BLADE DIAMETER - 30 in
BLADE SPEED - 1000 RPM



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LOW-LEVEL WASTE CLEANUP

HANFORD SITE

- DEFENSE WASTE PROGRAMS OVERVIEW
- PLUTONIUM REMOVAL FROM Z-9 CAVERN
- PLUTONIUM CRIB (216-Z-1A) CHARACTERIZATION
- LONG-TERM WASTE MANAGEMENT STRATEGY

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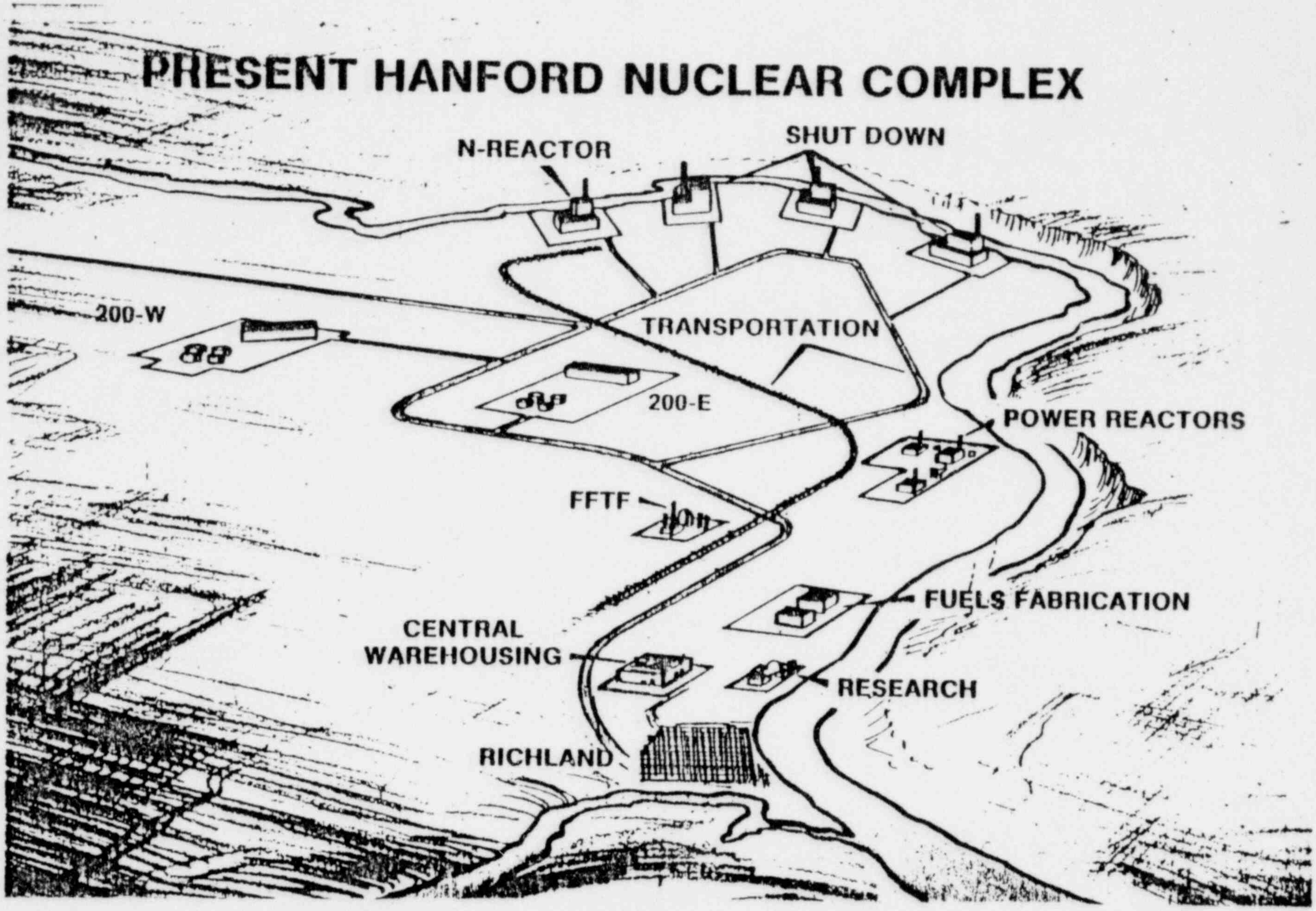
SUMMARY OF LOW-LEVEL WASTE SITES AT HANFORD

AREA	LOW-LEVEL WASTE PRODUCERS	NUMBER OF SITES	ESTIMATED INVENTORY		
			FISSION PRODUCTS (KCi)	PLUTONIUM (KCi)	(KG)
100	REACTORS	66	24.3	0.0	0
200	CHEMICAL SEPARATIONS & WASTE MANAGEMENT	311	1680.3	42.39	691
300	FUELS FABRICATION & LABORATORIES	9	0.05	0.0	0
600	INACTIVE SITES	6	3.6	0.2	3
	TOTALS	392	1708	42.75	694

PRESENT HANFORD NUCLEAR COMPLEX



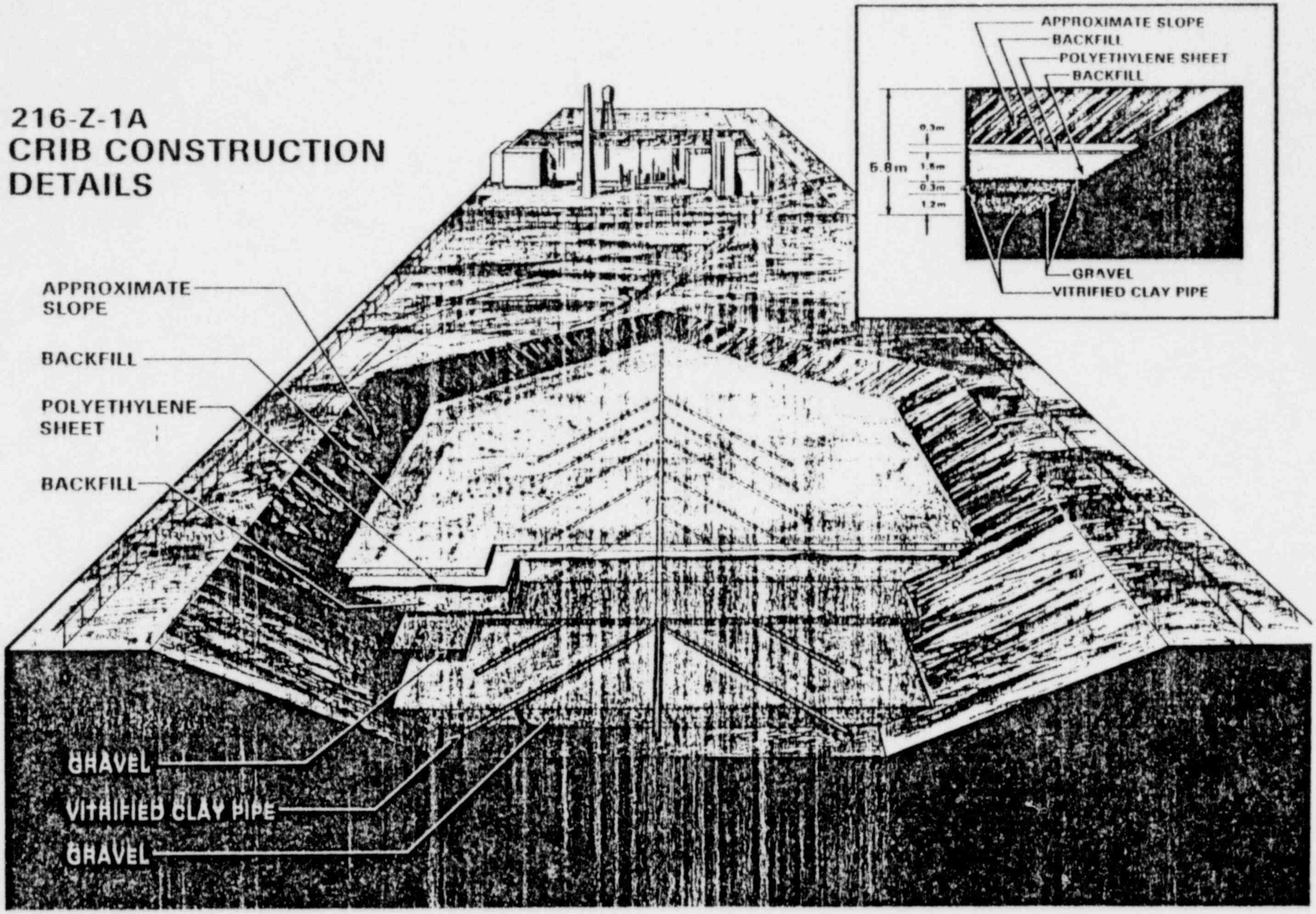
HANFORD LOW-LEVEL WASTE SOURCES

LIQUID DISPOSAL SITES	TOTAL NUMBER OF SITES	NUMBER OF SITES WITH Pu WASTE	ESTIMATED PLUTONIUM KILOGRAMS
CRIBS (116), TRENCHES (77), FRENCH DRAINS (30), REVERSE WELLS (12)	235	167	245
PONDS (17) AND DITCHES (22) (240 ACRES)	39	24	9
UNPLANNED RELEASES (45)	45	6	.25
SOLID DISPOSAL SITES			
BURIAL GROUNDS, VAULTS, CAISSONS	66	21	370
SOLID STORAGE SITES			
20-YEAR BURIAL GROUNDS, CAISSONS	7	7	67
TOTALS	392	225	691

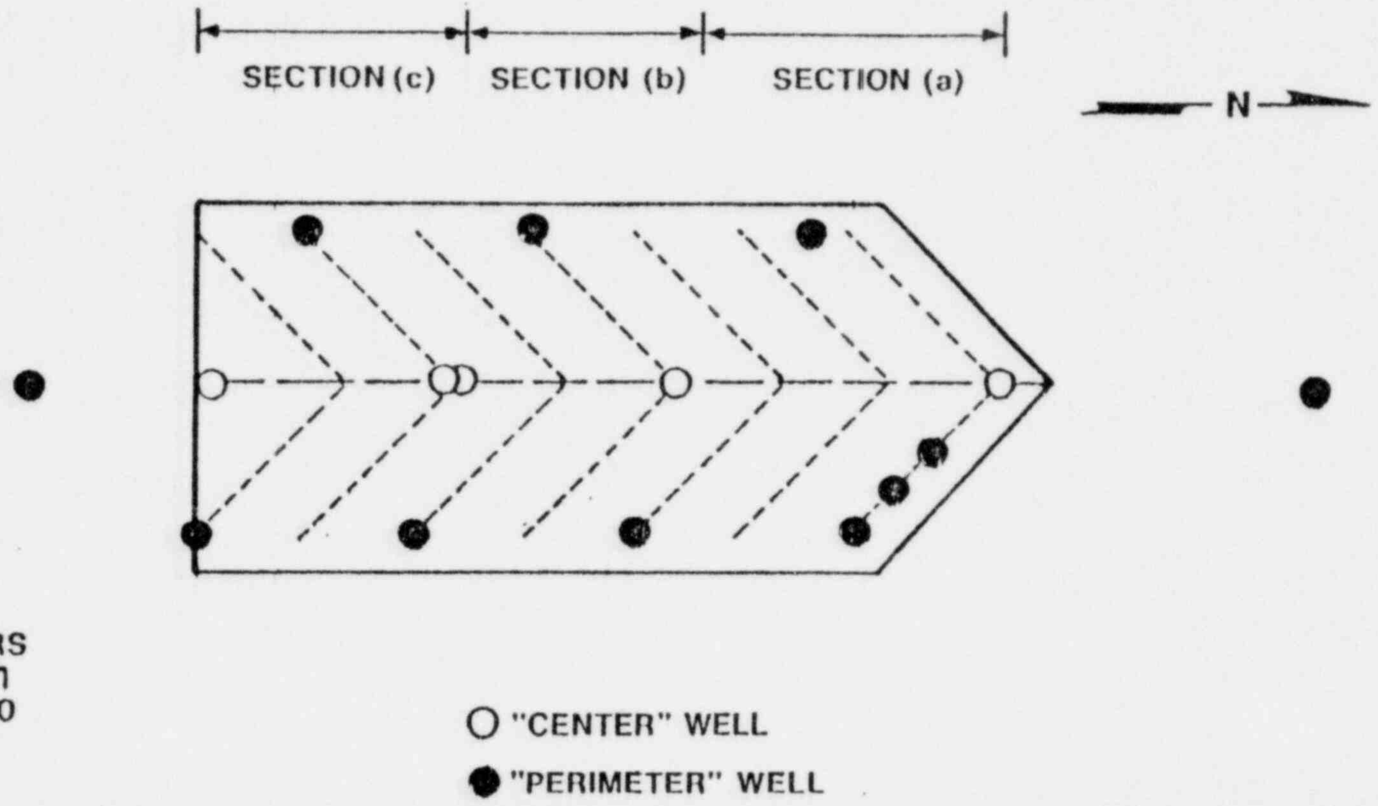
Z-9 MINING OBSERVATIONS

- PLUTONIUM BEARING SOIL CAN BE SAFELY REMOVED
- NONDESTRUCTIVE ASSAY OF SOIL WAS NOT PRECISE (± 10%) AND NEEDS IMPROVEMENT
- RADIOLYTIC GENERATION OF HYDROGEN, OXYGEN, AND OTHER GASES IS A PROBLEM THAT CAN BE ALLEVIATED THROUGH THE USE OF PACKAGE VENTS AND/OR RECOMBINATION CATALYSTS
- GENERATION OF CARBON DIOXIDE CAN OCCUR BY CHEMICAL MEANS IF CARBONATES, MOISTURE, AND ACIDIC SOIL ARE NOT TREATED OR SEGREGATED
- DRUMS CONTAINING RADIOLYTICALLY PRODUCED GASES CAN BE OPENED AND MADE SAFE FOR 20-YEAR RETRIEVABLE STORAGE
- MINING EQUIPMENT CAN BE USED IN ANY ENVIRONMENT REQUIRING REMOTE OPERATION TO PROTECT PERSONNEL FROM RADIATION EXPOSURE
- LESSONS LEARNED IN THIS OPERATION CAN BE APPLIED TO THE REMOVAL OF PLUTONIUM CONTAMINATED SOIL IF SUCH A DECISION IS MADE

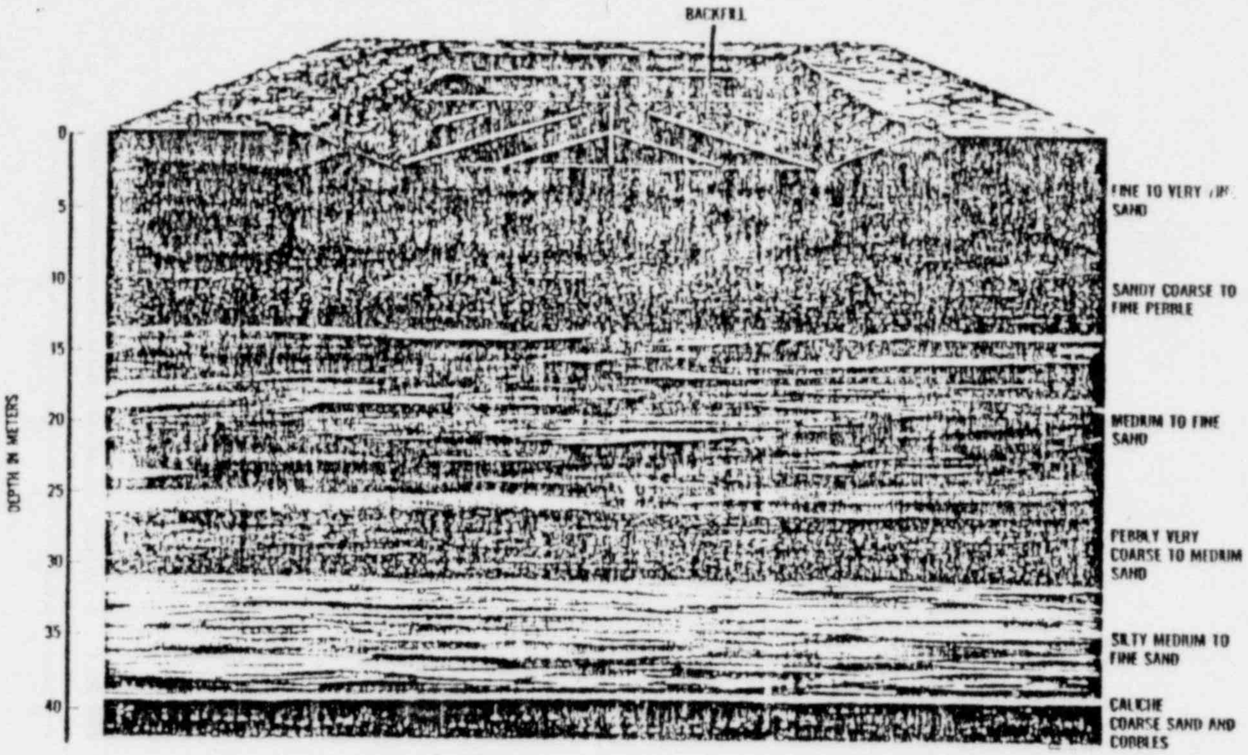
216-Z-1A CRIB CONSTRUCTION DETAILS



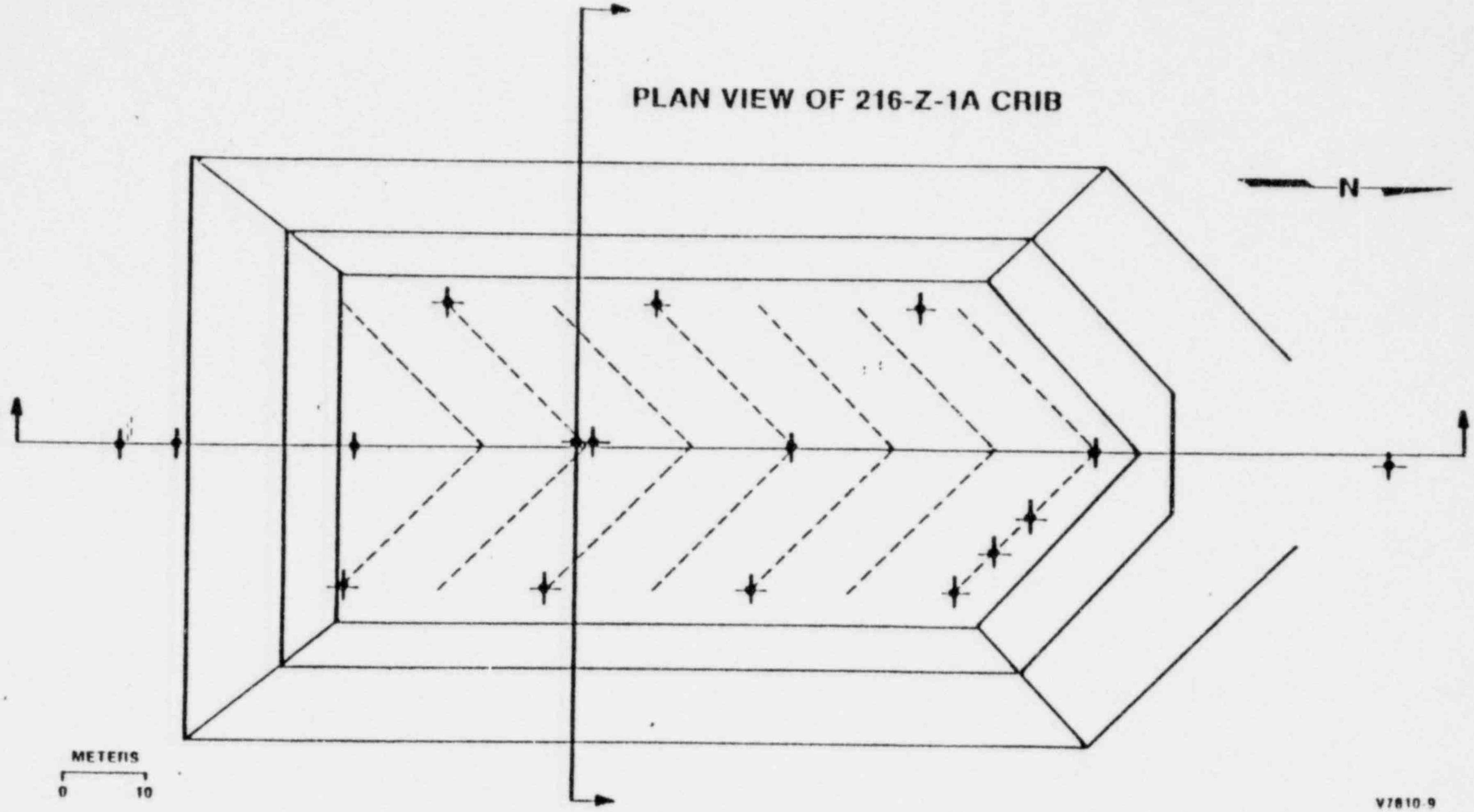
216-Z-1A PLOT PLAN



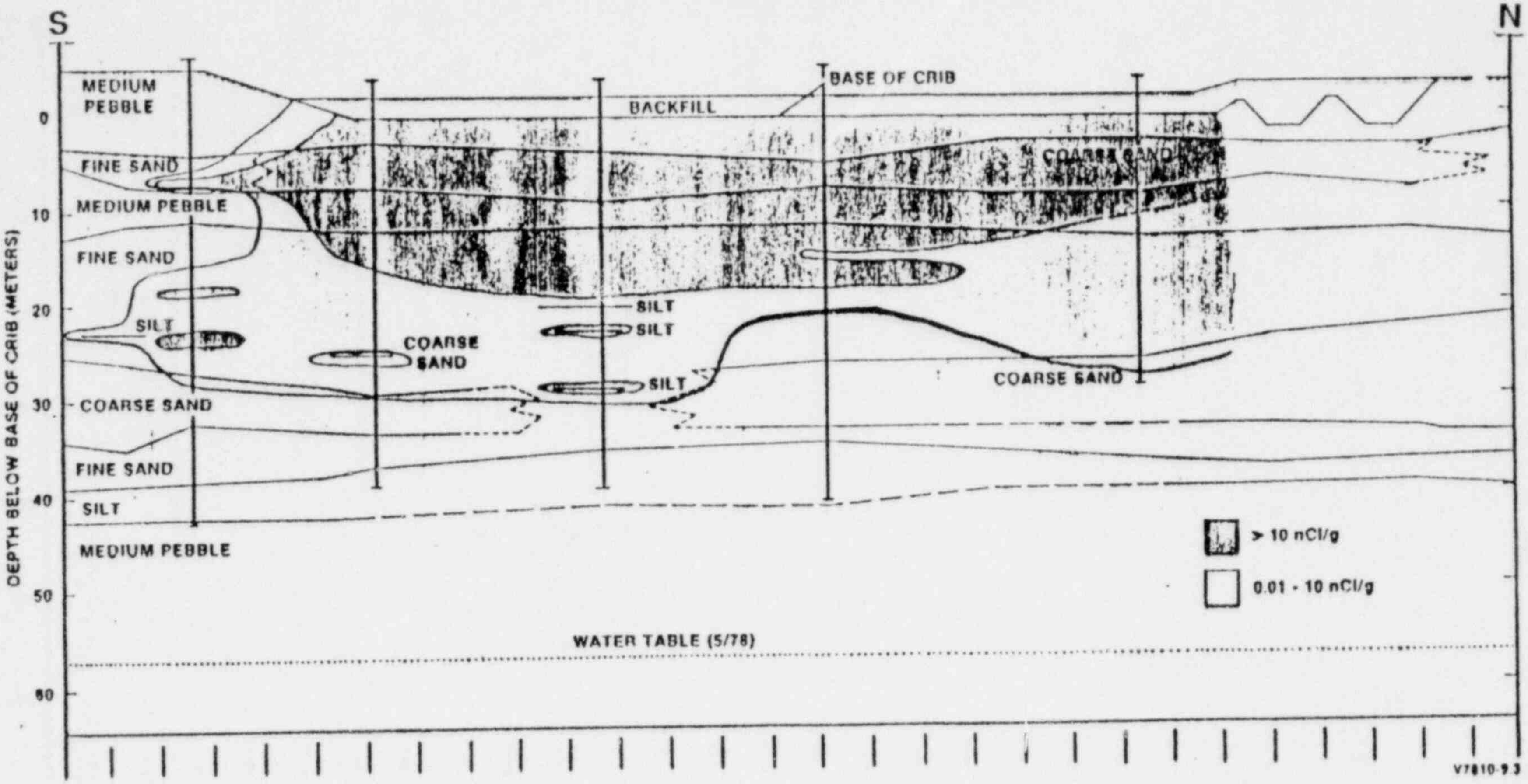
SEDIMENT DISTRIBUTION – 216-Z-1A CRIB



PLAN VIEW OF 216-Z-1A CRIB



TOTAL ACTINIDE ACTIVITY DISTRIBUTION; NORTH-SOUTH CROSS SECTION



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PROPOSED DISTRIBUTION MECHANISMS

- PHYSICAL
- CHEMICAL

DISTRIBUTION OF Pu AND Am BENEATH THE 216-Z-1A CRIB

CONTRIBUTIONS

- WASTE PLUME DEFINITION
- DISTRIBUTION MODELING INPUT
- CHARACTERIZATION TECHNOLOGY
- ALTERNATIVES DATA BASE INPUT

LOW-LEVEL WASTE EVALUATION

"RECOVERY OF PLUTONIUM FROM THE HANFORD SOIL --- IS NECESSARY TO AVOID THE ULTRA-LONG-TERM SURVEILLANCE, LAND CONTROL, AND TO AVOID CONSEQUENCES OF POTENTIALLY DISRUPTIVE CLIMATIC AND GEOLOGIC CHANGES THAT MIGHT OCCUR. --- THE PRACTICAL LEVEL OF RECOVERY NEEDED IS YET TO BE DETERMINED."

> Final Environmental Statement, Waste Management Operations, Hanford Reservation
> (ERDA-1538, December 1975)

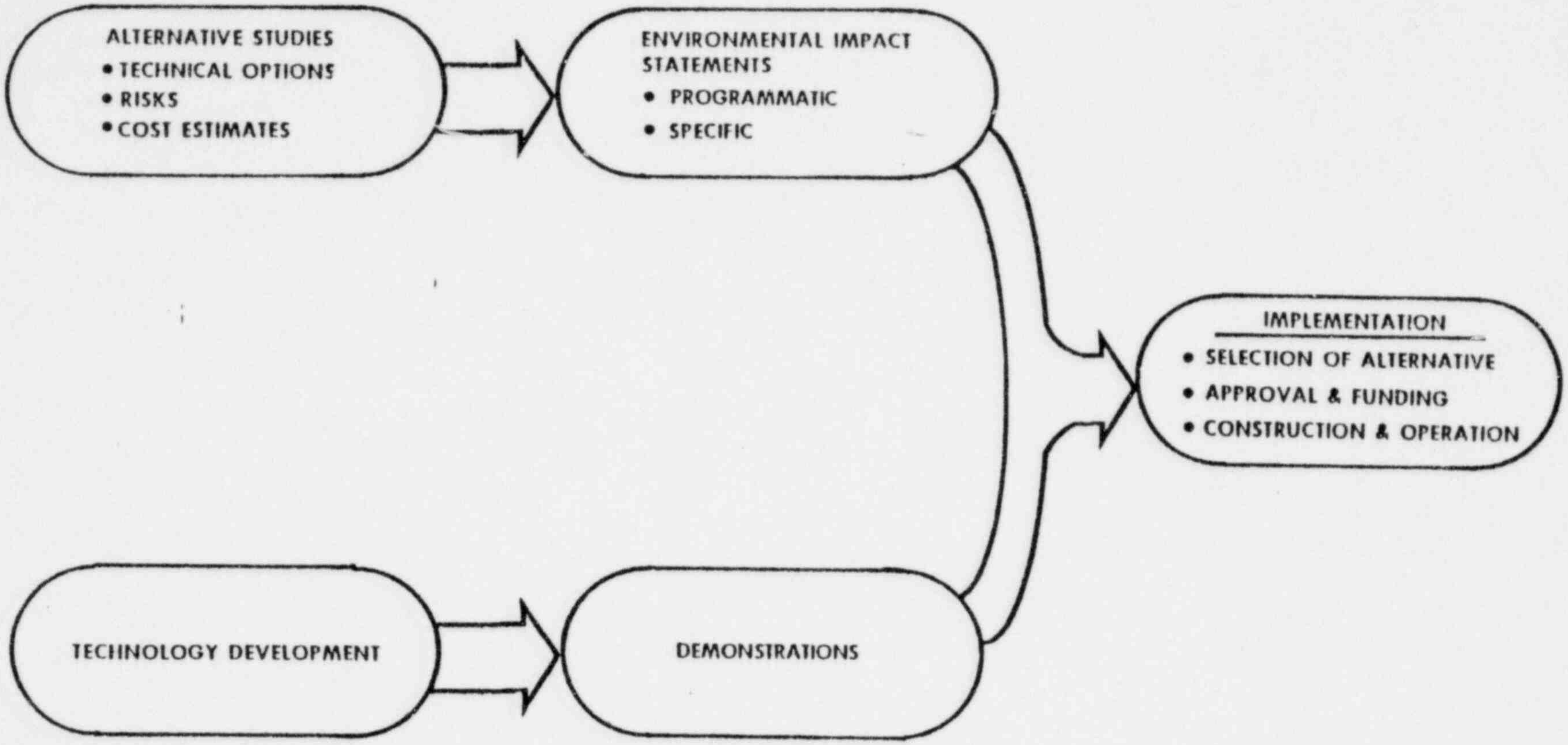
"MOST SOILS AND SEDIMENTS CONTAINING DISPERSED RADIONUCLIDES SHOULD BE LEFT IN PLACE, --- AND NOT EXHUMED UNTIL A MAJOR HAZARD TO THE ENVIRONMENT IS DEMONSTRATED, --- PLUTONIUM --- IS HAZARDOUS FOR SO LONG A TIME --- THAT REMOVAL OF SEDIMENTS CONTAINING CONSIDERABLE AMOUNTS MIGHT BE DESIRABLE."

> Radioactive Waste At The Hanford Reservation - A Technical Review
> (The National Research Council, 1978)

"FOR BURIED TRU WASTE, DOE SHOULD ACCELERATE ITS ENVIRONMENTAL AND TECHNICAL ANALYSIS OF DISPOSAL OPTIONS AT ALL DOE SITES --- AND REACH A CONCLUSION BY MID-1982 ON WHETHER THE BURIED MATERIAL SHOULD REMAIN IN PLACE OR BE EXHUMED."

> Report to the President by the Interagency Review Group on Nuclear Waste Management
> (March 1979)

STRATEGY FOR LONG-TERM WASTE MANAGEMENT



ALTERNATIVE STUDIES
- TECHNICAL OPTIONS
- RISKS
- COST ESTIMATES

ENVIRONMENTAL IMPACT STATEMENTS
- PROGRAMMATIC
- SPECIFIC

TECHNOLOGY DEVELOPMENT

DEMONSTRATIONS

IMPLEMENTATION
- SELECTION OF ALTERNATIVE
- APPROVAL & FUNDING
- CONSTRUCTION & OPERATION

LONG-TERM WASTE MANAGEMENT

ALTERNATIVES

NO ACTION

- DEFER ACTION TO FUTURE
- CONTINUE PRESENT PRACTICES INDEFINITELY

LEAVE

- ENHANCE SURVEILLANCE AND MONITORING
- LONG-TERM SITE STABILIZATION IMPROVEMENTS
- CONVERSION OF STORAGE SITES TO DISPOSAL SITES

RETRIEVE

- VARIOUS LEVELS OF TRANSURANIC WASTE CLEANUP
- PROCESSING TO MEET DISPOSAL CRITERIA
- PACKAGING AND TRANSPORTATION TO ONSITE OR OFFSITE REPOSITORY
- RESIDUAL SITE STABILIZATION

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