UNITED STATES ATOMIC ENERGY COMMISSION

IN THE MATTER OF:

CONSOLIDATED EDISON COMPANY

(Indian Point Station, Unit No.2)

Docket No. 50-247

Place - Croton-on-Hudson, New York

Date - 19 June 1972

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UNITED STATES OF AMERICA

ATOMIC ENERGY COMMISSION

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Springvale Inn
Croton-on-Hudson, New York

Monday, June 19, 1972

Hearing in the above-entitled matter was reconvened, pursuant to adjournment, at 2:30 p.m.,

BEFORE:

SAMUEL W. JENSCH, Esq., Chairman, Atomic Safety and Licensing Board

MR. R. B. BRIGGS, Member

DR. GEYER, Member

APPEARANCES:

(As heretofore noted.)

CONTENTS

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PROCEEDINGS

(2:30 p.m.)

CHAIRMAN JENSCH: Please come to order.

This proceeding of the further evidentiary session in the matter of Consolidated Edison Company of New York, Incorporated, with reference to Indian Point -acility Unit #2, as reflected in Atomic Energy Commission Docket No. 50-247, of this proceeding is convened in accordance with an order designating this place for the next evidentiary session of the proceeding.

The time mentioned in the last previous order was 1:30 to convene. The Board has schedules provided to accomplish that objective and be hear at 1:30, but after arriving on schedule at the Grand Central Terminal, we have encountered six land slides on the track between here and New York, and consequently we have been delayed until this time.

On behalf of the Penn Central Railroad, we extend apologies to you all.

The appearances, on behalf of the Applicant, Messrs. Trosten, Sack and Cohen; on behalf of the Regulatory Staff of the Commission, Mr. CKarman; on bhealf of the Hudson River Fishermen's Association, Mr. MacBeth; the New York State Atomic Energy Council, Mr. Martin.

I do not find any representative here of the Environmental Defense Fund or for the Citizens for the

Protection of the Environment.

MR. MACBETH: Mr. Chairman, Mr. Roisman asked me to say he would not be here today.

As far as the contentions and positions of the Environmental Defense Fund, he felt that I could represent those and essentially those of the Hudson River Fishermen's Association.

On behalf of the Citizens Committee, he wanted me to say that he felt the environmental issues would be sufficiently covered by the other intervenors, Hudson River Fishermen's Association, and Environmental Defense Fund, and therefore they felt no need to be represented by counsel on these issues.

CHAIRMAN JENSCH: Very well.

MR. MACBETH: He also would have been unable to get here this afternoon with present transportation.

MR. KARMAN: Mr. Chairman, prior to the Board's arrival this afternoon, Congressman Hamilton Fish was present and had hoped to read into the record a limited appearance statement. It seems he had written the Chairman before and was told to be present at the hearing if he so desired to have the statement read. If there was no objection, in all likelihood, it would be accomplished.

Congressman Fish handed to me his limited appearance statement. It seemed he had an appointment to get back to Washington and he had hoped to leave and get back some time today.

All the attorneys present today have agreed not to object to the inclusion of Congressman Fish's statement as a limited appearance statement in this proceeding.

CHAIRMAN JENSCH: Very well, if there is no objection, the statement may be handed to the reporter and copies in the transcript.

MR. KARMAN: Here you are, sir.

(THE COMPLETE TEXT OF THE DOCUMENT FOLLOWS:

STATEMENT OF HAMILTON FISH, JR., MEMBER OF CONGRESS, 28TH CONGRESSIONAL DISTRICT OF NEW YORK:

Mr. Chairman, I am Hamilton Fish, Jr., Member of Congress representing the 28th Congressional District of New York. My present district includes four counties which border the Hudson River and the entire area I represent has had a long continuing, historic interest in the Hudson for transportation, fishing and recreation. Further, I am now running for reelection in the new 25th Congressional District, which contains Dutchess, Putnam and Northern Westchester Counties, as well as parts of Ulster and Columbia Counties. All of these counties border on the Hudson River. Most significantly, the Indian Point Plant is physically located in the new 25th.

Thus, it is for the purpose of protecting these traditional interests of my present and future constituents that I am making this limited appearance before you today. I am appearing to express my concern over the possible consequences of a nuclear accident at this plant, as well as the environmental and public health implications of the proposed routine emission of radioactive materials from this plant into the water and into the air.

THE GRAVE RESPONSIBILITY OF THE ASLB:

Mr. Chairman, you and your colleagues have a grave responsibility, one that demands the best of scientific and technological competence on one hand and the rare ability to integrate into your deliberations, consideration of public welfare on the other.

You have before you a record in which the utility argues strongly about the need for this additional generating facility and warns of the potential power shortages that could occur should this project be delayed. It further asserts that the anticipated environmental effects are at least balanced in the scale of public values by the benefit of the electrical output of the plant.

To counter the powerful voice of this utility which is well amplified by the voices of its experts, there is only the voice of the intervenors, who lack the resources to launch the exhaustive analysis of the assumptions, oversights, or even possible errors in the analyses of the utility and of the AEC itself.

So the fundamental thought I would leave with you is that this Atomic Safety and Licensing Board should assert to the utmost its independence under AEC regulations, and that it probe deeply and incisively into the assertions of the utility. Further, that it treat with close attention the views of the intervenors, for in those views may be contained the kernals of some fundamental truths that bear directly upon the issue whether this plant should be licensed to operate, and, if so, under what special conditions.

ATTENTION TO NON-RADIOLOGICAL FACTORS:

Mr. Chairman, at this stage of the licensing process for the Indian Point 2 nuclear power plant, you have to deal with the non-nuclear environmental effects. You well know the Calvert Cliffs decision, with its judicial reading of the National Environmental Policy Act. You may know that in the Congress I was an original cosponsor of this legislation and have since been a vigorous supporter of it. Because of the interest of my constituents in the Hudson River, in preserving its quality and character, I particularly welcomed that part of this decision having to do with AEC's responsibility to consider the effects of nuclear power plants on water quality.

I would recall for the Board part of what Judge Skelley Wright wrote. He said, and I quote,

> "NEPA mandates a case by case balancing judgment on the part of federal agencies. In each individual case, the particular economic and technical benefits of planned action must be assessed and then weighted against the environmental costs; alternatives must be considered which would affect the balance of values...In some cases, the benefits and possible costs may lie anywhere on a broad spectrum... The point of the individualized balancing analysis is to ensure that, with possible alterations, the

"optimally beneficial action is finally taken."

Going further, the Court made it abundantly clear that while the granting of a license by the AEC is contingent upon a wa ter quality certification, the AEC is not precluded from demanding water pollution controls from its licencees which may be more strict than those demanded by the certifying agency. The Court clearly expects the Commission to balance the overall benefits and costs of a particular proposed project, and consider alterations above and beyond the applicable water quality standards which would further reduce environmental damage. Yours is the heavy responsibility of giving substance to this judicial reaffirmation of the purposes of NEPA.

THE NATURE OF MY PARTICIPATION:

At the outset let me say that I do not pretend to know about the intricacies and subtleties of design of a nuclear power plant. I am not a professional nuclear engineer, nor a health physicist, nor an expert in the effects of waste heat and what to do about it. I am none of these. Rather what I have to say reflects my continuing awareness as a Member of Congress who has strongly supported and closely followed the enactment and subsequent application of the National Environmental Policy Act.

THE DISADVANTAGE OF THE INTERVENOR:

In preparing this statement of concern, I have come to learn something more of the built-in disadvantages of AEC's licensing of the system to the intervenor; disadvantages which from my standpoint may make it too easy for the powerful, wealthy utilities to use big name experts to stifle the voices of the intervenors. So I would hope that the Board will listen carefully to what the intervenors have to say.

Despite possible expressions of impatience by the AEC, the utility or the nuclear industry with the pace of these hearings, I would hope that the Board will give the intervenors the full measure of time they will need to effectively make their case. The additional time this will take will be infinitesimal in comparison with the loss of time attendent upon a nuclear accieent in a plant too hastily licensed.

THE FISHKILL ISSUE:

Probably the most immediately pronounced environmental effect of Indian Point 2 will be its impact upon the microscopic plants, animals, and the fish of the Hudson River. We already know from experience with Indian Point 1 and from recent experiences with tests of the water pumps for Indian Point 2, that fish are being killed and will continue to be killed by the systems for taking cooling water from the river. In this connection, I would draw your attention in particular to the statement of the Hudson River Fishermen's Association, submitted to this Board on June 1, 1972.

From my own reading of the draft environmental statement for Indian Point 2, it is clear that the AEC's own regulatory staff see some real and as yet unresolved problems with regard to unacceptably severe effects of this power plant upon the fish and other marine life of the Hudson River. The Staff raises questions about the design of theintake structure; the thermal load level; the possibility of waste heat reducing the oxygen contents of the waters and the resulting toxic concentration that will be produced in the Hudson River.

Further the AEC staff report on page V-31 discusses the substantial fish kills earlier this year and notes that all the fish kills at Unit No. 1 appear to have been associated with the plant's condenser cooling water system. The draft statement then says, "Indian Point Unit No. 2 has an intake structure similar to that of Unit No. 1, and is likely to produce similar fish kills."

Mr. Chairman, I realize that a great deal of attention has been given to this one environmental effect of Indian Point. Perhaps the utility may argue that a few fish are not worth all this fuss and bother. I can assure you that we who live in the communities and counties along the Hudson River do not see it that way. If the utilities insist upon using modern technologies that can adversely affect the environment, then these technologies must be house-broken.

In the case of protecting the fish, the most reliable way to cope with the cooling problem may be to put in cooling towers. This would resolve the effects of waste heat upon microscopic plant life in the river, upon the plankton which is essential to the life cycle of the fish and other creatures, and upon reproduction and vitality of the fish population. It would also reduce the killing of fish and marine life from entrainment in the cooling system and from impingement upon the guards and other barriers of the cooling system inlets.

Putting it another way, there is no social justice in the concept that in order to save the Applicant's money, that the Hudson River at Peekskill should be turned into an aquatic desert. The technical means exist to keep the waste heat from Indian Point 2 out of the river. I submit that this Atomic Safety and Licensing Board should give every consideration to making construction and use of cooling towers a condition of the operating license.

THE REACTOR ACCIDENT ISSUE.

A less likely, but potentially enormously urgent cause for public concern, is the possibility of certain kinds of accidents occurring within a large nuclear power reactor of the Indian Point 2-type which could lead to an uncontrolled release of a dangerous amount of radioactive wastes. Certainly the Board is aware of the questions on the so-called emergency core cooling issue which are being raised at the controversial rulemaking hearings still going on before another Atomic Safety and Licensing Board.

I would hope, for example, that this Board will examine the statement of the Union of Concerned Scientists of March 23e, 1972, in which it submitted a technical evaluation of emergency core cooling systems. According to their analysis, under unfavorable meteorological conditions such as a temperature inversion at night, and assuming 20 percent release of the fission product inventory, lethal effects could extend 75 miles downwind in a strip as much as two miles wide, with radiation injuries likely from 100 to 200 miles.

Now I do not personally know how valid is the analysis of the Union of Concerned Scientists. But I must assume that because it is the product of reputable scientists, at as eminent an institution as Massachusetts Institute of Technology, that it has some basis. This suggests to me the need for some very definite answers to the questions they rais before Indian Point 2 is licensed for operation.

I would hope that at the very least, this Board will restrict the power output of Indian Point 2 to a level well below its maximum design output until the research and experimentation needed to demonstrate the adequacy and reliability of these and other safety features of large power reactors has been satisfactorily completed.

The facts that such results would not be available for several years at the earliest and that such limitation would reduce the income to the utility do not constitute sufficient reasons in my opinion to subject the surrounding communities to whatever degree of risk of an uncontrolled nuclear accident that may be revealed by future safety research and experimentation.

THE PROXIMITY TO POPULATION:

At this stage of the evolution of the nuclear industry, I am greatly concerned about a project which would ultimately place four nuclear power reactors so close to large centers of population. While the Board already has in hand information on this population, it bears reiteration that the Indian Point complex is located only a few miles south of Peekskill, that a population of over 50,000 is to be found within a five-mile radius, that the thriving city of White Plains is but 17 miles away, and that all of New York metropolitan area is within a 50-mile radius.

With Indian Point Unit 1 and 2 in operation, they together will contain an inventory of many billion curies of fission products, which is an amount of radioactive materials so enormous that I cannot comprehend it. Of course the Applicant will provide an impressive array of witnesses to testify that the protective devices and measures to safety confine these extremely hazardous materials to work as advertised.

I hope that as the Board considers the population issue, it will keep in mind the cautionary letter of the AEC's own Advisory Committee on Reactor Safeguards of September 1969 which pointed out that the proposed site represents a relatively high population density to be so near a large nuclear power plant. At the end of its hearings, should the Board decide to issue the construction permit, I hope the conditions of the permit will insure that the safety measures are generous, rather than the bare minimum which the Applicant thinks it can specify and still get favorable action.

THE ROUTINE EMISSION OF RADIOACTIVE WASTES ISSUE:

Indian Point 2 is designed to routinely emit certain radioactive wastes to the environment. The draft environmental report is specific on this matter. It says that the plant is designed to release radioactive materials to the environment "...in accordance with the Commission's regulations as set forth in 10 CFR Part 20 and 10 CFR 50."

I realize that the amounts of radioactive wastes so released are thought to be so small as not to warrant the expense of collecting them. On the other hand, I am aware that principles of radiation protection hold that exposure should always be as low as practicable, that no exposure should be allowed without expectation of benefit, and that all radiation is potentially harmful. To me these principles clearly indicate that if it is technologically feasible to contain even these small amounts of wastes as an alternative to discharging them into the environment, then economics should not be the deciding factor.

Also, as concerns emission of "small" quantities, it is by no means evident to the public what is meant by "small" and, furthermore, whether "small" routine emissions from many large nuclear power plants in the same air and water sheds could lead to accumulations of unacceptable quantities. The issue of levels for routine emission of such wastes is still very much an open item. The AEC's public rulemaking hearing on its regulations which would keep releases of radioactivity from light water cooled nuclear power plants to a level "as low as practicable" has yet to produce any new definition.

Considering this uncertainty as to the basis for AEC regulations governing routine release of radioactive materials, I find it difficult to see how this Board at this time can adequately analyze those features of the Indian Point 2 that relete to such release. While in principle, a licensee could be directed to make changes after the final regulations come down from the AEC, my experience with human nature and organizations and their administration strongly indicates that public safety would better be served by waiting until AEC concludes its rulemaking for this matter, rather than trying to get the utility to change the design after the fact.

THE AUTHORITY OF THE REACTOR OPERATOR:

Anotherimportant question concerns the authority ofthe man at the controls to shut down the reactor. I would hope that the Board will carefully explore and find out who has the authority to shut down the reactor should some aspect of its operation indicate that something is not normal. From some things I have heard, it is not clear to me how much the man in the control room can exercise his own judgment and how much he must inform and defer to higher authority and await their decision. It would seem to me to be more in the public interest that a power reactor may occasionally be shut down for reasons thatlater prove to be minor, rather than that it be operated up to the brink of disaster because no one is readily accessible with personal authority to shut it down.

In a similar vein, the Board may wish to indicate its view as to the desirability of having a resident AEC official present in the control room of the power plant during the first year of its operation with authority to shut down the reactor or to reduce its power level at any time in his judgment, without seeking concurrence from higher authority. Just as the launching of an enormously expensive space rocket is subject to the judgment of a range safety officer, so, too, the initial operation of a large nuclear power plant should be subject to supervision by an officer present in the control room with personal authority to shut it down if, in his opinion, there is any question of safety.

THE NEED FOR POWER ISSUE:

Let me finish with a brief discussion of the energy needs issue. Granted there is much talk of a power shortage in the service area of the applicant. But the AEC draft environmental statement seems deficient to me in the adequacy of its analysis of the true dimensions of this factor. The AEC seems to rely too much upon the self-serving statements of the applicant and the analyses of the Federal Power Commission which bases its reports on utility-supplied information. This situation reminds me of the recent decision in the U.S. Circuit Court of Appeals in Greene County versus the Federal Power Commission, 3 ERC 1595; I participated as a formal intervenor in this case where the FPC considered a utility's request for authority to construct a power transmission line.

The Court held that the FPC had to prepare its own NEPA review, that it could not simply accept the review of the Applicant and circulate that for comment. I bring this up in connection with the licensing of Indian Point 2 because so much of the urgency associated with this action is based upon analysis of the power demand situation. It seems to me that the logic of the Greene County case would require the AEC to more independently analyze the electricity supply and demand situation, and also the alternatives to immediate operation of Indian Point 2.

I hope the Board would require a thorough, independent, tough-minded analysis of the power situation before it reaches any conclusion that the demand for electricity in this instance is so immediate, real and urgent that the public should be subjected to the still-unknown risks that I mentioned earlier in connection with the issue of reactor accidents.

CONCLUSION:

In conclusion, my overall purpose in this statement of concern is precisely what its title indicates: to express to the Atomic Safety and Licensing Board which will hear testimony on the Indian Point 2 project the concerns and doubts of this Member of Congress. I hope that this expression will sharpen the perception of the Board in its utilization of the awesome decision they will make, and reinforce their realization of the need to be conservative and rigorous in its judgment. Finally, in making this judgment, I hope that this Board is guided by the spirit as well as the letter of the National Environmental Policy Act.

Thank you.

CHAIRMAN JENSCH: Prior to the session today, the Board inquired of the parties concerning the agenda that the parties would propose for consideration by the Board for this session of the evidentiary hearing. There were responses to that inquiry indicating that certain matters of environmental concerns would be proposed for this session.

In addition, there was a suggestion that the parties were continuing their endeavors to arrive at stipulations that would provide means for expediting the consideration of the matters and presentations of this session of the hearings.

I think we should hear a little further in that regard before we make inquiries as to the readiness of the parties to proceed with the presentation of evidence.

Will the applicant give us a statement in that regard, please?

MR. SACK: Mr. Chairman, Mr. Macbeth and I have been working on stipulations. We have made substantial progress but I don't think we are complete. We are not prepared to submit them yet.

We are working on stipulations on fish impingment experience and the need for power during the period October 1, 1962 to June 1, 1973. We hope these would be ready in the near future.

CHAIRMAN JENSCH: Can you put a finger on that time? How soon will you arrive at something?

MR. SACK: Maybe Mr. Macbeth can answer that. We gave him our comments last Friday.

MR. MACBETH: I think within ten days, Mr. Chairman, we could probably have a stipulation.

I'd like to just say a few words about the status of the dealings between the parties.

Since the last evidentiary hearing in May, I think all the parties have made a substantial effort to try and settle as many factual matters between themselves as possible, and also to try to make a sensible practical judgment about what issues could be taken up before the Staff's final statement was in, and what issues were best left until that statement was there, so that we would all have a clear notion of the position all the parties in the proceeding were taking.

I think it's the position both of Con Edison and the Hudson River Fishermen's Association that it's best to put off what I at least consider the really essential contentions that the fishermen are making in this proceeding until the final impact statements are here. Those are primarily to what impingement of fish Indian Point 2 would be, what the experience with entrainment would be, and subsidiary issues around that, compensatory effects, population of fish in the river, and so on; and also the question of alternative cooling systems.

The Applicant has agreed to that and that puts us in a position where we're ready to take up the remaining issues that are in contention between the parties: The impact of thermal discharges, of chemical discharges, and one or two other matters.

From the point of view of the Intervenors, these are subsidiary questions but are important questions, and we want to cross-examine on them and build a record on these points.

I think I can fairly report that generally the last few weeks of negotiations between the parties have gone reasonably well. We are in the position on stipulations of fish impingment experience, and the need for power question, and we have been quite close to a stipulation which would have substantially reduced a number of issues on which evidence has to be taken, cross-examination would have to be undertaken.

I frankly feel that would be extremely fruitful. I think it would not only save the time of the Board and all the parties, but it would also, I hope, focus the issues more clearly for the Board.

The stipulations, I think, would be shorter and much clearer than anything that would arise out of the record and cross-examination. I think that is a reason we should push on, too. Within ten days we ought to have stipulations on those two issues.

CHAIRMAN JENSCH: Since there has been kind of a statement of performance and since our last evidentiary hearing, it may not be improper for the Board to indicate that the Board has been engaged in every opportunity available to it in pursuit of some of the problems that are pending in this proceeding in an endeavor to arrive at a resolution of several of the pending matters, one of which is the motion made by the Applicant here for a testing license.

So the Board welcomes these statements of endeavors with reference to stipulation, and would appreciate any suggestions you can give the Board as to how soon the Board may resume its considerations of the pending motion which has already absorbed a great deal of time and is likely to entail some more considerations.

Do you have something that we should be doing today?

MR. TROSTEN: Yes, Mr. Chairman. We are prepared to proceed with cross-examination, subject to certain qualifications that Mr. Sack will address himself to concerning the contentions of the Intervenors.

However, before -- if the Board is agreeable, we can proceed to this matter of discussion of the contentions and cross-examination. However, I would like to make this suggestion:

In the past the Board has, from time to time, requested to be kept advised of the point at which the plant is expected to reach initial criticality. It is in view of the Board's expressed interest in this matter in previous hearings that I felt it would be worthwhile for us to provide for the information of the Board and a -- a more recent statement concerning this matter. Mr. Cahill is prepared to do that.

I thought it would be well to do that before we launched into the environmental hearing.

CHAIRMAN JENSCH: Proceed, pleese.

MR. CAHILL: Mr. Chairman --

CHAIRMAN JENSCH: It may be noted on the record before you start, Mr. Cahill, that travel arrangements have now been completed by all members of the Board. We are fortunate to have Mr. Briggs come through despite the airline or pending pilot strike. So, between landslide and the railroad and airplane strikes, I hope you lawyers will understand why there has been a few minute delay.

Will you proceed, please.

MR. TROSTEN: Mr. Chairman, before we proceed with this, I want to make certain that I understand the last comment that you made about resuming consideration of the motion.

#1 I understand that --

CHAIRMAN JENSCH: Not here. If the matter that the Board will welcome the opportunity to resume its consideration of the motion and welcomes the endeavors of the parties to arrive at stipulations and to take time in order to do that to relieve us of the endeavor to sit here on the stipulation matter.

Will you proceed, Mr. Cahill.

MR. CAHILL: Yes. At the last session of the hearing I indicated that our estimated time to be ready for criticality was late June and that the controlling to be accomplished was the reenforcing of the main steam super heater -- excuse me -- safety valve nozzle enforcement. That work has been accomplished.

I also mentioned at the last session of the hearing that in the testing program, the precritical testing program that we have been conducting, that we had run into a problem in the control rod motion tests that are prerequisite to the start up of the plant wherein four control rods either were stuck or indicated so bind or resistance to free action.

At that time we had only recently experienced the problem and had not fully evaluated or determined what the cause of the difficulty was.

The testing program is, of course, intended to determine the functional capability of the various plant components. I will schedule -- that is our plans for bringing this plant to operating condition --are very important in our minds, the paramount consideration that we always of is the reliability and safety of the plant and these two factors are almost synonymous. A reliable plant is generally a safe plant. Of course, a reliable plant is one that can function for its intended purpose.

We therefore don't want to proceed without the assurance that our plant would be reliable. I have indicated that philosophy several times during this hearing.

This is prelude to the fact that on experiencing this problem, we have launched a program to find its cause and correct it. This is involved in removing the head from the reactor, removing the upper internals, finding that foreign material was the cause of the rod jamming, proceeding to clean the foreign material, remove the fuel, examine the fuel, check the free operation of the rods, or for clearance of control rod action inside the thimbles of the -- guide tube thimbles inside the fuel and gauging that clearance and adjusting it as necessary.

This program we had anticipated and still in time to be ready for criticality in late this month or early next month. However, we still are concerned over foreign material and we intend to continue the program to the extent of removing the lower internals and going further to assure ourselves that the foreign materials are removed and this program, which we will explain and describe to you in some further detail after I complete my remarks, will take some further time, a few more weeks. So that it is possible we could be ready for criticality sometime in the latter part of next month. It is always possible, again allowing for the uncertainties, that it is difficult to estimate just how long this will take. I would have to say that criticality may come as late as sometime in August, possible still next month.

Mr. Hooten is vice president of Wedco, the Westinghouse Subsidiary that is constructing the plant, is available here to describe the program that we have undertaken to assure that the rods will function freely and that the foreign material will have been eliminated from the plant and assure us of a reliable operating and safe plant.

MR. BRIGGS: What is the source or nature of the foreign material?

MR. CAHILL: The one rod was jammed solidly. That was a rather large machine chip which I believe came from a diffuser part of one of the main coolant pumps. There is other foreign material, some chips of similar nature. But the program that has been underway and is being continued is intended to better define just the nature of all the foreign material.

CHAIRMAN JENSCH: This may seem like a very obvious question, but let us have it clearly on the record. In any event, the Applicant's program has not been delayed in any respect by awaiting the decision on the motion for testing license, is that correct?

MR. CAHILL: No, sir.

CHAIRMAN JENSCH: It has not been ~~effected~~ affected? Your program has not been ~~effected?~~ affected

MR. CAHILL: This is really part of the testing program which includes determining whether the plant and its components function properly and when they don't, to correct the malfunction. This would continue on through precritical testing. This control rod test will, of course, have to be repeated when we get back and on through the criticality and the various power level testing programs. Whenever we find something that doesn't function properly, we are going to correct it.

CHAIRMAN JENSCH: You are already on a testing program and have a further testing program that you contemplate by virtue of this motion that was made in September of 1971 and supplemented in October of 1971?

MR. CAHILL: Yes.

CHAIRMAN JENSCH: It is as to that latter motion, that your own program has not been delayed by any awaiting for an order pursuant to the motion made in September of 1971 and supplemented in October of 1971, is that correct? That is correct, is it not?

MR. CAHILL: Yes, that is correct.

CHAIRMAN JENSCH: Thank you.

Very well. If we may hear from the gentleman you referred, Mr. Cahill, in the Wedco organization.

MR. TROSTEN: Mr. Hooten will come here to the council table, Mr. Chairman.

CHAIRMAN JENSCH: Has Mr. Hooten been sworn?

MR. TROSTEN: No, sir.

Whereupon,

B. G. HOOTEN

was called as a witness on behalf of the Applicant and, having been first duly sworn, was examined and testified as follows:

XXXX

DIRECT EXAMINATION

MR. TROSTEN: Mr. Hooten, will you state your full name, please.

MR. HOOTEN: My full name is B. G. Hooten. I live in Pittsburgh.

MR. TROSTEN: Would you give your title, Mr. Hooten, please.

MR. HOOTEN: I am executive vice president of Wedco.

MR. TROSTEN: Mr. Hooten, you have heard Mr. Cahill's explanation of the present situation with regard to the testing of the rods. If you would provide the Board with additional information concerning the testing program, this would be helpful. Would you proceed, please.

MR. HOOTEN: Upon finding -- I may duplicate Mr. Cahill's comments somewhat. On finding that we had about four rods that were not moving properly, we have removed the --

CHAIRMAN JENSCH: Would you hold your microphone a little closer, please. Thank you.

MR. HOOTEN: We have removed the reactor vessel head and the upper internals, removed the fuel from the plant. During the process of cleaning the foreign and in some cases unidentified materials from the fuel elements, we have shipped two of these full elements to Columbia, South Carolina, to our manufacturing plant in Columbia. They are in the process of inspecting, cleaning and disassembling at least one of them, and verifying the adequacy of some of the tools to clean each of it, as necessary, the fuel elements of the plant. We anticipate completion of the clean up program early in July and expect to have the fuel reinstalled, the reactor vessel head on and ready for criticality in late July.

MR. BRIGGS: What kind of cleaning is being done to the fuel elements?

MR. HOOTEN: We are planning to use -- and this work is in progress down there now. They arrived in Columbia, the fuel elements, and work is in progress. We are planning to utilize mechanical tools, power tools to mechanically remove from it.

CHAIRMAN JENSCH: D, inside diameter, of the guide thimbles any foreign material that is there.

MR. BRIGGS: The cleaning is being done on the interior of the guide thimbles and not on the fuel rods themselves?

MR. HOOTEN: That is correct, yes, sir.

MR. BRIGGS: What on the cleaning would be done in

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the reactor system to get the foreign material out?

MR. HOOTEN: We will inspect the inside diameter of the reactor coolant pipe and remove any foreign material we may find there. We will lift the lower internals and inspect and clean as necessary both there and in the reactor vessel. The upper internals are removed. We are inspecting and cleaning, as necessary. We have found some metal chips in the upper internals as previously mentioned. The inspection techniques involve both direct visual and boroscopic techniques.

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MR. BRIGGS: Have you been able to combine the bottom reactor vessel below the internals?

MR. HOOTEN: Yes, we have. Although when we lift the lower internals out, we'll go through that evolution again.

MR. BRIGGS: Have you found anything down there?

MR. HOOTEN: We have found some things, but we haven't found very many things. If anything is undesirable, obviously --

MR. BRIGGS: Do you have a thimbleful or cupful of shaving chips?

MR. HOOTEN: Total estimate on my part would be more than a cupful.

MR. BRIGGS: A gallon?

CHAIRMAN JENSCH: It is more intriguing. More than a cupful is a basketful, a bushel basketful.

MR. HOOTEN: I can assure you it is less than a bushel.

DR. GEYER: How could you be sure that none of this is on the rod bundles?

MR. HOOTEN: We are inspecting for just that.

DR. GEYER: Can you see through these bundles?

sp?

MR. HOOTEN: We'll put lights on them and boroscope inside them. I don't mean inside the rod.

DR. GEYER: Is there any part of this system

mil-2

designed to attract this sort of material other than the reactor core itself?

MR. HOOTEN: As you well know, the core is an excellent filter. It has -- we had foreign material and we have trapped some in the core. We will clean it up. The situation is about that simple. In this design plant, it is usual, if you have foreign material, to also find it in other places, like the primary side of steam generators. We have inspected those locations already.

DR. GEYER: Maybe you should put a filter in there and run the thing a while.

MR. HOOTEN: We have had people bring up that subject.

DR. GEYER: Thank you.

MR. HOOTEN: I'm aware of what the Navy program does in that regard.

CHAIRMAN JENSCH: If you could just leave us hanging there, what will you do, accept it, reject it, modify it or change it, the filter, to which you just referred?

MR. HOOTEN: We are presently building and successfully building plants without filters in them, Mr. Jensch.

What the industry will do, no one today is using a filter, to my knowledge, in this kind of service. What they will be doing five years from now is --

CHAIRMAN JENSCH: Why is it necessary to take all

mil-3

these parts down to Columbia? Is it embedded crud that can't be removed or difficult to locate or difficult to remove?

MR. HOOTEN: We are doing not only verification of tooling and checking out of our cleaning techniques, Mr. Jensch, but we are also doing metallographic examinations. The best place to do this kind of work is in the factory. When we finish that work down there, we will ship two completed and acceptable fuel assemblies back to the job site. We plan to utilize the same cleaning techniques and tooling here on side to clean up any necessary foreign material on any of the remaining fuel assembles.

CHAIRMAN JENSCH: You don't contemplate or anticipate any shipment of other fuel assembles down to Columbia, is that correct?

MR. HOOTEN: Not at the present time.

CHAIRMAN JENSCH: Is there an indication that you might?

MR. HOOTEN: No, sir.

CHAIRMAN JENSCH: As far as you know, the principal difficulty with reference to these four rods that were not working properly and related fuel assemblies, is that correct?

MR. HOOTEN: We plan to complete an inspection and remove foreign material from the necessary fuel subassemblies. The foreign material is not necessarily restricted to the four assemblies thatinvolve sticky rods. I don't mean to imply that

mil-4

CHAIRMAN JENSCH: I take it it is still somewhat problemmatical. If you find that some do require shipment to Columbia, you will undertake that, is that correct?

MR. HOOTEN: We do have some confidence in completing the work early in July. The answer is yes. That is in preparation for the reloading of the core.

CHAIRMAN JENSCH: Therewon't be any problem in lower internals and upper internals?

MR. HOOTEN: We have done that sort of thing before and do not anticipate any problems.

CHAIRMAN JENSCH: You have done nothing in reference to cleaning of these that will be required?

MR. HOOTEN: We will clean them as necessary. Any foreign material will also be taken out of them. We do not see that work as being controlling whatsoever.

CHAIRMAN JENSCH: This I know is a naive question sitting next to Mr. Briggs. But let me ask it of you, if I may.

Why weren't these crud elements discovered sooner? You have been running a testing program of the kind short of criticality for some time. Why didn't these chips show up sooner and these stunt rods show up sooner?

MR. HOOTEN: I don't know the answer to that, Mr. Jensch. I know that they did in fact show up. They showed up during our test program. That is the basic program why we run

mil-5

such a program.

CHAIRMAN JENSCH: I understand. It is a good thing to find them, of course. That is why you are doing these tests I was wondering if you were running a series of tests involving pumps and motors and circulations and so forth. Were you building up accumulation of crud by the length of time you were running these tests? Did you have any indication of difficulty prior to this stuck rod situation that Mr. Cahill described to us last May?

MR. HOOTEN: No, we did not, to my knowledge, have any earlier indication. You are aware that we were running slow tests including the rod drive mechanisms, movement of control rods. Yes, we had moved a lot of water through the reactor vessel at that point in time.

CHAIRMAN JENSCH: You had no indication of any stuck rod until sometime near May at the time that Mr. Cahill described the situation to us, is that correct?

MR. HOOTEN: I believe that's correct.

CHAIRMAN JENSCH: Thank you for your statement.

MR. HOOTEN: Yes, sir.

CHAIRMAN JENSCH: Will you proceed, Applicant?

MR. SACK: At this point, Mr. Chairman, I would like to identify for the record certain testimony that was submitted in connectionwith Motion for Limited Operation, which is also applicable tothe full NEPA hearing,

mil-6

which is the subject of today's session.

I am referring to the testimony submitted by Dr. John P.Lawler on April 5, 1972, entitled, "The Effect of Indian Point Units 1 and 2 on Cooling Water Discharge on Hudson River Temperature Distribution." The testimony of Dr. Gerald J. Lauer submitted on April 5, 1972, entitled, "Effects of Chemical Discharges from Indian Point Units 1 and 2 on Biota and River Chemistry." The testimony of Dr. Gerald J. Lauer submitted on April 5, 1972, entitled, "Effects of Elevated Temperature and Entrainment on Hudson River Biota."

These three documents should be considered as part ofthe Applicant's testimony on the full NEPA review.

We would now like to offer at this time additional testimony in support of Applicant's application for a full power license. The first document is entitled, "Testimony of John P. Lawler, Ph.D.,Quirk, Lawler and Matusky, Engineers, on Supplemental Study of Effect of Submerged Discharge of Indian Point Cooling Water on Hudson River Temperature Distribution," dated June 19, 1972.

The second document is entitled, "Testimony of John P. Lawler, Ph.D., on Effect of Indian Point Plant on Hudson River Dissolved Oxygen," dated June 19, 1972. I believe the copies have previously been distributed. Dr. Lawler, would you come forward, please?

mil-7

Whereupon,

DR. JOHN P. LAWLER

was recalled as a witness on behalf of the Applicant, and, having been previously duly sworn, was examined and testified further as follows:

xxxx

FURTHER DIRECT EXAMINATION

MR. SACK: Dr. Lawler, were these two documents which I have described -- Dr. Lawler, have you been previously sworn, or need you be sworn again?

Dr. Lawler was previously sworn.

Doctor, were these two documents which I have just described prepared by you or under your supervision and direction?

DR. LAWLER: Yes, both of these documents were done under my supervision.

MR. SACK: Are these two documents true and correct to the best of your knowledge?

DR. LAWLER: Yes, they are.

MR. SACK: Do you desire to have these documents received inevidence in this proceeding?

DR. LAWLER: Yes, I do.

MR. SACK: Mr. Chairman, I now offer the two documents previously identified in evidence inthis proceeding.

CHAIRMAN JENSCH: Is there any objection?

MR. KARMAN: No objection, Mr. Chairman.

mil-8

MR. MACBETH: No objection.

MR. MARTIN: No objection.

CHAIRMAN JENSCH: The request of Applicant's counsel is granted, and the two presentations of testimony identified by Applicant's counsel from witness Lawler, the first of which is entitled, "Supplemental Study of Effect of Submerged Discharge of Indian Point Cooling Water on Hudson River Temperature Distribution," and the second entitled, "Effect of Indian Point Plant on Hudson River Dissolved Oxygen," may be accepted as the testimony of witness Lawler in evidence in behalf of the Applicant, and may be physically incorporated within the transcript as if read. The reporter is directed to incorporate these two statements inthe record.

(The documents follow.)

BEFORE THE UNITED STATES

ATOMIC ENERGY COMMISSION

In the Matter of Consolidated Edison Company of New York, Inc. (Indian Point Station, Unit No. 2)	)))))	Docket No. 50-247

Testimony of
John P. Lawler, Ph.D.,
Quirk, Lawler & Matusky Engineers,
on
Supplemental Study of Effect of Submerged Discharge of Indian Point Cooling Water on Hudson River Temperature Distribution

June 19, 1972

Quirk, Lawler & Matusky Engineers
Environmental Science & Engineering Consultants

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ROBERT A. NORRIS, DIR.
COMPUTER APPLICATIONS

May 8, 1972
File: 115-17

Mr. Alan Cheifetz
Office of Environmental Affairs
Room 1142
Consolidated Edison Company
of New York, Inc.
4 Irving Place
New York, New York 10003

Subject: Indian Point Submerged Discharge - Supplemental Study

Dear Mr. Cheifetz:

Pursuant to your request of May 5, 1972, we are submitting herewith a memorandum report presenting our response to the submerged discharge questions set forth in the May 2, 1972, letter from the AEC to Con Edison.

For convenience of presentation and since most of these questions are interrelated, our answers appear in the order of presentation given in Section III-E-1-g-2 of the "Draft Detailed Statement" of April 13, 1972, prepared by the U.S. AEC, rather than the order given in the May 2, 1972, letter. QL&M's response to these questions is given in a set of six items, as outlined below. For convenience, however, our specific answers to the individual AEC questions are located in the following outline.

QL&M item number and title	AEC Letter Question No.
1. Submerged discharge model and Evaluation parameters	1, 6, 7, 9, 10
2. Expansion of submerged discharge jet boundaries - literature review	2

Letter to: Mr. Alan Cheifetz
Date: May 8, 1972

3.	Sensitivity analysis of jet growth parameters using Indian Point units 1 & 2 discharge conditions	4,6
4.	Relationship between entrainment coefficient and slopes of jet boundaries	2, 3, 6
5.	Distribution of temperature rises over jet cross-sectional area	8, 6
6.	Interference between adjacent jets	5, 6

The theoretical treatment presented in this memorandum report employes a new version of our previously developed submerged discharge model. This version of the model is capable of handling submerged slots as well as ports. Rectangular slots as well as circular ports have been used to evaluate the sensitivity of the model to study input parameters.

Study results have been computed using this model and the final outfall design parameters. In particular, these results take the influence of the revised depth of submergence of 12 feet and the recirculation effects into account.

Computed results for a condition of a maximum ambient temperature, two unit condenser rise and recirculation conditions showed that the maximum surface temperature in the immediate vicinity of the outfall can be expected to be less than the New York State Criterion of 90°F.

We would be pleased to review the report with you if you desire additional discussion.

Very truly yours,

Karim A. Abood
Associate

KAA:gsf
enc. 1

Quirk, Lawler & Matusky Engineers

I. Submerged Discharge Model and Evaluation Parameters*

In 1969, Quirk, Lawler & Matusky Engineers (QL&M) developed and successfully programmed for computer solution a three-dimensional mathematical model describing the behavior of a submerged circular jet in an estuary. Detailed description of this hydraulic phenomenon and formulation of the mathematical model and computer program are given in Reference 1.

Additional development and modification of this model has occurred since 1969.[6] In addition to the improvements discussed in Reference 6, the theoretical analysis has been recently modified to make the mathematical model capable of handling rectangular slots as well as circular ports. This modification permits use of the model to directly describe the behavior of a submerged rectangular slot without having to convert the slot to an equivalent circular port.

Since a program deck is not available at present, we are enclosing a listing of the modified submerged discharge program, used in this study, as an Appendix to this Report.

This model was used to evaluate the expected behavior of the revised Indian Point outfall slots. Details of the revised design are given in Reference 5. For convenience, a brief description of the design is given below.

**Dr. Karel A. Konrad of QL&M performed many of the calculations and investigations reported herein and prepared the original draft of these notes.*

Details of the revised Indian Point outfall system are shown in Figure 1. The system consists of 12 discharge ports with rectangular openings 4 feet high by 15 feet long, spaced 21 feet apart (center to center) discharging horizontally and normal to the river flow, and located 12 feet at centerline of port below the U.S.C. & G.S. sea level datum (1929). Ten of these slots are equipped with fully adjustable gates to insure a submerged jet velocity of 10 fps for any combination of units in operation.

The original 18' depth of submergence was changed to 12' to improve mixing of the effluent with the ambient water and minimize river bottom scour action. Recent hydraulic model tests showed that the revised outfall design produced lower overall temperatures.

As shown in Figure 1, the combined Unit No. 1 & 2 effluent will be discharged through seven of the twelve slots of the three unit outfall.

Indian Point Units 1 & 2 design parameters are summarized in Table 1. As requested by the AEC, Table 2 summarizes the exposure time predictions corresponding to single and combined unit operation. These values have been computed by Consolidated Edison personnel.

The combined operation values correspond to two unit operation at rated capacity. This study employed the rated capacity summertime two unit operation values since the objective of this report is to compare the performance of the outfall with the 90°F criterion. During summer months, when ambient temperatures reach a maximum value, this criterion may control.

The Table values corresponding to cooling water flow reduction are associated with non-summer periods and may occur during some fall and winter months when the river ambient temperature is equal to or less than 50°F. A wintertime plant temperature rise of 25°F would yield maximum surface temperatures of less than 75°F. Therefore, the 90°F criterion is not controlling during such periods.

The controlling criterion during flow reduction periods may be the 67% surface width 4°F criterion. However, evaluation of the effect of two unit operation during wintertime conditions indicates that the 67% criterion will not be contravened. A summary of wintertime predictions is given in Figure 2.

In addition to the two unit rated capacity operation outfall temperature rise, this study takes the recirculation effects into account.

Hydraulic model thermal recycling studies indicate that two unit rated capacity operation may result in recirculation effects ranging from less than 0.1°F to less than 1.2°F, depending upon the prevailing tidal conditions. The tidal average increase in intake temperature rise over the entire water column due to recirculation of heated water will be about 0.75°F. This value has been rounded off to 1°F and used in this study to account for the recirculation effect.

The maximum naturally occurring river water ambient temperature used in this evaluation is 79°F. This value is considered to be the highest water temperature that can be experienced by the Indian Point intake at any time. Review of available Hudson River channel temperature data given in Reference 6 shows that this maximum temperature of 79°F in the Hudson River is reached around mid-August of certain years. Ambient temperature does not reach this value every year. For example, the maximum ambient water temperature observed in the vicinity of Indian Point in 1969 occurred on two days in August and was 77.6°F. Available temperature measurements, depicted in Figure 3, over a ten year period from 1956 through 1965 show that the 79°F monthly average is reached only once in eight years. The values shown in Figure 3 are based on temperature measurements of intake cooling water at Lovett. Although these temperatures may be somewhat high because of recirculation of effluent cooling water, they represent the most extensive survey of ambient river temperatures for the Indian Point-Lovett area. These measurements were grouped into monthly averages and statistically analyzed for the August months.

Data subsequent to 1965 were not included in the analysis because they represent a significantly greater degree of heat recirculation as a result of the Lovett Unit No. 4 being operational.

Figure 4 depicts the ambient temperature seasonal variation at Indian Point for the meteorological conditions of 1964. This Figure indicates that the maximum ambient temperature in this area was less than 79°F in 1964.

Several Hudson River temperature profiles and additional support of the 79°F value are given in Reference 6.

Section III-E-1-g-2 of the Draft Detailed AEC Statement and the AEC May 2, 1971 letter to Consolidated Edison refer to the 81°F August ambient temperature reported by New York University.

As explained during our several meetings with the AEC personnel, these NYU measurements were conducted in conjunction with a biological survey of the River and reflect the effect of recirculation due to Unit No. 1 operation. Biological surveys usually employ conventional temperature instruments rather than precision thermometers (since the major objective was the biological activity rather than temperature distribution, per se) using Centigrade rather than Fahrenheit units (a 10% error in °C is equivalent to about 20% error in °F). Moreover, the maximum ambient temperature measured by NYU in the Indian Point vicinity (east bank of the Hudson River) averaged 26.75°C or about 80°F rather than 81°F.

The 79°F value, used in this study, is based upon the above mentioned observations, does not include any recirculation effects (since these are treated separately in this study) and is indicative of overall intake water column rather than shore or surface conditions.

II. Expansion of Submerged Discharge Jet Boundaries - Literature Review

The previously developed Quirk, Lawler & Matusky Engineers' submerged discharge mathematical model utilizes jet boundary slopes (C_1 & C_2) to account for plume growth within the zones of flow establishment (initial zone) and established flow. Numerical values employed in Reference 1 are given below.

	Circular Port	Slot
Zone of flow establishment, C_1	0.16	0.15
Zone of established flow, C_2	0.20	0.25

As indicated in Reference 1, the length of the initial zone has been defined as 6.2 x D_o (initial jet diameter), for a circular jet, and as 5.3 x W_o (initial jet width), for a rectangular jet. A definition diagram of both zones is given in Figure 5.

A comprehensive literature review of reported observations of the slopes of expanding jets is given in T.R. Camp's "Water and Its Impurities" (2) on pages 238 and-239. For convenience, a sample of these observations is reproduced below.

Albertson and co-workers* found that the boundary of the expanding

* *Albertson, M.L., Dai, Y.B., Jensen, R.A. and Rose, Hunter, Trans. Am. Soc. Civil Engrs., 115, 630 (1950).*

jet from a circular orifice diverged at a slope of approximately 1 to 5 (or a slope of 0.2) from the centerline.

Tallmien, working with air, found that the boundary diverged at a slope of 1 to 3.92 (or a slope of 0.25). Rice working with freswater in salt water, with differences in specific gravity ranging from 0.01 to 0.035, found that the boundary diverged at a slope of 1 to 4.8 (or a slope of less than 0.21).

According to Person*, Folsom and Ferguson, who worked with gasoline, the boundary of the expanding jet diverged at a slope of 1:4.31 (or a slope of 0.23).

Rawn and Palmer, in experiments with freshwater jets in sea water, found that the boundary of the expanding jet diverged at a slope of 1 over 6 to 8 (or slopes of 0.17 to 0.13, respectively).

One of the best known investigators in the field of turbulent jets, G.N. Abramovich, has presented an analysis of spread of a turbulent submerged jet and its geometric features in his text, The Theory of Turbulent Jets.[3] On pages 505 through 509 of this publication, Abramovich reports a jet boundary slope of 0.158, for the initial zone, and of 0.22 for the zone of established flow. The length of the initial zone used in Reference 3 is equivalent to nine initial radii.

* *Person, E.A. "An Investigation of the Efficacy of Submarine Outfall Disposal of Sewage and Sludge," Publication No. 14, State Water Pollution Control Board, Sacremento, California, 1956.*

Lohn-Nien Fan[4] employes an initial zone lenth of 6.2 diameters for a nozzle (in referencing Albertson's results).

The brief literature review indicates that the slopes of jet boundaries, incorporated in the QL&M mathematical model agree very well with those observed and reported by many investigators.

III. Sensitivity Analysis of Jet Growth Parameters Using Indian Point Discharge Conditions

A. Circular Jets

In order to determine the effect of boundary slope on jet characteristics within the initial zone three computer runs* were conducted using QL&M submerged discharge model and initial jet slopes (C_1) of 0.10, 0.16 and 0.25.

Table 3 and Figure 6 summarize the variation in jet flow, velocity and dilution ratio corresponding to these three slopes. As to be expected, the results indicated that a higher slope of boundary results in a higher jet flow and dilution ratio and a lower average velocity. The differences between the jet characteristics increase with increasing distance from the outfall.

Effects of the jet boundary slope within the zone of established flow (C_2) was evaluated by using three C_2 values (0.15, 0.20, 0.30), while keeping slope C_1 and length of the initial zone (S_2) constant.

Table 4 and Figure 7 depict the variation of jet flow, velocity and dilution ratio with jet path distance, for C_1 = 0.16 S_2 = 6.2 D_o and C_2 = 0.15, 0.20 and 0.30.

Study results indicate that the effect of slope C_2 is similar to that of C_1, i.e., a higher slope C_2 results in a higher jet flow and dilution ratio and a lower jet velocity.

* *All computer runs reported herein and after were conducted for water slack conditions.*

The effect of length of the jet initial zone (or zone of establishment) is shown in Table 5. This table summarizes the influence of three initial zone lengths (4.0 D_o, 6.2 D_o, and 8.0 D_o) on jet flow, velocity and dilution ratio. Jet boundary slopes were kept constant during these runs. C_1 and C_2 values of 0.16 and 0.20 were used for this purpose.

As to be expected, the above presented results of the sensitivity runs indicate that the slopes, C_1 and C_2 of the jet boundaries significantly affect the jet growth characteristics. The jet characteristics are less sensitive to changes in length of the initial zone.

The main objective of this sensitivity analysis, however, is to determine variation of dilution ratios and subsequently average temperature rises at controlling jet critical sections, described in Reference 1, i.e., upper boundary, interference, lower boundary or centerline controls.

These jet controls have been defined, in Reference 1, as locations where the jet boundary interferes with boundaries of receiving water body (such as water surface, river bottom, etc.) or with the adjacent jet boundary. The control resulting in the lowest value of dilution ratio, i.e., the highest temperature rise, has been defined as the critical control.

In all sensitivity runs, reported in this study and including rectangular jet runs conducted for the revised outfall design, the critical control was the location where the upper boundary reaches the water surface.

Table 6 summarizes dilution ratios and average temperature rises at the critical controls for jets with different boundary slopes and different lengths of the initial zone. Although the variable coefficients spanned large intervals, the variation in dilution ratio and average temperature rise was small. The difference between the highest and lowest calculated temperature rises was about 1°F.

According to the literature survey presented in Item I, the uncertainties in determination of the coefficients C_1, C_2 and S_2 could be expressed by smaller intervals of these coefficients than those used for the above reported sensitivity analyses. It is concluded, therefore, that these uncertainties have an insignificant effect as far as the average jet temperature rise at the critical control is concerned. This value is the major objective of the submerged discharge model analysis.

B. Rectangular Jet Sensitivity Analysis and Comparison with Equivalent Circular Jets

The length of the initial zone of submerged jets used in the QL&M model has been taken as 5.3 times the initial width of the jet. This relationship has given results similar to those used for circular jets.

QL&M had used the jet initial width rather than height for determination of the initial zone of a rectangular jet. This assumption is conservative, i.e., yields lower dilution ratios.

We agree with the AEC's statement and question No. 3 in the May 2, 1972, letter that the jet height instead of width is more applicable for determination of the initial zone of the Indian Point jets.

Table 7 summarizes and compares computed jet flow, velocity and dilution ratio for two jets having initial zone lengths determined using 5.3 widths (5.3 W_o) and 5.3 heights (5.3 H_o) respectively. In both cases, boundary slopes were kept the same, i.e., $C_1 = 0.15$, $C_2 = 0.25$. The differences between calculated values of study variables are given in Table 7.

Table 8 compares dilution ratios and average temperature rises at the critical control of the two rectangular jets with three circular jets having different initial zone lengths. The table indicates that the dilution ratios at the critical controls are higher for rectangular jets (3.4 and 3.8) than those for circular jets (2.8, 2.8 and 2.9) and that the dilution ratio at the critical control of the rectangular jet is higher if the jet initial zone length is calculated using the jet initial height instead of width.

IV. Relationship Between Entrainment Coefficient and Slopes of Jet Boundaries

The concept of the entrainment coefficient, as defined in the following expression, has been introduced by several authors :

$$\frac{dQ}{ds} = 2\pi b\alpha u \qquad \text{...(1)}$$

in which:

Q = jet flow

s = distance measured along the jet centerline

b = characteristic length

u = characteristic velocity (usually centerline velocity)

The characteristic length, b, is determined using jet velocity profiles. Approximation of jet velocity profiles by a Gaussian function:

$$u(r) = u_c e^{\frac{r^2}{b^2}} \qquad \text{...(2)}$$

yields a characteristic length determined by the following equation:

$$\sqrt{2b} = (2\sigma) = R \qquad \text{...(3)}$$

in which, R is assumed to be nominal radius of the jet.

Some of the investigators* prefer use of slopes of jet boundaries rather than entrainment coefficients because these slopes are directly observable during physical experiments and also because the concept of entrainment coefficient requires predetermination of the type of velocity distribution.

Furthermore, the type of velocity distribution within the initial zone is not stable and may not be represented by a Gaussian function. The definition of the entrainment coefficient given in Equation 1 is not clear in this region. If the entrainment coefficient α is to be used in this region then Equation 1 should be changed to:

$$\frac{dQ}{ds} = 2\pi R \alpha u_o \qquad \ldots(4)$$

in which:

R = radius of the jet

u_o = initial jet velocity ($u_c = u_o$ = const. throughout the initial region)

The entrainment coefficients corresponding to the study jets may be determined by using computer printout of variables for finite segments of a jet. This is described below.

Use of finite jet segments within the flow establishment zone requires the following modification to Equation 4.

* *For example, Abramovich does not introduce the entrainment coefficient at all.*

$$\alpha = \frac{\Delta Q}{2\pi R^* u_o \Delta S}$$

...(5)

in which:

R^* = average radius in a given segment

Similarly, for the zone of established flow, Equation 1 becomes:

$$\alpha = \frac{\Delta Q}{2\pi b^* u_c^* \Delta S}$$

...(6)

in which:

b^* = average characteristic length in a given segment $\left(b^* = \frac{R^*}{\sqrt{2}}\right)$

u_c^* = average centerline velocity in the segment. Variation in the centerline velocity within a segment (10 ft. segments have been used in this study) is assumed to be linear.

Because the velocity distribution is assumed to follow a Gaussian function, it can be shown that the relationship between the centerline velocity and cross-sectional velocity is given by:

$$u_c = 3.27\overline{u}$$

Calculation of entrainment coefficients within the initial zone of a circular jet are shown in Table 9 for boundary slopes C_1 = 0.10, 0.16 and 0.25. The table indicates that the values of the entrainment coefficient decrease with increasing distance from the discharge port and that the entrainment coefficients generally are higher for a higher slope of jet boundary.

Calculation of entrainment coefficients within the zone of established flow for a circular jet ($C_1 = 0.16$, $C_2 = 0.20$, $S_2 = 6.2\ D_o$) is shown in Table 10. The table shows the variation in the entrainment coefficient along the path of the jet.

Figure 8 depicts variation in the entrainment coefficient along the path of a circular jet ($C_1 = 0.10$, $C_2 = 0.16$, $S_2 = 6.2\ D$). The values of the entrainment coefficient shown in this figure correspond to QL&M's basic coefficients, C_1, C_2 and S_2. All of these entrainment coefficient values are lower than the value of 0.082 reported in the literature[4] as representing an entrainment coefficient for buoyant jets. Therefore, the QL&M model gives somewhat more conservative results than those corresponding to reported values of entrainment coefficients.

V. Distribution of Temperature Rises over Jet Cross-sectional Area

Most mathematical models of submerged jets do not determine the cross-sectional area distribution of velocity and temperature. These distributions are approximated by some functions which more or less fit observed data.

Many authors have used a Gaussian function to simulate velocity distribution and some of them have assumed similarity between velocity and temperature distributions.

However, many observations indicate quite different shapes of these two distributions as can be seen for example, on three graphs reproduced in Figure 9 from The Theory of Turbulent Jets, by G.N. Abramovich.[3] These three figures indicate that the observed temperature distribution values follow a cosine, rather than a Gaussian, function. Such a cosine function (shown on these figures) can have a form similar to:*

$$\frac{\Delta T}{\Delta T_m} = 0.2 + 0.8 \cos \frac{Y}{Y_c} \frac{\pi}{4} \qquad \ldots(7)$$

* *The equation for calculation of maximum surface temperature rise used in Reference 1 is:*

$$\Delta T_m = 3.0 + (\Delta T_{avg} - 3.0) \cos \frac{\pi \bar{d}}{D/2} \qquad \ldots(10)$$

This function represents an empirical approach. QL&M mathematical model was applied to the Lovett Unit #4 and Indian Point Hydraulic model submerged discharges to calculate the average temperature rises at the critical controls. Equation 10 was derived in an attempt to covert computed average temperature rises over jet corss-sectional area to the surface temperature distributions observed at Lovett Unit #4 and on the Indian Point hydraulic model.

in which,

ΔT = temperature rise above the ambient temperature at the distance Y from the jet centerline

ΔT_m = maximum temperature rise at given section (at the centerline)

Y = distance between given point and centerline of jet

Y_c = distance at which the velocity is equal to 0.5 V_m

If we assume that the boundary of the jet is located at $Y = 2Y_c$ (this is a reasonable assumption considering that the velocity at this location is about 0.05 V max), then the average temperature over the jet cross-sectional area can be expressed as a fraction of ΔT_m in the following manner:

<u>For a Circular Jet</u>:

$$\frac{\Delta T_{avg}}{\Delta T_m} = \frac{\int_0^{2\pi}\int_0^{2} [0.2 + 0.8 \cos (Y^* \frac{\pi}{4})] \, dY^* d\theta}{\int_0^{2\pi}\int_0^{2} Y^* \, dY^* d\theta}$$

Where $Y^* = \frac{Y}{Y_c}$

$$\frac{\Delta T_{avg}}{\Delta T_m} = \frac{1}{4\pi}\int_0^{2\pi}\int_0^{2} [0.2 + 0.8 \cos (Y^* \frac{\pi}{4})] \, dY^* d\theta$$

$$\frac{\Delta T_{avg}}{\Delta T_m} = \frac{1}{4\pi} (0.2 \times 4\pi + 0.744 \times 2\pi) = 0.572$$

From this equation we can express the maximum temperature rise as a function of jet cross-sectional average temperature rise in the following equation:

$$\Delta T_m = \frac{\Delta T_{avg}}{0.572} = 1.75 \, \Delta T_{avg} \qquad \ldots(8)$$

For a Rectangular Jet:

If we assume similarity between the temperature distributions in both directions, then the dimensionless cross-sectional average temperature rise will be:

$$\frac{\Delta T_{avg}}{\Delta T_m} = \frac{\int_0^2 \int_0^2 [0.2 + 0.8 \cos (Y^* \frac{\pi}{4}) \cos (Z^* \frac{\pi}{4})] \, Y^* dY^* dZ^*}{\int_0^2 \int_0^2 dY^* dZ^*}$$

Where: $Z^* = \frac{Z}{Z_c}$

Z and Z_c are defined in a manner similar to Y and Y_c.

$$\frac{\Delta T_{avg}}{\Delta T_m} = \frac{1}{4} \left\{ 4 \times 0.2 + 0.8 \int_0^2 \int_0^2 [\cos (Y^* \frac{\pi}{4}) \cos (Z^* \frac{\pi}{4})] dY^* dZ^* \right\}$$

$$\frac{\Delta T_{avg}}{\Delta T_m} = \frac{1}{4} \left(4 \times 0.2 + 0.8 \frac{16}{\pi^2}\right) = 0.524$$

Maximum temperature rise can be expressed as a function of jet average temperature rise as follows:

$$\Delta T_m = \frac{\Delta T_{avg}}{0.524} = 1.91 \, \Delta T_{avg} \qquad \ldots(9)$$

Applying equations 8 and 9 at the critical control sections of the study jets, the maximum temperature rises corresponding to these sections are as indicated in the following tabulation:

Description of Jet	Avg. Temp. Rise at the Upper Boundary Control (3) °F	Max. Temp. Rise at the Upper Boundary Control (Eq. 8 & 9) °F	Max. Temp. Rise at the Upper Boundary Control Including Effect of Recirculation °F
Circular $C_1=0.16$, $C_2=0.20$, $S_2=6.2D_o$	5.30	9.3	10.3
Rectangular $C_1=0.15$, $C_2=0.25$, $S_2=5.3H_o$	3.90	7.5	8.5

Notes: 1. H_o is initial height of discharge slot.

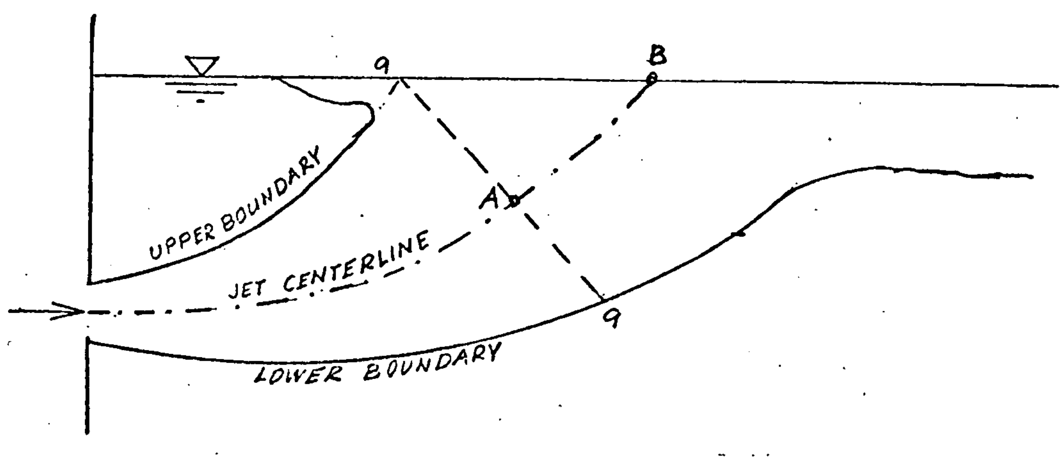
2. Average temperature rises were calculated using plant temperature rise of 14.8°F. An additional 1°F was added to final results, i.e., maximum surface temperature rises, to account for recirculation. This is tantamount to adding 1°F X dilution ratio to the plant temperature rise.

3. The values of average temperature rises taken from Table 8.

4. The upper boundary control is the critical control.

Once the upper boundary reaches the surface, entrainment of ambient water into the jet is limited to the lower boundary and partially to the sides of the jet and the velocity and temperature distribution are distorted. A mathematical determination of the jet behavior after jet interference with the surface is beyond the present knowledge of art.

The maximum temperature rise at the upper boundary control (section a-a in the schematic diagram below) shown in the tabulation above occurs at point A.



The temperature of water particles at location "A" will be decreased as those particles move upward to the surface (Location

"B") by additional dilution of the jet water by ambient water. Because of uncertainties in determination of such additional dilution, the maximum temperature rise at the upper boundary control is used, in this study, as a conservative estimate of the maximum surface temperature rise.

Therefore, the maximum surface temperature rise at Indian Point during rated operation of Units #1 and #2 is estimated to be approximately 8.5°F(see the tabulation above - rectangular jet). This maximum surface temperature rise agrees very well with the previously reported results.[5]

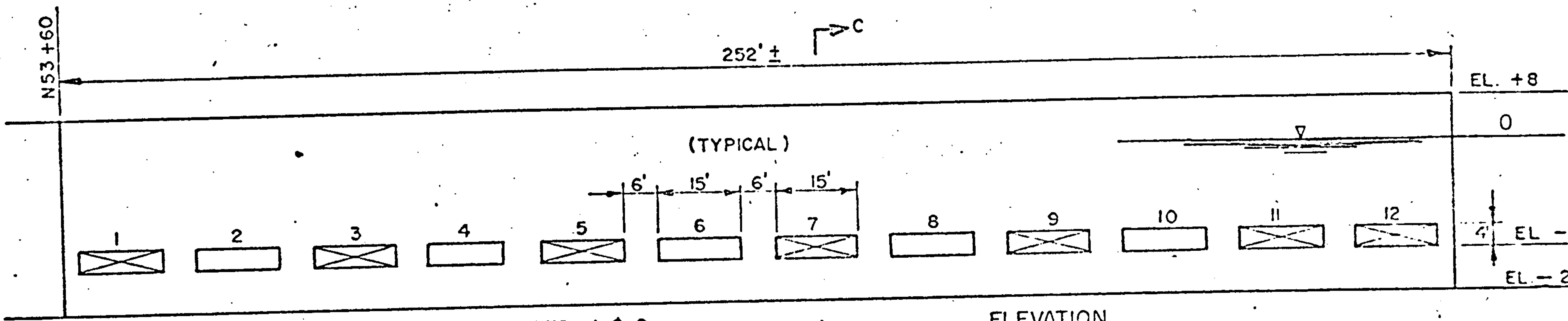
VI. Interference Between Adjacent Jets

As shown on Figure 1, full flow operation of Units 1 & 2 will require 7 of the 12 submerged slots. The outfall two unit operation arrangement depicted in Figure 1 provides a spacing of 42 feet between the centerlines of the jets.

The interference between jets will occur, wherever the jet widths reach 42 ft. In all computer runs made for the sensitivity analyses, the interference between jets occured at a greater distance from the discharge than that where the upper boundary reached the surface. Because the maximum temperature rise at the upper boundary control was shown to be the maximum surface temperature rise, the interference control value not controlling in 6 out of 7 jets (jets no. 1, 3, 5, 7, 9 and 11 of Figure 1).

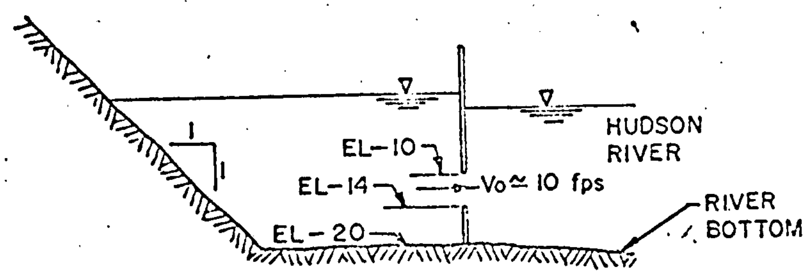
More interference will occur between the last two jets (no. 11 & 12), since these two slots may be employed. In this case, interference between these jets may occur at a distance of about 20 feet from the discharge slots, where the dilution ratio is about 2.1 and the average temperature rise is 7.5°F. For this case, Equation 9 gives a maximum temperature rise of 14.3°F. However, use of this temperature as the maximum surface temperature rise is extremely conservative and somewhat unrealistic. This temperature occurs at a depth of 11.7 ft. and the additional path of water particles before they reach the surface is about 50 ft. The additional entrained water, along the 50 foot path of the jet, will result in additional temperature rise reduction.

DETAILS OF INDIAN POINT UNITS 1 & 2 DISCHARGE STRUCTURE



NOTE : FOR DISCHARGE FROM UNITS 1 & 2, PORT NUMBERS 2, 4, 6, 8, 10 WILL BE BLOCKED

ELEVATION
(LOOKING S-E)



AS SECTION C-C
(REVISED DESIGN)

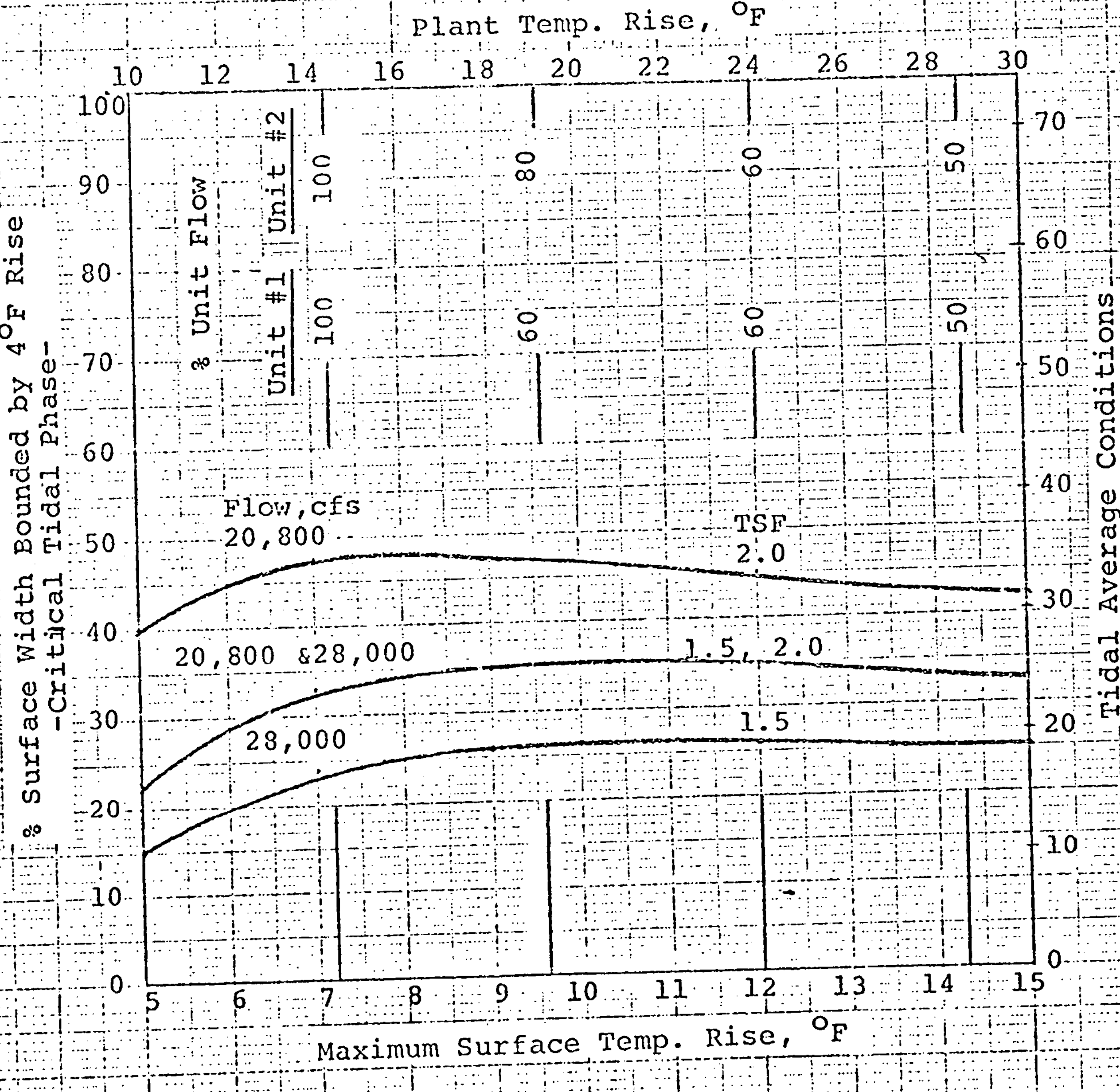
FIGURE 1

SURFACE WIDTH AT INDIAN POINT

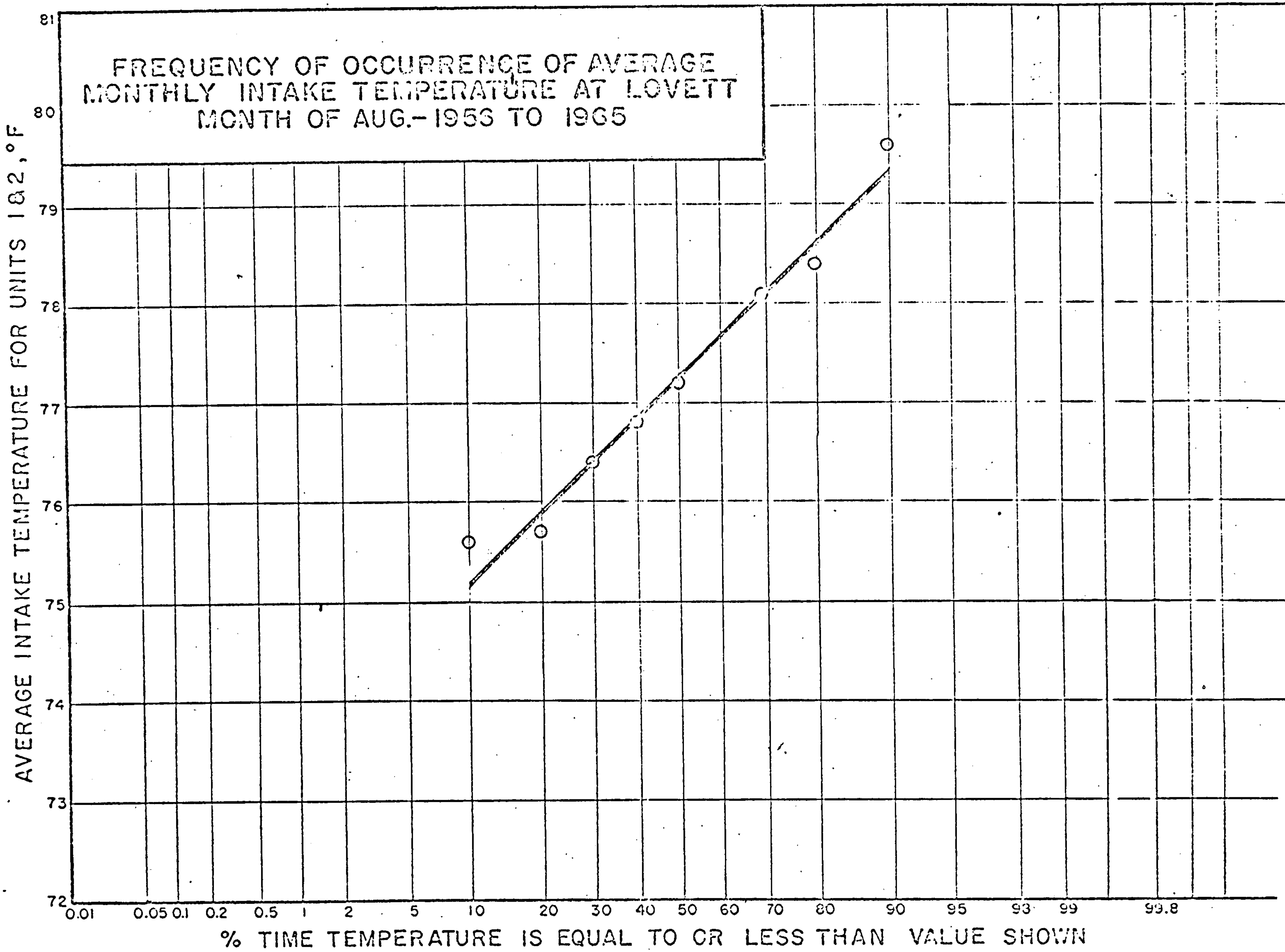
PLANE OF DISCHARGE SUBJECTED TO

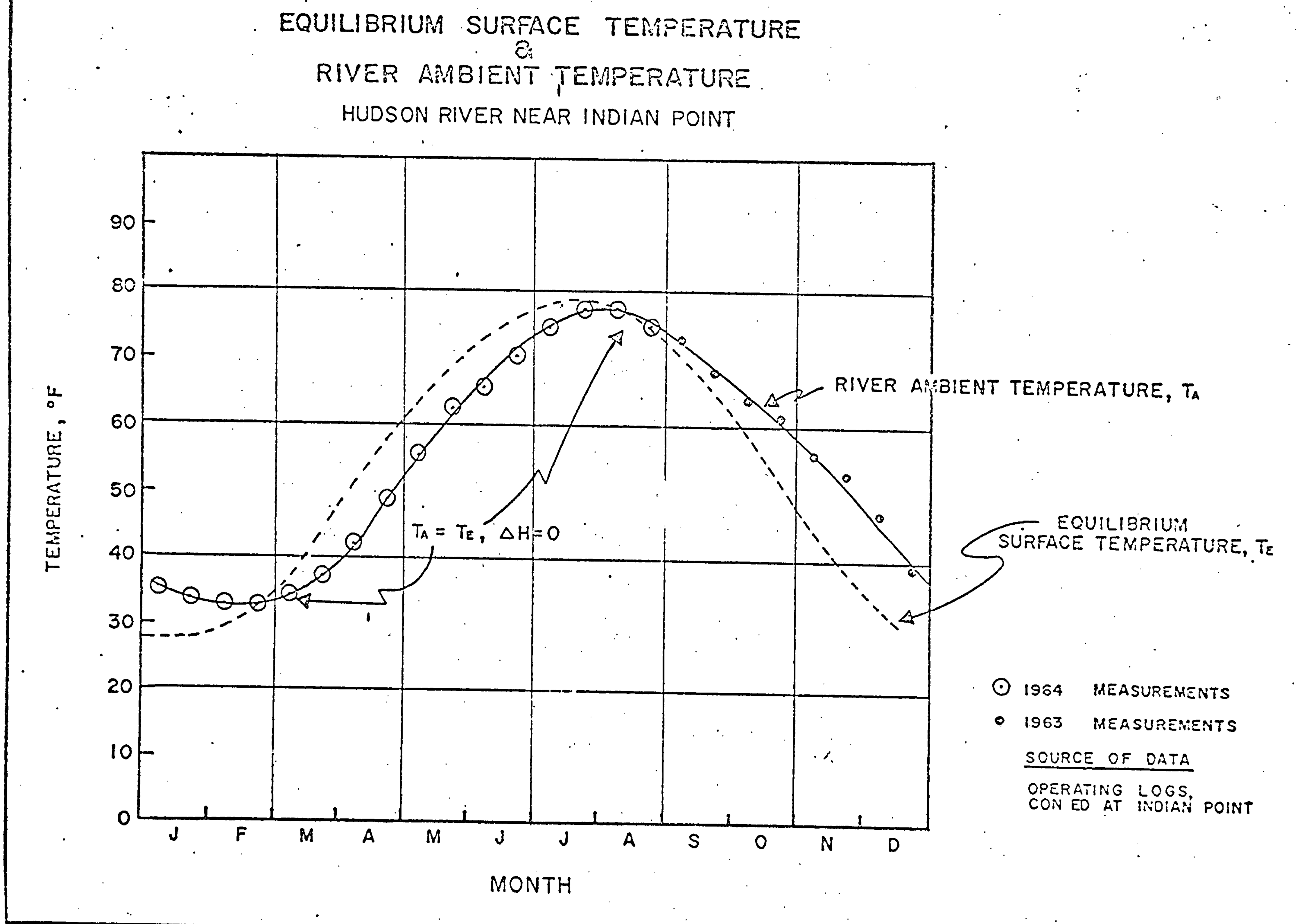
TEMPERATURE RISES IN EXCESS OF 4°F

-RATED CAPACITY OPERATION OF INDIAN PT. UNITS 1&2 AND LOVETT UNITS 1-5-



$\overline{K}$=90 BTU/ft^2 day °F
E= 6 smd
Dilution Ratio=1:2


FREQUENCY OF OCCURRENCE OF AVERAGE
MONTHLY INTAKE TEMPERATURE AT LOVETT
MONTH OF AUG.-1953 TO 1965
AVERAGE INTAKE TEMPERATURE FOR UNITS 1&2, °F
81
80
79
78
77
76
75
74
73
72
0.01
0.05 0.1
0.2
0.5
1
2
5
10
20
30
40
50
60
70
80
90
95
98
99
99.8
% TIME TEMPERATURE IS EQUAL TO OR LESS THAN VALUE SHOWN


EQUILIBRIUM SURFACE TEMPERATURE
&
RIVER AMBIENT TEMPERATURE
HUDSON RIVER NEAR INDIAN POINT
TEMPERATURE, °F
90
80
70
60
50
40
30
20
10
0
J
F
M
A
M
J
J
A
S
O
N
D
MONTH
RIVER AMBIENT TEMPERATURE, TA
EQUILIBRIUM SURFACE TEMPERATURE, TE
TA = TE, ΔH = O
1964 MEASUREMENTS
1963 MEASUREMENTS
SOURCE OF DATA
OPERATING LOGS, CON ED AT INDIAN POINT

DEFINITION SKETCH OF
ZONE OF FLOW ESTABLISHMENT AND
ZONE OF ESTABLISHED FLOW

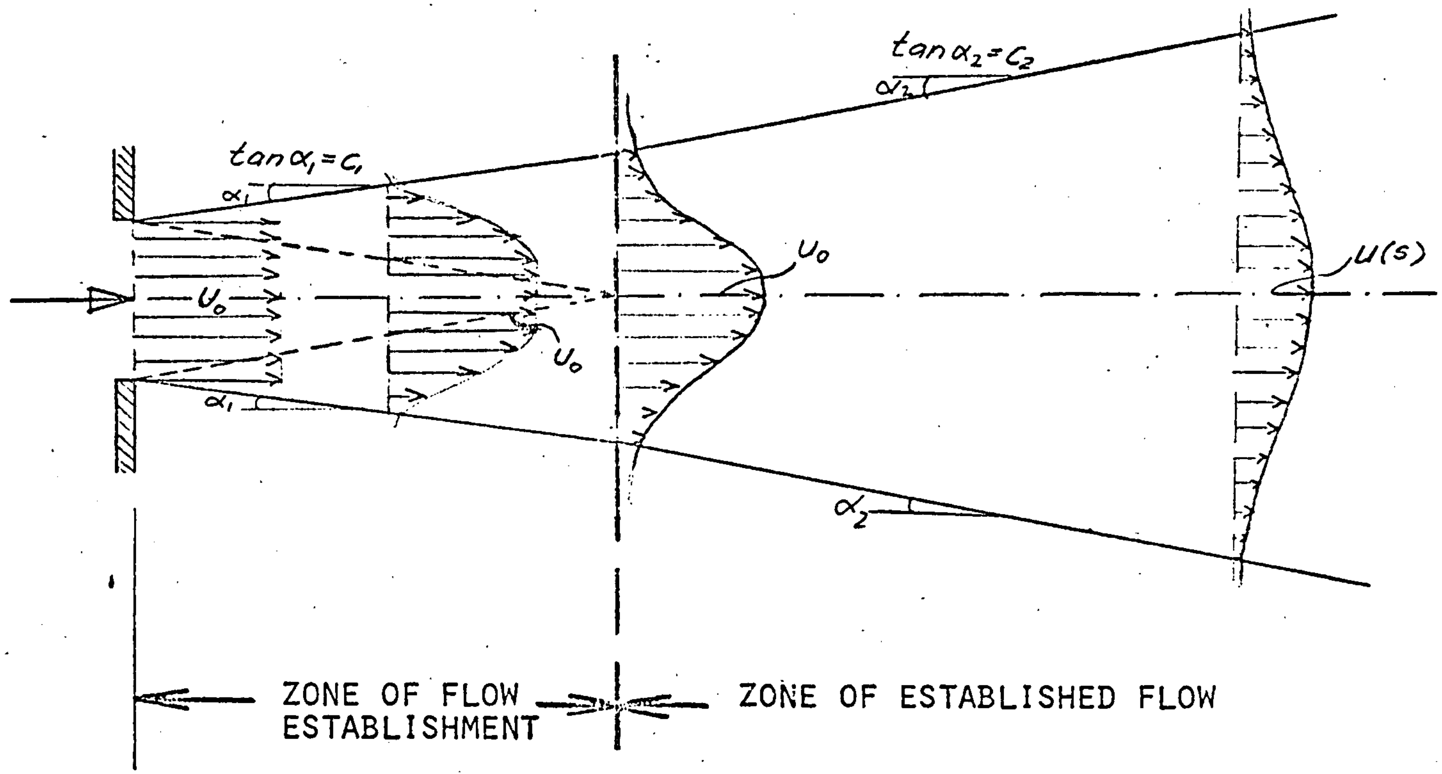
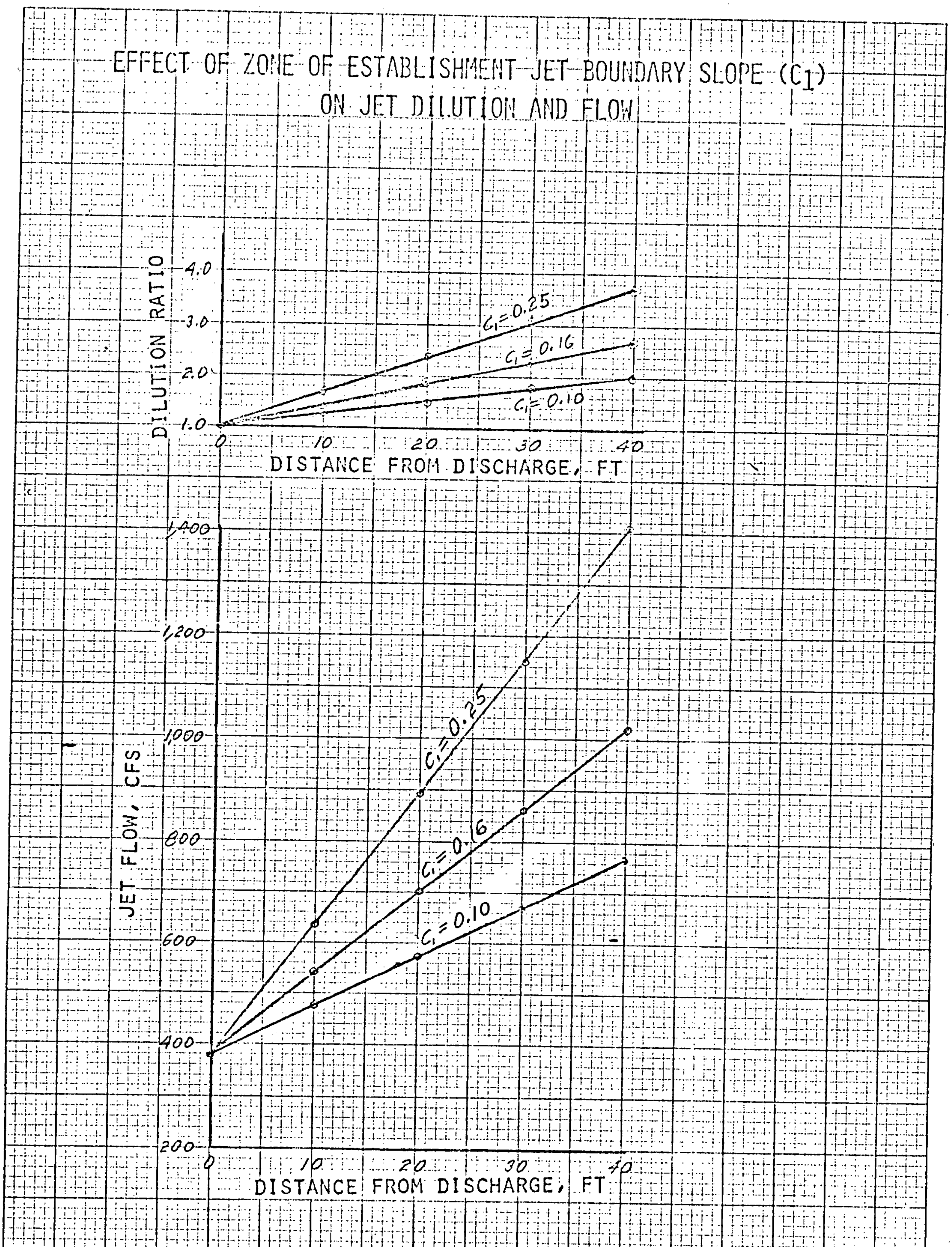


FIGURE 5

FIGURE 6


EFFECT OF ZONE OF ESTABLISHMENT JET BOUNDARY SLOPE (C1)
ON JET DILUTION AND FLOW
DILUTION RATIO
4.0
3.0
2.0
1.0
C1 = 0.25
C1 = 0.16
C1 = 0.10
0
10
20
30
40
DISTANCE FROM DISCHARGE, FT
JET FLOW, CFS
1,400
1,200
1,000
800
600
400
200
C1 = 0.25
C1 = 0.16
C1 = 0.10
0
10
20
30
40
DISTANCE FROM DISCHARGE, FT

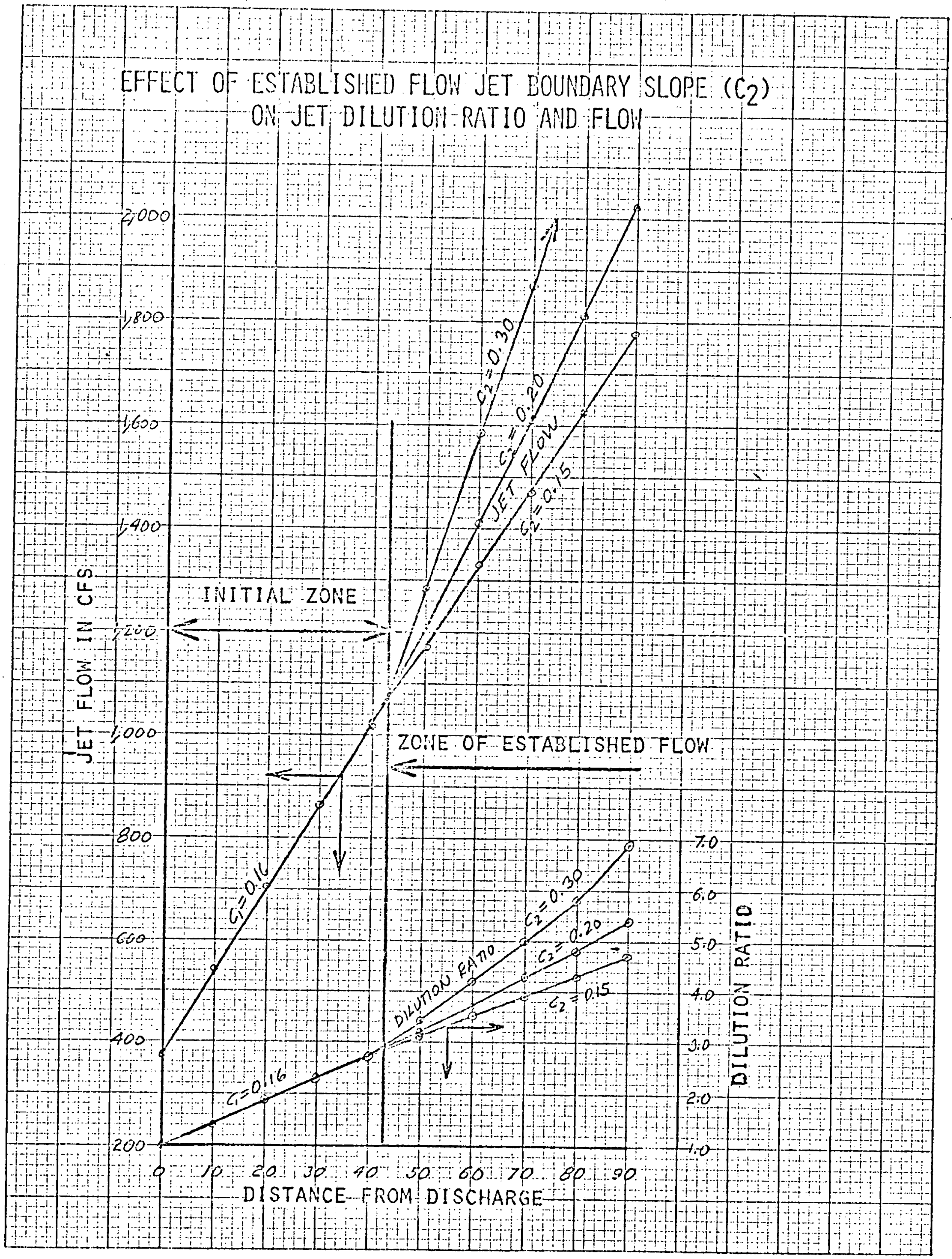
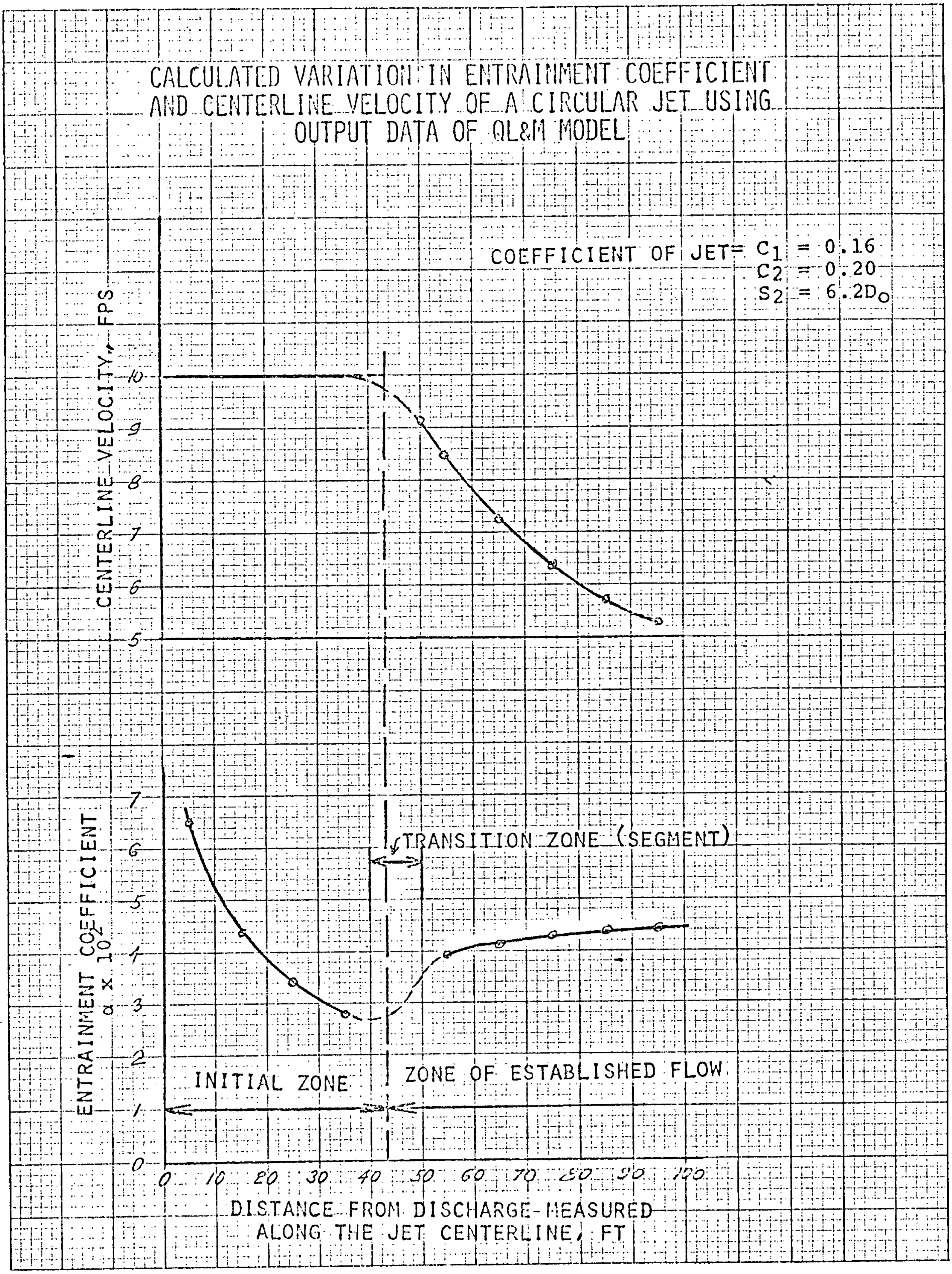

EFFECT OF ESTABLISHED FLOW JET BOUNDARY SLOPE (C_2)
ON JET DILUTION RATIO AND FLOW
JET FLOW IN CFS
2,000
1,800
1,600
1,400
1,200
1,000
800
600
400
200
INITIAL ZONE
ZONE OF ESTABLISHED FLOW
JET FLOW
C_2=0.30
C_2=0.20
C_2=0.15
C_1=0.16
DILUTION RATIO
C_2=0.30
C_2=0.20
C_2=0.15
C_1=0.16
7.0
6.0
5.0
4.0
3.0
2.0
1.0
DILUTION RATIO
0
10
20
30
40
50
60
70
80
90
DISTANCE FROM DISCHARGE

FIGURE 8



CALCULATED VARIATION IN ENTRAINMENT COEFFICIENT AND CENTERLINE VELOCITY OF A CIRCULAR JET USING OUTPUT DATA OF QL&M MODEL
COEFFICIENT OF JET= C1 = 0.16
C2 = 0.20
S2 = 6.2Do
CENTERLINE VELOCITY, FPS
10
9
8
7
6
5
ENTRAINMENT COEFFICIENT α x 10^2
7
6
5
4
3
2
1
0
TRANSITION ZONE (SEGMENT)
INITIAL ZONE
ZONE OF ESTABLISHED FLOW
0
10
20
30
40
50
60
70
80
90
100
DISTANCE FROM DISCHARGE-MEASURED ALONG THE JET CENTERLINE, FT

APPROXIMATION OF TEMPERATURE RISE DISTRIBUTION OVER JET CROSS SECTION BY A COSINE FUNCTION

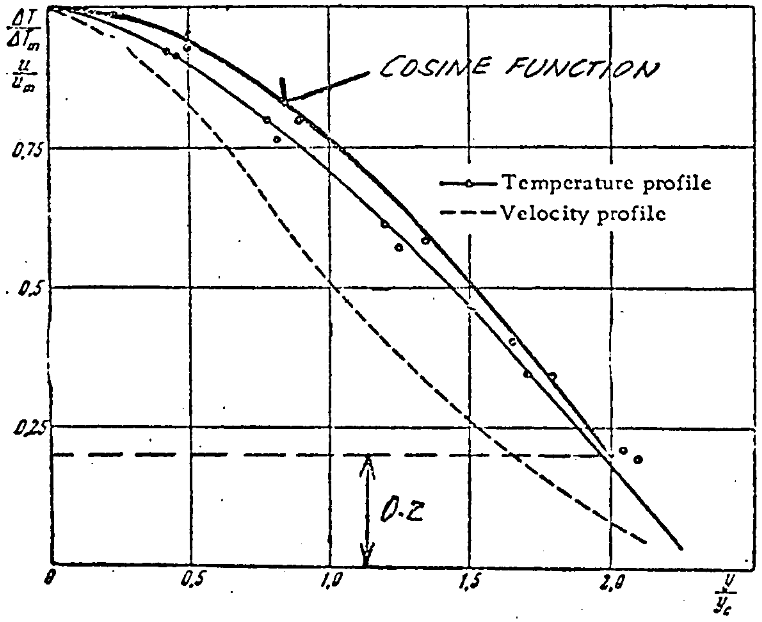


Fig. 1.16. Dimensionless temperature differences and velocity profiles in main region of axially symmetric jet according to Stark's data [11].

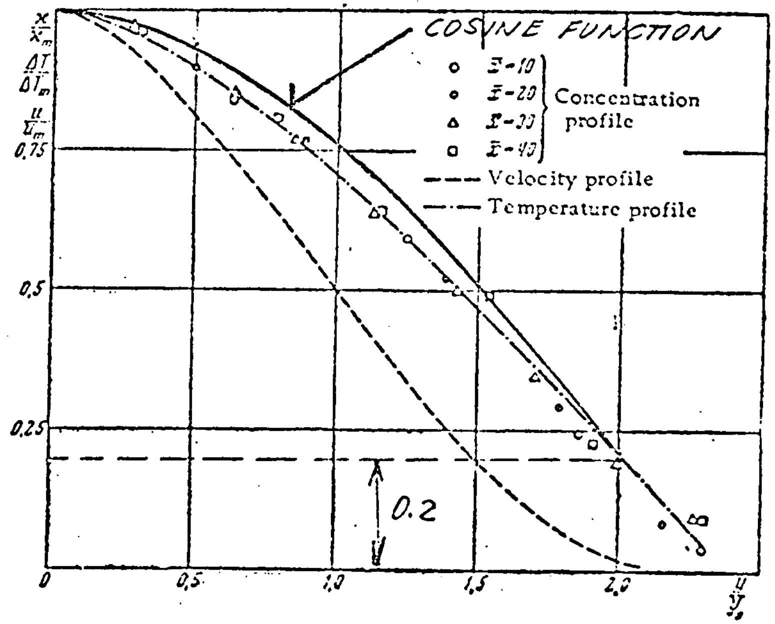


Fig. 1.17. Dimensionless profiles for temperature difference, concentration of admixture and velocity in main region of plane jet from data given by Abramovich and Borodachev ($\bar{x}=x/b_0$).

Note:

These figures were taken from Abramovich's text (Reference 3). The cosine function solid curves were computed using Equation 7 of this memo.

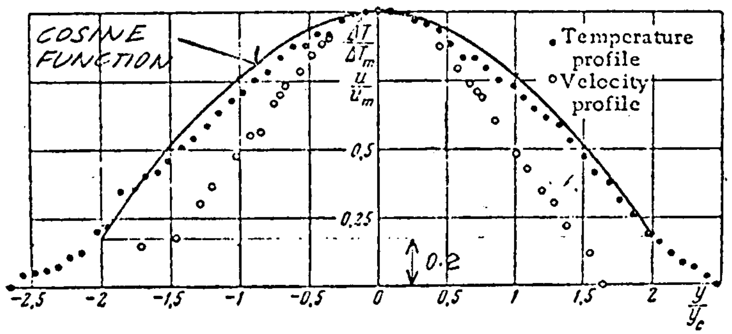


Fig. 1.15. Dimensionless temperature and velocity profiles in main region of plane jet according to Reichardt's experimental data [10].

FIGURE 9

TABLE 3

EFFECT OF JET BOUNDARY
SLOPE (C_1) ON JET FLOW
VELOCITY AND DILUTION RATIO
WITHIN THE INITIAL ZONE

Distance from port along the Jet ℄, ft	C_1 = 0.10			C_1 = 0.16			C_1 = 0.25		
	Flow cfs	Velocity fps	Dil. ratio	Flow cfs	Velocity fps	Dil. ratio	Flow cfs	Velocity fps	Dil. ratio
0*	378.0	10.0	1.0	378.0	10.0	1.0	378.0	10.0	1.0
10	477.5	7.6	1.3	542.1	6.7	1.4	638.9	5.7	1.7
20	575.4	6.1	1.5	703.8	5.0	1.9	896.6	4.0	2.4
30	672.1	4.4	1.8	863.9	4.0	2.3	1152.4	3.0	3.1
40	767.8	3.7	2.0	1023.0	3.3	2.7	1407.5	2.5	3.7

* *Vena contracta*

TABLE 2

INDIAN POINT UNITS 1 & 2 EXPOSURE TIME CALCULATIONS*

Assumptions

1. MHW Condition = EL 2.2'
2. Head @ Discharge Port = 3.5'
3. Neglect Head Loss Gradient Up to the Canal (Balanced by Flow From Aux. Pumps)
4. Organism Is Discharged at Extreme Southern Port (Low Flow Conditions) or in Mid-Section of the Outfall (Normal Flow Conditions)
5. Unit 2 Low Flow = 3 Pumps @ 60% Flow
   Unit 1 Low Flow = 60% of 140,000 gpm

		Single Unit Operation		Two Unit Operation	
Flow Condition	Unit No.	Flow, gpm	Exposure time, min.	Flow, gpm	Exposure time, min.
Normal	1	280,000	39	1,120,000	9.5
Normal	2	840,000	14	1,120,000	11
Low (winter)	1	84,000	140	336,000	35
Low (winter)	2	252,000	54	336,000	40

*Computed by Con Edison Personnel

TABLE 4

EFFECT OF JET BOUNDARY SLOPE (C_2)
ON JET FLOW, VELOCITY AND DILUTION
RATIO WITHIN THE ZONE OF ESTABLISHED FLOW

Conditions: Slope of the jet boundary within the initial zone $C_1 = 0.16$

Length of initial zone $S_2 = 6.2\ D_o$

Distance from port along the Jet ℄, ft	$C_2 = 0.15$			$C_2 = 0.20$			$C_2 = 0.30$		
	Flow cfs	Velocity fps	Dilution Ratio	Flow cfs	Velocity fps	Dilution Ratio	Flow cfs	Velocity fps	Dilution Ratio
40	1023.0	3.3	2.7	1023.0	3.3	2.7	1023.0	3.3	2.7
50	1174.0	2.9	3.1	1210.6	2.8	3.2	1282.0	2.6	3.4
60	1333.2	2.5	3.5	1410.9	2.4	3.7	1586.3	2.1	4.2
70	1473.0	2.3	3.9	1612.7	2.1	4.3	1872.5	1.8	5.0
80	1624.7	2.0	4.3	1817.4	1.8	4.8	2204.2	1.5	5.8
90	1779.4	1.9	4.7	2026.6	1.7	5.4	2524.6	1.3	6.9

TABLE 5

EFFECT OF LENGTH OF JET INITIAL ZONE ON JET FLOW, VELOCITY AND DILUTION RATIO

Conditions: Slopes of jet boundaries: $C_1 = 0.16$
$C_2 = 0.20$

Distance* from the discharge port along the Jet ℄, ft	$S_2 = 4.0\ D_o$			$S_2 = 6.2\ D_o$			$S_2 = 8.0\ D_o$		
	Flow cfs	Velocity fps	Dilution Ratio	Flow cfs	Velocity fps	Dilution Ratio	Flow cfs	Velocity fps	Dilution Ratio
0	378.0	10.0	1.0	378.0	10.0	1.0	378.0	10.0	1.0
10	542.1	6.7	1.4	542.0	6.7	1.4	542.0	6.7	1.4
20	703.8	5.0	1.9	703.8	5.0	1.9	703.8	5.0	1.9
30	874.3	4.0	2.3	863.9	4.0	2.3	863.9	4.0	2.3
40	1075.0	3.2	2.8	1023.0	3.3	2.7	1023.0	3.3	2.7
50	1275.3	2.7	3.4	1210.0	2.8	3.2	1181.7	2.9	3.1
60	1478.0	2.4	3.9	1410.9	2.4	3.7	1361.3	2.5	3.6
70	1580.1	2.1	4.5	1612.7	2.1	4.3	1562.6	2.1	4.1
80	1884.6	1.8	5.0	1817.4	1.8	4.8	1766.6	1.9	4.7
90	2095.0	1.6	5.6	2026.6	1.7	5.4	1974.8	1.7	5.2

* *from vena contracta*

TABLE 6

VARIATION IN DILUTION RATIO AND AVERAGE TEMPERATURE RISE AT THE CRITICAL CONTROL

Jet Coefficient			Distance of critical control from discharge port along the jet ℄ Sc ft	Lateral Distance of critical control from Discharge Xc ft	Dilution Ratio at Critical Control	Average Temp. Rise at Critical Control °F
C_1	C_2	S_2				
0.10	0.15	6.2 D_o	55.0	54.9	2.6	5.70
	0.20		53.0	52.9	2.6	5.70
	0.30		50.5	≃50.5	2.7	5.50
0.16	0.15	6.2 D_o	43.0	≃43.0	2.8	5.30
	0.20		43.0	≃43.0	2.8	5.30
	0.30		43.0	≃43.0	2.8	5.30
0.25	0.30	6.2 D_o	30.0	≃30.0	3.1	4.75
0.16	0.20	4.0 D_o	40.5	≃40.5	2.9	5.10
		6.2 D_o	43.0	≃43.0	2.8	5.30
		8.0 D_o	43.0	≃43.0	2.8	5.30

NOTES: 1. *The critical control was upper boundary control for all conducted runs.*

2. *Average temperature rises were calculated using plant temperature rise of 14.8°F.*

TABLE 7

COMPARISON OF JET FLOWS, VELOCITIES AND DILUTION RATIOS OF TWO RECTANGULAR JETS

Distance from the slot along the jet ft	$S_2 = 5.3 \times W_o$			$S_2 = 5.3 \times H_o$		
	Jet Flow cfs	Velocity cfs	Dilution Ratio	Jet Flow cfs	Velocity fps	Dilution Ratio
0	378.0	10.0	1.0	378.0	10.0	1.0
10	576.2	6.3	1.5	576.2	6.3	1.5
20	758.0	4.6	2.0	802.0	4.4	2.1
30	933.7	3.7	2.5	1091.8	3.1	2.9
40	1105.6	3.0	2.9	1387.9	2.4	3.7
50	1275.7	2.6	3.3	1676.3	2.0	4.4

Note: $C_1 = 0.15$, $C_2 = 0.25$ *in both cases*

W_o = *initial width of jet*

H_o = *initial depth of jet*

TABLE 8

COMPARISON OF DILUTION RATIOS AND AVERAGE TEMPERATURE RISES AT THE CRITICAL CONTROLS CORRESPONDING TO RECTANGULAR AND CIRCULAR JETS, FOR DIFFERENT LENGTHS OF THE INITIAL ZONE

Conditions				Distance along the jet ℄ (S_c) ft	Lateral Distance Xc ft	Dilution ratio at critical control	Average Temp. Rise ($T_o-T_I=15.8°F$) °F
Rectangular	0.15	0.25	5.3 W_o	51.5	≃51.4	3.4	4.35
Rectangular	0.15	0.25	5.3 H_o	41.5	≃41.5	3.8	3.90
Circular	0.16	0.20	4.0 Do	40.5	≃40.5	2.9	5.10
Circular	0.16	0.20	6.2 D_o	43.0	≃43.0	2.8	5.30
Circular	0.16	0.20	8.0 D_o	43.0	≃43.0	2.8	5.30

NOTES: 1. *Critical control was upper boundary control for all reported jets.*

2. *Average temperature rises were calculated using plant temperature rise of 15.8°F which includes a recirculation effect of 1°F.*

TABLE 9

CALCULATION OF ZONE OF FLOW ESTABLISHMENT ENTRAINMENT COEFFICIENT

a) Slope of boundary $C_1 = 0.10$

S (ft)	ΔS (ft)	Q (cfs)	ΔQ (cfs)	U_c (fps)	D (ft)	R* (ft)	α
0		378.0			6.9		
	10		99.5	10		3.96	0.040
10		477.5			8.9		
	10		97.9	10		4.95	0.0314
20		575.4			10.9		
	10		96.7	10		5.95	0.0259
30		672.1			12.9		
	10		95.7	10		6.95	0.0220
40		767.8			14.9		

b) Slope of boundary $C_1 = 0.16$

S (ft)	ΔS (ft)	Q (cfs)	ΔQ (cfs)	U_c (fps)	D (ft)	R* (ft)	α
0		378.0			6.9		
	10		164.1	10		4.01	0.0653
10		542.1			10.1		
	10		161.7	10		5.85	0.0440
20		703.8			13.3		
	10		160.1	10		7.45	0.0342
30		863.9			16.5		
	10		159.1	10		9.05	0.0280
40		1023.0			19.7		

c) Slope of boundary $C_1 = 0.25$

S (ft)	ΔS (ft)	ΔQ (cfs)	ΔQ (cfs)	U_c (fps)	D (ft)	R* (ft)	α
0		378.0			6.9		
	10		260.9	10		4.7	0.0900
10		638.9			10.1		
	10		257.7	10		7.2	0.0570
20		896.6			13.3		
	10		255.8	10		9.7	0.0420
30		1152.4			16.5		
	10		255.1	10		12.2	0.0332
40		1407.5			19.7		

TABLE 10

CALCULATION OF ZONE OF ESTABLISHED FLOW. ENTRAINMENT COEFFICIENT

S (ft)	ΔS (ft)	Q (cfs)	ΔQ (cfs)	$\bar{U}$ (fps)	$\bar{U}^*$ (fps)	U_c^* (fps)	R (ft)	R^* (ft)	b^* (ft)	α
60		1410.9		2.4			13.75			
	10		201.8		2.25	7.36		14.75	10.42	0.0418
70		1612.7		2.1			15.75			
	10		204.7		1.95	6.38		16.75	11.15	0.0433
80		1817.4		1.8			17.75			
	10		209.2		1.75	5.72		18.75	13.26	0.0440
90		2026.6		1.7			19.75			
	10		215.5		1.60	5.23		20.75	14.68	0.0445
100		2242.1		1.5			21.75			

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BEFORE THE UNITED STATES

ATOMIC ENERGY COMMISSION

In the Matter of	)	
	)	
Consolidated Edison Company of	)	Docket No. 50-247
New York, Inc.	)	
(Indian Point Station, Unit No. 2)	)	

Testimony of
John P. Lawler, Ph.D.,
Quirk, Lawler & Matusky Engineers,
on
Effect of Indian Point Plant
on Hudson River Dissolved Oxygen

June 19, 1972

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

SUMMARY OF FINDINGS AND CONCLUSIONS

1. The Indian Point nuclear generating station is located on the east bank of the Hudson River some 43 miles above the Battery. Cooling water withdrawn from the river removes excess heat from spent steam. The heated water is discharged back to the river at a point over 1,000 feet downstream from the intake structure.

Water passing through the power plant cooling system is exposed to an increase in temperature and to less than atmospheric pressure, both of which may affect the quantity of dissolved oxygen (D.O.) in the cooling water and subsequently, the D.O. concentrations in the river.

Gassing of oxygen from water will begin to occur at a point in the cooling system at which the oxygen concentration in the water is higher than the saturation concentration of oxygen corresponding to the temperature and pressure at that point. Gassed oxygen from the water creates bubbles which are carried by the water to the discharge, at which point they are released to the atmosphere. Some recompression of these bubbles may occur downstream of the condenser as the pressure increases back to its original condition. The effect of this process is considered to be small because of the short travel time in this section of the cooling system and because the reaeration is a slower process than the gassing.

The purpose of this report is to describe the effect on the dissolved oxygen content of the Hudson River water resulting from loss of D.O. during passage of the water through the plant.

The solution to this problem was developed in two phases. During the first phase (Item I), the loss of oxygen in the plant cooling system was calculated. The second phase utilizes the result of the conclusions reached in Phase I to calculate the corresponding changes in the Hudson River dissolved oxygen distribution (Item III).

2. The mathematical model of dissolved oxygen loss in the cooling system which was developed for the study recognized a linear relationship between the D.O. change over a certain period of time and the difference between saturation concentration and a given concentration of D.O. Dissolved oxygen solubility (saturation) is primarily a function of water temperature and pressure. Water temperatures and pressures in the cooling system were calculated using available cooling system characteristics and were expressed as functions of location in the system and were related to cooling water travel time between the intake and discharge.

For purposes of calculation, the cooling systems of both generating units were divided into several reaches. All calculations were initiated at the upstream reach with the entering dissolved oxygen concentration equal to the river concentration at the intake. The concentration at the end point of the first reach was used as an initial concentration for the subsequent reach. The calculations were repeated until the final D.O. concentration in the effluent from the condensers were determined. Loss of oxygen in the total system was computed as a difference between the intake and discharge values.

The rate coefficient of oxygen gassing was determined using the model and QL&M measurements of dissolved oxygen taken at the intake and discharge structures of Indian Point Unit No. 1. The tests and analytical determinations of dissolved oxygen were made in accordance with the most recent edition (13) of Standard Methods for the Examination of Water and Waste Water. Water temperatures were measured using precision thermometers certified by the National Bureau of Standards.

During the D.O. measurement survey, Unit No. 1 was operating at rated capacity and the cooling water flow was 204,000 gpm, i.e., throttled to about 85% of design flow and average cooling water temperature rise was 16.4°F. The observed average intake concentration of dissolved oxygen of 10.48 mg/l and the average loss of 0.18 mg/l in the cooling system indicates a rate coefficient of oxygen gassing of 9.0×10^{-3}/sec. which corresponds to 780/day.

3. Modelling of the Hudson River response to the inplant dissolved oxygen loss included mechanisms of (a) municipal and industrial liquid waste discharge, (b) transport by advection and dispersion, (c) first-order bio-oxidation, (d) reaeration, (e) benthic oxygen uptake and (f) a zero-order constant to account for other mechanisms such as addition of B.O.D. due to organism mortality, addition of D.O. by algal photosynthesis, etc.

For purposes of this model, the Hudson River was divided into 25 segments between the Troy Dam and the Battery. Material balances of B.O.D. and D.O. were developed for each segment and a set of 56 simultaneous equations were generated by inserting the segment B.O.D. and D.O. solutions into the appropriate boundary conditions. The simultaneous equations were solved on a digital computer using matrix inversion.

The effect of the Indian Point plant was introduced into the model as a direct withdrawal of oxygen from the segments adjacent to the plant. For each condition studied, runs with and without the plant in operation were modelled to determine the differences of river dissolved oxygen content and concentrations.

4. Further broadly catagorized summer and winter conditions were used to reflect the seasonal differences in river freshwater flow, dispersion and temperature with the corresponding river dissolved oxygen concentrations and saturations and the difference in the plant operational characteristics such as rate and in-plant temperature rise of cooling water flow.

The prediction runs were made for the 1971 and future (1990) levels of river dissolved oxygen concentrations. The future conditions were characterized by an increase in river dissolved oxygen recognizing a planned higher level of wastewater discharge treatments in the future.

Analytical results of the effects of in-plant loss of D.O. on river water under all conditions used in this report are summarized in Table S-1.

5. The results of the analyses indicate that the loss of dissolved oxygen

TABLE S-1

EFFECT OF INPLANT DISSOLVED OXYGEN LOSS ON HUDSON RIVER

DISSOLVED OXYGEN DISTRIBUTION AT INDIAN POINT

Item	Present Condition Summer	Present Condition Winter		Future Conditions Summer	Future Conditions Winter	
RIVER PARAMETERS						
River ambient temperature, °F	79	33	50	79	33	50
Freshwater flow, cfs	4,000	12,500		4,000	12,500	
River ambient D.O. concentration at I.P., mg/l	6.5	11.3	9.0	7.5	11.7	9.7
PLANT PARAMETERS						
Intake temperature, °F	79	33	50	79	33	50
Plant cooling water temp. rise, °F	14.8	24.7	24.7	14.8	24.7	24.7
Discharge Temperature (rounded), °F	94.0	58.0	75.0	94.0	58.0	75.0
Cooling water flow, cfs	2,500	1,500*	1,500*	2,500	1,500*	1,500*
D.O. saturation, mg/l						
- at intake	8.2	14.4	11.3	8.2	14.4	11.3
- at discharge	7.2	10.3	8.5	7.2	10.3	8.5
INPLANT LOSS OF DISSOLVED OXYGEN FROM THE COOLING WATER						
Intake D.O. concentration i.e., ambient conditions, mg/l	6.5	11.3	9.0	7.5	11.7	9.7
Discharge D.O. concentration (rounded), mg/l	6.3	10.9	8.6	7.2	11.2	9.3
Inplant loss of D.O.						
- lb/day	2,300	3,400	2,500	3,500	3,800	3,200
- mg/l	0.17	0.42	0.31	0.26	0.47	0.40
EFFECT ON HUDSON RIVER DISSOLVED OXYGEN DISTRIBUTION						
River ambient D.O. concentration at I.P., mg/l	6.5	11.3	9.0	7.5	11.7	9.7
River D.O. concentration at I.P. including plant operation (rounded), mg/l	6.48	11.27	8.88	7.47	11.67	9.67
Decrease in river D.O. concentration at I.P.						
- mg/l (rounded)	0.02	0.03	0.02	0.03	0.03	0.03
- % of ambient concentration	0.30	0.26	0.24	0.35	0.28	0.28
% of total Lower Hudson River Content	0.07	0.06	0.06	0.07	0.06	0.06

* T[illegible] cooling water flow throttled to about 60% of full [illegible] during winter months

of about 0.2 mg/l during summer and 0.4 mg/l during winter in Indian Point Units 1 and 2 water cooling systems will decrease Hudson River dissolved oxygen concentrations at Indian Point by about 0.3% (0.02 mg/l) and 0.25% (0.03 mg/l) during summer winter months, respectively. The corresponding decrease in total Hudson River dissolved oxygen content will range from 0.06% to 0.07% of the ambient content without the plant in operation.

These effects are insignificant in comparison with other deoxygenation processes and are below the minimum detectable concentrations of dissolved oxygen, using accepted procedures for D.O. measurement in flowing streams.

The New York State standard for dissolved oxygen in tidal waters is 5 mg/l. The present D.O. levels in the Hudson River at Indian Point are normally well above this value. Even if such an occassion were to occur in which the river D.O. concentration falls to 5 mg/l, no observable effect of the inplant D.O. loss on dissolved oxygen in the Hudson River would occur.

Memo To: Dr. Anthony J. Sartor, Office of Environmental Affairs
Consolidated Edison Company of New York, Inc.

From: Dr. Karel A. Konrad, Project Engineer

Date: February 4, 1972

Subject: Effect of Indian Point Plant on Hudson River Dissolved Oxygen

The nuclear power plant at Indian Point is located on the east bank of the Hudson River some 43 miles above the Battery. Cooling water withdrawn from the Hudson River is used to remove excessive heat from spent steam. Heated water is discharged back into the river more than 1,000 feet downstream of the intake structure. Figures 1 and 2* show the location of the Indian Point site and details of the intake and discharge structures.

The cooling water flow of Indian Point Units Nos. 1 and 2 is 1,120,000 gpm. The heat transferred into the cooling water in the condensers increases the water temperature by about 15°F. Additionally, water passing through the cooling system experiences changes in pressure. In some regions of the cooling water system, this pressure drops below that of the atmosphere. This is due to the design of the system taking an advantage of the well known siphon effect. The advantage of such a design is that less power is needed to circulate water through the system.

The plant temperature rise and pressure changes affect the concentration of dissolved oxygen.

The purpose of this memorandum report is to estimate the change of dissolved oxygen concentration in water passing through the Indian Point Units Nos. 1 and 2 cooling water system and subsequently, the effect of the plant operation on the Hudson River dissolved oxygen concentrations.

I. Change of Dissolved Oxygen Concentration in Water passing through the Indian Point Units #1 and 2 Cooling Water System

A. Theoretical Considerations

Considering a non-variable quality of water in the cooling system, the solubility (saturation) of oxygen in water is determined by the pressure in the pipe and by the temperature of water.

If, at a given point, the solubility of oxygen is less than the actual concentration of dissolved oxygen in the water particles passing the point, oxygen will tend to be released from water (gassing). The rate of change is proportional to the difference between the saturation and actual concentration of oxygen. This can be expressed by a differential equation as follows:

* Report figures and tables follow the text.

Memo to: Dr. Anthony J. Sartor, Office of Environmental Affairs
Consolidated Edison Company of New York, Inc.

Date: February 4, 1972

$$\frac{dC}{dt} = K(C_s - C) \quad \ldots(1)$$

where:

C_s = the saturation of oxygen in water at a given temperature and pressure
C = the actual concentration of dissolved oxygen (D.O.)
t = time
K = coefficient

For purposes of this study, the cooling system of both units 1 and 2 can be divided into five consecutive regions. (See Figure 3)

Region 1 - Suction pipe of cooling water pumps

The temperature of water passing through the suction pipe is equal to the river temperature and is constant along the pipe.

The pressure decreases from the intake to some minimum just before the cooling water pumps. This decrease of pressure (below the atmospheric pressure) can cause gassing of oxygen. However, the travel time through the suction pipe is very small and the amount of oxygen released from the water will be small. Furthermore, in the second part of the cooling system the oxygen loss will be recovered due to relatively high pressure. Therefore, Region 1 of the cooling system will be omitted in the calculations.

Region 2 - Pipe downstream of the cooling water pumps up to the inlet to the condenser

This part of the cooling system is characterized by constant water temperature equal to the river temperature and pressure decreasing from a maximum just after the pumps to a minimum at the entrace to the condenser. This minimum pressure is generally less than atmospheric pressure.

From a location where the pressure is dropping below the atmospheric pressure (or more accurately, from a location where C_s=C) the oxygen will again be released from water creating bubbles over the entire cross-sectional area. These bubbles will be transported by the flow through the condenser to the discharge channel which has an open surface, where they will be released to the atmosphere.

Region 3 - The Condenser

The condenser region is characterized by an increase of temperature from a minimum at the inlet ($T=T_R$) to a maximum at the outlet box of the condenser ($T=T_R+\Delta T_D$). The pressure decreases from the inlet to the outlet box due to the friction losses in the condenser. The gassing of dissolved oxygen continues throughout this region.

For practical calculation, this part is simplified in such a manner as to compute conservative results, i.e., the increase in cooling water temperature due to the condenser is assumed to occur instantaneously at the inlet, and the temperature is constant through the condenser. However, as will be shown later the temperature rise effect is not significant compared to the pressure drop influence.

Region 4 - Pipe between the condenser and the discharge channel

The water temperature is constant and is equal to temperature in the condenser ($T_p = T_R + \Delta T_p$).

The pressure increases from a minimum at the condenser outlet box to a maximum (atmospheric) at the outlet of the pipe.

Some recovery of oxygen loss should be expected due to an increase of the pressure. The travel time through this pipe, however, is small and, therefore, this effect is neglected in the calculations.

Region 5 - Discharge canal with a free water surface

The temperature as well as the pressure, is assumed constant along the channel and the oxygen bubbles formed in Region 2 begin transport across the free water surface.

The solubility of oxygen in water can be approximated using Henry's Law:

$$X_A = \frac{P_A}{H} \qquad \ldots(2)$$

where:

X_A = mole fraction of oxygen in the water
P_A = partial pressure of oxygen in air, atm.
H = Henry's factor, which is a function of the temperature and pressure

Henry's factor is considered constant for a given temperature of water and for pressures equal to or less than 1.0 atm.[1]

The relationship between the mole fraction of oxygen dissolved in water and the solubility of oxygen is as follows:

$$X_A = \frac{\frac{C_s}{32}}{\frac{C_s}{32} \quad \frac{10^6}{18}} \qquad \ldots(3)$$

Memo to: Dr. Anthony J. Sartor, Office of Environmental Affairs, Consolidated Edison Company of New York, Inc.

Date: February 4, 1972

where:

C_s = the solubility (saturation) of oxygen in water, ppm (or mg/1)

32,18 = molecular weights of oxygen (O_2) and water, respectively.

Solution of Equation 3 for C_s yeilds:

$$C_s = \frac{X_A}{(1-X_A)} \frac{32}{18} 10^6 \qquad \text{...(4)}$$

Because the mole fraction of oxygen under consideration will always be small (in the order of 10^{-6}), equation 4 can be simplified:

$$C_s = X_A \frac{32}{18} 10^6 \qquad \text{...(5)}$$

Substitution of Equation 2 into Equation 5 yields:

$$C_s = \frac{P_A}{H} \frac{32}{18} 10^6 \qquad \text{...(6)}$$

In regions of interest to this study, i.e., regions 1, 2... the partial pressure of oxygen is always less than 1.0 atm. and, therefore, Henry's constant will only be a funtion of the water temperature.

Furthermore, the water temperature is considered to be constant for each region. This means that for a given region of the cooling water system, Henry's constant is fixed.

The partial pressure of oxygen in air can be expressed as follows:

Memo to: Dr. Anthony J. Sartor, Office of E... ...ntal Affairs, Consolidated Edison Company of N... Inc.

Date: February 4, 1972

$$P_A = y_o P$$

where:

P_A = partial pressure of O_2

y_o = constant y_o = 0.207

P = pressure at the given locati... ...e cooling water system

Thus, the solubility (C_s) of oxygen in ... ...ssing through the cooling system can be expressed simplifying by ... as follows:

$$C_s = AP \qquad \ldots(7)$$

where:

$$A = \frac{0.207}{H}\,\frac{32}{18}\,10^6 = \frac{1}{H}\,0.368 \times 10^6$$

= s...ty of oxygen in water at a... temperature and the pressure o... 1.0 atm.

P = the pressure in the cooling s... ...hich is a function of the location in the cooling s... considering the travel time of the particle through t... ...ing system the pressure is a function of time

Substituting Equation 7 we get:

$$\frac{dC}{dt} = K[AP(t) - C]$$

or:

$$\frac{dC}{dt} + KC = R(t) \qquad \ldots(8)$$

where:

$R(t) = KAP(t)$

The general solution of the first order nonhomogeneous Equation 8 is:

$$C(t) = e^{-Kt}\left[\int e^{Kt}R(t)dt + C^*\right] \qquad ...(9)$$

where:

C^* = an integration constant

If it is assumed that the pressure in the particular pipe line changes linearly along the line from some initial value P_o to the end value P_1 (this is true if the velocity in the pipe is constant, the pipe has constant slope and no significant local head loss is present between the initial and end points), the pressure at time t will be:

$$P(t) = P_o + (P_1 - P_o)\frac{t-t_o}{t_1-t_o} \qquad ...(10)$$

where:

t_o = time measured at the initial point
t_1 = time at the end point

If initial time is set to zero, Equation 10 becomes:

$$P(t) = P_o + (P_1 - P_o)\frac{t}{t_1} \qquad ...(11)$$

From Equations 11 and 8 we get:

$$k(t) = KAP(t) = KAP_o + \frac{KA}{t_1}(P_1 - P_o)t \qquad \ldots(12)$$

Then, the general solution of Equation 1 is as follows:

$$C(t) = e^{-Kt}\left[\int e^{Kt}\{KAP_o + \frac{KA}{t_1}(P_1 - P_o)t\}dt + C^*\right] \qquad \ldots(13)$$

After integration the solution becomes:

$$C(t) = AP_o + \frac{A(P_1-P_o)}{t_1}t - \frac{A(P_1-P_o)}{Kt_1} + C^*e^{-Kt} \qquad \ldots(14)$$

The integration constant C* can be determined from the boundary condition described below.

At time equal to zero ($t = 0$) the concentration must be equal to its initial value ($C_{t=0} = C_o$). The initial value concentration C_o is either known or is computed as an end concentration of the previous region. Thus:

$$C_o = AP_o - \frac{A(P_1-P_o)}{Kt_1} + C^*$$

or:

$$C^* = C_o + \frac{A(P_1-P_o)}{Kt_1} - AP_o$$

Substituting the above result into Equation 14 the particular solution of Equation 1 is as follows:

Memo to: Dr. Anthony J. Sartor, Office of Environmental Affairs
Consolidated Edison Company of New York, Inc.

Date: February 4, 1972

$$C(t) = AP_o(1 - e^{-Kt}) - \frac{A(P_1 - P_o)}{Kt_1}(1 - e^{-Kt}) + C_o e^{-Kt} + \frac{A(P_1 - P_o)}{t_1} t \qquad \ldots(15)$$

where:

- P_o = the initial value of pressure in atm.
- P_1 = the end value of pressure in atm.
- A = $\frac{1}{H}\,0.368 \times 10^6$, ppm/atm
- H = Henry's constant for a given temperature
- t = the travel time from the initial point to a given point, sec.
- t_1 = travel time between the initial and end points, sec.
- C_o = initial value of D.O. concentration, ppm
- K = the reaeration constant, 1/sec.

For the case of the discharge canal, region 5, with constant temperature and pressure (equal to atmospheric pressure, i.e., 1.0 atm.), the Equation 15 simplifies to:

$$C(t) = A + (C_o - A)\, e^{-Kt} \qquad \ldots(16)$$

Since A is the saturation of oxygen for a given temperature and pressure, equal to 1.0 atm., Equation 16 can be rewritten as follows:

$$C(t) = C_s + (C_o - C_s)\, e^{-Kt} \qquad \ldots(17)$$

The total change of dissolved oxygen concentration in water passing through the cooling water system is then the difference between the river concentration at the outfall. .

Use of the above-presented model requires a knowledge of the cooling water system parameters, mainly the variation of pressure and temperature throughout the system, and of receiving water body parameters, i.e., river dissolved oxygen concentrations and ambient temperatures. The cooling water system parameters, as well as a description of the system is given in the next item. The river parameters and recent field measurements of change of the dissolved oxygen concentration in the water passing through the Unit No. 1 cooling water system are described in item C.

B. Indian Point Cooling Water System Parameters

Unit #1

Two condensers of this unit are supplied with cooling water by two circulating water pumps. The circulators are located at the intake and pump water through separate 84" I.D. lines to the condensers. At the condenser, each line bifurcates to two 60" lines which are cross-connected to the four inlet water box nozzles in such a manner that each pump serves one zone in each half condenser. The purpose of this arrangement is to provide equal back pressures on turbine exhausts when either pump is out of service.

Four separate 60" I.D. lines conduct the river water from the condenser to the discharge canal with free water surface. A 72" I.D. recirculation loop having eight 36" nozzles at the screenwell has been provided for river "de-icing" purposes. Water admission to the recirculation loop is controlled by four 48" manually operated butterfly valves on the river water discharge side of the condenser. Figure 4 shows diagramatically the arrangement of the cooling water system.

Each of the four inlet and four outlet lines is provided with a rubber-seated butterfly valve. While one purpose of the valves is that of isolating the condenser of acid washing, the valves primary purpose is to remove either half of the total condenser of the entire condenser from service for cleaning water boxes or plugging leaking tubes. The valves on the discharge side of the condenser have been used also to throttle the cooling water flow during winter conditions. The purpose of flow throttling is to reduce the intake velocity and by this manner maximize the degree of protection for fish. This is usually done during winter months.

The unit design cooling water flow is 280,000 gpm, the water temperature rise in the condenser is 14.0°F at rated capacity operation. During winter months, the flow may be reduced to 60% of full flow, i.e., to about 165,000 gpm. This flow reduction results in a condenser temperature rise of 23.3°F.

Memo to: Dr. Anthony J. Sartor, Office of Environmental Affairs
Consolidated Edison Company of New York, Inc.

Date: February 4, 1972

Table 1 summarizes the variation of the pressure and temperatures, as well as the travel time of the water particles passing through the Unit #1 cooling water system for conditions of design, i.e., 100% cooling water flow and 60% flow. The pressures at the selected locations of the cooling water system and the travel time between these points were computed using all available information about the system sizes, pump characteristics and other hydraulic characteristics of the cooling water system.[7]

These locations were selected to satisfy the basic assumption of the mathematical model as much as practical. These assumptions were a linear variation of the pressure and a constant temperature within any cooling system reach.

Unit #2

The Unit #2 cooling water system is provided with three condensers. Each condenser is divided into two separate equivalent zones. Each of these condenser zones is supplied with cooling water from one of six circulating water pumps located at the intake. The design capacity of each pump is 140,000 gpm. at the design head of 21 feet.

From the hydraulic point of view, the Unit #2 cooling water system can be divided into six identical units, consisting of:

- circulating water pump with the suction pipe
- pipe connecting the pump and the inlet box of the condenser. Outside diameter of this pipe is equal to 84 inches in the first 210 feet of length and to 96 inches for approximately the last 45 feet.
- inlet box of the condenser
- one half of the condenser
- outlet box of the condenser
- discharge pipe conducting the cooling water from the outlet box to the discharge canal.

The outlets of the discharge pipes are located at the uppermost reach of the discharge canal, more than 100 feet upstream of the unit #1 discharge.

An adjustable wier, located in the discharge canal approximately 80 feet downstream of the discharge of Unit #2, is operated in such a manner that the water surface in the discharge canal at Unit #2 is constantly at an elevation +5.5 feet above mean sea level regardless of the Unit #2 cooling water flow.

For purposes of the water cooling flow reduction during winter months, each of the six units of the unit #2 cooling water system will be provided with a bypasspipe connected to the main line just downstream of the circulating water pumps. This pipe, closed by a valve under full flow operations, will conduct 40% of the water cooling flow from the main line back to the intake structure. The flow in the system will be throttled by an additional increase of friction at the outlet box of the condenser.

The Unit #2 cooling water system arrangement is diagramatically shown on Figure 5.

Table 2 summarizes the computed variation in the pressure and temperature rise and gives travel times between the selected locations of the Unit #2 cooling system for an operation at the design cooling water flow and at a flow reduced to 60%. The procedures of hydraulic calculations, as well as, or similar to those for Unit #1.

The cooling water discharged from the condensers flows through the discharge canal with a free surface and finally is discharged back to the river through the discharge slots (4' x 15') located in the discharge canal wall parallel to the river bank.

The water surface elevation in the discharge canal varies with time, reflecting mainly, the tidal variation of the river water surface and partially, the rate of the cooling water flow. The water depth varies along the length of the canal. At mean low water it is about 17 feet at the upstream end of the canal and about 20.5 feet at the discharge slots. The width of the canal changes with location from about 18 to 60 feet. The total canal length is aobut 1,360 feet. The travel time of a water particle from the center of Unit #2 to the center of the discharge slots is about 6 minutes for conditions of design flow, and about 10 minutes when the cooling water flow is reduced to 60%.

C. Hudson River Parameters and Measurements of Change of Dissolved Oxygen Concentration at Indian Point

River Ambient Temperature

Temperature measurements made by Con Ed at Indian Point in 1963 and 1964 shows that the river temperature changes from a minimum of about 32° in February to a maximum of 79° in August.[3] (see Figure 6)

Available temperature measurements over a ten year period from 1956 through 1965 conducted at the Lovett plant intake structures show similar results. The Lovett plant is located on the west bank of the of the Hudson River and is approximately one river mile downstream of the Indian Point site.

Memo to: Dr. Anthony J. Sartor, Office of Environmental Affairs
Consolidated Edison Company of New York, Inc.

Date: February 4, 1972

River Dissolved Oxygen Concentrations

Several water quality surveys made during recent years in the vicinity of the Indian Point site show that the maximum dissolved oxygen concentration in August is 6.5 ppm.[4] The 1970 measurements at the Indian Point intake indicate that an average dissolved oxygen concentration is about 11.3 ppm, when the temperature reaches 33°F during winter conditions.

River Salinity

The river salinity varies during the course of the year, and from year to year. The main factor affecting the Hudson River salinity is the freshwater flow. A higher salinity corresponds to a lower freshwater flow and vice versa. Long term average summer freshwater flow is approximately 8,500 cfs, while the average winter freshwater flow is 14,000 cfs. Corresponding Hudson River salinities at Indian Point are 4,700 mg/l and 2,800 mg/l, respectively.

Measurements of Change of Dissolved Oxygen Concentration in the Indian Point Unit #1 Cooling Water System

Detailed measurements of the dissolved oxygen concentration at the Unit #1 intake and discharge were conducted recently by Con Ed and QL&M.

Measurements were taken each hour for a period of twenty six hours. Each time, several water samples and temperature measurements were taken, two in the intake structure and three in the discharge canal (50' downstream of the last condenser) to obtain representative averages of intake and discharge dissolved oxygen concentrations.

Periodically (approximately each fifth sampling), river water samples in the vicinity of the intake structure and discharge water samples from the downstream reaches of the discharge canal were taken. These samples showed an insignificant variation along the discharge canal and a negligible difference between river and intake concentrations.

Tests and analytical determinations of dissolved oxygen were made in accordance with the most recent edition (13th) of Standard Methods for the Examination of Water and Waste Water. Water temperatures were measured using precision thermometers certified by the National Bureau of Standards.

During the survey, Unit #1 was operating at rated capacity and the cooling water flow was 204,000 gpm, e.e., throttled to about 85%. The average cooling water temperature rise corresponding to these conditions was 16.4°F.

Table 3 summarizes all the intake and discharge temperatures, as well as dissolved oxygen concentrations measured by QL&M during the sampling period.

The tabulation which follows lists the characteristic values of variables measured by QL&M.

(1)	Intake Temp.+ (2)	Discharge Temp. (3)	Intake D.O.++ (4)	Discharge D.O.++ (5)	ΔD.O.* (4 - 5)
Average	43.8	60.2	10.48	10.30	-0.18
Maximum	45.5	61.7	10.70	10.50*	-0.30
Minimum	42.4	58.9	10.30	10.10	-0.00

The measured losses of dissolved oxygen range from zero to 0.3 mg/l which represent zero to 2.8% of the intake D.O. concentration. The effect of these inplant losses on the river D.O. concentrations at Indian Point is insignificant as it will be shown in item III.

D. Prediction of Dissolved Oxygen Change in the Cooling Water Systems of Units #1 and 2

The mathematical model of a dissolved oxygen change in the cooling water system, presented in item A, was, for practical considerations, computerized. The computer input consists of:

- river parameters (water temperature, dissolved oxygen concentration of the intake)
- cooling water parameters (pressures and temperature rises in selected locations of the system)
- net rate of change coefficient, K

The computer output is the dissolved oxygen concentration in the cooling water discharged from the condensers ot the canal. Calculations are made separately for the Unit #1 and Unit #2 systems. The two obtained discharge dissolved oxygen concentrations are then combined to obtain the concentration in the mixed water from both units.

+ Temperature in °F
++ Dissolved oxygen in ppm
* Excluding two samples indicating increase of D.O. in the system

Memo to: Dr. Anthony J. Sartor, Office of Environmental Affairs
Consolidated Edison Company of New York, Inc.

Date. February 4, 1972

Verification of the Mathematical Model

QL&M's measurements of dissolved oxygen concentrations at Indian Point taken in December 1971 and presented in the previous item, were used. For the prupose of verification, the entire set of data was divided into several groups, according to the intake concentrations of D.O. For each group, the observed average, maximum and minimum losses of oxygen through the cooling system was determined, as shown in the following tabulation:

Intake D.O. ppm	Observed Loss of Dissolved Oxygen in ppm: Average	Maximum	Minimum
10.3	0.16	0.2	0.1
10.4	0.15	0.3	0.0
10.5	0.20	0.3	0.1
10.6	0.20	0.3	0.1
10.7	0.25	0.3	0.2

These values are shown graphically on Figure 7.

The mathematical model was implemented to compute the dissolved oxygen losses for each of the above listed intake concentrations, using the observed average cooling water flow and temperature conditions. Coefficient K used in Equations 1 and 15, was assumed to have a value of 9.0×10^{-3}/sec (≈780/day). The results of these computations are shown in Figure 7 (indicated by a dashed line) and indicate reasonably good agreement with the observations.

Predictions of Inplant Dissolved Oxygen Loss

The verified mathematical model was used to predict dissolved oxygen changes in the cooling water passing through the Unit #1 and 2 cooling systems. Predictions were made for several different sets of input data to show the effect of variable river and plant operation conditions on dissolved oxygen loss. These conditions are tabulated below:

Season	River Ambient Temp. °F	Plant Operational Conditions	River D.O. Concentration
Summer	79	Rated capacity output, full cooling water flow of 1,120,000 gpm	5.5 6.5* 7.5**

* Present river D.O. concentration
** Future (1980) river D.O. concentration

Season	River Ambient Temp. °F	Plant Operational Conditions	River D.O. Concentration
Winter	33	Rated Capacity output, cooling water flow throttled to 60% (670,000 gpm)	10.0 11.3* 11.7**
	50	same as above	8.0 9.0* 10.0

The results of the calculations for all nine conditions are shown in Table 4, and graphically on Figure 8.

The dissolved oxygen loss in the Unit #2 cooling water system is generally higher than that in Unit #1. This is due to higher temperature rises, greater travel time and lower pressures (during throttling flow) in the Unit #2 system.

Observation as well as calculation indicates a negligible change in dissolved oxygen during the waters course through the discharge canal. Gassing in the open discharge canal with a free water surface is a much slower process than that described for a closed water cooling system. In the closed system, whenever a supersaturation occurs as a result of a drop in pressure, dissolved oxygen is released at any point over the cross section because of the uniform distribution of pressure over the entire section. In the open discharge canal, the pressure and D.O. saturation increase from surface to bottom, and the process of gassing can be observed only in the layers close to the water surface. The rate of the dissolved oxygen change (gassing) is the same or slightly higher than that of reaeration.

The change of dissolved oxygen concentration in the canal was calculated using the most severe conditions, i.e., the highest difference between the D.O. saturation at the water surface in the discharge canal, obtained during the course of the dissolved oxygen loss calculations, presented above. A conservative estimate of the coefficient K of 1.0/day = 6.9×10^{-4}/ minute was assumed. Equation 17 was used as shown below:

$$C(t) = C_s + (C_o - C_s)\, e^{-Kt}$$

* Present river D.O. concentration
** Future (1990) river D.O. concentration

Memo to: Dr. Anthony J. Sartor, Office of Environmental Affairs
Consolidated Edison Company of New York, Inc.

Date: February 4, 1972

where:

t = travel time in the discharge canal, min.
(= 10 minutes for 60% design cooling water flow)

C_s = dissolved oxygen saturation in the canal
(= 10.3 ppm at discharge temperature of 58°F - See Table 5, Winter Conditions)

c_o = discharge dissolved oxygen concentration
(= 11.2 ppm - See Table 5, Winter Conditions and future level of the river D.O.)

$C(t)$ = outfall concentration of D.O., to be computed

K = Coefficient of change, expected to be equal to 1.0/day = 6.9×10^{-4}/min

The change of the D.O. concentration during the waters course through the discharge canal is as follows:

$$\Delta C = C_o - C(t) = C_o - C_s - (C_o - C_s)e^{-\bar{K}t}$$

$$= 11.2 - 10.3 - (11.2 - 10.3) \times \exp.(-6.9 \times 10^{-4} \times 10) = 5.4 \times 10^{-4} \text{ ppm}$$

Such a loss is beyond the accuracy of the calculations and is, therfore, neglected.

Table 5 summarizes the predictions of the dissolved oxygen loss through the Indian Point plant cooling system for present and future levels of the river D.O. concentration in lbs/day and in ppm. Table 5 also gives all the basic parameters taken into consideration when making the calculations.

The highest level of the inplant dissolved oxygen loss can be expected during winter operations, when the river temperature dropts to about 33°F and the cooling flow is throttled to about 60% of the design flow (670,000 gpm). This loss is equal to 3,400 lbs/day. The discharge D.O. concentration is reduced by about 0.4 ppm against the intake concentration. This is mainly due to high D.O. level (more than 11 mg/l) in the river and also due to higher temperature rise during throttling the cooling water flow. In general, throttling of the flow results in a less inplant D.O. loss because of higer pressures in the system (see Tables 1 & 2).

The results presented in Tables 4 and 5 are used in item II to predict the effect of the Indian Point plant on the river D.O. concentration profiles.

II. <u>The Effect of Indian Point Inplant Dissolved Oxygen Loss on Hudson River D.O. Concentrations</u>

The purpose of the anlysis presented in this item is to evaluate the effect of the inplant loss of dissolved oxygen at Indian Point on the Hudson River dissolved oxygen distribution.

The mathematical modelling of the river dissolved oxygen concentrations included: (a) transport mechanisms by advection and dispersion, (b) first-order bio-oxidation, (c) reaeration, (d) benthic oxygen uptake and (e) constants (zero-order) to account for other mechanisms such as addition of B.O.D. due to river organisms mortality, addition of D.O. by algal photosynthesis, etc.

The Hudson River was divided into 28 segments between the Troy Dam and the Battery. A material balance of B.O.D. was developed for each segment and a set of 56 simultaneous equations was generated by inverting the segment B.O.D. and D.O. solutions into the appropriate boundary conditions. The simulataneous equations were solved using matrix inversion on digital computer.

The effect of the Indian Point plant was introduced to the model as a direct withdrawal of oxygen from the river segments adjacent to the plant.

The computer runs were made for summer an winter conditions. The summer conditions were characterized by a Hudson River freshwater drought flow of 4,000 cfs, river ambient temperature of 79°F and cooling water flow of 2,500 cfs. For winter runs, freshwater flow of 12,500 cfs and cooling water rate of 1,500 cfs (flow throttled to 60% of full flow) were used. To estimate the winter time effect, two winter ambient temperatures of 32° and 50°F were included in analysis. In general, this temperature range coincides with cooling water reduction period.

The final results of the analysis are shown in Table 6 and indicate that passage of cooling water through the plant will decrease the Hudson River D.O. concentration at Indian Point by about 0.3% or 0.02 mg/l during summer months and by 0.25% or 0.03 mg/l during winter conditions. At the estimated future (1990) levels of river D.O. the decrease is expected to be about 0.03 mg/l. In terms of the total Lower Hudson River (between the Battery and Troy) dissolved oxygen content, the above mentioned values correspond to a decrease of 0.07% during summer months and of 0.06% during winter months.

These effects are insignificant by comparison with other deoxygenation processes and are below the minimum detectable dissolved oxygen concentrations. In conclusion, therefore, the cooling water passage through the plant will have an immeasureable effect on the distribution of dissolved oxygen in the Hudson River.

TABLE 1

INDIAN POINT UNIT #1 COOLING WATER SYSTEM

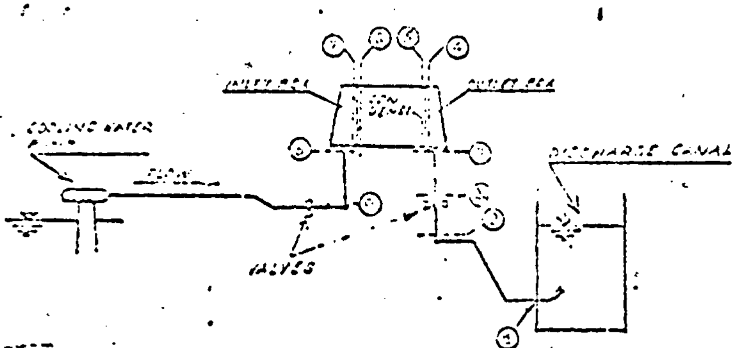
SUMMARY OF PRESSURES, TEMPERATURE RISES AND TRAVEL TIMES

Design Cooling Water Flow Operation

Location*	Absolute Pressure atm.	Temp. Rise °F	Travel Time sec.
1	1.353	14.0	
			10.00
2	1.000	14.0	
			1.56
3	0.590	14.0	
			1.40
4	0.465	14.0	
			ø
5	0.449	14.0	
			5.00
6	0.743	14.0	
			≈ 0
7	0.759	0	
			1.40
8	0.987	0	
			1.19
9	1.267	0	

b). Cooling Water Flow Throttled to 60% of Design Flow

Location*	Absolute Pressure atm.	Temp. Rise °F	Travel Time sec.
1	1.353	23.3	
			16.7
2	0.981	23.3	
			0.50
2a	1.443	23.3	
			2.40
3	1.104	23.3	
			2.34
4	0.927	23.3	
			≈ 0
5	0.921	23.3	
			8.35
6	1.027	23.3	



iagram

TABLE 2

INDIAN POINT UNIT #2 COOLING WATER SYSTEM

SUMMARY OF PRESSURES, TEMPERATURE RISES
AND TRAVEL TIMES

a). Design Cooling Water Flow Operation

Location*	Absolute Pressure atm.	Temp. Rise °F	Travel Time sec.
1	1.338	15.1	≈ 0.5
2	1.338	15.1	Ø
2a	1.342	15.1	3.3
3	0.744	15.1	1.4
4	0.498	15.1	≈ Ø
5	0.475	15.1	8.3
6	0.771	15.1	Ø
7	0.783	0	1.4
8	1.084	0	1.5
9	1.362	0	Ø
9a	1.260	0	3.8
10	1.371	0	Ø
10a	1.334	0	24.4
11	1.340	0	

* See diagram

b). Cooling Water Flow Throttled to 60% of the Design Flow

Location*	Absolute Pressure atm.	Temp. Rise °F	Travel Time sec.
1	1.338	25.2	≈ 0.83
2a	1.342	25.2	5.50
3	0.736	25.2	2.33
4	0.714	25.2	Ø
5	0.709	25.2	13.80
6	0.816	25.2	Ø
7	0.821	Ø	2.33
8	1.116	Ø	2.50
9	1.393	Ø	

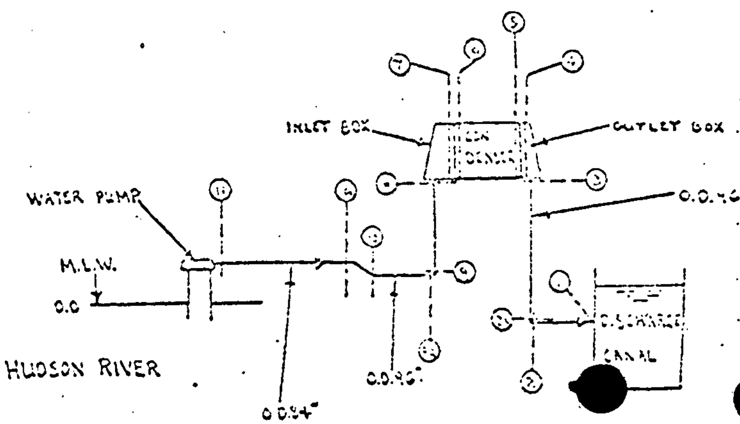


TABLE 3

SUMMARY OF DISSOLVED OXYGEN MEASUREMENTS AT THE INDIAN POINT UNIT #1 INTAKE AND DISCHARGE TAKEN BY QUIRK, LAWLER & MATUSKY ENGINEERS, DECEMBER 1971

	Intake		Discharge		
Time* Hrs.	Avg. Temp. °F	Avg. D.O. PPM	Avg. Temp. °F	Avg. D.O. PPM	ΔD.O.** PPM
0	43.6	10.7	60.4	10.5	-0.2
2:13	45.0	10.3	61.5	10.1	-0.2
3:46	44.8	10.5	61.7	10.4	-0.1
5:09	44.8	10.5	61.5	10.2	-0.3
5:49	44.5	10.3	61.5	10.2	-0.1
7:38	44.2	10.5	60.9	10.2	-0.3
9:12	43.8	10.3	60.4	10.2	-0.1
10:05	43.7	10.4	60.5	10.2	-0.2
11:25	43.6	10.4	60.5	10.4	0.0
13.22	43.2	10.3	59.3	10.5	+0.2
14:10	42.9	10.5	59.5	10.4	-0.1
15:13	44.5	10.3	-	-	-
16:19	44.2	10.4	60.9	10.3	-0.1
17:36	44.4	10.3	61.5	10.1	-0.2
18:41	45.5	10.4	61.3	10.3	-0.1
19:28	43.5	10.4	60.6	10.1	-0.3
20:33	43.8	10.3	60.7	10.1	-0.2
21:49	43.2	10.4	60.3	10.2	-0.2
23:00	43.2	10.6	59.8	10.3	-0.3
24:08	42.4	10.5	53.4	10.7	+0.2
25:32	42.6	10.6	58.9	10.5	-0.1
26:30	42.6	10.7	59.8	10.4	-0.3

* zero time is at the beginning of survey
** Difference between the intake and discharge concentration of dissolved oxygen

TABLE 4

INDIAN POINT UNITS #1 & 2

INPLANT DISSOLVED OXYGEN LOSSES COMPUTED FOR DIFFERENT RIVER AND PLANT OPERATION CONDITIONS

Summer Conditions
Ambient Temp. = 79°F

	Cooling Water flow, cfs	Plant Temp. rise, °F	River Dissolved Oxygen Concentration, ppm: 5.5	6.5	7.5
			Loss of D.O. through Cooling Water System, ppm		
Unit #1	625	14.0	0.08	0.14	0.21
Unit #2	1,880	15.1	0.09	0.18	0.27
Total	2,505	14.83	0.087	0.17	0.255

Winter Conditions
Ambient Temp. = 33°F

	Cooling Water flow, cfs	Plant Temp. rise, °F	River Dissolved Oxygen Concentration, ppm: 10.0	11.3	11.7
			Loss of D.O. through Cooling Water System, ppm		
Unit #1	375	23.3	0	0.11	0.15
Unit #2	1,130	25.2	0.32	0.52	0.58
Total	1,505	24.73	0.24	0.417	0.472

Winter Conditions
Ambient Temp. = 50°F

	Cooling Water flow, cfs	Plant Temp. rise, °F	River Dissolved Oxygen Concentration, ppm: 8.0	9.0	10.0
			Loss of D.O. through Cooling Water System, ppm		
Unit #1	375	23.3	0	0.10	0.14
Unit #2	1,130	25.2	0.22	0.38	0.53
Total	1,505	24.73	0.165	0.31	0.432

TABLE 5

PREDICTIONS OF LOSS OF DISSOLVED OXYGEN IN THE INDIAN POINT UNITS 1 & 2 COOLING WATER SYSTEM

		summer	winter	
	Intake temperature	79	33	50
	Dissolved Oxygen Saturation at the intake temp. ppt	8.2	14.4	11.3
	Cooling water flow, cfs	2,500	1,500	1,500
	Plant temp. rise, °F	14.8	24.7	24.7
	Discharge Temp., °F	94.0	58.0	75.0
	Dissolved Oxygen Saturation at the discharge temperature, ppm	7.2	10.3	8.5
Present Conditions	The intake dissolved oxygen concentration, ppm	6.5	11.3	9.0
	Loss of D.O. lb./day	2,300	3,400	2,500
	ppm	0.17	0.42	0.31
	The discharge dissolved oxygen concentration, ppm	6.3	10.9	8.6
Future Conditions	The intake dissolved oxygen concentration, ppm	7.5	11.7	9.7
	Loss of D.O. lb./day	3,500	3,800	3,200
	ppm	0.26	0.47	0.40
	The discharge dissolved oxygen concentration	7.2	11.2	9.3

TABLE 6

EFFECT OF DISSOLVED OXYGEN LOSS IN THE INDIAN POINT COOLING WATER SYSTEM ON THE HUDSON RIVER DISSOLVED OXYGEN CONCENTRATIONS AND CONTENT

	Present Conditions			Future Conditions		
	Summer	Winter		Summer	Winter	
River Ambient Temp., °F	79	33	50	79	33	50
River freshwater flow, cfs	4,000	12,500	12,500	4,000	12,500	12,500
River ambient dissolved oxygen concentration at Indian Point (mg/l)	6.5	11.3	9.0	7.5	11.7	9.7
Plant cooling water flow, cfs	2,500	1,500*	1,500*	2,500	1,500*	1,500*
Inplant loss of D.O.						
mg/l	0.17	0.42	0.31	0.26	0.47	0.40
lb/day	2,300	3,400	2,500	3,500	3,800	3,200
River D.O. concentration at Indian Point including plant operation (rounded), mg/l	6.48	11.27	8.88	7.47	11.67	9.67
Decrease in River D.O. due to inplant loss						
mg/l (rounded)	0.02	0.03	0.02	0.03	0.03	0.03
% of ambient concentration	0.31	0.26	0.24	0.35	0.28	0.28
Decrease in River D.O. content % of total Lower Hudson River Content	0.07	0.06	0.06	0.07	0.06	0.06

* The cooling water flow throttled to about 60% of full flow during winter conditions

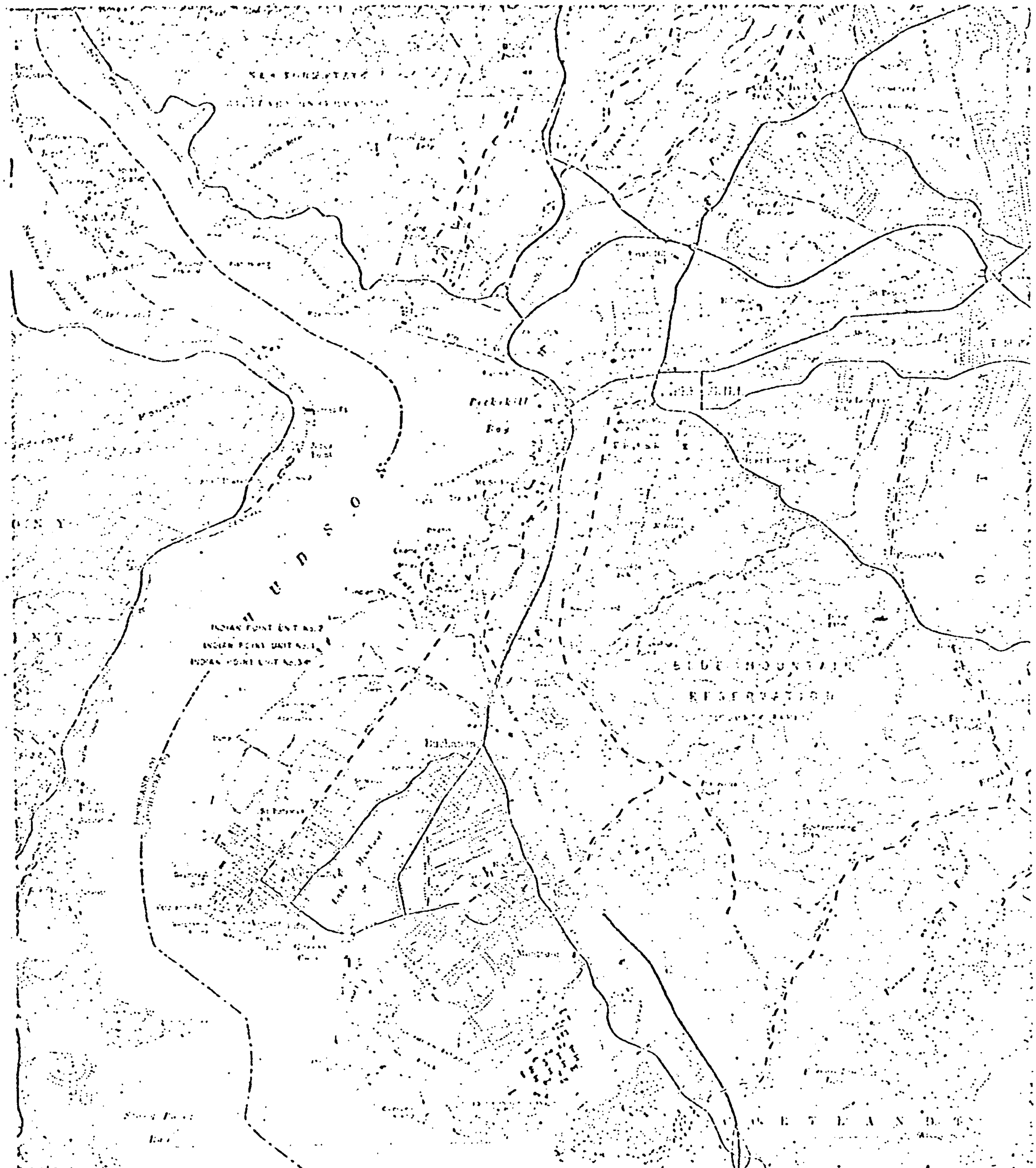


FIGURE NO.1
TOPOGRAPHICAL MAP OF INDIAN POINT SITE AND SURROUNDING AREA

FIGURE 2

INDIAN POINT PLANT INTAKE AND DISCHARGE STRUCTERS ARRAGEMENT-SCHEMATIC DIAGRAM

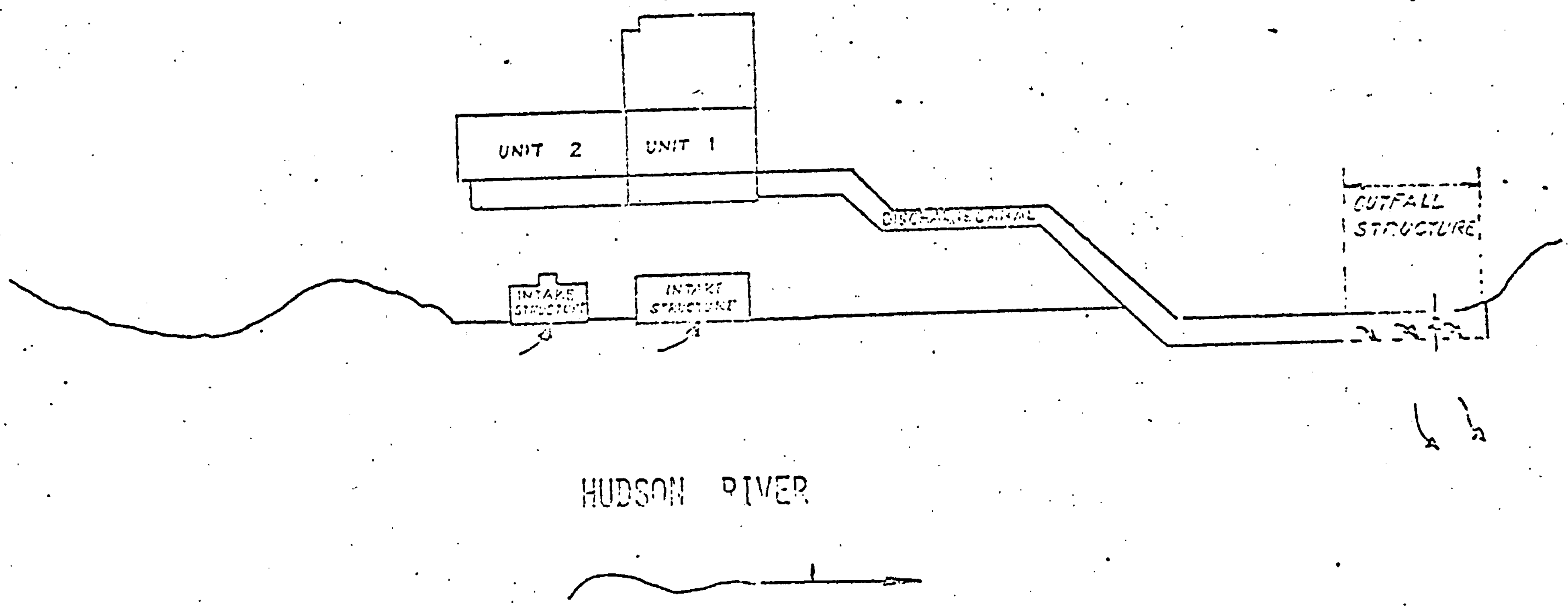


FIGURE 3 VARIATION IN PRESSURE AND TEMPERATURE IN COOLING SYSTEM OF A POWER PLANT

(SIMPLIFIED)

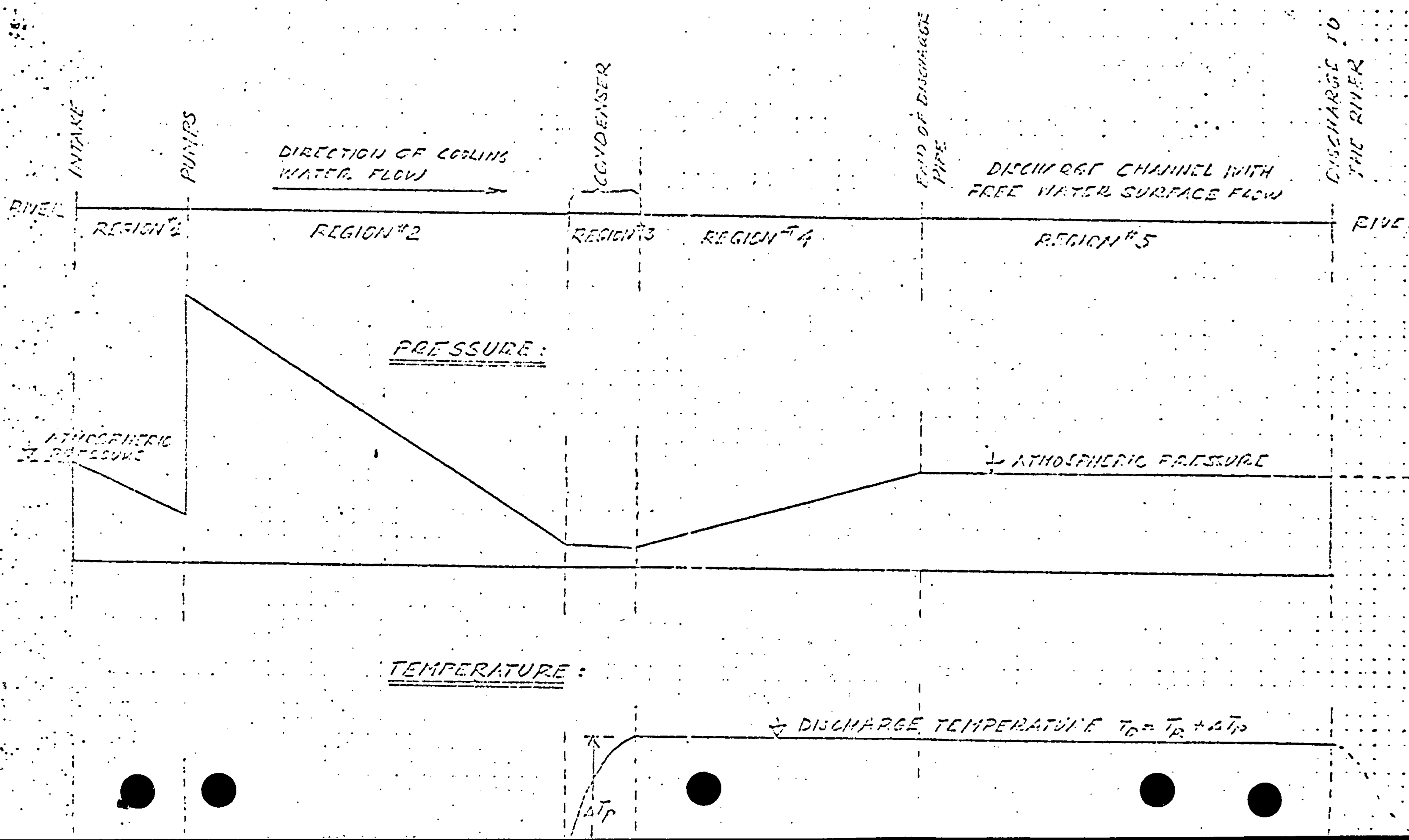


FIGURE 4

INDIAN POINT UNIT # 1 COOLING WATER SYSTEM
ARRANGEMENT-SCHEMATIC DIAGRAM

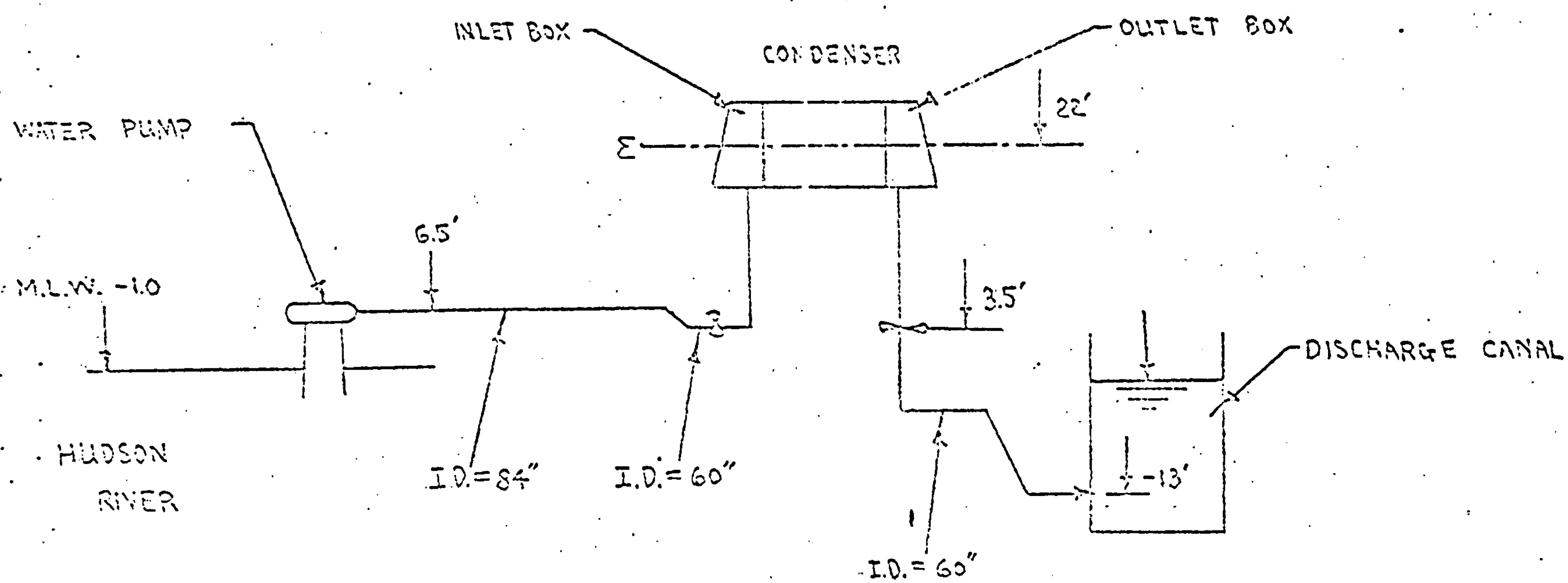
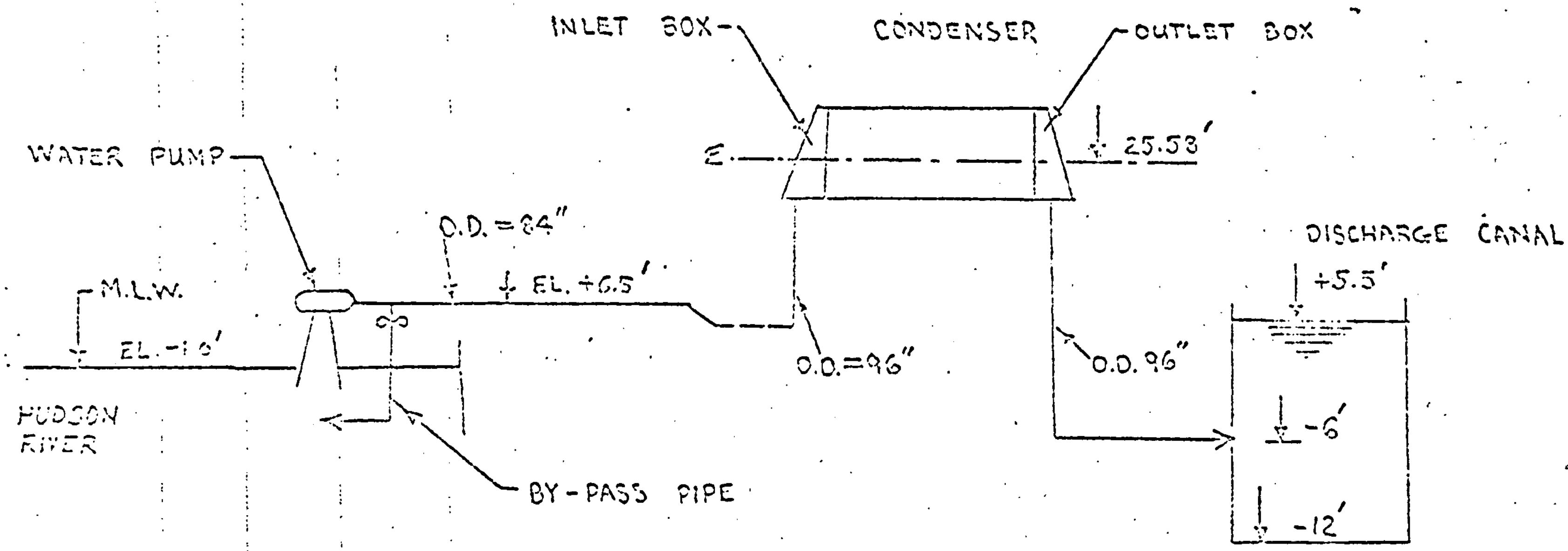


FIGURE 5

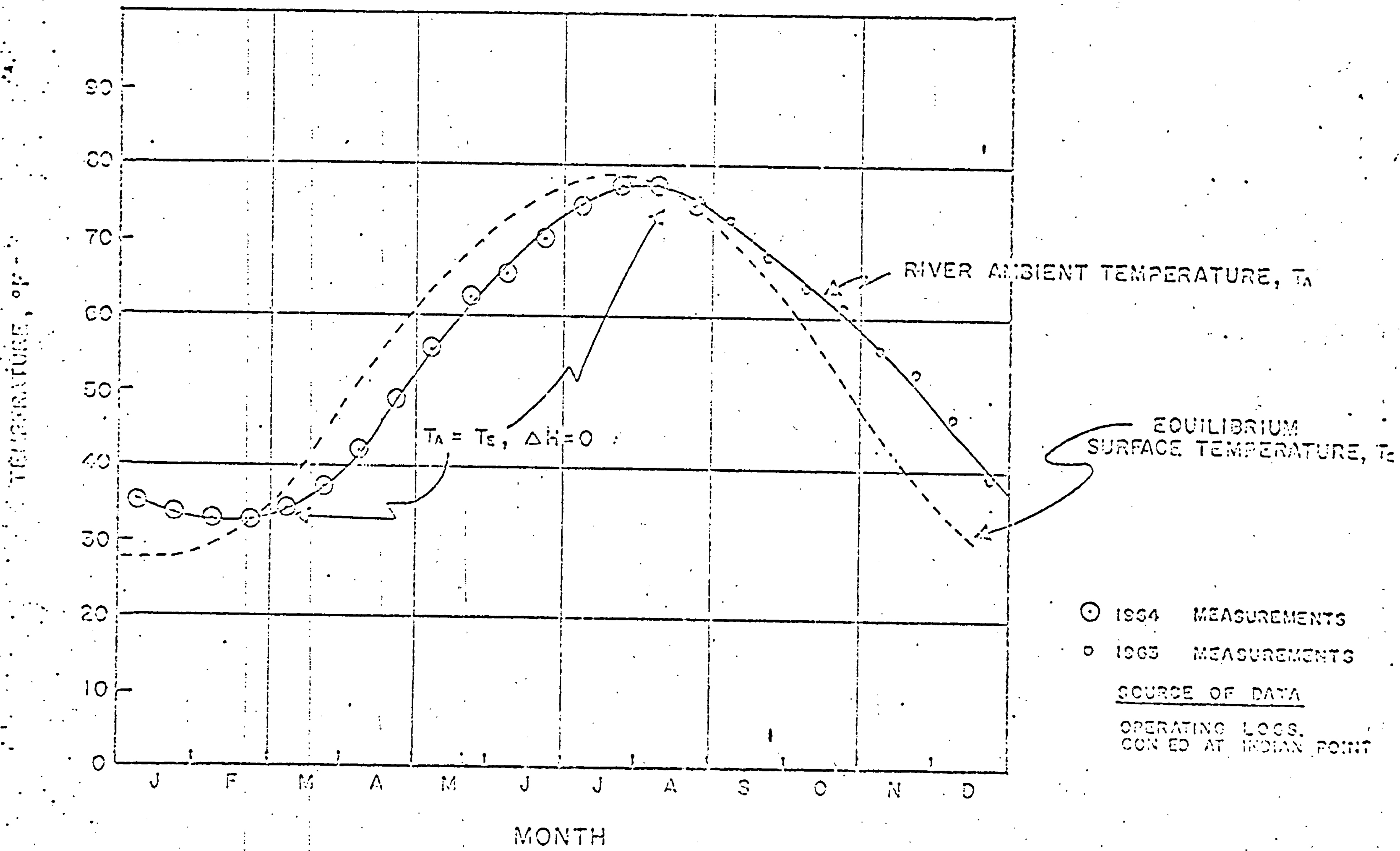
INDIAN POINT UNIT # 2 COOLING WATER SYSTEM

ARRAGEMENT-SCHEMATIC DIAGRAM



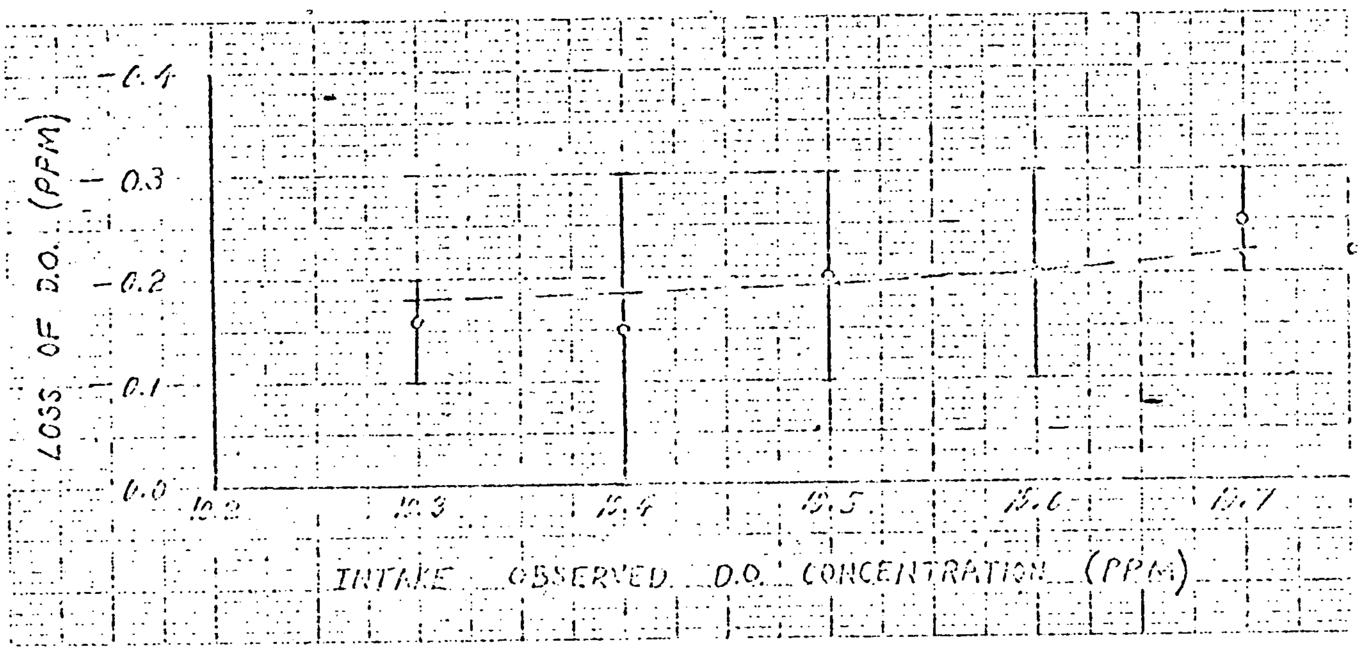
EQUILIBRIUM SURFACE TEMPERATURE
&
RIVER AMBIENT TEMPERATURE

HUDSON RIVER NEAR INDIAN POINT



VERIFICATION OF MATHEMATICAL MODEL OF DISSOLVED OXYGEN LOSS IN A COOLING WATER SYSTEM

(USING OBSERVED D.O. LOSSES IN THE INDIAN POINT UNIT #1 SYSTEM)



LEGEND

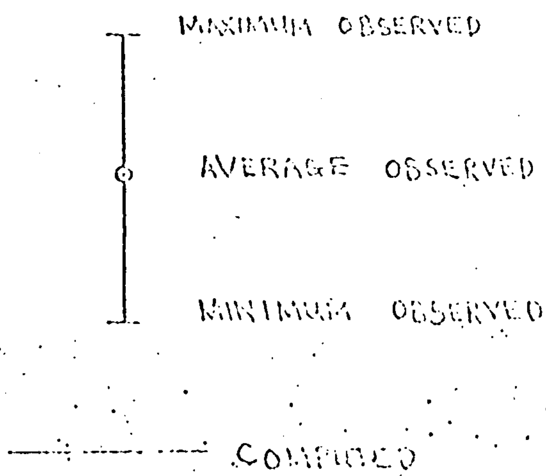
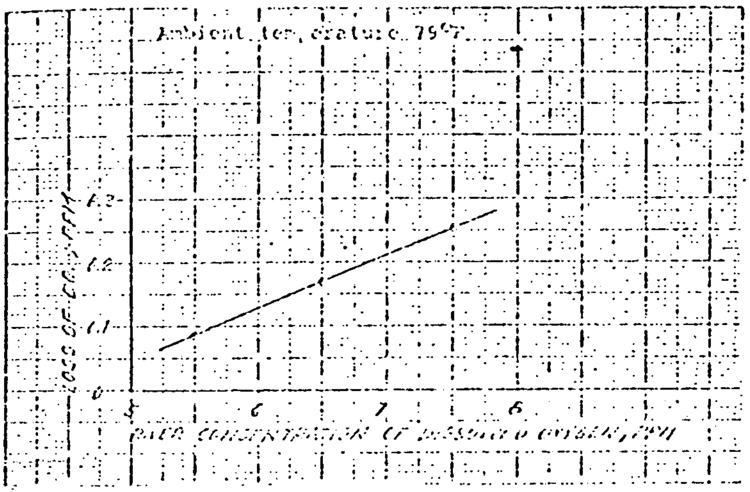


FIGURE 6

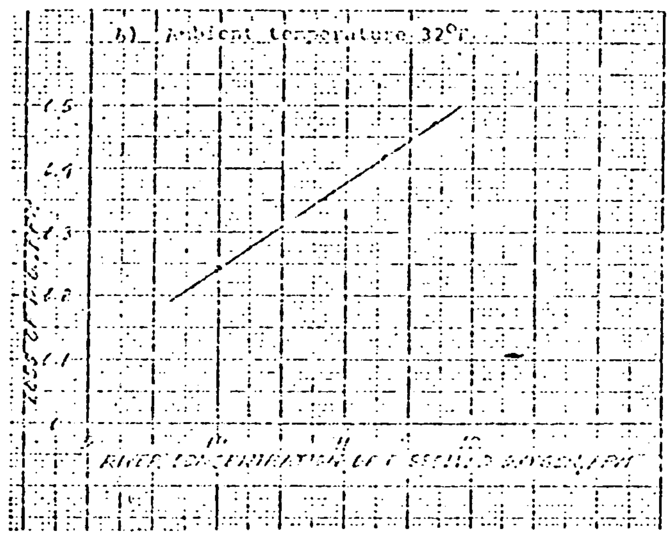
LOSS OF DISSOLVED OXYGEN IN THE INDIAN POINT

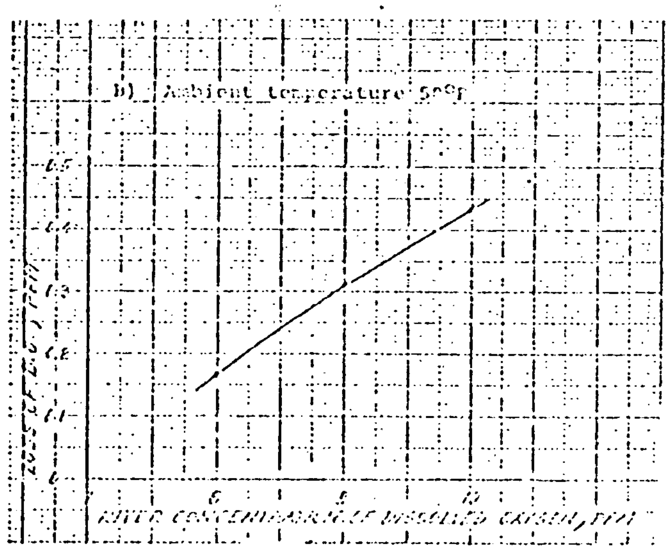
UNITS NOS. 1 & 2 COOLING WATER SYSTEM

SUMMER CONDITIONS:



WINTER CONDITIONS:





APPENDIX A.

LIST OF REFERENCES

1). Perry, John H. "Chemical Engineers' Handbook", New York, 1963

2). Consolidated Edison Company of New York, Inc. "Indian Point Generating Station - Engineering Instructions", February 1963

3). Quirk, Lawler & Matusky Engineers. "Effect of Indian Point Cooling Water Discharge on Hudson River Temperature Distribution", Report to Consolidated Edison Company of New York, Inc., January 1968

4). Quirk, Lawler & Matusky Engineers. "Hudson River Water Quality and Waste Assimilation Capacity Study", Report to New York State Department of Health, May 1970

5). Quirk, Lawler & Matusky Engineers. "Environmental Effect of Bowline Gnerating Station on Hudson River", Report to Orange & Reckland Utilities, Inc. and Consolidated Edison Company of New York, Inc., March 1971

6). Quirk, Lawler & Mttusky Engineers. "Environmental Effects on Hudson River, Lovett Plant Unit #5 Submerged Discharge", Report to Orange & Reckland Utilities, Inc., March 1971

7). Quirk, Lawler & Matusky Engineers. "Indian Point Units #1 and 2 Cooling System Hydraulics", Details of these analyses have not been presented in this letter, but are available.

8). Lawler, John P. and Karim A. Abood. "Thermal State of the Hudson River and Potential Changes", Presented at the Second Symposium on Hudson River Ecology, October 28-29, Sterling Forest Conference Center, Tuxedo, New York.

mil-1

CHAIRMAN JENSCH: Will you proceed.

MR. SACK: Earlier there was an order issued by the New York State Department of Environmental ~~Conversation~~ Conservation with respect to the circulating water pumps at Indian Point, Unit No. 2. I would now like to offer inevidence in this proceeding another order of the Department of Environmental Conservation in a proceeding entitled, "In the Matter of Alleged Violations of the Conservation Law, the Public Health Law and the Environmental Conservation Law of the State of New York by Consolidated Edison Company of New York Inc., Indian Point Plant No. 2."

This order is dated April 28, 1972. It is signed by Henry L. Diamond, Commissioner, New York State Department of Environmental Conservation, and has been consented to on behalf of the Consolidated Edison Company of New York, Inc., by Louis H. Roddis, Jr., President.

This order is offered in evidence for the purpose of showing that the earlier order of the same department have been vacated.

Copies of this order have previously been distributed to the Board.

CHAIRMAN JENSCH: Do you desire to have this matter physically incorporated in the transcript?

MR. SACK: Yes, sir.

CHAIRMAN JENSCH: Is there any objection, Regulatory

mil-2

Staff?

MR. KARMAN: No objection.

MR. MACBETH: No objection.

MR. MARTIN: No objection.

CHAIRMAN JENSCH: The request of the Applicant's counsel is granted and copies of the order identified by the Applicant's counsel as having been issued by the State of New York Department of Environmental Conservation, should be physically incorporated in the transcript as if read by the Applicant.

(The document follows.)

STATE OF NEW YORK

DEPARTMENT OF ENVIRONMENTAL CONSERVATION

---X

In the Matter of Alleged Violations of the Conservation Law, the Public Health Law and the Environmental Conservation Law of the State of New York by

File No. 1013

CONSOLIDATED EDISON COMPANY OF NEW YORK, INC.
INDIAN POINT PLANT NO. 2
(Westchester County)

Respondent

---X

ORDER

An Order and Notice dated February 29, 1972 having been issued by the Commissioner of the Department of Environmental Conservation and duly served upon Consolidated Edison Company of New York, Inc., the Respondent herein, and

Pursuant to the provisions thereof, Respondent was ordered to cease the operation of cooling water circulators at its Indian Point Plant No. 2 in Buchanan, New York based upon the allegation that operation of said circulators caused the killing of over 100,000 fish in the Hudson River during the months of January and February 1972, and

Respondent having requested that the Order be vacated and consented to be bound by the provisions contained herein,

NOW, having considered this matter and being duly advised, it is ORDERED;

I. THAT the Order and Notice issued by the Commissioner in this proceeding under date of February 29, 1972 shall be and the same is hereby vacated effective this date upon the following conditions:

A. Respondent shall complete the installation of by-pass systems on all circulators at Indian Point Plant No. 2 which shall be designed to maintain a water intake velocity at an average rate of 0.5 (1/2) feet persecond. The by-pass systems shall be operable by May 15, 1972 and shall be used at all times when the water temperature of the Hudson River in the area of said plant is below forty (40) degrees fahrenheit.

B. Respondent shall install facilities for maintaining a double air bubble screen in front of all circulator water intakes at Indian Point Plants number 1 and number 2 by December 1, 1972 and shall thereafter operate such air bubble system during all periods said Plants are in operation and the water temperature of the Hudson River in the area of said Plants is below forty (40) degrees fahrenheit, except for such times as shall reasonably be required to perform and make inspection, maintenance, repairs or replacements to such air bubble system.

C. Respondent shall cause hydraulic model studies of a screened lagoon adjacent to the cooling water intakes at its Indian Point Plants numbers 1, 2 and 3 to be conducted and completed by March 1, 1973 pursuant to its existing contract with LaSalle Laboratories, Montreal, Canada, or by such other recognized independent laboratory as Respondent may select. If after the completion of such studies it shall be determined by the Commissioner, after Public Hearing at which Respondent shall be noticed as a Party, that the air bubble system provided for above in paragraph B is not satisfactorily protecting the fish population of the Hudson River, and that the screened lagoon will provide a level of fish protection significantly higher than the air bubble system, Respondent shall upon final determination of the Commissioner forthwith apply for all permits, licenses, approvals and land rights required for the construction and operation of the screened lagoon and shall prosecute all such applications with due diligence. Upon the granting of all such applications, Respondent shall with due diligence construct and operate said screened lagoon.

D. Respondent shall submit monthly reports to the Department detailing daily records of fish collections at Indian Point Plants number 1 and number 2.

E. Respondent shall notify the Department of Environmental Conservation during normal business hours, at least 24 hours in advance, of Respondent's intention to conduct testing operations of the cooling water circulators at Indian Point Plant No. 2, until such time as Respondent shall receive authority from the Atomic Energy Commission to operate such Plant. The Department may during all such periods of testing of the circulators designate Department personnel to observe such testing operations, and to report the results of the same to the Commissioner.

F. By its consent to the foregoing Respondent does not admit any of the allegations set forth in the Notice and Order of February 29, 1972, and does not waive, relinquish or otherwise prejudice any defenses it may have or may have had, or any of its rights to assert such defenses, with respect to any violation of law or other cause of action alleged in said Notice and Order or or heretofore hereafter/alleged in any proceeding whatsoever.

DATED: April 28, 1972
Albany, New York

HENRY L. DIAMOND, Commissioner
New York State Department
of Environmental Conservation

Respondent hereby consents to the issuing and entering of the foregoing Order and agrees to be bound by the terms, provisions and conditions contained therein.

CONSOLIDATED EDISON COMPANY
OF NEW YORK, INC.

By ____________________

Title: President

Date April 24, 1972

State of New York) ss:
County of New York)

On this 24th day of April, 1972, before me personally came Louis H. Roddis, Jr. to me known, who being by me duly sworn did depose and say that he resides in 12 Philips Lane, Rye, New York, that he is the President of Consolidated Edison Company of New York, Inc., the corporation described in and which executed the foregoing instrument; and that he signed his name as authorized by said corporation.

Clotilde M. Regazzi
Notary Public

CLOTILDE M. REGAZZI
Notary Public, State of New York
No. 41-8521650 Queens County
Cert. filed in New York County
Commission Expires March 30, 1974

CHAIRMAN JENSCH: Will you proceed.

MR. SACK: At this point we are ready for Mr. Macbeth to commence his cross-examination on four issues which we earlier agreed were suitable for discussion at this stage of the hearing. These four issues are thermal discharges, chemical discharges, dissolved oxygen and entrainment of organisms ~~on the~~ other than fish. Applicant's case is complete on these issues, and we are ready to dispose of them at this time. We are, however, faced with the problem that we have not received from the Intervenors a statement of contentions in reasonably specific detail.

In this proceeding we have completed a discovery process that I believe is unprecedented in nuclear licensing cases. We have answered a large number of questions, which is indicated by this volume of answers. We have established a document room for the Intervenors convenience and placed in it over 80 documents. We have permitted informal questioning of our Staff and consultants over the last six months. In the last few weeks, we have furnished additional documents in an effort to proceed on these issues. This, of course, is in addition to our environmental reports and testimony in this proceeding.

The purpose of this process is to narrow the issues in controversy and is to be reflected by a statement of contentions with reasonable specificity. That is the only way

mil-2

we can identify the matters in controversy and conduct a reasonable hearing.

We were furnished with a list of questions by Mr. Macbeth last Thursday, and a list of very generalized contentions just three hours ago. The questions appear to be a continuation of the discovery process, and the contentions are phrased in the same generality as the contentions were last fall.

Since neither HRFA or EDF have presented a proper statement of contentions on any of the issues to be considered at this session of the hearing, I believe we are entitled to a ruling from the Board that they are not entitled to any cross-examination on these subjects. Nevertheless, we are willing to give Mr. Macbeth a final chance.

I suggested, as we take up each subject separately, Mr. Macbeth state on the record what his specific contentions are. We can then proceed to cross-examination relative to that contention. But in the absence of a specific contention, I do not know what the subject matter of this will be.

MR. MACBETH: Mr. Chairman, can I answer that and start by providing the Board with a contention -- supplemental contentions?

CHAIRMAN JENSCH: Yes. We would like to see that and maybe the Board will have an opportunity to decide whether you have another chance. We are glad to have it in view, but

mil-3

the Board will make a ruling based on the record.

The Board has not received any of these matters, those from the Applicant which have been incorporated within the record, as well as the two documents just handed to us by counsel for the Hudson River Fishmens Association. I take it these two documents reflect --

MR. SACK: Excuse me, Mr. Chairman. What documents did you say the Applicants did not receive?

MR. MACBETH: Could I explain the situation for a moment, Mr. Chairman?

CHAIRMAN JENSCH: Well, yes, but our thought was that the Board was considering taking a recess and giving some review to the matter before we proceed too far into it.

Mr. Briggs has indicated that we have received the Applicant's presentation from witness Lawler prior to today in the course of this copy of the order from the New York State Department of Environmental Conservation. I think it came in just the other day.

MR. SACK: We submitted them June 9th.

CHAIRMAN JENSCH: Yes, June 9, 1972. So we have had 10 days on that one, at least.

MR. MACBETH: Mr. Chairman, I'd like to reply, generally, to both the Board's question and Mr. Sack.

I have handed the Board two documents, one simply reprints of the various contentions made on the 1st of

mil-4

December, 1971. Since those are theones that are the subject of this hearing, I have simply reproduced them for the convenience of the Board and the parties. I have added to that a new document, supplemental contentions of the Hudson River Fishmens Association and Environmental Defense Fund and I believe questions that should be taken up on cross-examination this afternoon.

The Applicant contends that they are not sufficiently precise. I think that the heart of this problem is that the contentions must fundamentally reflect the subject matter that they discussed. If one is discussing a strictly mathematical question, one can be extraordinarily precise in contentions.

When one is discussing biological areas of the migration of fish and the effect of the thermal plume among them, the amount of concrete,hard evidence is not nearly as great. The range for opinion is much larger, and it seems to me there the more qualitative contention is altogether proper. It may be that the-- I think it is a fair and accurate statement to say that the thermal plume from the Indian Point Plants 1 and 2 and the other plant will have an adverse effect on migration patterns and seasonal movement patterns of fish in the river.

Study, as far as I know, precise studies of exactly what that impact would be have not been made. It would be, I

mil-5

think, foolish to predict with absolute certainly precisely what would happen. I think one has to take the state of the art and studies inthe field as one finds them, that it is altogether proper to make a contention that puts the matter qualitatively, saying that there would be an adverse impact, without going from what reasonably could be drawn from the knowledge in the field to be even more precise.

I think that fundamentally the Applicant realizes that he is the case. If one looks at the environmental report which the Applicant turned in last September or October, on this question the Applicant says thermal discharge from Unit No. 2 will be added to the common discharge from Unit No. 1.

Model studies have indicated they will not extend 25 feet from across the river from Indian Point. It would appear therefore that migration of the fish in Indian Point will not be affected by thermal barriers or as a result of thermal discharge --

We have said not much more than the reverse of that, that there will be an adverse impact, and I think the fact that the Applicant, in putting forward its own case, really doesn't feel, or certainly not in that statement, made any more precise contention that reflects that essentially that is the state of knowledge and the state of the art.

mil-6

We contend there will be an adverse impact. We can't quantify it exactly. We feel the Board should take it into account, should have in the record and should weigh in making the final decision. There will be other areas where we can be more precise. But I feel that the precision of the contentions has to reflect what reasonable opinion on the topic is.

We are not, I think, proposing here some contention that is outlandishly vague. We are not saying that thermal plume will have a bad effect on the entire environment within 50 miles of Indian Point and some parts will be more adversely affected than others, and leave it at that. We are talking about the movement of fish. We are talking about this movement. We think there will be an adverse effect.

CHAIRMAN JENSCH: Let me see if I understand the Applicant's position by propounding the question to you. Take your initial contention of December 1, 1971. That is Item No. 26. Perhaps I don't pronounce this correctly. "Gammarus and Neomysis have reproduction cycles of one to three generations a summer.

Is that good or bad, or is something going to be thermally activating, if I use the term in that regard? Is the ratio going to be one to two, or one to four? How does this thing work? What happens when we read that? What should we think about when we get done reading that Item 26?

MR. MACBETH: The Intervenors there are trying to

mil-7

establish factually the reproduction cycle of gammarus and neomysis. We then go on to contend that a large number of these organisms will be killed when they pass through the condensor tubes.

The importance is that if they had one generation a summer, and you pass a significant amount through, you have obviously a very significant impact. If they had 20 generations a summer or constantly regenerating, the impact would not be as great.

We are trying to give the Board a fair impression of the kind of impact there will be. We think an important part of that is a contention as to how many generations there are in the summer, what kind of reproductive rate these organisms have.

CHAIRMAN JENSCH: I wonder, by just looking -- going on through down to Item 30, you say the precise impact is unknown, but will involve a loss of food organisms. Aren't many of the matters you have set out in those several contentions, 26 through 30, a basis for stipulation? Won't they agree that this is unknown and there is probably a loss of food organisms? Should we take time with that sort of a contention?

MR. MACBETH: Some of these points I think the Applicant would probably stipulate to. I think they will probably agree with us on the reproduction cycle, for instance.

mil-8

I really don't intend to spend a great deal of time on those facts if they seem to be in agreement with us. I would be willing to sit down with the Applicant again and go over this and see if we could --

CHAIRMAN JENSCH: Take 47. "Control over expected chemical discharge from Indian Point Unit No. 2 is inadequate or unknown."

MR. MACBETH: Then you see number "b", that the Applicant will probably stipulate to. We had some discussion of it and we are going to have more today. They will at least stipulate to that point, "b", "Copper detection sensitivity in the discharge canal is limited to one part per million."

I think that could be disposed of.

CHAIRMAN JENSCH: What happens when they do have a copper detection sensitivity in the discharge canal limited to one part per million? Is that good?

MR. MACBETH: If copper is being discharged in any large quantities, but less than the concentration of one part per million, it would be a toxic effect on fish and would be adverse. We feel that in this particular case it is inadequate to monitor copper as to one part per million.

CHAIRMAN JENSCH: I infer from the Applicant's position that the Applicant has read all these things. Then they say, what else is new? What is your view about it? Are you making the contention that instruments do not exist to

mil-9

permit adequate copper detection because the sensitivity of the instruments is inadequate, or are you saying that if the release of copper is greater than one part per million, there will be a toxic effect,and at one part per million it is satisfactory?

MR. MACBETH: No. I am saying that the Applicant presently plans to monitor copper sensitivy of one part per million. If copper were being discharged at a concentration slightly below that, it would not be monitored and there would be an adverse effect on the fish in the Hudson River.

CHAIRMAN JENSCH: So you are urging that more continuous and more precise monitoring --

MR. MACBETH: More sensitive monitoring.

CHAIRMAN JENSCH: What part per million, point five?

MR. SACK: Mr. Chairman, this is very helpful to us, because this is the very first time we have been advised that there is a contention that discharges of less than one part per million of copper are toxic. I have not seen that as a contention before. If this is the contention, this ought to be stated on the record and then we can address it. That is our problem as the Applicant stated before.

MR. MACBETH: The Applicant has had this document for more than six months and certainly never raised this kind of question before.

CHAIRMAN JENSCH: Maybe they are trying to understand

mil-10

it, as they have indicated. Six months is a fair enough trial, I think.

MR. SACK: The document does not say anything about toxic effects on fish. It says that the copper detection sensitivity in the discharge canal is limited to one part per million.

We agree with that. The document doesn't say anything about that the toxic levels for fish are in contention.

MR. MACBETH: It does say that the control of the chamical discharge is inadequate. I have excerpted No. 47 from a longer series of contentions in which I believe, if we look back at it, another one is there of the total impact of the control of the discharge would have an adverse effect to the fish and be toxic to them.

I apologize for having taken this particular piece out, but I thought that we would be able to save time by not reproducing the whole first document.

MR. SACK: Mr. Chairman, the first subject we want to address is thermal discharges. Maybe we should get back to that. The contention here says adverse impact. My point is that the adverse impact should be identified.

Is there a contention that there would be a thermal block to migration? If that is the contention, we are prepared to address it. Is it the contention that the thermal discharges will kill fish? If that is the contention, we are prepared to

mil-11

address that. Is the contention of the thermal discharges attract fish to the intake? Then we will address that.

But the simple statement that there is an adverse impact, we don't know what questions to address.

MR. MACBETH: Which contention?

MR. SACK: Contentions 7, 8, and 9.

MR. MACBETH: Mr. Chairman, I think it is unfair to take No. 7, as 7 refers to attraction to the intake. It is quite clearly aimed at migratory and seasonal movement patterns of fish inthe Hudson. Fish migrate up the Hudson. Shad migrate up the Hudson. Bass migrate up the Hudson. Striped bass. Herrings do.

CHAIRMAN JENSCH: Thank you.

MR. MACBETH: We think the presence of the thermal plums will have a disruptive effect on the patterns. There have not been thorough studies of exactly what that impact will be. We can state that the studies show that thermal changes affect the behavior patterns of fish, and we will put in expert testimony of the opinion that this will have a disruptive pattern on these migration patterns. But I think neither the Applicant nor the Intervenors can say with precision exactly what is going to happen in the situation. After all, a great deal of the Applicant's testimony has been aimed at the fact that they will feel they need an enormous research program, what is going on with the fish in the river

mil-12

after 10 years of operating Indian Point 1. They now turn around and say that the Intervenors should know precisely what is going to happen.

We can offer expert opinion that that thermal plume will have an adverse impact, will disrupt, in some not precisely defined fashion, a pattern to fish. They can't be too much more precise about that.

We can go with thos forever. We can get down, is it going to move them a foot oneway or a foot the other? I think there is a clear issue here. We are talking about the migration patterns of fish in the Hudson River, and we are talking aboutthe relation of that to thermal plume and the fact that we believe that thermal plume will have an adverse impact and disruptive impact on those movements, migration patterns.

End 3

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CHAIRMAN JENSCH: I have been puzzled about the Applicant's presentation after its frequent reference to the application of Indian Point 1, that in reading the proposal of Indian Point 2 is starting all over again because a program is undertaken to get the data that has been developed on Indian Point 1. Do you remember the research going on with reference to Indian Point No. 1?

MR. MACBETH: It is accepted by the Applicant, if it is, we will certainly address that problem. That is a very real problem.

MR. SACK: If the contention on thermal discharges is that the thermal discharge will create a thermal block, which I understand from Mr. Macbeth's statement, then I will consider that a specific contention and we are prepared to respond today. Adverse impact and migratory patterns, I am not sure what that means.

MR. MACBETH: Perhaps we have trouble with the English language. Do I want to go so far and say that the fish are going to be permanently blocked in going up the river. It seems to be a long way with fish being able to migrate in their normal pattern and being to some extent disrupted. Perhaps some of the weaker fish will become confused. I am not going to say there is going to be a block and will cut off all fish moving up.

It seems to me that -- I don't think. I frankly feel in saying there is going to be an adverse impact on the migration patterns reasonably specific in the light of the knowledge in the area, that is what the experts that I have dealt with tell me. To go further and put in something that no striped bass will get past this poing, that isn't the honest opinion of the experts in the field and still feel there will be an adverse affect. It seems to me to be nonsensical and to ask for specificity where specificity isn't possible. I really do feel that specificity has to be judged in the light of the amount of knowledge in the field.

If this were a mathematical formula, I would say that specificity is necessary. On something on which little is known as migration patterns of fish, where it is enough for experts to have opinions, we can't fairly be asked to be that specific. Read what the Applicant had to say about it. All he says is that plume is going to be out there 2500 feet and therefore not going to have an affect on the migration of fish. That doesn't seem to me to be very specific or give any kind of indication about the real relationship between that plume and migration pattern. Would it have been 2600 feet or more? There is no analysis there or no bold statement.

CHAIRMAN JENSCH: Is it your thought that the Applicant, in saying that the plume may go out 2600 feet, and therefore there will not be a thermal block or will not be a disruption of the reproductive activity, could they prove the negative? That is what I have in mind.

MR. MACBETH: I think they assert it. I don't consider that a proof.

CHAIRMAN JENSCH: If all evidence is that there isn't any showing that there will be a damage or an injury to the fish -- everybody will agree to that. There are some who feel that there might be sometime. Is that enough to say that you can make a contention because you think it might happen later? What is the situation today? Today you say you can not say that there will be a thermal block. Does that take it out of the contention phase?

MR. MACBETH: We are not making a contention there will be a thermal block. We are contending there will be an adverse impact. We will be putting in testimony of an expert to that effect.

CHAIRMAN JENSCH: What will be the illustration of the adverse impact from your testimony?

MR. MACBETH: A disruption of the migration pattern in some of the fish not being able to reach the spawning ground.

CHAIRMAN JENSCH: You are saying there will be a thermal block then?

MR. MACBETH: No. I don't think that is what I have said.

CHAIRMAN JENSCH: You said they won't be able to reach the spawning ground. What would prevent them from reaching the spawning ground?

MR. MACBETH: They will be confused and move in other directions. Maybe that is what one means by thermal block. I read that to mean a block through which no fish of a certain species will pass. If the Applicant only means by block a thermal discharge in a higher thermal area in the water, which will disrupt the migration pattern, then I think what I have written here and what the Applicant contended will be a more specific contention of the same thing. I will ammend it. I had the feeling we are going to get into an endless wrangle about the meaning of the English language. I think I have been comparatively straightforward and pointed on this. If the Applicant reads block to mean some disruption in the migration pattern, I will ammend it to say a thermal block. Then I think the Applicant -- if that will make the Applicant happier, I wouldn't mind amending it to that since that is essentially what I have written down here in other words.

I don't think it would be too great to do that.

CHAIRMAN JENSCH: Does the Staff desire to make any expression in this regard?

MR. KARMAN: Mr. Chairman, it would seem to me that there might be a more concerted effort to make some of these contentions more reasonably specific under the Commission's rules. Of course, it maybe difficult for the Applicant and the Intervenor to get to go on something like that. Although, in looking at this question of producing an adverse impact, it certainly would seem that there could be more added to that to clearly define what adverse impact is there, and I think possibly the Applicant and the Intervenor could, with a little effort, make these somewhat more -- or agree to a somewhat more reasonably specific contention so that the Applicant could respond to them. I think that that effort would probably produce a short end cross-examination as to exactly what the Intervenor is contending with respect to some of the Applicant's statements.

CHAIRMAN JENSCH: I infer from the Applicant's statement that he is really seeking some information and not raising any great objection about your assertions. I think insofar as you could put thermal block into the context of adverse impact or whatever on the illustrations you might have, I think it would be helpful. For instance, supposing you put Doc Lawler on the stand and you are going to cross-examine him about thermal discharge having an adverse impact. What would be your first question?

MR. MACBETH: Assuming that we pursue first with Doc Lawler, my feeling on this would be probably to best to pursue it with someone speaking about what is known of the migration patterns of fish. I would try and get as much knowledge as the Applicant has on that subject on the record as possible. All I would be seeking from Doc Lawler would be a description -- and I think most of it is there in the testimony already. Extensive cross-examination wouldn't be necessary and I wasn't planning it. That is what the outline of the thermal plume from the two plants is. I feel that Doc Lawler has covered most of that ground and I don't think I would have any questions from him. I am more interested in pursuing the question of what the Applicant knows about the migration patterns of fish when it says that this plume as it describes will have no adverse impact on the migration patterns and seasonal movement.

DR. GEYER: Why can't you pick out of this the things that are really in contention? On the first page I don't see any. On the second page, No. 7 is a contention that we are talking about. No. 9 is a contention that would be in dispute and No. 13. There are 3 on that page. The rest is something that is really insignificant.

MR. MACBETH: To some extent I have been trying to lay a simple factual basis in these contentions, too. On most of these points on the first page, I wouldnot be intending to cross-examine Con Edison. They do agree to it. I would be concentrating on the topics that I have put down for cross-examination that have been sent out.

DR. GEYER: Why can't you sort them out and look at the other stuff?

MR. MACBETH: I would be happy to. I think that gives another indication of what should be cross-examination. I don't think that we need to have any real cross-examination on the amount of heat that is going to be produced by the plant. I think we are all in agreement on that. I did want to put it in so there would be some fundamental facts there so the Applicant would kind of know where we are moving. I felt if I left all of those out and put in the final conclusion, the Applicant

eak 7

would be equally annoyed that there is no basis as to how he can see how I was arriving at my conclusion. I was really trying to produce a little bit of background and foundation in there so he can see how I was building toward some of the more clearly contested points.

I am not intending to go into any real cross-examination on the number of Btu. I don't think that is a matter of contention.

CHAIRMAN JENSCH: Doesn't this discussion assist the Applicant in knowing the form of the presentation made by the Hudson River Fishermen's Association, knowing that in several of these numerically identified paragraphs he is really setting forth a foundation of matters as a basis for a later paragraph which, in effect, constitutes the contention, as I understand it, that would add some such words, that they contend that there will be an adverse impact or something like that. It gets to be in the form of what you are asserting.

MR. MACBETH: I would certainly be happy to ask those where the Applicant and the Inte-venor would disagree, where we say we contend that this would happen and identify further for the Applicant.

CHAIRMAN JENSCH: Could we spend 30 minutes on that right now?

MR. SACK: Yes, that would be an excellent suggestion.

CHAIRMAN JENSCH: Let us recess to reconvene in this

eak 8

room at five minutes after four.

end 4

(Recess.)

CHAIRMAN JENSCH: Please come to order.

Can yougive us the further report on the status of your assertions, Mr. Macbeth, please?

MR. MACBETH: Yes, I can, Mr. Chairman.

I have discussed the matter with the Applicant during the recess. We agreed on wording for two contentions, which meet the Applicant's standards for specificity. I am willing to accept the language.

Number 7 would be changed to read, "The heated plumes from Indian Point and Lovett will interfere with the migratory and seasonal movement patterns of fish in the Hudson to and from their spawning grounds."

Number 9 would be changed to read, "The discharge of heated water from Indian Point in its 1 or 2 will attract fish to the intakes of Indian Point Units 1 and 2 where they are subject to impingement."

CHAIRMAN JENSCH: Does that mean that they will be killed?

MR. MACBETH: Yes, I think that means they will be killed. I was trying to find language where -- of course, the Applicant will never admit they are going to be killed. Yes, impingement means death in this case.

CHAIRMAN JENSCH: You didn't change your thought that you expressed?

MR. MACBETH: No. I am just trying to find some word.

mil-2

MR. SACK: I think the contentions will be subject to. Whether all of them will be impinged, we don't know.

CHAIRMAN JENSCH: That takes care of the only two you want so far?

MR. MACBETH: Yes. As Dr. Geyer pointed out as we were discussing earlier, a number of others will probably be the subject for stipulation, Apparently the Applicant really doesn't feel, for instance, the first five are contentions over which there should be much argument, and neither do I. While we haven't formally agreed to stipulate to them, we are all treating them as foundation material for the contentions of the issues.

MR. SACK: We are prepared to submit to cross-examination at this time on those two issues along the lines of the cross-examination topics Mr. Macbeth delivered to us last week.

CHAIRMAN JENSCH: Let us proceed, then. Call your first witness.

MR. SACK: Mr. Macbeth, if you will identify which question you want to proceed with, I will tell you which are the appropriate witnesses. Perhaps it would be best if Dr. Lawler and Dr. Raney came up here to the table.

CHAIRMAN JENSCH: If they have been previously sworn, they need not be sworn.

MR. SACK: Dr. Raney has not previously been sworn.

mil-3

His qualifications were presented on April 5, but he ~~has~~ was not present at that time.

Whereupon,

EDWARD C. RANEY

was called as a witness on behalf of the Applicant, and, having been first duly sworn, was examined and testified as follows:

DR. RANEY: Edward C. Raney, R-a-n-e-y, 401 Forrest Drive, Ithaca, New York.

MR. MACBETH: It ismy understanding from the Applicant that it is preferable to begin with Dr. Raney, if we could.

MR. SACK: Yes, that would be your Question 5, and then continuing to the next one on page 3.

CHAIRMAN JENSCH: I wonder what would be more convenient, Dr. Raney, could you move to the end of the table so your papers will still be before you and you can face the interrogator.

DR. RANEY: Yes.

CHAIRMAN JENSCH: Proceed, please.

XXXX

CROSS-EXAMINATION

MR. MACBETH: Dr. Raney, if we could start with the questions of migration, could you identify for us the species of fish that migrate past Indian Point to and from spawning ground.

DR. RANEY: Yes, sir. There are approximately 91 mii-4

species found in the river south of Albany. These, as they regularly migrate past Indian Point for the purpose of spawning, sea sturgeon, American smelt or rainbow smelt, alewife, blueback herring, American shad, several species of sucker, the striped bass. There are other fishes that move past this area. As a matter of fact, probably two-thirds of the fishes that live in the river south of Albany would pass this area at some time during their life. As an example, tom cod, sea-horse, pipe fish, four species, the blue fish, jack, butter fish, spot. Then there are a group of fishes which are basically resident fishes which live in this area, which may move to some extent. These movements are probably not in relation to spawning. These include two species of the catfishes, or one species of catfishes, bullheads, the white perch, the yellow perch and a half a dozen species of basses and sunfish.

MR. MACBETH: Are eels included in the list of those that migrate?

DR. RANEY: I didn't mention it, but the eel is a migratory fish which moves out of the river and moves down to the Sagasso Sea and spawns at sea. The young return, migrate up the river, live for seven or eight years of their life.

MR. MACBETH: And they would go past the Indian Point site?

DR. RANEY: Yes, that is true, sir.

MR. MACBETH: Let's take some of the fish. Can you

mil-5

describe the time in which the alewife migrates through the river, and particularly in passing --

DR. RANEY: Yes, the alewife is an early spring spawner. It moves up the river normally when the temperature begins to reach the range of 45 to 50 degrees. It usually enters the lower tributaries, and it is followed by its close relative, the blueback herring and the American shad, the shad being the last of the three members of this group to run or to migrate.

MR. MACBETH: Each of these fish in turn is migrating at a slightly higher temperature when the river reaches it?

DR. RANEY: Yes, sir. Temperature apparently is the factor which triggers migration along with natural changes in -- differences inlength of daylight.

MR. MACBETH: What would be the temperature range in which the blueback herring would be likely to pass Indian Point?

DR. RANEY: Blueback herring usually reach a maximum when water temperatures are about 60. They are still present in the river at a temperature of 75. Actually they are present now both in the Hudson and also present in the Susquehanna and Delaware at the present time. So that they cover a range, or each of themcovers a range of about six weeks in its migration unless there are substantial changes in physical condition during the migratory period.

mil-6

This year, for example, many of them were affected by the unusually high run-off which was often accompanies by decreased temperatures.

MR. MACBETH: By changes in physical condition, you mean the surrounding environment will not do anything internal tothe fish?

DR. RANEY: Everything that happens externally to some extent affects the internals of the fish because it is submersed in its environment. We speak of them as being cold-blooded because they are not necessarily -- not necessarily because their blood is cold, but because it is the same temperature as the surroundings.

MR. MACBETH: You were thinking of matters like fresh water run off of amount of sunlight, general weather temperature? Were you thinking of disease of fish?

MR. SACK: I object to what Mr. Macbeth is categorizing what Dr. Raney is thinking of. He can ask what he is thinking of rather than a suggestion.

CHAIRMAN JENSCH: In a cross-examination we try and move it along. Dr. Raney doesn't have to agree with the suggestions.

DR. RANEY: You mentioned some of the factors.

MR. MACBETH: Have I missed the important ones?

DR. RANEY: As far as migration is concerned, temperature, and these innate, inbuilt genetic factors which cause

mil-7

them to migrate at all.

MR. MACBETH: Could you give us the temperature range at which the shad would be migrated?

DR. RANEY: The shad usually reach their peak at around 65 to 70 degrees.

Here again, like theothers, they run over a period usually of about six weeks. You can get some of them coming inthe Hudson, for example, in May. Others will stay in as late as the middle of June. This year you will probably find a lot of spent shad in the Hudson past the middle of June. This has been our experience this year on the Susquehanna River.

MR. MACBETH: I think both for blueback herring and the shad, you have given me the peak temperature, which is the temperature at which most would be migrating.

DR. RANEY: Most would be at a given place inthe river. I am assuming here, for reference purposes, Peekskill.

MR. MACBETH: When the temperature is 65 to 70 at Peekskill, the greatest number of shad would be inthe Peekskill area, is that correct?

DR. RANEY: In most years, yes.

MR. MACBETH: Could you describe to me the place in the water column in which the alewife migrates? Is there a particular part of the water column?

DR. RANEY: The alewife, blueback herring and

mil-8

American shad, on the upstream migration to spawn, normally move at night and normally move fairly close to surface waters. The downstream migration in the fall, at the end of the year, they move both day and night. Those that move during the day usually move in deeper waters. Those thatmove in the evening and night usually move near the surface.

MR. MACBETH: Is your statement based on particular studies inthe Hudson River of these three fish?

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MR. RANEY: Yes.

MR. MACBETH: Could you describe when those studies were done, just an outline?

MR. RANEY: The basic studies in the Hudson River were done by the State of New York, Conservation Department, in 1936, as part of a series of biological surveys which covered the entire state. They were published in 1937 as a supplement to the 26th Annual Report of the State of New York, Conservation Department. It was entitled "The Biological Survey of the Lower Hudson Watershed, No. 11".

This document, which is some 370 pages, is entirely with the fish of the Hudson River, and much of it deals with a so-called uprunning or an anadromous fish, or migratory fish found in the Hudson.

Since that time, a rather extensive series of studies of fishes have been done ~~done~~ in the Hudson. I personally was involved in studies between 1949 and 1965. These studies resulted in a series of papers which I won't read but which we listed -- and cover two printed pages.

Studies have also been done, of course, by the ~~Tatheon~~ Raytheon Company over a period of approximately three years.

The New York State Conservation Department has on various occasions studied fishes in the Hudson River and have made surveys from the point south of Haverstraw to a point near Coxsakie, about 20 miles south of Albany, New York.

Many of these studies were not published. I was able, when I was working on striped bass, to get many of the specimens that were collected during these studies, and I believe the specimens are on deposit at one of the local headquarters.

Could I finish this?

MR. MACBETH: Certainly.

DR. RANEY: There is one other series:

New York State University -- I am sorry. New York University also, over the last five years, have undertaken a series of studies, and then more recently, my group has undertaken experimental studies, not on the Hudson River, but on fishes which occur in the Hudson River and which are of particular concern as far as heated plumes are concerned.

MR. MACBETH: I would just like to pick up one or two things that weren't entirely clear to me.

When you said the studies were not published, you were referring only to the New York State Conservation Department studies?

DR. RANEY: Yes, the more recent studies. There have been occasional publications in the New York State Conservationist, which have outlined these studies. The details in general have not been published.

MR. MACBETH: You said your group studies fishes in the Hudson. Did those studies -- now we are dealing generally with the alewife, blue back herrings and American shad -- with some of those studies?

DR. RANEY: Yes, and studied specifically for Consolidated Edison in an effort to learn what the temperature preferences of these fishes are.

MR. MACBETH: Which of those three fish were studied?

DR. RANEY: The blue back herring and alewife were studied in the greatest detail. The American shad was studied to some extent, but a former student of mine, Sanford Moss, has spent three years studying that species in a Connecticut River published study -- these studies are, in my opinion, adequate to make most of the interpretations that might be called for with regard to its behavior in or near a heated plume.

Actually we did not emphasize that. We emphasized the striped bass and the white perch because these are fishes which are ecologically significant in the vicinity of the Indian Point plant.

MR. MACBETH: Perhaps we can take up the studies first.

You said that was not a study in the Hudson River. What were the conditions under which the fish were studied in that group?

DR. RANEY: These were actually fishes of the same species found in the Hudson. We have an experimental laboratory set up on Appoquini creek at the delta where Highway 9 is crossing near Odessa, Delaware. These laboratories were set up in trailers.

They were set up so that at high tide we have Delaware River water, the salinity of which varies basically like the salinity varies at or near Indian Point.

We did the studies there because the labs were set up. We used the same species of fishes. The conditions, if they varied at all, were minor variations which probably had to do most with chemical conditions in the water.

MR. MACBETH: What would those variations have been?

DR. RANEY: The Delaware River, in the vicinity between Wilmington and Philadelphia, is the site of a number of chemical plants. We have more chemical pollution there than we do have in the Hudson.

Nevertheless, our studies were done in a place where we had 100 species of fishes. There was no obvious pollution, and the tests that we were able to run with the usual methods indicated no large amounts of copper, zinc, cadmium, mercury and other chemicals which some people might consider a problem.

MR. MACBETH: Could you describe the experiments that were undertaken by the ichthyological associates, first, the time of year in which the experiments were undertaken? Let us start there.

DR. RANEY: These studies were carried on throughout the year so that we had the advantage of studying their behavior, the behavior of fishes. There are two different temperatures.

As the temperatures were rising, as the temperatures were falling, and under winter conditions. These studies basically had to do with the temperature that a fish would go to or stay away from at a given time, and we also did studies on what we call shock experiments.

We take a given group of fishes and subject them to a sudden change such as they might undergo in an unusual situation.

CHAIRMAN JENSCH: Excuse me.

Did you publish a report of these tests?

DR. RANEY: Yes, sir.

CHAIRMAN JENSCH: I wonder if that could be submitted with that same kind of interrogation and you can review it.

MR. SACK: That was made available to Mr. Macbeth last week when he raised these questions.

CHAIRMAN JENSCH: Proceed.

MR. MACBETH: In response to that, there are parts that I was trying to get.

CHAIRMAN JENSCH: I wanted you to have an opportunity to review it.

Proceed.

MR. MACBETH: Could you describe the kind of tank or whatever you kept the fish in?

DR. RANEY: What we do is bring the fish into the laboratory and keep them under the same conditions that we found them in nature.

In other words, we would keep them acclimated to what we call the ambient water temperature, the temperature in which they were living.

We have a tank that is divided into four quadrants. On one side of this quadrant we have what we call T. The ambient temperature. On the other end we have T-plus 3 or 4 degrees. On the other half of the quadrant we have the reverse so that at one time we can run our replication experiment.

So we put the fishes in, for instance, at 40, and then they have a chance to either stay in water that is 40 or move toward the alternate temperature, say, of 45 degrees or 40 degrees. We observe using closed television system, using videotape, so that our presence will not be a disturbance to the fishes.

MR. MACBETH: What were the temperature ranges that

that you covered in these experiments?

DR. RANEY: Basically from around 35 degrees Fahrenheit up to more than 80 degrees Fahrenheit, and through a year.

MR. MACBETH: Perhaps I should phrase it differently.

What kind of delta-T or what kind of differences across the experimental pond did you use?

DR. RANEY: Normally we would use a delta-T of basically four or five degrees. The reason we chose this was this was in Sanford Moss' studies on American shad, it indicated that in temperatures up to five degrees Fahrenheit, in summer, were ecologically ~~significant~~ insignificant as far as fishes were concerned.

It passed through this ~~rtange~~ range of ~~temepratures~~ temperatures as they go from, say, top to bottom, mid-river to shore. But when you get temperatures that are in excess of this in a given area, the fish tends to move away.

In other words, they are attracted up to about five degrees.

We have a temperature differential higher than that and they tend to be ~~repeled~~ repelled.

So that in a given series of experiments, we start with a different temperature, and acclimate the fish, give them a choice, see which way they go, and see how far they will go until they are repelled.

MR. MACBETH: At the relevant ranges for the three species which we are describing, 45 and 50 degrees for alewife, a 60 -- around 60 -- for blue back herring, and 70 for shad, did you find the fish were either rejected or repelled?

MR. SACK: Mr. Macbeth is ~~Mr. Macbeth~~'s characterizing the previous testimony as far as temperatures go. We are not sure he has correctly phrased these questions.

I think we should leave that to the record.

MR. MACBETH: I will rephrase it if you like.

Taking the alewife, did you have any experiments where the temperature to which the alewives acclimated to 60 degrees?

DR. RANEY: Yes, sir.

MR. MACBETH: Did you find that over any of the temperature ranges that you studied, there were either an attraction or a repulsion to the water?

DR. RANEY: Yes, sir.

MR. MACBETH: What temperatures did you find attraction at?

DR. RANEY: We found that fishes which were acclimated to a temperature of 63 degrees Fahrenheit on 3 November 1971 avoided the temperature of 79 degrees Fahrenheit.

On 21 October 1971 fishes that were acclimated to a temperature of 64 degees Fahrenheit avoided the temperature of 76 degrees Fahrenheit. They were attracted to the intermediate temperatures.

On 5 August 1970, alewife acclimated to 77 degrees and avoided a temperature of 86 degrees, but was attracted to the intermediate temperatures.

These data that I have been reading are on page 36 of a paper called "Temperature Preferences, Avoidance and Shock Experiments with Estuarian Fishes" done by Doctors John W. Meldrin and James J. Gift, and published in ~~Ecological~~ Ichthyological Associates Bulletin 7, dated November, 1971.

Mr. Chairman, if you would like a copy of this for the record, I would be glad to leave this copy.

CHAIRMAN JENSCH: We'll let your counsel handle that. Thank you.

MR. MACBETH: Taking the blue back herring did you do --

DR. RANEY: We did so for the herring, also.

MR. MACBETH: Could you give us a rundown on that?

DR. RANEY: Yes, sir.

A specimen acclimated at 59 degrees, 28 October 1969, avoided temperatures of 76 degrees but were attracted to intermediate temperatures.

On the same date another group of blueback herring acclimated to 59 degrees, avoided 77 degrees.

This was on page 34.

MR. MACBETH: Take the shad, just briefly, 65 to 70 for the temperature.

DR. RANEY: I have no data in this report on shad.

MR. MACBETH: Let me return to the series of studies which you yourself made between 1949 and 1965.

I believe you had a list of studies there?

DR. RANEY: Yes, sir.

MR. MACBETH: ARe all of them published papers?

DR. RANEY: Som of them appeared in various documents.

MR. MACBETH: I would like to have that list, but I don't see too much point in reading it in the record. Could we place it in the record as if read, and provide me with a copy of it?

CHAIRMAN JENSCH: You will have to furnish the requirement to the reporter, 30 copies of whatever it is.

MR. SACK: If Mr. Macbeth wants to undertake it, all right. I am not sure I understand the relevance of a list of these papers.

MR. MACBETH: I assume that is one of the foundations for Dr. Raney's opinion. We would like to have that list so that our own experts can look at it. When we give it to them on this point, it would be useful to know they are covering the same basic materials as Dr. Raney's.

MR. SACK: We think this is in the nature of discovery. I don't think this is evidentiary.

MR. MACBETH: It is evidentiary. It is a foundation of Dr. Raney's opinion.

He stated he relied on this list of studies.

MR. SACK: I don't think he said he relied on all of these.

MR. MACBETH: Dr. Raney, could you distinguish on those which you relied and those on which you did not rely?

MR. SACK: Could the reporter repeat the question, please?

(Whereupon, the reporter read the pending question, as requested.)

MR. TROSTEN: The Applicant is perfectly willing to make a copy of this available, this list, available to the Intervenors for their review.

In the course of his general discussion, Dr. Raney mentioned that he was the author of a number of papers, and that he participated in a number of studies. In order to determine whether he has relied on a particular study for a particular portion of his testimony, it would be necessary to determine exactly the question involved, and so on.

I see no reason why this list of documents should somehow become a part of the record in the proceeding. We are perfectly willing to give a copy of it to Mr. Macbeth if he doesn't already have it. He may well have it at the present time.

CHAIRMAN JENSCH: I understand the last pending question was, on what papers did you rely for the formulation of the opinions as expressed here, and he was in the process of answering that when the question came about re-reading some previous portion of the inquiry.

MR. TROSTEN: Mr. Chairman, I would suggest that Dr. Raney has expressed a number of opinions here. I think it would be rather difficult for him to go back through the record and determine exactly which opinions he expressed to see whether he happened to rely on one of the studies which span a period of some 20 years.

CHAIRMAN JENSCH: Won't that be foundation evidence in any event? He expressed many opinions and how he derived the opinion would still be a matter of inquiry, would it not?

MR. MACBETH: I believe Dr. Raney stated that as a foundation for his opinion, he mentioned this list of studies. I believe we can go back and ask him which it is that he relied on.

MR. TROSTEN: I really believe, Mr. Chairman, we would have to go back to look at the particular statement involved.

CHAIRMAN JENSCH: My recollection was that he stated he participated in many papers. Doesn't that indicate that he had used them? I think the pending question seeks to determine that.

MR. TROSTEN: Mr. Chairman, I believe the record will show that Dr. Raney, when he read or mentioned this list of statements, was simply referring to the studies that he had made over a period of time.

CHAIRMAN JENSCH: That was my understanding of his statement, only that far. I think the interrogation now is, did you rely on or what were the ones you did rely for your opinions.

I think that is pending now. He hasn't determined that any of the papers has been used yet. I think the question is still pending.

MR. MACBETH: Did you indicate which of those papers in that period you relied on in reaching your opinion as to the effect which heated plume will have on the migration habits of blueback herring, alewives and American shad?

MR. SACK: I don't think Dr. Raney has expressed an opinion on the effects of the heated plume on migration. We haven't asked -- discussed the heated plume. We have been discussing migratory appearances so far.

MR. MACBETH: That is accurate. I will rephrase it.

I think at the moment we got into the list, I posed to you a question on the migration appearances through water colume of alewife, blueback herring and American shad.

Would you indicate which of those studies you relied on in giving us your opinion as to those migration appearances?

DR. RANEY: The studies I referred to are basically on striped bass. The studies I have relied on with regard to my opinion on blueback herring and alewife and American shad is the literature which consists of hundreds of papers.

MR. MACBETH: Are there any on the particular studies of those fish beside those undertaken by the ~~Ecological~~ Ichthyological Associates on which you relied, and the studies that you made or made under your direction rather than the studies that are in the general literature?

DR. RANEY: The studies made under my direction are now in the general literature.

MR. SACK: I don't understand the question. Maybe Dr. Raney does. It would seem general to me.

CHAIRMAN JENSCH: Perhaps the -- perhaps you can work it out later. I am having difficulty knowing what the opinions -- as I understand the witness, he has indicated his findings of fact that certain fish were accustomed to a certain temperature and they avoided temperatures at 64, 77, 76, 66, degrees, respectively, as an illustration.

The herring, if it was accustomed to 59 degrees, avoided 77 degrees. These are findings of fact. I don't understand where the opinion evidence has been reflected yet.

MR. MACBETH: I was going further back, Mr. Chairman, to my earlier question about the way in which the fish migrate through the water column. Dr. Raney said his answers he based on a number of different studies. He listed off a great many, one of which is Ichthyological Associates. I was coming to that.

6

CHAIRMAN JENSCH: Proceed.

MR. MACBETH: Have you urself made studies, aside from those of ichthyological associated, which examine the facts of where alewife, blue back herring and American shad migrate through the water column?

DR. RANEY: If I understand it, are their patterns in the literature which describe where young American shad migrate as they move down stream?

MR. MACBETH: Either written by you or under your direction. I don't expect -- my only point is, I don't expect you to review the entire general literature but I would like to pinpoint anything which you yourself has done.

DR. RANEY: The major study done on downstream of small young American shad was done by a biologist working under the direction of a committee of six specialists, of which I am a member. These studies were done in the Connecticut River in connection with the Connecticut Yankee plant. The biologist is Bart Marcey. The last issue appeared in Chesapeake Science which appeared a week ago.

MR. MACBETH: Are there any others?

DR. RANEY: The major paper which I referred to with regard to the American shad and its avoidance of temperature is that by Sanford Moss. This paper was also prepared under the technical direction of the group of experts, so-called, advising on the Connecticut Yankee Studies. This has been published in transactions of the American Fishery Society in approximately 1969.

MR. MACBETH: Could you tell us where across the river ~~yellow life~~ alewife would migrate?

DR. RANEY: On a given night you might find alewife at any point in the river but the larger number of them which are actually migrating rather than milling around would be found in or near the channels. At night they would be moderately close to the surface. This is the indication that we get from gill net sets.

Our difficulty here is that some fishes can avoid gill nets. We did know that nets set near the surface, which hang from the surface, catch fishes such as the ~~yellow life~~ alewife, blue back herring and American shad, when they are set in or near channel areas. This does not mean that they do not also use the shallower areas to migrate to some extent.

One of the reasons we don't know very much about this is that normally fishermen do not fish in these shallow areas because of difficulties in getting there.

MR. MACBETH: Could you tell me where the blue back herring migrate?

DR. RANEY: Basically, riverwide, but they seem to be concentrating -- here again, they can be distributed in great numbers from bank to bank below obstruction, such as dams. But in channels below dams they appear to be most common in channels.

MR. MACBETH: Tell me about the American shad.

DR. RANEY: It had the same basic migratory pattern. Basic migration seems to occur in or near the channels.

MR. MACBETH: Is your statement on the place in the river, cross-section of the river in which the fish are migrating based on particular studies you have made or made under your direction?

DR. RANEY: Either observations that I have made or have been made by people working for me and under my direction, or as stated in the literature.

MR. MACBETH: Are all the studies that you have undertaken also reported in the literature?

DR. RANEY: Ultimatly, yes.

MR. MACBETH: Are there any studies that you have that you haven't reported?

DR. RANEY: Yes, sir.

MR. MACBETH: Where are these?

DR. RANEY: These have only not been reported because they are still underway.

MR. MACBETH: Would you be in a position to give the results of those studies at this time or are they not in sufficiently concrete form?

MR. SACK: Objection, Mr. Chairman. The witness has testified that he hasn't completed these studies. Then it is improper to ask for results.

CHAIRMAN JENSCH: Any kind of results are you looking for? Does he have anything that you consider final in any respect, whether you publish them or not?

MR. SACK: Mr. Chairman, this is a man that does a lot of work and has many projects. I think the question has to be more specific. I am not sure what contention we are working on now and what specific study Mr. Macbeth is looking for. I think the question is too broad.

CHAIRMAN JENSCH: Objection overruled.

DR. RANEY: The question, please, Mr. Reporter.

(The reporter read the record as requested.)

CHAIRMAN JENSCH: Can you restate it, Mr. Macbeth?

MR. MACBETH: Yes.

Do you have any results that you can state of studies that have not been reported in the open literature which indicate where in the cross-section of the river alewife, blue back herring and American shad are?

DR. RANEY: Yes. Over the last two years in the Susquehanna River and the Susquehanna flats, that is the upper part of Chesapeake Bay, we have been studying the migration of these three species plus the hickory shad which is closely related. For the most part, these fishes migrate in or near the channels. In most of the movement of adults upstream is at night.

MR. MACBETH: Let me turn at this point to the striped bass. When in the course of the year do the striped bass migrate to and from the spawning grounds?

DR. RANEY: Striped bass spawn basically shortly after American shad have reached their peak, water temperatures are 65 to 75. They spawn normally in virtually fresh water.

MR. MACBETH: What about their seaward migration?

DR. RANEY: The seaward migration of the striped bass is a very complicated business. The reason it is complicated is that there are different contingents of striped bass. For example, in the middle of the Atlantic coastal region, most of the striped bass that we enjoy catching, say, off Montauk or off Cape Cod, are actually three years old or older, and they were born either in Chesapeake Bay or Delaware Bay.

Most of them were spawned in the Chesapeake Bay. When they are two years or older, they begin to make this migration. They migrate northward in the spring. They come back sometimes over winter in North Carolina, sometimes at the lower Hudson or Mullica region of New Jersey or on the eastern rivers. This is the big group for, as I call them, race of striped bass. The striped bass so come on in the Hudson River -- I call it the Hudson River race. It is 80 percent from the Chesapeake Bay race upon the basis of comparable characters, such as fin rays, scales, this sort of thing. Our studies, and these have been confirmed by studies of others, indicate that these fishes were spawned in the Hudson River. They undertake migrations of the following type. They move out of the Hudson River into the western quarter of Long Island Sound where they form an important summer fishery. Others move out of the

eak 6

river and are found in the lower bays in the New York area. Some of them spill out around the New Jersey coast. Basically they are in or near the New York City area or in the Connecticut area. This does not mean, of course, that members of other races along the Atlantic coast do not at times come in the Hudson and ~~in~~ studies, have indicated that they do.

So that in trying to give a simplistic explanation of the movements of great species of fish, it is very, very difficult.

end 7

MR. MACBETH: Is there a particular time when they go to the -- those of the Long Island Sound or the New Jersey Coast move along?

DR. RANEY: Yes, sir.

MR. MACBETH: What is that time?

DR. RANEY: After spawning or before spawning, in the case of mature fishes, they move out in the late spring and are found in the western quarter of Long Island Sound through the summer, or in the New York Bay area, or spilled out in the area along North Jersey, and then near November, depending somewhat on temperature, they move back in the Hudson River, and over winter there, when they become mature, they spawn.

After spawning, they undertake these local migrations again.

MR. MACBETH: Have you undertaken studies of the attraction or repulsion of stripped bass by heated water?

DR. RANEY: Yes, sir.

MR. MACBETH: Were they the same series of studies that you described the Ichthyological Associates had undertaken?

DR. RANEY: Yes, they were described in Bulletin No. 7 of November, 1971, of Ichthyological Associates.

MR. MACBETH: I assume that the general description of the tank andthe way in which the temperatures were distributed would be the same for the striped bass as it was for the

mil-2

other fish?

DR. RANEY: Yes, sir. The experiments were done in the same tank, yes.

MR. MACBETH: Did you do experiments on the attraction or repulsion of heater water, striped bass where temperature of the ambient waters was 65 and 75?

DR. RANEY: Yes, sir, we did a series of experiments starting with ambient temperatures of 41 and going as high as ambient temperatures of 77. These included most of the year. These are shown on page 26, Table 3 of the Bulletin 7.

MR. MACBETH: Could you briefly describe the results where the ambient was 65 to 75, please?

DR. RANEY: Yes. On October 22, 1970, when the acclimation temperature was 61, striped bass preferred temperatures of 73.

MR. MACBETH: Should I read that to mean that they were repelled by the numbers up to 73 and attracted above that?

DR. RANEY: They prefer temperatures of 73. If the temperatures had been higher than that, they would have been repelled.

MR. MACBETH: They would have been repelled?

DR. RANEY: Yes.

MR. MACBETH: Were they attracted at any temperatures lower than 73?

DR. RANEY: On October 15th, when the acclimation temperature was 68, they preferred a temperature of 77. On October 14th, when the acclimation temperature was 70, they preferred a temperature of 79. Basically the higher the acclimation temperature, the higher the preferred temperature. Whatthis means from plume standpoint is, the fishes will move, basically, into a plume until it reaches its preferred temperature. If the temperature becomes higher than that, it moves out. This is the reason we very, very rarely have any fishes killed in the heated plume.

MR. MACBETH: When a fish moves into a heated area and reaches the temperatures to which it would be attracted, does it tend to remain there?

DR. RANEY: It would tend to remain there if it is close to a preferred temperature, yes, sir.

MR. MACBETH: Have you conducted any other studies or have there been any other studies made under your direction aside from this series of Ichthyological Associates which deal with the attraction or repulsion of striped bass to temperatures of this sort?

Perhaps that is too vague.

That is that deal with the attraction or repulsion of striped bass to heated water.

DR. RANEY: These studies that I am referring to are the best, most detailed studies of preferred temperature

mil-4

attraction dash repellant temperatures of striped bass that have ever been done.

MR. MACBETH: I just want to establish that we were on the firmest ground.

DR. RANEY: There have been occasional studies that have been done where striped bass may have been acclimated to a givên temperature, and given an opportunity to go at another. These studies were done basically through a whole year, both for striped bass and for white perch.

MR. MACBETH: Where were these striped bass taken from?

DR. RANEY: At Augistine Beach, Delaware River.

MR. MACBETH: Do you know where they spawned?

DR. RANEY: On Augistine Beach.

MR. MACBETH: On Augistine Beach?

DR. RANEY: Yes.

MR. MACBETH: So they are not at any rate, fish of the Hudson River race of which you spoke?

DR. RANEY: No, they are not.

MR. MACBETH: Could you describe where in the cross-section of the river the striped bass migrate to and from the spawning grounds?

DR. RANEY: In my experience, based upon extensive gill netting of over 35 years, they are mostly found in or near the channels during migration. But they may spawn

mil-5

almost any place in the river. They spawn near the surface in groups.

MR. MACBETH: When you say in the channel, is that always the deepest part of the river or is that generally parts of the river that are below a certain depth?

DR. RANEY: The distribution can vary tremendously from day to day. It depends also on what chemical conditions might be, whether dissolved oxygen is present or not. In other words, they often tend to avoid the deeper parts of a 40-foot channel if the dissolved oxygen is low.

MR. MACBETH: In other words, is there a particular depth toward which they tend? If you had a choice, say, from 0 to 60, would they tend to be 20 rather than 40?

DR. RANEY: Well, in my experience, the rivers that I worked with, have 40-foot channels. In these rivers the distribution is basically in the top 30 feet.

This is the channel which is kept dredged for shipping, or which, in many cases, would be a natural channel.

MR. MACBETH: Is your opinion or statement where the striped bass, in which cross-section they migrate, based on particular published studies? You gave me the impression it might be your general experience.

DR. RANEY: It is my general experience based on gill netting. But we also have the advantage of having

mil-6

sonically tagged fish, relatively few samples. It basically indicates they follow channels. We have much more extensive data on American shad. These, again, are mostly Connecticut River studies. Studies also have been done elsewhere. We do have a few examples of sonically tagged striped bass that we have been able to follow for several miles. These were basically followed in the channels.

MR. MACBETH: How few is a few, 10 or 100?

DR. RANEY: Fewer than five, as I recall.

MR. MACBETH: Whereabouts were those tests taken?

DR. RANEY: In the Delaware.

MR. MACBETH: In the Delaware?

DR. RANEY: Yes.

MR. MACBETH: It sounds like such a small number. Is there some particular reason that the experiment was only to do five?

DR. RANEY: The tags are very expensive. You can work for seven or eight weeks and maybe be lucky and get a few tagged and be able to follow a couple. It takes a lot of years of work on a given fish to really get significant data.

For example, as far as the studies that were concerned in Connecticut, it took five or six years of experimenting with various kinds of sonic tags before they started to get any results at all. But the technique now has worked out to a point where a young investigator could take it, and if

mil-7

he were diligent, he could get results.

MR. MACBETH: Getting back to these five or seven in the Delaware, were more tagged and lost?

DR. RANEY: Yes.

MR. MACBETH: How many were tagged?

DR. RANEY: Upwards of 20.

MR. MACBETH: Let me go back for a moment to your statements about the Hudson River race of striped bass. Are there striped bass that spawn in the Hudson that winter over in other areas, other rivers?

DR. RANEY: It could be, but we, over a five-year period, found little evidence of it. My recollection of John Clark's paper which appeared in the transaction of the American Fisher Society, that he did not find substantial evidence of a fish which actually belonged to the Hudson race having ever wintered elsewhere. But the striped bass is the type of a fish -- from all we know about the Chesapeake Bay race, that occasionally do not go back to the Chesapeake Bay and may go off to North Carolina and Albermarle Sound. Some of them go into the Mullica River. We have a few of them over wintering in the Connecticut River, and some in the Thames River in Connecticut. There are a few places in Cape Cod where they find over wintering population. The conclusion of this is that it would not surprise me that if occasionally a Hudson River striped bass might over winter someplace else.

mil-8

But the results from our tagging experiments -- and there were several thousand tags involved -- it ~~inticated~~ indicated a relatively short movement either to the western portion of the Sound, or around the mouth of the Hudson River.

Let me turn to the white perch. They are not a seasonally migrating fish, but a resident fish in the Hudson.

I think they are a resident fish that migrate. In other words, I don't think the white perch go out of the Hudson River like the striped bass did, but there is migration in the Hudson, and there is over wintering in the lower part of the Hudson. It is much more extensive than the over wintering in the upper part.

MR. MACBETH: When would the white perch be most likely to be around Indian Point?

DR. RANEY: In the winter, except that any time you will find white perch around Indian Point. You will find a very great concentration of white perch in that area. It is probably one of the greatest over wintering areas for any fish that I know.

MR. MACBETH: Have you done studies on the attraction or repulsion of heated water to white perch?

DR. RANEY: Yes, sir.

MR. MACBETH: Are they, again, the -- principally Ichthyological Associates?

DR. RANEY: Yes, in the Bulletin, and they were

mil-9

carried on through the year.

MR. MACBETH: Have you done studies of the water temperatures that you would find in the Hudson and Indian Point in the winter?

DR. RANEY: We have done them in acclimation temperatures of as low as 34 degrees on February 11, 1971.

MR. MACBETH: What did you find was the attraction or repulsion of fish?

DR. RANEY: We found that they preferred a temperature of 41 degrees at that time. In other words, they went toward the warm water, but they were repelled instantaneously at temperatures higher than that. This is the general principle.

In any of these fishes that live in the Hudson River at temperatures of 34, they will be attracted to warmer water. They will all go toward the preferred temperature.

MR. MACBETH: Up to 41 degrees?

DR. RANEY: Well, 41 degrees. This was a given experiment. We would begin another experiment, starting at 41, to see what would happen. For example, if we have a fish which is acclimated to 43 degrees, then it prefers a temperature of 52 degrees, still going toward higher and higher temperatures if they have a chance to acclimate, until they get somewhere in the temperatures which are in the low 80s, Fahrenheit.

mil-10

MR. MACBETH: Do you have other particular experiments other than white perch up to an acclimated temperature of 45 degrees? Do you have the results of those, quickly?

DR. RANEY: We have one at 46, 24 November 1969, acclimated at 46. This would prefer a temperature of 45. This is the fall of the year. The temperatures were falling.

On the other hand, in December, fish acclimated to 43 degrees and preferred a temperature of 49. Again, these are on page 23 of Bulletin 7.

MR. MACBETH: Let me go back to a statement you made a moment ago, that fish in the Hudson at 34 degrees prefer, I believe --

DR. RANEY: I said they prefer warmer temperatures. In 99 percent of the cases, they do. The exception of this is when temperatures are falling in the fall of the year. This is one of the reasons they did these temperatures, both falling and rising temperatures and through the summer. There is some variation of the temperatures we prefer, depending on the time of the year the experiments are done. Possibly we have the other factor coming in there of the --

MR. MACBETH: In the winter it would be the warmer temperatures, is that correct?

DR. RANEY: These are our results: In December, January and February, in experiments, they all went from a cold to a warmer temperature.

MR. MACBETH: How much warmer would the water have to be to attract them? If it was only one degree Fahrenheit warmer, would that still act as an attractor?

DR. RANEY: Yes. Fishes are very acute in their perception of temperature difference. This doesn't mean that they avoid them because they are one or two or three or even five degrees. But fishes can perceive temperatures of much less than one degree Fahrenheit.

MR. MACBETH: Would fish be attracted to differences of much less than one degree Fahrenheit?

DR. RANEY: If the start of a gradient has to be almost one-tenth of a degree. So if you have a gradient leading from a heated plume, it actually ultimately comes down to one-tenth the degree. If the fish senses this, it would follow toward the gradient and toward the higher temperature until it comes to a temperature which repels it. The degree will depend upon the original acclimation temperature.

For example, a fish acclimated at 36 will go to 45. If the temperature were higher than 45 in the deeper part of the plume and nearer the effluent, it would be repelled. Here again, this is the reason that we did not get kills of fishes near heated plumes except in very, very extremely small specimens.

MR. MACBETH: By this, you mean kills directly from

mil-12

thermal discharge?

DR. RANEY: Yes, sir.

MR. MACBETH: When the fish inthe winter move from those temperatures to slightly warmer ones they prefer, are there marked changes in their metabolism and behavior?

DR. RANEY: There can be with certain species. If you decrease the temperature 10 degrees and if they acclimate to this, you may get a doubling of metabolism. But with a white perch, the fish that we have been discussing, they stayed very lethargic until you get a temperature of almost 45. They can swim rapidly in cold water, but they don't prefer to it. They are lethargic. It is a behavior character.

MR. MACBETH: Could they, in a very laymanlike way, if you went out and disturbed them, they would be likely to swim, but if you left them alone, they would be in a lethargic state or equivalent to a hibernation, almost?

DR. RANEY: Well, white perch do not hibernate, but they do become very lethargic. Some fish do, actually. They go down in the mud when the water temperature becomes 40. They are quiescent until it warms up in the spring. White perch and striped bass are active near the bottom, but the white perches are a lethargic species.

MR. MACBETH: Whatabout the striped bass? Is it --

DR. RANEY: A striped bass is more active than the white perch in winter and will feed more often. It often is

mil-13

the source of a winter fishery.

MR. MACBETH: As it moves up gradient toward a preferred temperature, would it increase its activity considerably?

DR. RANEY: ~~The~~ It increases its metabolism, doubling basically in 10 degrees. It would tend to swim faster if it had a reason to. For instance, if it were feeding. In the winter you get most striped bass in places like the Mullica River, in New Jersey, when the temperature is 40 to 45 rather than when the temperature is 33 to 37.

MR. MACBETH: Would the striped bass, as it moves into that preferred temperature, tend to remain lethargic in behavior?

DR. RANEY: Well, they will because under normal conditions in the winter you seldom have an opportunity to go in the winter that is greater than 40 degrees.

End 8

CHAIRMAN JENSCH: Proceed.

MR. MACBETH: I just have a few more questions for this witness.

CHAIRMAN JENSCH: Will you proceed, please.

MR. MACBETH: If a heated plume was present in the winter months in the Indian Point area, do you think white perch would be attracted to it?

DR. RANEY: Yes, sir.

MR. MACBETH: What part of the plume would they be attracted to?

DR. RANEY: They are going to be attracted to it if there is any kind of a gradient leading out of it. They will go into the plume. How far they go will depend upon the delta-T, it's imcrease in various parts of the plume above ambient.

MR. MACBETH: Let's say acclimated temperatures.

DR. RANEY: Yes, sir.

MR. MACBETH: How about the striped bass, again a winter with a heated discharge? Would they be attracted to that?

DR. RANEY: Yes, indeed. They have been, any place you want to go in the winter along the east coast, if you want to catch striped bass, you fish in heated plumes. There's where they are.

They are going toward their preferred temperature.

They stay in there and they feed. Later on they move out and spawn.

MR. MACBETH: No place like a power plant to catch fish, one way or the other; is that correct?

Maybe we can do a couple of the other fish. What about tom cod at that time of the winter?

DR. RANEY: Tom cod is a winter spawner.

MR. MACBETH: Would you also find it attracted to a heated plume?

DR. RANEY: To a lesser extent.

MR. MACBETH: Are there other fish that you feel are important in the Hudson River area? I don't want you to go down the whole list of 93. That is that would be attracted to a heated plume in the winter months at Indian Point?

DR. RANEY: In the winter months, virtually all the fishes that were in the Hudson that had not already retired to the deeper waters or gone into the bottom mud, if they came in contact with a gradient leading from the heated plume, they would go toward the gradient, go toward the heated plume.

So that heated plumes are an attraction to fishes in wintertime.

MR. MACBETH: We have no further questions of the witness at this point, Mr. Chairman.

CHAIRMAN JENSCH: Regulatory Staff?

MR. KARMAN: I have no questions.

CHAIRMAN JENSCH: New York State Atomic Energy Council?

MR. SACK: Could we have a short recess before the redirect?

CHAIRMAN JENSCH: Let me ask Dr. Raney to consider something.

Would you tell us, what are the similarities and dissimilarities between the experimental conditions under which you carried on this experimental work and the Hudson River conditions, both summer and winter?

DR. RANEY: Any experiment that you carry on is subject to the experimental conditions. In the first place, you are limited to the size of the fishes you use. Most of the fishes we used were basically three to five inches in length. So that we can only assume that these results are applicable to a larger fish.

However, we do know that larger fishes are attracted to heated plumes in winter. The only striped bass fishery that ever developed in the lower Connecticut River developed in the plume of a Connecticut Yankee atomic plant. It was an excellent sport fishery and lasted real good for one winter. There was no natural spawning of striped bass in the Connecticut and only assumed that these were

Cheasepeake bass that found their way in there to over-winter, and were attracted.

So we do have the factor of only being able to work with fishes of relatively small sizes. Obviously we can't work with mature fishes because striped bass mature when they are two to three years old, at a length of 12 to 14 inches.

Females mature when they are four to seven years old, at which time they may be 14 to 24 inches long. They may live as much as 25 years.

Obviously all these kinds of things are variables that you can't cover in an experimental situation.

However, there are very good confirmations between where you find fishes in nature and where you find them under experimental conditions.

CHAIRMAN JENSCH: Have you completed your answer?

DR. RANEY: Yes, sir.

CHAIRMAN JENSCH: How about the constituency, if I use the word correctly, of the water? Does it vary with the conditions of the water?

DR. RANEY: Yes. Every piece of water differs from that of every other piece. You could never make identical water. Even distilled water differs.

So there is this matter of difference between the water that we use and the water in the Hudson.

CHAIRMAN JENSCH: What affect would that have on your results?

DR. RANEY: I would say none whatsoever. The only way it could affect the results is if there was something present in concentrations which would be lethal or sub-lethal.

CHAIRMAN JENSCH: How about something nutritious?

DR. RANEY: The fishes that we used for experiment are all fishes that are in excellent physical condition. We don't use sick or diseased fishes.

We do not need them during experimentation. We keep them at their acclimation temperature usually for 24 hours to give them a chance to adjust. We run the experiments. Sometimes we do additional experiments with them, but usually we go with fresh specimens for additional experiments.

CHAIRMAN JENSCH: Why didn't you use the specimens from the Hudson River?

DR. RANEY: We had our operator set-up, in connection with another series of experiments that we were doing. The apparatus cost $100,000.

I had two young men who had gotten their doctorates that had specialized in these type of experiments. They had their homes and families near Odessa, Delaware.

It seemed only logical to me to do these things where you have the equipment and the expertise. However, we do have this setup in a trailer, a house trailer. It could be moved. I would anticipate we would find no difference.

Why do I say that? Within the Delaware River we have a 100-mile stretch between the Delaware Memorial Bridge and the mouth of the River. We have taken, at various times, fishes for experimentation throughout this 100-mile stretch.

You run into the varied conditions both in salinity and presumably in chemical quality of the water, because we assume that the chemical quality is poorer close to the Delaware Memorial Bridge, which is near Wilmington and near the vast chemical plants.

So, considering all of these factors and the fact that the results which you get in taking fish one place and another have convinced me that it would not have been -- that it is not necessary to do the fish with the conditions you find in the Hudson River.

However, if we were starting from scratch, so to speak, this was what should be done. These studies should be done dock-side, using the river water where the fishes occur.

CHAIRMAN JENSCH: When you do take a fish from one area to another, don't you take a scoop of water and some fish, and you have fish in thewater, and you can do the same thing by moving the Hudson River water and the fish to your Odessa lab just as easily as you could by picking it up in the

100-mile stretch in the Delaware River, could you not?

DR. RANEY: You could do it just as easily, sir. That is the crux of it. Just as Dr. Geyer knows in experimentation, whenever you undertake to move fish considerable distances, then what you are doing is, you are getting involved first with different acclimation temperatures, different degrees of salinity.

We prefer to run it at the same salinity and in the same ~~watter~~ water in which we capture them. This doesn't mean you can't do these experiments.

A lot of people do. They go to Florida and bring back fishes and do experiments on them in the north. These fish experiments are valid. These are different types of fish.

CHAIRMAN JENSCH: How large are these tanks in which you had them?

DR. RANEY: The experimental tanks shown in Figure 2 in the Bulletin 7 are six feet long, two feet wide, and they are divided by a center compartment, so that each of the experimental compartments is one foot wide. The depth of the water that we usually use was from three to seven inches, depending upon the behavioral characteristics of various species which differ somewhat.

For our temperature preference apparatus, we have a tank which is 13 feet long, which is heated along the lower side with infrared bulbs. In this Bulletin, these are both described in detail and pictured.

CHAIRMAN JENSCH: Do you have any control of temperature?

DR. RANEY: Yes, sir.

CHAIRMAN JENSCH: You do?

DR. RANEY: Yes. We have a very good temperature control.

CHAIRMAN JENSCH: AVe those on rheastatic arrangements?

DR. RANEY: Yes.

CHAIRMAN JENSCH: What was the range of the temperature used in the control of your bulbs?

DR. RANEY: We used temperatures from 32 degrees to 86 degrees for our preference studies.

CHAIRMAN JENSCH: Did you find any of those conditions present in the Hudson River?

DR. RANEY: 32 degrees course in the Hudson River. In my experience, the higher temperatures were somewhere in the low 80's in the Hudson.

CHAIRMAN JENSCH: What work have you done on the Hudson specifically? Is the list as long as your arm?

DR. RANEY: My specific work on the Hudson, sir, was largely in connection with striped bass. These resulted in a series of published papers to which I have alluded previously.

CHAIRMAN JENSCH: And you have a list that shows all of your results of all of your work done on the Hudson River; is that correct?

DR. RANEY: It shows the results of work that I have done. It does not include the results of some of my 40 Ph.D.'s that also studied the Hudson and other rivers along the coast, and my thousands of other students that have also contributed studies both to the Hudson and elsewhere.

CHAIRMAN JENSCH: What, in brief summary, did you do in the Hudson River? Can you tell us in a brief way what your papers showed? Did you do the same kind of thing, for instance, with striped bass on the Hudson River in finding different temperatures to which they were exposed and that type of thing, and that was the range of those temperatures?

Maybe we are eventually going to get this book in evidence if we keep asking enough questions. Which would you prefer, letting us read it or reciting it piecemeal?

MR. SACK: Mr. Macbeth can introduce it in evidence if he wishes.

MR. MACBETH: So could the Applicant. I have no objection ito it going in evidence.

MR. SACK: I don't think that last question relates to the green book. Perhaps Dr. Raney should answer this last question.

CHAIRMAN JENSCH: Tell us what you did with the striped bass. As I understand, that was the principal fish you have examined in the Hudson River; is that correct?

DR. RANEY: Well, I have examined every species that lives in the Hudson River, and over a period of 40 years; my major experience and publications on the Hudson River have involved the striped bass.

The early experiments had to do with whether the striped bass in the Hudson River was different from the striped bass that occurred in the Cheasepeake Bay. Quite by accident, we had young from both places and by coincidence we made counts of them and found that these counts were different.

To us this indicated that there probably was a racial difference. During the spawning time there was not complete mixing of striped bass from the Hudson and striped bass from the Cheasepeake, which is what you would expect.

Having found this, we went into it further and studied the fishes from as close to the mouth of the Hudson as we could find striped bass, up to Coxacki Beach, which is close to Albany. We hit all the spots on the river where striped bass could be obtained. We did find that there was consistency in the difference; in other words, that there was a good racial difference in all of the specimens that we took in the Hudson River. We did -- in order to make sure, we repeated it for three or four years. Then at that time I was asked by the U.S. Fish and Wild Life Service, to undertake to coordinate a study on striped bass which would include all of the states from Massachusetts through Florida.

I did so.

During those years, many of my graduate students worked on problems that had to do with the striped bass and related these to our results which we found in the Hudson. But as part of this study, Warren Ratchin, a young biologist, by the name of Lou Miller, made a study of the distribution of eggs and larvae of the striped bass.

I served as overall technical adviser to this study. This was published in the New York State Fish and Game Journal.

There was a period of years when we worked on blue fishes, and we got to the mouth of the Hudson River again. Later I served as consultant to the Raytheon Company during the period they were studying fishes near Indian Point. This was over basically a three-year period.

CHAIRMAN JENSCH: There are situations that would be similar in the Hudson River to those in your experimental work. Let me ask you this question:

First, how long does it take to acclimate a fish? I think you said in your experimental work if fish were acclimated to a certain temperature, they would prefer some other temperature. How long is that experimental work?

DR. RANEY: You bring a group of fish in, sir. And if you keep them at the same temperature, they are already acclimated.

CHAIRMAN JENSCH: You went out in February and came in with a bunch and how cold was the temperature then?

DR. RANEY: If it's 32 and you come in with a bunch and put them in temperature 40, 45, 60, 70, you would have trouble with your fish. You could not experiment with them.

So we have our experimental set-up and holding tanks set. If we go out, we know the ambient temperature outdoors will be 40 and you have your tank set up inside at 40. You bring your fish in and put them in the same temperature, leave them there for 24 hours to adjust, and acclimate, and give them a chance to become basically adjusted to the surroundings, and then run the experiments.

If you were to bring fishes in, where you caught them at 35 and brought them into the lab at 50, you might have a very, very hard time acclimating them at all. If you did, it may take 20 or 30 days.

The key to all of these experiments is to know how to get a fish and keep him alive and well and not violate any of the principles. Don't suddenly increase or decrease temperature.

CHAIRMAN JENSCH: let me take that situation that you have described and relate it to the Hudson River.

Supposing it's in the wintertime, say February, and the water temperature of the Hudson River -- I don't know what it is. Say 40. I don't know which way they are going in the river, but either up or down.

They go by the plume and it goes up to 60 degrees. Bang. What happens?

DR. RANEY: No, sir, it wouldn't do that. It's a fine example. Please use what the delta-T is going to be.

CHAIRMAN JENSCH: I am asking you.

Supposing the general ambient temperature of the river, if I use the term correctly, is 40 degrees.

DR. RANEY: Yes, sir.

CHAIRMAN JENSCH: And the fish are going either up or down.

DR. RANEY: Yes, sir.

CHAIRMAN JENSCH: And the plume is coming out of the river. They haven't operated this plant for a week or ten days or something, and they suddenly develop a plume condition in the river.

The fish haven't received the word yet, but whichever way they are going, they hit the plume.

DR. RANEY: They will go toward the plume.

CHAIRMAN JENSCH: What will be the temperature of the plume?

DR. RANEY: This Dr. Lawler's field.

CHAIRMAN JENSCH: Would you fill us in a figure for a February plume, Dr. Lawler, after a plant has not been operating and suddenly -- the river, you see, has been kind of a fine home for a while for two weeks, and suddenly we got the plume out there.

Put a number on the plume, please?

DR. LAWLER: First of all, in February the ambient temperature will probably be closer to 32 to 33 degrees than to 40. Then the description of the plume would be rather similar to the description I gave in the testimony in November, which described how the plume started out right in front of the discharge and gradually dissipated as it moved away.

Do you need a more detailed description than that?

CHAIRMAN JENSCH: I am looking for a figure of the temperature of the plume at any space, the edge, the middle, the discharge, or something.

MR. SACK: There is a problem of definition of what you are calling the plume. I think Dr. Lawler could respond in certain isotherms, how far you would see a 4-degree temperature rise, or how far you would see different temperature rises.

9

CHAIRMAN JENSCH: However he likes. However he explains would be all right for me. I would be anxious to learn a different figure.

DR. LAWLER: The maximum temperature rise that you would expect to see at surface under those conditions would be on the order of six or seven degrees. The maximum temperature that you would expect to see at any point in the jet would depend on the flow condition in the plant and could vary -- and also could depend on the power output of the plant. It could be, with a full flow condition as high as 13 and 14 degrees, and with a reduced flow condition, again of full flow, it would be as high as 20 to 21, 22 degrees. I should point out that those temperatures would exist in the jet at the same point where the velocities in the jet would be as high as ten foot per second.

By the time the velocity in the jet had dropped down to the order of, let's say, five foot per second, the temperatures that you would be looking at would be on the order of five or six, seven degrees.

CHAIRMAN JENSCH: Dr. Raney, is it your thought that the striped bass couldn't exist with the velocity of ten foot per second?

DR. RANEY: Striped bass would have a very difficult time swimming against the velocity. Actually, under winter conditions it would not even attempt it. What would happen, the striped bass would come and become a part of the plume water. He would stay in the water.

MR. SACK: Mr. Chairman, may I ask a few questions to clarify this point? I think something is missing in your discussion with Dr. Lawler.

Dr. Lawler, the temperatures you gave are full power, are they not?

DR. LAWLER: That is true. I said that.

MR. SACK: And the plant would start out with very small temperature rise over a period of time before it came up to full power that would produce those temperatures, is that correct?

DR. LAWLER: I am not familiar with the number of minutes or hours that it takes to bring the plant up to full power but I would presume it wouldn't occur instantaneously.

MR. SACK: Mr. Chairman, it might be helpful to have another witness discuss the temperatures that Dr. Lawler suggests.

CHAIRMAN JENSCH: It would be fine but it wouldn't help my question. The fish suddenly come up the river and got their full power or any range, I think Dr. Lawler indicated, of 13 to 14 degrees in one instance and 21 to 22 degrees.

MR. SACK: They wouldn't be hit with that instantaneously, is our position.

CHAIRMAN JENSCH: Yes, but the fish would suddenly come into that.

DR. LAWLER: I indicated that in the jet where the velocities are ten foot per second, you could see temperatures as high as 13 degrees under full flow.

CHAIRMAN JENSCH: And also 21 to 22 degrees at full flow or full power?

DR. LAWLER: No, reduced or what is known as throttle flow which would not normally be the condition under start up.

CHAIRMAN JENSCH: I think Dr. Lawler is trying to help me, and I appreciate it.

When would the 21 to 22 degrees occur?

DR. LAWLER: The 21 to 22 degrees is the condition in the effluent channel, not in the river. That condition corresponds to full power and reduced flow, flow reduced to roughly 60 percennt of design conditions.

CHAIRMAN JENSCH: How far would water with that temperature get out into the river, do you know?

DR. LAWLER: It would get out like two feet or thereabouts. As soon as that water enters the river in a high velocity jet, river water is entrained or brought into the jet and the temperatures begin to drop down. What I indicated was that as the temperature of the jet -- I don't really look at it as river water but rather as the jet of water that is merging from the discharge channel. As those temperatures drop down, the velocities of that jet drop down similarly. What I indicated was that by the time your velocity drops to the order of roughly five feet per second, your temperatures will be on the order of five or six or seven degrees. I can be more specific if you need it, but that is the general order.

CHAIRMAN JENSCH: Are those the measurements or calculations?

DR. LAWLER: Well, they are calculations and they are also measurements. There is a whole host of literature on the behavior of submerged jets. Generally, you would find it to be the behavior of a submerged jet.

CHAIRMAN JENSCH: Have you made any measurements at the Indian Point facility based on Indian Point No. 1 operation so we can confirm those calculations?

DR. LAWLER: No. Indian Point No. 1 does not yet operate in the manner I have described because the out facility was originally designed for the operation of all three units at Indian Point and only recently has been constructed in such a manner that you could operate the unit 1 discharges to obtain that kind of high velocity jet. At this point in time, you do not get those high velocities.

CHAIRMAN JENSCH: To get back to Dr. Raney, I think you answered the question that the striped bass would have great difficulty swimming against that. Perhaps my question wasn't clear. He is not trying to swim against it but he gets caught in the swirl of it and gets pushed out of it. He is in a temperature range that is quite different than that to which he was accustomed a few days or hours prior thereto. Would that affect his activity or have any harmful effect?

DR. RANEY: It will have an effect on his activity. In order to investigate this, we did a series of experiments in the winter under conditions which you described. In order to find out what the effects would be on striped bass, if we suddenly increased the temperature to ten, fifteen, twenty degrees, and then suddenly decreased it, and we found out that a sudden increase or decrease in winter of as much as 20 degrees has an effect on the fish in the sense that they may temporarily lose their equilibrium. As Dr. Lawler has explained, with this jet system, except for a minute area, a matter of a few square feet, we are not going, even under the worst conditions in winter, we are not going to have a temperature differential of more than ten degrees at most in plume.

Our experiments indicate -- and incidentally, these are included in Bulletin 7, sir. We do not expect mortalities even for a sudden increase or a sudden decrease under the system which has been designed at Indian Point for Indian Point 1 and 2.

end 10

CHAIRMAN JENSCH: I understand your statement. I am trying to find out what experimental indications you have from the Hudson River, not the tank down in Delaware, but something occurring as if, or you can tell it as it is. I take it you don't have any actual experimental catches of fish under Indian Point No. 1 operations that would give you any data, is that correct?

DR. RANEY: Well, you can't experiment in the field. You can collect fish in the field and you can observe them and note whether they seem to be in good condition or poor condition. What we note around heated plumes in the eastern United States including the Hudson River, is that you get concentrations of fishes in heated plumes. Some of these are sickly.

The winter is the time when most organisms die. You find perfectly healthy ones. You find some of them there that are lethargic. They may swim fast, but they don't. So that -- as far as experiments are concerned, you can't experiment out there.

CHAIRMAN JENSCH: But you can collect data bearing upon your knowledge about the situation, can you not?

DR. RANEY: Yes. As I mentioned previously, our data obtained over a long period of years indicate that the results in nature are basically similar to the results that we found and reported in Bulletin 7.

MIL-2

CHAIRMAN JENSCH: Are you familiar with the impingement problem out there in Indian Point?

DR. RANEY: In a general way, yes, sir.

CHAIRMAN JENSCH: Are you able to say whether you looked at the fish which were impinged on the screens and if they were affected at all by the plume activities prior to the impinging?

DR. RANEY: I could not answer that. I know that the fishes which are impinged are in various conditions. Some of them are dead before they become impinged. Others are sick. Still others are swimming out in front of the screens in good condition. Ultimately they get tired and come up against the screens and die.

CHAIRMAN JENSCH: They can't fight the intake flow, is that correct?

DR. RANEY: It isn't just a matter of fighting the intake flow. Certainly the striped bass and the white perch can swim fast enough to do this. Even in winter it is a matter of behaviorial situations. It is a matter of design of the whole screen system.

CHAIRMAN JENSCH: Have you reported it into your results and analyses, the fish taken from the impingement process to determine whether there have been any changes in the temperatures that would affect their activity and lead to the impingement?

mil-3

DR. RANEY: I'm sorry, sir. I don't understand the question.

CHAIRMAN JENSCH: Let me ask you in two parts. I thought you had answered the first. I was using the premise.

Have you made any analyses of the fish and their conditions, those fish which were impinged on the screens to determine whether heat changes had any effect on their ultimate fate?

DR. RANEY: Yes, I can answer that question. What we, Consolidated Edison's biologists did, was to take fishes that had been impinged on the screen and send them around to various specialists on fish diseases, parasites, to get autopsy reports. However, there is nothing really basically different in a fish that has been killed by a parasite or bacterial disease, or by some type of a shock or by what you might refer to as a temperature condition. We got various reports back on these fishes that nobody would give an estimate as to what actually cuased the death.

CHAIRMAN JENSCH: Are you saying, then, that if a fish had been affected by a sharp temperature change and later became impinged, you couldn't tell whether the fish had died from some problem with a disease or a parasite? It would make no difference when you ran the analysis, is that correct?

DR. RANEY: I couldn't tell, right.

CHAIRMAN JENSCH: So, in other words, you can't say

mil-4

whether the heat change aspect has any effect on the impingement or the number of fishes, is that correct?

DR. RANEY: Only in reference to what happens in numerous other places where screens have been designed in a different way, proper escape areas. In those places, we do not get large fish kills.

MR. SACK: Excuse me, Mr. Chairman. Can you explain the premise of your question? Are you premising fish kill by thermal shock of some kind?

CHAIRMAN JENSCH: Some thermal changes. I understood the gentleman to say where you can't tell a difference in analysis of a fish that has been subject to impingement, as to whether some parasite caused its death or disease or thermal shock.

MR. SACK: There is no testimony or cross-examination that the thermal rises you will see at Indian Point will reach any lethal proportions. That is not part of the Intervenors' contentions. The contentions, we stated, did not include any death by thermal rise.

CHAIRMAN JENSCH: I don't know just what the Intervenors are contending. I am trying to find out -- as I understood, Dr. Raney said sometimes even a thermal change will lead the fish to a loss of equilibrium. So whether they had reached a lethal stage or not is kind of a separate consideration, as I understood it.

mil-5

MR. SACK: Those are temperatures not seen at Indian Point. Perhaps we can clarify that with some questions, if there is any doubt.

CHAIRMAN JENSCH: I don't know that there has been an analysis at Indian Point. The fish can't tell the difference, when they are dead, if it is caused by a parasitic disease or some other disease or thermal shock. I don't know if the fish had a lethal result because of the impingement. We don't expect it, but we don't have any proof, either way.

MR. SACK: Our position is that we have an analysis of the temperatures which will cause thermal shock or will cause death in fish. Those temperatures would not be seen at Indian Point under any conditions. That is the position I am making. There are fish impinged. We have agreed with that. But there is no evidence and no contention so far that that impingement is related to thermal shock.

CHAIRMAN JENSCH: It may be that this will develop, even though the evidence isn't yet in the record. That is what I am asking Dr. Raney, that you may not have presented this, but it may be a part of it. I don't know. That is to see if the thermal change would lead to a condition to determine the fishes' fate. I am asking him, outside of his tank work, whether he has made any measurements of fish at Indian Point. I understand the fishes taken from the impingement, they can't analyze to tellwhether thermal shock had a part in it, is that

mil-6

correct?

DR. RANEY: That's correct. We can't ~~geil~~ tell by the examination of the fish. These fishes are taken under conditions where there is absolutely no evidence where there would be thermal shock. At Indian Point 1, the Delta T is such that it is inconceivable thatyou would have death due to thermal conditions.

CHAIRMAN JENSCH: Would you have a combination of thermal change plus the chemical content of the river affecting the equilibrium or the flow characteristics of the fish that would lead to impingement problems? Do you know?

DR. RANEY: I don't know of any chemical condition which, working together with a temperature rise, that would have caused this. This is not my field. I am not familiar with it.

CHAIRMAN JENSCH: You haven't analyzed any of the fish with autopsies or what-not?

DR. RANEY: I have not personally. We have sent them around to various groups of specialists who do these things.

CHAIRMAN JENSCH: And from your understanding of their reports, have there been any -- if I use the term correctly, synergistic effects beween the heat and the chemical composition of the river that would resist impingement?

mil-7

DR. RANEY: The only reports they gave were that these fishes showed evidence of certain bacteria, certain parasites. But they were unable to attribute their deaths to any of these.

CHAIRMAN JENSCH: They didn't know?

DR. RANEY: They could not determine on the basis of their examination of the specimens that were sent to them.

MR. BRIGGS: Dr. Raney, when you indicated fish would be attracted to the plume, I have visions of a very large number of fish in the Hudson River, and they all couldn't get into the plume. What is the variation in fish density that one might expect in a region like this?

DR. RANEY: It depends on the season of the year, what species are available and what species have a chance to get into it by reason of a gradient leading from the plume to wherever they might happen to be, where they are migrating past. The basic evidence is at Indian Point, that it is an over wintering grounds for white perch. There are great numbers that have been present. There are many more present in the preheated plume than there are in the vicinity of the intakes.

The white perch in the river are stunted and also stunted in the Delaware River, most of them in Chesapeake Bay, as compared with Maine lakes, for example.

mil-8

The wintertime is the time that I said before when a lot of fish, which are accumulated against screens or other objects, weaken and die. Populationwise, this might be beneficial.

MR. BRIGGS: As far as the striped bass are concerned, there are not many of them there in the wintertime?

DR. RANEY: The evidence from the counts on the screen indicated they are a very small percentage, and by weight, they are a very minute amount.

MR. BRIGGS: Where is it that they winter?

DR. RANEY: Normally they winter in the deeper water, in the channel, sir.

MR. BRIGGS: In the Hudson River, but in the deeper water?

DR. RANEY: Yes. Haverstraw area is one major wintering area, and the deeper areas for larger fish. Normally when the temperatures drop much below 45, I don't think striped bass move out into deeper water.

MR. BRIGGS: How much does the population tend to vary from year to year? By what fraction?

DR. RANEY: Well, in striped bass, it may vary tremendously. Now, or over a period of the last four or five years, we might have as many striped bass as ever existed in the Atlantic Coast. But some of us can remember back to 1933, '34, '35, when there were hardly any striped bass in the

Chesapeake Bay area. Yet, from a very small dull population in 1934, there was a large year class for this. We didn't realize that they had been producing and they got to be two years old. At that time in 1936 they started to migrate up along the coast, and there was a source of a big fishery. There also was a source of a fishery in 1937. Actually it was only a few years ago that some of the 25-year-old striped bass from the 1934 year class that was finally gone, tremendously large fish.

Since that time, we have had good year classes of striped bass in Chesapeake Bay. '42, '43 was a good year class. Why is this? Why, under conditions now where there is obviously more domestic pollutions in rivers, are there more striped bass than there were back in 1933 and '34 when things were, quote, cleaner, quote?

The striped bass largely is preadapted to utilizing the nutrients that become available in polluted situations. It stays up. It stays moderately close to the bottom, but it stays off the bottom. The egg is semi-immersible. It doesn't sink to the bottom if there is some current. It tends to stay near the bottom.

So that when the larvae hatch, they are ingood, very good shape to take advantage of the small organisms which have flourished because of pollution.

CHAIRMAN JENSCH: Is it your premise that Chesapeake

mil-10

Bay is better now than it was in1933?

DR. RANEY: I think it is worse now. But you see, what you would have to do is, we would have to go to a place where the striped bass spawn and where the larvae occur. This is basically not inthe bay, but in the rivers leading to the bay. I think there is little doubt that the Potomac River is more polluted now than it was in 1933.

CHAIRMAN JENSCH: You don't have any striped bass there anyway, do you?

DR. RANEY: Yes, sir. Yes, indeed, you do.

CHAIRMAN JENSCH: I withdraw the statement.

DR. RANEY: The lower Susquehanna, you are at the end of a long sewer. It is one of the longest sewers in the eastern United States. It is full of small striped bass. It was last week and has been every year for the last 10 years.

DR. GEYER: Did you say that the species -- not the species, but the races of bass return to the same place to spawn, just as salmon do?

DR. RANEY: There are some evidence from tagging that this is true, Dr. Geyer. If they didn't actually do this, I don't think we would find these differences and characters just as we find in salmon.

DR. GEYER: In your experiments down on the Delaware, is the use of river water in these tanks --

DR. RANEY: We use creek water at high tide, which

mil-11

is basically river water.

DR. GEYER: What do you do, store that?

DR. RANEY: Yes, sir.

DR. GEYER: Do you treat it in any way?

DR. RANEY: No, we do not treat it. We start on the roof of the trailer so we can draw it off and adjust the temperature.

DR. GEYER: And you recirculate it, then, for a while?

DR. RANEY: Yes, sir. But we take our water only to the tank at high tide. So we assume that this is basically like river water.

DR. GEYER: How do you heat the water?

DR. RANEY: With regular aquarium heaters.

DR. GEYER: You have a heater right in the tank?

DR. RANEY: Well, or below the tank. In our long preference tank, we have infra red bulbs underneath. We have a metal bottom to the tank.

DR. GEYER: Do you think the attraction of fish to the warm plume brings them into an area where there is apt to be greater chance of them being caught in the intake or showing up on the screen?

DR. RANEY: If there is recirculation, there is this possibility. If they are attracted to the long plume and if there is recirculation at the intake, the trick here is

mil-12

to design your plume and intake so there is no recirculation.

DR. GEYER: Is it going to be done here?

DR. RANEY: I am not in a position to say. I know or I have been informed that one of the reasons for extending the canal to the south was to decrease recirculation to the intakes.

DR. GEYER: Thank you.

CHAIRMAN JENSCH: Did you desire a recess before you considered redirect, Applicant's counsel?

MR. SACK: Yes, Mr. Chairman.

CHAIRMAN JENSCH: Did you have any question before they considered the amount of redirect?

MR. MACBETH: I had just a few that came out of the Board's questions.

CHAIRMAN JENSCH: Proceed.

MR. MACBETH: Just as a general matter, I would like to say that some of the areas that the Board has raised, both the Applicant and Intervenors have treated differently, such as the density of the fish. You said a number of these issues will be dealt with as later cross-examination and stipulation. I don't want to give the impression, that some of the areas the Board recognizes are important, haven't been touched on now. It isn't that we don't intend to touch on them at all. It is rather that we have been trying to keep it to a certain specified area right now.

mil-13

I would like to clarify, as best I could, the relation of the fish during the winter, especially white perch and striped bass to a heated plume. The gradient would cover considerable areas of the river. Would you find fish attracted to different places along the gradient?

DR. RANEY: Yes.

MR. MACBETH: So there would be a heavier population of fish across the attracted gradient from low temperatures to whatever the high attractive temperature is?

DR. RANEY: Yes, they would be going to whatever their preferred temperature was at thattime.

MR. MACBETH: Is there a neutral zone for the fish, a neutral temperature? You described a situation in which the white perch or all the fish, I think, were attracted up to a certain point, and then withheld by higher temperatures. Is that an instantaneous change from attraction to repulsion, or is there some neutral range in there?

DR. RANEY: Well, in our experimental apparatus, it comes very clearly. It is basically a degree or degree and a half difference. It is actually pretty hard to measure a degree of Fahrenheit. We find it comes right up to about a five degree change and mill around without any repellants.

You get six degrees and seven degrees, and they will move out.

MR. MACBETH: This may just be adding onto something

mil-14

Mr. Jensch was talking about earlier.

Have you done direct studies of the plume at Indian Point measuring density of fish at various parts of the plume and outside the plume?

DR. RANEY: I have not, not personally.

MR. MACBETH: Anyone under your direction or control?

DR. FANEY: No, sir.

MR. MACBETH: You described the situation in the Connecticut River where striped bass have matured outside of this natural breeding ground and plume by the Yankee plant. Would it be fair to characterize that as interference with the migratory patterns of those striped bass to and from their spawning grounds?

DR. RANEY: I wouldn't characterize it as such. I would say it was a very happy event that happened that gave pleasure to a great many people. I am one of those people that think that striped bass are for people rather than for striped bass.

MR. MACBETH: But it wasn't moving to and from its natural sparning grounds?

DR. RANEY: The reason that it concentrated in the heated plume was because the heated plume was there. That was not the reason that it came into the Connecticut River. Normally those were what I would assume to be Chesapeake Bay

mil-15

striped bass on their way out. For some reason they came into the Connecticut River.

Two winters ago there was a fishery there and never did they have that kind of fishery on the river before. You could say this is kind of too bad.

One of the things that we need mostly are concentrating mechanisms so people can utilize these resources that we have. Why not?

MR. MACBETH: I didn't want to suggest that having fish in the Connecticut was a bad thing. I was just looking at the point that the natural spawning ground or natural migration pattern would have been somewhere else.

DR. RANEY: They were in a pattern to go into the Connecticut in the first place. Once in there, they were attracted to the plume and they were utilized.

MR. MACBETH: I won't press it. Those are the additional questions I have.

CHAIRMAN JENSCH: Does the Staff have any inquiry?

MR. KARMAN: No, Mr. Chairman.

CHAIRMAN JENSCH: At this time, let us recess, to reconvene in this room at 6:45.

MR. SACK: I note the hour is late. Perhaps you might consider resuming this tomorrow morning.

CHAIRMAN JENSCH: We might consider going on now unless you have some reason to resume in the morning. We plan

mil-16

to accommodate the parties. We are trying to expedite the proceeding with the least amount of delay to the parties to accommodate their interests.

MR. SACK: I am not sure we would finish at a reasonable hour this evening. That is my suggesting for going over tomorrow.

CHAIRMAN JENSCH: On that subject, what do the parties envision for tomorrow?

MR. SACK: For tomorrow, if we have redirect of Dr. Raney, we still have some questions for Dr. Lawler on the two contentions that Mr. Macbeth has stated. I would then hope to be able to meet with Mr. Macbeth and define his contentions on the other issues scheduled for this hearing, which I identified earlier. Those are the chemical discharges and the entrainment of organisms other than fish and dissolved oxygen.

If we can identify contentions on those issues, we would then proceed to cross-examination on those.

MR. MACBETH: I don't think we are going to have too much trouble identifying the contentions. There seem to be certain linguistic problems between the Intervenors and the Applicant. I imagine we could settle them neatly. We have been able to and I think we can do it on the rest if I explain a little more depth to Applicant's counsel what I mean each time they do seem to get it. I am not worried about it.

MR. SACK: It is not a question of getting it. It

mil-17

is a question of getting contentions from Mr. Macbeth. We are very satisfied if he seeks or if he raises a specific contention and we know what we are talking about.

MR. MACBETH: I want to preserve the position that I think the previous contentions are reasonably specific. I would also sit down with the Applicant and talk about what I mean and the Applicant agrees to. I don't want to go along with this debate. I don't feel I ought to or I am conceding the point that these contentions weren't sufficiently specific.

I think that the cross-examination tomorrow, I believe, ought to be able to cover most of the outstanding items. We have Dr. Lawler on thermal discharge problems, Dr. Lauer on chlorine discharge, and the effect on gammarus and neomysis, and just a couple of questions on the issues of dissolved oxygen and copper monitoring.

We ought to be able to get through that in the course of the day.

CHAIRMAN JENSCH: We ought to conclude tomorrow night on the issues you are presently proposing at this time, is that correct?

MR. MACBETH: That is my estimate. Of course, it could take longer.

CHAIRMAN JENSCH: Is that the Applicant's anticipation of the agenda?

MR. SACK: Yes, sir.

mil-18

CHAIRMAN JENSCH: Very well. Sometimes we have found that the anticipations abouttime schedules aren't always realized. The Board is anxious to accommodate the parties in any way we can. I might add that if we can get out of here tomorrow night, we can get back on that motion a little faster. So we are trying to suggest to the parties that we take a recess of 15 minutes and see what you can do with redirect. Maybe we can conclude Dr. Raney tonight. Thatwill shorten the day tomorrow. Does that seem a feasible procedure?

MR. SACK: Maybe we can go to another subject now if you wish to continue the hearing at this time to get Dr. Lawler's testimony in.

CHAIRMAN JENSCH: Will we take a pledge tonight that if we let Dr. Raney go tonight, that we will finish by 5:00 o'clock tomorrow night with no lunch, starting at 8:30 or thereabouts?

MR. TROSTEN: One thing we could do, Mr. Chairman, is to commence the cross-examination of Dr. Lawler. It seems to me, to Applicant's counsel, that it would be desirable, before we just go into redirect, to have an opportunity to look at the transcript and to have that additional chance to scrutinize this before we go immediately into redirect tomorrow. We would like to conclude Dr. Raney's presentation, certainly, at this session. It would seem to be preferable to have an opportunity to take a little more time on that rather than

mil-19

simply going immediately to redirect. We certainly agree with the Board that we want to expedite the proceeding, and we are perfectly happy to remain here this evening and go on to another subject if the Board wants to do that. That is entirely satisfactory to us.

CHAIRMAN JENSCH: Is the Hudson River Fishmens Association able to go ahead with Dr. Lawler, sir?

MR. MACBETH: I think we can get started. I would hate to promise to finish Dr. Lawler. It depends on the speed at which the Applicant is willing to pass the buck to go on working.

CHAIRMAN JENSCH: He is impressed with your capability and wants to give you an opportunity, I take it, to further that recognition. Could we take a few minutes' recess before you proceed?

MR. MACBETH: Yes.

CHAIRMAN JENSCH: At this time, let us recess, to reconvene in this room at 6:45.

(Recess.)

End 11

CHAIRMAN JENSCH: Please come to order.

Before we resume or undertake with Dr. Lawler, I wonder if I could ask Dr. Raney a question. I think I may have misunderstood his answer.

You indicated, Dr. Raney, that the pollution was worse in the Potomac and some of these areas feeding the Chesapeake Bay then it was a few years ago when we had great increase of striped bass, is that correct?

DR. RANEY: I said that since 1934, in the major rivers of the eastern United States, domestic pollution is worse.

CHAIRMAN JENSCH: I think, as a layman, perhaps I misinterpreted the definition of pollution to which you referred. I kind of have pictures of sulfuric acid, chemicals, together with sewerage and everything else, and all the synergistic effects there. Pollution can likewise be very life giving activity, can it not, like the nutrients on which the striped bass may feed?

DR. RANEY: Yes, sir, and as long as there is oxygen available, they can stand the conditions.

CHAIRMAN JENSCH: So there isn't as a deplorable condition as I envisioned for the Potomac River as far as the striped bass are concerned and there may be nutrient conditions that may explain the number above, is that correct?

DR. RANEY: I can't say off-hand that the striped bass have increased in the Potomac. I do know from my personal experience that there are large populations of striped bass in the Potomac estuary.

CHAIRMAN JENSCH: But you don't know if there has been an increase or not?

DR. RANEY: I have to depend upon my colleagues for this. They say that they have. I can't say personally that they have. I do know that there are large populations.

CHAIRMAN JENSCH: That is good enough. Thank you very much. Does anybody have any questions? Otherwise, please proceed with Dr. Lawler.

CROSS-EXAMINATION

MR. MACBETH: Yes, Mr. Chairman.

I would like to take up what I call the profile of the heated plume in relation to the intakes at Indian Point 1 and Indian Point 2. What I am thinking of when I say profiles is, if you take a cross-section directly in front of the intake to Indian Point 1 or 2, what differences of temperature do you find on your various operating conditions of the plant? I would like to start with some of the past history of Indian Point 1 at the time when the intake was 320 feet, or the discharge was 320 feet downstream from the intake and take a winter condition when the river temperature would be 32 degrees and assume the plant has been operating for some time at full power and full flow. There is a point in the tidal cycle where it is changing from flood to ebb. What profile, what arrangement of temperature isotherms do you have in the area directly from the intake at Indian Point 1?

DR. LAWLER: You are referring now to the organizational configuration of the unit 1 intake as well as the unit 1 discharge?

MR. MACBETH: That is right.

DR. LAWLER: This is the configuration that existed in the early '60s. I have not been able to find data on that configuration. I read in various reports that in the early '60s there was circulation under that configuration of a 320 foot differential, distance differential between the intake and the discharge during flood tide that did reach as high as six degrees. As I say, I have not been able to find actual operating data to confirm that.

I also have the impression that during ebb tide the temperature at the intake was virtually the ambient condition.

MR. MACBETH: Define what you mean by recirculation?

DR. LAWLER: My definition of recirculation would be the temperature rise that one sees in the intake itself, not necessarily in front of it but in the intake channel, by comparison to the ambient temperature in the river, that is. In other words, it would be the rise that the intake sees over ambient conditions in the river.

MR. MACBETH: Does that mean that that recirculation rise could be made up of water that was drawn from temperature areas both higher and lower than the recirculation figure?

DR. LAWLER: Sure, I suppose so. It depends on the conditions. If you tagged all the water particles that make up the water recirculated through the system, you would probably find some of those water particles came from an area of ambient water and some came from an area of heated discharge.

MR. MACBETH: When you say you have these reports on recirculation, do you also mean that you do not have any reports or calculations of what I call profile where you would see in front of the intake itself?

DR. LAWLER: I am referring now to the organizational configuration. The answer is no. I am not saying it can't be done. I am just saying I don't have them.

MR. MACBETH: Let's take the situation in which the -- I will phrase it differently. It is fair to say, then, that you don't know the answer to the question? Let's leave it at that.

DR. LAWLER: No. I said that I have seen reports that indicated that the temperature did, on occasion, reach up to six degrees. I have also seen operators reports that show no temperature rise but I haven't seen sufficient carefully measured -- careful measurements under the condition you describe to conclude what the recirculation was at that time.

MR. MACBETH: Or profiles as well as the recirculation?

DR. LAWLER: Yes. You are talking about the temperature in front of the intake. That is what I am referring to.

MR. MACBETH: Is it your opinion that those are accurate reports as far as you know, that they don't reflect the recirculation temperature or are you essentially just reporting something that you have seen?

DR. LAWLER: I don't have any reason to presume that the report of measurements are incorrect. It could have happened.

MR. MACBETH: Did you see any reason for them being inaccurate?

DR. LAWLER: I could see that that could have happened under that particular configuration.

MR. MACBETH: I am not quite sure you are directly answering my question. Do you have reason to presume that they are correct measurements?

DR. LAWLER: Well, I think I have answered it as best I can. I have no reason to presume that they aren't. So I presume that means that I presume that they are.

MR. MACBETH: You could take a perfectly neutral position and say that is something you have read and have no further opinion about it. I take it you have a little stronger opinion about it and presume that they are accurate reports and conditions.

DR. LAWLER: Don't know what your definition of a little stronger is. I am saying that I have no reason to quarrel with the reports that I have read on that particular item.

MR. MACBETH: Take the situation in which the discharge was moved downstream 540 feet from the Indian Point 1 intake. Again, take the situation where the river ambient temperature is 32 degrees and Indian Point 1 is operating at full flow. Take the point at which the tide is turning from flood to ebb.

Do you know what the profile of heat distribution from the intake would be or was?

DR. LAWLER: Well, in that condition we have looked at some of the operators' reports. These show that at temperatures generally in the vicinity of 33 degrees, a temperature rise during flood about a half a degree. During ebb again, you don't see a temperature rise.

end 13

MR. MACBETH: Again, these figures are direct results of measurements, is that correct?

DR. LAWLER: These are direct field measurements of the intake temperatures.

MR. MACBETH: At 35 to 40 degrees, would you see an equivalent rise?

DR. LAWLER: I haven't seen primarily because I haven't gone through all the operators' reports, a particular condition of 37 degrees or 38 degrees or 35 degrees, but I would presume it's of the same order.

MR. MACBETH: And you have done no calculations which would allow you, on a calculated basis, to describe the recirculation or the heated situation?

DR. LAWLER: I have done some fairly rough calculations that would lead me to agree with those numbers.

MR. MACBETH: How long a period of flood would a temperature rise under a tenth of a degree?

DR. LAWLER: How long during a period of flood would the temperature rise more than a tenth of a degree be present?

MR. MACBETH: Yes.

DR. LAWLER: Probably during most of the period of the flood.

MR. MACBETH: If you took the situation in which Indian Point was operating and later there was a change from flood to ebb, what temperature rise would you --

DR. LAWLER: Are you still referring to the configurations thatyou just referred to?

MR. MACBETH: Yes.

DR. LAWLER: I am not aware of any reduced flow situation under those conditions. I don't think that the plant flow is ever reduced at that point.

MR. MACBETH: If it was, you know of no reports?

DR. LAWLER: I know of no numbers right off-hand.

MR. MACBETH: Have you done any calculations?

DR. LAWLER: No.

MR. SACK: Mr. Chairman, we might state, if it clears things up, the plant was not operated under reduced flow in that configuration.

MR. MACBETH: I will take counsel's word for it.

Let's move on to the situation where the discharge channel is 960 feet downstream. Again, take the river ambient at 32 degrees, Indian Point 1 operating at full flow, and the point at which the tide turns from flooding to ebb.

Do you know of any reports or have you done any calculations which would indicate what the heat profile from the intake would be?

DR. LAWLER: This is the case we -- you just said something about -- are you referring to the 960 foot case where the water discharged to the south before the ports were built?

MR. SACK: 960 feet did not have ports on them. If you are interested in ports, that is something else.

MR. MACBETH: I didn't inject the ports, I think.

DR. LAWLER: I thought I heard you say something about ports.

MR. MACBETH: If I did, it was a slip of the tongue.

MR. SACK: The 960 feet configuration was straight out. That is surface discharge.

DR. LAWLER: In that case, there were measurements made on the automatic monitoring system. We find thatunder the condition of -- Do I have a condition of full flow?

I am not sure that we will be able to find a condition of full flow for these temperatures under that condition. To the best of my knowledge, the plant was operated under a throttle condition at those very low temperatures. If not all the time, most of the time.

We have seen them under all throttle conditions.

In that case we saw at ambient condition of 33 degrees, and full power, a .9 of a rise in the intake over the flooding period.

MR. MACBETH: When you say over the flooding period, that is averaging through flood time?

DR. LAWLER: Yes, that's correct.

MR. MACBETH: And that figure would be a little higher if it were to turn from flood to ebb and lower removed toward the slack tide?

DR. LAWLER: Well, it would be a little higher at some point during the flood period. It would be a little lower during other points during the flood period. I won't characterize it as a turn.

MR. MACBETH: Have you made any measurements or calculations for any other ambient temperatures between 32 and 40?

DR. LAWLER: Another at an ambient temperature of 34-1/2 degrees, and under a condition of, again, throttle flow and approximately half-flow.

MR. MACBETH: Half flow?

DR. LAWLER: Half power, yes. The temperature rise over the flooding period was a half a degree.

MR. MACBETH: Are there any other measurements?

DR. LAWLER: I don't have any other measurements.

MR. MACBETH: ARe there any other measurements?

DR. LAWLER: I don't have any at the moment. These aren't individual single measurements. These are a series of measurements on successive days at each of those ambient temperatures.

MR. MACBETH: Do you know how many days are included in each series?

DR. LAWLER: Usually four days.

MR. MACBETH: Do you know or can you have it calculated, from the data that you have, what power level one would have to operate at 32 degrees in order to have a tenth of a degree rise in the intake over the flood period?

MR. SACK: Jus t a minute. It's not clear what configuration you are talking about?

MR. MACBETH: I am still at the 960.

DR. LAWLER: I'm not sure you can correlate plant flow to river circulation temperature to any degree of precision of the low temperature rises we are talking about here.

MR. MACBETH: As far as what is concerned?

DR. LAWLER: Because the temperature rises that I am talking about is the measurement. So therefore what I am saying, I am not sure I can relate those observations to differences in output of the plant.

MR. MACBETH: I take it that the discharge system under which Indian Point 2 will operate is 1115 feet from the intake from INdian Point 1, and you now do have the port system there.

Taking that discharge configuration, and again assuming river ambient temperature of 32 degrees, and taking this over the flood period with Indian Point 1 and 2 operating at reduced flow but full power, what recirculation of heat profile would you expect at the Indian Point 1 area?

DR. LAWLER: We have observed, for the condition of Unit 1 operating, under ambient condition of about 37 degrees, a rise during flooding period of .2 of a degree.

I should point out that this condition is only for Unit 1, which is only up to this point.

Also, two, that the discharge velocities for that case, rather than being the ten foot per second design velocities there referred to a few moments ago, were about one-half of one foot per second, of that order.

So therefore what you are seeing there is more likely the greater distance from the intake than the performance of the high velocity diffuser.

To answer your question you would expect, under full operation of the both units, two things would occur:

One, the heat load and the flow would increase, and you would expect this to increase the temperature, then you recirculate.

Secondly, the high velocity discharge would tend to mix the contents ofyour effluent water much more rapidly with the surrounding waters than I would expect to decrease the recirculation effect.

The net effect is really a good question.

Based on what I have seen in the hydraulic model and also based on calculations, I would not expect the temperature recirculation -- well, let me rephrase it.

I would expect the temperature recirculation during the flood period to range between one degree and two degrees.

MR. MACBETH: At which intake, Indian Point 1 or 2?

DR. LAWLER: Well, that is really a tough question.

You would expect it to be at Unit 1. Some of the modeling results that I have seen show that result to occur at Unit 2, and slightly lower values to occur in Unit 1.

We are talking -- the models have an explanation in terms of the particular curvature and geometry of the river at that point in conjunction with the structure. At the moment I am not prepared to describe that in detail.

I will say one thing, that the numbers really don't look too much different.

MR. MACBETH: In Indian Point 1 and 2?

DR. LAWLER: Yes.

MR. MACBETH: That was the situation in which both plants had a full load and operating with a reduced flow?

DR. LAWLER: Yes.

MR. MACBETH: Perhaps I ought to be a little more clear about the exact produced flow. As I remember it, there are two different variations at Indian Point 2; aren't there?

DR. LAWLER: That, sir, was the condition when both plants were operating at full flow.

MR. MACBETH: At full flow?

DR. LAWLER: Yes.

MR. MACBETH: What would the situation be where they were operating with full load but reduced flow?

DR. LAWLER: Then, provided that the ports were adjusted to run the system at ten feet per second, I would expect that the temperature recirculation would be slightly lower.

MR. MACBETH: Slightly lower?

DR. LAWLER: Yes, but again, this is very difficult to correlate. We are really talking of some pretty small values.

I would suspect that it's not going to be the world's easiest thing to correlate either. Changes in the output or changes in flow to recirculate, that is.

MR. MACBETH: Obviously Dr. Raney gave us some very low values for sensitivity of fish.

When you say slightly lower with the reduced flow, are you talking about a tenth of a degree or a half a degree?

DR. LAWLER: I would think of it more in terms of a half a degree than a tenth of a degree, but I think that at this point in time -- I will indicate an educated guess.

MR. MACBETH: If the river ambient temperature is increased to 35 or 40 degrees, and the other elements in the system are held constant, taking first full flow, would you expect any change in these values?

DR. LAWLER: Well, supposedly when the temperature increases beyond 40 degrees, and we are no longer in a situation where the density changes are -- we are dealing with a fluid that may be heavier than the ambient situation rather than lighter, supposedly the effect would not be as severe.

Frankly, with the high velocity mixing, I'm not so sure that the buoyant effect, which is described in detail in the reports I was referring to in response to your first question, would really play the role that they were presumed to have played in that early situation before there was any change at the intake or the discharge at Unit 1.

MR. MACBETH: I may have lost you somewhere along the way. Perhaps I could return to the number of it.

Are you saying that up to 40 degrees you won't expect a change, but at 40 there are increasing differences in density of hot water being less dense and would create a change in these values?

DR. LAWLER: I am saying that the theory is that the recirculation should improve the temperature rises seen at the intake should drop off as temperature increases, as ambient temperature increases.

MR. MACBETH: Over 40 degrees?

DR. LAWLER: Yes. What I am saying is that I am not certain that that would be terribly meaningful. I presume it would drop somewhat. How much is a good question.

I think it would be doing the job there rather than the question of points on plumes.

MR. MACBETH: Between 32 and 40 you won't expect any noticeable change in values?

DR. LAWLER: Any noticeable change in what, in the numbers I have mentioned? In the one to two degrees?

I'll say again that I would not expect to see the numbers higher than that. They may be lower. No, I would not expect to see a bigger change in that range.

MR. MACBETH: Take the situation where Indian Point 1 is not operating and Indian Point 2 is operating. Again, starting on a 32 degrees and a flood period.

What temperatures would you expect at the intake at Indian Point 2?

DR. LAWLER: My comments would be the same because the reduced flow situation that I referred to would be affected by that situation just as much as any other situation. You would have reduced power, also.

MR. MACBETH: Then does that come out to be that the temperatures would be less than they are, higher, or the same?

DR. LAWLER: If anything, they would be less. I certainly don't see them increasing under that situation.

MR. MACBETH: I was really aiming at whether you would expect a major change and go down to the point where you couldn't measure it?

DR. LAWLER: I take it my answer there would be similar to my question as to whether I saw the reduction due to the reduction of flow, would be on the order of a tenth or on the order of a half a degree.

I said I would be more inclined to say on the order of a half a degree than on the order of a tenth of a degree.

MR. MACBETH: Just so I am clear about this, the outflow configuration we have just been discussing is the outflow configuration under which it is planned to operate Indian Point 1 and 2; is that correct?

DR. LAWLER: That is correct.

MR. MACBETH: And you don't foresee any further changes of this immediately with all these figures we have been discussing?

DR. LAWLER: No.

MR. MACBETH: Perhaps this would be a point to pick one small point on dissolved oxygen that was on my mind in the testimony that was submitted today.

On the affect of the Indian Point Plant with reference to dissolved oxygen --

MR. SACKS: Excuse me. On the contention of dissolved oxygen that we have agreed on, if I may -- I may be anticipating. I think this is a discovery point that we can clear up.

CHAIRMAN JENSCH: Let's here what it is and then we can resolve it.

Maybe we can work out what the contention is without the agreement?

MR. MACBETH: There seems to me to be an error in one of these charts that I wanted to clarify. I will put it off to tomorrow.

CHAIRMAN JENSCH: Pick it up right now. You have it in your hand.

MR. MACBETH: Unfortunately the copy I have is not paginated. There is a chart showing intake temperature, discharge temperature.

CHAIRMAN JENSCH: What page is it on?

MR. MACBETH: It's unpaginated.

CHAIRMAN JENSCH: What is the number of the page previous?

MR. MACBETH: The whole report seems to be unpaginated.

CHAIRMAN JENSCH: Count from the back forward if that will help you.

MR. BRIGGS: What does the table look like? Maybe I have it here. Yes, I have it here.

MR. MACBETH: Do you have it, Dr. Lawler?

DR. LAWLER: Yes.

MR. MACBETH: As I read across that bottom line marked "minimum", the intake was .0.3 and the discharge D.O. was 10.1.

The delta D.C. comes out to 0.0.

Is there some error there? Have I misread the meaning of that?

It seemed to me the delta-D.O. should be .2?

DR. LAWLER: It certainly appears that it should. I would say, just looking at the others, that it probably -- I will presume for the moment it should be 02. If I find after reviewing it tonight that it should be 00, I will let you both know in the morning.

MR. MACBETH: The next thing I'd like to take up, Mr. Chairman, is the thermal plume in relation to migration appearances. Frankly, this is a point at which I would also 1 like to see the transcript of today so that I could be clear as to what Dr. Raney said about the times of the year and places of the river.

If we could, I think I would like to leave that for tomorrow.

CHAIRMAN JENSCH: If the parties can confer a little while after this recess on what the contentions are for tomorrow, it will save some time out of the session for tomorrow.

Is there any other matter we can take up before we recess this evening? I hear no such suggestion.

At this time let us recess to reconvene in this room tomorrow morning at 9:00 o'clock.

(Whereupon, at 7:45 p.m., 19 June 1972, the hearing was adjourned, to reconvene at 9:00 a.m., 20 June 1972, at the same place.)

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