Information
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Proceedings and Final Action

Treatment Requirements for Sewage Discharged into the Ohio River between Huntington and Cincinnati

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Treatment Standard No. 2

Adopted April 2, 1952

OHIO RIVER VALLEY
WATER SANITATION COMMISSION

OHIO RIVER VALLEY WATER SANITATION COMMISSION

An interstate agency representing Illinois, Indiana, Kentucky, New York, Ohio, Pennsylvania, Virginia and West Virginia

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PROCEEDINGS AND FINAL ACTION

Determining Treatment Requirements for Sewage
Discharged into the Ohio River between Huntington and Cincinnati

Hearing held at 10:00 a.m. on the 29th day of February, 1952, Rooms 218 and 220, U. S. Post Office and Court House, Huntington, W. Va.

Members of the Hearing Board:

Hudson Biery, *Chairman*
Commissioner from Ohio

Henry Ward
Commissioner from Kentucky

W. W. Jennings
Commissioner from West Virginia

Appearances for the Commission:

Edward J. Cleary, *Executive Director and Chief Engineer*
Leonard A. Weakley, *Counsel*
Robert K. Horton, *Sanitary Engineer*
Harold W. Streeter, *Consultant*
Robert F. Rocheleau, *Commissioner from West Virginia and Executive Secretary-Engineer, West Virginia State Water Commission*
H. E. Moses, *Consulting Chief Engineer, Pennsylvania Department of Health*
F. H. Waring, *Secretary of the Commission and Chief Sanitary Engineer, Ohio Department of Health*
Louis F. Birkel, *Assistant Technical Secretary, Kentucky Water Pollution Control Commission*
E. W. Landenberger, *Engineer, Ohio River Division, U. S. Corps of Engineers*
W. W. Towne, *Officer-in-Charge, Ohio and Tennessee Drainage Basins, U. S. Public Health Service*

OHIO RIVER VALLEY WATER SANITATION COMMISSION
414 Walnut Street Cincinnati 2, Ohio

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TREATMENT STANDARD NO. 2

ACTION DETERMINING DEGREE OF TREATMENT TO BE GIVEN TO SEWAGE DISCHARGED INTO THE OHIO RIVER BETWEEN HUNTINGTON, W. VA. AND CINCINNATI, OHIO

WHEREAS, at a meeting duly held on January 9, 1952, this Commission determined that it was necessary, through the exercise of powers granted to it by the language of Article VI of the Ohio River Valley Water Sanitation Compact, to determine what, if any, degree of treatment, higher than that specified in said Article, should be given to sewage from municipalities or other political subdivisions, public or private institutions or corporations discharged or permitted to flow into that portion of the Ohio River between Huntington, W. Va. and Cincinnati, Ohio; and

WHEREAS, pursuant to action taken by the Commission at said meeting, a Hearing Board was appointed, empowered and instructed to conduct a public hearing with regard to the foregoing matter; and

WHEREAS, after notice of the time and place of said hearing had been given in the manner and to the extent set forth in the transcript of proceedings which has been filed with this Commission, the Hearing Board appointed as above set forth did, on the 29th day of February, 1952, conduct a public hearing at which technical reports and opinions, as well as other evidence relating to the foregoing matter, were received and at which all interested parties were given opportunity to express their opinions and to present evidence with respect to the problem under investigation; and

WHEREAS, copies of a full and complete stenographic transcript of the proceedings had at the hearing thus held, together with copies of findings and recommendations of the Hearing Board, have been filed with this Commission and have been distributed among the members hereof;

NOW, THEREFORE, following due consideration of the findings and recommendations contained in the report of the Hearing Board covering the proceedings had at the hearing held as above set forth, and following due consideration of the testimony and other evidence produced at that hearing, together with the various views and opinions there expressed, all as set forth in the above-mentioned transcript of proceedings, this Commission does hereby find that:

1. The notice of the time and place at which the above-mentioned was to be held was sufficient in form and extent of publication to advise all interested parties and all parties likely to be affected thereby.

2. The procedure followed by the Hearing Board in the conduct of the hearing held as above described adequately provided to all interested parties and all parties likely to be affected thereby full opportunity to be heard and to present any pertinent testimony, evidence, opinions or views which they might wish to submit for the consideration of the Commission.

3. The evidence obtained at the hearing held as above described conclusively shows that in order to protect the public health and to preserve the waters of the Ohio River in that stretch between Huntington, W. Va. and Cincinnati, Ohio for other legitimate uses within the contemplation of the Ohio River Valley Water Sanitation Compact a degree of treatment must be given to sewage discharged or permitted to flow into those waters higher than that prescribed in Article VI of the Compact.

and, subject to further revision as changing conditions may require, the Commission does hereby establish the following standard for the treatment of sewage from municipalities or other political subdivisions, public or private institutions or corporations discharged or permitted to flow into that portion of the Ohio River extending from U. S. Corps of Engineers Dam No. 27, located about five miles upstream from Huntington, W. Va.and being 301 miles downstream from Pittsburgh, Pa., to U. S. Corps of Engineers Dam No. 36, located about three miles upstream from Cincinnati, Ohio and being 461 miles downstream from Pittsburgh, Pa.:

(a) Substantially complete removal of settleable solids; and

(b) Removal of not less than forty-five per cent of the total suspended solids; and, in addition

(c) Reduction in coliform organisms in accordance with the following schedule:

Not less than 90% reduction during the months May through November.

Not less than 80% reduction during the months December through April.

* * *

The foregoing action was taken by the Ohio River Valley Water Sanitation Commission at a regular meeting duly held on April 2, 1952 at Cincinnati, Ohio.

Attest: /s/ F. H. Waring
Secretary

/s/ Clarence W. Klassen
Chairman

REPORT ON PUBLIC HEARING HELD AT HUNTINGTON, W. VA. FEBRUARY 29, 1952

Ohio River Valley Water
Sanitation Commission
414 Walnut Street
Cincinnati 2, Ohio

Gentlemen:

The undersigned, appointed pursuant to action taken by the Commission at its meeting of January 9, 1952, constitute the Hearing Board empowered and instructed to conduct a public hearing with regard to the degree of treatment which shall be given to sewage discharged or permitted to flow into the waters of the Ohio River between Huntington, W. Va. and Cincinnati, Ohio. In accordance with the direction of the Commission, the undersigned submit the following report of the conduct of such hearing together with their findings and recommendations based upon the testimony and other evidence produced at that hearing.

1. The hearing was held, with all members of the Hearing Board present, on the 29th day of February, 1952, at the United States District Court, Room Nos. 218 and 220, Second Floor, U. S. Post Office and Court House, Ninth Street and Fifth Avenue, Huntington, W. Va., commencing at 10:00 o'clock, a.m. A complete stenographic transcript was made of the proceedings had at the hearing and a copy thereof is filed herewith.

2. Prior notice of the hearing had been published and had been served upon interested parties in the manner and to the extent set forth in the attached transcript of proceedings.

3. Parties interested in the subject matter of the hearing were present or were represented to the extent indicated by the roster of appearances which is attached to the transcript of proceedings filed herewith.

4. A written report of the Commission staff setting forth information, data, testimony and other evidence, relevant and material to the subject matter of the hearing, was presented in evidence and was supported by oral testimony of members of the Staff. A copy of that report is attached as an exhibit to the transcript of proceedings filed herewith.

5. Full opportunity was given to all parties present or represented at the hearing to introduce evidence or testimony relevant or material to the subject matter of the hearing and to express their views with regard to the report and recommendations of the Staff. No evidence other than that presented by the Staff was offered and the only views expressed by parties present affirmed the findings and approved the conclusions set forth in the above-mentioned report.

6. Opportunity for the submission of written evidence or views pertinent to the subject matter of the hearing was expressly provided to any interested party, subject to the condition that it be submitted to the Hearing Board on or before the 31st day of March, 1952. No such additional evidence or views were submitted to this Board prior to the expiration of the period specified.

7. From a consideration of the evidence presented at the hearing, this Board finds that the information and other data submitted as above stated by the

Staff are accurate and pertinent to the subject matter of the hearing, and the Board further finds that the conclusions of the Staff which are expressed in the written report presented at the hearing, as above stated, are reasonable and are fully supported by the evidence and data therein contained.

8. The Board finds that a standard of treatment for sewage to be discharged or permitted to flow into this section of the Ohio River, should be adopted by the Commission and put into effect, which (1) will provide adequate protection for public water supplies by reducing the presence of coliform organisms at all water supply intakes located in this section of the Ohio River to not more than 5,000 per 100 milliliters, as a probable monthly average, (2) will under normal summer flow conditions, maintain in substantial areas of the Ohio River between Cincinnati and Maysville, between Maysville and Portsmouth and between Portsmouth and Ironton, a water quality, suitable for recreational purposes, of not more than 1,000 coliform organisms per 100 milliliters as a probable monthly average, and (3) will otherwise accomplish the objectives of the Ohio River Valley Water Sanitation Compact with respect to the discharge of sewage into this stretch of the Ohio River. On the basis of information and data submitted at the hearing the Board is of the opinion that the establishment of the standard of treatment for sewage which is hereinafter recommended is based upon these considerations, is reasonable and is in conformity with the provisions of the Ohio River Valley Water Sanitation Compact.

9. Therefore, this Board recommends that the Commission take appropriate action to establish, subject to further revision as changing conditions may require, the following standard for the treatment of sewage from municipalities or other political subdivisions, public or private institutions or corporations discharged or permitted to flow into that portion of the Ohio River extending from U. S. Corps of Engineers Dam No. 27, located about five miles upstream from Huntington, W. Va., and being 301 miles downstream from Pittsburgh, Pa., to U.S. Corps of Engineers Dam No. 36, located about three miles upstream from Cincinnati, Ohio and being 461 miles downstream from Pittsburgh, Pa.:

(a) Substantially complete removal of settleable solids; and

(b) Removal of not less than forty-five per cent of the total suspended solids; and, in addition

(c) Reduction in coliform organisms in accordance with the following schedule:

Not less than 90% reduction during the months May through November.
Not less than 80% reduction during the months December through April.

Respectfully submitted,

/s/ Hudson Biery
Chairman

/s/ Henry Ward

/s/ W. W. Jennings

Hearing Board

Cincinnati, Ohio
April 1, 1952

PROCEEDINGS AT HEARING

CHAIRMAN BIERY: Gentlemen, the meeting will come to order.

We are using these excellent facilities through the courtesy of the United States District Court. I understand that it is not customary to smoke in this room and Judge Watkins has expressed the hope that we might conform to tradition, so if you gentlemen will please refrain from smoking we will remain in good standing with Judge Watkins.

This is a public hearing being held by direction of the Ohio River Valley Water Sanitation Commission contained in a resolution that was adopted January 9th, 1952. This Compact Commission represents the combined police power of the eight sovereign states forming the Ohio River Valley in a collective effort to abate and prevent pollution of the Ohio River and its tributaries.

It is worthy of mention that the Commissioners of the various states perform their duties without compensation.

The Ohio River between Huntington and Cincinnati receives wastes from three states. The principal objective of this hearing is to expedite a coordinated effort on the part of the three states and the Commission for the abatement of existing and future pollution. We would like to emphasize at this time that the location of the hearing has no particular significance with respect to the City of Huntington, whose hospitality we appreciate. We are considering the pollution problem as it relates to many cities and 160 miles of the Ohio River.

Before we proceed with the hearing I should like to introduce the members of the Hearing Board. I am Hudson Biery, Ohio Commissioner from Cincinnati. On my right is Senator Henry Ward, Commissioner from Frankfort, Kentucky. On my left is W. W. Jennings, West Virginia Commissioner. At my right is Leonard Weakley, counsel for the Commission, of the law firm of Taft, Stettinius & Hollister. On my left is Edward J. Cleary, Executive Director and Chief Engineer of the Ohio River Commission. We have present the Secretary of the Commission, Mr. F. H. Waring of Ohio. We have many other distinguished guests and specialists who will be introduced and they will present matter that is material to the hearing.

I presume you know that all the evidence will be made a matter of record and the full transcript of the proceedings will be available to those interested. We suggest that anyone interested in obtaining a copy of the transcript contact the Chairman or the Executive Director of the Commission.

At this time we will ask Mr. Cleary to read the formal notice for this meeting.

MR. CLEARY: "Pursuant to authority contained in Article VI of the Ohio River Valley Water Sanitation Compact, and pursuant to direction of the Ohio River Valley Water Sanitation Commission, a public hearing will be held by the Commission at the United States District Court, Room Nos. 218 and 220, Second Floor, U. S. Post Office and Court House, Ninth Street and Fifth Avenue, Huntington, West Virginia, commencing at 10:00 a.m. o'clock, on the 29th day of February, 1952, and continuing thereafter from day to day until completed.

"The purpose of said hearing will be to obtain and record data, information and other evidence for use by the Commission in determining the degree of treatment which shall be given to sewage discharged or permitted to flow into the waters of the Ohio River in that stretch extending from U. S. Corps of Engineers Dam No. 27, located about five miles upstream from Huntington, West Virginia and being 301 miles downstream from Pittsburgh, Pa., to U. S. Corps of Engineers Dam No. 36, located about three miles upstream from Cincinnati, Ohio and being 461 miles downstream from Pittsburgh, Pa.

"Any and all parties whose interests may be affected by such determination are invited to be present or to be represented at the hearing to be held as above stated. All interested parties present or represented at said hearing will be given an adequate opportunity to express either orally or in writing, their views upon the issues there to be considered.

"Interested parties who desire additional information concerning the conduct of this hearing or who desire information with regard to evidence, views or recommendations which are to be submitted at such hearing are requested to call at the offices of the Ohio River Valley Water Sanitation Commission, 302 Mercantile Library Building, 414 Walnut Street, Cincinnati, Ohio.

"On and after the 14th day of February, 1952, there will be on file and available for examination at the offices of the Commission, located as above stated, copies of the report of the Commission covering its investigation of the treatment requirements for sewage discharged or permitted to flow into the stretch of the Ohio River as above defined and including the recommendations with regard to the degree of treatment which should be established for such sewage. Ohio River Valley Water Sanitation Commission by Clarence W. Klassen, Chairman." (Copy of notice attached hereto as Exhibit A.)

CHAIRMAN BIERY: Another Commissioner is present whom I would like to present, Commissioner Robert Rocheleau, Engineer-Secretary of the West Virginia Water Commission and Commissioner for West Virginia.

There is a certain amount of informality about these hearings, although this is a formal hearing, gentlemen. I particularly want to invite my colleagues, Mr. Jennings and Senator Ward, to feel free to interpose their questions and views at any time. There is no rank as between us. We three are conducting this hearing and I hope they will take advantage of my invitation to take a vigorous part in it at any stage of the proceedings when they would like to question a witness or develop any points that seem pertinent to the hearing.

At this time I think it is proper that we should have some points developed by counsel for the Commission with respect to the responsibility of the Compact Commission under the interstate compact and I will ask Leonard Weakley to present the things that he feels should be made a part of the record in these proceedings.

MR. WEAKLEY: Mr. Chairman, ladies and gentlemen, the first point that I would like to bring out is to indicate to the members of the Board, as well as to those people who are interested in the hearing, the objectives of the Commission insofar as the Compact does indicate its objectives and its duties.

Article I of the Compact reads as follows: "Each of the signatory States pledges to each of the other signatory States faithful cooperation in the control of future pollution in and abatement of existing pollution from the rivers, streams and water in the Ohio River basin which flow through, into or border upon any of such signatory States, and in order to effect such object, agrees to enact any necessary legislation to enable each such State to place and maintain the waters of said basin in a satisfactory sanitary condition, available for safe and satisfactory use as public and industrial water supplies after reasonable treatment, suitable for recreational usage, capable of maintaining fish and other aquatic life, free from unsightly or malodorous nuisances due to floating solids or sludge deposits, and adaptable to such other uses as may be legitimate."

With that basic description of objectives, the Compact goes further and in Article VI provides for certain standards of treatment and also provides the authority under which this hearing is being held today.

The pertinent parts of Article VI read as follows: "It is recognized by the signatory States that no single standard for the treatment of sewage or inductrial wastes is applicable in all parts of the District due to such variable factors as size, flow, location, character, self-purification, and usage of waters within the District. The guiding principle of this Compact shall be that pollution by sewage or industrial wastes originating within a signatory State shall not injuriously affect the various uses of the interstate waters as hereinbefore defined.

"All sewage from municipalities or other political subdivisions, public or private institutions, or corporations, discharged or permitted to flow into these portions of the Ohio River and its tributary waters which form boundaries between, or are contiguous to, two or more signatory States, or which flow from one signatory State into another signatory State, shall be so treated, within a time reasonable for the construction of the necessary works, as to provide for substantially complete removal of settleable solids, and the removal of not less than forty-five per cent, of the total suspended solids; provided that, in order to protect the public health or to preserve the waters for other legitimate purposes, including those specified in Article I, in specific instances such higher degree of treatment shall be used as may be determined to be necessary by the Commission after investigation, due notice and hearing," and it is under the authority of the last part of that Article that this hearing is being held this morning.

MR. JENNINGS: You might mention that a copy of this Compact can be made available to anyone who would like to have it.

CHAIRMAN BIERY: I don't know whether you could hear Commissioner Jennings. His suggestion is that copies of the Compact are available. We do not have very many at this meeting but they can be obtained on request from Mr. Cleary.

I would like to make a part of the record a description of the manner in which this hearing has been publicized through legal notice and other channels of publicity. For that purpose I will call on the Secretary of the Commission, Mr. F. H. Waring.

MR. WARING: A notice of this hearing, which you have heard read by Mr. Cleary, was advertised duly and certification is had hereto from Mr. Horton (Exhibit B), who represents the Commission. The notifications went to ten classes of individuals and groups of people.

First, the notice was put in as a paid advertisement in some seventeen newspapers published in the principal municipalities along the river between Huntington and Cincinnati. I have here affidavits of the publications and they are made a part of the record.

Next, the notices were given to the municipal officials in the several municipalities along that stretch of the Ohio River from Huntington down to Cincinnati, also to the Board of County Commissioners of the counties abutting the river in the stretch under consideration, the Chambers of Commerce of these places and also the State Chambers of Commerce of the three states, Ohio, West Virginia and Kentucky.

The leagues of municipalities of the several states were also notified. Industrial concerns who were known to have sanitary sewage directly tributary to the Ohio River in this stretch were also notified; trade associations or manufacturers' associations of the three states; the Attorneys General of the three states; the State Water Pollution Control Agencies of these three states; and, finally, the Departments of Conservation of the three states.

The official notification and certifications are herewith placed in the record (Exhibit B).

CHAIRMAN BIERY: You will find on the benches and perhaps you may have been handed an identification slip. The Hearing Board will appreciate it if everyone present will register and indicate whether or not you would like to be heard. We expect to give everyone full opportunity to present any views that are relevant to the purposes of the hearing.

Where several people are present who may represent a group, in the interest of conserving time it might be well to select a spokesman, although as I have already stated, we expect to hear anyone who has data to present to the Hearing Board.

We will ask Mr. Horton to collect these identification slips so that we may make a study of the names and call upon in due time those who have indicated that they would like to be heard. Before we call on those witnesses we will ask the Commission to present its views with respect to the subject matter of the hearing. (Roster of Attendance attached hereto as Exhibit C.)

At this time we will ask the Executive Director of the Commission, Mr. Edward J. Cleary, to take over and present the witnesses that he would like to use in preparing the record, showing the case for the Commission. Mr. Cleary.

MR. CLEARY: Mr. Chairman, members of the Hearing Board, ladies and gentlemen: The technical findings that are to be presented have been made in accordance with a Commission directive to the staff on April 4, 1951. This investigation has been reviewed by the Engineering Committee of the Commission

and certain conclusions have been reached. These findings, recommendations and conclusions have been embodied in a report to the Commission, on the basis of which the Commission has ordered that a hearing be held. For the record, Mr. Chairman, I offer a copy of a report: "Ohio River Pollution-Abatement Needs, Huntington-Cincinnati Stretch." (Report attached hereto as Exhibit D.)

CHAIRMAN BIERY: Mr. Cleary, how long has that report been available for request by people who might be interested?

MR. CLEARY: Since February 14.

The testimony that we present this morning will address itself to three questions. The first is: What quality of water in the river will fulfill the Compact requirements and why. The second question: What conditions now exist in the river; and, third: What treatment of municipal sewage discharges is required in order to achieve and maintain certain river quality objectives established by the Commission, and which will be set forth in question one.

To present this testimony in a logical manner we are going to call upon two of our staff specialists. The work was done by Mr. Robert K. Horton and Mr. Harold W. Streeter. Mr. Horton is a graduate of the University of North Carolina and he holds degrees of Bachelor of Science in Civil Engineering and Master of Science in Sanitary Engineering. He is a registered professional engineer. His experience has included research work on textile wastes and he conducted important sanitary engineering investigations for four years as an officer (rising to the rank of Lieutenant Colonel) in the Sanitary Corps of the Army in South America. Returning from the Army he joined the Commission staff and since 1949 has been in charge of our river purification investigations. His investigations have included studies on the Wabash River and within the past two years on the Ohio River itself.

Mr. Horton has been working under the guidance of Mr. Streeter, who is internationally recognized as an authority on the phenomenon of river purification. Mr. Streeter is staff consultant to the Ohio River Commission. He is a retired sanitary-engineer director of the Water and Sanitation Investigations Station of the U. S. Public Health Service in Cincinnati, and has been studying the Ohio River continuously since 1913.

I feel secure in saying, Mr. Chairman, that no one has more profound knowledge of purification phenomena and pollution conditions in the Ohio River than Mr. Streeter. His work has produced fundamental knowledge that is employed throughout the world in analyzing river pollution conditions and suggesting remedial measures. The testimony that you will hear is that compiled by Mr. Horton with the aid of Mr. Streeter.

I now call on Mr. Horton to develop the first question, which is: What quality of water will fulfill the Compact requirements in the river and why. This involves discussion of our bacterial-quality objectives. Mr. Horton.

MR. HORTON: Mr. Chairman, the staff study looking into the matter of the bacterial-quality objectives that would fulfill the requirements of the Compact, first with regard to protecting water supplies, has involved an investigation and an analysis of information from four different sources.

The first material investigated consisted of the results of a five-year study by the United States Public Health Service on the operation of an experimental water filtration plant. The purposes of these studies were to determine the efficiencies of our water filtration processes, and to evaluate the limiting number of coliform organisms that could be handled by these processes while at the same time permitting them to produce a safe drinking water meeting the Public Health Service standards.

The second source of information was a study, also by the Public Health Service, covering five years of observations on the efficiencies of water treatment plants in actual operation in the Ohio basin. In this study a total of thirty-one plants was investigated, ten of which were on the Ohio River.

The third part of the staff investigations has been a review of present-day efficiencies in some of the water treatment plants on the Ohio River, and comparison of these efficiencies with efficiencies that were obtained some twenty-five years ago.

The fourth part of our study has been a review of the standards and objectives now in use by other regulatory agencies.

The findings, after review of this information, may be summed up in three points. The first one is that the limiting number of coliform organisms that can be handled by a normal water filtration plant -- meaning a plant of the rapid-sand filter type, providing post-chlorination to low residuals -- has been found to be 5,000 coliform organisms per 100 milliliters.

The second finding has been that water plants can handle -- and there are many now handling -- higher concentrations of coliform organisms, but they are doing this only by the use of auxiliary treatment processes. These auxiliary processes consist primarily of the use of greater chlorine dosages and the maintenance of higher chlorine residuals in the finished water; other auxiliary processes may include multistage coagulation and sedimentation, pre-settling, pre-chlorination, and perhaps other additional forms of treatment.

The third finding has been that as a result of the use of these auxiliary treatment processes, principally the use of greater dosages of chlorine to maintain higher residuals in the finished water, taste and odor problems in our water supplies have been intensified and palatability of the water has been lessened.

On the basis of these data, then, the conclusion has been reached that insofar as the protection of water supplies is concerned, the limiting number of coliform organisms should be 5,000 per 100 milliliters. This conclusion is premised on the desirability of a return to normal water treatment processes with elimination of the need for auxiliary treatment processes.

A level of 5,000 organisms would provide maximum safety to our water supplies, and since auxiliary treatment processes could be eliminated the palatability of the water would be increased and the cost of water treatment would be decreased.

With regard to recreational waters, the staff studies have looked into the information that is available from limited research by several agencies, and these studies have also included standards and objectives in use by other regulatory agencies. We have found that epidemiological data pertaining to bathing water is quite meager, but insofar as it has been possible to calculate the risks involved to a swimmer who might use the river, our conclusion is that a reasonable safeguard would be provided if the coliform organisms were limited to a level of 1,000 per 100 milliliters. This level of 1,000 is in harmony with the objectives and standards in use by other agencies.

Mr. Chairman, these two objectives and a full description of the study on which the conclusions have been based are set forth in a printed report, and I would like to submit a copy of that report -- entitled "Bacterial -Quality Objectives for the Ohio River" -- as a part of the testimony of this hearing. (Report attached hereto as Exhibit E.)

MR. JENNINGS: Is that report available to anyone who may be interested?

MR. HORTON: Yes, sir, we have plenty of copies here.

MR. CLEARY: To emphasize what you have reported, Mr. Horton, these objectives were established with a view toward providing greater safeguards to public health, take the tremendous burden off some of our water treatment plants under which they now operate, and also to establish a basis for providing safe recreational use of the water.

Mr. Chairman, I wonder if there are any questions concerning these conclusions.

CHAIRMAN BIERY: I am wondering, Mr. Cleary, if you are planning to develop through Mr. Horton a description of any of the charts which form a part of your Ohio River presentation.

MR. CLEARY: We propose to take that up in discussing the next point. Are there any questions pertinent to our discussion of bacterial-quality objectives before we proceed to the next point?

CHAIRMAN BIERY: Anyone who would like to direct a question to any of these specialists is privileged to do so. As I told you, there is a certain amount of informality about these hearings and while we are on the subject matter is a good time to develop any points on which there should be pertinent questioning.

MR. ENRIGHT (Cincinnati): The 5,000 coliform organisms per 100 milliliters; is that based on the indicated number or the most probable number?

MR. HORTON: That is based on the most probable number.

CHAIRMAN BIERY: Any other questions that you would like to direct to Mr. Horton?

You may proceed, Mr. Cleary.

MR. CLEARY: Gentlemen, the second question is: What are the conditions that now exist in the river matched against what the conditions ought to be? Mr. Horton, will you please develop that point.

MR. HORTON: Mr. Chairman, information on coliform concentrations in the Ohio River has been assembled and studied from two different sources. The first source consists of the results of analyses at water supply intakes at the water plants in this stretch of the river with which we are concerned. The other source is information from House Document 266 of the 78th Congress, which contains the results of the survey by the U. S. Public Health Service conducted in 1939 and 1940.

I have summarized these data on a chart which I now show you (chart attached hereto as Exhibit F). On this chart the concentration of coliform organisms is shown on the vertical scale and the horizontal scale shows mile points or positions in the river starting at the upper end with Huntington and going downstream to Cincinnati.

I wish to point out first that each one of these bars shown on the chart has two significant points, the top point and the bottom of the blacked-out area or the bottom of the crosshatched area. The top point is the maximum result observed during the period of study, as I will explain, and the bottom point is the average of all the results obtained during the study.

I would call your attantion to the bars that are marked with the crosshatching. They represent the coliform concentrations observed at the water supply intakes over the past seven years, starting with Huntington on the right side of the chart, then Ashland, Ironton, Portsmouth and Cincinnati. These are the water plants for which we have a seven-year record of coliform analyses on the raw water.

CHAIRMAN BIERY: Mr. Horton, the lettering on the names of the cities is so small I am sure the gentlemen in the rear can't read them. Will you point to them and identify them?

MR. HORTON: Yes, sir. This represents the coliform concentration at Huntington. You may see that the maximum is slightly over 5,000. The average is about 3,000.

The next crosshatched bar is the water intake at Ashland with a maximum at about 70,000 and an average of around 30,000. The next crosshatched bar represents concentrations at Ironton; the level of coliform organisms here is somewhat lower than it is at Ashland.

The next crosshatched line is at Portsmouth (maximum slightly over 5,000, average at about 3,000) and the last one over here is at Cincinnati (maximum around 50,000 and average at about 6,000).

The columns that are blacked out completely represent the results published from the 1939-1940 survey of the U. S. Public Health Service. The analyses made in connection with that survey are not identical to the analyses made at the water intakes, but the data from the survey do corroborate the water intake data by showing coliform concentrations of the same general order of magnitude.

I might call attention to the bars here, showing concentrations in the vicinity of Portsmouth. You will see that the blacked out areas are considerably higher than the intake record at Portsmouth. These results from the Public Health Service do not consist of the results of one sample but are cross-sectional averages; in other words, they represent the average of three samples taken across the width of the river, whereas results at the Portsmouth intake, which is located on one side of the river, represent the coliform concentration at only that one point. So what these columns show is that the concentration of coliforms at Portsmouth is higher as a cross-sectional average across the width of the river than it is along the right or north bank of the river.

A difference is also found at Ashland, but in an opposite sense. The Ashland intake is on the left or southern side of the river, and the results at the intake are higher than the cross-sectional average across the river.

I would conclude by calling attention again to the level of coliforms in this stretch of the river (between Huntington and Ashland) and particularly to concentrations at the Ashland intake; here, as I said, the maximum is about 70,000 and the average around 30,000. I wish to point out that in every month during the past seven years the average coliform concentration at the Ashland intake has been higher than 5,000 organisms per 100 milliliters; that is, in 100 per cent of the months the concentration has been over 5,000.

That's all on this point, Mr. Chairman.

CHAIRMAN BIERY: Mr. Cleary, the Hearing Board would like to have you reproduce this chart and have it made a part of the record when the minutes are printed.

MR. CLEARY: It shall be done. Are there any questions?

MR. WARD: I would like to ask a very simple question. The water in the Ohio River when it reaches Huntington is in pretty good shape and when it leaves Huntington is in pretty bad shape?

MR. CLEARY: Yes, bacterially speaking. Using the "5,000-line" as reference you can compare conditions above and below Huntington.

MR. WARD: Is that a fair statement?

MR. CLEARY: It is a fair statement.

Mr. Horton, are you going to develop any other charts in connection with the conditions in the river now?

MR. HORTON: No, sir. Additional charts will be presented in connection with the third point.

MR. CLEARY: In other words, Mr. Horton, you have completed your summary of investigations with regard to present conditions in the river. This shows the situation we have now.

Are there any questions?

CHAIRMAN BIERY: Any questions from the floor?

FROM THE FLOOR: What is the concentration at Portsmouth?

MR. HORTON: The maximum is slightly over 5,000 -- about 5,500 -- and the average is about 3,000 over the past seven years.

FROM THE FLOOR: That is at the intake or as a cross-sectional average?

MR. HORTON: That is at the intake.

MR. WILLIAMS (Huntington): In taking those samples, is that surface water or is that a subsurface sample?

MR. HORTON: Which are you talking about, the intake?

MR. WILLIAMS: No, the three across the river.

MR. HORTON: I will ask Mr. Streeter to answer that.

MR. STREETER: These are samples taken at the approximate center of gravity of each one-third section across the river.

CHAIRMAN BIERY: Any other questions?

You may proceed.

MR. CLEARY: Finally, now, we come to the questions of what sewage-treatment requirements are needed in order to remedy this condition and provide a water in accordance with the bacterial-quality objectives sought by the Commission. I will ask Mr. Horton to continue with that phase of the discussion.

MR. HORTON: Mr. Chairman, on the basis of the data available and with particular reference to water plant records for two full years, we have approached the problem of evaluating the amount of treatment needed to meet the recommended objectives in two different methods.

The first method consisted of projecting known coliform conditions in the river at a certain flow to expected conditions of coliform concentrations at other flows. The results of this study take the form of coliforn profiles and I can best discuss them by referring to certain charts that have been prepared.

I show you first this chart on which have been plotted observed and computed coliform profiles. (This chart is shown as Figure 7 in the report titled "Ohio River Pollution-Abatement Needs, Huntington-Cincinnati Stretch," which report is attached hereto as Exhibit D.)

On this chart the horizontal scale represents mile points in the river starting up Huntington and moving downstream to Cincinnati; the vertical scale represents coliform concentrations. This black line represents a

computed coliform profile that would be expected at a certain flow. It starts off at a coliform concentration of about 54,000 at the right side of the chart, representing the contribution of coliform organisms from the City of Huntington.

CHAIRMAN BIERY: Would any of you gentlemen like to move up into the front seats? Don't hesitate to do so if you would like to.

MR. HORTON: As you can see, there is a decrease in coliform organisms at Ashland, and so on down the river. This particular profile was calculated at a river flow of 21,900 cubic feet per second. The reason it was calculated at that flow is that we had for comparison some actual observations in the river at the same flow from the 1939-1940 survey of the Public Health Service.

The results of the Public Health Service survey are indicated by the circles on the chart. If you will examine the chart you will see that there is rather close correlation between the calculated profile and the actual observations as reported in the survey. Because there was good correlation between the two profiles we felt that we were justified in calculating other profiles at other runoff conditions. I will present some of these other profiles to you.

MR. CLEARY: May I interrupt at this point, Mr. Horton, to emphasize the fact that what happens in the river can be determined mathematically. This black line is the mathematical determination.

The testimony by Mr. Horton indicates that this mathematical calculation was then checked against actual sampling data. These points indicate close correlation between what actually was observed in the river and what was calculated, thus indicating the validity of the method of calculation.

MR. HORTON: That is correct.

Remember that this profile is at a flow of 21,900 cubic feet per second. The next profile shows expected coliform conditions in the river at a much lesser flow, at a flow of 8,040 cubic feet per second feet, which is the minimum monthly average flow expected once in ten years. (This profile is attached hereto as Exhibit G.)

In general, because of less water in the river, the coliform concentrations are considerably higher. At one point they are actually lower, but in general they are higher and run in some cases up to 76,000 and even up to 142,000.

This illustrates the method of constructing these profiles, which can be calculated for any flow we chose. With this in hand, the next step was to determine what adjustment in the profile -- that is, what adjustment in coliform concentrations -- is needed in order to reduce coliform concentrations in the river so that they will meet the recommended quality objective for water supplies, which objective is shown by this line here.

Studying that problem, we found that, in general, under summer conditions it would take about ninety per cent reduction of the coliform

concentrations in the river to bring them to the 5,000 level.

I have here an adjusted profile which I wish to show you. (This profile is shown in Figure 8 of the report titled "Ohio River Pollution-Abatement Needs, Huntington-Cincinnati Stretch," which report is attached hereto as Exhibit D.) This profile has been adjusted to show conditions that might be expected with ninety per cent reduction in coliform concentrations at each point in the river. I wish to point out that the coliform concentration at each water supply intake is equal to or less than 5,000. As you can see the concentration at Ironton just meets the 5,000 level, but at the other intakes the concentration is less than 5,000.

MR. CLEARY: May I just interrupt there, Mr. Horton? What you are saying is that if all this sewage were treated to remove ninety per cent of the coliform organisms, it would so reduce the number in the river as the water flows downstream so that at every water supply intake it would be below the 5,000 level.

MR. HORTON: That is correct.

CHAIRMAN BIERY: I would like to ask Mr. Horton a question. A few years ago we weren't talking about coliforms. We were talking about colon bacillus, which was fairly easy to understand. There may be some newspapermen present who want to give the layman some inkling as to what this is all about. I wonder if Mr. Horton wouldn't give us a curbstone description as to what is a coliform; what are we talking about?

MR. HORTON: I would like to ask Mr. Streeter to answer that.

CHAIRMAN BIERY: You can be as frank as you like because we are all fairly familiar with the facts of life. Mr. Streeter, could you do so?

MR. STREETER: As Mr. Biery says, the facts of life are quite familiar to all of us and I think most of know that the colon bacillus, as it was known, took its name from the colon or large intestine. It so happens that according to a number of studies that have been made in the past, sewage contains an accumulated discharge of about 200 billion coliform organisms from each human being who contributes to that sewage per day.

That's an almost astronomical figure but it has been confirmed by quite a number of very careful studies by bacteriologists who could speak with authority. Those astronomical figures make us wonder why we don't have more of them in our streams, but, of course, the amount of dilution water in a river like the Ohio is tremendous and that particular organism, which is a normal inhabitant of the human intestine, is still considered the best index of sewage pollution, the most delicate and the most definite index of sewage pollution from the public health viewpoint.

Recently there has been proposed another group of bacteria, the enterococci group, which is also a normal inhabitant of the human intestine, but in much smaller numbers. I don't think the difference in the validity of the enterococci and the coliform group as we call it is sufficiently great to invalidate all that we have learned about the colon bacillus and its significance in waters of different degrees of pollution.

CHAIRMAN BIERY: Some of us don't use the metric system every day. In terms of a glassful of water when you talk about 100 milliliters, how much water are you talking about?

MR. STREETER: I think about a half a tumblerful. About half a glassful of water would be 100 cubic centimeters and the drinking water standard provides that that half glassful of water should contain not more than one of these colon bacilli.

The objective that we are talking about for the raw water in the river, prior to purification at the water treatment plant, would permit up to 5,000 of those same bugs in half a glassful of water.

CHAIRMAN BIERY: Thank you. Pardon me, Mr. Horton. Go ahead.

MR. HORTON: With this particular profile (profile adjusted for 90% reduction in coliform organisms, shown in Figure 8 of the report attached hereto as Exhibit D) I would like to bring out another point, namely, its indication that under this condition of flow (8,040 cubic feet per second) there would be some areas in this stretch of river between Huntington and Cincinnati that would meet the recommended objective for recreational waters. The recommended objective for recreational waters is 1,000 coliform organisms per 100 milliliters.

As to the coliform levels in the river as we go downstream, you will see that here just above Portsmouth the concentration dips below the 1,000 level. Therefore, this stretch of the river right in here would meet this recommended objective of 1,000. Also immediately above Maysville there would be a stretch of the river where the coliform level would be expected to go below 1,000, and likewise just above Cincinnati (the level would go below 1,000).

Remember again that this is the adjusted profile based on ninety per cent reduction in the concentration of coliform organisms in the river at all points.

CHAIRMAN BIERY: May I ask you another question? How much additional treatment would be required to bring the reduction in coliform organisms to ninety-five per cent, having in mind that according to your chart you are attaining the recreational objective in a few places? How many more places would be protected if you were to go five per cent more and say ninety-five per cent reduction instead of ninety per cent reduction.

MR. HORTON: I do not have here a profile based on ninety-five per cent reduction. I do have a profile that shows the amount of reduction in coliform loads required to maintain the recommended bathing water objective at all points in the river, if you would like to see that.

CHAIRMAN BIERY: You might develop that a little.

MR. HORTON: In order to show the level of coliforms in the river such that at no point does it exceed 1,000 we have constructed this profile which I show you now (profile attached hereto as Exhibit H). There would be a decrease in coliform concentration below Huntington owing to natural purifi-

cation, but then with a contribution from Ashland the concentration would go up again. The profile has been adjusted so that it does not go above a thousand coliforms at this point (that is, after the addition of sewage from Ashland). Likewise at Ironton and Portsmouth, always keeping this point where the concentration increases as a result of the sewage effluent discharges from these cities so that it is never higher than the recommended objective of 1,000.

Down along the bottom of the chart we have written the percentage reduction that would be required in order to meet this condition. These percentages run as follows: at Huntington, ninety-nine per cent reduction in the coliform contribution to the river; at Ashland, ninety-eight per cent; at Ironton, ninety-nine per cent; at Portsmouth, ninety-nine per cent; at Maysville, ninety-one per cent. You can see that this means, particularly in the upper stretches of the river, very nearly 100 per cent reduction to keep the coliform level below 1,000 at all points.

Your question was how much bathing-water area would there be with ninety-five per cent reduction. As I say, I don't have a profile here, but it would simply extend the distances above those cities (that is, above Cincinnati, above Maysville and above Portsmouth).

CHAIRMAN BIERY: One other question. If it should be found that ninety per cent is adequate, would the facilities that would be established for ninety per cent be capable of being operated to attain substantially these higher percentages that you have indicated by merely more chlorination or more intensive use of the equipment?

MR. HORTON: Mr. Chairman, it is our recommendation that facilities capable of ninety-five per cent reduction should be installed and we have worked out a treatment schedule to provide between eighty and ninety per cent reduction as a normal operating procedure, but the additional five per cent capacity we feel should be installed in order to provide for any emergencies that might occur under particular conditions of runoff and local pollution.

CHAIRMAN BIERY: Then my ninety-five per cent question was hardly as foolish as it might seem.

MR. HORTON: It is not foolish at all, sir.

MR. WARD: May I ask a question?

MR. HORTON: Yes, sir.

MR. WARD: In general, in easily understood terms, what type of treatment would be required to achieve ninety-five per cent reduction?

MR. HORTON: Chlorination essentially. Mr. Streeter has worked on that phase of the problem.

MR. STREETER: Chlorination I think is the most widely practiced and considered the most economical method of simple disinfection. Am I right about that, Mr. Waring?

MR. WARING: Yes.

MR. WARD: In terms of settleable solids, that would mean complete removability. What I am trying to drive at, you talk in technical language, maybe you all understand completely, but I am a newspaper man. I don't understand your technical language. In the case of Ashland -- is there any treatment at all at Ashland?

MR. HORTON: No.

MR. WARD: What would Ashland have to do to its sewage?

MR. STREETER: It would have to settle it first, and that's the minimum treatment provided by the Compact.

MR. WARD: Does that mean remove all the settleable solids?

MR. STREETER: That means removing all the settleable solids, and for further bacterial reduction the addition of chlorine from large pressue cylinders through measuring machines. These are used very widely in water and sewage treatment plants for the continual addition of measured amounts of pure chlorine.

MR. WARD: But you must first settle out the solids and then use chlorine?

MR. STREETER: Yes. The chlorine is used to kill off the coliform bacteria. It has been shown that you can sterilize sewage that way; if you add enough chlorine. It might not be economical to attempt to do that all the time and everywhere.

MR. WARD: In the case of, say, Ashland, if you added enough chlorine in order to take out ninety-five per cent of the bacteria, would that concentration of chlorine cause the Ironton water plant any trouble in treating that water to make it palatable?

MR. STREETER: No, I think it is fairly safe to say that as soon as the sewage, even with risidual chlorine in it, was discharged into the river, dilution would take care of that.

MR. WARD: In other words, if the cities of Huntington and Ashland would add that amount of chlorine, it still would not affect the Ironton water supply adversely?

MR. STREETER: No, the chlorine should all be absorbed and disappear by the time the water reaches Ironton. The residuals that they carry in chlorination are very small but that amount should be dissipated almost immediately in the river.

MR. WARD: Have any studies been made of the economics of complete chlorination as to whether or not it is a process so expensive that the average municipality could not undertake it?

MR. STREETER: That's a good question. It has come up in staff

discussions and we have done some estimating on it. Very briefly, our estimates indicate that the cost per person per year for chlorinating sewage up to ninety per cent efficiency or over would be about eighteen to twenty cents. That is to say, about the price of a package of cigarettes.

MR. WARD: That's for chlorination?

MR. STREETER: That's for chlorination alone and it would add about 14 to 15 per cent to the cost of primary treatment. It depends so much on the amount of chlorine used. That's the big item of expense.

MR. WARD: Have you made any studies as to what the cost would be per person on the same basis for the building and operation of a treatment plant, a settling plant, removal of the solids? How much would the total cost be?

MR. STREETER: The total cost of a settling plant would be estimated at about $1.25 per person per year, on the basis of present costs, and of that about half would be capitalized cost of construction with amortization over a thirty-year period, and the other half represents operation costs.

MR. WARD: Does that include chlorination?

MR. STREETER: That does not include chlorination, which would bring it up to about $1.45 per person.

MR. WARD: In other words, in the case of Ashland where they do not have treatment at all, for $1.40 per person per year they could build, amortize the cost of construction, and operate a treatment plant?

MR. STREETER: They should be able to do that on that basis. It isn't so formidable as one might think when you get it down to per person cost.

CHAIRMAN BIERY: My question to the witness as to the ninety-five per cent reduction treatment and recreational use of the river was intended to place in the record recognition of the fact that there is growing pressure throughout the entire Ohio Valley and throughout the United States, for that matter, to improve the recreational facilities for the good of the people.

Most of you are familiar with the tremendous sums that are being appropriated by the various states to develop recreation. I noticed in the Louisville Courier Journal last week figures that astounded me on development for recreation in Kentucky, Senator Ward, under your direction. It is a splendid thing.

When this Hearing Board gives consideration to the recommendations of the Commission's engineers as to the bacterial improvement of the river I suspect that the Hearing Board is going to give definite consideration to the recreational aspects which may not have been fully covered in the report that we have before us.

It is encouraging to discover that the facilities which it is proposed to establish for attaining ninety per cent could be used without too much

strain to obtain ninety-five per cent, and from the charts that have been exhibited it is apparent that ninety-five per cent would go much farther toward restoring the recreational uses of the Ohio River than even the most optimistic of us have hoped for.

You may proceed, Mr. Horton.

MR.HORTON: I have just one more chart to discuss.

The second approach to this problem of determining how much reduction in the sewage load is required to meet the recommended objective of 5,000 organisms for the protection of water supplies was based on an investigation of records of coliform analyses at the water supply intakes.

These records showed that the Ashland intake is the most critical point in this section of the river and, therefore, any remedial program would have to be designed to protect this point. Taking two full years of records at Ashland, we determined what reduction in coliform concentrations in the river would be needed to meet the objective of 5,000.

We found that the amount of reduction would vary, depending on the flow in the river and also depending on season. One reason it depends on season is that from any given population there are more coliform organisms discharged in the summer than there are in the winter.

From the Ashland intake record, then, we were able to work out a recommended treatment schedule, and I have a chart here that illustrates our findings. (Chart shown as Figure 9 in report titled "Ohio River Pollution-Abatement Needs, Huntington-Cincinnati Stretch," which report is attached hereto as Exhibit D). On this chart the vertical scale represents coliform concentrations and the horizontal scale represents river flow in cubic feet per second.

These points here are the observed monthly average coliform concentrations, at the Ashland intake. Each circle represents one monthly average result. On the chart, coliform concentrations have been plotted against the river flow at which the observations occurred. That's the way all of these points were plotted. There are two sets of data. We distinguished between the seasons. The solid circles represent the observations made in the summer period or from May through October. The open circles represent the observations that were made during the winter period from November through April.

This chart represents a two-year period which, incidentally, were the years 1948-1949. The reason those years were selected was this: these were the latest two years for which flow records were available from the United States Geological Survey. You will see that during these two years all of the monthly average results at Ashland were higher than the 5,000 recommended objective line, ranging up to around sixty thousand in some instances.

Studying the record, we worked out a recommended treatment schedule and it is this: In the summer with river flows up to 100,000

cubic feet per second ninety per cent reduction in coliform organisms should be applied. With flows over 100,000 cubic feet per second, a lesser degree of reduction, or eighty per cent reduction, in coliform loads could be applied.

In the winter at flows less than 50,000 cubic feet per second the higher reduction in coliforms would be required, that is, ninety per cent. At flows greater than 50,000 cubic feet per second a lesser reduction in coliforms, or eighty per cent, could be used.

We applied such a schedule to these monthly average results and plotted them at the values that would have been expected if the loads had been reduced in accordance with that schedule - the points are down here. The significant thing, as you will see, is that all the points either fall on or below the 5,000 objective. In other words, with that treatment schedule the level of coliforms at Ashland would have met this objective of 5,000.

Mr. Chairman, this treatment schedule is our recommendation, the details of which are written into the report which Mr. Cleary has submitted as a part of the record, (report titled "Ohio River Pollution-Abatement Needs, Huntington-Cincinnati Stretch," which report is attached hereto as Exhibit D). That concludes what I have to say,

MR. CLEARY: Members of the Hearing Board, may I sum up the recommendations resulting from this detailed technical study. Reading from the report, they are: "All sewage discharged into the Huntington-Cincinnati section of the Ohio River shall be so treated as to provide for substantially complete removal of settleable solids and not less than forty-five per cent of the total suspended solids."

I might point out that this is the minimum written into the Compact. Our studies reveal, however, that we have to go a little further because of the excessive bacterial pollution load and so;

"In addition, facilities shall be provided for bacterial-reduction treatment capable of effecting overall reductions in coliform bacteria up to ninety-five per cent of the numbers present in the raw sewage."

CHAIRMAN BIERY: Any questions?

MR. FISCHER (Covington): Mr. Chairman, the proposed cost of $1.40 or $1.45 per capita, does that take into consideration any segregation of the sewage?

MR. STREETER: It does not include cost of interceptors. I should have pointed that out and the reason for that is that it is very difficult to make an overall estimate at the present time of what interceptors would cost in any specific location.

MR. FISCHER: That is the cost of the interceptors only and the operation of the interceptors, but the operation of the plant would be included?

MR. STREETER: No, just the construction and operation of the plant.

MR. FISCHER: Over what period of time is this amortized?

MR. STREETER: We figured on a thirty-year period of amortization.

MR. FISCHER: Thirty years?

MR. STREETER: Yes, and we figured the total annual payments to amortize that at two and one-half per cent over a thirty-year period.

MR. FISCHER: But there are no interceptors at all included?

MR. STREETER: No interceptors at all included.

CHAIRMAN BIERY: Any other questions?

MR. MAYNARD: (Ashland) That $1.40 or $1.45, it is on a per capita basis?

MR. STREETER: Yes, sir.

MR. MAYNARD: If the population is 35,000 or 40,000, it would be figured on that basis?

MR. STREETER: That's right.

MR. BURNS (Portsmouth): What will it cost Portsmouth to build a sewage plant? Would it be a million dollars?

MR. STREETER: You mean the actual capitalized cost? I am afraid we are not in a position to answer that question without a detailed engineering study. The best we can do is take an overall estimate of what it has cost to build settling plants throughout the country and then estimate on the basis of average cost per capita to build and operate those plants.

Local conditions would govern, no doubt, what it would actually cost in dollars and cents. But, you could get a reasonable estimate by multiplying the population served by $1.40 or $1.45 per capita per year. That would be the annual cost.

As to how much it would cost for the whole thing at once, one down payment, that, of course, is a matter of figuring back from the annual amortization cost.

MR. MAYNARD: Mr. Chairman, I would like to interject this, that $1.25 or $1.40 referred to there by Mr. Streeter is about the figure we figure on a month to build a plant and our interceptors and everything. If the report comes out from this finding here that we could do it for $1.40 per capita, it is going to be very confusing for us in our locality.

We can't charge that. We have to charge more than that. I think to stress that this is just for the plant alone and the treatment -- not even the treatment but just for the plant alone and based on per capita cost, then that would be right. That would come pretty close to us.

MR. STREETER: I think that's all it is intended to do.

CHAIRMAN BIERY: Thank you. We are glad to have that comment in the record.

MR. WARD: Mr. Chairman, I would like to reinforce a point Mr. Maynard is making. My home is in Paducah and right now if Paducah attempted to build a sewage treatment plant it would cost at least one-third more than under ordinary circumstances because of the cost of construction involved in that particular locality.

You are going to have those factors in several instances and because of construction difficulties involved right now these figures might not apply in every instance. I know exactly the problem that may be created in some of these municipalities if we try to create the impression that you can do this for $1.25 or $1.40 per capita. They are trying to sell a bill of goods to the community in which they estimate it will cost more than that.

I think it is a fair statement that one thing we ought to emphasize in dealing with people is that they have got an obligation to do this job and it can be done at a reasonable cost. $1.40 a month is not an unreasonable cost.

CHAIRMAN BIERY: It might be pointed out that the Compact contains no references to cost. It requires a job to be done and the states with their soveriegn authority have guaranteed to each other that they propose to do it, so that while the discussion of cost is extremely interesting and must be given economic consideration, yet it does not necessarily govern the final results which we expect to obtain in this Ohio Valley.

MR. CLEARY: Mr. Chairman, I think it would be most unfortunate if the impression were left that we had devoted our best thinking to establishment of cost of these plants. That wasn't the intention at all. The question that occurred to us was this: how much does this additional treatment - percentagewise - cost over what the minimum Compact calls for. And our cost figures have been designed purely to show that it would cost about fourteen per cent more to add chlorination to a primary treatment plant, and that should not be taken as an index of cost at Portsmouth, Ironton or any other community.

The size of the community has something to do with cost as well as the required complexity of construction. We have analyzed certain cost data merely to provide some guide for estimating.

If there are no further questions relating to this point, Mr. Chairman, I would like to call upon supporting testimony of the findings made by the staff and the first witness is the Chairman of our Engineering

Committee. The Engineering Committee of the Ohio River Valley Water Sanitation Commission includes among its members the chief sanitary engineers of the eight states. In addition, there are other highly qualified representatives from certain Federal agencies. As a result, we feel that we have a very competent engineering review body to pass on the work done by the staff.

Mr. H. E. Moses, Consulting Chief Engineer of the Pennsylvania State Health Department, is Chairman of our Engineering Committee. I will ask Mr. Moses if he would express the views of the Engineering Committee on the facts that have been presented here today. Mr. Moses.

MR. H. E. MOSES: Mr. Chairman, ladies and gentlemen, you have heard the recital of the experts who have already testified. I have been connected with a lot of groups. I don't know of any that is more expert than our Engineering Committee in the Ohio River Valley. We have here a group of men who have these problems in their own states and they have worked hard to try to solve some of these problems on a basin-wide basis.

It might be well to indicate the names of those who are serving on the Engineering Committee to show you what a group of experts we have here. Mr. F. H. Waring is the Vice-Chairman and he is the Chief Engineer of the Ohio Department of Health. Mr. Earl Devendorf of New York is the Chief Engineer of the New York Department of Health.

A number of these men have the title of Director, but the real meaning of this is that they are Chief Engineers. Mr. F. Clarke Dugan is the Chief Engineer of Kentucky. Mr. Harry K. Gidley is the Chief Engineer of West Virginia, and we also have from West Virginia Mr. Robert F. Rocheleau who was introduced earlier and he is Executive Secretary-Engineer of the State Water Commission.

Mr. Clarence W. Klassen is the Chief Engineer of Illinois. Mr. Edgar Landenberger is a civilian engineer of the U. S. Army Engineers stationed at Cincinnati. Mr. Maurice LeBosquet is connected with the Public Health Service, a long time employee of the Service and an expert in the field.

Mr. O. Lloyd Meehean is with the U. S. Fish and Wildlife Service. Mr. Richard Messer is the Chief Engineer of the State Health Department of Virginia. Mr. Blucher A. Poole is the Chief Engineer of Indiana. Mr. W. W. Towne, formerly Chief Engineer of one of the Dakotas, is now with the Tennessee-Ohio basin regional office of the U. S. Public Health Service in stream pollution and control work.

I have the honor to head up this committee. I am the former Chief Engineer and now the Consulting Chief Engineer of the State Department of Health of Pennsylvania.

This Engineering Committee meets once every three months prior to the meeting of the Commission during which they consider carefully technical problems. One of these problems, of course, is establishment of treatment requirements.

On January 8th, 1952 they devoted much time to the Huntington-Cincinnati requirements. After considering carefully the information supplied by the experts of the Commission staff and other material presented to it, the committee reached a conclusion as to the degree of treatment needed for this particular stretch of the river. The conclusions of the committee are reflected in the treatment requirements that are now recommended for this stretch of the river.

These men all have their problems back in their own states and problems on the Ohio basin are just one part of their duties. I think every state has many, many problems, We have a tremendous one in Pennsylvania, if you will permit a personal reference. The Pittsburgh section probably puts more load on the Ohio River than any other area in the whole basin, and we are proceeding to clean that up. It is going to cost us about $80,000,000 and we are going beyond the degree of treatment that is recommended for the section of river that we are discussing here this morning.

New York State is in the midst of it and all the other states are similarly engaged, so I think you can have some assurance that this program and these recommendations presented here have been the object of careful study by experts throughout the entire basin. After all, engineers are pretty realistic. They think objectively and they think also in terms of what it is going to cost and how you are going to do it. You can have sincere assurance that what is proposed here is a practical thing and is all that is necessary at this time to protect your river. You are all interested in that because practically all of you are taking your drinking water out of the river. We believe that what is proposed here is going to protect you very well. Thank you.

MR. CLEARY: Thank you, Mr. Moses.

Are any questions from the Hearing Board directed to Mr. Moses?

Are there any questions from the participants in the hearing?

I wish now to call for additional testimony and this from the man who not only is Secretary of the Ohio River Valley Water Sanitation Commission but occupies as well the role of Chief Engineer of the Ohio State Health Department.

Mr. Waring, would you report on conditions as viewed by the State of Ohio?

MR. WARING: In the course of the many years in which we have been connected with the Ohio River through water purification plants in Ohio I have noticed that the stiffest blow from the bacteriological standpoint is at Ironton.

We have Ohio River water treatment plants at East Liverpool, Toronto, Steubenville and Bellaire, used to have one at Marietta, and now also have them at Ironton, Portsmouth, Cincinnati. Of those several plants, watching the loads over the period of years in which these plants have been

running, the load bacteriologically at Ironton is the greatest. We have always considered it the most difficult one from the standpoint of operation.

Also in the study of the situation of water purification there are seasonal variations. That was mentioned by Mr. Horton. It so happens that the most difficult or greatest bacterial load at Ironton occurs in the summer months or low-flow months. September is usually the peak.

The opposite is true at Cincinnati. That is to say, the natural self-purification of the river takes place in the river at low flow and no introduction of sewage below Maysville amounts to very much, so the opposite is true of the Cincinnati plant.

Those are factors which are hard to comprehend, but not too hard to understand when you consider that dilution or concentration is apparent in short stretches of the water, whereas in long stretches of the river nature comes to bat and relieves that concentration of bacteria to a great extent.

I was interested in compiling results at Ironton especially on a seven-year basis, a fourteen-year basis and on a twenty-one year basis to see if that trend persisted. It is remarkable in a sense, and I should call to your attention that the man in charge of the Ironton plant, who is here this morning - Mr. Edwards, has been there through this period of time, twenty-five years. Early in the game he was coached in the exact methods by Mr. Streeter on how to make these tests.

I had an excellent opportunity for comparison year by year through all these years. I find that the peak is in the month of September, whether it be seven years, fourteen years, twenty-one years or what have you. The peaks, of course, are not as high as they are at Ashland but they are high. The average for the peak month is 68,000. We have many months in which it is up over 10,000, 12,000, 15,000 for the raw water supply at Ironton.

At Portsmouth, as you observed on the maps and charts, the peaks are not as great. Nevertheless, they are influenced in the same way; that is, the peaks are in the low-flow periods and in the month of September, the early part of the month of September more than in the latter part of September.

I made a diagram of these variations at Ironton to bring out the point (diagram attached hereto as Exhibit I). You can't see it from the back of the room, but that big peak in here is the month of September, both seven-year and fourteen-year plot, and very considerably higher than the month of January or February. Some people might think high runoff months would bring about the highest loads. No -- it is the close proximity to the sources of pollution and the low flow or concentration factors that prevail in this stretch.

That explains why this Commission is concerned in this stretch of the river. It is the most aggravating one to us from the standpoint of bacteriological control.

MR. CLEARY: Thank you, Mr. Waring. Are there any questions, Mr. Chairman, from the Hearing Board?

MR. BIERY: Will you place Mr. Waring's charts in the minutes also? Also the four charts that were described and presented by Mr. Horton a short time ago.

MR. CLEARY: It will be done.

Are there any questions from the participants?

MR. DANIEL M. HEEKIN (Cincinnati): I was very much interested in what Mr. Waring had to say about the river at least partially purifying itself in some miles distance run. We have had discussion and evidence offered as to what introduction of chlorine will do to sewage and also, of course, the elimination of the solids insofar as you can, but nothing was mentioned of aeration and I assume that is included in these plants. Besides separation of solids and introduction of chlorine gas it will be necessary to aerate in order to improve the possibility of purification as the stream flows on.

MR. CLEARY: In answer to that question, Mr. Heekin, the sedimentation of the sewage itself through the primary treatment plant plus the chlorination will provide all the treatment that is needed in order to maintain the river at the degree of purity that is recommended.

The addition of aeration facilities in order to achieve recommended purification quality is not needed at this time because the river has great natural powers of purification. By simply removing from present sewage loads the material which would form sludge deposits and by killing those bacteria which may cause a hazard to health, there would be no necessity for the additional expense of aeration. Some parts in this basin will require that, but we are blessed here in this stretch of the Ohio River with tremendous quantity of flow for dilution and purification.

MR. HEEKIN: Thank you.

CHAIRMAN BIERY: Any other questions?

MR. CLEARY: Mr. Chairman, I would like to call for additional testimony and this from the Assistant Technical Secretary of the Kentucky Water Pollution Control Board and a member of our Engineering Committee, Mr. Louis Birkel.

MR. BIRKEL: I would like to say that the findings presented here are in accordance with Kentucky's program. We have approved a preliminary report to the City of Maysville submitted through our engineers in which the degree of treatment specified was primary plus chlorination.

I might also add that we furnished bacteriological data to the Ohio Valley Commission staff for the Ashland intake. This was taken from records on file in our office submitted by the Ashland Water Company.

MR. CLEARY: Are there any questions?

Additional testimony, Mr. Chairman, is now to be presented by the Executive Secretary-Engineer of the West Virginia Water Board and also a Commissioner representing West Virginia on the Ohio River Valley Water Sanitation Commission. Mr. Robert Rocheleau, may we hear from you.

MR. ROCHELEAU: Mr. Chairman, the State of West Virginia through the State Water Commission and State Health Department has for many years been aware of its responsibilities as far as the lower Ohio is concerned with respect to West Virginia. We have had numerous complaints from downstream communities with respect to sewage originating in the West Virginia portion here.

The staff of the West Virginia Commission has carried on investigations in this stretch of the Ohio River. I would like to cite some figures from an independent survey by the State Water Commission. These results are not included in those which have been given by the staff of the Ohio River Commission.

The Water Commission collected these samples, which were taken to our Charleston laboratory and analyzed. Ohio Lock 27 was sampled the summer of 1948. The average coliform result at that point was 390 organisms per 100 ml.

A BOD sampling point in the Ohio River was Kenova. The most probable number of coliform organisms per 100 ml was 34,000 during that summer survey. That is the average figure. The maximum secured by the Commission was 39,000.

Going back to the evidence produced by the staff of the Ohio River Commission, I might say that our independent results here fall very much in line with those which have been presented to you. I would like to offer this report as part of the record (report attached hereto as Exhibit J).

CHAIRMAN BIERY: Thank you, Mr. Rocheleau.

MR. CLEARY: Mr. Rocheleau, what you have said indicates that you found quality conditions in the river seven times worse than the recommended objective.

MR. ROCHELEAU: That's right.

MR. CLEARY: The last member of our Engineering Committee that I am going to call upon for testimony is the Basin Engineer for the Ohio River-Tennessee drainage area who appears here today representing the

Surgeon General of the United States. Mr. W. W. Towne.

MR. TOWNE: Mr. Chairman, ladies and gentlemen, under Public Law 845 of the 80th Congress the Surgeon General, Public Health Service, in cooperation with other Federal agencies, state water pollution control agencies, and interstate agencies and with the municipalities and industries involved, is charged with the responsibility of either developing or adopting comprehensive plans for controlling or abating water pollution of interstate waters.

With that thought in mind, the report (see Exhibit D) which you have presented to the Board, Mr. Cleary, has been reviewed with the thought that the recommendations contained therein might be adopted by the Surgeon General as a part of his comprehensive program for eliminating or reducing pollution in this section of this interstate stream. I think the report and substantiating evidence which has been presented clearly points out that bacterial pollution in this stretch of the stream is excessive, resulting in a quality of water at most public water supply intakes which is far inferior to the objectives established by the Commission and also to any objectives which have been generally accepted by competent public health authorities as necessary to adequately protect public health.

In fixing these requirements, the Commission has recognized that the use of the Ohio River as a source for public water supplies must be maintained and protected. The Public Health Service feels that the use of public waters for domestic water supply probably constitutes prior use and I think the Commission has recognized this fact.

Following this review we have concluded that bacterial pollution in this stretch of the Ohio River must be materially reduced in order to provide adequate public health protection of its over one million people using it as a source of water.

It is further concluded that the recommended plan as presented for controlling pollution due to sewage constitutes a part of an acceptable comprehensive program for the Huntington-Cincinnati stretch of the Ohio River, and after final action on the report by the Commission the Ohio-Tennessee Drainage Basins Office proposes to submit the report to the Surgeon General to be considered for adoption as an acceptable part of a comprehensive program for the section of the river covered by the study.

I have here a prepared statement from which I have read excerpts, Mr. Chairman (statement is attached hereto as Exhibit K).

I would like to make one more statement and that is as a part of Public Law 845 Congress has stated it to be their policy that the rights of states to control and abate pollution shall be preserved and protected. The Public Health Service is in entire accord with this policy and it is pleasing to note that the states are not relying upon the Federal agency to control their own problems and we are very happy to see the Ohio Commission with the states involved and the industries

and municipalities attack their problems and seek a solution. Thank you.

CHAIRMAN BIERY: Mr. Towne, since you have the document in your hand, I think it would be nice to let the record show the sentence in the preamble to Public Law 845 which sets forth the responsibilities for the states as you have just orally described them. I would like to have you quote that to be a part of the record.

MR. TOWNE: All right. Quoting from the Act, that "In connection with the exercise of jurisdiction over the waterways of the nation and in consequence of the benefits resulting to the public health and welfare by the abatement of stream pollution, it is hereby declared to be the policy of Congress to recognize, preserve and protect the primary responsibilities and rights of states in controlling water pollution."

CHAIRMAN BIERY: Thank you.

MR. CLEARY: Thank you, Mr. Towne. It should be satisfying to the Ohio River Commission to know that the Federal Government looks with merit upon these findings that have been presented here today as a fitting part of the national as well as the regional picture for water improvement.

Mr. Chairman, that concludes our supporting testimony. There is important additional information that should be put on the record dealing with the proposal for construction of a high dam at Greenup, Kentucky. This proposed aid to navigation would raise the level of the pool in the area above the Greenup dam. It will mean that those communities who are faced with the job of building sewage treatment plants ought to know something about the probable levels of that pool. They ought to know something about the imminence of the construction of that dam and, finally, we would like to put on the record some of our conclusions with regard to what effect that dam may have on the purification program recommended here today.

Mr. Edgar Landenberger, another member of our Engineering Committee, but today representing the U. S. Corps of Engineers, has a statement and I will ask Mr. Landenberger if he will present that statement.

MR. LANDENBERGER: Mr. Chairman, gentlemen, my name is Landenberger and I represent the Ohio River Division of the Corps of Engineers. The material that I have to present is in the form of two letters addressed to Mr. Cleary, Executive Director and Chief Engineer, Ohio River Valley Water Sanitation Commission, which letters are signed by Paschal N. Strong, Colonel, Division Engineer. (Letters are attached hereto as Exhibits L and M.)

(reading) Reference is made to your letter of the 13th of February, 1952, in which you advise that the Ohio River Valley Water Sanitation Commission will conduct a public hearing on the 29th of

February at Huntington, West Virginia, concerning the establishment of sewage treatment requirements in the Huntington-Cincinnati stretch of the river. You request a statement from this office, to incorporate in the record of the hearing, setting forth the status of the proposed Greenup high-level dam project and the effect it may have on river levels in the area. In accordance with your request, I am pleased to furnish the following information.

Preliminary studies which have been made to determine the best adapted plan for the replacement of navigation facilities on the Ohio River in the reach from Greenup, Kentucky, to Gallipolis, Ohio, indicate that this best can be accomplished by provision of a single high-lift dam and locks in the vicinity of Greenup, to provide a navigation pool extending upstream to the existing Gallipolis Locks and Dam. While features of the locks and dam under consideration have not been determined finally, detailed studies are under way for that purpose.

As now contemplated, the dam would be located about a mile below existing Lock and Dam Number 30 and about 341 miles below the head of the Ohio River at Pittsburgh, Pennsylvania, and would be of non-navigable type with gated crest. It would replace existing Locks and Dams Numbers 27, 28, 29, and 30 on the Ohio River and Number 1 on the Big Sandy River. Normal pool elevation would be about 515 feet. In comparison, the present normal pool elevations provided by the structures which would be replaced are as follows:

Ohio River Dam No. 27, 301 miles below Pittsburgh, normal pool elevation of 512 feet.

Ohio River Dam No. 28, 311.6 miles below Pittsburgh, elevation of 505.6 feet.

Ohio River Dam No. 29, 319.9 miles below Pittsburgh, elevation of 498.5 feet.

Ohio River Dam No. 30, 339,4 miles below Pittsburgh, elevation of 490.5 feet.

Big Sandy River Dam No. 1, three-tenths of a mile above the mouth of Big Sandy River, elevation of 512 feet.

The budget submitted to Congress for Fiscal Year 1953 includes a request for funds to continue detailed planning of the Greenup project. Depending upon the appropriation of funds, planning would be completed in Fiscal Year 1954 and construction would be initiated in Fiscal Year 1955.

In respect to your desire that the Corps of Engineers be represented at the Huntington hearing on the 29th of February, I have requested the District Engineer at Huntington to have a qualified representative in attendance.

This letter may be made a part of the official record of your Huntington hearing, if you so desire. (This concludes reading of letter. See Exhibit L).

In regard to this scheduling we have a supplemental letter which was furnished to Mr. Cleary which indicates the possibility of earlier initiation of construction of that job (see Exhibit M). The letter indicates that it is possible, depending of course upon the appropriation of funds, that construction may be initiated as early as Fiscal Year 1954.

Copies of both these letters have been mailed to the Commission.

MR. CLEARY: I insert these letters in the record. (Letters are attached hereto as Exhibits L and M.)

MR. WARD: This Greenup dam has been referred to as a high dam. It is not a high dam as we think of a multipurpose dam. It is a navigation dam, isn't it?

MR. LANDENBERGER: That is true. The term high dam relates to the present dam which would be replaced. It is in a sense relatively high.

MR. WARD: It is not recommended that it would be used for flood control of power?

MR. LANDENBERGER: No, it is a navigation dam.

CHAIRMAN BIERY: What stage will that produce?

MR. LANDENBERGER: The probable elevation will be in the neighborhood of 515 feet above sea level. In comparison it would be three feet above the normal pool of Dam 27 and approximately nine and one-half feet above the normal pool of Dam 28 and approximately fifteen feet above the normal pool of Dam 29 and in the neighborhood of twenty-five feet above the present normal pool of Dam 30.

MR. JENNINGS: It is nice to know about the new dam but what effect will that have on pollution?

MR. LANDENBERGER: I think the Commission staff will cover that point.

MR. CLEARY: Are there any other questions to be addressed to Mr. Landenberger concerning the status of the Greenup dam project? The matter has been under discussion for a number of years and the Commission has been aware of the possibility of the construction of that dam.

Naturally this question occurs: Having studied the river under the conditions that exist now and having made recommendations for remedial measures, what effect, if any, will this new structure that creates quite a large lake have on the corrective measures needed in the Huntington-Cincinnati stretch of the river? With that in mind we have made such a study.

I am going to call on Mr. Streeter, if he will, to present a statement indicating to the best of our knowledge what may be the effect of that dam.

MR. STREETER: Mr. Chairman, ladies and gentlemen, I have here a prepared statement which will be inserted in the record. I would like to read parts of that statement at this time. (Statement is attached hereto as Exhibit N.)

The effects of increased pool area of the new dam on surface aeration will tend to cause increased absorption of oxygen from the atmosphere whenever the oxygen in the river is below the saturation point, but this increased aeration will tend to be offset by increased depth and decreased flow velocity, both of which tend to retard reaeration of the total stream volume. It is quite possible, in fact, that the dissolved oxygen content may be lowered by the high dam, judging from results of observations above Gallipolis Dam in July through September, 1940. This is taken from House Document 266, of which we have a copy here.

The next point is that the effect of the high dam will approximately double the time of flow from present Dam 27 to Dam 30. This should, of course, improve the bacterial quality of water from Portsmouth downstream during periods of summer low flow and probably should materially improve the quality of water in the low end of the pool.

Its effect on the minimum dissolved oxygen would probably be to move the critical point upstream for a short distance. That depends upon flow conditions at the time; that is, during the full stage of the river. This result was observed by our laboratories at the time of a resurvey of the Cincinnati-Louisville section of the river following completion of the new dams in that section. That is, the tendency was for reduced velocities of flow and increased times to move the minimum dissolved oxygen point upstream.

Reduced velocities of flow above the proposed high dam will result in more sedimentation in the pool from uncontrolled sources of pollution (that is, tributaries and storm-sewage flows), and thus tend to accentuate scour effects during increased flow periods after periods of low-flow accumulation.

Increased pool volume -- In addition to beneficial effects on bacterial quality of river downstream from the dam, increased volume should tend to iron out immediate effects of pollution increases due to tributary and storm-water flows following local rains. That is to say, it will have a tendency to absorb these pollution peaks that may come from local rains either along the river or on the tributaries while the river is in pool stages. In other words, the sponge will be twice as big as it is now.

Some tendency to concentrate pollution near major outlets probably will result from increased pool volume, as frequently noted in lakes

and river impoundments. Average concentration in the larger pool should be no greater than under present conditions, though a longer time may be required to clear the pool of accummulated water when rises in the river occur.

Intercepting sewers -- Elevations of outlets will control those of treatment plants. It is assumed that these are being carefully considered by consulting engineers. If Greenup Dam is to be built within a few years -- if it were to be delayed a few years, I should say, it might tend to delay construction of treatment plants in the area above the new dam, pending final settlement of this question of elevations. Mr. Landenberger, however, has indicated that those elevations have been fairly well set. I take it that point doesn't need to be made, but this matter of intercepting sewers and their elevations determining elevations of treatment plants is perhaps the most important question affecting the economy of the treatment program in this area.

Oxygen relationships -- The effects of the proposed high dam on dissolved oxygen relationships should not become a matter of much concern until the density of pollution in this section has reached considerably greater magnitude than at present. It could result, however, in establishing critical oxygen conditions earlier than otherwise would be expected unless a complete program of primary treatment of sewage is in operation before such conditions may be possible. One advantage of the present low bear-trap dams is that they permit self-cleansing action in their pools. That is, it is almost complete in these present pools. Such action would not be so effective in the case of a high fixed dam, although above the Gallipolis dam we have not observed any cumulative bad effects except a tendency in the summertime during low water periods for a depression of the dissolved oxygen content in the lower end of the pool. It is not critical now because pollution is not critical in that section.

With the minor exceptions above noted, the conclusions reached in the report, made in 1949 (see Exhibit N), seem to be sound and reasonable. So far as conditions in the immediate future are concerned, the project for a high dam at Greenup would seem to make little if any difference in the sewage treatment requirements envisioned to meet pollution-abatement needs in the near future.

MR. CLEARY: Thank you, Mr. Streeter. We will enter this in the record (Exhibit N), and I think the point to be emphasized is that studies made by the Commission in 1949 and again most recently indicate that the new dam will have no effect on the proposals offered here today. The imminence of the dam construction program points up, first, that there should be no reason why a community would have to delay its construction program because the pool levels are being established now; and, secondly, that if there is a delay in sewage plant construction and such plants are not built before the new dam is installed, pollution conditions might be aggravated by the build-up of larger concentrations of untreated sewage in the new pool.

Are there any questions, Mr. Chairman, of Mr. Streeter?

CHAIRMAN BIERY: Any questions of the witness?

MR. CLEARY: Before proceeding, then, I might state that the additional statements now are those to be volunteered and also coming from people who have indicated that they wish to be heard.

CHAIRMAN BIERY: How much more time do you want, Mr. Cleary, would you estimate?

MR. CLEARY: Well, I don't know how much time these people will need.

CHAIRMAN BIERY: Several gentlemen in the audience have indicated their desire to be heard and the Hearing Board would like to defer to their convenience and either recess until 2:00 or proceed until 12:30 if you suspect that we might be able to finish.

We don't want to unnecessarily prolong the hearing and yet at the same time we do want to give ample time to anyone who wishes to be heard, and will gladly recess until 2:00 and then take up further testimony and statements and comments and questions.

MR. WARD: It seems to me that there may be some people to whom the matter of time is important. If there is anyone who is objecting, you might raise the question of how much time the opposition would like to have. How many people are to be heard?

MR. CLEARY: I know of three people who wish to be heard. They are representatives of cities now using Ohio River water. I am inclined to believe their testimony would support ours.

MR. WARD: Is there anyone that wants to be heard against this proposal?

MR. CLEARY: May I call on those that wish to support it?

CHAIRMAN BIERY: I am wondering if in the light of testimony that has been presented some of the gentlemen who have indicated their desire to be heard may find that some of their questions have been answered.

Suppose we ask the gentlemen to stand who would like to be heard and then it will give us a good idea as to whether or not we should recess until 2:00 or go ahead and work through until 12:30 or 1:00. Won't you gentlemen please stand who would like to be heard?

FROM THE FLOOR: You mean those in favor?

CHAIRMAN BIERY: Either side. This Hearing Board wants to get all the information it can.

MR. GEORGE R. SNIDER (Huntington): I would like to ask a question of Mr. Streeter. I don't think it would take very long. I am speaking as a layman. It is my understanding that if sufficient

oxygen is available in the water, that the oxygen will convert the aerobic bacteria into a harmless substance. Is that correct?

MR. STREETER: When you speak of "harmless substance", sir, you mean stable, organically stable?

MR. SNIDER: That's right. In other words, harmless to human beings.

MR. STREETER: I think we have to make a distinction between organically stable material in the stream and biological material such as bacteria.

MR. SNIDER: I mean harmless for human consumption.

MR. STREETER: I don't think that the question or organic stability has very much relation to human consumption except for the fact that none of us like to think of drinking sewage even though it had been sterilized, but I think your question has to do with the stabilizing of organic material in sewage. Is that right?

MR. SNIDER: Let me proceed a little bit further. Maybe I can make myself clear. In other words, I understand there are certain industrial wastes which are discharged into the streams contributing to the Ohio River which contain substances which by removing the free oxygen from the water prevent the culture of the aerobic bacteria.

If that is true, to what extent would that be responsible for the need for sewage treatment by the City of Huntington? In other words, if that was prevented, if you removed industrial harmful waste, would it still be necessary for the City of Huntington to engage in sewage treatment?

MR. STREETER: Yes. I think the question of treatment of sewage all along this section of the river, which has been discussed here this morning, has little to do with the question of organic stability and of robbing the stream of oxygen.

At the present time that question is not nearly as acute as the question of bacterial pollution, which is overburdening water treatment plants and endangering the safety of water supplies.

MR. SNIDER: In other words, the aerobic bacteria do not destroy the harmful bacteria?

MR. STREETER: So far as I know the aerobic bacteria do not destroy other bacteria. The organisms that destroy bacteria are higher organisms of the type which we find in normal streams and which are probably responsible for a great deal of this effect on sewage bacteria that we have shown this morning. That has nothing to do with the battle between aerobic and anaerobic bacteria. I don't think we can count that as an asset at all.

MR. WARD: Mr. Chairman, may I make one comment on that point?

Two or three years ago we were up at Pittsburgh, made a trip up and down the river there looking at pollution resulting from both the 125 municipalities in Allegheny County and the industrial plants.

One thing that interested me very much was the statement by an engineer up there who said that if it weren't for the fact that industrial wastes from some of those plants up there had the effect of pickling the organic sewage from those municipalities that they couldn't live in those areas, that the stench would be so bad that they couldn't live there. The industrial sewage had the effect of pickling the organic sewage and after that wore off downstream you had that to contend with.

As far as an individual who has responsibility in the field of pollution abatement, I don't think any Commission could take the view that the industrial waste offset the effect of the organic waste.

We have been talking about treatment by municipalities. One of the biggest problems we have is the matter of industrial waste and it is something that is being treated somewhat separately. While we have been talking here about coliforms and colon bacillus and all that stuff this morning, the fact still remains that if there is an industry that is dumping some waste into the sewage system that requires some special treatment, the city is going to have that to worry with because if that industry were located outside the city it would be required to take care of its industrial wastes.

There may be some problems involved, as I understand it, in a municipal sewage treatment plant beyond that of taking care of the bacteria that has to be treated because in obvious fairness to the individual industries, it is obviously unfair to permit an industry because it may be located in a city and is dumping its industrial waste into the city sewage plant to get away with something that we would not permit that industry to do if it were located outside the city.

Those problems are coming up all the time right now before the agencies that are trying to do something about pollution abatement, but any argument that industrial waste may be doing something to the organic waste is one that as far as I am concerned, as a fellow with some responsibility in the field of pollution abatement, can't go for because what we are out to do is require both of them, as I understand it, to take care of their wastes.

CHAIRMAN BIERY: What Senator Ward says, of course, is perfectly sound. I believe Cincinnati has drafted an ordinance which I believe has been approved by council and probably is already in effect in which the city is setting up its own regulations with industries that have peculiar problems which complicate the treatment of the municipal sewage and in that situation Cincinnati is dealing directly with her own people, as Mr. Heekin knows, and the city has recognized its responsibility and is proceeding to deal with it in its own way, independent of the Commission. As Mr. Ward says, if these industries were located outside the municipality, then they would have to deal with the state authority or the Compact Commission.

MR. CLEARY: Mr. Chairman, I would like to ask the man who purifies the water for Cincinnati and is in charge of the water plant at Cincinnati to make a statement. Mr. Enright.

MR. ENRIGHT: Gentlemen, I am not necessarily wishing to be heard but I do have a brief summation of Cincinnati's experiences in the past and what it has meant in fighting or combating pollution in general. (Mr. Enright's statement is attached hereto as Exhibit O.)

(reading) The need for pollution reduction is well recognized. Communities using the Ohio River as a source of water supply pay heavily because of pollution. Because of many factors, each community can be affected differently by the various pollution loads and an evaluation of this cost can be but an approximation.

At Cincinnati, the influence of pollution is primarily reflected in treatment costs for the control of tastes and odors. The practical elimination of the increased bacterial load due to pollution has never been too difficult a problem. But the reason for this lies in the foresightedness of the original design engineers, who fifty years ago, provided primary settling basins that give us a theoretical retention time of three days, even at today's higher filtration rates. The bacterial reduction at this point with no treatment other than the occasional use of a coagulant varied, over the years, between eighty and ninety per cent. We are well aware that if we lacked this important treatment feature, the increased bacterial load existing since about 1935 would have been of much greater concern to us.

As chlorination gradually became accepted by both the water works industry and the general public, the concentration of chlorine applied after filtration was increased. Thus, from our operational records the highest yearly average until 1930 was about two pounds per m.g. In the '30's we increased gradually to five pounds per m.g. And in the '40's we edged up close to seven pounds per m.g. A part of this increment could be charged to the greater bacterial load, yet we feel that the acceptance of chlorination and the realization of the need of greater chlorine residuals throughout the distribution system does account for a portion of this greater chlorine usage.

Throughout the years, our fight to control the many periods of distasteful water experienced has been costly -- both in money and, to some extent, consumer good will. However, there is no way to accurately proportion these periods to the type of pollution involved. Seldom were the taste and odor characteristics so well defined that we could charge any one period to any one type of pollution. Frequently industrial pollution was known to be responsible yet there were times when it was suspected but not proven. Similarly, microscopic examination sometimes confirmed the presence of algal types known as offenders, yet here too, there were periods of indecision.

The complex interrelationship of industrial wastes, sewage wastes and algal life may well be better understood as more information is obtained from the basic pollution studies now being made by the U. S.

Public Health Service of Lytle Creek, near Wilmington, Ohio.

Ammonia, with its specific purpose of blocking phenolic tastes, was first used in 1931. Activated carbon was initially tried in 1932 and since then has been used when needed. In February, 1949, break-point chlorination of the raw water was started and, with the exception of minor shut-downs due to mechanical difficulties, has been employed continuously. Though secondary benefits of this type of operation have been realized yet it still must be considered an expense of taste and odor control, and therefore, of pollution.

In attempting to evaluate this cost, we have taken the three years prior to 1949 as representative of normal operation and projected the average tonnages used with the increased unit prices paid for chemicals during '49, '50, and '51. Obviously, this but gives the cost of break-point chlorination over these three years and does not include certain operating charges of the past which were due to pollution. However, it is a minimum figure and the true cost of pollution would be in excess of it. By such calculation, we find that the cost of pollution per m.g. delivered into service during 1949 was $3.09; in 1950, $3.22 and in 1951, $3.90. The average total cost per year over these three years for taste and odor control was about $105,000.

This figure does not include any of the original expenses of equipment and installation, which were approximately $200,000. Nor does it include maintenance costs which, while comparatively small now, will increase in the future.

It can be readily seen why Cincinnati is wholeheartedly supporting all measures for pollution abatement. As you may know, the first of four proposed sewage treatment plants for Cincinnati is now under construction and will probably be in operation by next year. We have been assured by those in charge of these projects that all recommendations of this Commission regarding degree of pollution abatement can, and will, be met. The completion of this first unit will be a milestone in Cincinnati's history for we will then take our place with those communities that have done something to stop this needless abuse of our waters.

MR. CLEARY: Thank you, Mr. Enright.

I think, Mr. Chairman, I would like to comment on the fact that Cincinnati, in the middle of the 980-mile Ohio River is going ahead with its part of the job so far as sewage treatment is concerned. This puts an added obligation upon this Commission to see that those municipalities above and below Cincinnati likewise attend to their responsibilities.

CHAIRMAN BIERY: Do you have further testimony you want to present?

MR. CLEARY: Opposite Cincinnati is the City of Covington

which likewise draws its water from the Ohio River. We have Mr. Fischer in the audience. He is in charge of water purification for the City of Covington. Perhaps he would like to make a statement.

MR. FISCHER: There is not much I can add to what Mr. Enright has said. Our conditions are practically the same. We have settling basins which hold about a six-day supply in our presedimentation basins. We get about eighty-five or ninety per cent of the bacteria out of the water prior to the time it comes into our chemical plant where, of course, it is treated.

I believe there has been some money now acquired for a sewage disposal plant. Plans are in the making and it won't be too long until we get the process of the segregation of our sewers into operation. However, our plant will connect with that of the adjoining towns, Ludlow and Newport. The plant will probably be located in Ludlow and will take care of three or four communities there so we are in the process of getting the sewage disposal plant started. That's about all.

MR. CLEARY: Thank you, Mr. Fischer. I have a letter from the City of Newport, Kentucky, adjoining Covington signed by A. H. Root, City Engineer, and I would like to have this entered on our record. (Letter is attached hereto as Exhibit P.)

(reading) Your letter under date February 5th with reference to the above captioned received.

The raw water situation as regards the City of Newport and its waterworks has long been an acute problem. In the last few years this condition has grown steadily worse and the raw water of the river here has reached the saturation point as regards bacterial content. Our system is no longer able to cope with this situation, and it is necessary to treat the water after filtration with large quantities of objectionable tasting chemicals to render it pure.

The Campbell and Kenton County Sanitary District, which includes the Cities of Newport, Covington, Bellevue, Dayton, Fort Thomas, Southgate, Wilders, Ludlow and Bromley, all of which are a part of the greater Cincinnati area, are now engaged in the construction work necessary to provide adequate control of water pollution in the Ohio River basin.

The City of Newport is therefore very much interested in having the upstream riparian communities making provision to take care of their sewage discharge into the Ohio River, as the work being carried on and accomplished here will be of little avail unless our neighboring up river communities take similar action.

In view of the foregoing, it is our fond hope that the hearing on the date referred to will result in such action as is necessary to accomplish this purpose.

I offer this for the record, Mr. Chairman (see Exhibit P).

I am wondering if Mr. Anderson of the Northern Kentucky Sanitation District Number 1 is in the audience. I haven't seen him.

CHAIRMAN BIERY: Mr. LeFeber is here, I believe.

MR. CLEARY: Mr. LeFeber, do you wish to make a comment?

MR. ALFRED C. LEFEBER (Cincinnati): I represent a financial institution. I believe you refer to my father, who is a consulting engineer.

CHAIRMAN BIERY: I thought you were the engineer.

MR. LeFEBER: I am sorry, I am not.

CHAIRMAN BIERY: That's all right. Thank you.

Does that conclude your presentation?

MR. CLEARY; The people who have expressed a desire to be heard have been heard, Mr. Chairman.

CHAIRMAN BIERY: I would like to ask if there is anyone who would like to say anything further for the City of Huntington or the Commissioners of Cabell County or any other West Virginia municipality. We don't want to overlook anyone who would like to add anything to the record. Anyone from Ashland that would like to make any comment?

MR. MAYNARD (Ashland): I would like to state --

CHAIRMAN BIERY: Yes, Mr. Maynard.

MR. MAYNARD: The City of Ashland realizes and respects the Commission's views and we know that we are responsible for the pollution of the water and we want to clean it up. Last year the city employed a board of engineers to make a study of our sanitary sewer system and to make some designs and we are in the process of that now.

CHAIRMAN BIERY: Anyone who would like to speak for the Commissioners of Boyd County Kentucky, or from any other Kentucky municipality?

Senator Ward, is there anything further you want to add for Kentucky other than a plug for your beautiful park system? I didn't tell you that Henry Ward is Director of Conservation of Kentucky and I know he liked what I said about the recreational aspects of water treatment in the Ohio River. I didn't say it for his particular benefit either.

Any comment further from the City of Portsmouth or the City of Ironton?

MR. H. M. STANLEY (Ironton): Since the first of the year

we have been working on financing our plant and are working toward that end now. Our worst offenders are fellows above the river, our neighbors, and it is not going to do much good for us to make some progress until our neighbors immediately above us do.

CHAIRMAN BIERY: Being from Cincinnati, I can fully appreciate the force of your remarks. We are on the receiving end, as are Louisville and Paducah, the Senator's home cities.

MR. DAVID ARONBERG (Ashland): Mr. Chairman, I happen to be the Mayor of Ashland. I can assure the gentleman from Ironton we are trying to be good neighbors.

CHAIRMAN BIERY: Thank you. We are glad to have that statement.

Anyone representing the Commissioners from Scioto County, Ohio? Mr. Waring, any comment? Any other Ohio municipality that would like to make a statement?

Are there any particular industries that would like to discuss any of these matters that have been brought up by our specialists? We have several representatives of industry here today. We are very happy to have them here. We would like to augment the record with their distinguished advice if they will volunteer some.

The Hearing Board and the Commission are very aware of the industrial problems and I suspect that you gentlemen from industry are aware of the philosophy of the Commission with respect to solving these problems together and that much is being accomplished, we think, and hope to gradually work out that phase of the problem.

Is there any statement we should get now from any industrial representative?

MR. GEORGE F. JENKINS (Union Carbide and Carbon, South Charleston): I would like to direct my question to Mr. Moses, if I may. He spoke briefly before about the interest in obtaining objectives of the Ohio River Valley and Water Sanitation Commission and I am sure that everyone present here has indicated similar interest.

I would like to ask a question in two parts: first, can he in his opinion or from his judgment and experience give some idea of the time it will take to achieve the objective of 5,000 coliforms per 100 ml in the Ohio River and also can he estimate how long it might take to achieve the objective of 1,000 coliforms?

CHAIRMAN BIERY: Two good questions.

MR. MOSES: It is quite a task. Frankly, I don't know. I think this whole thing is progressive and this is just a sample of what is being done all over the entire watershed. I can speak perhaps for Pennsylvania as to the Pittsburgh metropolitan district.

You may know that they set up for Allegheny County an Allegheny County Sanitary Authority and they developed a preliminary plan there which proposed to collect and treat the sewage from the 106 municipalities comprising that area. On second thought it was discovered that it was too costly, particularly to the City of Pittsburgh, and they broke it down into several subgroups, one of which is the City of Pittsburgh, and some other fifty-nine municipalities that constitute what is known as the Z Section. They will go along with the collection and treatment of wastes from all those municipalities in one plant.

There are about eight or ten other subdistricts which are developing their projects on a local basis. As far as the Allegheny County Sanitary Authority is concerned, they are proceeding with the preparation of detailed drawings and it is expected that those will be finished within the course of the next two years, perhaps earlier than that.

Then the next step, of course, will be actual construction and we are hopeful that they will proceed without too much delay and the other towns, the other subdistricts, are also proceeding in the development of their local plants, so that whole project is moving forward.

As to reaching this objective that we speak of here, the treatment provided in the metropolitan Pittsburgh district is of an intermediate degree. It is higher than is proposed for the Cincinnati-Huntington area here. In terms of BOD removal -- we haven't heard much about BOD removal -- it is fifty per cent roughly, which is about fifteen per cent higher than the primary treatment proposed here. That is the objective of the Pittsburgh area and I am not sure exactly what it will do to the coliform content up there.

I don't think we have in mind for the moment that we are going to put the river in shape for recreational purposes at every place along the entire stream there. It doesn't adapt itself very well to that but we do intend to protect the river for use as to domestic and industrial water supply.

Someone this morning -- I think Senator Ward here -- said something about the pickling effect of certain industrial wastes. That is quite true in that area up there because we have the coal mine drainage, which does just that in brief, and we don't know, frankly, how to take care of it in a practical way at the present time, though we are working on it.

We have already spent in Pennsylvania about $300,000 at the Mellon Institute to make a definite and specific research study of a method of handling coal mine drainage. When we find that out it will change the complexion of the picture quite considerably there. This year I am happy to report the coal interests themselves are participating in this continuation of the Mellon Institute study and they are contributing half the cost. Everything is moving along satisfactorily in a sense and that is about all we can hope for at the present time.

I don't know whether that answers your question. It probably doesn't, but I am unable to answer it specifically.

With the reduction of BOD in the Pittsburgh area there is going to be a wonderful improvement. Whether it will reach 1,000 or 5,000 I can't say offhand. That's our present objective.

CHAIRMAN BIERY: You didn't ask me that question but I am willing to stick my neck out and expect to be supported by Commissioner Jennings and Commissioner Ward. When I am asked the question that you have just asked -- and it is a very pertinent question -- I say that the job is going to be finished as fast as the economy of the Ohio Valley can pay for it.

You tell me whether we are going to have a major war with the Communists and I can give you a more intelligent answer to your question, but if we go along about like we are for the next ten or fifteen years I think we can all look back upon that period as one in which we have largely accomplished the major objective of this program.

That's not a very good answer either but the essence of it is that it is going to be done as fast as the economy of the valley can afford to pay for it. I don't know of any better way to say it than that. The Commission is not going to try to make water run uphill but it does have a job to do and it proposes to do it.

If there is any additional data that any industry or municipality would like to file with the Hearing Board, the Board would like very much to have such data within the next two weeks or thirty days. We will not set a hard and fast limit on it. We don't want to close the record until we feel that we have given everyone a full opportunity to discuss any points that may be in question.

We are going to make a complete stenographic record of this hearing. Copies of the minutes will be available later, including the participants in this hearing and those who have attended it, and a complete record of the notice and the various legal aspects of the hearing. The Hearing Board will attend to the matter of presenting this material to the Commission as soon as it is possible to give consideration to the things that have been discussed.

I am convinced that the members of the Hearing Board are not entirely satisfied with some minor details of the recommendations and I know that they intend to give it very earnest study before reporting to the Commission, so that the matter is still open for full consideration and any additional data or information which should be presented for consideration by the Commission.

As soon as practicable after the completion of the hearing under authority of Article VI of the Compact the Hearing Board will review the testimony, evidence and opinions that have been presented and prepare for submission to the Commission recommendations with regard to

the subject matter of this hearing.

Is there any further question or any additional data that anyone wants to present at this time?

MR. THOMAS E. PHIPPS (Catlettsburg): Mr. Chairman, I am Tom Phipps from the City of Catlettsburg. I would like for the record to show that the city has employed a firm of consulting engineers to make preliminary estimates of costs and locations and so forth and that work is now in progress.

CHAIRMAN BIERY: Thank you. We are very glad to have that in the record.

MR. CHARLES S. STEVENSON (Portsmouth): Mr. Chairman, for the record, our city has plans prepared now since about 1946, I believe, and, of course, our next move will have to be some method of finance. We are like our neighbor, Mr. Stanley -- we wanted to see what the other cities up the river are going to do and we probably will be hearing more about that shortly.

CHAIRMAN BIERY: Anyone else that would like to make any comment or ask any questions of any of these witnesses at this time?

MR. STEVENSON: Mr. Chairman, until such time as this Commission makes its findings as to the extent of purification, we will more or less have to hold our plans in abeyance, will we not?

CHAIRMAN BIERY: I think that is a reasonable statement. For that reason the Hearing Board will proceed as fast as it can, allowing a reasonable period for any additional data that may come to it in the next two weeks or thirty days. We do hope to make recommendations to the Commission at a very early date.

I don't know how it appeals to you gentlemen who have listened to this hearing, but as one member of the Hearing Board, I find a great deal of encouragement in the practical aspects of the recommendations that have been presented. Apparently the problem is not so insurmountable as some of us thought it was.

It seems to me that the staff and the Engineering Committee of the Commission should have the appreciation of the Hearing Board for the concise and direct manner in which they have presented their information. The very absence of what we might expect to find in the matter of opposition is a compliment to the quality of the talent that has presented this information. It is heartening to feel that there has been general acceptance of the philosophy that this is a job that ought to be done and that the industries and municipalities apparently are desirous of cooperating with the Commission to that end.

Mr. Cleary, have you anything further to add to the record?

MR. CLEARY: No.

CHAIRMAN BIERY: Mr. Weakley, counsel?

MR. WEAKLEY: No.

CHAIRMAN BIERY: Commissioner Jennings?

MR. JENNINGS: No.

CHAIRMAN BIERY: Mr. Ward?

MR. WARD: No.

CHAIRMAN BIERY: We want to thank you all for your patience and for the enlightening questions that have been asked and we want to thank the witnesses who have offered their services and testimony.

Unless there is something else to come before the hearing, we shall adjourn.

(Whereupon, at 12:45 P.M., Friday, February 29, 1952, the hearing was closed.)

EXHIBIT A

OHIO RIVER VALLEY WATER SANITATION COMMISSION

NOTICE OF PUBLIC HEARING

Pursuant to authority contained in Article VI of the Ohio River Valley Water Sanitation Compact, and pursuant to direction of the Ohio River Valley Water Sanitation Commission, a public hearing will be held by the Commission at the United States District Court, Room Nos. 218 and 220, Second Floor, U. S. Post Office and Court House, Ninth Street and Fifth Avenue, Huntington, West Virginia, commencing at 10:00 A.M. o'clock, on the 29th day of February, 1952, and continuing thereafter from day to day until completed. The purpose of said hearing will be to obtain and record data, information and other evidence for use by the Commission in determining the degree of treatment which shall be given to sewage discharged or permitted to flow into the waters of the Ohio River in that stretch extending from U. S. Corps of Engineers Dam No. 27, located about five miles upstream from Huntington, West Virginia and being 301 miles downstream from Pittsburgh, Pa., to U. S. Corps of Engineers Dam No. 36, located about three miles upstream from Cincinnati, Ohio and being 461 miles downstream from Pittsburgh, Pa.

Any and all parties whose interests may be affected by such determination are invited to be present or to be represented at the hearing to be held as above stated. All interested parties present or represented at said hearing will be given an adequate opportunity to express either orally or in writing, their views upon the issues there to be considered.

Interested parties who desire additional information concerning the conduct of this hearing or who desire information with regard to evidence, views or recommendations which are to be submitted at such hearing are requested to call at the offices of the Ohio River Valley Water Sanitation Commission, 302 Mercantile Library Building, 414 Walnut Street, Cincinnati, Ohio. On and after the 14th day of February, 1952, there will be on file and available for examination at the offices of the Commission, located as above stated, copies of the report of the Commission covering its investigation of the treatment requirements for sewage discharged or permitted to flow into the stretch of the Ohio River as above defined and including the recommendations with regard to the degree of treatment which should be established for such sewage.

OHIO RIVER VALLEY WATER SANITATION COMMISSION

By Clarence W. Klassen, Chairman

January 31, 1952

EXHIBIT B

CERTIFICATION OF PUBLICATION AND DISTRIBUTION OF NOTICE OF HEARING

I, Robert K. Horton, hereby certify that the notice of public hearing attached hereto (said hearing to be held in Huntington, West Virginia, February 29, 1952) was published and distributed in accordance with the following schedule:

(a) Notice was published as a paid advertisement in the newspapers and on the dates indicated in attached List No. 1. Affidavits of publication are on file in the Commission offices.

(b) Notices were mailed February 4, 1952 to one or more city officials (officials being Clerk of Council, City Manager, and/or City Engineer as indicated) of the cities and towns indicated on attached List No. 2; these cities and towns being those shown on the Rand McNally Road Atlas (1951 edition) and on U. S. Geological Survey Maps as located along that section of the Ohio River with which the Hearing is concerned.

(c) Notices were mailed February 4, 1952 to the Boards of County Commissioners of the counties shown on attached List No. 3; these counties being those bordering that section of the Ohio River with which the Hearing is concerned.

(d) Notices were mailed February 4, 1952 to Chambers of Commerce at places shown on attached List No. 4; List No. 4 includes all places named previously in List No.2 and in addition the state Chambers of Commerce of Kentucky, Ohio, and West Virginia.

(e) Notices were mailed February 4, 1952 to the Leagues of Municipalities of the three states concerned (Kentucky, Ohio, and West Virginia); names of these Leagues are indicated on attached List No. 5.

(f) Notices were mailed February 4, 1952 to those industrial concerns shown on attached List No. 6. This list shows those industries known or reported by the State Sanitary Engineers as discharging or which might possibly discharge liquid wastes directly into the section of the Ohio River involved, and includes some, but not all, of the industrial concerns located within the City of Huntington, West Virginia.

(g) Notices were mailed February 4, 1952 to certain trade associations as shown on attached List No. 7; these associations being selected from state directories as those whose members most likely would be interested in or affected by the hearing.

(h) Notices were mailed February 4, 1952 to the Attorneys General of Kentucky, Ohio, and West Virginia. Names of Attorneys General are indicated on attached List No. 8.

(i) Notices were mailed February 4 or 5, 1952 as indicated to the state water pollution control agencies of Kentucky, Ohio, and West Virginia. These agencies are shown on attached List No. 9.

(j) Notices were mailed February 4 or 5, 1952 as indicated to the state departments of conservation of Kentucky, Ohio, and West Virginia. These agencies are shown on attached List No. 10.

/s/ Robert K. Horton
Robert K. Horton

STATE OF OHIO, COUNTY OF HAMILTON: SS:

ROBERT K. HORTON, being first duly sworn, says that the allegations contained in the foregoing certificate are true.

/s/ Robert K. Horton
Robert K. Horton

Sworn to before me and subscribed in my presence this 27 day of February, 1952.

/s/ Verna B. Ballman
Notary Public
Hamilton County, Ohio

LIST NO. 1 -- NEWSPAPERS

Name of Newspaper	Place of Publication	Dates Notice Published
The Ironton Daily News	Ironton Daily News Co.,Inc. Ironton, Ohio	2/7/52, 2/14/52
The Portsmouth Times	Brush-Moore Newspaper Co. 110 Chillocothe Street Portsmouth, Ohio	2/7/52, 2/14/52
The Adams County News	West Union, Ohio	2/7/52, 2/14/52
The People's Defender	Defender Publishing Co. West Union, Ohio	2/7/52, 2/14/52
Ripley Bee	Ripley, Ohio	2/7/52, 2/14/52
The News Democrat	Brown County Publishing Co. Georgetown, Ohio	2/7/52, 2/14/52
The Huntington Advertiser	Huntington Publishing Co. Huntington, W. Va.	2/7/52, 2/14/52
Ashland Daily Independent	Ashland Publishing Co. Ashland, Ky.	2/7/52, 2/14/52
Lewis County Herald	Lewis County Herald Publishing Co. Vanceburg, Ky.	2/7/52, 2/14/52
The Daily Independent	James Purdon & Co.,Publishers Maysville, Ky.	2/7/52, 2/14/52
Bracken Chronicle	Augusta, Ky.	2/7/52, 2/14/52
Bracken County News	Augusta, Ky.	2/7/52, 2/14/52
The Cincinnati Enquirer	617 Vine Street Cincinnati, Ohio	2/7/52, 2/14/52
The Cincinnati Post	Post Square and Elm St. Cincinnati, Ohio	2/7/52, 2/9/52, 2/14/52
Cincinnati Times-Star	800 Broadway Cincinnati, Ohio	2/7/52, 2/14/52
The Russell Times	Russell Publishing Co.,Inc. Russell, Ky.	2/1/52, 2/8/52
Manchester Signal	William Woolard, Publisher	2/7/52, 2/14/52

LIST NO. 2 -- TOWNS AND CITIES

Code
CC = Clerk of Council
CM = City Manager
CE = City Engineer
x = county indicated on envelope

Ohio

Clermont County

New Richmond CC, CM, CE
Point Pleasant CC, x
Moscow CC, x
Neville CC, x
Chilo CC, x
Utopia CC, x

Brown County

Boudes Ferry CC, x
Higginsport CC, x
Levanna CC, x
Ripley CC, CM, CE
Aberdeen CC, x

Adams County

Manchester CC, CM, CE
Wrightsville CC, x
Rome CC, x
Stout CC, x
Sandy Springs CC, x

Scioto County

Buena Vista CC, x
McGaw CC, x
Pond Run CC, x
Friendship CC, x
Sugar Grove CC, x
Portsmouth CC, CM, CE
West Portsmouth CC, CM, CE
New Boston CC, CM, CE
Sciotoville CC, x
Wheelersburg CC, x
Springside CC, x
Franklin Furnace CC, x
Haverhill CC, x

Lawrence County

Hanging Rock CC, x
Ironton CC, CM, CE
Coal Grove CC, CM, CE
Sheridan CC, x
South Point CC, x
North Kenova CC, x
Burlington CC, x
Sybene CC, x
Chesapeake CC, CM, CE
Corryville CC, x
Bradrick CC, x
Proctorville CC, x

West Virginia

Cabell County

Guyandot CC
Barboursville CC, CM, CE
Huntington CC, CM, CE
Westmoreland (Wayne Co.?) CC

Wayne County

Ceredo CC, CM, CE
Kenova CC, CM, CE

Kentucky

Campbell County

California CC, x
Mentor CC, x

Bracken County

Foster CC, x
Bradford CC, x
Augusta CC, CM, CE
Elmgrove CC, x

Pendleton County

Carntown CC, x

Mason County

Dover CC, x
Maysville CC, CM, CE
Springdale CC, x

Lewis County

Trinity CC, x
Concord CC, x
Carrs CC, x
Vanceburg CC, CM, CE
Garrison CC, x
St. Paul CC, x
Quincy CC, x
Firebrick CC, x

Greenup County

South Portsmouth CC, x
Fullerton CC, CM, CE
Edgington CC, x
Greenup CC, CM, CE
Raceland CC, CM, CE
Riverton CC, x
Worthington CC, x
Russell CC, CM, CE
Bellefonte CC, x
Wurtland CC, x
Siloan CC, x
Tongs CC, x
Mackoy CC, x

Boyd County

Ashland CC, CM, CE
Normal CC, x
Catlettsburg CC, CM, CE

LIST NO. 3 -- COUNTIES

Example: Board of County Commissioners
Hamilton County
Cincinnati, Ohio

State	County	County Seat
Ohio	Hamilton	Cincinnati
	Clermont	Batavia
	Brown	Georgetown
	Adams	West Union
	Scioto	Portsmouth
	Lawrence	Ironton
Kentucky	Campbell	Alexandria
	Campbell	Newport
	Pendleton	Falmouth
	Bracken	Brooksville
	Mason	Maysville
	Lewis	Vanceburg
	Greenup	Greenup
	Boyd	Catlettsburg
West Virginia	Cabell	Huntington
	Wayne	Wayne

LIST NO. 4 -- CHAMBERS OF COMMERCE

Ohio

New Richmond
Point Pleasant
Moscow
Neville
Chilo
Utopia
Boudes Ferry
Higginsport
Levanna
Ripley
Aberdeen
Manchester
Wrightsville
Rome
Stout
Sandy Springs
Buena Vista
McGaw
Pond Run
Friendship
Sugar Grove
Portsmouth, James V. Skaates, Manager, Chamber of Commerce,812 Sixth Street
West Portsmouth
New Boston
Sciotoville
Wheelersburg
Springside
Franklin Furnace
Haverhill
Hanging Rock
Ironton, James B. Gregg, Managing Director, Board of Trade
Coal Grove
Sheridan
South Point
North Kenova
Burlington
Sybene
Chesapeake
Corryville
Bradrick
Proctorville
Columbus, Herschel C. Atkinson, Exec. Vice Pres., Ohio Chamber of Commerce, Columbus 15

WEST VIRGINIA

Guyandot
Barboursville

Huntington, Don Baker, Manager, Chamber of Commerce
Westmoreland
Ceredo
Kenova
Charleston, Managing Dir., W.Va. Chamber of Commerce, C. of C. Bldg.,Charleston

KENTUCKY

California
Mentor
Foster
Bradford
Augusta
Elmgrove
Carntown
Dover
Maysville
Springdale
Trinity
Concord
Carrs
Vanceburg
Garrison
St. Paul
Quincy
Firebrick
South Portsmouth
Fullerton
Edgington
Greenup
Raceland
Riverton
Worthington
Russell
Bellefonte
Wurtland
Siloan
Tongs
Mackoy
Ashland, H. R. McWhorter, Exec.Secy. and Treas., Board of Trade
Normal
Catlettsburg
Louisville, Geo.T.Mascott, Exec. V.Pres., Ky.State C. of C., 317 Fincastle Bldg.,Louisville 2

LIST NO. 5 -- LEAGUE OF MUNICIPALITIES

Mr. Pat E. Maloney, Executive Secretary
West Virginia League of Municipalities
P. O. Box 3141
Charleston, West Virginia

Mr. Joseph H. Crowley, Secretary
Association of Ohio Municipalities
Department of Law - 204 City Hall
Cleveland, Ohio

Mr. Carl B. Wachs, Executive Secretary
Kentucky Municipal League
University of Kentucky
Lexington 29, Kentucky

LIST NO. 6 -- INDUSTRIES

Addressed to the General Manager of the following companies:

E. I. duPont de Nemours & Co., Wurtland, Ky.
The King Powder Co., Inc., Riverton, Ky.
The Geo. T. Stagg Co., Blue Run Rd., Maysville, Ky.
Koppers Co., Inc., Wood Preserving Div., P.O.Box 277, Russell, Ky.
Armco Steel Corp., Ashland, Ky.
The Semet-Solvay Co., Div. of Allied Chem. & Dye Corp., Ashland, Ky.
Ashland Oil and Refining Co., Ashland, Ky.
United Fuel Gas Co., Catlettsburg, Ky.
Carbide & Carbon Chemical Corp., Catlettsburg, Ky.
Solvay Process Co., South Point, Ohio
Semet Solvay Div., Allied Chem. & Dye Corp., Ironton, Ohio
Barrett Div., Allied Chem. & Dye Corp., Ironton, Ohio
Cranston Chemical Co., (Hanging Rock) Ironton, Ohio
Truax-Traer Coal Co., Ceredo, W. Va.
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Houdaille-Hershey Corp., 900 Ninth Ave., West, Huntington, W.Va.
W. Va. Rail Co., Huntington, W. Va.
Cissel Packing Co., Huntington, W. Va.
S. S. Logan & Son, 1935 Third Ave., Huntington, W. Va.
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Allied Chemical & Dye
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Harrisburg, Penna.

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Houdaille Hershey Corp.
Huntington, West Virginia

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OHIO RIVER

Pollution-Abatement Needs

Huntington - Cincinnati Stretch

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These findings on treatment requirements for maintaining oxygen and bacterial-quality objectives form part of the comprehensive plan of the . . .

OHIO RIVER VALLEY
WATER SANITATION COMMISSION

OHIO RIVER VALLEY WATER SANITATION COMMISSION

An interstate agency representing Illinois, Indiana, Kentucky, New York, Ohio, Pennsylvania, Virginia and West Virginia

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OHIO RIVER VALLEY
WATER SANITATION COMMISSION

414 WALNUT STREET CINCINNATI 2, OHIO

To the Chairman and
Members of the Commission

Gentlemen:

In accordance with formal action of the Commission at its April 4, 1951, meeting in Hot Springs, Va., a study has been made of conditions in the Huntington-to-Cincinnati stretch of the Ohio River directed toward the establishment of pollution-abatement requirements. Findings from this study were reviewed by the Engineering Committee and certain conclusions were reached.

This report sets forth the findings and the recommendations. The latter were adopted by the Commission on January 9, 1952, to serve as the basis for a public hearing. In brief, it was concluded that treatment requirements for municipal sewage must be greater than the minimum set forth in the Compact in order to meet bacterial quality objectives adopted by the Commission in April, 1951.

Among the municipalities in three states that will be affected by ultimate action taken by the Commission regarding the discharge of sewage are those listed in Table VI of this report.

Technical analysis and preparation of the report represent the combined efforts of Robert K. Horton, staff sanitary engineer and Harold W. Streeter, staff consultant.

Respectfully submitted,

Edward J. Cleary

EDWARD J. CLEARY
Executive Director
and Chief Engineer

February 1, 1952

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Fig 2 -- Drainage Area Above Points in Ohio River between Huntington, W. Va. and Cincinnati, Ohio

Fig 3 -- Coliforms increase with diminished flows

Fig 4 -- Coliforms tend to increase and decrease with river flow at points remote from immediate sources of pollution

Fig 5 -- Coliform Trends in the Ohio River between Huntington, W. Va. and Cincinnati, Ohio

Fig 6 -- Rates of Coliform Decrease in the Ohio River

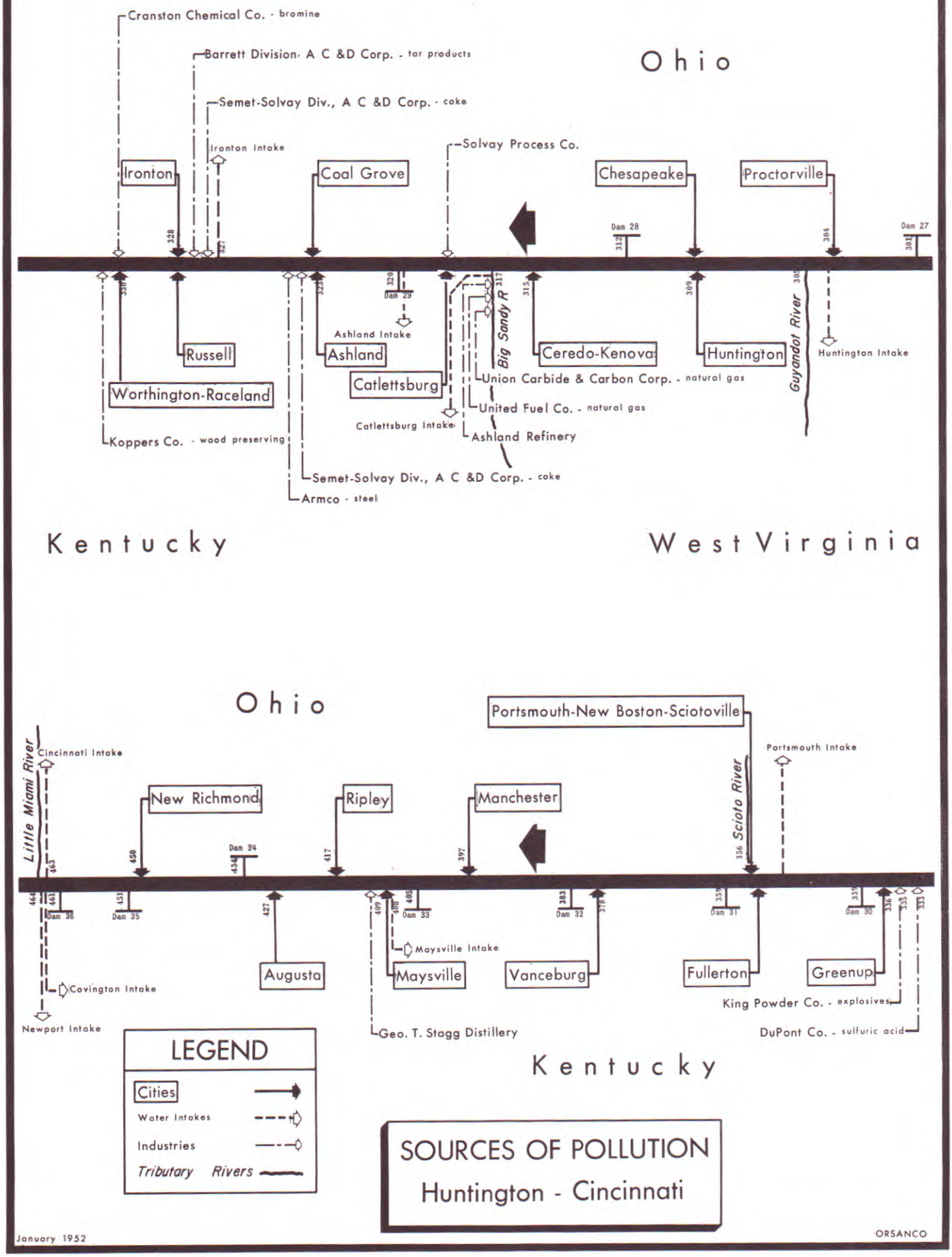
Fig 7 -- Computed Coliform Profile in the Ohio River between Huntington and Cincinnati

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Cranston Chemical Co. - bromine
Barrett Division, A C &D Corp. - tar products
Semet-Solvay Div., A C &D Corp. - coke
Ironton Intake
Solvay Process Co.
Ohio
Ironton
Coal Grove
Chesapeake
Proctorville
Dam 28
Dam 27
328
327
312
304
301
330
325
320
315
309
305
317
Dam 29
Ashland Intake
Big Sandy R
Guyandot River
Russell
Ashland
Ceredo-Kenova
Huntington
Huntington Intake
Worthington-Raceland
Catlettsburg
Union Carbide & Carbon Corp. - natural gas
United Fuel Co. - natural gas
Catlettsburg Intake
Ashland Refinery
Koppers Co. - wood preserving
Semet-Solvay Div., A C &D Corp. - coke
Armco - steel
Kentucky
West Virginia
Ohio
Portsmouth-New Boston-Sciotoville
Portsmouth Intake
Little Miami River
Cincinnati Intake
Scioto River
New Richmond
Ripley
Manchester
Dam 34
450
434
417
397
356
464
463
461
Dam 36
451
Dam 35
427
409
408
405
Dam 33
383
Dam 32
378
359
Dam 31
339
Dam 30
336
335
333
Maysville Intake
Covington Intake
Newport Intake
Augusta
Maysville
Vanceburg
Fullerton
Greenup
King Powder Co. - explosives
Geo. T. Stagg Distillery
DuPont Co. - sulfuric acid
Kentucky
LEGEND
Cities
Water Intakes
Industries
Tributary Rivers
SOURCES OF POLLUTION
Huntington - Cincinnati
January 1952
ORSANCO

CONCLUSIONS

This report is one of a series leading toward establishment of a comprehensive plan for pollution abatement on the Ohio River. The portion of the Ohio River covered by the report is that stretch between Huntington, West Virginia and Cincinnati, Ohio, a distance of 160 river miles.

Preparation of this report has been undertaken in accordance with Paragraph 12 of the Statement of Policies, which declares that one of the functions of the Commission shall be the preparation of comprehensive reports on pollution problems in the basin with recommendations for their correction, elimination and prevention.

The report has been directed toward the assembly and interpretation of information needed in establishing treatment requirements for municipal wastes. Information has been obtained from the states of West Virginia, Ohio and Kentucky, from reports of consulting engineers, from the Ohio River Pollution Survey (House Document 266, 78th Congress), and from available records of raw water quality at the several water supply intakes.

On the basis of investigations made, and in accordance with recommendations of the Engineering Committee, the following conclusions are reached regarding treatment requirements for municipal wastes discharged into the Ohio River between Huntington, West Virginia and Cincinnati, Ohio:

1. All sewage discharged into the Huntington-Cincinnati section of the Ohio River shall be so treated as to provide for substantially complete removal of settleable solids and not less than 45 percent of the total suspended solids (minimum Compact requirement). In addition, facilities shall be provided for bacterial-reduction treatment capable of effecting overall reductions in coliform bacteria up to 95% of the numbers present in the raw sewage.

2. During the months of May through October, the minimum overall reduction in coliform bacteria for all sewage discharged into this section shall be not less than 90 percent with river flows at Huntington less than 100,000 cfs (cubic feet per second), and not less than 80 percent with river flows of 100,000 cfs or more.

3. During the months of November through April, the minimum overall reductions in coliform bacteria for all sewage discharged into the section shall be not less than 90 percent with river flows at Huntington less than 50,000 cfs, and not less than 80 percent with flows of 50,000 cfs or more.

BACKGROUND

The section of the Ohio River with which this report is concerned is shown diagramatically in Figure 1. The section may be defined as that stretch extending from Dam No. 27 at Mile Point 301, which is immediately above Huntington, to Mile Point 464, near which point are located water intakes for the cities of Cincinnati, Covington and Newport (mile points are miles below Pittsburgh).

Eight public water supplies are taken from this stretch of the river. These supplies serve a combined population of more than 1,000,000 people (including Cincinnati, Covington and Newport).

Wastes discharged into this portion of the river have a population equivalent (biochemical-oxygen-demand basis) of 287,000. Sources of pollution are indicated in Figure 1.

Commission concern with pollution abatement needs in the Huntington-Ashland-Ironton area was first expressed in 1949 with issuance of a preliminary report on waste-treatment requirements. Major conclusions of this report were:

1. Satisfactory dissolved oxygen conditions would be maintained by treatment of municipal wastes (in the river stretch considered) in accordance with minimum requirements of the Compact.

2. All sewage discharged into the Ohio River above Ironton up to Dam 27 (immediately upstream from Huntington) should be given treatment for bacterial reduction to a degree in excess of that provided by sedimentation.

3. Facilities for bacterial reduction should be such as to permit flexibility of operation. The report pointed out that this would make it possible to provide treatment in the degree necessary to meet bacterial quality objectives that would be established by the Commission at a later date.

In the present report the preliminary study has been extended by investigating anticipated water-quality conditions in the river, in terms of oxygen balance and coliform levels, under varying circumstances of river flow and pollution loads. Furthermore, this report embraces a larger section of the river than did the preliminary report, namely a stretch of 160 river miles compared with the 38-mile stretch between Huntington and Ironton.

Bacterial quality objectives for the Ohio River were established by the Commission in April 1951. Establishment of these objectives has made possible the translation of information on river conditions and pollution loads into a knowledge of specific treatment requirements.

The purpose of this report has been to present findings regarding the extent and control of pollution caused by sanitary sewage.

The Ohio River between Huntington and Cincinnati receives wastes from three states. A principal objective of this report, therefore, is to expedite a coordinated effort on the part of the three states and the Commission for the abatement of existing and future pollution.

HYDROMETRIC DATA

Runoff records for the USGS gage at Huntington have been used as the basis for flow-probability studies. This record was selected because it is the longest continuous record of any of the gaging stations on the Ohio River between Huntington and Cincinnati. USGS gaging stations in this reach of the river and dates when continuous records were started are as follows:

Huntington, W. Va. -- August 1934
Ashland, Ky. -- October 1939
Maysville, Ky. -- October 1940
Cincinnati, Ohio -- October 1939

From the Huntington record the following data were tabulated for each year from 1934 to 1948 inclusive (1948 is the latest year for which a complete record is available): minimum daily flow, minimum weekly flow, minimum two-week flow, and minimum monthly (i.e. calendar month) flow. These data, together with the month of occurrence, are shown in Table I. From this tabulation, it is revealed that the various minimum flows recorded during the 15-year period are as follows:

Minimum day -- 3,200 cfs (1934, 1935 and 1937)
Minimum week -- 5,960 cfs (1946)
Minimum 2-week -- 6,300 cfs (1946)
Minimum month -- 7,340 cfs (1946)

Drainage Areas -- For convenience in estimating runoff at intermediate locations between Huntington and Cincinnati the chart shown in Figure 2 has been prepared. This chart shows the drainage area tributary to any point along this section of the river.

Adjustment in flows for reservoir operation -- The recorded flows given in **Table I have** been adjusted to show the effect of low-flow regulation from multiple-purpose reservoirs in the drainage area above Huntington. Adjustments have been made in accordance with procedures followed by the Commission in preparing the Cincinnati Pool Hearing Report.

Adjusted flows, which are shown in Table II, indicate what runoff values would have been if low-flow regulation had been in effect at the time gagings were taken. The months during which low-flow increases may be expected are June through October.

In making these adjustments, consideration has been **given** only to those reservoirs already in operation or to those now under construction. No allowance has been made for reservoirs which have been proposed, but construction of which is uncertain.

Reservoirs providing low-flow regulation and the amount of flow increase from each are detailed in Table III. The values of flow increase shown in the table are considered to be conservative. This information has been supplied by the Ohio River Division office of the U. S. Corps of Engineers.

Drought-Flow Probabilities -- On the basis of adjusted flow records, studies were made to determine the probability of droughts of varying severity. These studies were made in accordance with Gumbel's statistical theory of extreme values.

Results of these studies are shown in Table IV. To illustrate use of the table, it may be pointed out that the drought flow to be expected once in ten years as a daily average value is 4,110 cfs, and as a monthly average value is 7,840 cfs. For nine years out of ten -- or 90 percent of the years -- drought flows equal to or greater than the values indicated may be expected.

Critical-Flow Duration -- It should be noted that droughts of the same expectancy become less severe as the interval over which runoff is averaged increases. This is demonstrated by the data previously shown, which compares daily and monthly droughts expected once in ten years.

The significant interval over which to measure consecutive low flow may be different for different types of wastes. In dealing with toxic wastes, for example, drought flows of one-day duration may be of major significance.

In dealing with oxygen-demanding wastes, the significant interval is that which is equal to the time of passage of pollution through the critical stretches of the stream where oxygen content is lowest. In the section between Huntington and Cincinnati it was found that under conditions of low flow the time of passage was very nearly equal to one week.

In investigating bacterial pollution between Huntington and Cincinnati calendar-monthly average flows have been used. The reason for this is that the bacterial quality yardstick adopted by the Commission is expressed in terms of average coliform concentrations during a calendar month.

Seasonal Flow Expectancies -- Studies of bacterial conditions required the investigation of flow probabilities during different seasons of the year. Seasons were selected to include months in which water-temperature conditions were similar. The grouping of months by seasons was as follows: summer: June, July, August and September; fall: October and November; winter: December, January, February and March; spring: April and May.

Monthly-average flows for each month were tabulated from Huntington gage readings for the period of record. Adjustments for reservoir operation were made in accordance with information supplied by the U. S. Corps of Engineers. On the basis of seasonal groupings, then, the normal distribution of flows were determined by statistical analysis. Results are summarized in Table V.

Table V shows, for example, that in 50 percent of the summer months (June through September) expected flows will be equal to or less than 40,000 cfs; in 50 percent of the fall months (October through November) expected flows will be equal to or less than 34,000 cfs.

Time-of-Flow -- Time-of-flow data used in the analysis of oxygen and bacterial changes in the river were obtained from a report to the Engineering Committee of the Commission entitled "The Ohio River -- Estimates of Time-of-Flow," prepared by Mr. Edgar Landenberger of the U. S. Corps of Engineers from hydrometric observations made in connection with the 1939-40 Ohio River Pollution Survey of the USPHS (House Document 266).

In this report, Mr. Landenberger developed a graphical method for showing times-of-flow from points of origin in three sections of the Ohio River by a series of slope-lines plotted on a horizontal river mileage scale, and with ordinates representing times-of-flow in hours. The general slope of each line is determined by the total time-of-flow through the section corresponding to a given discharge as indicated by the reading at a reference gage sensitive to changes in flow. For purposes of this study, it has been expedient to use river discharges rather than gage heights, as being more direct, in selecting particular slope-lines for given flow conditions.

In using the charts, the discharge at a design-flow reference point, such as Huntington, is converted to the corresponding discharge at a reference point used by Mr. Landenberger (for example, at Maysville, Ky.), and a slope-line corresponding to the latter is then selected as representing times-of-flow at this runoff condition. Times between intermediate points are read off the ordinate scale by differences between the time to the lower point and the time to the upper point. Total times-of-flow from Huntington to successive points downstream are thus taken from the proper slope-line in this manner. (The basic method is described fully in Mr. Landenberger's report).

Temperature -- Temperature data for these investigations were obtained from the Ohio River Pollution Survey Report of the U. S. Public Health Service (House Document 266), other reports of the USPHS, and the report on the 1950 survey conducted by the Commission. For seasonal periods, stream temperatures have been averaged by months during such periods.

OXYGEN CONDITIONS

Pollution Loads -- Estimated BOD (biochemical oxygen demand) loads now being discharged into the Ohio River between Huntington and Cincinnati are shown in Table VI. Estimates have been made, for the most part, by adjusting loads shown in the Ohio River Pollution Survey Report (House Document 266) to present levels on the basis of population increases reported by the 1950 Census. It should be noted that data in the Ohio River Pollution Survey Report include population equivalents of both municipal and industrial discharges.

In Table VI data are shown for several cities and towns not listed in the Ohio River Pollution Survey Report, but which are included in the current inventory of municipal sources of pollution reported to the Commission by the several states. Loads (in population equivalents) for these cities and towns have been taken as equal to the census population, except for Chesapeake, Ohio and Raceland, Kentucky where sewage treatment facilities are available. As shown in the table, the total estimated BOD load discharged into this stretch of the river is 71,890 lb. per day (population equivalent 287,300).

Reports by consulting engineers on sewage-treatment programs for the cities of Huntington, Ironton and Portsmouth have been reviewed. Reasonably close agreement has been noted between the data in these reports on municipal loads and load increases at these cities with the data in Table VI.

It is believed that load data shown in Table VI are sufficiently accurate for present purposes. As will be shown below, oxygen conditions in the river are far from being critical, indicating that more precise measurement of loads at this time is unjustified.

Observed River-Quality Conditions -- The best information available on oxygen conditions in the river has been derived from the 1939-40 Ohio River Pollution Survey Report by the U. S. Public Health Service, these observations having covered a period of a full year or more. Also available are the results of a two-week survey made in September, 1950 under the sponsorship of the Commission. Other data, used for purposes of comparison, have been available from the earlier USPHS surveys of 1914-16 and 1929-30.

For purposes of illustration, observed average results from the 1939-40 survey are shown in Table VII, covering the month of September, 1939, when the average flow at Huntington was 9,000 cfs, a drought flow to be expected, as a monthly average flow, about once in seven years (see Table IV). In Table VII it is shown that the minimum dissolved oxygen (DO) content of the river below Huntington was 7.3 ppm or 86% of saturation at the prevailing stream temperature, 24.5 deg C.

It will be noted that from Dam 28, just below Huntington, to Dam 31, below Portsmouth, the DO content remained nearly constant, with a maximum deviation of 0.2 ppm from an average of 7.5 ppm, and the 5-day BOD also was nearly constant, with a maximum deviation of 0.1 ppm from an average of 1.0 ppm. No well-marked "oxygen-sag" was apparent in this zone of the river, indicating that deoxygenation and reaeration were practically in balance with each other in this zone.

Below Portsmouth, an increase of 0.6 ppm in DO content from 7.5 ppm at Dam 31 to 8.1 ppm at Dam 36 (just above the Cincinnati intake), together with a decrease of 0.5 ppm in 5-day BOD from 1.4 ppm at Dam 32 to 0.9 ppm at Dam 36 is noted. Making due allowance for observational error, a state of practical balance between deoxygenation and reaeration is again indicated. In this case the absence of any major sources of pollution between Portsmouth and Cincinnati tended to permit relatively undisturbed oxidation, with a measurable decrease in BOD and an increase in DO resulting from reaeration.

Computed Oxygen Profiles -- On the basis of these observations, a dissolved oxygen profile has been computed for an assumed 5-year, 7-day average drought flow of 7,400 cfs at Huntington, at a river temperature of 25 deg C. In making these computations, the Streeter-Phelps oxygen sag formula has been applied successively at each major source of BOD, beginning at Huntington, adjusting the value of the initial BOD (L_a) for the BOD added at each point, figured as 0.25 pounds per day per capita of contributing population, and converted to parts per million by the relation:

$$ppm = \frac{\text{lbs. per day}}{5.4 \times \text{cfs discharge}}$$

In applying the oxygen sag formula, the value of the deoxygenation rate coefficient (k_1) has been taken as 0.12 at 25 deg C by means of the relation:

$$k_1 \ (25^{\circ}) = 1.047^{5} \times 0.10 \ (20^{\circ}C)$$

The value of the reaeration coefficient (k_2) has been taken as 0.10, being derived from a value of 0.12 observed in the same zone in September, 1939, and allowing for a decreased flow from 9,000 to 7,400 cfs (7,400/9,000 x 0.12 = 0.10). This value is lower than generally observed at higher flows, but appears to be quite reasonable in view of the pool depth and extremely low velocity of flow under the assumed drought-flow condition. The value of the initial DO deficit (D_a) below Huntington has been taken as 1.0 ppm, as observed in September, 1939. The initial value of (L_a) (below Huntington) has been computed from a 1950 population equivalent of 112,000 for the Huntington area, or as 28,000 lb. per day (112,000 x 0.25) converted to parts per million. Readjustment of (L_a) at each downstream source of pollution has been made on the basis of the residual BOD at that point plus the added increment in pounds per day.

These calculations show that with an assumed five-year drought flow of 7,400 cfs (7-day average flow), the minimum DO content of the river at a summer temperature of 25 deg C would be estimated to approximate 7.3 ppm, or 87% saturation under present conditions of pollution, assuming no sludge deposits.

Following this method, dissolved oxygen profiles may be drawn for other conditions of flow and for varying BOD loadings. Such profiles may be used for re-evaluating oxygen conditions in the future, when and if this should become necessary because of changes in the distribution or concentration of present BOD loads.

Conclusion -- With present BOD loads, approximately 72,000 lb. per 24 hours, oxygen conditions are not critical at any season of the year, or at any flows.

Therefore, the conclusion is reached that so far as oxygen conditions are concerned, sewage treatment in excess of the minimum required by the Compact is unnecessary.

BACTERIAL CONDITIONS

Bacterial conditions in this section of the river have been studied with special reference to sewage treatment requirements which would secure river water quality at water works intakes meeting the Commission's coliform objective.

Recommendations resulting from this study reflect two decisions made by the Engineering Committee at its meeting on November 20, 1951. The first was to the effect that in fixing requirements for bacterial reduction in sewage the primary aim was to provide adequate protection for water supplies drawn from the river. It was recognized by the Committee, however, that in meeting the coliform objective for water supplies, the objective for recreational waters would also be secured in certain areas. The second decision was that the same percentage of reduction in coliform bacteria be required at all points of sewage discharge in the section, according to whatever degree might be needed under a given flow and seasonal condition at the most critical point in order to meet the Commission's bacterial-quality objective for water intakes; namely, average coliform most probable number (MPN) not exceeding 5,000 per 100 ml in any month.

Seasonal variations in per capita contributions of coliform bacteria in sewage, previously established through observations by the United States Public Health Service, have been a complicating element, further intensified by the effects of local runoff during each season. For purposes of estimate, overall contributions of 0.14 "quantity unit" per capita in summer, and 0.065 per capita in winter have been assumed, as a conversion factor between sewage-contributing population and coliform densities produced in the river at various flows. ("Quantity units" - coliform MPN per ml x discharge in thousand cfs).

A study of the relations between observed coliform densities and river flows, based on United States Public Health Service data of 1939-40, shows that in the Huntington-Portsmouth section, cross-sectional average coliform MPN's tend to increase with diminished flow, and vice versa, exceeding 5,000 per 100 ml at flows ranging below 40,000 to 50,000 cfs at Huntington (see Fig 3). In this stretch, dilution thus appears as the dominant factor in coliform densities. In the Portsmouth-Cincinnati stretch, the effects of natural purification, modified by increased flows, tend to offset this predominant dilution effect, to the extent that at Dam 36 (immediately above the Cincinnati intake and 105 miles below Portsmouth) coliform densities tend to vary almost directly, rather than inversely, with the flow (see Fig 4). This reversal in the coliform-flow relation has an important bearing on the flow conditions under which supplementary bacterial reduction treatment of sewage discharged into the upper and lower portions respectively of the Huntington-Cincinnati section may be needed, though its effects may be reduced through primary sewage treatment throughout the section.

From a study of coliform density trends in the river as shown by the United States Public Health Service data of 1939-40, it is indicated that the more critical conditions tend to coincide with summer low flows, as well as summer high flows, in the latter case especially when sharp rises in the

river follow periods of low water (as for example during the Ohio River quality survey of September, 1950), (See Table VIII and Fig 5). Under winter conditions of low and high flows, cross-sectional average coliform MPN's were observed to exceed 5,000 per 100 ml at some points above and below Portsmouth, respectively, but tended to run below 10,000 per 100 ml at all points. This was in marked contrast to coliform densities observed in summer, which at low flows exceeded 10,000 throughout the greater part of the Huntington-Portsmouth stretch and at high flows tended to run above this level throughout the entire Huntington-Cincinnati section.

Application of coliform "die-away" curves derived from three years of continuous observations by the United States Public Health Service in 1914-16, shows a very fair agreement between calculated coliform MPN's at various points, allowing for accretions due to added sewage at major and more important minor sources of pollution, and the average cross-sectional MPN's observed at these points during corresponding periods of the 1939-40 United States Public Health Service survey. The "die-away" curves are reproduced in Fig 6, and the calculated coliform profile in Fig 7. During periods of high water, however, both in winter and in summer, deviations in observed MPN's above computed trend lines shaped by self-purification effects suggest that under these conditions such effects are masked to some extent by those of inflow and channel scour due to increased runoff. These effects are illustrated in Fig 5, and are particularly apparent in the Portsmouth-Cincinnati stretch, where the effects of self-purification are most evident during low-flow periods. With primary treatment of all sewage, these deviations should be materially reduced.

A study of these self-purification trends in relation to upstream sources of pollution affords a possible method for evaluating the relative percentage responsibility of each major source of pollution for coliform densities at downstream points. The accompanying tabulation shows a comparison of these percentages derived for three different stream conditions; namely, summer low-flow, winter low-flow, and winter high-flow.

Percentage of Total Coliforms at Water Intake:

	Ashland			Ironton			Portsmouth			Maysville			Cincinnati		
	SL	WL	WH	SL	WL	WH	SL	WL	WH	SL	WL	WH	SL	WL	WH
Originating At	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%
Above Huntington	2	5	40	1	2	30	--	--	28	--	--	13	--	--	11
Huntington Dist.*	98	95	60	45	61	48	30	47	41	5	17	20	2	13	18
Ashland				54	37	22	39	32	21	7	11	9	3	7	8
Ironton							31	21	10	5	6	5	3	7	4
Portsmouth **										83	66	27	46	53	25
Maysville													46	20	8

Symbols: SL = summer low-flow WL = winter low-flow WH = winter high-flow
(*) includes Ceredo, Kenova and Catlettsburg (**) includes New Boston

It is noted that the relative responsibility of each upstream source of pollution for coliform loads at downstream points varies with season and flow, and at more distant points is greatest at winter high-flows, because of lowered stream temperatures and shortened times of flow. The effect of pollution from the Scioto River is measurably high at Maysville

and Cincinnati only at high flows, being roughly equivalent to that of Portsmouth under this condition. The effect of pollution from above Huntington also is materially great only under the same condition, being of minor significance at both winter and summer low-flows.

A coliform profile similar to the one shown in Fig 7, has been drawn for an assumed 10-year minimum monthly average flow of 8,040 cfs at Huntington. This profile emphasizes the intensification of critical coliform loads to be expected throughout the entire Huntington-Cincinnati section under this condition. On this basis it is estimated that supplementary bacterial treatment of all sewage discharged into the river would be necessary under conditions approaching such a flow, ranging up to 90% for water supply protection, and up to 98.8% for protection of recreational areas. In this latter connection, it appears likely that with 90% bacterial reduction, bathing water quality requirements cannot be met except in limited stretches above Maysville and Cincinnati not subject to local pollution. This profile, together with the estimated effect of 90% reduction, is shown in Fig 8.

In view of the primary need for protecting sources of water supply in accordance with the recommendation of the Engineering Committee, a study has been made of the more recent available records of bacterial quality at various water supply intakes in the river, which are located at fixed points and do not necessarily represent average cross-sectional quality at their respective locations. These records have consisted of two series of coliform data, one based on routine filtration plant laboratory reports; the second, on results from the United States Public Health Service monitoring survey, instituted in the summer of 1950 (shown in Table IX). Methods of coliform enumeration differed for the two series, the first being based on 48-hour presumptive tests in single-tube plantings; the second, on confirmed tests in 3-tube plantings.

The only results which could be correlated with river flows were those from the first series, as flow data provided by the United States Geological Survey have not yet been made available after September, 1950. Comparison of the two series of results during the same months of the year has indicated, however, that despite the dissimilarities in the methods of coliform enumeration, the coliform densities shown in the second series were of the same order of magnitude as those of the first series. Thus, for the 8-month period of December-July, the average "indicated number" of coliforms per ml at the Ashland intake was 20,100 in 1948 and 28,000 in 1949 (first series), and the corresponding average MPN from the 3-tube confirmed tests was 22,400 in 1951 (second series). The agreement in averages from the two series for the same individual months was also close, being well within the limits of error for each average.

At the lower end of the Huntington-Cincinnati section, a similar comparison of results obtained from routine plant tests at the Cincinnati intake and from samplings of the river at Dam 36, just above the intake, over a concurrent period of 14 months in 1939-40 have shown an average indicated number of coliforms at the Cincinnati intake (based on the presumptive tests) of 7,900 per 100 ml, and an average MPN at Dam 36 (based on the 3-tube confirmed test) of 5,200 per 100 ml. The higher average at the Cincinnati intake

probably was due in part to the influence of pollution from the Little Miami River on the quality of river water at the intake during the months of higher flows, when deviations above the Dam 36 results were decidedly greater than in months of low flow.

Based on the plant records for 1948 and 1949, and available monitoring survey data for 1950-51, the coliform results reported at the Ashland, Kentucky intake were measurably and consistently higher than observed as cross-sectional averages during the United States Public Health Service survey of 1939-40 (see Table X). This indicates that the quality of water at this intake is disproportionately influenced by the tendency of sewage from the upstream Huntington area to follow the Kentucky shore of the river for a considerable distance downstream. Further evidence of this tendency is afforded by the reported results at the Ironton intake, located on the Ohio side of the river, which are in general better than would be expected from the cross-sectional averages observed in the United States Public Health Service survey of 1939-40. The tendency of combined pollution from Huntington and Ashland to follow the Kentucky shore line as far downstream as Portsmouth under low river flow conditions is also shown by similar comparative data. From these results, both prior to and after the institution of the United States Public Health Service monitoring survey in 1950, it is clearly indicated that the Ashland water supply is the one most vitally affected by upstream pollution, and that any program of uniform bacterial reduction treatment of sewage throughout the section must be largely conditioned by requirements for providing adequate protection to this supply. Such a program, however, can be formulated on the basis of requirements for bacterial reduction which will protect this supply, as well as those located downstream, during periods of relatively low and relatively high river flows occurring in the warmer months of the year (May - October), and in the colder months (November - April).

On this basis, an analysis of monthly average coliform numbers at the water intakes in relation to concurrent river flows has indicated that during the period of May - October, with river flows less than 100,000 cfs or thereabouts, a minimum uniform coliform reduction of not less than 90% for all sewage discharged into the Huntington-Cincinnati section would be required in order to meet the Commission's water-supply objective of 5,000 coliforms per 100 ml at all water intakes below Huntington. With flows exceeding 100,000 cfs, a lower degree of coliform reduction, amounting to 80%, should be sufficient to meet this same objective, in view of the added dilution provided by the higher flows in the zones immediately below major sources of pollution.

Under conditions of the colder half of the year (November - April), with stream temperatures averaging less than 10^{o} C, coliform densities tend to be somewhat lower in river zones immediately below major sources of sewage pollution, and hence the higher 90% level of bacterial reduction treatment is required only at flows ranging below 50,000 second-feet at Huntington. At flows exceeding 50,000 second-feet, all sources of water supply in the section, including Ashland and Ironton, would appear from the recent plant records to be adequately protected against overburden with the lower 80% treatment level. The effects of following this plan of coliform reduction on the quality of

water at the Ashland intake are illustrated in Fig 9.

Conclusions -- On the basis of the foregoing analysis, the following conclusions have been reached regarding bacterial-reduction requirements necessary to maintain water quality in conformity with coliform-density levels prescribed by the Commission's bacterial-quality objectives.

1. In addition to primary sewage treatment to meet the minimum compact requirements, bacterial reduction treatment facilities should be provided for all sewage effluents discharged into this section of the river whereby overall reductions up to 95% of coliform bacteria in the raw sewage may be accomplished.

2. As normal operational guides, the following degrees of bacterial reduction should be carried out for all sewage discharged into the section:

   a. During the months of May through October, the minimum overall reduction in coliform bacteria should be not less than 90% with river flows at Huntington less than 100,000 cfs, and not less than 80% with flows of 100,000 cfs or more.

   b. During the months of November through April, the minimum overall reduction in coliform bacteria should be not less than 90% with river flows at Huntington less than 50,000 cfs, and not less than 80% with flows of 50,000 cfs or more.

3. Bacterial reduction treatment in accordance with (a) and (b) above is intended to meet the requirements of normal stream conditions, but cannot be expected to cover unusual conditions which may arise from time to time; for example, in some cases resulting from irregular distribution of rainfall and runoff in the tributary drainage area, and in others, from sudden rises in the Ohio River following periods of low flow. Under these circumstances, bacterial reduction treatments in excess of those above indicated may be required temporarily, until normal conditions have been restored.

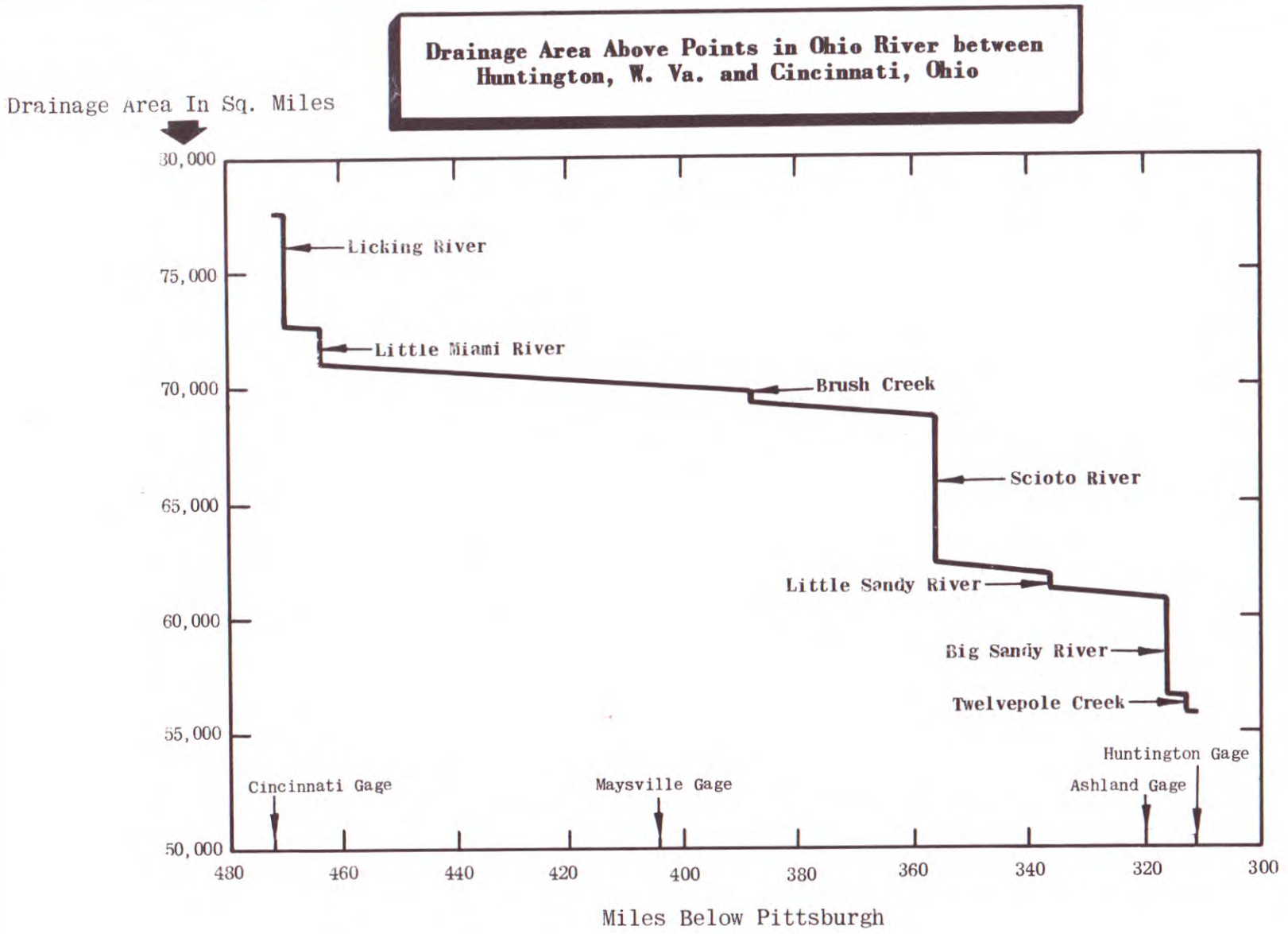
In summary, it may be emphasized that any program of bacterial reduction in this section should be flexible in its operation if it is to be fully effective under all conditions of season and runoff. If adequate bacterial reduction facilities are installed at all primary sewage treatment plants in the Huntington-Cincinnati section, the proper regulation of these facilities in order to meet either usual or unusual conditions should be a matter of no great difficulty, once the general pattern of treatment has been well established. The recommendations in this report are designed to provide such a pattern, capable of variation in accordance with whatever needs may arise.

APPENDIX

Illustrations

and

Tables



January 1952

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Figure 2

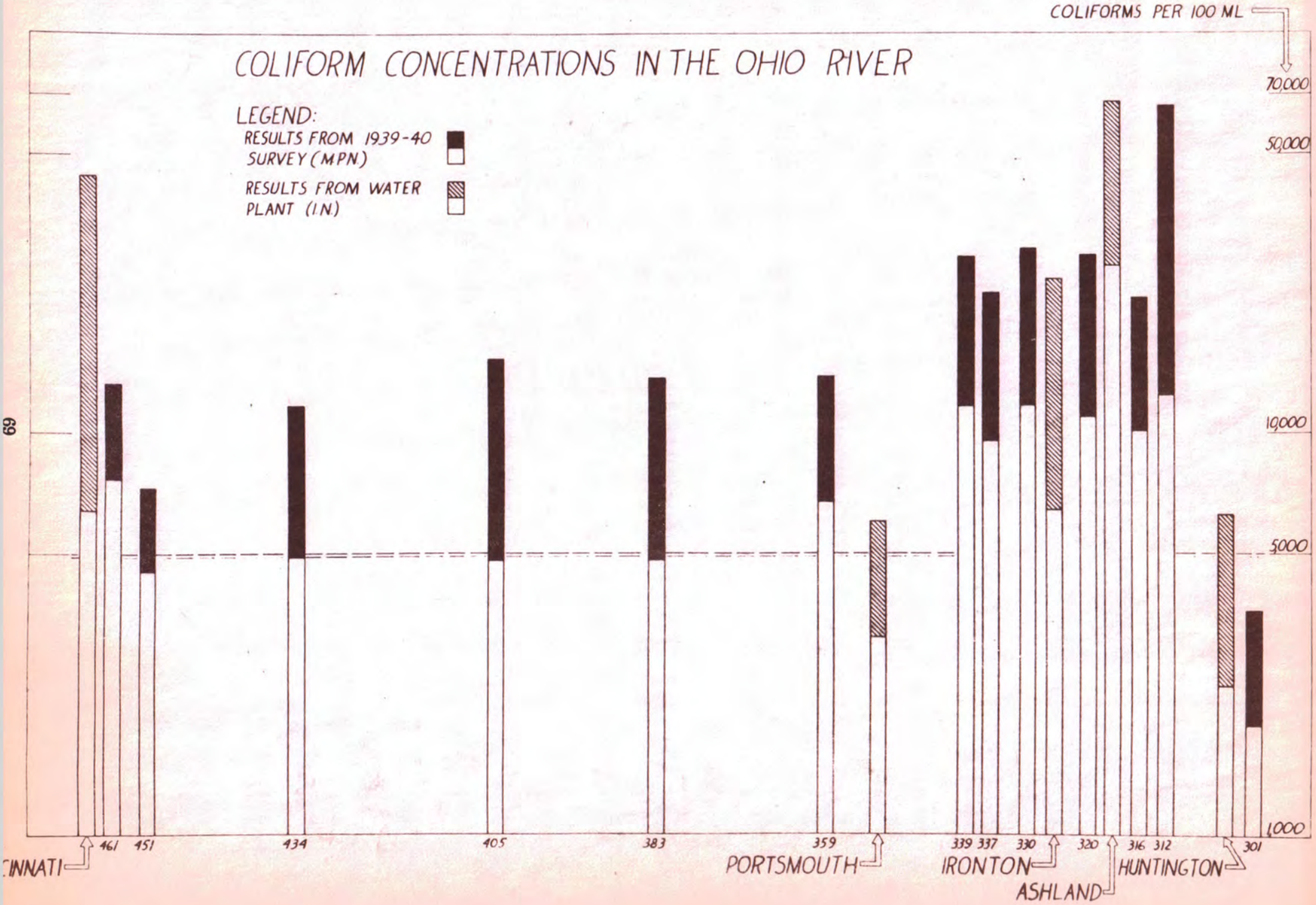
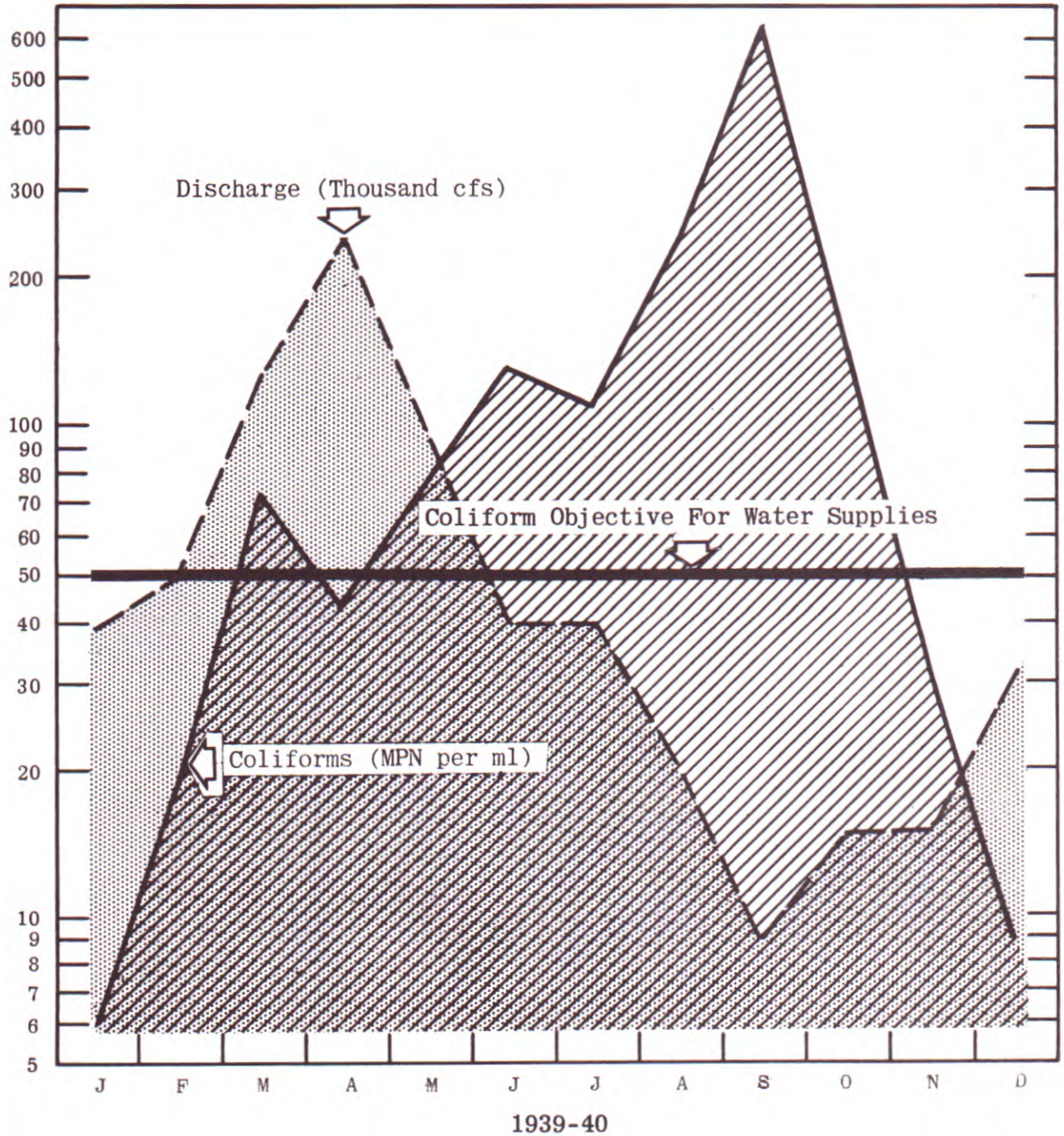
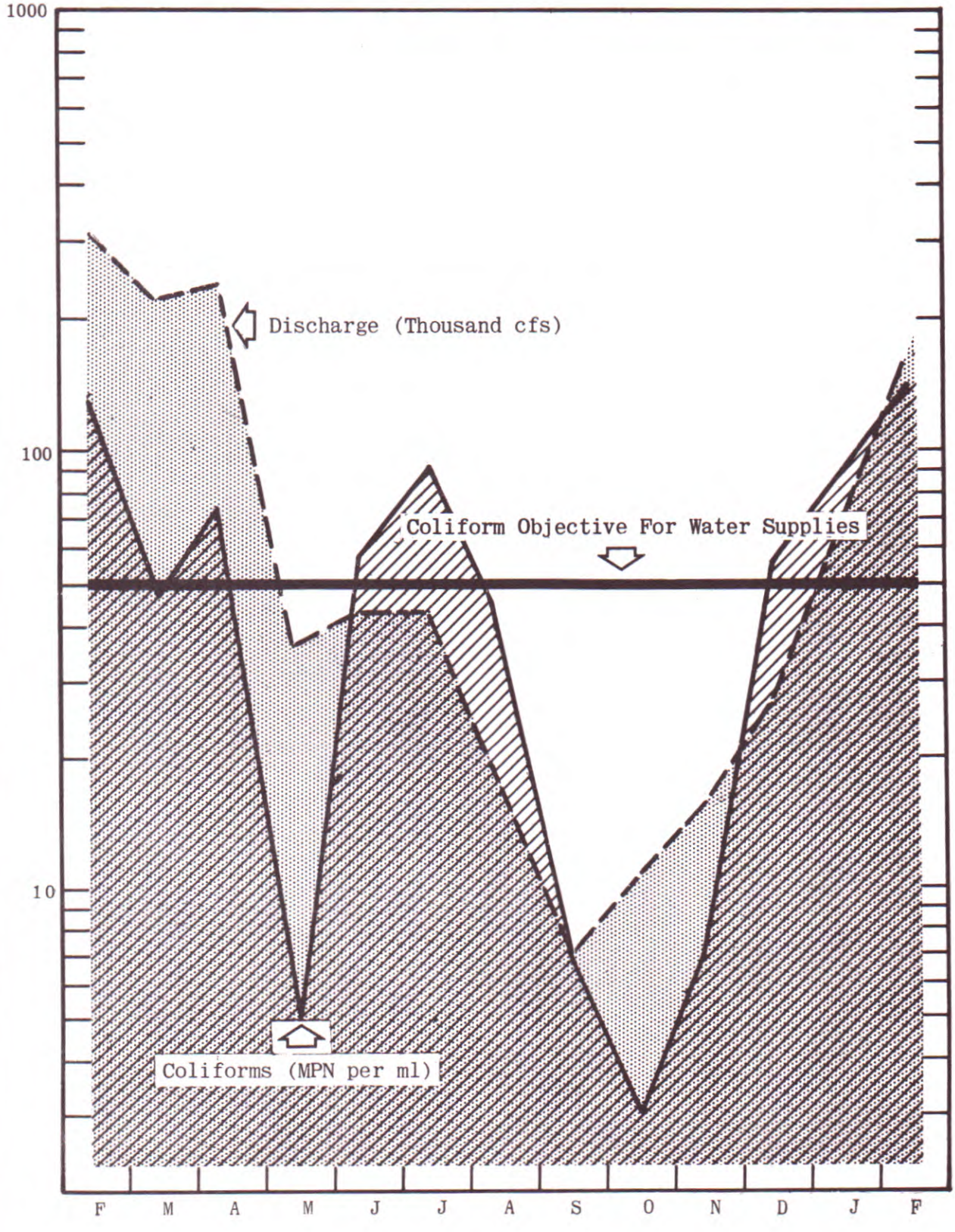

COLIFORMS PER 100 ML
COLIFORM CONCENTRATIONS IN THE OHIO RIVER
LEGEND:
RESULTS FROM 1939-40 SURVEY (MPN)
RESULTS FROM WATER PLANT (I.N)
70,000
50,000
10,000
5000
1,000
461
451
434
405
383
359
339
337
330
320
316
312
301
CINNATI
PORTSMOUTH
IRONTON
ASHLAND
HUNTINGTON

Exhibit F

Coliforms increase with diminished flows. This is a general monthly variation pattern below major sources of pollution -- such as at Dam 28, immediately below Huntington, W. Va.



Coliforms tend to increase and decrease with river flow at points remote from immediate sources of pollution. This monthly variation pattern is demonstrated at Dam 36 near the Cincinnati, Ohio water-intake.



1939-40

January 1952

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Coliform Trends in the Ohio River between Huntington, W. Va. and Cincinnati, Ohio -- Most critical bacterial-load conditions occurred (1) throughout the entire section during Sept 1950 when high river flows predominated and (2) in the Huntington-Portsmouth stretch at summer low flows with minimum dilution and heavy immediate pollution from city outfalls. Note the effects of self-purification during summer-and-winter low flows.

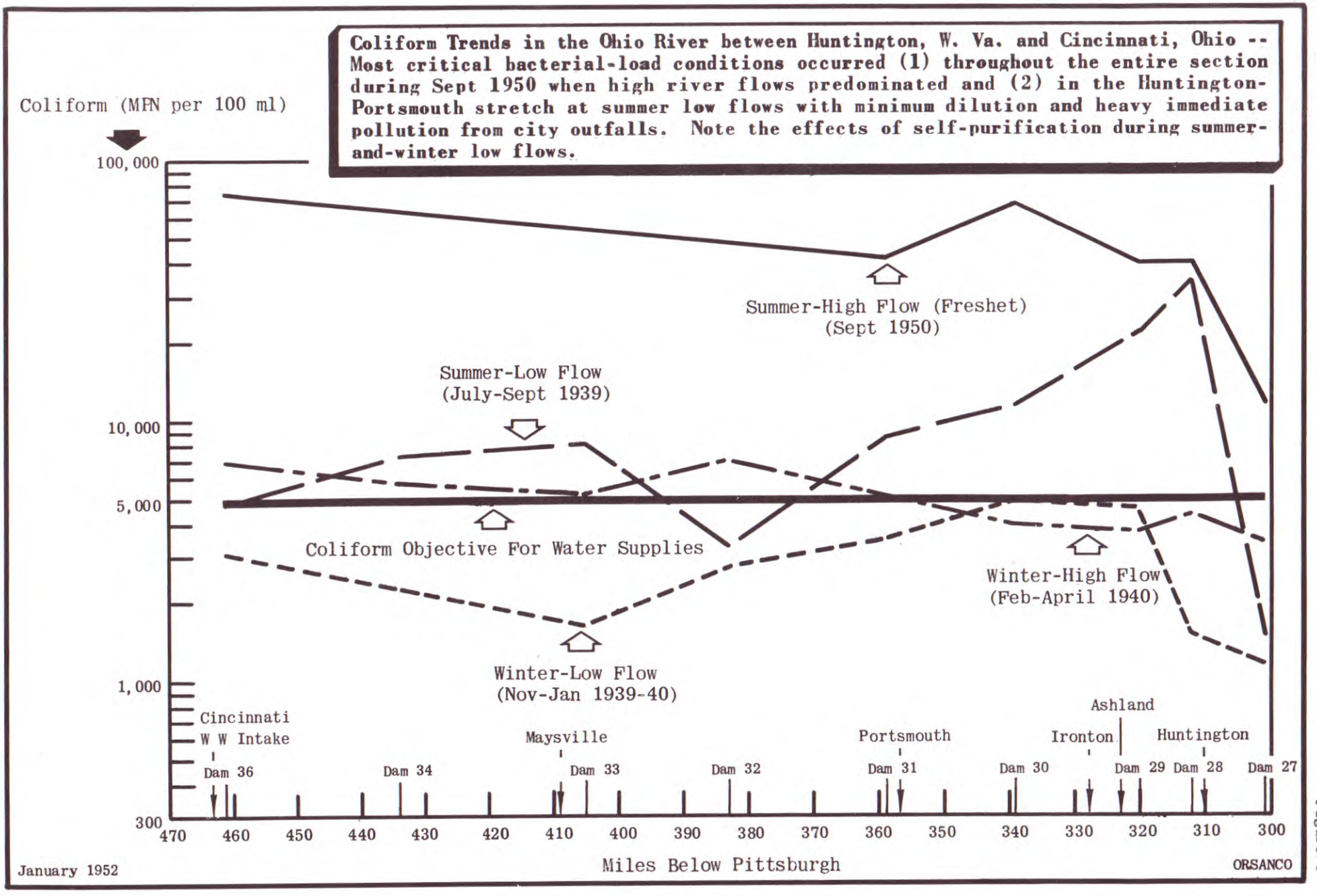
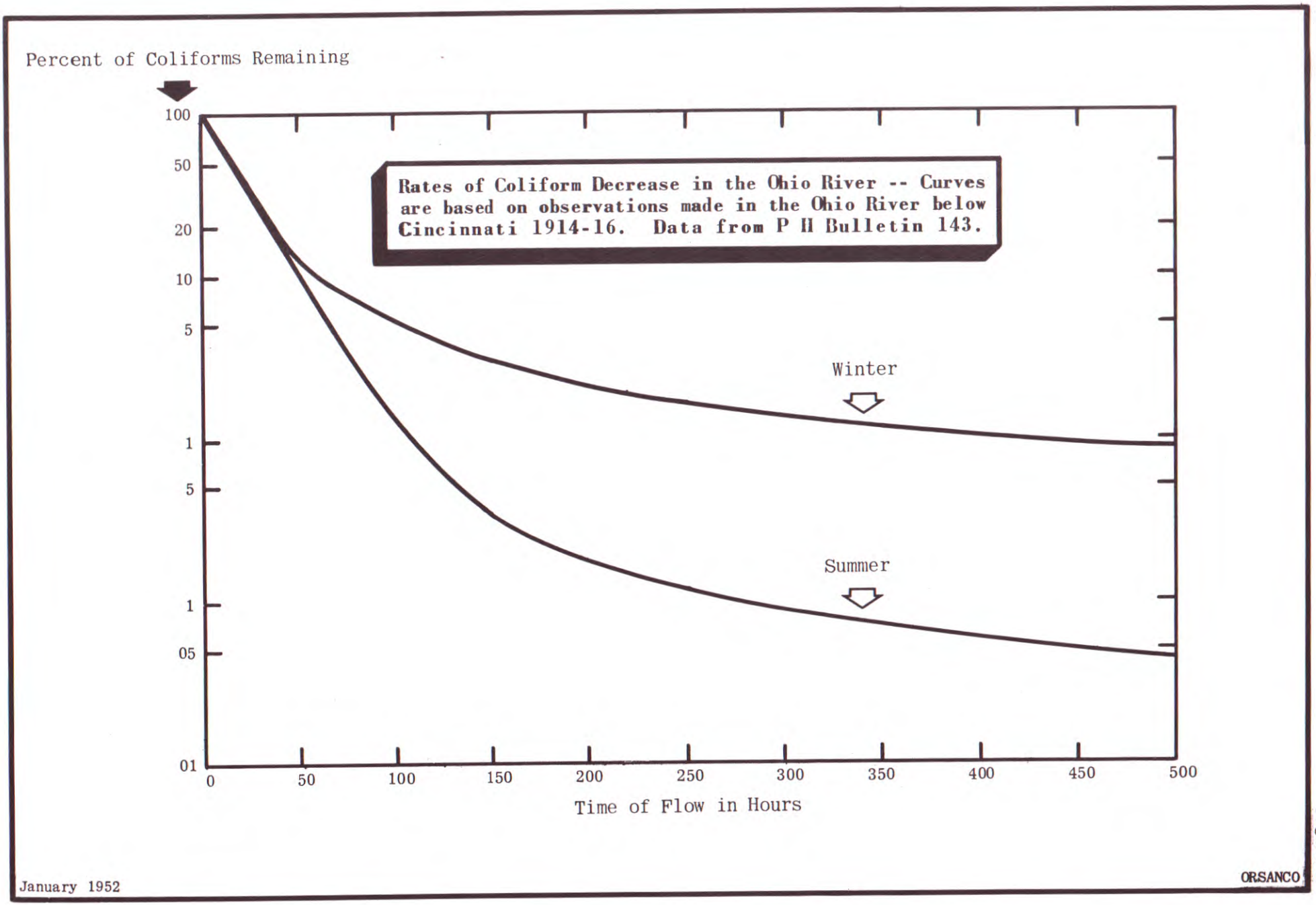


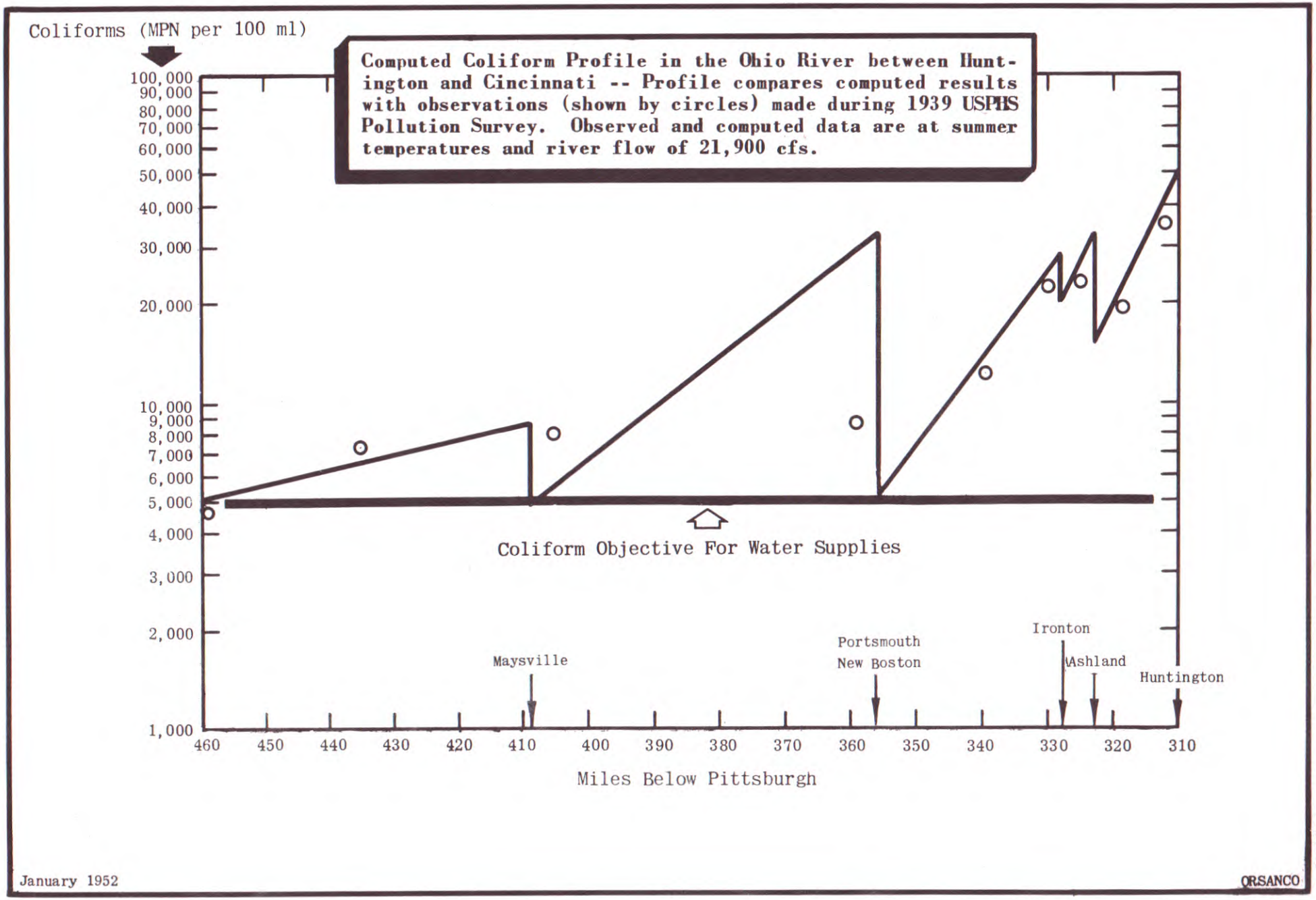
Figure 5



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Figure 6



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Figure 7

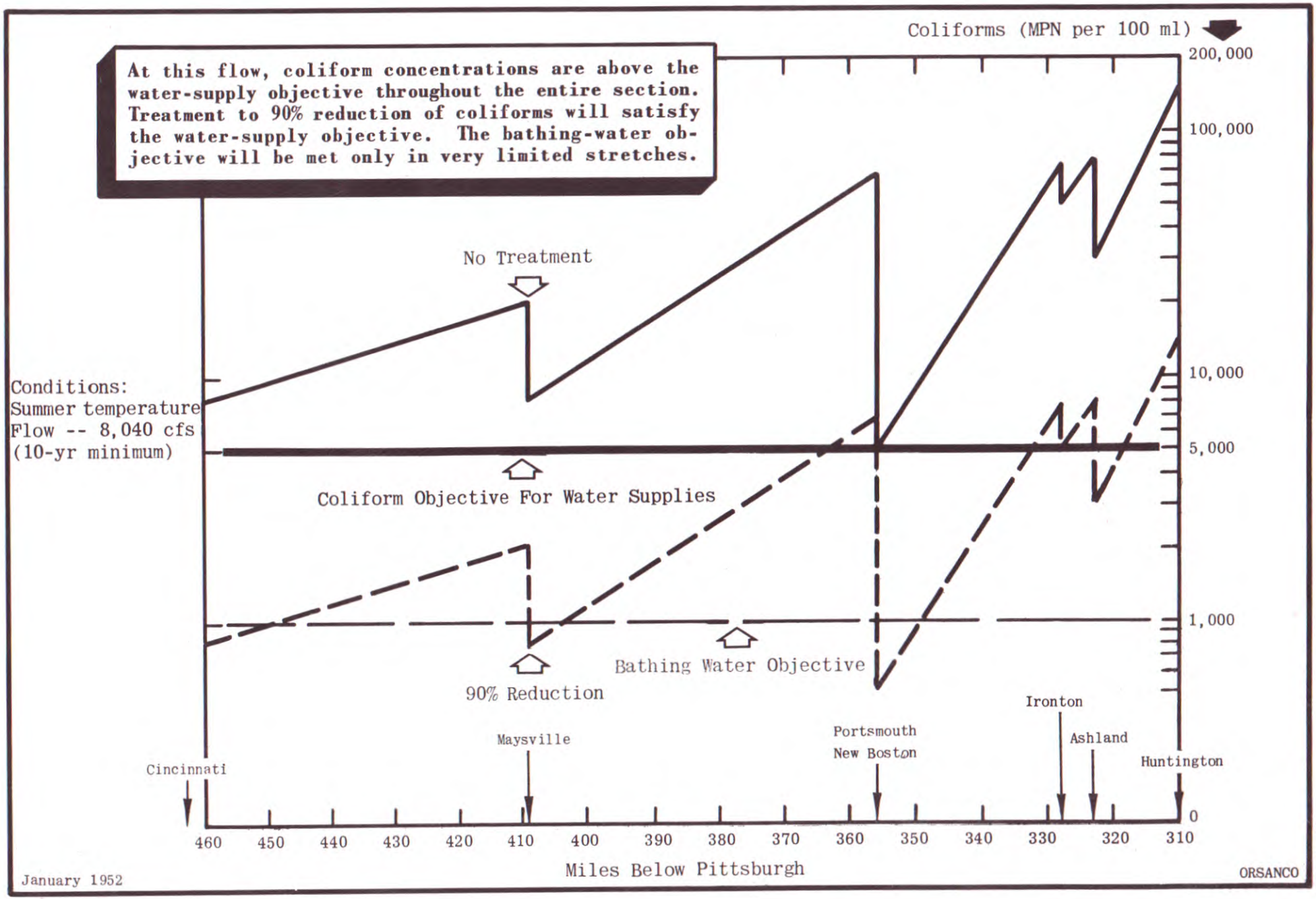
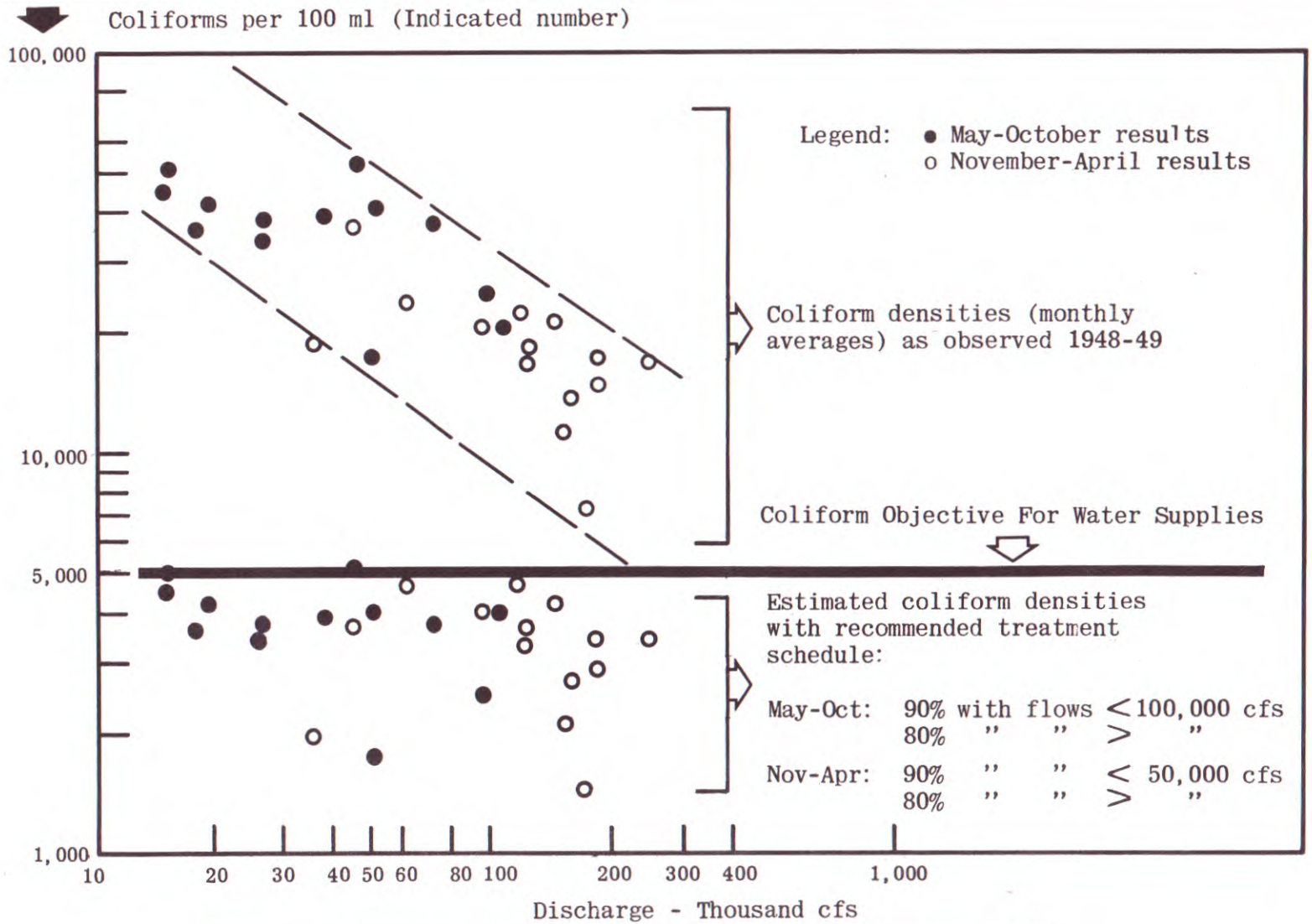

Coliforms (MPN per 100 ml)
200,000
100,000
10,000
5,000
1,000
0
At this flow, coliform concentrations are above the water-supply objective throughout the entire section. Treatment to 90% reduction of coliforms will satisfy the water-supply objective. The bathing-water objective will be met only in very limited stretches.
No Treatment
Conditions:
Summer temperature
Flow -- 8,040 cfs
(10-yr minimum)
Coliform Objective For Water Supplies
Bathing Water Objective
90% Reduction
Cincinnati
Maysville
Portsmouth
New Boston
Ironton
Ashland
Huntington
460 450 440 430 420 410 400 390 380 370 360 350 340 330 320 310
Miles Below Pittsburgh
January 1952
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Figure 8



Effect of bacterial-reduction treatment on coliform densities at Ashland intake -- Treatment in accordance with recommended schedule reduces bacterial densities observed at Ashland 1948-49 to level of 5,000 coliforms per 100 ml or lower.

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Figure 9

Table I - *Minimum recorded river flows at Huntington gage*

Year	Min. daily avg. flow		Min. weekly avg. flow		Min. 2-week avg. flow		Min. monthly (calendar) avg. flow	
	Recorded flow (cfs)	Month of occurrence	Recorded flow (cfs)	Month of occurrence	Recorded flow (cfs)	Month of occurrence	Recorded flow (cfs)	Month of occurrence
1934	3,200	9 & 11	6,740	9	7,140	8-9	12,770	9
1935	3,200	10	6,340	10	7,760	10	11,840	10
1936	4,400	9	6,640	9	7,610	9	11,690	9
1937	3,200	10	7,440	9-10	8,650	9-10	26,780	9
1938	3,940	10	6,570	10	6,660	10-11	9,106	10
1939	4,880	10	6,030	9	6,860	9	7,837	9
1940	7,460	10	9,930	10	10,310	10	11,790	10
1941	4,100	9	6,280	9-10	7,530	9-10	11,890	10
1942	9,590	9	15,660	9	21,720	10	29,670	9
1943	5,330	10	7,030	10	7,250	9-10	10,650	10
1944	5,550	8	7,390	8	7,990	7-8	8,409	8
1945	5,380	9	11,330	9	12,960	8-9	24,520	7
1946	3,220	10	5,960	9	6,300	9	7,343	9
1947	5,270	10	9,460	10	10,480	10	11,660	10
1948	6,260	11	10,500	9	11,900	9	15,830	9

Table II - Minimum recorded river flows adjusted for reservoir operation (Huntington gage)

Year	Adjusted Flows			
	Min. daily avg. flow (cfs)	Min. weekly avg. flow (cfs)	Min. 2-week avg. flow (cfs)	Min. monthly (calendar) avg. flow (cfs)
1934	4,610	8,150	8,550	14,180
1935	4,610	7,750	9,170	13,250
1936	5,810	8,050	9,020	13,100
1937	4,610	8,850	10,060	28,190
1938	5,010	7,640	7,730	10,176
1939	5,950	7,100	7,930	8,907
1940	8,530	11,000	11,380	12,860
1941	5,170	7,350	8,600	12,960
1942	10,660	16,730	22,790	30,740
1943	6,230	7,930	8,150	11,550
1944	6,250	8,090	8,690	9,109
1945	6,080	12,030	13,660	25,220
1946	3,920	6,660	7,000	8,043
1947	5,970	10,160	11,180	12,360
1948	6,460	10,700	12,100	16,030

Table III - Increases in river flow resulting from operation of multiple-purpose reservoirs

Name of reservoir	Date of completion	Minimum flow increase (cfs)	Increase added to flows of record	
			Date of records	Increase (cfs)
Tygart	1938	340	Prior to 1938	1,410
Berlin	July 1943	170	1938 to July 1943	1,070
Mosquito Creek	April 1944	200	July 1943 to April 1944	900
Youghiogheny	1948	500	April 1944 to 1948	700
East Branch Clarion	Scheduled for late 1952	200	1948 to 1953	200
	Total	1,410		

Table IV - Probability of drought flows at Huntington (based on adjusted flow records)

Drought severity	Min. daily avg.	Min. weekly avg.	Min. 2-week avg.	Min. monthly (calendar) avg.
Most probable drought	6,050	8,350	9,260	14,010
Once in 5 years	4,760	7,400	8,010	10,030
Once in 7 years	4,440	7,170	7,700	9,050
Once in 10 years	4,110	6,930	7,380	8,040
Once in 15 years	3,740	6,660	7,030	7,170
Once in 20 years	3,490	6,480	6,750	6,750

Table V - Seasonal flow expectancies at Huntington
(based on adjusted flow records)

Percent of months	Monthly average flow - (cfs) (Flows equal to or less than values shown below may be expected for indicated percentage of months in each season)			
	Dec - Mar	April - May	June - Sept	Oct - Nov
10	30,000	45,000	-	-
20	60,000	69,000	20,000	-
30	82,000	86,000	28,000	21,000
40	102,000	100,000	34,000	28,000
50	118,000	114,000	40,000	34,000
60	136,000	127,000	46,000	40,000
70	154,000	141,000	53,000	46,000
80	176,000	158,000	60,000	54,000
90	206,000	182,000	71,000	65,000

Table VI - Estimated BOD loads discharged into the Ohio River between Huntington and Cincinnati (data include population equivalents of industrial discharges as reported in House Document 266)

Municipality	State	Population (census)		Pollution load in population equivalents		Estimated 1950-51 load in lb. first-stage BOD per day (0.25 lb BOD per pop.equiv.)
		1940	1950	1939-40 (From Ohio River Pollution Survey)	Estimated 1950-51 load	
Proctorville	Ohio	731	737		700	180
Huntington	W.Va.	78,836	86,353	95,800	105,000	26,250
Chesapeake *	Ohio	1,068	1,285		800	200
Ceredo-Kenova	W.Va.	5,114	5,719	5,100	5,700	1,430
Catlettsburg	Ky.	4,524	4,750	8,400	8,800	2,200
Ashland	Ky.	29,537	31,131	43,100	45,500	11,380
Coal Grove	Ohio	2,351	2,492		2,500	630
Ironton	Ohio	15,851	16,333	32,500	33,500	8,380
Russell	Ky.	1,844	1,681		1,700	430
Worthington-Raceland *	Ky.	1,964	1,696		1,300	330
Greenup	Ky.	1,063	1,276		1,300	330
Fullerton	Ky.		1,501		1,500	380
Portsmouth-New Boston	Ohio	46,490	41,552	59,100	52,700	13,180
Vanceburg	Ky.	1,184	1,528		1,500	380
Manchester	Ohio	2,163	2,281		2,300	580
Maysville	Ky.	6,572	8,632	13,000	17,100	4,280
Ripley	Ohio	1,623	1,792		1,800	450
Augusta	Ky.	1,701	1,599		1,600	400
New Richmond	Ohio	1,767	1,960		2,000	500
Total		204,383	214,298	257,000	287,300	71,890

* Sewage treatment provided (facilities inadequate)

Table VII - Oxygen and coliform conditions in the Ohio River between Huntington and Cincinnati during September 1939 (from House Document 266)

Sampling Station	Miles below Pittsburgh	Discharge cfs	Temp. deg C	Dissolved oxygen ppm	5-day BOD ppm	Coliform MPN per 100 ml
Dam 27	301	8,200	24.7	7.8	0.8	100
Dam 28	312	9,000	24.5	7.3	1.0	66,000
N & W RR Bridge	316	8,800	24.6	7.5	0.9	17,500
Dam 29	320	8,900	24.7	7.6	0.9	12,900
White Oak Cr.	326	8,900	24.6	7.4	0.9	19,000
Hanging Rock Light	330	8,300	24.4	7.5	0.9	23,000
Coal Branch Light	337	8,300	24.3	7.5	1.0	5,200
Dam 30	339	8,300	24.2	7.5	1.1	3,700
Dam 31	359	7,900	23.0	7.5	0.9	10,500
Dam 32	383	7,000	24.2	7.5	1.4	300
Dam 33	405	6,100	24.3	7.6	1.4	15,400
Dam 34	434	6,600	23.7	7.8	0.8	100
Dam 36	461	7,000	23.2	8.1	0.9	700

Table VIII - Seasonal Averages of Coliform Densities, 1939-40

Discharge in thousands cfs; coliforms in MPN per 100 ml (confirmed)

Station	Miles From Pitts-burgh	Summer Flow (July - Sept.)		Winter Low Flow (Nov. - Jan.)		Winter High Flow (Feb. - Apr.)		Summer High Flow (Sept. 1950)	
		Disch.	MPN	Disch.	MPN	Disch.	MPN	Disch.	MPN
Dam 27	301	21.9	1,500	27.2	1,200	158.8	3,300	58.6	11,100
Dam 28	312	21.9	33,700	26.7	1,500	139.5	4,400	70.2	40,800
N. & W. Bridge	316		19,000		4,000		4,100		
Dam 29	320	24.6	21,600	26.7	4,700	184.7	3,800	82.3	39,900
White Oak Cr.	326		22,900		6,200		5,000		
Hanging Rock Lt.	330		22,300		5,700		3,200		
Coal Branch Lt.	337		14,800		5,900		4,200		
Dam 30	339	24.4	11,700	28.3	4,900	179.7	4,000	91.5	69,700
Dam 31	359	25.3	8,700		3,500	184.0	5,200	104.0	40,900
Dam 32	383	24.6	3,200		2,800	184.3	6,900		
Dam 33	405		8,000		1,700	167.0	5,300		
Dam 34	434	23.3	7,300	26.6	2,200	166.6	5,600		
Dam 35	451								
Dam 36	461		4,800	24.8	3,100	191.0	7,000	107.0	76,000

Table IX - Comparison of "Indicated" and "Most Probable" Numbers of Coliform Bacteria Observed at Ashland Intake

	I.N. per 100 ml		MPN per 100 ml
	1948	1949	1950-51
December	21,000	21,300	20,500
January	24,000	14,700	13,600
February	14,000	17,000	11,400
March	7,100	18,400	17,600
April	16,900	24,200	18,200
May	20,500	37,600	20,000
June	40,000	37,000	28,000*
July	17,500	53,500	50,000
Average	20,100	28,000	22,400

(*) Omitting one extremely high result on June 3rd. With this result included, June average would be 104,000.

Note: "Indicated" numbers based on 48-hour presumptive test in single-tube plantings.
"Most probable" numbers based on confirmed test in 3-tube plantings.

Table X - Comparison of Cross-Sectional Average Coliform Numbers Observed at Dam 29, Near Ashland Intake, and Numbers Observed at Same Intake During Corresponding Months of the Year

	Average Coliform Numbers per 100 ml		
	Dam 29	Ashland W.W. Intake	
	(1939-40)	(1948)	(1949)
July	24,000	17,500	53,500
August	28,000	39,000	36,100
September	12,900	31,000	35,800
October	15,100	42,000	44,800
November	7,200	37,000	19,000
December	4,900	21,000	21,300
January	2,100	24,000	14,700
February	3,600	14,000	17,000
March	3,700	7,100	18,400
April	4,200	16,900	24,200
Average	10,570	24,950	28,480



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BACTERIAL-QUALITY OBJECTIVES

for the Ohio River

A guide for the evaluation of sanitary condition of waters used for potable supplies and recreational uses.

OHIO RIVER VALLEY WATER SANITATION COMMISSION

An interstate agency representing Illinois, Indiana, Kentucky, New York, Ohio, Pennsylvania, Virginia and West Virginia

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OHIO RIVER VALLEY
WATER SANITATION COMMISSION

414 WALNUT STREET CINCINNATI 2, OHIO

June 1, 1951

To the Chairman and
Members of the Commission:

This is the final report of bacterial-quality objectives for the Ohio River, which you adopted on April 4, 1951 and ordered published. The report sets forth the objectives for both water supply and recreational uses, the manner in which the objectives are to be interpreted, and the background for their validity.

In large measure this report is the work of Harold W. Streeter, U. S. Public Health Service (retired) who now serves the Commission in a consultant capacity. Mr. Streeter, an international authority on water-quality investigations has been studying Ohio River conditions since 1914. Drawing upon this experience and supplementing it with new information gathered by the Commission and its signatory states, Mr. Streeter prepared findings that were scrutinized by your Engineering Committee and other authorities over a period of a year.

The Engineering Committee recommended adoption of these objectives since they provide a sound basis for the Commission to reach decisions on acceptable limits and control of bacterial contamination. Heretofore, the task was complicated by a wide divergence of viewpoints and standards throughout the nation.

Respectfully submitted,

Edward J. Cleary

EDWARD J. CLEARY
Executive Director
and Chief Engineer

Bacterial-Quality Objectives
for the Ohio River

Adopted by the

OHIO RIVER VALLEY WATER SANITATION COMMISSION

on the basis of findings reported by

Harold W. Streeter, Consultant

and approved by members of the Engineering Committee

C. W. Klassen, Chairman
Fred H. Waring
Earl Devendorf
F. Clark Dugan
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June 1, 1951

TABLE 1 — SUMMARY OF CERTAIN STATE AND REGIONAL BACTERIAL QUALITY STANDARDS FOR SOURCES OF WATER SUPPLY.

State or Region	Class	Units	Limiting Coliform Numbers per 100 Ml	Remarks
New York	A-1 & A-2	Mo. Av. MPN	50	1
	A-4	Mo. Av. MPN	5,000 and not over 20% samples above 5,000.	2
New England	A	MPN	50	1
Tenn. Valley	I	Geom. Av. MPN	50	1
Authority	II	Geom. Av. MPN	5,000	2
	III	Geom. Av. MPN	20,000	3
Tennessee (state)		Av. MPN	5,000	4
West Virginia	AA	Mo. Av. MPN	100	5
	A	Mo. Av. MPN	1,000	5
	B	Mo. Av. MPN	10,000	3
Indiana	- -	Max. MPN	5,000	
Washington		Av. MPN	50	1
Potomac River	A	Mo. Av.	50	1
Commission	C	Mo. Av.	5,000	2
Incodel	Zone 1	Av.	10% not over 100	5
		Max.	10,000	
	Zone 2	Av.	25% not over 100	2
		Max.	10,000	
Ohio River	Desirable	Mo. Av.	50	1
Committee	Desirable	Mo. Av.	5,000	2
(House Doc.	Doubtful	Mo. Av.	5,000 - 20,000	3
266)	Unsuitable	Mo. Av.	Over 20,000	
U. S. P. H. S.	II	Mo. Av.	50	1
Recommenda-	III	Mo. Av.	5,000	2
tions		Max.	20% over 5,000	
(Bull. 296)				
	IV	Mo. Av.	Over 5,000	2, 3
		Max.	5% over 20,000	

Remarks: 1—Chlorination 2—Filtration and chlorination 3—Auxiliary treatment 4—General sanitation 5—Good sources

OBJECTIVES summarized:

As a guide in the establishment of treatment requirements for sewage discharged in the Ohio River, and as a yardstick for evaluating sanitary conditions in waters used for potable supplies and recreational purposes, the Ohio River Valley Water Sanitation Commission on April 4, 1951, adopted these bacterial-quality objectives:

Water Supply Uses—The monthly arithmetical average "most probable number" of coliform organisms in waters of the river at water intakes should not exceed 5,000 per 100 ml in any month; nor exceed this number in more than 20 percent of the samples of such waters examined during any month; nor exceed 20,000 per 100 ml in more than 5 percent of such samples.

Recreational Uses—For bathing or swimming waters, monthly arithmetical average "most probable number" of coliform organisms should not exceed 1,000 per 100 ml during any month of the recreation season; nor exceed this number in more than 20 percent of the samples examined during any such month; nor exceed 2,400 per 100 ml on any day. For non-bathing or non-swimming waters, the monthly arithmetical average "most probable number" of coliform organisms should not exceed 5,000 per 100 ml in any month of the recreational season, nor should exceed this number in more than 20 percent of the samples examined during any such month.

The limits for potable supply sources are premised on the desirability of a return to normal water-treatment methods (coagulation, sedimentation, rapid-sand filtration, and pre- and/or post-chlorination) with a minimum of chlorine residuals in the finished water, in order to insure palatability as well as bacterial safety of water supplies drawn from the river. Too many water treatment plants must now resort to auxiliary processing as a regular practice because of excessive pollution loads. It cannot be denied, however, that the availability of such facilities for emergency use is highly desirable.

Recommendations for recreational waters are tentative, pending further knowledge of the epidemiology of bathing-water sanitation, and are intended to provide reasonable safeguards to bathers along the river against more serious water-borne diseases. For recreational uses not involving bathing or swimming, a bacterial-quality goal at the water supply level is recommended.

It is recommended that the improved methods of coliform-bacteria enumeration employed in the Commission's Ohio River water quality survey of September, 1950, be adopted as standard procedure for future routine tests in connection with bacterial-quality investigations.

As an aid in the interpretation of these objectives and the manner in which they are to be applied, see the next section for detailed explanation.

INTERPRETATION and APPLICATION

Application of bacterial-quality objectives for the Ohio River involves evaluation of existing pollution levels with reference to those which should be attained to meet potable supply and recreational requirements. Such an evaluation — in terms of coliform-bacterial densities — cannot be expected to be precise in the same degree that is possible with chemical analyses of the river water.

Methods now available for enumerating bacteria of the coliform group are subject to errors far beyond those of chemical determinations, or even of biochemical tests such as "biochemical oxygen demand". This fundamental fact should be kept in mind when interpreting and applying bacterial-quality objectives expressed in terms of "most probable numbers" of coliform organisms. Experienced judgment and common sense, together with a thorough knowledge of local conditions affecting sewage pollution, are essential to a rational application of these objectives.

Averages and single results— According to an estimate by Velz, the upper 95 percent confidence limit for the result of a single-coliform test with three tubes planted in each dilution is 3.6 times the MPN determined from the test. (Velz, C. J., Inservice Training Course lecture, March 14-15, 1949, University of Michigan, School of Public Health, Ann Arbor, Mich.)

If the MPN resulting from the test were 2,300 per 100 ml. there is a 95 percent probability that the true number of coliform organisms in the sample would range up to, but not exceed, 8,300 per 100 ml. An average of 25 results would theoretically narrow the range to one-fifth of that for a single result, bringing the upper 95 percent confidence limit to about 72 percent above the observed mean of the 25 results. This illustrates the statistical advantage of averages versus individual results with regard to their stability and range of error.

Sampling effect—Another source of error in evaluating coliform density in river waters is due to sampling. For ordinary catch-sampling in a well-mixed stream, this error may run 15-20 percent for a single sample. Where the stream is not well mixed across a section, the error may run considerably higher, especially if samples are collected at single mid-stream points. This latter error is variable and practically impossible to evaluate, except by direct measurement in a particular situation. Sampling errors generally are compensating; their range may be greatly reduced by averaging. They probably are of a lower order than those involved in the coliform determination itself.

In the Commission's Ohio River water quality survey of September, 1950, results from coliform tests made on daily

samples were obtained for a period of two weeks at 36 sampling points, of which 27 points were located in the Ohio River, and nine points at the mouths of principal tributaries. Methods followed in these tests, carefully standardized by the USPHS Environmental Health Center at Cincinnati, involved planting three tubes in each of three or more dilutions, arranged in decimal series. Results of the standard confirmed test were reported from the survey; 24-hr and 48-hr presumptive results were also recorded. A separate report on this survey has been prepared by the Commission. Reference here is only to a section of the coliform results, which have provided excellent illustrative material for application of bacterial-quality objectives.

Period averages and daily maximums—A summary of the period-average and daily-maximum confirmed results of the coliform tests at each sampling point, together with the percentages of days on which the coliform MPN exceeded 5,000 and 20,000 per 100 ml, respectively, is given in Table 2. A plot of the period-averages at the various sampling points, with ordinates representing the corresponding percentages of samples in which MPN exceeded 5,000 per 100 ml, is given in Fig. 1. A similar plot for the percentages of samples showing MPN's exceeding 20,000 per 100 ml is also given. For those sections of the two curves within an average MPN range up to 20,000, trends of plotted points follow nearly straight lines, and the correlation coefficient in each case is over 0.90, indicating a high degree of correlation in this range.

Inspection of Table 2 shows that average coliform MPN was less than 5,000 at only four sampling points (Nos. 5, E, 26, and 27), though it exceeded this figure only slightly at a fifth point (No. 9). At these five points the frequency of daily samples exceeding 5,000 MPN was 25 percent or less, averaging 14 percent, and the frequency exceeding 20,000 MPN was less than 10 percent, averaging 5 percent.

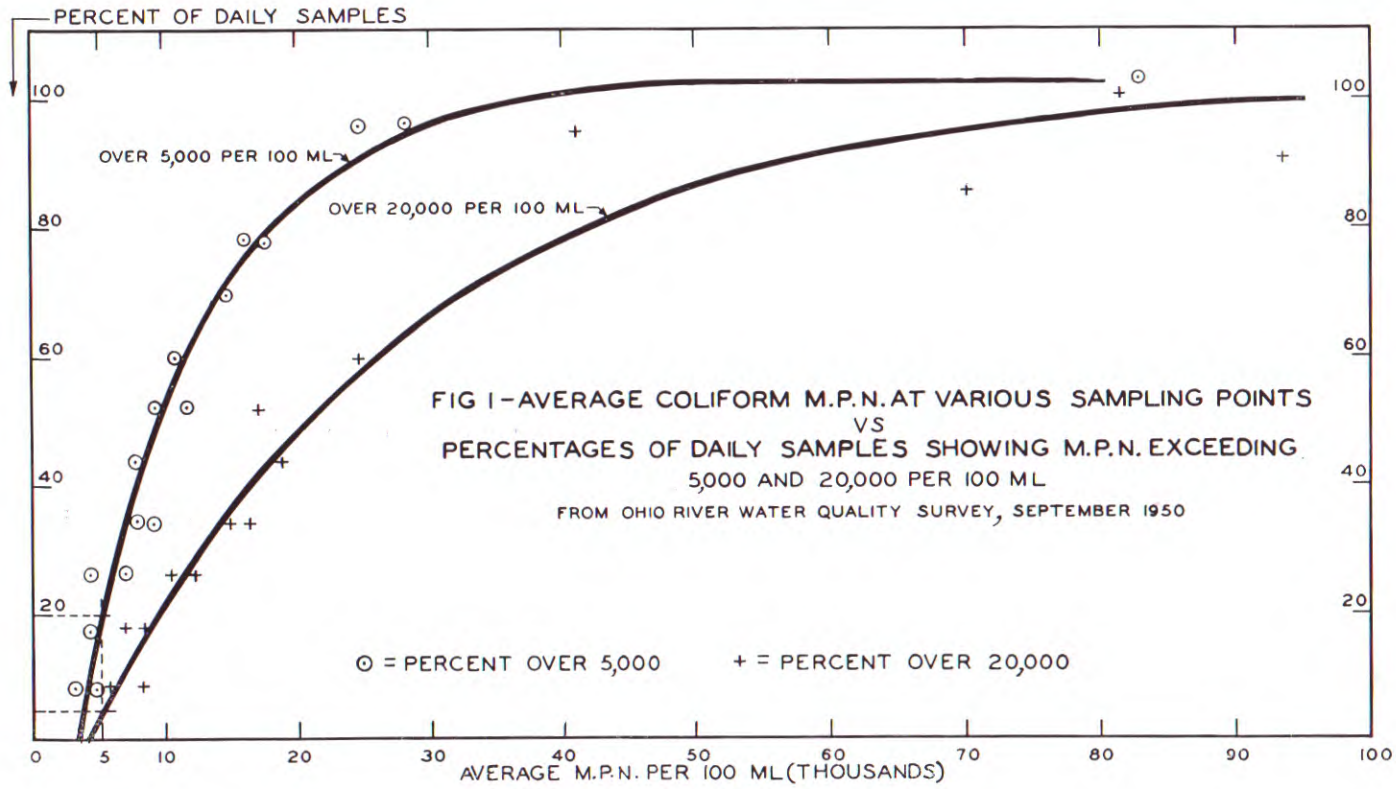
It is noted that with an average coliform MPN of 5,000 (Fig. 1) intersections of the two curves at this vertical show 20 percent and 5 percent, respectively, as frequency of individual MPN's exceeding 5,000 and 20,000. These intersections have provided a basis for adjusting the "over-run" frequency allowances made in connection with the bacterial-quality objectives recommended for potable supply requirements. They reflect more accurately the natural run of variability in the river's coliform content when measured by the improved method of routine tests followed in the survey of September, 1950.

The maximum daily coliform MPN recorded at any of the five sampling points above noted was 23,000 per 100 ml, being 9,300 at two of them, and 23,000 at the other three points. It thus appears that at average-coliform levels of 5,000 or below, natural variability in the Ohio would tend to limit the daily maximum MPN to about 23,000. Within the range of expected error this approximates the 20,000 level marking the safe-load limit for water-filtration plants using auxiliary treatment.

A further study of the ratios of maximum-to-average MPN's recorded in Table 2 brings out some interesting points concerning the general run of these ratios, and a few divergences from this trend. At all except five of the 36 sampling points, the maximum-to-average ratio was less than 6.0, and at 23 of the points, was less than 5.0. At the five points where these ratios were exceeded, divergence was found to be due to a single exceptionally high daily result in each case, exerting a marked influence on the period average. Although these departures from the general trend of the ratios were a small minority, they raise an important ques-

TABLE 2 — AVERAGE AND DAILY MAXIMUM RESULTS OF COLIFORM DETERMINATION IN OHIO RIVER WATER QUALITY SURVEY — SEPTEMBER, 1950.

Sampling Point No.	Confirmed Coliform MPN		Ratio	MPN Greater than: 5000/100 ml		20000/100 ml	
	Average	Maximum	Max/Avg	days	%	days	%
A	24,500	75,000	3.1	11	92	7	58
B	88,700	930,000	10.5	7	58	3	25
1	81,700	230,000	3.0	12	100	12	100
C	14,400	43,000	3.0	8	67	4	33
2	9,600	43,000	4.5	6	50	1	8
3	8,000	23,000	2.9	5	42	2	17
4	15,500	93,000	6.0	4	36	3	25
5	4,400	23,000	5.2	2	17	1	8
6	6,400	23,000	3.6	3	25	2	17
D	321,000	930,000	2.9	12	100	11	92
7	18,400	43,000	2.4	7	58	5	42
8	7,900	43,000	5.5	4	33	1	8
E	3,800	9,300	2.4	3	25	0	0
9	5,300	23,000	4.3	2	17	1	8
10	11,100	43,000	3.9	3	25	6	50
11	40,800	230,000	5.6	7	58	5	42
12	39,900	150,000	3.8	10	83	5	42
13	70,000	430,000	6.2	12	100	10	83
F	162,000	930,000	5.8	12	100	11	92
14	40,900	230,000	5.6	10	83	6	50
15	76,000	430,000	5.7	6	50	4	33
G	192,000	930,000	4.9	8	67	5	42
16	210,000	930,000	4.4	9	75	8	67
17	94,000	430,000	4.6	12	100	11	92
H	11,700	75,000	6.4	3	25	2	17
18	44,400	230,000	5.2	8	73	6	55
19	211,000	2,300,000	10.9	8	67	4	33
20	156,000	290,000	1.9	12	100	12	100
21	14,700	43,000	2.9	9	75	6	50
22	28,000	93,000	3.3	11	92	9	75
23	12,100	43,000	3.6	7	58	3	25
I	29,500	93,000	3.2	9	75	6	50
24	15,100	43,000	2.9	9	75	4	33
25	7,600	23,000	3.0	4	33	2	17
26	3,300	9,300	2.8	1	8	0	0
27	2,500	4,300	5.6	0	0	0	0


PERCENT OF DAILY SAMPLES
100
80
60
40
20
OVER 5,000 PER 100 ML
OVER 20,000 PER 100 ML
FIG 1 - AVERAGE COLIFORM M.P.N. AT VARIOUS SAMPLING POINTS
VS
PERCENTAGES OF DAILY SAMPLES SHOWING M.P.N. EXCEEDING
5,000 AND 20,000 PER 100 ML
FROM OHIO RIVER WATER QUALITY SURVEY, SEPTEMBER 1950
⊙ = PERCENT OVER 5,000
+ = PERCENT OVER 20,000
0
5
10
20
30
40
50
60
70
80
90
100
AVERAGE M.P.N. PER 100 ML (THOUSANDS)

tion as to the application of water-supply objectives to situations of this kind. A single high result, far out of line with the others, may exert an undue influence on the average at a given point. It tends to show an average water condition materially worse than otherwise would be indicated.

At three of the five points in question, average coliform MPN's were so high, even excluding single maximum results, that quality of the river water at these points would fail to meet an objective of 5,000 per 100 ml by a wide margin. At the other two points, exclusion of single high results would bring period average only slightly above the objective level. In the first case, it would be immaterial, for all practical purposes, whether or not high results were discarded, as the evaluation would be substantially the same in either event.

No rational conclusion in the second case could be reached until an analytical check had been made to determine whether the exceptionally high result recorded at each point was due to error in the test, or whether its occasional recurrence was normally to be expected at that point. Local sources of pollution might be revealed by a sanitary survey of the immediate drainage area. Any wide departure from the normal maximum-to-average ratio would call for a thorough check on the point in question before any final judgment could be reached.

Recreational waters—Application of bacterial-quality objectives to waters used or intended to be used for recreation involves the same general principles and raises the same questions of interpretation as those arising for water-supply objectives. In this case it would seem that wide departures in daily maximum MPN's from the average run of the data might have greater public health significance for natural bathing waters because of the direct exposure of bathers without the intervention of any artificial purification process. For this reason it has been thought expedient in revising the bathing-water objective, to provide a limiting maximum, subject as it may be to the possibility of wide errors in routine determination. In this case judgment should be exercised in applying such a maximum, lest a bathing water of generally good sanitary quality be unjustly condemned and its recreational values thereby sacrificed.

A check should be made on the coliform-enterococci ratio in accordance with the recommendations of Scott and Clark.

Waters draining agricultural lands—Where the sanitary survey shows a water intake or a bathing area to be definitely unaffected by some source or sources of sewage pollution, as in streams draining solely agricultural lands, the coliform limits herein recommended should be interpreted with considerable latitude.

Need for standard coliform test—A final point to be emphasized in the application of the objectives is the desirability of a concerted effort on the part of the signatory states to bring about at the earliest time practicable the adoption of a standard method of routine coliform tests for Ohio River and its tributary waters based on the same procedures as followed in the Ohio River Commission water quality survey.

This method would involve planting three tubes in each sample dilution, with a sufficient range of dilutions (at least three) to insure an accurate determination of the "most probable manner" in each sample. The standard "confirmed" test should be made on all samples, as prescribed in Standard Methods. Variations in the ratio of confirmed results to those obtained from 24-hr and 48-hr presumptive tests in connection with the September survey were sufficiently wide to suggest that it would be inadvisable to depend on either of these two presumptive tests for comparable results at all stream points.

BACKGROUND and VALIDATION

by Harold W. Streeter, *Consultant*
Ohio River Valley Water Sanitation Commission

In a communication received from the Commission's executive director, under date of March 6, 1950, I was requested to review "available information and practice on the use and validity of bacterial-quality standards as related to water supply and recreational requirements", and "to prepare a report and submit recommendations for the establishment of bacterial-quality objectives for the Ohio River". This report deals with conclusions reached from such a study, and explains the reasons for such conclusions. It follows the general outline of an interim report made to the Engineering Committee of the Commission at its meeting on July 11, 1950, and is modified to incorporate further data.

The study followed two general lines of inquiry:

(1) A review of representative state and regional standards currently proposed to meet the requirements of the two stream uses indicated in the reference; and

(2) An analysis of available research and observational data bearing on the fundamental bases of current standards, and their application to conditions of pollution and water uses in the Ohio River. In this connection, particular attention has been given to the practical aspects of the problem, as viewed from the standpoint of the long-range plans and policies which are understood to motivate the Commission's program for establishing effective pollution control both in the Ohio River and in its tributary streams.

In carrying out the study, advantage has been taken of interchanges in views with the Commission staff, with Mr. M. LeBosquet and his associates in the U. S. Public Health Service and with Mr. F. H. Waring, chief engineer of the Ohio State Department of Health, with whom frequent meetings have been held in connection with another project touching somewhat closely the problems of the Ohio River. These conferences, together with the views of the Engineering Committee obtained at its July 11, 1950 meeting, have been of much value to me in orienting my viewpoint with the general policies of the Commission. Special acknowledgement is also made to Mr. LeBosquet for his kindness in loaning files containing valuable information on stream standards, and also for his helpful advice. Thanks are also due to Messrs. F. M. Middleton and H. F. Clark of the Environmental Health Center at Cincinnati for their kindness in collecting certain bacteriological data for me while visiting water treatment plants along the Ohio River, and also

to Mr. Waring for making available the files at his office containing annual summaries of similar data as reported during past years from plants in Ohio located on the river.

Because of the difference between bacterial-quality requirements for water supplies and for recreational water uses, especially for bathing, this study has been divided into two parts, each dealing separately with its own phase of the problem. In the section of the report which immediately follows, attention will be confined to water supply requirements, and the bacterial-quality objectives which have been and may be established in order to meet such requirements.

Water Supply Objectives

The history of bacterial-quality standards to meet water supply requirements dates back for some thirty-five years in the United States to the International Joint Commission standard, which was adopted in 1914 on recommendation by a board of consulting sanitary engineers headed by the late George W. Fuller. This standard provided in effect that the yearly average coliform bacteria index in the international boundary waters of Canada and the United States as delivered for treatment should not exceed 500 per 100 ml. In recommending this standard the board pointed out that the index would be expected to exceed this limit at times during the year, and to be less at other times. The standard was based on an assumed efficiency of coliform bacterial removal of 99.6 percent by the average filtration plant treating these waters, and the production of an effluent containing not over 2.0 coliform bacteria per 100 ml., the upper limit then provided in the U. S. Treasury Department drinking water standard.

During the period of 1915 to 1916, the U. S. Public Health Service began a series of observational studies of the efficiency of water treatment plants which, after being discontinued because of World War I, were resumed in 1924 and continued through 1929. These studies covered a year's observation of the performance of 31 representative municipal water filtration plants, including 10 plants on the Ohio River, and five year's operation of a large-scale experimental filtration plant at Cincinnati, equipped with modern treatment devices and designed in two parallel sections throughout, so that any two different methods or combinations of treatment could be observed under the same raw water and other conditions. The results of these investigations, published in a series of reports, provided the only available information on the efficiency and limitations of various combinations of water treatment at that time, and have served as the basis for bacterial-quality standards for sources of treated water supplies in many of our states up to the present time.

Within the limits of observational error, it was found that the average water filtration plant of the rapid-sand type, with postchlorination to low residuals (0.05 - 0.30 ppm by the OT test), could deliver an effluent meeting the bacterial requirements of the 1925 drinking water standard (average coliform index not exceeding 1.0 per 100 ml) from raw waters containing an average of not over 5,000 coliforms per 100 ml. For relatively short periods of time, such as a month, this average would not ordinarily be exceeded by a degree sufficient to vitiate its applicability as a working limit, though for longer periods, such as a year, or several months, variations above the average would be greater in degree, and sometimes too high for safety.

In connection with the same series of studies, the effects of certain auxiliary measures of water treatment on the overall efficiency of bacterial removal were investigated. These measures in-

cluded prechlorination and multi-stage coagulation-sedimentation, both of which have been in use, either separately or in combination, at some plants on the Ohio River. It was found that prechlorination and double-stage sedimentation, when added to normal filtration treatment, would permit higher average numbers of coliform bacteria in the raw water and enable plants thus equipped to take care of temporary overloads of bacterial pollution, ranging up to 20,000 coliform bacteria per 100 ml. or thereabouts. Thus two general levels of permissible raw water pollution were established observationally, the lower one applicable to normal filtration with low-residual postchlorination, and the higher one to the same treatment reinforced by auxiliary measures such as above described, providing a safety factor, when needed, to offset peak loads on the normal filtration process. This was the general concept of the proper function of auxiliary treatment at that time, as an adjunct to normal filtration.

With increased sewage pollution of the Ohio River, and the concomitant problem of industrial wastes pollution, the role of auxiliary treatment has changed gradually from that of a temporary safety measure to one of continuous integration with the treatment process as a whole. This step has brought about a chain of circumstances, ranging from increased chlorine residuals through and after treatment to measures such as aeration, activated carbon treatment, chlorine dioxide treatment, and "breakpoint" chlorination, designed to deal with tastes and odors resulting in part from intensified chlorination, and in part from increased sewage and industrial pollution. Multi-stage coagulation-sedimentation, together with pre-settling, also have been resorted to in an effort to meet increasing bacterial loads.

The past twenty-five years has thus been a record of a continuing struggle to deal with this problem at the water intake, with consequent deterioration in the quality of water supplies except for bacterial content, which has been held down mostly within safe limits as defined by current drinking water standards. With this historical background in mind, a brief review of state and regional bacterial-quality standards for sources of water supply, together with a somewhat more detailed review of the present bacterial efficiencies of a few representative water treatment plants on the Ohio River studies some twenty-five years ago, will follow in the order just named.

State and Regional Standards

In connection with this study, a review has been made of eleven state and regional standards proposing bacterial-quality requirements for sources of water supply. In Table 1 (page 4) is given a summary of these requirements, as taken from the latest source material available. These are the only standards of this character found among the laws and regulations of some forty-odd states relating to the control of stream and lake pollution. A majority of them, it will be noted, are based on recommendations for regional or general pollution control, only five of them having been drawn up for individual states. Eight of the eleven standards named are set up as parts of a classification of streams according to various water uses. In two cases (New England's Class A and Washington's general standard), bacterial-quality limits set for sources of water supply have been based evidently on requirements for waters treated by chlorination alone. In one case (Tennessee), the standard recommended is indicated as a general one for streams of the state, including those used for water supplies after normal filtration treatment. In eight of the standards, a limit of 5,000 coliform bacteria per 100 ml. is given for waters subjected to normal filtration-postchlorination treatment.

In seven of these eight cases, the standard is given as an average, and in one case (Indiana), as a maximum.

In all of the eleven standards, the coliform group of bacteria is taken as the index organism, and is expressed numerically either in terms of the "most probable number", or unspecified. In one standard (T.V.A.) the geometric mean is used rather than the arithmetic mean. In two of the standards (New York and U.S.P.H.S. recommendations), an over-run above 5,000 coliforms per 100 ml. is limited to 20 percent of samples tested, and in the latter case, an over-run above 20,000 per 100 ml., to 5 percent. This is a wise provision in standards expressed as long-term averages, as it places a definite limit on variations above the average. It should take account, however, of the natural variability of a stream or lake in this respect, as otherwise an upper limit may be set which cannot be controlled.

In reviewing these standards, the recurrence of the figure, 5,000 per 100 ml., suggests the influence of the U. S. Public Health Service's studies of the 1920's. It is significant in this connection that this standard has stood for a period of nearly twenty-five years where it has been used, and has in fact gained in favor with the years, having been incorporated into some of the more recent standards. The reason for this survival of an old standard probably lies mainly in the fact that it has served its purpose well, and also that little change has occurred in the basic processes of water filtration since it was originally recommended, though some of them, such as chlorination and multi-stage sedimentation, have been intensified, as previously noted, where excessive raw water pollution has forced such additional defensive measures. That only two of the ten standards reviewed have mentioned a higher coliform limit as permissible with auxiliary treatment suggests that in a majority of cases a definite reservation exists concerning any compromise with a standard which assumes more than normal filtration treatment as a desirable practice. This is a highly significant fact, which should not be lost sight of in the preesnt situation of water treatment along the Ohio River.

Efficiency of Filtration Plants

In view of the marked increase in pollution of raw water supplies in general along the Ohio River during the past twenty-five years, and the consequent necessity for reinforcement of the filtration plants treating these raw waters, an important aspect of this study has been to compare the present bacterial efficiency of a few representative plants along the river with that which was observed at the same plants some twenty-five years ago in connection with the survey previously mentioned. It has been possible to obtain comparable data from only six of the ten plants previously studied, namely, at East Liverpool, Steubenville, Huntington, Ironton, Cincinnati, and Louisville. From records of these six plants, monthly average coliform results for one year from each plant during the period of 1945-1949 have been compared with those obtained at the same plants for a year during the period of July, 1923 through June, 1924, in connection with the U.S.P.H.S. surveys. For the recent period, 1945-49, the years selected have not been in all cases the same, because it has been desired to avoid years in which any material change in treatment has beenmade.

At all of the plants included in this review, coliform enumerations are expressed in terms of the "indicated number" (Phelps index), and in all except the final effluent samples, are determined from fermentation tests with single-tube plantings in decimal series dilutions. As this is the same procedure as was followed in the routine coliform tests in 1923-1924, the results obtained at that time are directly comparable

with those at the present time, making some allowance for minor changes in the methods followed in making confirmatory tests. In final effluent and distribution tap samples, the standard test in five 10-ml. portions is the rule, with additional single-tube plantings in 1 ml. in some cases. In general, enumerations of coliform bacteria in raw and other samples up to the final effluent are based on the standard presumptive test. In the final effluent and tap samples, the results are in some cases expressed in terms of the "gas-former" index (48-hour gas), presumptive index (24-hour gas), and confirmed index. In such cases, an opportunity is thus afforded to compare the final results in these three terms.

Of the six plants selected for study, all except the Ironton plant now use high chlorine residuals. At Cincinnati, "breakpoint" prechlorination has been added recently in an endeavor to minimize objectionable tastes and odors. At Ironton, chlorine residuals have remained at less than 0.2 ppm, which is about the same level as in 1923-1924. At the other five plants, residuals have been increased from about the same levels as at Ironton 25 years ago until they now range from 0.3 to 0.8 ppm or more. In some cases an effort is made, through the addition of ammonia, to maintain chloramine residuals throughout the distribution system. In general, tastes and odors in the treated water supplies have been considerably more serious in recent years than they were in 1923-1924, when the major cause of such troubles was the occasional presence of phenols in the river.

It is somewhat difficult to determine whether the intensified difficulties in respect to tastes and odors have been due mainly to increased industrial wastes pollution, increased sewage pollution, or both combined, together with the necessity of using much higher chlorine residuals. Probably all of these elements have exerted some influence. It seems quite likely that if industrial pollution were completely eliminated as a causitive factor in the present taste and odor problem, this problem would still continue to exist in those sections of the river where sewage pollution is high, if only for the reason that intensified chlorination would still be necessary in order to combat sewage pollution at the water intakes.

The exception at Ironton is notable because unusual coagulation-sedimentation facilities, together with the fact that this plant is still working at an output well below its designed capacity, have enabled this plant to meet increased bacterial loads without resorting to heavy chlorination. Incidentally, it is understood that taste and odor troubles have been somewhat less acute at Ironton than in most of the other water supplies along the river, though industrial wastes pollution has caused some increase in these difficulties.

In Table 3 is given a tabulation of the comparative annual average numbers of coliform bacteria recorded in the raw water and final effluent at each plant during the year 1923-1924 and during one year of the 1946-1949 period. Also shown are the same results for each plant during the poorest month of the year, when the confirmed coliform index averaged the highest in the plant effluent. Except at Ironton, it is noted that yearly average coliform numbers have increased measurably in the raw water during the 25 years since 1923-24. It is not clear why this exception at Ironton should exist, unless it may be due to the combined influence of the high dam at Gallipolis, and the effect of the pool above Dam 26, which would tend to retard the lateral diffusion of pollution from Huntington and cause it to follow more closely the left bank of the river. This is borne out by the fact that the yearly average coliform index at Ashland had increased from 11,500 per 100 ml. in 1923-24 to 30,000 per 100 ml. in 1949. In the last

TABLE 3—AVERAGE INDICATED NUMBERS OF COLIFORMS PER 100 ML. IN RAW AND FINAL CHLORINATED EFFLUENT WATERS OF SIX OHIO RIVER FILTRATION PLANTS DURING ONE-YEAR PERIODS.

Plant	Year	Annual Average		Poorest Month Average		% of Raw in Effluent	
		Raw	Effluent	Raw	Effluent	Annual	Poorest Month
E. Liverpool	1949	3300	0.05	8600	0.30	.0015	.0035
	1923-24	2680	.40	3890	1.30	.015	.033
Steubenville	1946	640	.06	4630	.40	.0094	.0086
	1923-24	330	.20	210	.60	.061	.290
Huntington	1947	2260	.04	1510	.13	.0018	.0086
	1923-24	2370	.80	5280	1.60	.034	.030
Ironton	1945	6200	.02	3270	.17	.0003	.0052
	1923-24	14900	.01	19100	3.40	.00007	.018
Cincinnati	1945	4360	.08	8550	.32	.0018	.0037
	1923-24	2980	.50	9910	2.0	.017	.020
Louisville	1949	4570	.14	8900	1.0	.0031	.011
	1923-24	2220	.10	2300	.30	.0045	.013

Note: Raw water numbers based on presumptive tests; effluent numbers on confirmed test.

two columns of Table 3 are shown the percentages of raw water coliforms observed in the final effluents of the six plants during the recent period, as compared with those recorded during the period 1923-24. It is also to be noted that despite the increased bacterial loads during the more recent periods, the average coliform content of the final effluents has been lower than during the period 1923-24. This trend is reflected in the lower percentages of raw water coliforms remaining in the final effluents, as compared with 1923-24.

That this increased bacterial efficiency is due almost wholly to more intensified chlorination is suggested by the results shown in Table 4, in which the average coliform numbers and their residual percentages observed in the unchlorinated filtered effluents of four plants during periods between 1945 and 1949 are compared with those observed in 1923-24. In these four cases direct comparison is possible because the filtered effluent samples during both periods represent the purification efficiencies accomplished by each plant without chlorination. Such a comparison has not been possible with the other plants on the river because of prechlorination not practiced in 1923-24, or because the filtered effluent samples were not directly comparable during the two periods.

It will be noted that two of the four plants show slightly greater, and two of them, slightly lower efficiencies of coliform removal during the two periods. In all cases no marked improvement in filtration process efficiency in itself is indicated. This evidences that the overall gain in bacterial efficiency of filtration processes along the river during the past 25 years has been accomplished very largely through the more liberal application of chlorine, and not through any material improvement in those features of filtration plant design and operation which in themselves would tend to bring about augmented bacterial efficiencies.

TABLE 4—COMPARATIVE NUMBERS AND PERCENTAGES OF COLIFORMS REMAINING IN UNCHLORINATED FILTER EFFLUENTS OF FOUR OHIO RIVER FILTRATION PLANTS.

Plant	Year	Coliforms per 100 Ml. Raw	Filtered	% of Raw in Filtered
Ironton	1949	5770	0.29	.005
	1923-24	14900	1.6	.011
Portsmouth	1949	2250	3.6	.11
	1923-24	3490	1.7	.05
Cincinnati	1945-48	4330	6.2	.14
	1923-24	2980	3.4	.11
Louisville	1947-49	3400	20.0	.59
	1923-24	2220	17.0	.77

In order to show somewhat more graphically the overall increase in bacterial removals effected by intensified chlorination, the figures given in Table 3 have been utilized to estimate, on the basis of the observed efficiencies, the maximum average coliform numbers in the raw waters as delivered to each of the six plants which would permit the delivery of final effluents containing an average coliform content of not over 1.0 per 100 ml., the limit set by the current drinking water standard, during each of the two periods covered in Table 3. This has been done by the simple process of dividing the number of raw water coliforms by the corresponding number recorded in the final effluent, thus giving the raw water content which would yield a number of 1.0 per 100 ml. in the effluent if the same bacterial removal efficiency should hold at the higher level.

This procedure is of course an approximation, but appears to be justified for purposes of estimate because previous studies have indicated that in general, the bacterial removal efficiency tends to increase with the bacterial loading on a treatment process up to a point where it levels off, and then remains fairly constant at higher loads. In the case at hand, except at Steubenville, where the bacterial load is relatively low in the raw water, the tendency for plant efficiencies to reach a fairly stable level would be expected to be attained at average coliform densities above 2,000 per 100 ml. or thereabouts, which density is exceeded by all of the raw waters except at Steubenville during both of the two periods studied.

On a yearly average basis, the raw water coliform limits thus estimated are shown to range from 11,000 to 66,000 (omitting the result for Ironton as being far out of line with the others), and to average 38,000 during the periods of 1945-49. During the period 1923-24, they ranged from 1,500 to 22,200, averaging 6,500, a figure which incidentally was not far from the coliform limit found for the average Ohio River plant in the U.S.P.H.S. studies carried out at that time. During the poorest months of the two periods, the estimated coliform limit in the raw waters averaged 18,000 for 1945-49, and 4,200 for 1923-24, the latter of which again was not far from the limit observed for the average Ohio River plant at that time.

In this connection it should be noted, however, that during these poorest months the efficiency of three of the six plants studied was such that their estimated limiting average coliform load would tend to approximate 10,000 per 100 ml., ranging from 8,900 to 11,600. Although this indicated load limit doubtless could be increased by more

TABLE 5—ESTIMATED AVERAGE INDICATED NUMBERS OF COLIFORMS IN RAW WATERS OF SIX OHIO RIVER FILTRATION PLANTS GIVING NOT OVER 1.0 PER 100 ML. IN FINAL EFFLUENTS.

(Based on average efficiencies during one-year periods)

Plant	Average Annual		Poorest Month	
	1945-49	1923-24	1945-49	1923-24
E. Liverpool	66000	6500	29000	3000
Steubenville	11000	1500	11000	350
Huntington	56000	2960	11600	3300
Ironton	310000*	140000*	19000	5600
Cincinnati	62000	6000	29000	4960
Louisville	33000	22000	8900	7700
Average	38000	6500	18000	4200

(*) Omitted from average.

highly intensified chlorination, it is nevertheless a significant indication that under conditions of normal operation, with the relatively high chlorine residuals being carried, occasional months occur in which the average plant efficiencies are shown to deteriorate to the extent indicated. (See Table 5)

Discussion

In interpreting the foregoing data, the following indications are noteworthy:

1. Increasing sewage pollution of the river has brought about a general need for augmenting treatment facilities in order to offset increased bacterial loads at the water intakes.

2. This has been accomplished for the most part by adding prechlorination to existing filtration facilities, and by carrying much higher chlorine residuals through the treatment process to the distribution system. Complete plant reconstruction has been undertaken only in two cases, though strengthening of certain stages of treatment has been carried out at several plants.

3. A general increase has been noted in the bacterial efficiency of practically every plant along the river, though most of them have shown a tendency for lowered efficiency during occasional months, sometimes under unusually heavy average bacterial loads, and at other times, under unfavorable conditions, which apparently occur more frequently during periods of marked seasonal changes, though not necessarily closely related to such changes.

4. On the basis of yearly average efficiencies, all except one of the plants studied can produce effluents of average drinking water bacterial quality from estimated raw water coliform bacteria loads ranging above 30,000 per 100 ml., and averaging roughly 40,000. As yearly average data tend to mask significant lapses in the bacterial efficiency of practically every plant studied, they may be considered only as indicating general trends in comparison with average efficiencies observed in 1923-24.

5. On the basis of performances observed during the poorest months of single years, by which is meant the months when the coliform numbers in the final effluents averaged the highest during the year, a somewhat different picture is shown. In this case, the estimated safe limit of coliform loading

would tend to center around 10,000 per 100 ml. for a significantly large proportion of the plants studied. This limit would represent that which could be handled safely under more adverse conditions of plant operation, but with existing facilities for high-residual chlorination. It would not provide in all cases a working factor of safety, though in others a fairly liberal margin in this respect would prevail.

Bacterial-Quality Objectives

In establishing bacterial-quality objectives for the Ohio River to meet water supply requirements, a distinction should be made between those which are tolerable and those which are desirable. From the standpoint of tolerance, a limiting average coliform density of 10,000 per 100 ml. would be adequately safe, but would involve the continued dependence on intensified chlorination as an integral part of every water filtration plant. This in turn would entail a continuance of existing difficulties with unpalatability in water supplies derived from the river, largely as the result of the need for carrying high chlorine residuals into the distribution systems. Although such a condition might be tolerated during emergencies, and treatment plants should be equipped to meet them, it cannot in my opinion be considered as a desirable situation permanently, from the standpoint of the nearly three millions of people who depend on the river as their only source of domestic and industrial water supply.

It has been shown conclusively that normal filtration processes, with low-residual or "marginal" chlorination, can deliver both safe and palatable effluents from raw waters containing monthly average numbers not exceeding 5,000 per 100 ml., provided of course that such waters are free from taste-producing industrial pollutants. In view of plans now underway to reduce and ultimately eliminate all harmful industrial pollution from the Ohio River, a return to normal filtration methods would be a highly desirable concomitant of such a development.

It therefore is recommended that pollution-control measures along the Ohio River and in its tributaries be aimed to meet an ultimate bacterial-quality objective such that the monthly arithmetical average "most probable number" of coliform bacteria in the river at all water supply intakes will not exceed 5,000 per 100 ml. in any month; nor will exceed this figure in more than 20 percent of the samples of raw water examined during any month; nor will exceed 20,000 per 100 ml. in more than 5 percent of such samples.

In making this recommendation, the month has been taken as the period of the average for two reasons. First, it is the shortest common period for reporting bacterial results which will permit a fairly stabilized average to be taken. Secondly, it usually is based on at least 25 daily results from individual tests, and thus involves a range of statistical error which is roughly one-fifth or less the expected error of an individual coliform result. In view of the very large errors of individual results which have been shown to be involved in the ordinary MPN determination, it would be highly unwise, in my opinion, to base any limiting standard on a single maximum expressed in such terms. The month appears to be the best compromise between a period which is either so short as to involve large errors of measurement, or so long that seasonal and other natural variations in the coliform content of a stream would exert an undue influence on an average.

Use of an arithmetic average has been followed in stating this objective because the main statistical reason for using a median, or a geometric mean, namely, a definite pattern of logarithmic skewness in the frequency distribution of individual results, has not been found in the normal trend of these re-

sults when taken over periods as short as a month, though various degrees of skewness, highly irregular in pattern, have been noted in some months and at some points, owing to the effect of a few high results. Moreover, in the case at hand, every individual result has its significance in showing the average condition of a stream during short periods of time; hence any tendency to suppress the full effect of even a few high results would tend to distort the true significance of an average, where the public health is so vitally concerned, and where, as in the Ohio River, sewage pollution dominates every situation.

Provision of "over-run" frequency controls in the objective as stated is designed to place a definite limit to the frequency of high results above those which would normally be expected as being due to natural variance in the stream content, at average levels not exceeding 5,000 per 100 ml. A slight revision in these "controls" has resulted from an analysis of the results of the Commission's Ohio River Water Quality Survey of Sept., 1950, in which improved methods of coliform enumeration were followed.

As a rough guide in estimating the degree of reduction in bacterial pollution to meet such an ultimate objective, an analysis has been made of a ten-year record of monthly average raw water coliform densities reported at ten water filtration plants during the years 1926-1935, inclusive. This study has indicated that under normal stream conditions in the Ohio River, an average coliform density of 5,000 per 100 ml. may not be expected to be exceeded in any month of the year if the yearly average coliform density is held within an upper limit of 2,000 per 100 ml. Referring to Table 3, it will be noted that the yearly average coliform densities recorded at the six intakes listed in the table were slightly more than twice this limit at Cincinnati and Louisville during 1945 and 1949, respectively, somewhat over three times the limit at Ironton in 1945, about 65 percent higher at East Liverpool in 1949, very slightly higher at Huntington in 1947, and lower at Steubenville in 1946. At Ashland, Kentucky, however, where the reported raw water coliform index averaged 30,000 per 100 ml. in 1949 (the highest along the river), a reduction of nearly 95 percent in the bacterial load would be required. The excessive load on this plant is quite evidently due to the influence of sewage pollution from the Huntington district, which apparently tends to follow the left bank of the river downstream.

The foregoing recommendation may be criticized on the ground that it is unduly conservative, because it fails to credit the increased bacterial efficiencies which have been developed at the sevral Ohio River filtration plants in a continued effort to combat increased raw water pollution. The provision of added facilities to accomplish this purpose has been an expensive undertaking, and represents a very considerable investment. Some plant supervisors are honestly convinced that the bacterial-quality standards of past years are outmoded, and should be modified so as to take account of the greater bacterial efficiencies of water treatment processes made possible by intensified chlorination, and other auxiliary measures of reinforcement.

In this writer's opinion, the answer to these arguments rests in the simple fact that water consumers along the river are not obtaining the consistently palatable water supplies to which they are entitled, despite the ingenious and costly methods which have been developed in an effort to combat such unpalatability. As the only major change in water treatment has been intensification of chlorination, the inference seems quite clear that this practice lies at the root of present difficulties, though doubtless aggravated by the effects of certain industrial pollution. Reduction

of bacterial loads in accordance with the objectives herein recommended would go far to obviate the necessity of heavy chlorination, and thus make it possible, with the improved chlorination techniques of recent years, to produce even more palatable water supplies than were being delivered some 25 years ago.

Pending the time when adequate pollution control has become established in the river and its tributaries, a monthly average coliform number not exceeding 10,000 per 100 ml. in any month should serve the purpose of maintaining reasonably safe water supplies, though at the price of continuation of present practices of intensified chlorination. If sewage pollution of the river could be brought within the boundaries of such a temporary standard, it is possible that at plants equipped with improved coagulation-sedimentation facilities, some reduction in the present high level of chlorine residuals could be effected, and in some cases carried to a level of "marginal" chlorination, as has been done at the Ironton plant during the past 25 years, despite heavy bacterial loads in the raw water. Although a monthly average coliform load up to 10,000 per 100 ml. doubtless could be carried without undue difficulty at practically every Ohio River filtration plant with present equipment, an objective at this level would serve only as a temporary expedient, and in my opinion would not afford a permanent solution of the problem.

Recreational Water Objectives

The approach to considering bacterial-quality objectives to meet recreational requirements is quite different, and in some respects more difficult, than that of water supply requirements. In this case, no background of systematic observation and experiment exists, except a few studies of bathing beaches such as have been made in Connecticut and California, correlating known sanitary conditions with bathing water quality. Although some recent studies instituted by the U. S. Public Health Service have made a more direct approach to the problem by undertaking to correlate bathing water quality with the incidence of water-borne diseases among the bathing population, these studies are still in progress, and may require some time before definite results will be available. In Illinois, a novel approach has been made through a study aimed to correlate sanitary surveys with coliform-enterococcus levels in lake waters. Further results of this study will merit the closest attention, and likewise those of the U.S.P.H.S. Meanwhile it is possible only to review existing standards proposed in several states and regional areas, and attempt to appraise their public health significance as applied to streams like the Ohio River.

In Table 6 is given a summary of 11 state and regional standards for bathing and recreational waters. In five of these standards are parts of classification schemes for natural waters used for different purposes. In 9 of the 11 standards, a limiting coliform bacterial density of 1000 per 100 ml. is given, either as an average or as a maximum. This, in fact, is the most recurrent figure appearing in the standards, and may well be taken as a base line for discussion. For desirable bathing waters, preferred coliform densities range from 50 to 100 per 100 ml. as averages, especially where classification of bathing waters has been adopted or proposed. Between this level and that of 1,000 per 100 ml. seems to be an intermediate zone, in which many stream and lake waters of relatively low degrees of pollution fall. Current bacteriological surveys of some 25 bathing beaches along the Ohio shore of Lake Erie have disclosed a considerable number of beaches comparatively free of local pollution falling into this intermediate class on the basis of their average coliform bacteria counts.

TABLE 6 — SUMMARY OF BACTERIAL-QUALITY REQUIREMENTS FOR BATHING WATERS IN CERTAIN STATE AND REGIONAL STANDARDS

State or Region	Class	Units	Limiting Coliform Numbers per 100 Ml.
New York	B-1	Av. MPN	1000
		Max. MPN	2400
New England	B	Max. MPN	1000
Connecticut	A	Av. MPN	0 - 50
	B	Av. MPN	50 - 500
	C	Av. MPN	500 - 1000
	D	Av. MPN	Over 1000
Tennessee Valley Authority	I	Geom. Av. MPN	50
	II	Geom. Av. MPN	1000*
West Virginia	AA	Mo. Av. MPN	100
	A	Mo. Av. MPN	1000*
Potomac River Commission	B	Av. MPN	50 - 500
		Max. MPN	1000
Indiana	—	Max. MPN	1000
Washington	—	Av. MPN	50
A.P.H.A. Joint Comm. (1948)	—	Av. MPN	1000
		Max. MPN	2400
Ohio R. Committee (House Doc. 266)		Av.	100
		Max.	1000
California		Av. MPN	1000
		Max. MPN	20% samples over 1000

(*) Also for general recreation.

For waters devoted to general recreational pursuits other than bathing, only a few standards have been found in which coliform bacterial requirements are specified. The Tennessee Valley Authority indicates in its recommended standard a limiting average coliform MPN (geometric mean) of 1,000 per 100 ml. for Class II waters, stating that such waters should be good for general recreation. West Virginia's coliform standard for Class A waters also indicates 1,000 per 100 ml. as suitable for general recreation. The Tennessee (state) standard does not specify whether its general coliform limiting average level of 5,000 per 100 ml. also applies to recreational waters, and hence is omitted from Table 6. The New England, Potomac River Commission, Indiana, and Ohio River Committee standards give a coliform density of 1,000 per 100 ml. as a maximum for bathing waters. Among the standards allowing densities in excess of this amount, New York (state) specifies a maximum of 2,400 per 100 ml., and California a frequency of 20 percent above 1,000 which is the limiting average for both of these standards.

It thus appears that in the very few cases where a general recreational standard is given, it is at the same average level as that of a majority of the bathing water standards (i.e. 1,000 coliforms per 100 ml.). A fairly logical reason for this in some cases would be that in general, recreational uses of streams and lakes, especially for camping, picnicking, etc., tend to merge to a

considerable extent with bathing uses, as in many cases people will seek for such purposes water areas where bathing is permissible, even if only incidentally to other recreational pursuits. For some types of recreation, notably boating, bacterial-quality requirements should be definitely less stringent than for bathing, as in such cases little or no hazard of human ingestion of the water is involved. Thus along the Ohio River it is common to observe active boating in sections of the river where the quality of the water would permit bathing. For this particular activity, a common-sense view would seem to be that it could be readily pursued, with practically no hazard, in natural bodies of water which in general are fit sources of filtered water supplies, that is, which average not over 5,000 coliform bacteria per 100 ml.

With reference to bathing water standards, special mention has been made of a study by the Illinois Department of Public Health concerning the relation between sanitary surveys and the coliform-enterococcus levels in a lake pollution investigation. In a paper presented in October, 1949 by Scott and Clark*, the authors, from a statistical study of coliform-enterococcus ratios as correlated with a "relative pollution factor" ranging numerically from 1 to 5, concluded that in areas subject to sewage pollution, a satisfactory water would contain: (a) coliform MPN less than 700 if enterococci is 23 or more, or (b) coliform MPN 700 or over, but less than 2,400, if enterococci is less than 23 (all expressed per 100 ml.). In areas not subject to sewage pollution, a satisfactory water would contain: (a) coliform less than 2,400, if enterococci is 23 or more, or (b) coliform MPN over 2,400, but less than 7,000, if enterococci is less than 23. In setting up this scale, the authors in effect have taken an enterococci MPN level of 23 per 100 ml. as the dividing line between significant sewage pollution and pollution resulting from birds, rodents, and land wash.

In a paper given before the American Society of Civil Engineers in January, 1950, Cox** has reviewed the public health significance of bacteriological findings in natural bathing waters. He notes the efforts of bacteriologists to develop more specific tests for fecal bacteria, including tests for "sewage streptococci", indicating that in his view these investigations have not yet developed any tests more specific or of public health significance than the standard plate count and the test for coliform organisms. He concludes that bacterial tests should serve only as a general guide, forming part of the information pertaining to any given bathing beach, and that bacterial standards for natural waters used for bathing cannot be placed on a precise quantitative basis as disclosing the intrinsic quality of the water, or certain public health safety for the bathers. He indicates approval of beach waters in the New York City area if epidemiological data pertaining to bathers, and the sanitary survey, are both satisfactory, and the average coliform content of the water is not in excess of 2,400 per 100 ml., except when the other two criteria justify the use of the lower average of 240 per 100 ml. Cox also points out the well-known distinction between the types of infections con-

*Scott, R. M. and Clark, E. S. Correlation of the Sanitary Survey and the Coliform-enterococcus Levels in a Lake Pollution Investigation. Presented at the Society of Illinois Bacteriologists meeting, Springfield, Illinois, Oct. 13, 1949.

**Cox, C. R. Acceptable Standards for Natural Waters Used for Bathing. Presented before Sanitary Engineering Division, A.S.C.E., January, 1950.

tracted from natural bathing waters and those of artificial swimming pools, the latter including skin, mucous membrane, and other bather-to-bather infections, whereas the former usually are intestinal, resulting from ingestion of the water by bathers.

These two studies, though somewhat contradictory to each other in their specific findings, are illuminating in expressing trends of recent thought on the subject of bathing waters. According to both studies, coliform densities ranging up to 2,400 per 100 ml., or even higher if sewage pollution is known to be absent, are not necessarily out of line with good sanitation, though a rigid interpretation of the Illinois findings would tend to limit the coliform densities to something less than 1,000 if definite evidence of sewage pollution is present.

In connection with the present investigation, a study has been made of the possibility of utilizing the findings of Kehr and Butterfield* several years ago as a rough check on the rationality of various proposed bathing water standards, as viewed from the standpoint of water-borne disease hazards. Without going into their study in detail, it may be noted here that they derived from a number of studies in England, Indonesia, and California, where the successful enumeration of both coliforms and typhoid and para-typhoid organisms was carried out in sewage and sewage-polluted waters at the time of outbreaks of these enteric diseases, a correlation between the morbidity rates from typhoid fever in different areas and the ratios of E. coli to E. typhosa in the sewage and sewage-polluted waters of the areas. Although present typhoid morbidity rates in the Ohio Valley are extremely low, the rates for certain other enteric diseases, such as dysentery and diarrhea-enteritis, are sufficiently high to indicate a carrier reservoir which might be a factor in bathing water sanitation.

According to the U. S. Census mortality reports for various diseases, the average typhoid mortality rate for seven Ohio River states in the years 1945-47 was 0.4 per 100,000 (as compared with a rate of 0.2 per 100,000 in the U. S. registration area). Assuming a morbidity:mortality ratio of 10 to 1, this would indicate a morbidity rate of 4 per 100,000, or 0.04 per 1,000. From Kehr and Butterfield's curve, the corresponding ratio of E. typhosa: E. coli in the sewage and sewage-polluted waters of such an area would be 6 E. typhosa per million coliforms, or about 170,000 coliforms for each E. typhosa organism. This of course is an extremely low infection ratio for typhoid fever, but nevertheless measurable according to the Kehr-Butterfield results.

In order to apply these data to an evaluation of the typhoid hazard in bathing waters of an area, it is necessary to assume the average volume of water ingested per bather per day. For purposes of estimate, let this volume be assumed as 10 ml., which probably would be high for trained swimmers, and low for children. Now let:

R = the number of coliforms per single E. typhosa in the bathing water.

B = the number of bathers per day.

V = the volume of water, in ml. ingested per bather daily.

C = the average coliform content of the bathing water per ml.

Then the chance of exposure (P_e) of (B) bathers to a single E. typhosa on any day is:

$$P_e = BVC/R$$

and the exposure interval, in days, between successive ingestions of a single organism is:

$$I_e = 1/P_e = R/BVC$$

*Kehr, R. W. and Butterfield, C. T. Notes on the Relation Between Coliforms and Enteric Pathogens. Public Health Reports, Apr. 9, 1943. Reprint No. 2469.

For illustration, let us assume R = 170,000; V = 10 ml., and C = 10 per ml., or 1,000 per 100 ml. Then the chance that a single bather would be exposed to ingestion of one E. typhosa organism would be:

$$P_e = 1/1{,}700$$

During a 90-day bathing season, *if he bathes every day*, his risk of exposure would be 90/1700, or 1/19. If he bathes every other day, the risk then will be 1/38.

Butterfield and Kehr estimated that about 2 percent, or one out of every 50 persons exposed to ingestion of a single E. typosa organism, actually contract the disease. On this basis, it may be estimated that our bather's risk of contracting typhoid fever during a 90-day season would be $1/19 \times 50$, or 1/950, a very remote hazard.

From estimates compiled from surveys of water-borne diseases by Wolman and Gorman*, and by Eliassen and Cummings**, it appears that water-borne diarrhea-enteritis morbidity rates tend to average about 20 times those of typhoid fever. In the seven Ohio River states, the ratio based on mortality records was 22 to 1 during the years 1945-47.

If the ratio of 20 : 1 be applied to the typhoid risk for an individual bather, his risk of contracting diarrhea-enteritis during a 90-day season would be 20/950, or about 1/50. This again is a rather remote hazard.

If similar estimates are made for groups of bathers, it must first be assumed that every bather of a group bathes regularly every day, or that a certain proportion of the group bathes daily. For a group of 100 regular bathers, the typhoid risk under the conditions assumed above thus would be about 1/10 for a 90-day season. For the same group, the diarrhea-enteritis risk would be about 2/1 during a 90-day season, again assuming each member of the group to bathe regularly every day. This is of course a tangible hazard, though reduced in proportion to the percentage of the group bathing each day.

When viewed from the standpoint of calculable risk, a bathing water coliform standard of 1,000 per 100 ml. or thereabouts would seem to involve no great hazard for the individual bather, or even for moderate sized groups of bathers. From the computations shown above, it can be readily estimated that a water meeting this standard should provide a high degree of protection for groups of several hundreds of people against typhoid infections, and reasonable protection for smaller groups against diarrheal diseases. Moreover, a standard at this level is probably the most stringent one which could be met in the Ohio River under any conditions of pollution which can be visualized during the near future, even with some degree of pollution control established. Pending the outcome of future epidemiological studies of bathing waters, it probably would be the most logical tentative objective at which immediate measures of pollution control could be aimed. If adopted as a tentative objective, however, it should be properly safeguarded against excessive "overrun", both in degree and in frequency.

It is therefore recommended that for bathing and other recreational requirements other than boating, a bacterial-quality objective be established tentatively for the Ohio River under the following conditions:

Waters suitable for this purpose should show a monthly arithmetical average "most probable number" of coliform bacteria, not exceeding 1,000 per 100 ml. in any month of the normal bathing

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*Water-borne Outbreaks in the United States & Canada 1930-1936. AP.H.A. Annual Year Book, Vol. 20, No. 2.

**Analysis of Water-borne Outbreaks, 1938-45. Jour. Am. W. W. Assoc., May, 1948.

season, nor exceeding this number in more than 20 percent of the samples examined during any such month; nor exceeding 2,400 per 100 ml. on any day.

For general recreational purposes not involving the use of the river waters for bathing or swimming, a monthly average "most probable number" of coliform bacteria not exceeding 5,000 per 100 ml., nor exceeding 5,000 per 100 ml. in more than 20 percent of the samples examined during any month of the recreation season, is recommended as a minimum bacterial-quality requirement.

As to the significance of the term "average" as used in this recommendation, it is intended to mean the ordinary arithmetic average. This is done not to exclude, or minimize, the full effects of wide deviations from the average which in the case at hand are believed to be of definite public health significance.

The above recommendations are a compromise between that which would be desirable and that which is administratively practicable. They represent the best judgment of this reviewer after considering the problem from several different angles.


OHIO RIVER VALLEY
AN INTERSTATE AGENCY
ESTABLISHED JUNE 30, 1948
WATER SANITATION COMMISSION

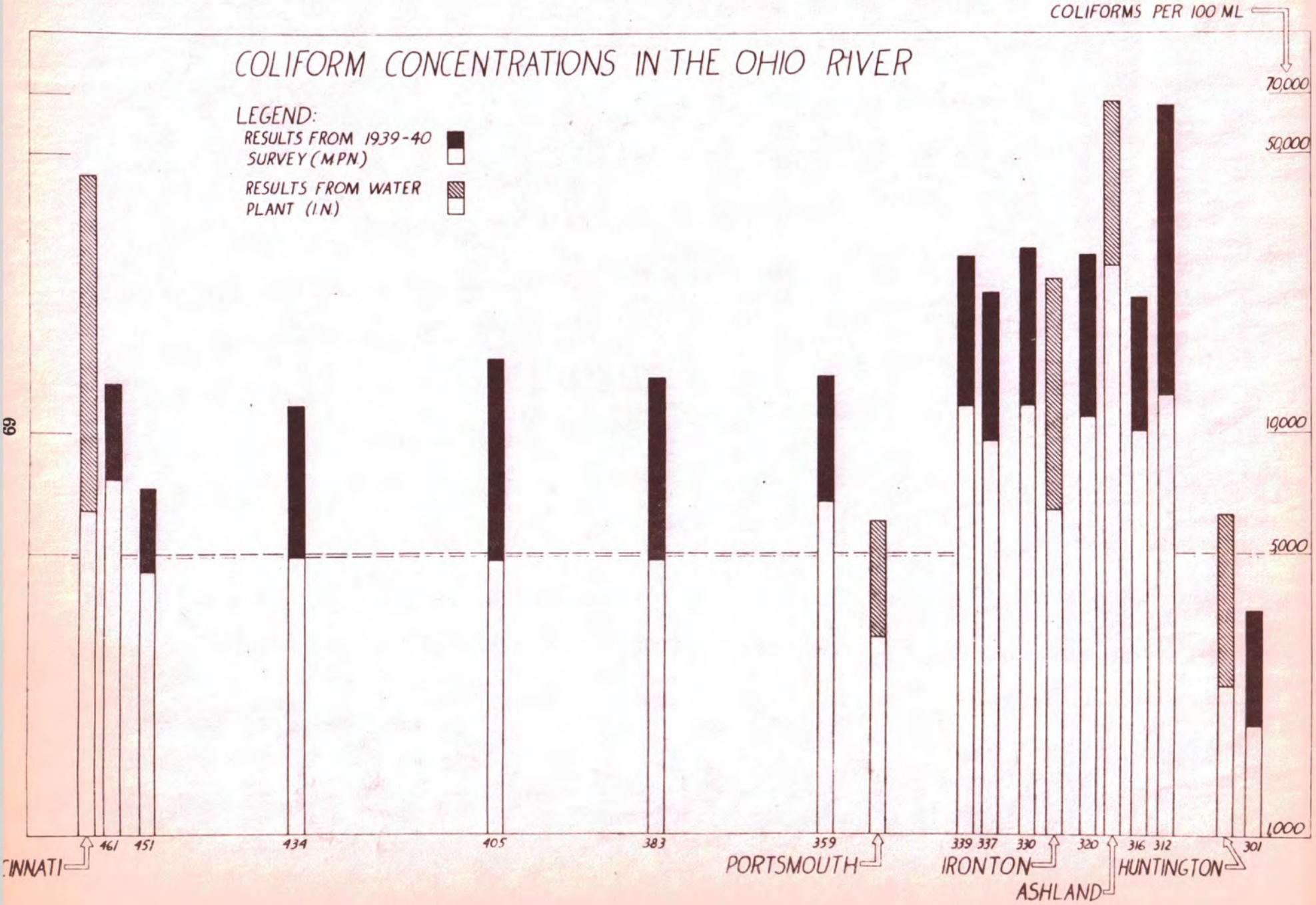
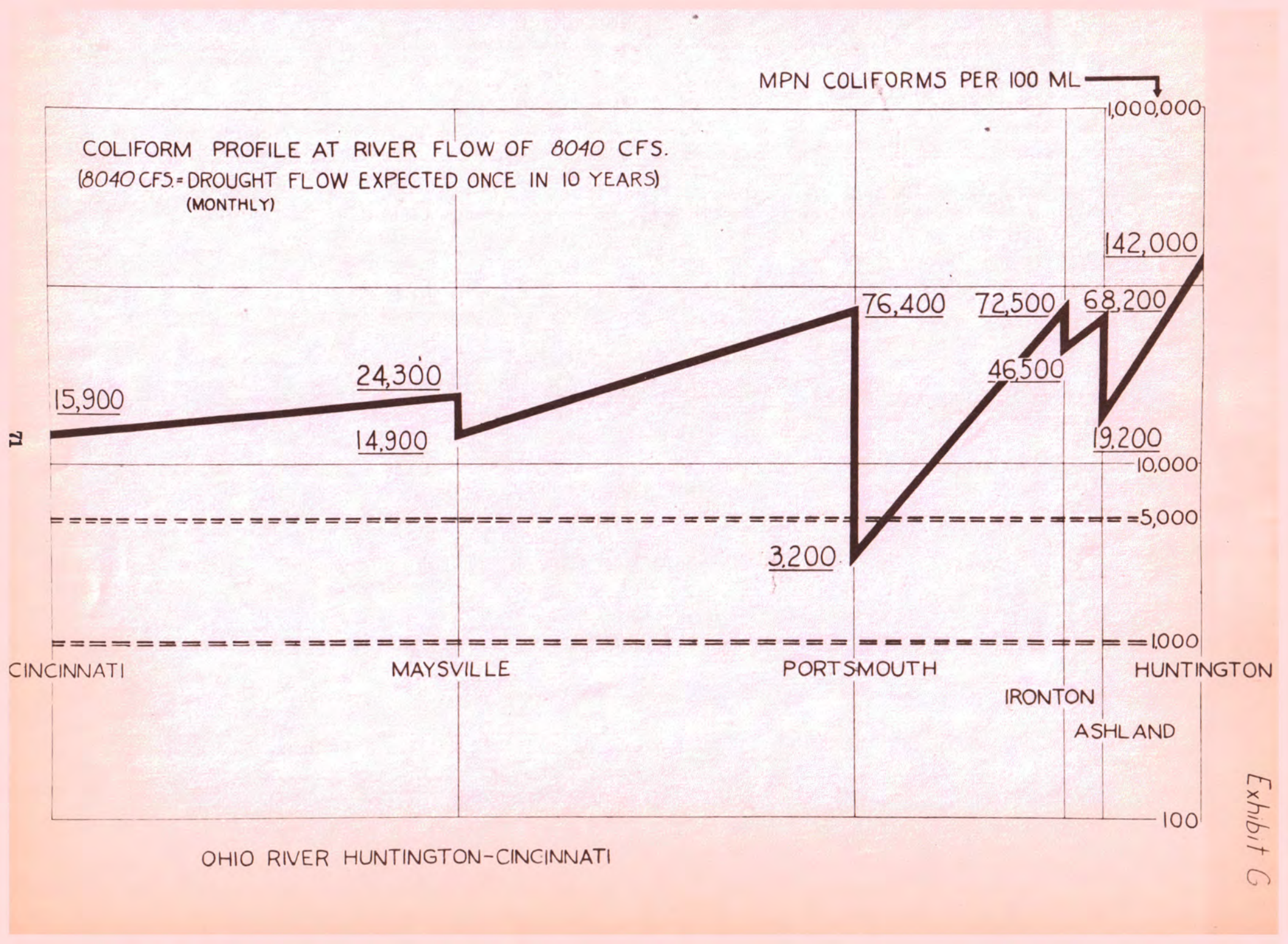
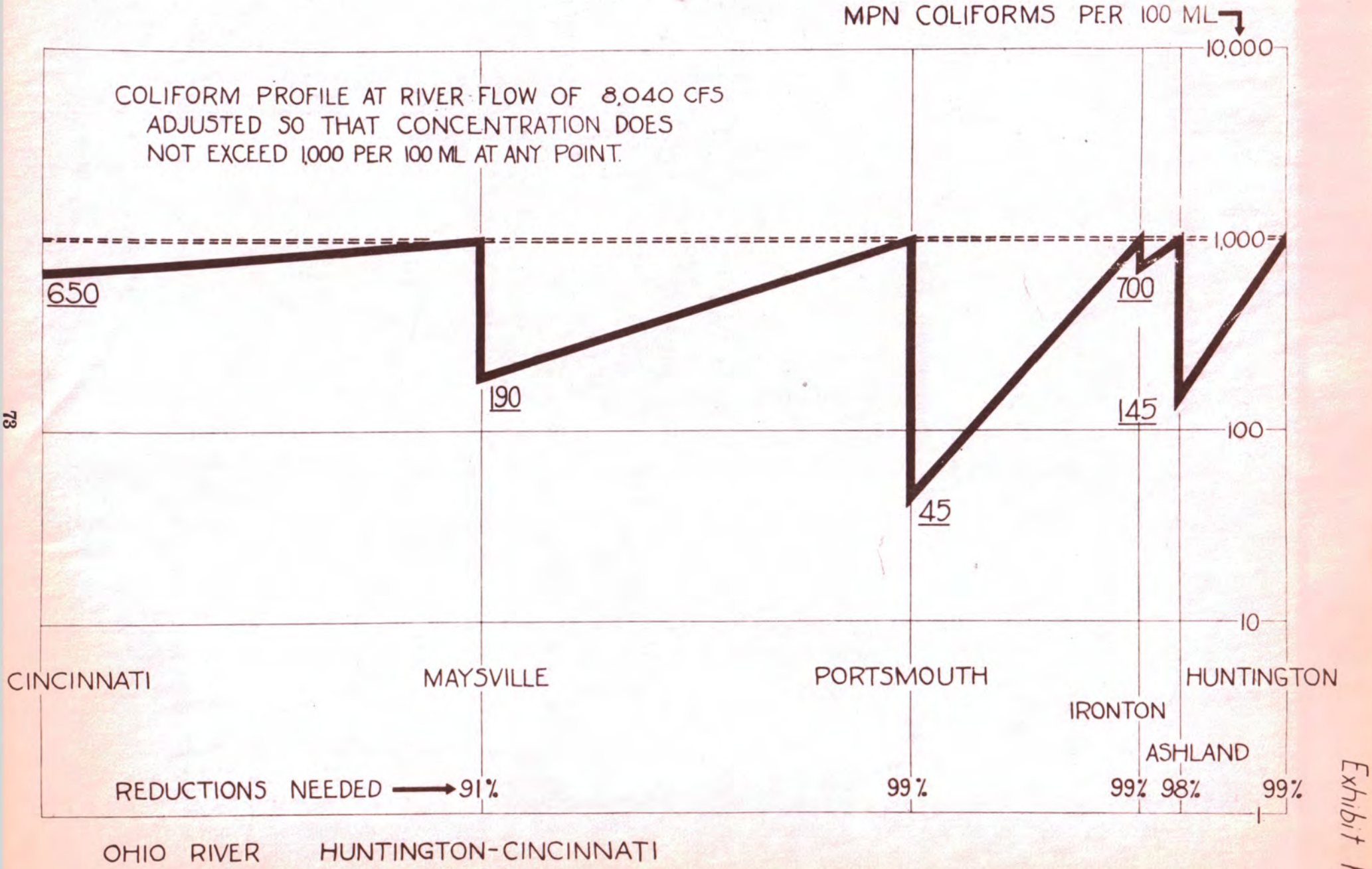

COLIFORMS PER 100 ML
COLIFORM CONCENTRATIONS IN THE OHIO RIVER
LEGEND:
RESULTS FROM 1939-40 SURVEY (MPN)
RESULTS FROM WATER PLANT (I.N)
70,000
50,000
10,000
5000
1,000
461
451
434
405
383
359
339
337
330
320
316
312
301
CINNATI
PORTSMOUTH
IRONTON
ASHLAND
HUNTINGTON

Exhibit F


MPN COLIFORMS PER 100 ML
1,000,000
COLIFORM PROFILE AT RIVER FLOW OF 8040 CFS.
(8040 CFS. = DROUGHT FLOW EXPECTED ONCE IN 10 YEARS)
(MONTHLY)
142,000
76,400
72,500
68,200
24,300
46,500
15,900
14,900
19,200
10,000
5,000
3,200
1,000
100
CINCINNATI
MAYSVILLE
PORTSMOUTH
IRONTON
HUNTINGTON
ASHLAND
OHIO RIVER HUNTINGTON-CINCINNATI
71
Exhibit G



OHIO RIVER HUNTINGTON-CINCINNATI

Exhibit H

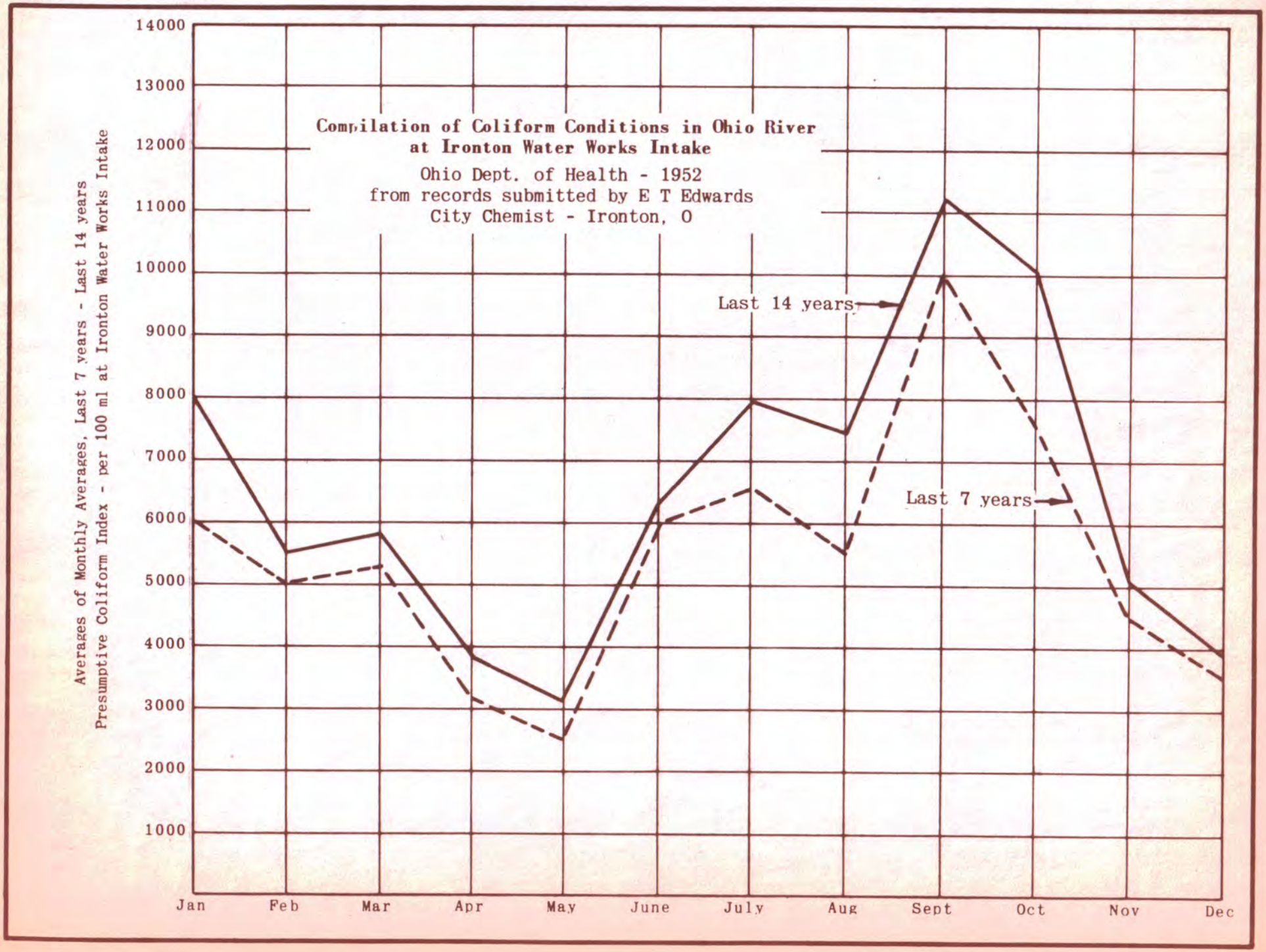

Compilation of Coliform Conditions in Ohio River
at Ironton Water Works Intake
Ohio Dept. of Health - 1952
from records submitted by E T Edwards
City Chemist - Ironton, O
Averages of Monthly Averages, Last 7 years - Last 14 years
Presumptive Coliform Index - per 100 ml at Ironton Water Works Intake
14000
13000
12000
11000
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
Last 14 years
Last 7 years
Jan
Feb
Mar
Apr
May
June
July
Aug
Sept
Oct
Nov
Dec

Exhibit I

EXHIBIT J

REPORT BY STATE WATER COMMISSION OF WEST VIRGINIA

Judge D. Jackson Savage, Chairman
West Virginia Water Commission
Charleston, West Virginia

Re: Stream Conditions in the Huntington Area

Dear Judge Savage:

The following report covering the effect of the sanitary sewage of Huntington on the Ohio and Guyandotte Rivers, the need for sewage treatment and effects at state level to have such treatment provided, is submitted for your consideration.

R E P O R T

The City of Huntington is bounded by the Guyandotte River on the east and by the Ohio River on the north, and is so located as to have an abundant supply of water from these streams for its municipal and industrial uses. Huntington is the largest city in the State of West Virginia, covering an area of approximately fifteen square miles and having a population of 85,000. It has a large industrial center with an employment of over twenty thousand people. The city's residential section shows foresight and planning which is second to none in West Virginia in beauty and convenience.

The State Water Commission is charged with regulating stream pollution in West Virginia, and in this connection, is carrying out a state-wide program to preserve and improve one of the state's most valuable natural resources, its surface waters. The program of stream improvement must be accomplished by the installation of necessary waste treatment facilities by municipality and industry. The Commission is committed to a program of aiding and assisting pollution offenders in every way toward the solution of their pollution problem. If cooperative efforts fail, the Commission must use the legal machinery provided as a final resort, to insure that the program is impartial and that a small number of uncooperative offenders will not stalemate the program. This report covers the Water Commission's program as it pertains to Huntington.

Efforts Toward Sewage Treatment

Representatives of the State Health Department and Water Commission discussed the need for sewage treatment with the officials of the City of Huntington on a number of occasions prior to World War II. With the inauguration of an accelerated program of pollution control at the end of the War, representatives of the interested state agencies appeared at a Council meeting on June 12, 1946 and pointed out in detail the need for sewage treatment in Huntington and the ways and means of financing same. At that time, it was suggested that the City make application for a Federal Works Agency loan to plan sewage treatment. The City did make application for a loan and received sufficient money to plan

an adequate storm water system and make the preliminary survey for an interceptor system and treatment plant. On January 19, 1948, representatives of the Water Commission and Health Department appeared at a joint meeting of the Sanitary Board and Council of Huntington and urged that the City inaugurate a service charge or other method of raising sufficient funds to complete the planning of sewage treatment. On October 5, 1948 representatives of the state agencies again met with the Sanitary Board of Huntington and stressed further the need for the City to proceed with the planning of sewage treatment. The point was brought out in this meeting that the Ohio River Compact had been ratified on June 30, 1948 and that this interstate agreement specified that all municipalities in the Ohio River Basin must provide at least primary treatment. On February 8, 1949 representatives of the Health Department and Water Commission met with the officials of the new administration in Huntington for the purpose of urging that funds be raised to complete the planning of sewage treatment. At this meeting, the fact was stressed that in addition to the Water Commission's responsibility, at state level, of requiring treatment, that the Ohio River Compact and Public Law 845 both require the provision of treatment, and it is the further responsibility of the Commission to keep West Virginia cities and industries ahead of this Federal and Interstate program.

As a part of a commendable educational program started by the new administration in Huntington, state representatives appeared on March 18, 1949 at a town-hall type meeting for the purpose of educating the citizens of the City to the fact that waste treatment action was required. The administration of Mayor W. W. Payne has taken much interest in sewage treatment for Huntington and has made considerable effort to acquaint the citizens of the City with the need for sewage treatment. In spite of this interest, which resulted in the passage of ordinances establishing a service charge, it is understood that 10% of the registered voters are now in the process of petitioning against the establishment of the charge, thus, requiring the matter to be submitted to a vote of the citizens. It would seem that the Commission has exhausted every cooperative effort and should now proceed with the last resort, that of legal action to require the City to provide necessary treatment facilities.

Stream Conditions

The condition of the water in the Guyandotte River in the Huntington area has been observed and sampled by Water Commission personnel on many occasions. There is considerable visual evidence of both industrial and domestic pollution between the upper limits of the City and the mouth of the stream. On many occasions during the low-flow season, the water has a foul sewage odor, a variety of different colors originating in dye wastes and carries a considerable quantity of floating solids having their origin in sanitary sewage. Since the Ohio tends to prevent the Guyandotte from flowing freely into the larger stream, the discharge of untreated domestic and industrial wastes into this pool at the mouth of the stream causes some nuisance conditions and is objectionable to the esthetic senses of the people living and working in this section of Huntington.

The analytical results which have been run on the water in the mouth of the Guyandotte River substantiate the physical evidence of polu-

tion already mentioned. Table I, attached to this report, which covers average stream conditions found during the summer of 1947 indicates that the dissolved oxygen decreased to 5.2 p.p.m. and the biochemical oxygen demand (B.O.D.) increased to 6 p.p.m. A comparison of this B.O.D. of 6 with 0.5 for a stream practically free of pollution shows conclusively the presence of contamination in this water. It might be pointed out that the B.O.D. or oxygen demand of the water has its origin in the domestic and industrial wastes which the stream carries. This oxygen demand has a tendency, at summer temperatures, to rapidly consume the dissolved oxygen available in the water of the stream. When dissolved oxygen becomes low or absent in a stream, the water loses its ability to recover naturally and takes on an objectionable appearance and foul odor.

An examination of the coliform results in Table I indicates that there was an increase of 30 to 50 fold in the concentration of these organisms in the Guyandotte River between the Route 60 bridge near Barboursville and a bridge near the mouth of the stream. These organisms have their origin in the intestinal tract of man and animal and thus, indicates the possible presence of typhoid and dysentery germs. Obviously, the higher the concentration of such coliform organisms, the more seriously polluted is the stream.

An examination of Table II indicates that conditions during the summer of 1948 in the Guyandotte River in the Huntington area were quite similar to those found during 1947. It is interesting to note that the B.O.D. of a single sample collected at the mouth of the stream was 11.4 p.p.m.

Table I and II also indicate contamination of the Ohio River. The most significant measure of this pollution is the two-fold increase in the coliform organisms between the U. S. 52 bridge in Huntington and the Ashland Bridge during the summer of 1947, and the 100-fold increase in the concentration between Lock 27 and the boat point at Kenova during the summer of 1948. It will be observed from this table that the average coliform count increased from 390 to 34,000 between the two points mentioned. The Ohio River is used by Ashland as a source of public water supply.

It is interesting to note that on page 12 of the manual of "Recommended Water Sanitation Practice" published by the United States Health Service, that it is stated that water containing more than 20,000 organisms per 100 millimeters of sample in more than 5% of the samples examined during any month can not be used as a source of public water supply without auxilary treatment. It will be observed from Table II that during the summer of 1948, the coliform results at Kenova boat point averaged 34,000 or 50% higher than the maximum limit set by the United States Public Health Service. It can also be noted from Table II that the average B.O.D. increased from 1.3 at Lock 27 to 2.3 at the Kenova point. This is a fairly large increase when the tremendous flow of the Ohio River is considered.

Sources of Pollution

The domestic sewage from Huntington is the most serious pollution problem in this area due to the effect on the Ohio, which is being

used as a source of water supply. This domestic sewage discharges through a number of outfalls into the Ohio proper, the Guyandotte, Four-Pole Creek and a number of smaller streams. There are a number of industries located within the City limits discharging pickling liquors, alkalis, dyes, iron, chemicals and oil into the city sewer system. There are also a number of industries which produce organic wastes such as milk plants and slaughter houses and these are also connected to the Huntington sewer system. It will be necessary for some of these industries to pre-treat their wastes before they can discharge into the sewer system for treatment in a domestic treatment plant. All industries that have quantities of cooling water of magnitude should connect these discharges directly to the storm sewer system. There are probably about three plants in the city which have wastes of a type that can not be handled in the domestic treatment plant, and these industries will have to provide separate treatment before their wastes can be discharged to the stream in the area. As the first step in providing sewage treatment for the City, it will be necessary for Huntington to employ a competent consulting engineering firm to devise a sound plan for the collection and treatment of the wastes. When the engineering firm has completed its task, the City will have available final plans and specifications for the sewer system and plant. The engineer's report will also cover the cost of these facilities and will indicate the magnitude of the service charge necessary from each home to construct and operate the plant in question.

Conclusions

After surveying and studying the conditions in the Huntington area, the following conclusions may be drawn, that:

1. The analytical surveys show critical pollution conditions in the Guyandotte and Ohio Rivers in and below the City of Huntington by recording a high oxygen demand and a high concentration of coliform organisms which indicates the probable presence of typhoid and dysentery organisms in the water of the stream.

2. The survey indicates that the water in the Guyandotte and Ohio Rivers in and below the City of Huntington has been contaminated by the wastes of the city and made unclean and impure to such an extent that it is directly and indirectly detrimental to the public health; unsuitable with reasonable treatment for use as present or possible future sources of public water supply and unsuitable without unreasonable treatment for the other reasonable commercial, industrial and agricultural uses which might be expected of it.

3. The City of Huntington is making an unreasonable use of the Guyandotte and Ohio Rivers by expecting them to serve as treatment facilities for the city's sewage, and by so doing, reducing the down-stream value of the Ohio for the water supply and recreational uses expected of it by other users.

4. The City of Huntington, and many other West Virginia cities, must provice sewage treatment if one of the most valuable natural resources

of the state - the surface waters - are to be preserved and improved so an orderly private, industrial and municipal development can continue.

5. The West Virginia Revenue Bond Act provides a means whereby a city can provide sewage treatment facilities and pay for same on a service charge basis, in spite of a statute limiting municipal bonded indebtedness.

6. The Ohio River Compact and Public Law 845 both require the provision of sewage treatment and both hold the state regulatory agency primarily responsible for pollution control, so the Commission is acting under three compulsions in demanding that Huntington provide sewage treatment.

7. A comprehensive, state-wide program of pollution control and stream improvement is now underway in West Virginia in which most municipalities and industries are actively cooperating with the Water Commission.

8. That the Commission and State Health Department have exhausted every cooperative effort to get the City of Huntington to improve stream conditions by the provision of sewage treatment to no avail.

Recommendations

That the State Water Commission order the City of Huntington to cease and desist from polluting the Guyandotte and Ohio Rivers by the installation of some practical and reasonable available system for treating the sewage of the city which will meet with the approval of the Commission and reduce stream pollution to an acceptable minimum.

Respectfully submitted,

/s/ K. S. Watson
Executive Secretary-Engineer

KSW/lm

July 25, 1949

TABLE I

Average Stream Conditions in the Huntington Area

Summer, 1947

Determinations		Ohio Bridge U.S. Route 52	Ohio Bridge Ashland	Guyandotte * Highway Br. Rt. 60 near Barboursville	Guyandotte Highway Br. off Rt. 60 above Huntington	Guyandotte Bridge second from mouth in Huntington	Relatively Unpolluted Water
Dissolved Oxygen p.p.m.	Average	7.6	7.8	8.2	8.15	6.6	---
	Minimum	6.95	7.45	7.75	7.5	5.2	7.5
Biochemical Oxygen Demand p.p.m.	Average	1.11	1.3	0.7	0.8	3.0	---
	Maximum	1.15	1.4	0.8	1.05	6.0	0.5
pH	Average	7.1	7.1	7.5	7.5	7.3	7.5
	Maximum	7.4	7.15	7.8	7.6	7.5	9.5
Most probable No. Coliform Organisms per 100 ml. x 1000	Average	5.5	13.6	2.9	35	104	---
	Maximum	15	26	5.1	51	120	0.1
Flow Second Feet x 1,000	Average	19.4	23.7	0.090	0.103	0.103	---
	Minimum	11.2	12.8	0.080	0.100	0.100	---

* Note correction made on page 17 of transcript - this point should be designated

Huntington - Chesapeake Bridge

T A B L E II

Average Stream Conditions in the Huntington Area

Summer, 1948

Determinations		Ohio Lock 27	Ohio Bridge U.S.Rt. 52	Ohio Lock 28	Ohio Kenova Boat Point	Guyandotte Highway Br. Rt. 60 near Barboursville **	Guyandotte Highway Br. Rt. 60 above Huntington	Guyandotte Br. second from mouth in Huntington	Relatively Unpolluted Water
Dissolved Oxygen p.p.m.	Ave.	7.1	7.45	7.8	7.4	9.65	8.7	7.3	---
	Min.	6.4	6.75	7.15	6.65	9.65	7.1	6.05	7.5
Biochemical Oxygen Demand p.p.m.	Ave.	1.35	1.5	1.5	2.3	0.55	0.57	3.5	---
	Max.	2.25	2.0	1.75	3.3	0.55	0.65	6.0 *	0.5
pH	Ave.	6.8	6.8	6.8	6.8	7.9	7.87	7.75	7.5
	Max.	7.1	7.1	7.1	7.1	7.9	7.9	7.85	9.5
Most probable No. Coliform Organisms per 100 ml x 1000	Ave.	0.39	4.47	2.07	34	8.9	17	79	---
	Max.	0.51	15	3.9	39	8.9	26	150	0.1
Flow Second Feet x 1000	Ave.	11.9	12	12	12	0.098	0.113	0.113	---
	Min.	8.9	9	9	9	0.098	0.100	0.100	---

* Sample collected on October 13, 1948 at mouth of Guyandotte River had B.O.D. of 11.4 ppm

** Note correction made on page 17 of transcript - this point should be designated Huntington-Chesapeake Bridge

EXHIBIT K

STATEMENT BY W. W. TOWNE, U. S. PUBLIC HEALTH SERVICE

To: Mr. E. J. Cleary, Exec. Director & Chief Engineer
Ohio River Valley Water Sanitation Commission
414 Walnut Street, Cincinnati 2, Ohio

Subject: Report on Ohio River Pollution Abatement Needs,
Huntington-Cincinnati Stretch

1. Your report of February 1, 1952, entitled "Ohio River Pollution-Abatement Needs, Huntington-Cincinnati Stretch", has been reviewed by the Ohio-Tennessee Drainage Basins Office, Division of Water Pollution Control, U. S. Public Health Service.

2. The report establishes the following facts concerning the effects of municipal sewage discharged into that stretch of the Ohio River under consideration.

a. The dissolved oxygen content of the river water is not now critical.

b. Bacterial pollution is excessive, resulting in a quality of water at the public water supply intakes far inferior to the objectives established by the Commission and generally accepted by the public health authorities as necessary to adequately protect public health.

c. More than 1,000,000 people, living in eight municipalities along this stretch of the stream, are dependent upon the Ohio River as a source of public water supply.

3. The report recommends treatment for municipal sewage discharging into the Huntington-Cincinnati section of the Ohio river in excess of that required as a minimum under Section VI of the Ohio River Valley Water Sanitation Compact. The primary purpose for requiring additional treatment is to reduce bacterial pollution to the point that the bacterial quality of water at public water supply intakes will meet the bacterial quality objectives for public water supplies as adopted by the Commission in April, 1951.

4. In fixing these requirements for additional treatment, your Commission has recognized that the use of the Ohio River as a source for public water supplies must be maintained and protected. Also, as a result of making the water suitable for this important use, all water uses will be benefited while others, now seriously damaged, will be restored in some sections of the stream.

5. The report considers pollutional effects of oxygen consuming wastes and bacteria from domestic sewage. The recommended corrective measures apply to municipal sewage. The effects of other wastes upon the quality and use of the waters of the river and the corrective measures which may be necessary to abate pollution from such wastes are not included. The report may be considered, therefore, as the initial step in the development of a complete com-

prehensive pollution abatement program for the stretch of the river under consideration. It is understood that remedial measures required for these other wastes are under consideration by the States and the Commission.

6. Under Section 2(a) Public Law 845, 80th Congress, 2nd Session, the Surgeon General, Public Health Service, in cooperation with other Federal agencies, State water pollution control agencies and interstate agencies and with municipalities and industries involved, is charged with the responsibility of preparing or adopting comprehensive programs for eliminating or reducing pollution of interstate waters. The Act further stipulates that in the development of such comprehensive programs due regard shall be given to the conservation of such waters for public water supplies, propagation of fish and aquatic life, recreational purposes, and agricultural, industrial and other legitimate uses. This report has been reviewed, therefore, with the thought that the recommendations contained therein might be adopted by the Surgeon General as a part of the comprehensive program for eliminating or reducing pollution in this section of an interstate stream.

7. Following this review it is concluded that bacterial pollution in this stretch of the Ohio River must be materially reduced in order to provide adequate public health protection and that the treatment requirements proposed to accomplish the bacterial objectives established by the Commission are reasonable.

8. It is further concluded that the recommended plan for controlling pollution due to sewage constitutes a part of an acceptable comprehensive program for the Huntington-Cincinnati stretch of the Ohio River.

9. After final action on the report by the Commission, it is proposed that the report be considered for adoption by the Surgeon General as an acceptable part of a comprehensive program for the section of the river covered by the study, as provided for by the National Water Pollution Control Act.

/s/ W. W. Towne
Officer in Charge, Ohio-Tennessee Drainage Basins Office, Division of Water Pollution Control, U. S. Public Health Service

Feb. 27, 1952

EXHIBIT L

STATEMENT BY PASCHAL N. STRONG, U. S. CORPS OF ENGINEERS

Mr. Edward J. Cleary, Executive Director and Chief Engineer
Ohio River Valley Water Sanitation Commission
414 Walnut Street
Cincinnati 2, Ohio

Dear Mr. Cleary:

Reference is made to your letter of 13 February 1952 in which you advise that the Ohio River Valley Water Sanitation Commission will conduct a public hearing on 29 February at Huntington, West Virginia, concerning the establishment of sewage treatment requirements in the Huntington-Cincinnati stretch of the river. You request a statement from this office, to incorporate in the record of the hearing, setting forth the status of the proposed Greenup high-level dam project and the effect it may have on river levels in the area. In accordance with your request, I am pleased to furnish the following information.

Preliminary studies which have been made to determine the best adapted plan for the replacement of navigation facilities on the Ohio River in the reach from Greenup, Kentucky to Gallipolis, Ohio indicate that this best can be accomplished by provision of a single high-lift dam and locks in the vicinity of Greenup, to provide a navigation pool extending upstream to the existing Gallipolis Locks and Dam. While features of the locks and dam under consideration have not been determined finally, detailed studies are under way for that purpose.

As now contemplated, the dam would be located about a mile below existing Lock and Dam No. 30 and about 341 miles below the head of the Ohio River at Pittsburgh, Pennsylvania, and would be of non-navigable type with gated crest. It would replace existing Locks and Dams Nos. 27, 28, 29, and 30 on the Ohio River and No. 1 on the Big Sandy River. Normal pool elevation would be about 515 feet. In comparison, the present normal pool elevations provided by the structures which would be replaced are as follows:

Existing Lock and Dam	Location Miles Below Pittsburgh	Normal Pool Elevation (Feet)
Ohio River No. 27	301.0	512.0
Ohio River No. 28	311.6	505.6
Ohio River No. 29	319.9	498.5
Ohio River No. 30	339.4	490.5
Big Sandy River No. 1	(0.3*)	512.0

* Miles above mouth of Big Sandy River

The budget submitted to Congress for Fiscal Year 1953 includes a request for funds to continue detailed planning of the Greenup project. Depending upon the appropriation of funds, planning would be completed in Fiscal Year 1954 and construction would be initiated in Fiscal Year 1955.

In respect to your desire that the Corps of Engineers be represented at the Huntington hearing on 29 February, I have requested the District Engineer at Huntington to have a qualified representative in attendance.

This letter may be made a part of the official record of your Huntington hearing, if you so desire.

/s/ Paschal N. Strong
PASCHAL N. STRONG
Colonel, Corps of Engineers
Division Engineer

18 February 1952

EXHIBIT M

SUPPLEMENTARY STATEMENT BY PASCHAL N. STRONG, U. S. CORPS OF ENGINEERS

Mr. Edward J. Cleary, Executive Director
and Chief Engineer
Ohio River Valley Water Sanitation Commission
414 Walnut Street
Cincinnati 2, Ohio

Dear Mr. Cleary:

In supplementation of my letter of 18 February 1952, responsive to your request of 13 February for information concerning the status of the proposed Greenup high-level dam project, I am pleased to advise you that depending upon appropriation of funds for that purpose, construction of the project may be initiated as early as fiscal year 1954.

In view of the present condition of the navigation structures to be replaced by Greenup Locks and Dam and the importance of efficient and continuing Ohio River navigation to national defense, early completion of the project is to be desired.

Sincerely yours,

/s/ Paschal N. Strong
PASCHAL N. STRONG
Colonel, Corps of Engineers
Division Engineer

27 February 1952

EXHIBIT N

COMMENTS ON PRELIMINARY REPORT ON EFFECT OF HIGH DAM AT GREENUP

1. According to information supplied by Col. West on February 12, 1952, pool elevation of 515 feet provided by Greenup Dam will raise present pool levels about 7 feet at Huntington, 12 feet at Ashland, and 25 feet at Dam 30.

2. Effects of increased pool area on surface aeration will tend to be offset by increased depth and decreased flow velocity, both of which tend to retard reaeration of the total stream volume. It is quite possible, in fact, that the D.O. content may be lowered by the high dam, judging from results of observations above Gallipolis Dam in July - Septemper, 1940. (House Doc. 266, Part II, page 217).

3. Doubling time-of-flow from present Dam 27 to Dam 30 should improve bacterial quality of water from Portsmouth downstream during periods of summer low flow. Its effect on oxygen sag curve would probably be to move the critical D.O. minimum point upstream during pool stages of river. This point was brought out in Crohurst's report on effects of new dams on sanitary conditions in the river between Cincinnati and Louisville in 1930-31. Reduced velocities of flow above proposed high dam will result in more sedimentation in pool from uncontrolled sources of pollution (i.e. tributaries and storm-sewage flows), and thus tend to accentuate scour effects during increased flow periods after periods of low-flow accumulation.

4. Increased pool volume -- In addition to beneficial effects on bacterial quality of river downstream from dam, increased volume should tend to "iron out" immediate effects of pollution increases due to tributary and storm-water flows following local rains, while river is in pool stages. Some tendency to concentrate pollution near major outlets probably will result from increased pool volume, as frequently noted in lakes and river impoundments. Average concentration in the larger pool should be no greater than under present conditions, though a longer time may be required to clear the pool of accumulated water when rises in the river occur.

5. Intercepting sewers -- Elevations of outlets will control those of treatment plants. It is assumed that these are being carefully considered by consulting engineers. If Greenup Dam is to be built within a few years, it may tend to delay construction of treatment plants in area above new dam, pending final settlement of this question of elevations. It is perhaps the most important question affecting the economy of the treatment program in this area.

6. Oxygen relationships -- The effects of the proposed high dam on D.O. relationships should not become a matter of much concern until the density of pollution in this section has reached considerably greater magnitude than at present. It could result, however, in the establishing of critical oxygen conditions earlier than otherwise would be expected unless a complete program of primary treatment of sewage is in operation before such conditions may be possible. One advantage of the present low bear-trap dams is that they permit self-cleansing action in their pools. Such

action would not be so effective in the case of a high fixed dam.

7. With the minor exceptions above noted, the conclusions reached in the Preliminary Report (dated September 28, 1949) appear sound and reasonable. These conclusions were as follows:

1. Increased time of flow following construction of Greenup Dam will improve conditions in the lower river.
2. Minor detrimental effects may be experienced due to increased time required for displacing the increased volume of polluted water in the new pool during high flows immediately following periods of critical low flow.
3. Prior to construction of Greenup Dam, it would be advantageous for municipalities to construct intercepting sewers required in connection with sewage treatment improvements.
4. Reduced aeration due to elimination of three dams is not significant as oxygen relationships are not now critical nor expected to be in the foreseeable future.

8. So far as conditions in the immediate future are concerned, the project for a high dam at Greenup would seem to make little if any difference in the sewage treatment requirements envisioned to meet pollution-abatement needs in the near future.

Harold W. Streeter

February 14, 1952

EXHIBIT O

STATEMENT BY DAN ENRIGHT, SUPERVISOR OF PURIFICATION, CINCINNATI, OHIO

"POLLUTION COSTS AT CINCINNATI"

The need for pollution reduction is well recognized. Communities using the Ohio River as a source of water supply pay heavily because of pollution. Because of many factors, each community can be affected differently by the various pollution loads and an evaluation of this cost can be but an approximation.

At Cincinnati, the influence of pollution is primarily reflected in treatment costs for the control of tastes and odors. The practical elimination of the increased bacterial load due to pollution has never been too difficult a problem. But the reason for this lies in the foresightedness of the original design Engineers, who, 50 years ago, provided primary settling basins that give us a theoretical retention time of three days, even at today's higher filtration rates. The bacterial reduction at this point with no treatment other than the occasional use of a coagulant varied, over the years, between 80 and 90 percent. We are well aware that if we lacked this important treatment feature, the increased bacterial load existing since about 1935 would have been of much greater concern to us.

As chlorination gradually became accepted by both the water works industry and the general public, the concentration of chlorine applied after filtration was increased. Thus, from our operational records the highest yearly average until 1930 was about 2 lbs. per m.g. In the '30's we increased gradually to 5 lbs. per m.g. And in the '40's we edged up close to 7 lbs. per m.g. A part of this increment could be charged to the greater bacterial load, yet we feel that the acceptance of chlorination and the realization of the need of greater chlorine residuals throughout the distribution system does account for a portion of this greater chlorine usuage.

Throughout the years, our fight to control the many periods of distasteful water experienced has been costly -- both in money and, to some extent, consumer good will. However, there is no way to accurately proportion these periods to the type of pollution involved. Seldom were the taste and odor characteristics so well defined that we could charge any one period to any one type of pollution. Frequently industrial pollution was known to be responsible yet there were times when it was suspected but not proven. Similarly, microscopic examination sometimes confirmed the presence of algal types known as offenders, yet here, too there were periods of indecision.

The couplex inter-relationship of industrial wastes, sewage wastes and algal life may well be better understood as more information is obtained from the basic pollution studies now being made by the U. S.

Public Health Service of Lytle Creek, near Wilmington, Ohio.

Ammonia, with its specific purpose of blocking phenolic tastes, was first used in 1931. Activated carbon was initially tried in 1932 and since then has been used when needed. In February, 1949 break-point chlorination of the raw water was started and, with the exception of minor shut-downs due to mechanical difficulties, has been employed continuously. Though secondary benefits of this type of operation have been realized yet it still must be considered an expense of taste and odor control and, therefore, of pollution.

In attempting to evaluate this cost we have taken the three years prior to 1949 as representative of normal operation and projected the average tonnages used with the increased unit prices paid for chemicals during '49, '50 and '51. Obviously, this but gives the cost of break-point chlorination over these three years and does not include certain operating charges of the past which were due to pollution. However, it is a minimum figure and the true cost of pollution would be in excess of it. By such calculation, we find that the cost of pollution per m.g. delivered into service during 1949 was $3.09; in 1950, $3.22 and in 1951, $3.90. The average total cost per year over these three years for taste and odor control was about $105,000.

This figure does not include any of the original expenses of equipment and installation, which were approximately $200,000. Nor does it include maintenance costs which, while comparatively small now, will increase in the future.

It can be readily seen why Cincinnati is whole-heartedly supporting all measures for pollution abatement. As you may know, the first of four proposed sewage treatment plants for Cincinnati is now under construction and will probably be in operation by next year. We have been assured by those in charge of these projects that all recommendations of this Commission regarding degree of pollution abatement can, and will, be met. The completion of this first unit will be a milestone in Cincinnati's history for we will then take our place with those communities that have done something to stop this needless abuse of our waters.

Reference to graphs:

Cost Variation:

'37 Because of plant rehabilitation, higher costs were due to use of alum and soda ash instead of the cheaper ferrous sulphate and lime.

Coliform Bacteria:

Since 1935, (17 years), 39 percent of the months have exceeded the U.S.P.H.S. 'yard-stick' of 5000 Coliforms per 100 ml. Prior to 1935 (24 years), but 11% of the months exceeded that value.

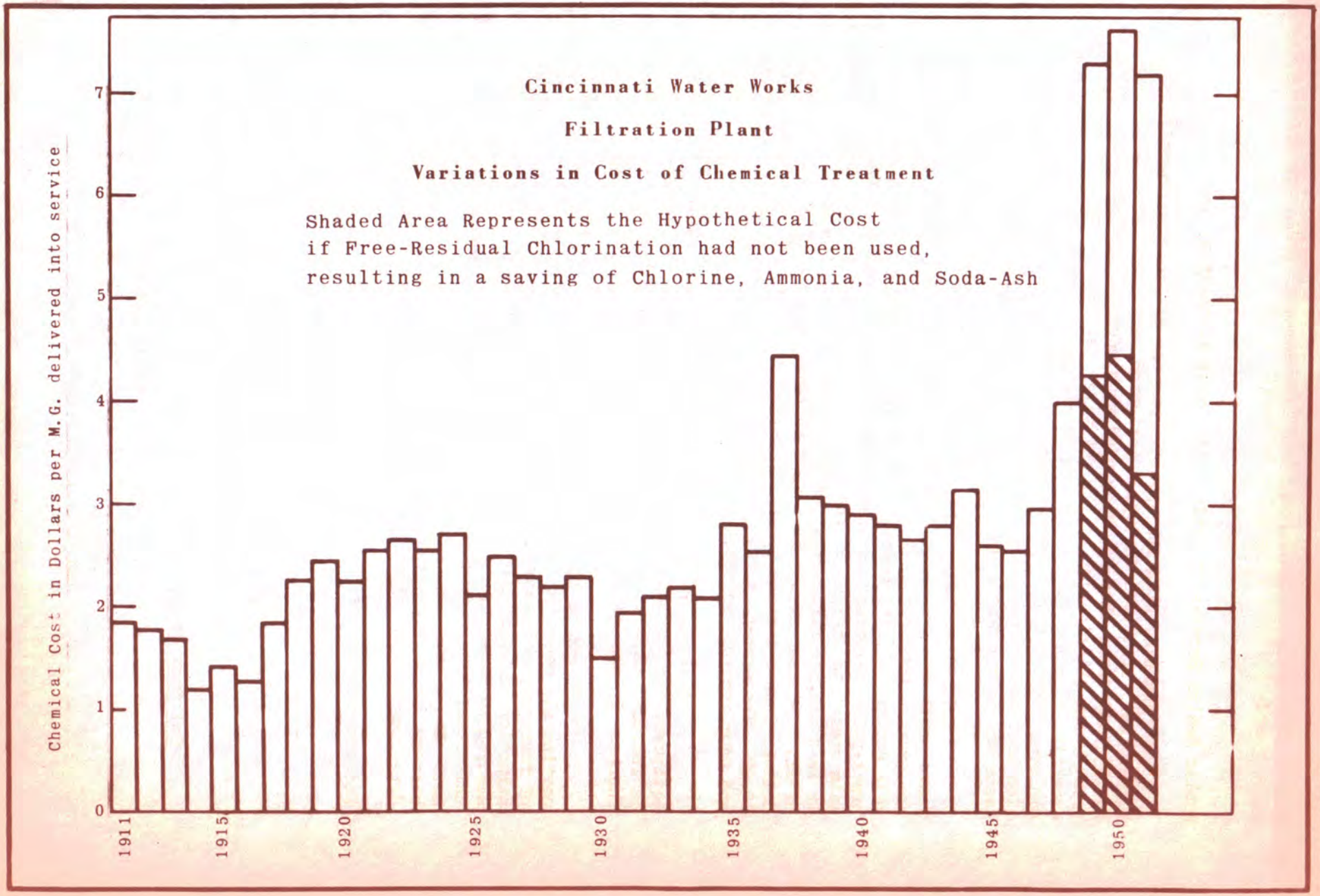

Cincinnati Water Works
Filtration Plant
Variations in Cost of Chemical Treatment
Shaded Area Represents the Hypothetical Cost
if Free-Residual Chlorination had not been used,
resulting in a saving of Chlorine, Ammonia, and Soda-Ash
Chemical Cost in Dollars per M.G. delivered into service
0
1
2
3
4
5
6
7
1911
1915
1920
1925
1930
1935
1940
1945
1950

Exhibit O

Cincinnati Water Works

Ohio River Water

Yearly Average Indicated Number of Coliforms per 100 ml

(notation (x) indicates number of mouths exceeding 5000 Coliforms per 100 ml)

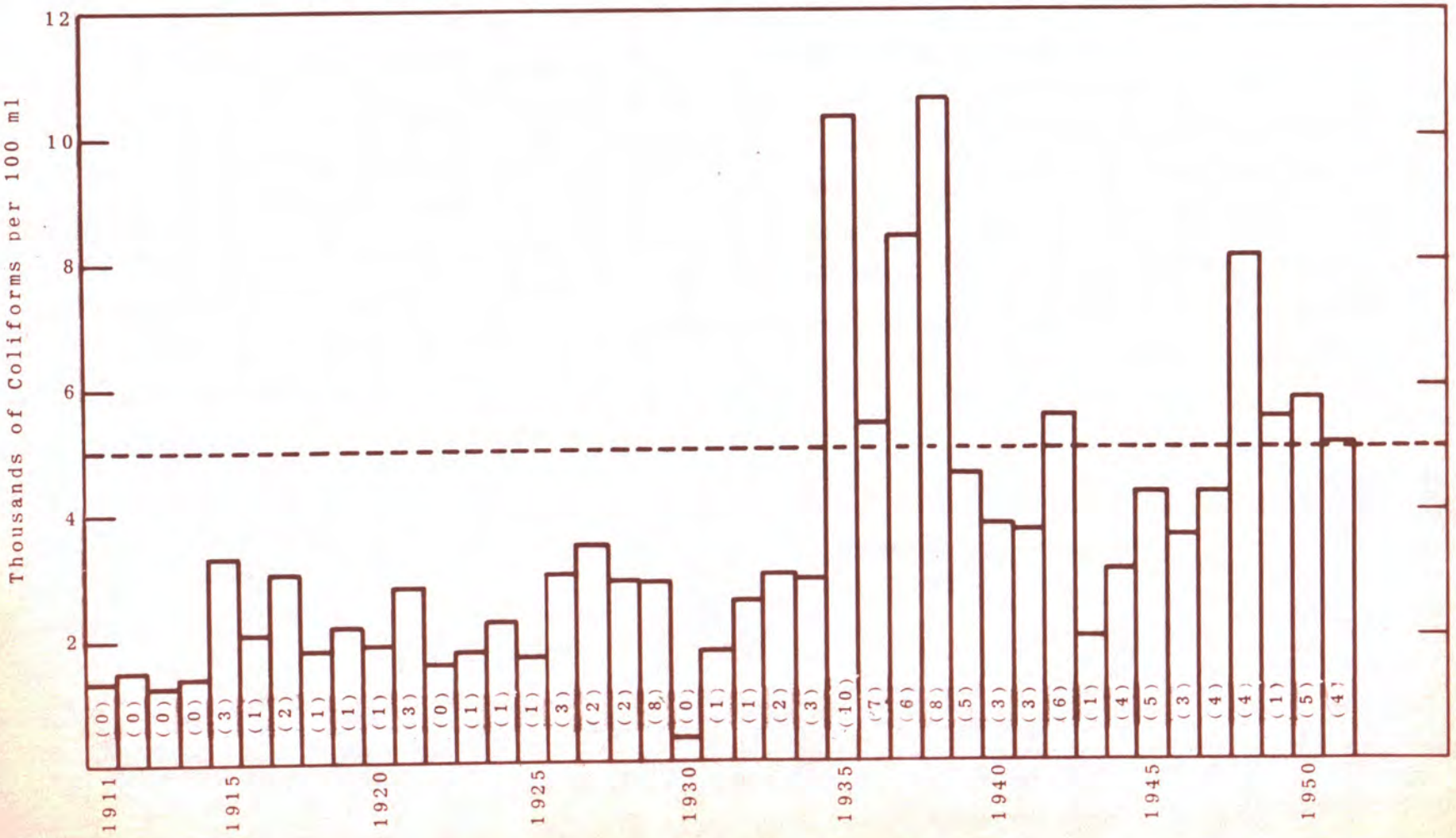


EXHIBIT P

STATEMENT BY A. H. ROOT, CITY ENGINEER, NEWPORT, KENTUCKY

Ohio River Valley
Water Sanitation Commission

Attention: Mr. Edward Cleary
Chief Engineer

Re: Ohio River Valley
Water Commission
Hearing

Dear Mr. Cleary:

Your letter under date February 5th., with reference to the above captioned received.

The raw water situation as regards the City of Newport and its waterworks has long been an acute problem. In the last few years this condition has grown steadily worse and the raw water of the river here has reached the saturation point as regards bacterial content. Our system is no longer able to cope with this situation, and it is necessary to treat the water after filtration with large quantities of objectionable tasting chemicals to render it pure.

The Campbell and Kenton County Sanitary District which includes the Cities of Newport, Covington, Bellevue, Dayton, Fort Thomas, Southgate, Wilders, Ludlow and Bromley, all of which are a part of the greater Cincinnati area, are now engaged in the construction work necessary to provide adequate control of water pollution in the Ohio River basin.

The City of Newport is therefore very much interested in having the upstream reparian Communities making provision to take care of their sewage discharge into the Ohio River, as the work being carried on and accomplished here will be of little avail unless our neighboring up river communities take similar action.

In view of the foregoing, it is our fond hope that the hearing on the date referred to will result in such action as is necessary to accomplish this purpose.

With kindest personal regards, I am,

Very truly yours,

/s/ A. H. ROOT
CITY ENGINEER

AHR:n

Feb. 25, 1952

STATEMENT OF W. D. ANDERSON, SECRETARY-TREASURER, SANITATION DISTRICT NO. I OF CAMPBELL AND KENTON COUNTIES, KENTUCKY

Mr. Edward J. Cleary
Executive Director
Ohio River Valley Water Sanitation Commission
414 Walnut Street
Cincinnati 2, Ohio

Dear Mr. Cleary:

May I again express regret that Mr. Beuttel and I were late in arriving in Huntington on last Friday and consequently missed the public hearing held there by the Commissions. Had we been privileged to make a statement at the meeting it would have been substantially as follows:

"The Ohio River Valley Water Sanitation Compact, of which Kentucky is a member, is now in force; the program for cleaning up the Ohio River is underway.

Sanitation District No. 1 of Campbell and Kenton Counties, Kentucky, was organized to carry out the purpose of the Compact in Northern Kentucky. We have received an order from the Kentucky State Board of Health directing us to proceed with the construction of a system of collector sewers and the treatment facilities to prevent further pollution of the Ohio River and local feeder streams. We are now engaged in the work of complying with that order.

It has required a tremendous effort on the part of the Commissioners of Sanitation District No. 1 to place in effect the program necessary to accomplish the purpose for which the District was formed. Imperfections, - which can only be corrected by experience - now exist in the Act under which we operate and they have served as impediments to our progress. We have had amended certain sections of KRS 220, the effects of which will be to make the Act more operable for other Districts formed under the provisions of this Legislation, but obstacles of a formidable nature have made our work difficult, and will continue to do so.

The river pool with which we are concerned lies immediately above and immediately below the metropolitan areas of Hamilton County, Ohio, and Campbell, Kenton and Boone Counties, Kentucky. The work being done by Sanitation District No. 1, while beneficial to the citizens of Northern Kentucky, will also benefit all communities down-stream from Cincinnati. For us to receive the full benefit of the work we are doing, it will be necessary for communities up-stream on the Ohio River and its tributaries to institute anti-pollution efforts and keep developments as nearly abreast as possible with comparable efforts being made up and down the Valley so that communities up-stream will not continue to pollute the River after the nuisance has been abated down-stream.

The provisions of the Compact apply equally to all, and the Commissioners of Sanitation District No. 1 respectfully request the Ohio River Valley Water Sanitation Commission to take whatever steps seem appropriate to require an immediate start on anti-pollution work by those communities not now engaged in such work."

Very cordially yours,
SANITATION DISTRICT NO. 1 OF
CAMPBELL & KENTON COUNTIES, KENTUCKY

/s/ W. D. Anderson

March 4, 1952

(Statement submitted to Hearing Board
after close of Hearing)

ADDITIONAL DATA REGARDING AREAS AVAILABLE FOR BATHING IN OHIO RIVER BETWEEN HUNTINGTON AND CINCINNATI

The accompanying diagram is intended to show the approximate river mileages that would be expected to be suitable for bathing under average summer pool conditions of June - September with flow of 20,000 cubic feet per second (cfs), and with 90% and 95% reductions, respectively, of coliform bacteria at all points of sewage discharge between Huntington and Cincinnati. An analysis of average summer flows in the river has indicated that such average flows should be 20,000 cfs or more during nine out of ten summers.

The diagram shows that with an average flow of 20,000 cfs, about 80 miles of river should be suitable for bathing with 90% reduction of coliform bacteria, and roughly an additional 30 miles with 95% reduction. This would not mean, however, that 95% reduction would open up any new areas for bathing, but merely would extend those established by 90% treatment. This is clearly indicated in the accompanying chart. At flows ranging from 20,000 to 40,000 cubic feet per second, mileages reclaimed by 90% treatment probably would be slightly increased. At flows exceeding 40,000 cfs, the river would tend to pass from pool to open-channel conditions, and presumedly would not be attractive, or perhaps even safe, for bathing regardless of its sanitary quality.

This estimate is based on cross-sectional average profiles, and hence does not take account of the effects of localized sources of pollution between the major sources indicated. Such local sources at the smaller towns, such as Manchester, Ripley, Augusta, etc. might tend to create small zones of pollution immediately surrounding their sewer outlets where bathing probably would be unsafe. It would require a detailed water quality survey "on the spot" to define these local zones, which doubtless would be limited in their extent, and also confined to their own side of the river.

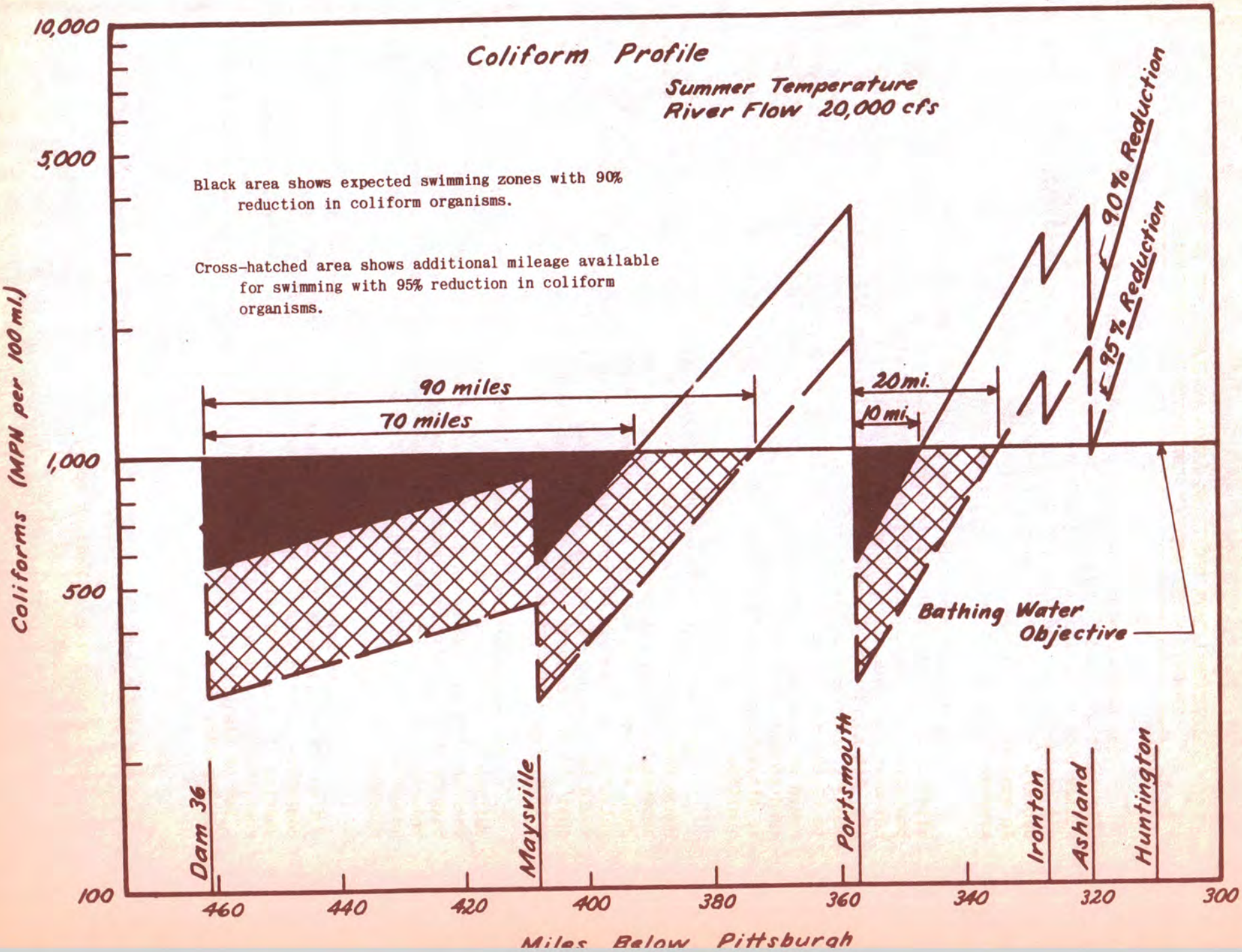
The estimate also is based on average summer flow conditions prevailing during nine out of ten summers. During shorter periods, flows may be less than an average of 20,000 cfs. When flows approach 10,000 cfs, bathing mileages may be temporarily reduced, or may require higher than 90% reduction of coliform bacteria in order to maintain summer average conditions. Reductions of 95% or more would be difficult to attain, though theoretically possible.

The added cost of increasing the bacterial removal in sewage from 90% to 95% would be difficult to estimate accurately, but probably would be somewhere between 30 and 50 per cent over that of 90% purification. After passing above 90% efficiency, the amount of chlorine required, and thus its cost, tends to increase disproportionately to the added efficiency secured. A law of diminishing returns apparently operates above this point, as in all purification processes.

Harold W. Streeter

March 13, 1952

(Memorandum submitted to Hearing Board
after close of hearing)


Coliform Profile
Summer Temperature
River Flow 20,000 cfs
Black area shows expected swimming zones with 90% reduction in coliform organisms.
Cross-hatched area shows additional mileage available for swimming with 95% reduction in coliform organisms.
90 miles
70 miles
20 mi.
10 mi.
90% Reduction
95% Reduction
Bathing Water Objective
Coliforms (MPN per 100 ml.)
10,000
5,000
1,000
500
100
Dam 36
Maysville
Portsmouth
Ironton
Ashland
Huntington
460
440
420
400
380
360
340
320
300
Miles Below Pittsburgh



ILLINOIS • INDIANA • KENTUCKY • NEW YORK

OHIO • PENNSYLVANIA • VIRGINIA • WEST VIRGINIA