THE INTERRELATION OF VARIOUS DESIGN FACTORS RELATED TO B.O.D. LOADING OF ACTIVATED SLUDGE PLANTS

by

WILLIAM L. SAMUEL

B. C. E.

Alabama Polytechnic Institute

1943

SUBMITTED IN PARTIAL FULFILLMENT OF THE

REQUIREMENTS FOR THE DEGREE OF

MASTER OF SCIENCE IN SANITARY ENGINEERING

from the

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

1948

Signature of Author_ Signature Redacted

Department of Civil and Sanitary Engineering

Certified by Signature Redacted

Thesis Supervisor

Chairman of Departmental Committee
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Department of Civil and Sanitary Engineering

Certified by Wm. E. Stanley

Thesis Supervisor

Chairman of Departmental Committee

on Graduate Students A. M. Fife

Cambridge, Mass.
May, 1948

Professor Joseph S. Newell, S.B.
Secretary of the Faculty
Massachusetts Institute of Technology
Cambridge 39, Massachusetts

Dear Sir:

In partial fulfillment of the requirements for the degree of Master of Science in Sanitary Engineering from the Massachusetts Institute of Technology, I present this thesis entitled "The Interrelation of Various Design Factors Related to B.O.D. Loading of Activated Sludge Plants."

Respectfully submitted,

William L. Samuel

William L. Samuel

ACKNOWLEDGEMENT

The author wishes to express his sincere thanks and appreciation to the various plant officials whose co-operation in supplying the basic information has made this investigation possible, and to Professor William E. Stanley for his help and suggestions during the course of the investigation.

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I SYNOPSIS

Although the activated sludge process of sewage treatment has been in use for many years, the practice is more advanced than the theory of the mechanism of the process. Previous research has resulted in the formulation of various concepts of basic design factors and good operation practice, but many problems have not been completely solved due to the complexity of the interrelationship between the various factors which comprise the process and determine to a great extent its ability to function properly. Until such time when the theory of the process is advanced far enough to permit a more scientific approach in design practice, these plants must necessarily be designed on empirical rules which have been formulated from the operation results of existing plants.

The purpose of this investigation was to analyze available operating data from existing activated sludge plants to determine the interrelation of the several major factors involved with the ultimate objective of setting up a logical procedure for designing such plants on the basis of B.O.D. loadings.

Routine operating data have been obtained thru correspondence with the officials of a number of conventional type plants, and the results of 15 of these plants have been selected for inclusion in this study on the basis of the completeness and apparent reliability of the data.

In analyzing the monthly average operating results of the 15 plants, periods of normal plant performance and periods of sub-standard performance were established. Loading parameters for each of these periods were computed to include the B.O.D. load applied per 1000 cubic feet of aeration tank, the aeration contact time, and the concentration of suspended solids in the mixed liquor.

Plottings of the computed values of the loading parameters show graphically the interrelation existing between the major factors when plant performance was normal. For comparison, the results of three plants with sub-standard operating efficiencies have been included in these plottings.

The results obtained by this investigation point out the advisability of making the type and character of the organic matter one of the major considerations in determining an allowable B.O.D. load for the aeration process.

It appears that activated sludge plants treating typical domestic sewage with little or no industrial wastes are capable of maintaining normal efficiencies with loadings as high as 50 pounds of B.O.D. per 1000 cubic feet of aeration tank.

For those plants operating under more or less constant conditions, an increase in sewage temperature seems to affect a higher degree of purification of the decomposable organic material. Thus, the required concentration of activated sludge solids in the mixed liquor will be higher during periods of low temperature if a given degree of purification is to be maintained.

II INTRODUCTION

The activated sludge process of sewage treatment is one in which sewage is purified by being brought into intimate contact with air and biologically active sludge, which has been previously produced by the process..It is generally agreed upon that the action of the sludge during the process of purification is primarily of biological nature, probably induced by enzymes produced by bacteria.

The San Marcos, Texas plant, put into operation in 1916, was the first plant built in the United States. Since this beginning, the process has been developed thru laboratory and plant scale studies and is now recognized as one of the major methods of treating sewage, which is evidenced by the fact that in 1945 there were 335 such plants in operation. However, to date, many design and operation problems remain unsolved due to the complexity of the many interrelated factors that affect the functioning of the process.

1 - Factors Affecting the Process

It seems pertinent to briefly point out the major interrelated factors that comprise and control the activated sludge process. These factors are:

a) Organic Loading which is expressed in terms of ppm or pounds of 5 - day B.O.D. being imposed on the aeration process.

b) Aeration Contact Time, i.e., the time in which the settled sewage is in contact with the activated sludge and air.

c) The Concentration of Activated Solids in the mixed liquor as it reflects the clarification and purification abilities of the sludge.

d) The Amount of Air Required to keep the process aerobic and provide sufficient agitation to facilitate intimate contact of the organic matter and the organisms with which it is associated.

e) Temperature and its effects on the sewage and the oxidation activity of the activated sludge.

f) Character of the Activated Sludge, i.e., its oxidation activity, concentration, settleability, and nitrifying ability.

Consideration of these interrelated factors, in the design of a plant, is necessary in order that the operator be allowed to exercise a maximum amount of control over the functioning of his plant.

2 - Previous Investigations

Generally speaking, investigations of the afore mentioned factors have been either laboratory research problems in which the variables, in some measure, under the control of the plant operator have been studied, or extensive studies covering the operation of many plants for the ultimate purpose of setting forth empirical rules for design and operation procedure. Many concepts of fundamental design factors and good operation practice have been developed, but no completely satisfactory basis of design has yet been found.

The existing activated sludge plants have been designed mainly on an empirical basis, by providing from 4 to 8 hours detention period for mixed liquor aeration with about 25% returned activated sludge. Diffused air type plants have been designed with blower capacities ranging up to 2.0 cubic feet of air per gallon of sewage treated. Newer designs provide more ample facilities for flexibility in operation to meet the demands of unforseen and changing conditions.

Greeley (1) proposed the following as loading yardsticks:

a) Pounds of B.O.D. applied per 1000 cubic feet of aeration tank capacity.

b) Pounds of B.O.D. applied per 1000 cubic feet of air supplied, or 1000 cubic feet of air supplied per pound of applied B.O.D.

c) The parts per million of suspended solids in the mixed liquor in the aeration tanks.

He stated that for average domestic sewage, a conventional load is 25 to 30 pounds of applied B.O.D. per 1000 cubic feet of tank and for normal sewage, one to two pounds of applied B.O.D. per 1000 cubic feet of air. Suspended solids in the mixed liquor range from 1,500 to 2,000 ppm, but the present tendency is toward lower concentrations. He presented the following operation data supporting his conclusions.

Plant	Year	Lb. B.O.D. app. per 1000 C.F. Aeration Tank	Lbs. of B.O.D. per 1000 C.F. of Air
Chicago, North Side	1941	27.7	2.68
Chicago, S.W. Side	1941	18.0	1.08
Cleveland, O. (E)	1941	13.6	0.67
Gary, Indiana	1941	26.2	1.59
Indianapolis, Ind.	1940	25.2	1.12
Pasadena, Calif.	1942	26.4	0.72
Peoria, Ill.	1941	29.9	1.13
Wards Island, N.Y.	1940	38.4	2.15
Springfield, Ill.	1941	20.0	1.25

Schroepfer (2) investigated the performance of 17 activated sludge plants to determine the effect of the aeration period on B.O.D. removal. By using weighted averages of operating periods of one year or longer and excluding certain plants in which the sewage had unusual characteristics, or for other reasons where the data was not considered representative, he concluded that the following reductions were accomplished by complete activated sludge treatment.

Aeration Period - Hrs.	% Removal of B.O.D.
3	74
4	84.5
5	91
6	93
7	95

In regard to the loading of aeration tanks, the National Research Council reported (3) that activated sludge plants at military installations had handled loads ranging from 7.0 to 31.5 pounds of B.O.D. per 1000 cubic feet of tank with suspended solids concentrations varying from 590 to 1500 ppm. Air quantities varied from 6.1 to 13.0 cubic feet per square foot of tank surface.

The National Research Council also reported, relative to the efficiencies of aeration and final tanks of military and municipal activated sludge plants, that the efficiency of the process relative to B.O.D. loadings, could be expressed on a "S.S. - hour" basis. This method of rating loading was claimed to reflect both the amount of biologically active material and the effective time for biochemical reaction.

Their results were presented in graphical form, as illustrated by Fig. A , which shows that B.O.D. removals, in plants treating sewage from military installations and from industries, are considerably less than removals obtained at plants treating ordinary domestic sewage with little or no industrial wastes.

The committee, therefore, concluded that the unfavorable results obtained in plants showing sub-standard performance indicated the advisability of making sewage conditions one of the criteria upon which the kind and degree of treatment should be based.

Bloodgood (4) has pointed out that the capacity of an activated sludge plant for any month is dependant on the concentration of B.O.D. applied and the temperature of the sewage; that the required aeration contact period is directly dependant on these two factors if all other conditions remain more or less the same. Accordingly, he has developed the following loading formula which is based on one year's operation of the Indianapolis plant:

$\underline{Y} = \frac{M}{X}$, where:

Y = M.G.D. treated per M.G. of aerator capacity.

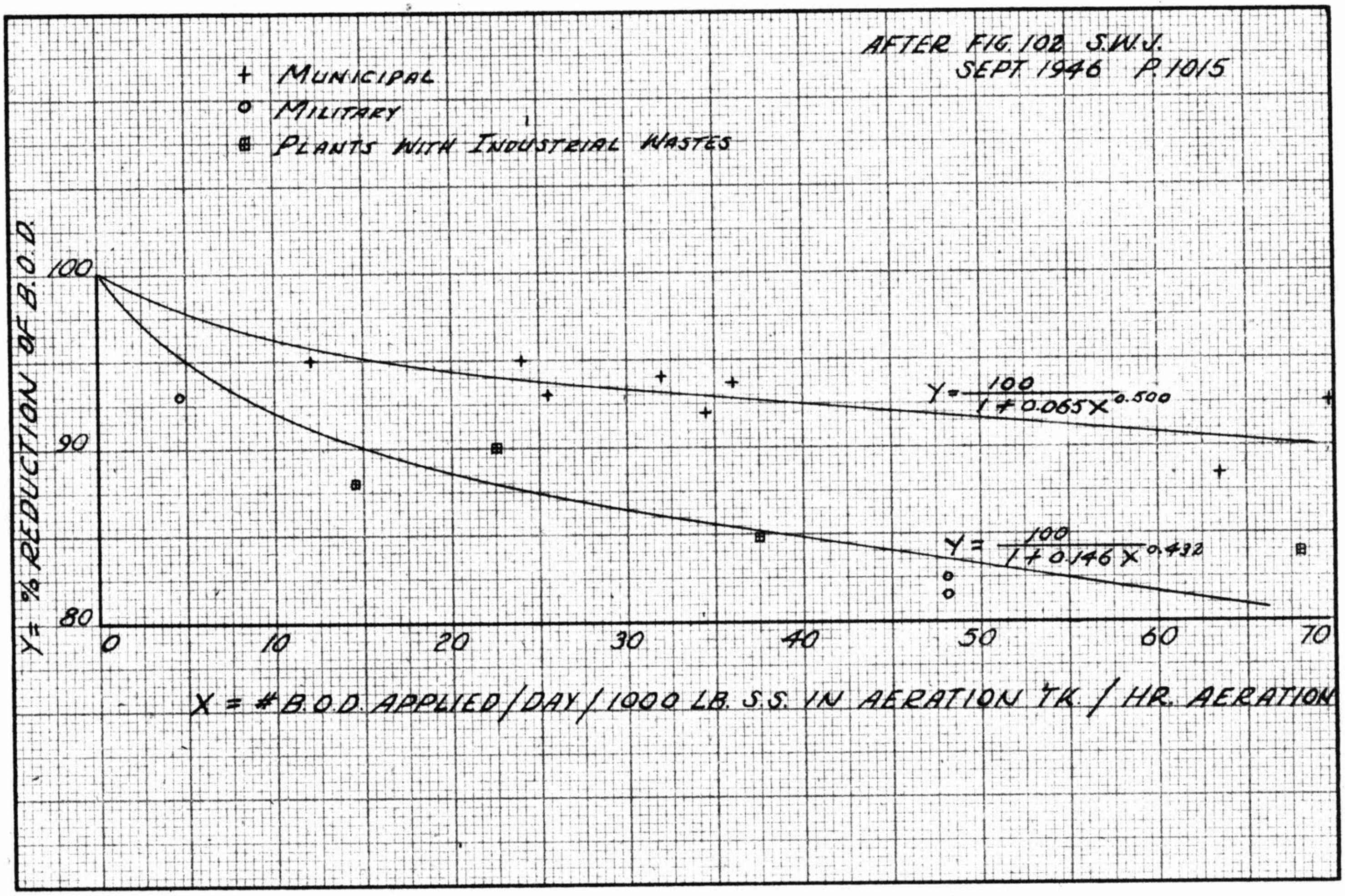

AFTER FIG. 102 S.W.J.
SEPT 1946 P. 1015
+ MUNICIPAL
o MILITARY
⊞ PLANTS WITH INDUSTRIAL WASTES
Y = % REDUCTION OF B.O.D.
100
90
80
0
10
20
30
40
50
60
70
$Y = \frac{100}{1 + 0.065X^{0.500}}$
$Y = \frac{100}{1 + 0.146X^{0.432}}$
X = # B.O.D. APPLIED / DAY / 1000 LB. S.S. IN AERATION TK. / HR. AERATION

FIG. A

X = ppm B.O.D. in the sewage.

M = a constant calculated for each month and based on the sewage temperature.

Step aeration, a modification of the activated sludge process, incorporates a principle of incremental loading whereby sewage is introduced in regulated amounts at multiple points throughout the course of the flow of the returned activated sludge thru the tanks. Torpey (5) proposed that better results are obtained by step aeration because it makes possible longer solids detention in the aerator and allows the storage of more solids under aeration for a given aerator effluent concentration than does conventional aeration.

Utilizing this principle, he explained that the performance of the process is a function of the "sludge age" which he defines as the average number of days the sewage solids remain under aeration from the time they first enter the secondary process until they leave. He reported that operation of the Bowery Bay plant on an experimental basis for 7 months, during which time an effort was made to keep the sludge age at 3½ days, has shown that this method of loading would yield efficiencies of 90% for loads as great as 84 pounds of B.O.D. applied per 1000 cubic feet of tank.

Berberich's (6) thesis investigation of 30 conventional diffused air type activated sludge plants in which loadings varied from 12 to 52 pounds of B.O.D. per 1000 cubic feet of tank, seemed to show that minimal percent reductions in B.O.D. were obtained with loadings in the magnitude of

30 to 35 pounds of B.O.D. per 1000 cubic feet of tank.

He also made efforts to correlate plant performance with single variables such as aeration contact time, suspended solids concentration in the mixed liquor, air quantities, and nitrate content of the final effluent.

Berberich's plottings of single variables show an increase in the reduction of B.O.D. with increased aeration periods and suspended solids concentrations.

No definite relationship was established between air quantities and B.O.D. reduction on a percentage basis. He concluded that these variables are so interrelated that each is mutually dependent on the others and attempted to develop more complex relationships or parameters by which plant performance might be measured.

These proposed parameters, in order of complexity from most complex to least complex, were as follows:

K_1 = lbs. of B.O.D. applied per 1000 cu. ft. of aeration tank capacity per hour detention time per cu. ft. of air per gallon of sewage per ppm of S.S. in the mixed liquor x 1000.

K_2 = lbs. of B.O.D. applied per 1000 cu. ft. of aeration tank capacity per hour detention time per cu. ft. of air per gallon of sewage.

K_3 = lbs. of B.O.D. applied per 1000 cu. ft. of aeration tank capacity per hour detention time.

K_4 = lbs. of B.O.D. applied per 1000 cu. ft. of aeration tank capacity.

Berberich computed such parameters for each plant and plotted them in various combinations. He suggested that design capacities might be determined by using a combination of curves from which might be determined B.O.D. loading, detention periods, air quantities, and suspended solids concentration in the mixed liquor.

However, the data used by Berberich was widely scattered on the several plottings. Since he used ppm residual B.O.D. as his major dependent factor, it appears that similar results would be derived from wide variations in sewage concentrations.

3.- Scope of this Investigation

The investigation covered by this thesis is, in effect, a continuation of the work done by Berberich and includes an extensive addition to the operation data which he analyzed. After making a careful review of the completeness and apparent reliability of the operation data from a number of diffused air type activated sludge plants, the data from 15 of these plants was selected for this study.

Computations and plottings of the results have been made in an effort to discover the interrelationship between and the magnitude and influence of the several major factors affecting the reduction of B.O.D. by activated sludge plants. The tabulations and charts included hereinafter summarize these computations and plottings.

III FUNDAMENTAL CONSIDERATIONS

1 - B.O.D. Loading

To serve the purpose of measuring the efficiency of sewage treatment or for the evaluation of pollutional load, a measure of oxygen requirement known as the Biochemical Oxygen Demand, usually designated B.O.D., has been developed. Standard Methods for the Examination of Water and Sewage defines B.O.D. as the oxygen (in parts per million) required during stabilization of the decomposable organic matter by aerobic bacterial action. This standardized test has become the most useful single determination in the routine examination of sewages and effluents of sewage treatment plants.

Sufficient operation data on B.O.D. determinations have become available that it seems reasonable to express the work to be done, i.e., loadings on activated sludge plants, in terms of the B.O.D. in the sewage as applied to the aeration and final tanks. This corresponds to the rather general practice of using B.O.D. loadings for biological sewage filters.

The B.O.D. test, as outlined by Standard Methods, is designed to measure the 5-day B.O.D. and represents only the carbonaceous demand, i.e., that due to carbohydrates and fats. The non-nitrogenous materials are more readily oxidized than are the proteins which require synthesis before oxidation. The breaking down of porteins, called deaminization, must proceed in a stepwise manner with the result that more time is needed before oxygen can be utilized. During deaminization, ammonia is liberated and may be readily oxidized by the nitrifying bacteria to nitrites and nitrates.

Sewage treatment oxidation may be carried into the so-called "incipient nitrification" stage. Under these conditions, laboratory tests of the effluent B.O.D. result in greater B.O.D. values being indicated due to nitrification in the test bottles. New techniques for preventing this anomalous situation have been suggested by Sawyer (7) and Hurwitz (8).

A new facet to the problem of B.O.D. loading is the character or source of the B.O.D.. A more complete knowledge of the type of organic matter contributing the B.O.D. would be useful in determining the length of time required to effect the desired degree of purification.

2 - Air Requirements

Another major factor affecting the operation of an activated sludge plant is the amount of air supplied to the process. In the case of diffused air type plants, the quantity of air needed is governed by 1) the amount of oxygen needed to keep the process aerobic and for stabilization of the organic matter undergoing oxidation, and 2) the amount of air needed to provide sufficient agitation so as to facilitate intimate contact of the organic matter and its associated organisms.

It may be further stated that the first requirement for air is dependent on the oxygen required to satisfy the B.O.D. of the sewage but more so on the biochemical character and activity of the return sludge. Bloodgood (9) has defined "sludge activity" as the rate of oxygen consumption, less sludge demand, when synthetic sewage and sludge are combined to form a 0.50 percent mixture. The activity is reported as oxygen consumed in parts per million per hour.

Grant, Hurwitz, and Mohlman (10) have shown that the rate at which activated sludges use oxygen increases as the percent of volatile solids in the sludge increases. Sawyer's (11) work confirms this and further shows that for sludges with 60 percent or less volatile solids very little oxygen would be required, but for each 10% increase in volatile solids above 60 percent, the oxygen required per gram of volatile solids per hour is more than doubled.

It has been shown (12) that the oxygen being utilized by the biochemical reactions taking place is only 5 to 9% of the oxygen within the air bubbles being adsorbed. Therefore, from 80 to 150 times the volume of oxygen utilized is being supplied by the diffused air being discharged into the sewage. This excess air has no biochemical value but merely aids in the coagulation of solids by imparting motion to the liquid. Heukelekian (13) has expressed the opinion that aeration should be sufficient to maintain a minimum of 0.5 to 1.0 ppm of dissolved oxygen at all times and in all sections of the aeration tank.

Over aeration, as well as under aeration, has been found detrimental to the sludge. Studies (14) show that if an activated sludge is over aerated, its oxidation rate falls to that of normal biochemical oxidation.

3 - Aeration Contact Time

The aeration period required is directly proportional to the activity and concentration of the sludge. It is important to keep in mind the fact that the aeration phase of the process may be divided into two stages, the first being a period during which the impurities of the sewage are rapidly coagulated and adsorbed by the activated sludge, and the second being a period during which purification takes place by oxidation of the adsorbed colloidal organic matter. A proper design should necessarily provide sufficient time for both stages of the process to function properly.

The rate at which the first stage is completed is proportional to the percentage of biologically active sludge in the mixed liquor. The time required by the second stage is dependent on the activity of the sludge and also upon the biochemical nature of the substrate, i.e., whether or not the organic matter contributing the B.O.D. requires a great deal of synthesis and little oxidation or vice versa. Purification takes place much more slowly than does clarification and is retarded by the oxygen demand of the return sludge.

Reaerating the sludge removed from sedimentation tanks before returning it to the aeration tanks may be necessary in some cases to keep the sludge in an active state. This is especially true for sewages containing large amounts of industrial wastes or when high temperatures are likely to induce septicity in the sewage and activated solids. Claims have been made that reaeration of return sludge reduces the time required to aerate the mixed liquor.

4 - Activated Solids Concentration in the Mixed Liquor

The concentration of activated solids in the mixed liquor is one of the major factors affecting the functioning of the process..This concentration, usually reported as ppm of S.S., is a measure of the adsorbing and coagulating material which is active in the purification and clarification of the incoming sewage.

Several investigators have shown that activated sludges from different sources might have widely different characteristics and that there is no single optimum concentration for all plants.

Edwards (15) states that no more solids should be carried in the aerators than are needed to purify the sewage properly. Ridenour (16) has shown that the "activation" of sludge can be maintained under continuous plant operation with normal detention periods using solids in amounts as low as 150 ppm. While the overall purification efficiency is less, the "unit" efficiency of the low solids is as high or higher than that of higher concentrations.

However, these sludges are very flocculent and have poor settling characteristics. The chief advantage in using low S.S. is to reduce the air required to stabilize the

B.O.D. load. Generally speaking, for a given food supply, a sludge with low S.S. will be overfed with the result that more food is available for sludge growth and necessitates the wasting of larger quantities of sludge.

Sawyer (17) has shown that when different concentrations of S.S. are used to stabilize the same amount of B.O.D., the rate of oxidation will be highest in the case of the high concentration of S.S. resulting in the greatest reduction of volatile solids and loss of activity. In order to prevent this loss in activity, greater quantities of oxygen must be supplied since activity is a function of the rate at which the sludge utilizes oxygen. High concentrations of solids are also conducive to stable operation in plants receiving shock loads and afford a somewhat higher degree of purification.

There appears to be an increasing trend toward recognition of the volatile matter content of the mixed liquor solids as a control factor rather than the suspended solids content. This appears logical since the volatile matter is actually the active constituent of the sludge. The fact that sludges with high volatile solids content are very active should be kept in mind when designing plants, since such sludges, because of their high activity, must be removed from final settling tanks sooner than otherwise and kept in contact with dissolved oxygen to keep them in condition.

Edwards (18) opines that there is a direct relationship between the volatile solids content of the sludge and the sludge index, i.e., sludges with high volatile content are bulkier and have high indicies due to their poor settling qualities.

5 - Effects of Temperature

It is well known that temperature is one of the most important environmental factors governing activity in forms of biological life, either accelerating or retarding the activity of the organism. The effect of temperature on the activated sludge process is many-sided and not yet completely understood. Ardern and Lockett (19) were the first to show that lowering the temperature slowed down the process of purification of sewage by activated sludge.

Kessener and Ribbius (20) stated that the ability of the process to absorb oxygen and deplete its B.O.D. at an identical rate is as a rule determined by the rate of oxygen absorption and the physiological oxygen content. Since temperature affects the rate of oxygen absorption, it seems that an increased temperature tends to lower the purification capacity if all other factors remain constant.

Temperature also influences the rate of biological oxygen depletion; in general, it increases with a rise in temperature. Kessener further pointed out that if the aeration were increased so as to compensate for the effect of a rise in temperature on the rate of oxygen absorption, an increased rate of deoxygenation would still cause a decrease in the oxygen content below the physiological limit, which could be prevented by decreasing the amount of organic material. When strong aeration is practiced, a maximum rate of deoxygenation will result in an increase in the purification capacity of the sludge.

Extensive studies by Phelps (21) on the effect of temperature on the deoxygenation of dilute sewage showed the deoxygenation coefficient at any temperature, t, to be equal to 0.1 times $1.047^{(t-20)}$; where t is the temperature in degrees centigrade. The $1.047^{(t-20)}$ is a temperature factor related to the activity of aerobic microörganisms. Thus, it is clearly seen that a rise in temperature causes a logarithmic increase in the activity of the microörganisms which in turn has the effect of reducing the time required to oxidize a given substrate.

Sawyer and Rohlich (22) have shown that the relative activity, y, of microörganisms in activated sludge - sewage mixtures is $0.71 \times^{1.54}$ where x is the temperature in degrees centigrade. The results of this work are shown graphically in Appendix "D" and have been utilized in this investigation.

Experience with the activated sludge process shows that no great difference in the character of the effluent produced seems to be traceable to changes in seasonal temperatures. This has been explained (22) as follows:

> "For sludges fed identical amounts of food, those at the lower temperatures will be overfed with respect to those at the higher temperatures, because of the lower rates of stabilization of food at the lower temperatures; as a result, there

is an increase in the volatile solids content and activity at the lower temperature."

IV INVESTIGATIONAL PROCEDURE

1 - Collection of Data

The data on which this investigation has been based was taken largely from the monthly and annual operating reports of activated sludge plants located throughout the country. Many of these reports were on file in the Sanitary Engineering Department of the Institute and the remainder were obtained thru correspondence with the various plant officials.

Additional specific information, not contained in the operating reports, was obtained thru correspondence or from engineering publications. A considerable portion of the data included in the operations reports were not necessary to the actual calculations involved in this investigation, but were fundamental to the proper interpretation of the operating data and its selection for inclusion in this study. The data selected for this study are tabulated in Appendix "A".

2 - Selection of Sewage Treatment Plants

Three main principles governed the selection of the plants from which operation data was to be studied. It was thought that consideration should be focused on 1) plants operating under good technical supervision, 2) those of basically similar designs and operating procedures, and 3) those from which the most complete and accurate data could be obtained. With the exception of the Muncie, Indiana plant, only those plants previously recommended (6) by the various State Sanitary Engineers were included in this study.

Relative to plant design, all the plants are of the conventional diffused air type and employ primary sedimentation, in plain settling tanks, or by the use of Imhoff tanks. In an investigation of this nature it is impossible to select a large number of plants that are identical in design and use the same method of operation. Although the basic principles of operation may be the same, some plants practice reaeration of sludge while others utilize the full aeration tank capacity for aeration of mixed liquor. Pertinent facts related to the design, operation, and type of sewage being treated by each plant are included as Appendix "C".

The author feels that the plants selected form a representative group of the diffused air type activated sludge plants and that in so selecting these plants, the results presented hereinafter should portray a logical picture of their functioning.

3 - Method of Analysis

After assembling and tabulating operating data, it was necessary to establish a period of study for each plant. This period was set for one year so as to include all seasonal fluctuations of flow and loading. The first attempt of analysis was to correlate plant performance by means of parameters based on arithmetic means of the monthly data, but it soon became apparent that inconsistencies were developed by including certain months when the performance was sub-standard due to mechanical difficulties, shock loads and industrial wastes of a toxic nature being imposed upon the process and other special operating problems.

Accordingly, the author felt that those periods of sub-standard performance should not be included when comparing one plant with another. Citing one example of this situation, the Austin, Texas plant removed only 49% of its B.O.D. load during the month of December, 1945 while the efficiencies of the other months ranged from 80 to 95%. Obviously, the data for this one particular month should not be included in an average of the yearly data because it is not representative of the true performance of the plant and its inclusion would merely have the effect of distorting the true picture.

Working on these principles, weighted averages, designated "A" were made so as to include only those months in which the plant was functioning properly. In the case of plants having several months of sub-standard performance, these periods were grouped for a weighted average, designated "B". The operation data sheets contained in Appendix "A" are marked with an "A" or "B" at the head of each column of monthly data as a means of designating the category in which each month was included.

4 - Computation Methods

The performance of the activated sludge process has been measured by the percent reduction of 5 - day B.O.D. and suspended solids being imposed upon the process. Since this study is concerned primarily with B.O.D. loading, efficiencies have been calculated as follows:

$$\% \text{ Efficiency} = \frac{\text{Reduction of B.O.D.(ppm)}}{\text{Influent B.O.D.(ppm)}} \times 100$$

The basic measurement of loading has been taken as pounds of 5-day B.O.D. applied per day. Thus, for a settled sewage flow of 10 M.G.D. having 150 ppm of 5-day B.O.D., the loading is:

$$\text{Lb. B.O.D./Day} = 150 \text{ ppm} \times 8.34 \times 10 \text{ M.G.D.}$$
$$= 12{,}500$$

However, this loading is of no significance until it is applied to a unit volume of aeration tank, which in this case has been taken as 1000 cubic feet, including volume used for sludge reaeration. The first loading parameter, designated P_1, therefore becomes:

$$P_1 = \text{Lbs. B.O.D. applied/day/1000 C.F. of Tank}$$

The second loading parameter takes into consideration the time during which clarification and purification takes place.

$$P_2 = P_1/\text{Aeration Contact Time - Hrs.}$$

The third and most complex parameter involves the amount of biologically active material available for adsorbing the organic constituents of the sewage.

$$P_3 = P_2/\text{ppm S.S. in Mixed Liquor} \times 1000$$

(to give numbers greater than 1.0)

In the case of individual plant studies, the results of which are tabulated in Tables B-1 thru B-15 and plotted in Figures #1 thru #16, the values of the parameter P_2 were computed by dividing P_1 by the equivalent aeration period rather than the actual aeration period.

Equivalent aeration periods were obtained by making application of the Sawyer-Rohlich formula (22). A sample computation best serves to explain this application.

Given: Aeration period @ 60° F = 6.0 hours.

Find: Equivalent aeration period @ 77° F.

From Table D-1, Appendix D, the relative activity factor = 0.485.

Equivalent aeration period = 6.0 x 0.485 = 2.9 hours.

In the studies including all 15 plants, the results of which are tabulated in Table B-16 and plotted in Figures #17 thru #21, the values of the parameter P_2 were obtained by dividing P_1 by the actual aeration period.

For those plants where no settled sewage flow was reported, this value was taken to be the same as the raw sewage flow and no correction made for the slight reduction in volume due to solids settling out in the primary tanks. Mixed liquor flows were taken as reported or calculated by adding settled sewage flow and return sludge flow.

The aeration contact time has been taken as that for mixed liquor aeration only, and no consideration given to length of preaeration or reaeration periods.

5 - Sources of Error

In calculating the B.O.D. load imposed upon the aeration tanks only that portion of the B.O.D. contributed by the incoming settled sewage has been considered. This is not entirely correct since the sludge returned to the aerators imposes an additional B.O.D. load. This value is not determined in routine plant study. Some investigators have attempted to refine their calculations by taking the B.O.D. of the final effluent as the B.O.D. of the returned sludge.

In general, errors originating in laboratory analyses are compensating in nature and tend to average out over long periods such as are used in this investigation. However, the error due to nitrification taking place in the B.O.D. bottles is not compensating but residual. Reports indicate that the error in final effluent B.O.D.'s due to incipient nitrification will average 20 to 30%. Thus, for a settled sewage with 200 ppm B.O.D. being applied to the aeration process and a final effluent of 20 ppm B.O.D., the apparent removal is 90%. Assuming an error of 30% in the effluent B.O.D. value, the corrected effluent B.O.D. would be 14 ppm and the corrected percent removal would be 93%. In the absence of full nitrogen data from the plants studied, corrections for this error could not be made.

The N.R.C. report (3) estimates that the probable error in percent reduction of B.O.D. in a given plant is about 4% but when a dozen plants are analyzed, the probable error is reduced to about 1%.

Other errors due to different techniques of sampling and different methods of reporting operation results and physical dimensions enter the picture, but are beyond the scope of this investigation.

V RESULTS

The results of this investigation include four types of data: (1) Operating data abstracted from routine operating reports or received from plants officials thru special reports or memoranda, (2) tabular data computed from the operating data, (3) a graphical presentation of the computed loading parameters, and (4) descriptive information about each plant to indicate any special factors which might affect the operation of the plant differently from other plants.

Extracted operating data are recorded in Tables A-1 to A-15, inclusive, in Appendix "A". These items of information, comprising monthly averages of the more important operation data, have been selected to show those phases of operating results which are routinely recorded in most technically controlled activated sludge plants. A few items such as the volatile solids content of the mixed liquor, pH of the sewage, organic nitrogen content of the incoming sewage, and others, have been included when available so as to facilitate a better interpretation of plant performance.

Computed loading parameters are tabulated in Tables B-1 to B-16, inclusive, in Appendix "B". These items have been selected as being the major factors for comparison of the operation results of various conventional type activated sludge plants.

A graphical presentation of the interrelated factors is included in Figures #1 thru #21. These figures may be grouped into two main divisions; (1) Figures #1 thru #16 which are related to individual plant studies, and (2) Figures #17 thru #21 which include a combination of all 15 plants.

Descriptive information on the 15 selected plants is included in appendix "C". This information relates to the design features of the plants, their operating procedures, if unusual, and the type and character of the wastes they treat.

Individual Plant Studies

Figures #1 thru #15 show the interrelation of the loading parameters and plant performance for each of the 15 plants studied. Figure #16 is a composite of Figures #1 thru #15.

The parameters used in these individual studies are as follows:

P_1 = Lbs. B.O.D. App./1000 C.F. Tk.

P_2 = Lbs. B.O.D. App./1000 C.F. Tk./Equiv. Aer. Pd.

P_3 = Lbs. B.O.D. App./1000 C.F. Tk./Equiv. Aer. Pd./ ppm S.S. in Mixed Liquor x 1000.

FIG. # 1

ANN ARBOR, MICH. 1947

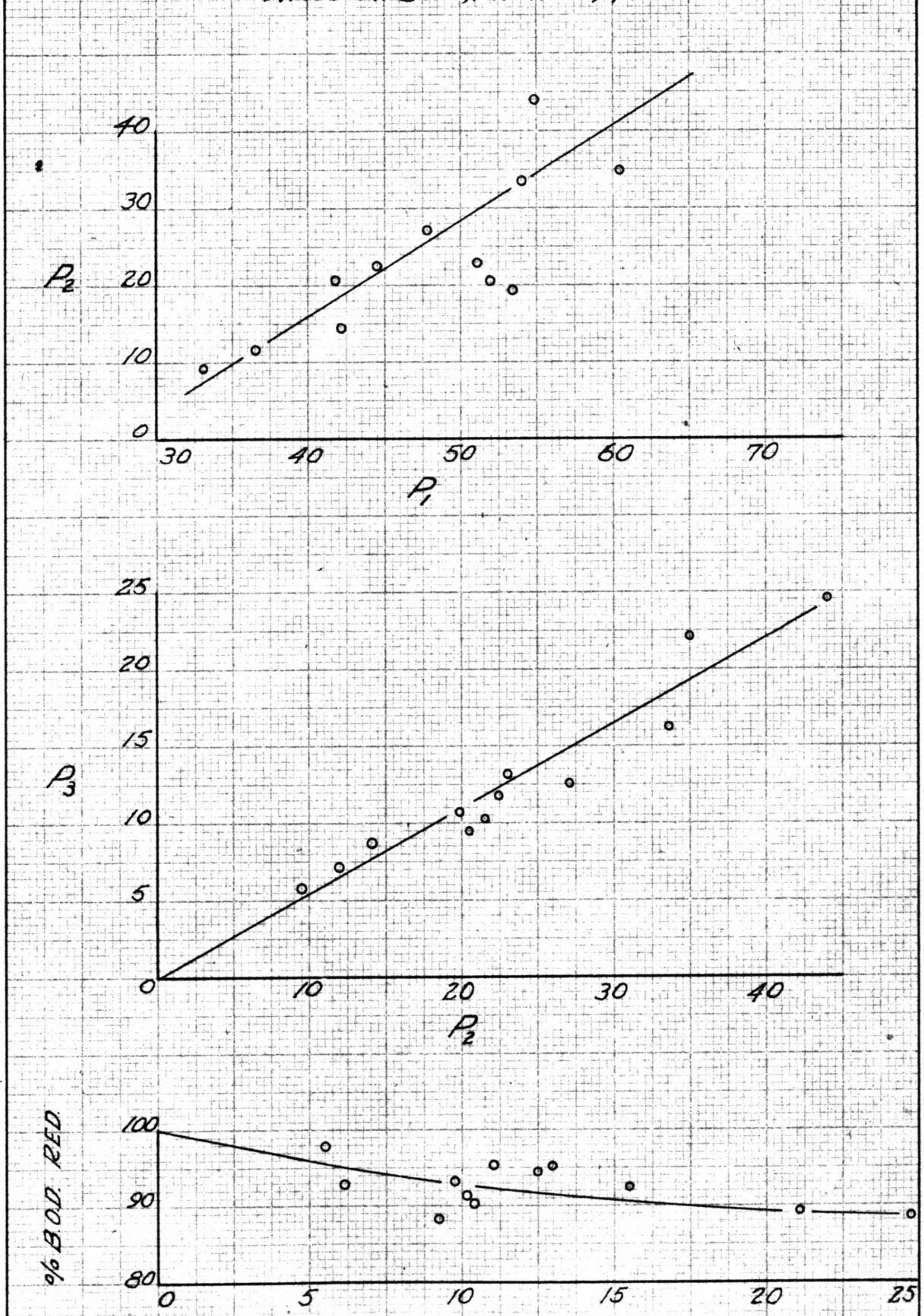


FIG. # 2

AUSTIN, TEX. 1945

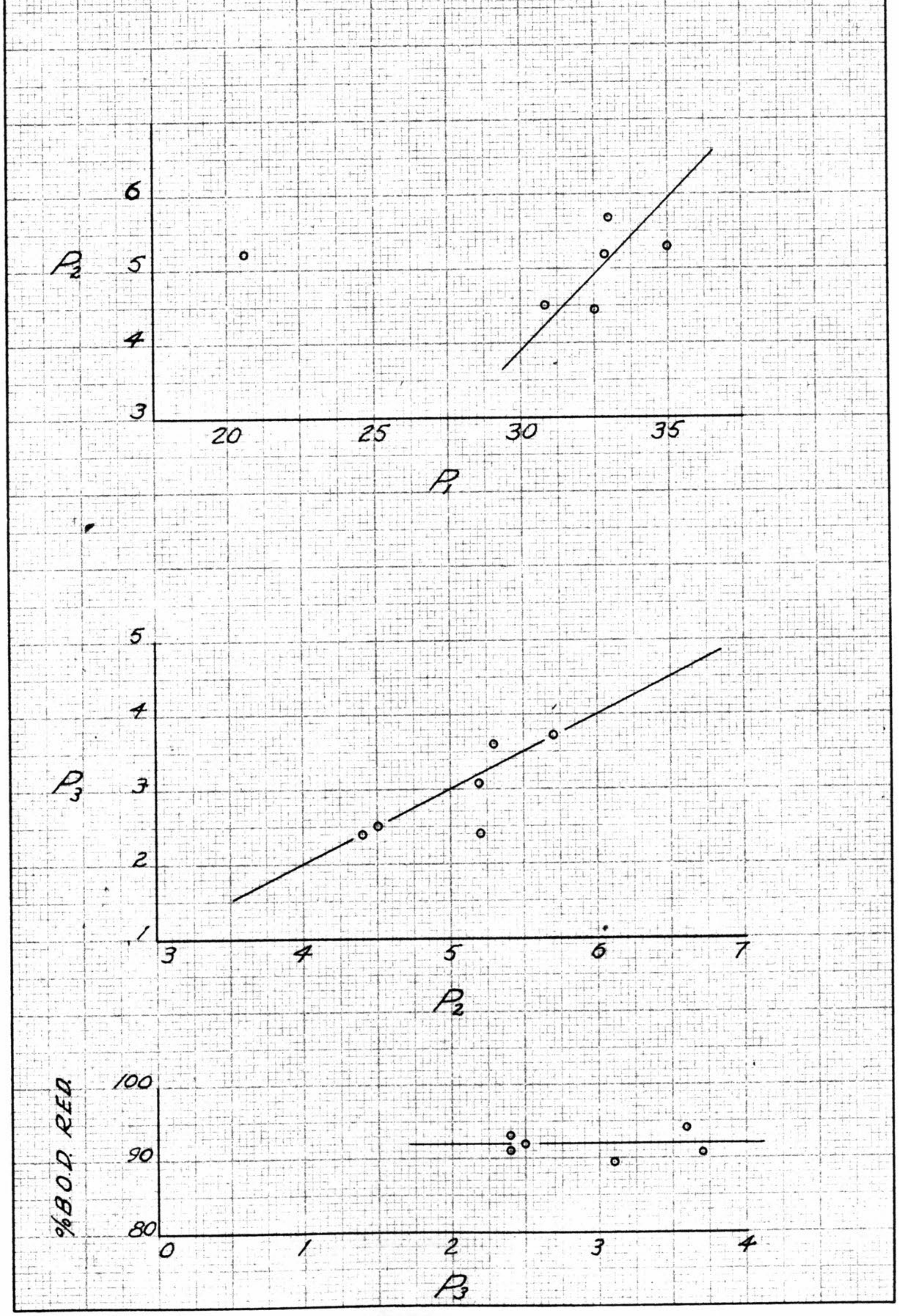


FIG. # 3

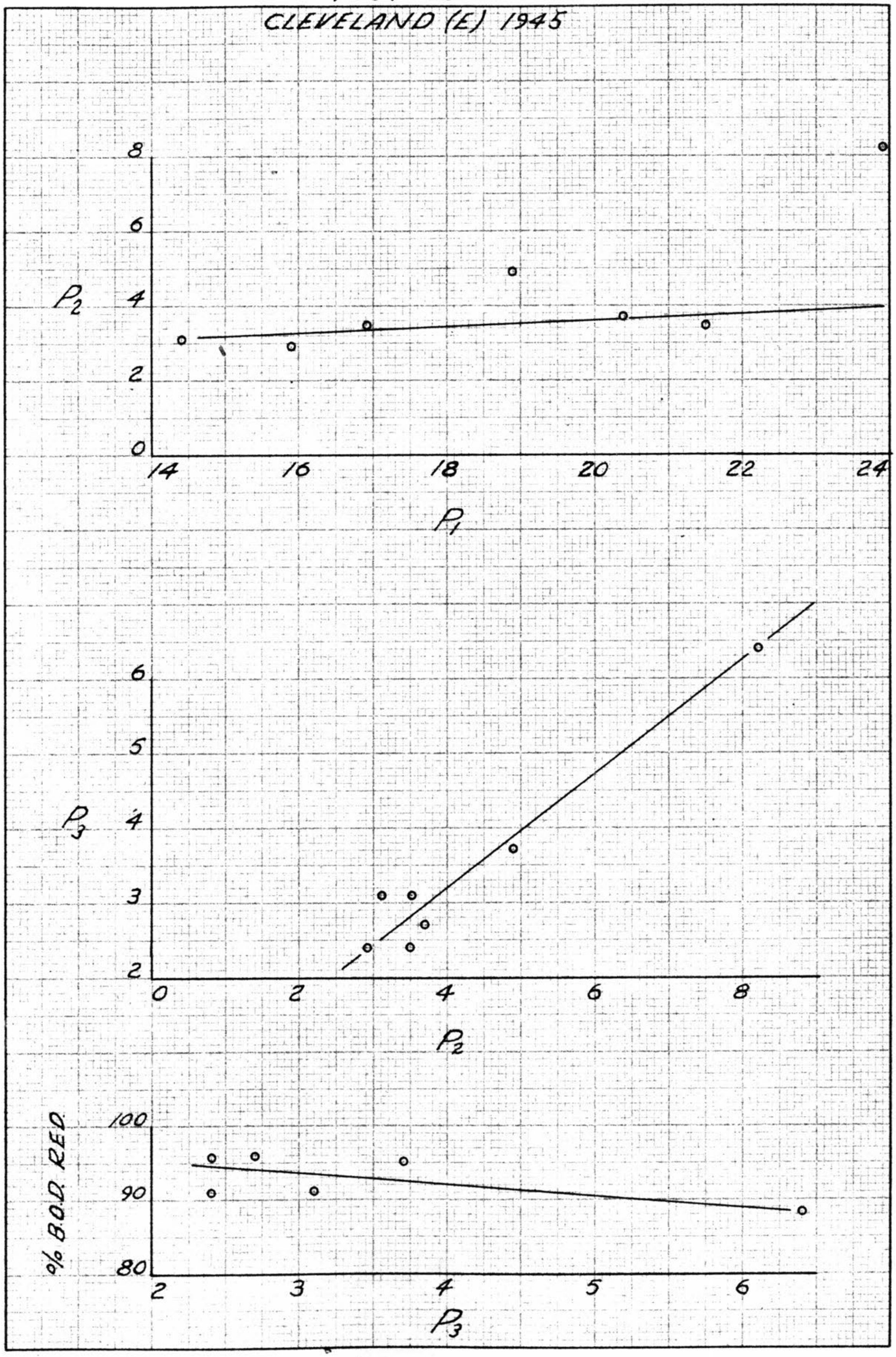

CLEVELAND (E) 1945
P_2
8
6
4
2
0
14
16
18
20
22
24
P_1
P_3
6
5
4
3
2
0
2
4
6
8
P_2
% B.O.D. RED.
100
90
80
2
3
4
5
6
P_3

FIG. # 4

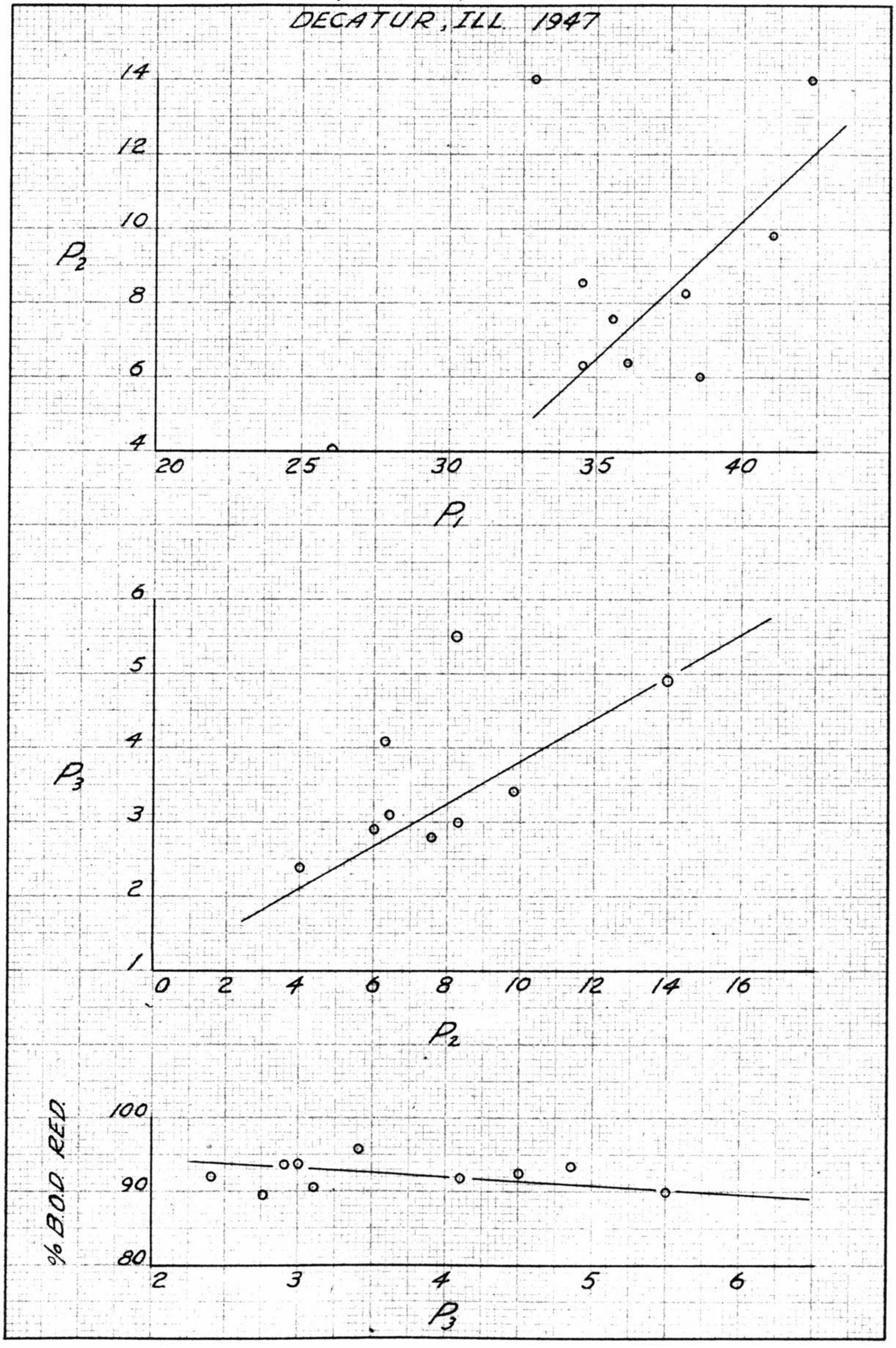

DECATUR, ILL. 1947
14
12
10
8
6
4
P_2
20
25
30
35
40
P_1
6
5
4
3
2
1
P_3
0
2
4
6
8
10
12
14
16
P_2
100
90
80
% B.O.D. RED.
2
3
4
5
6
P_3

FIG. # 5

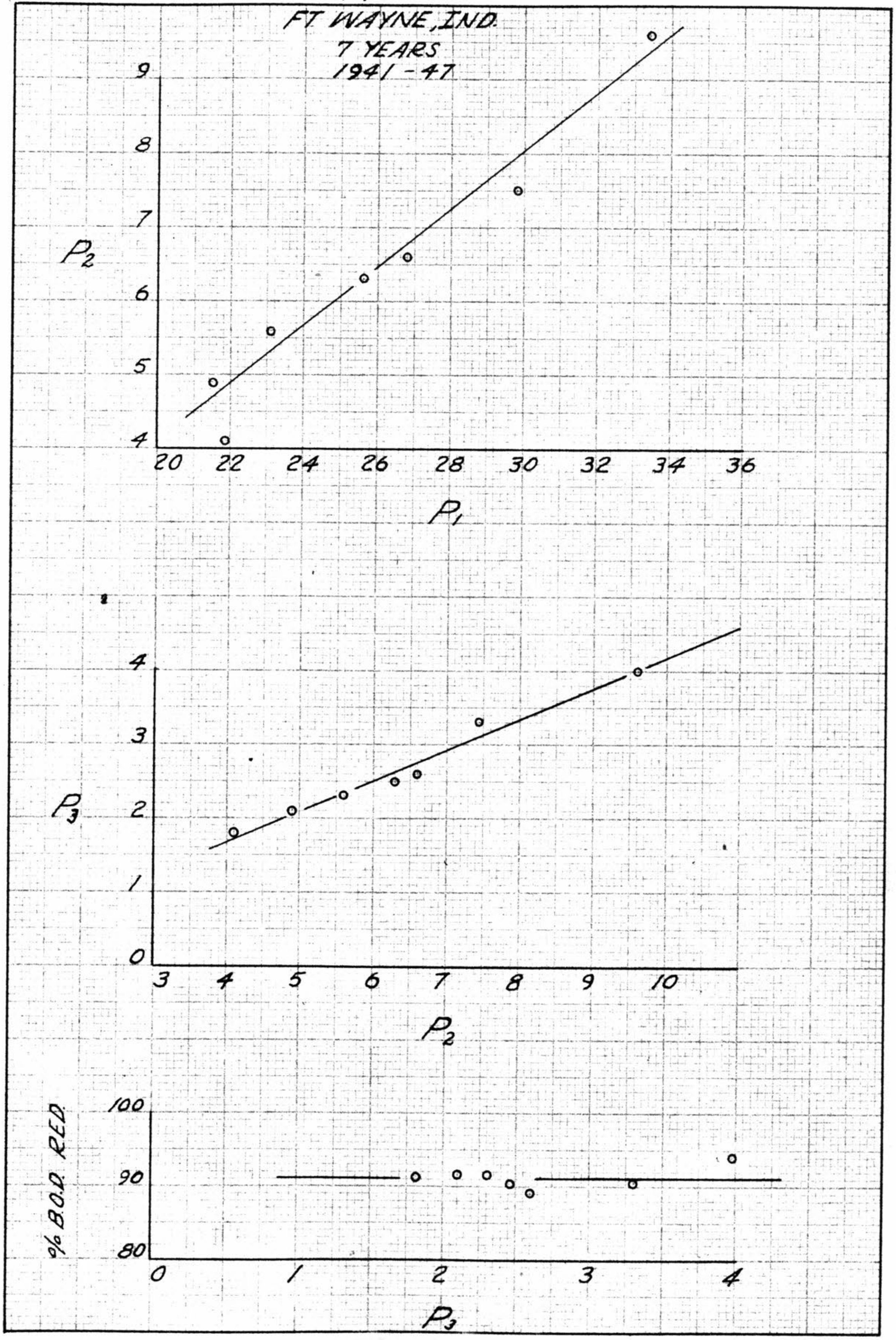
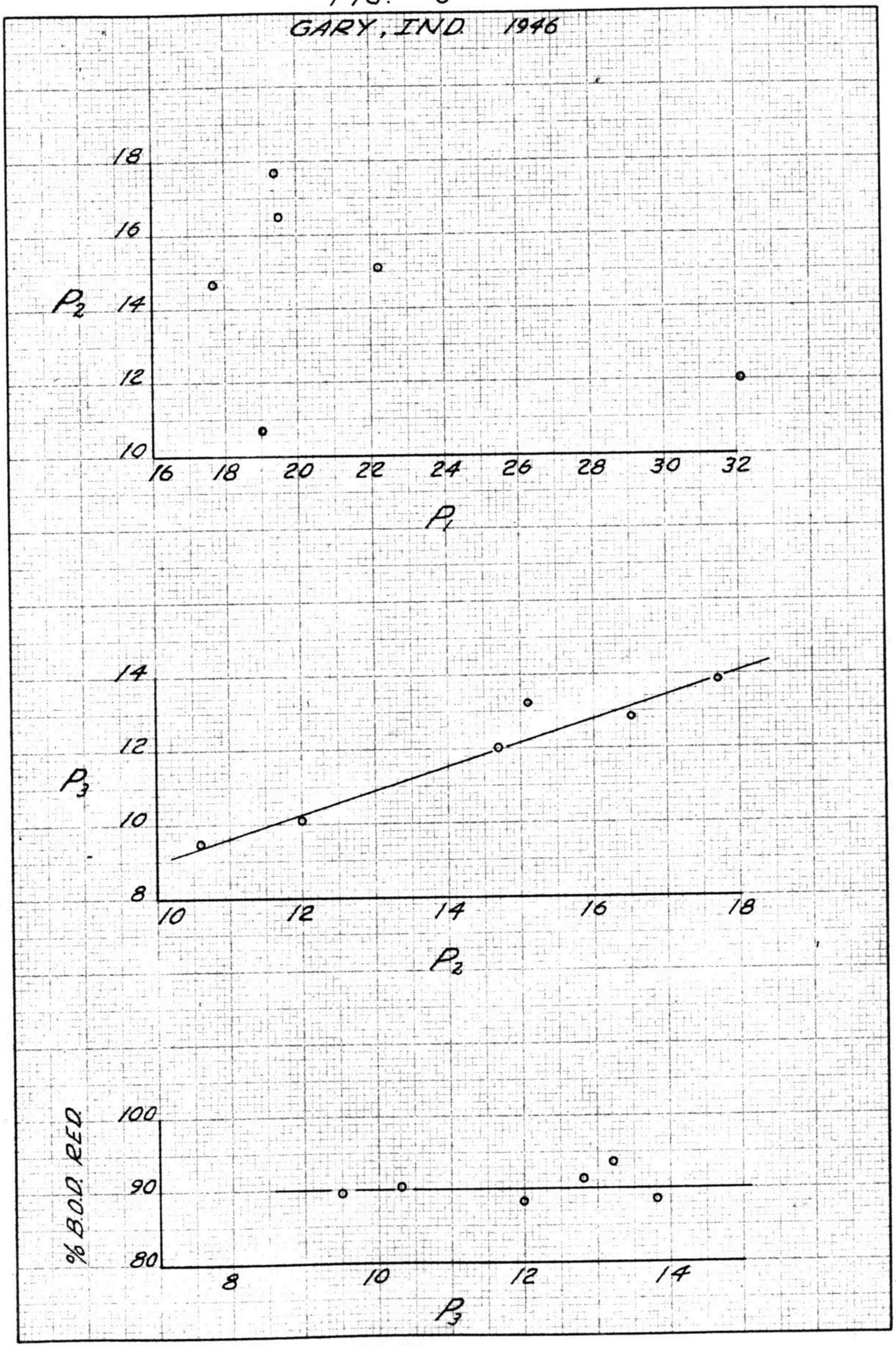

FT WAYNE, IND.
7 YEARS
1941 - 47
P2
9
8
7
6
5
4
20
22
24
26
28
30
32
34
36
P1
P3
4
3
2
1
0
3
4
5
6
7
8
9
10
P2
% B.O.D. RED.
100
90
80
0
1
2
3
4
P3

FIG. # 6



GARY, IND. 1946
P_2
18
16
14
12
10
16 18 20 22 24 26 28 30 32
P_1
P_3
14
12
10
8
10 12 14 16 18
P_2
% B.O.D. RED.
100
90
80
8 10 12 14
P_3

FIG. # 7

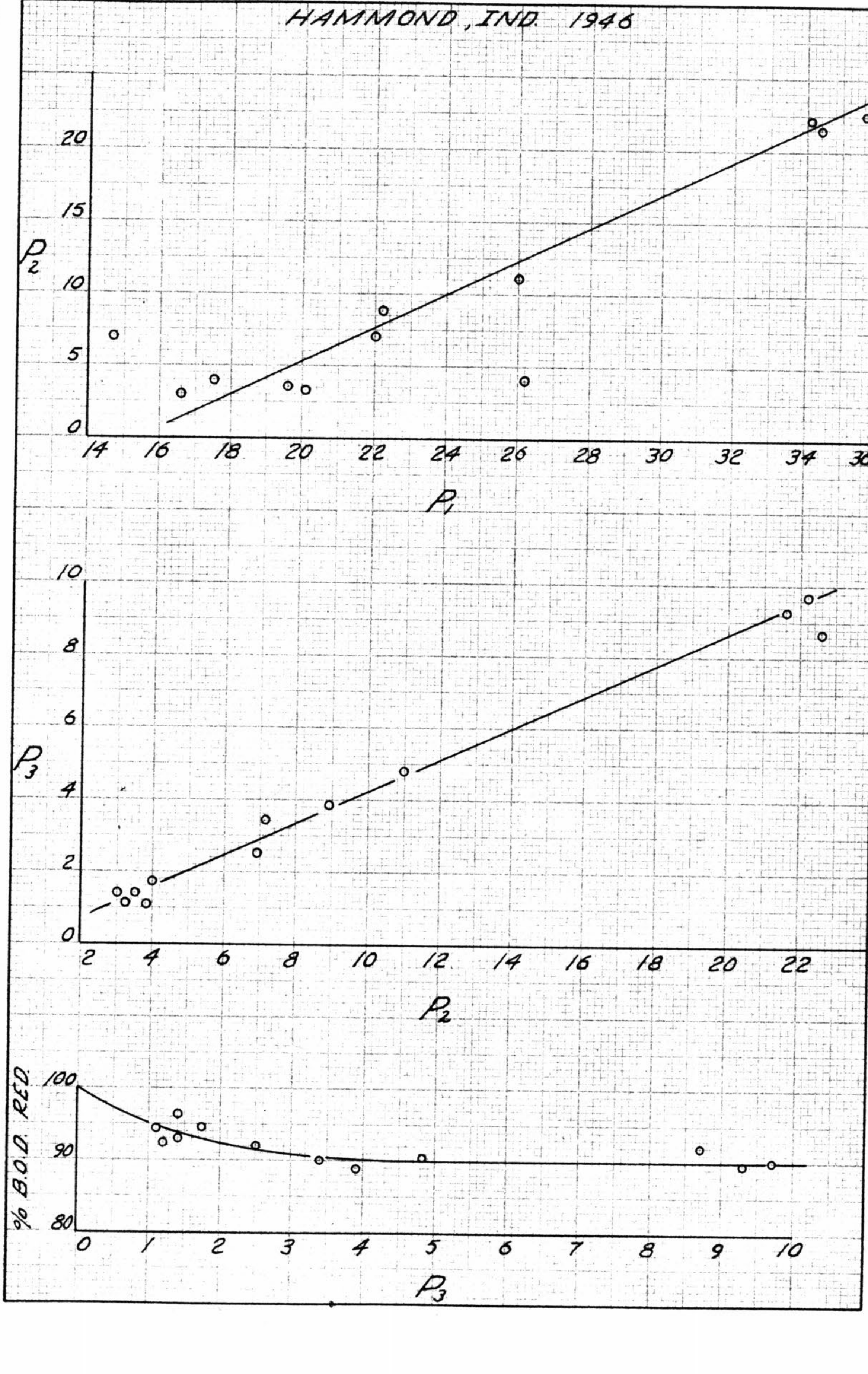

HAMMOND, IND. 1946
P2
20
15
10
5
0
14
16
18
20
22
24
26
28
30
32
34
36
P1
P3
10
8
6
4
2
0
2
4
6
8
10
12
14
16
18
20
22
P2
% B.O.D. RED.
100
90
80
0
1
2
3
4
5
6
7
8
9
10
P3

FIG. # 8

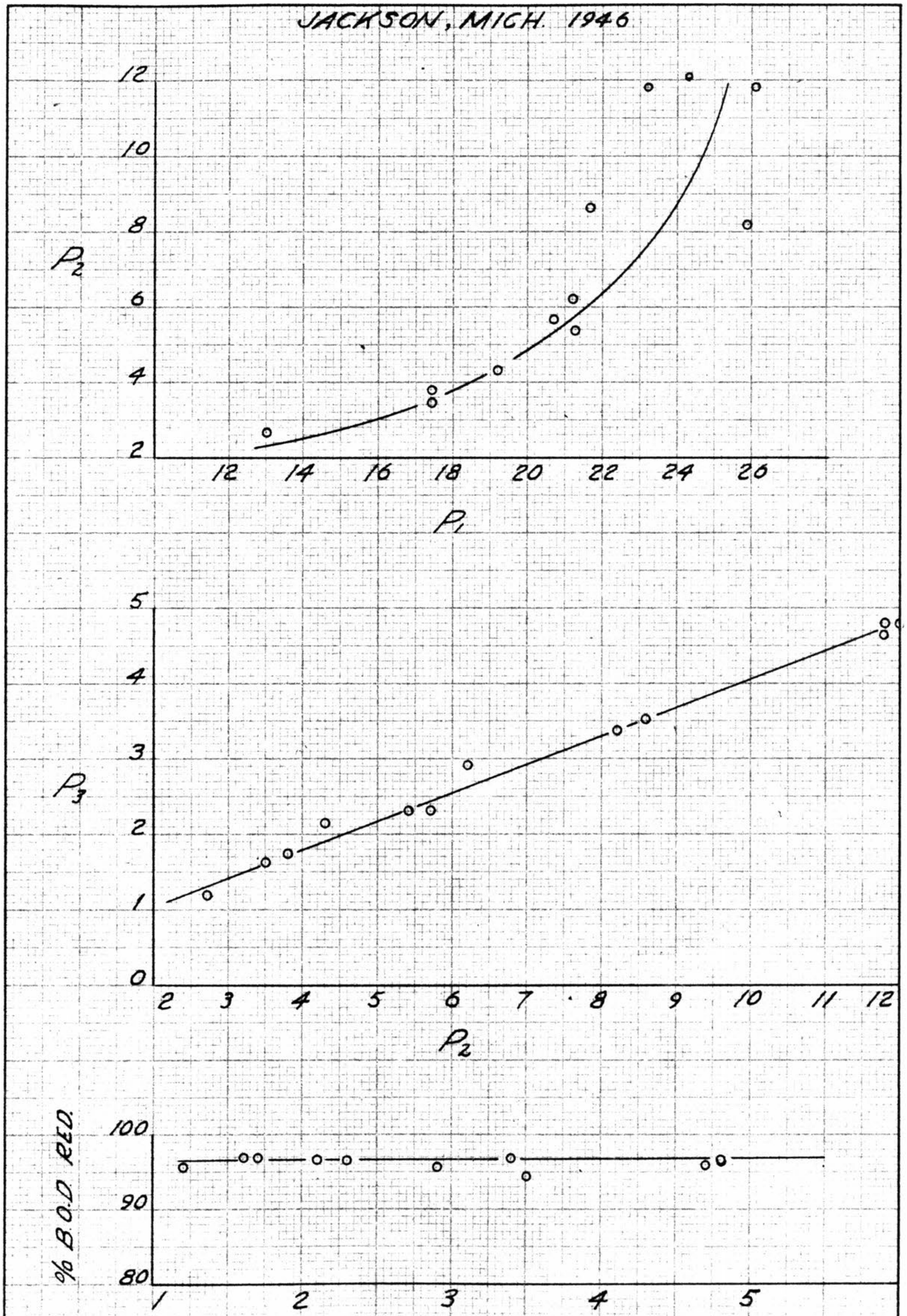

JACKSON, MICH. 1946
P2
12
10
8
6
4
2
12 14 16 18 20 22 24 26
P1
P3
5
4
3
2
1
0
2 3 4 5 6 7 8 9 10 11 12
P2
% B.O.D. RED.
100
90
80
1 2 3 4 5
P3

FIG. # 9

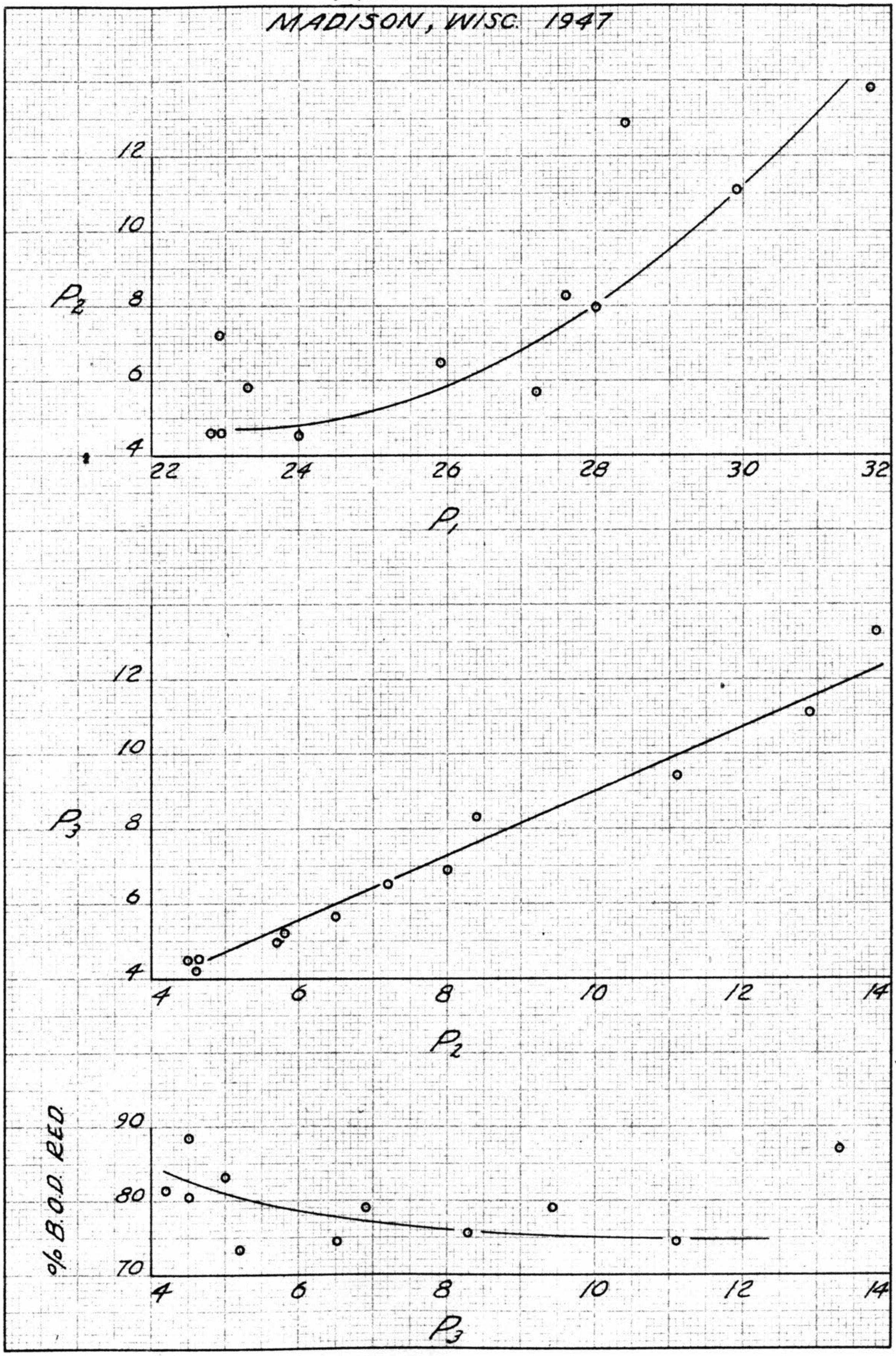

MADISON, WISC. 1947
P2
12
10
8
6
4
22
24
26
28
30
32
P1
P3
12
10
8
6
4
4
6
8
10
12
14
P2
% B.O.D. RED.
90
80
70
4
6
8
10
12
14
P3

FIG. # 10

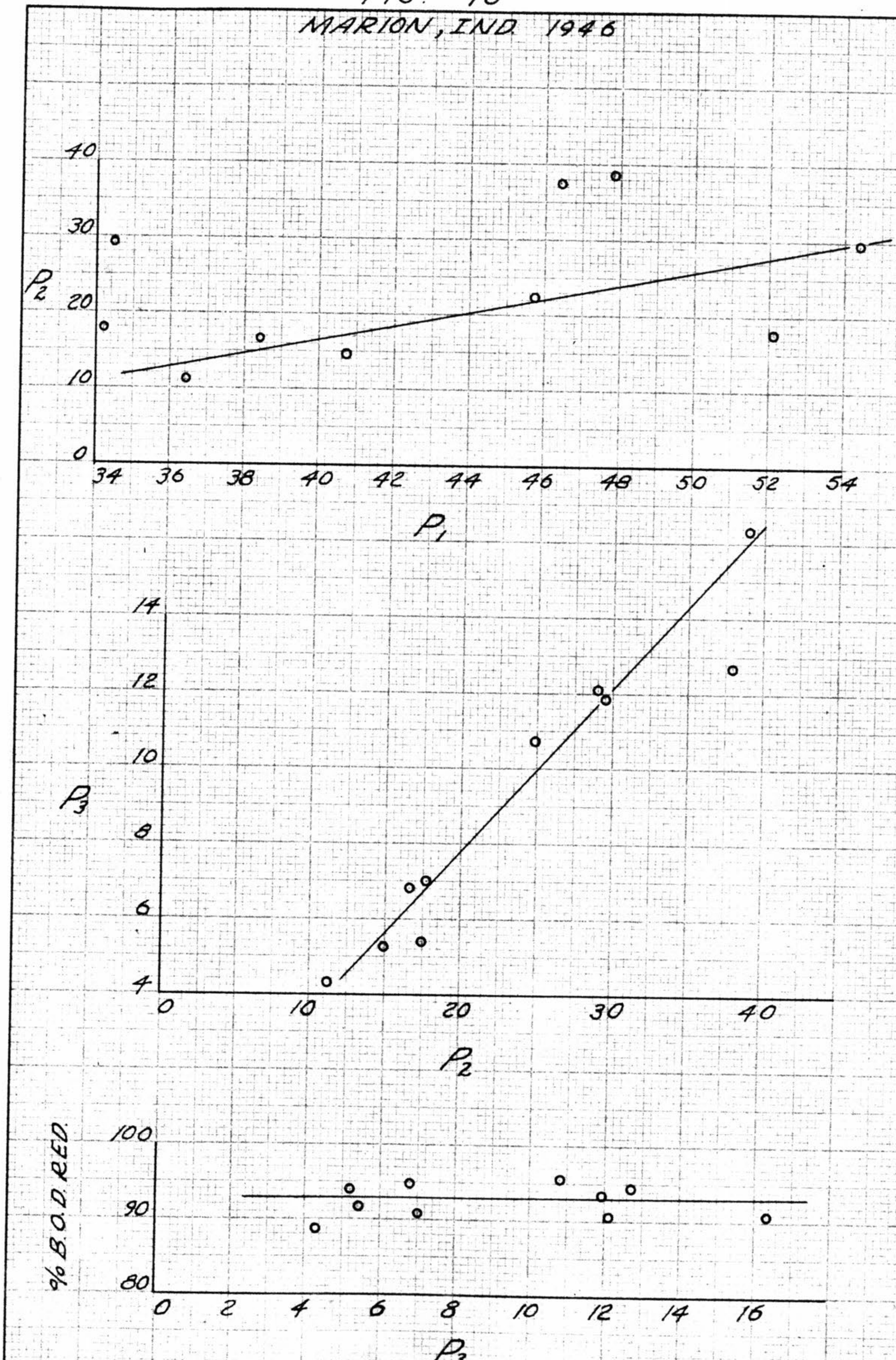

MARION, IND 1946
40
30
20
10
0
P_2
34 36 38 40 42 44 46 48 50 52 54
P_1
14
12
10
8
6
4
P_3
0 10 20 30 40
P_2
100
90
80
% B.O.D. RED.
0 2 4 6 8 10 12 14 16
P_3

FIG. # 11

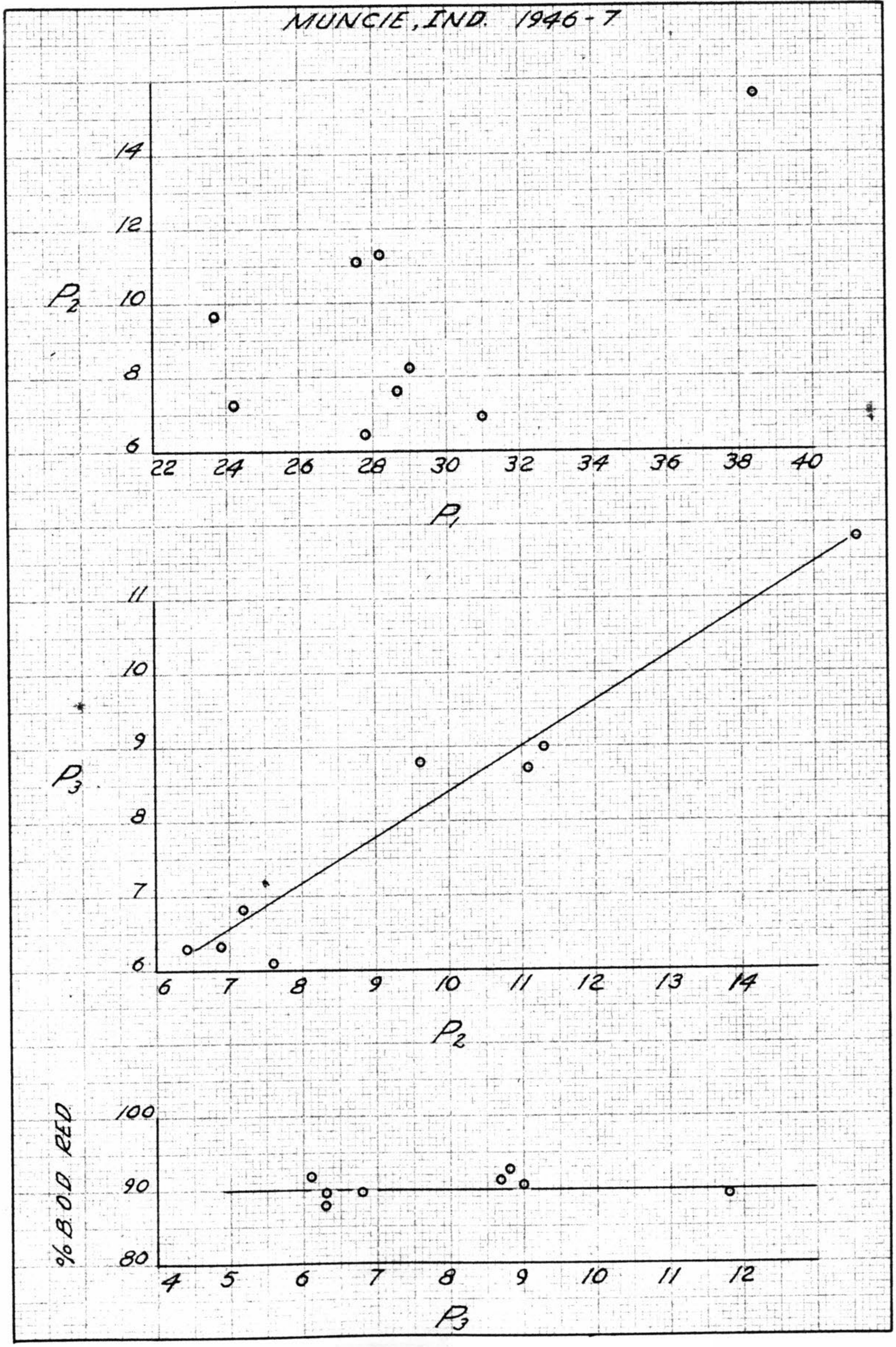
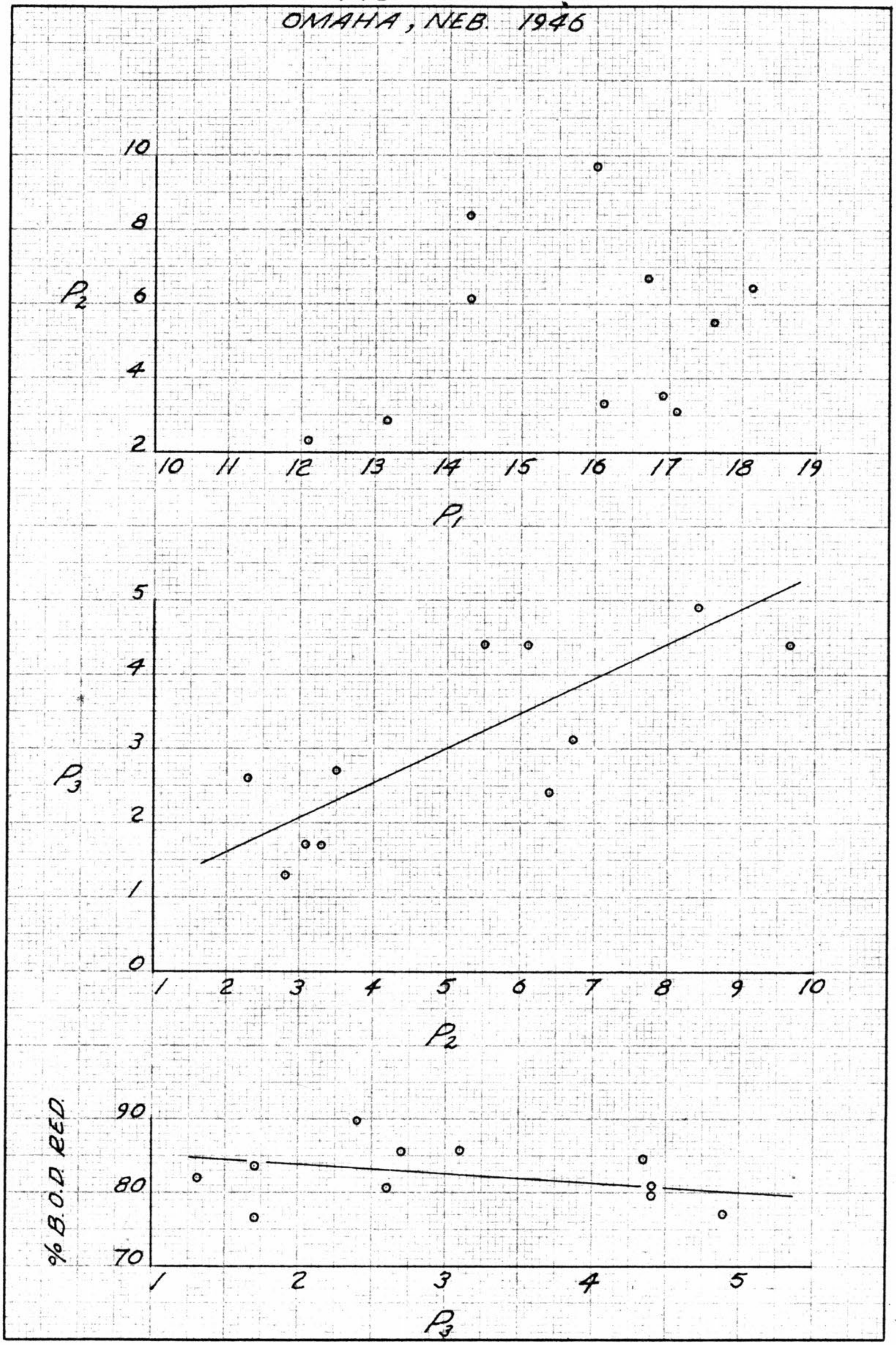

MUNCIE, IND. 1946-7
P2
14
12
10
8
6
22
24
26
28
30
32
34
36
38
40
P1
P3
11
10
9
8
7
6
6
7
8
9
10
11
12
13
14
P2
% B.O.D. RED.
100
90
80
4
5
6
7
8
9
10
11
12
P3

FIG. # 12



OMAHA, NEB. 1946
10
8
6
4
2
P_2
10
11
12
13
14
15
16
17
18
19
P_1
5
4
3
2
1
0
P_3
1
2
3
4
5
6
7
8
9
10
P_2
90
80
70
% B.O.D. RED.
1
2
3
4
5
P_3

FIG. # 13

PEORIA, ILL. 1946

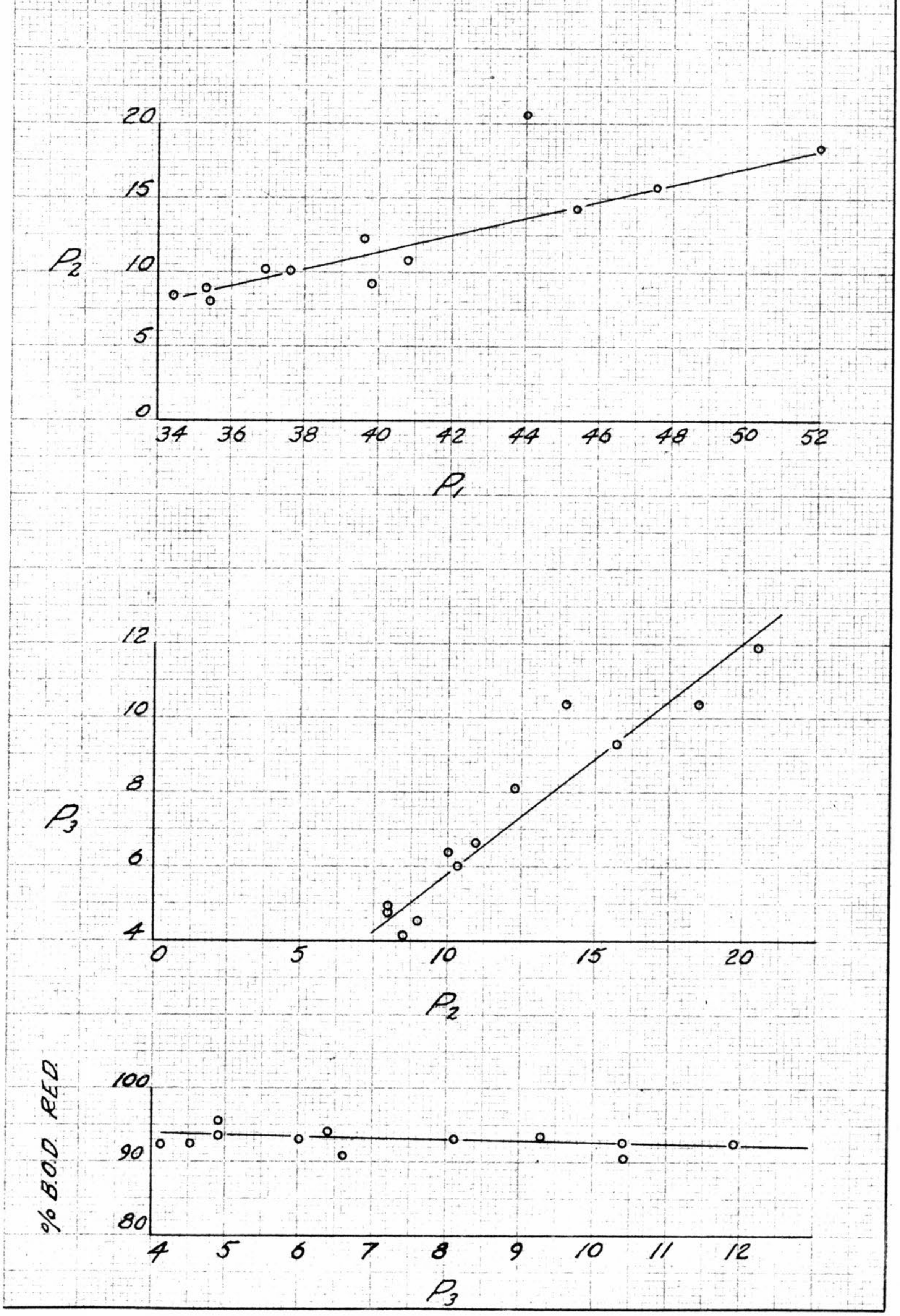


FIG. # 14

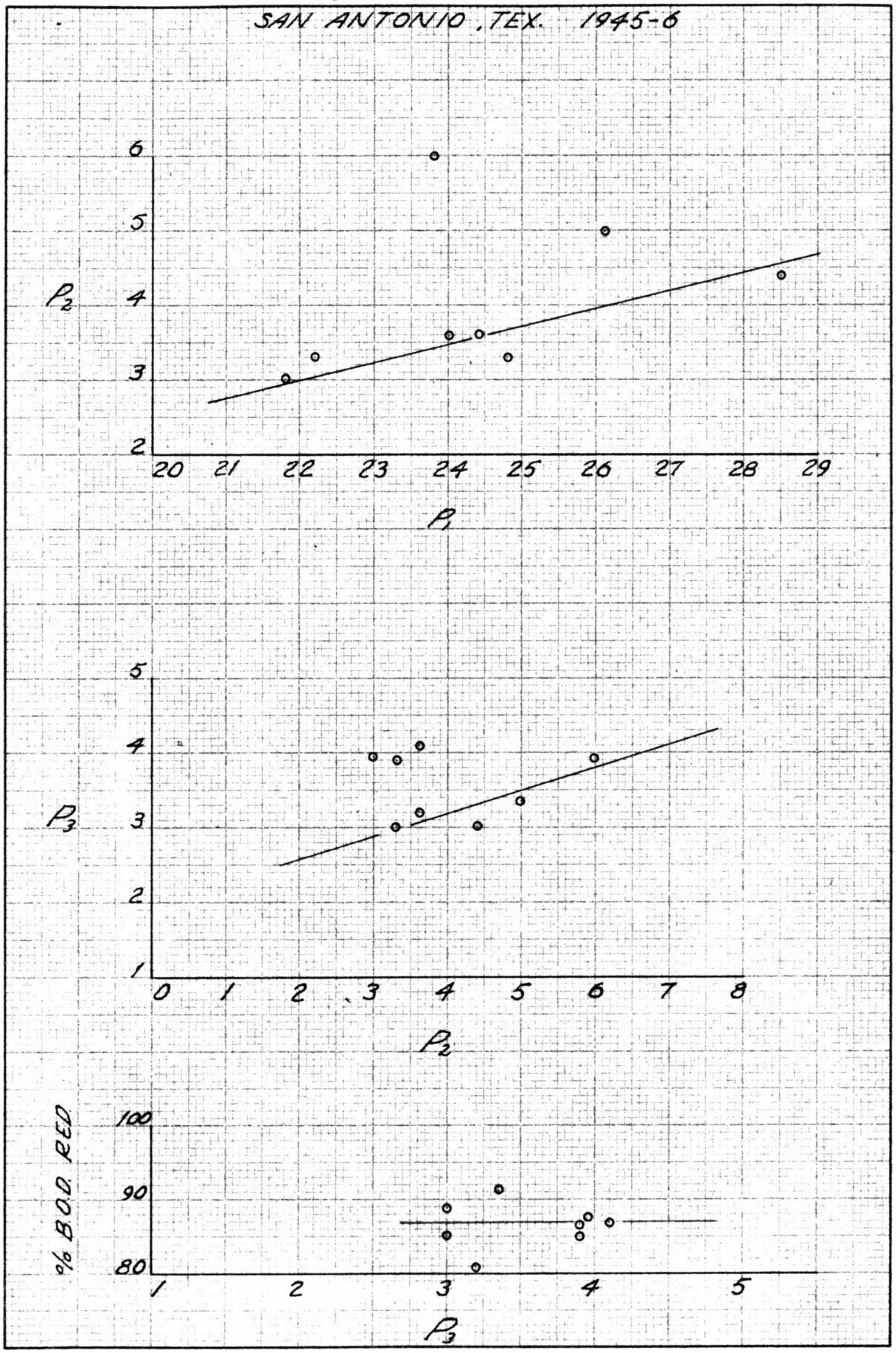

SAN ANTONIO, TEX. 1945-6
P_2
6
5
4
3
2
20 21 22 23 24 25 26 27 28 29
P_1
P_3
5
4
3
2
1
0 1 2 3 4 5 6 7 8
P_2
% B.O.D. RED
100
90
80
1 2 3 4 5
P_3

FIG. # 15

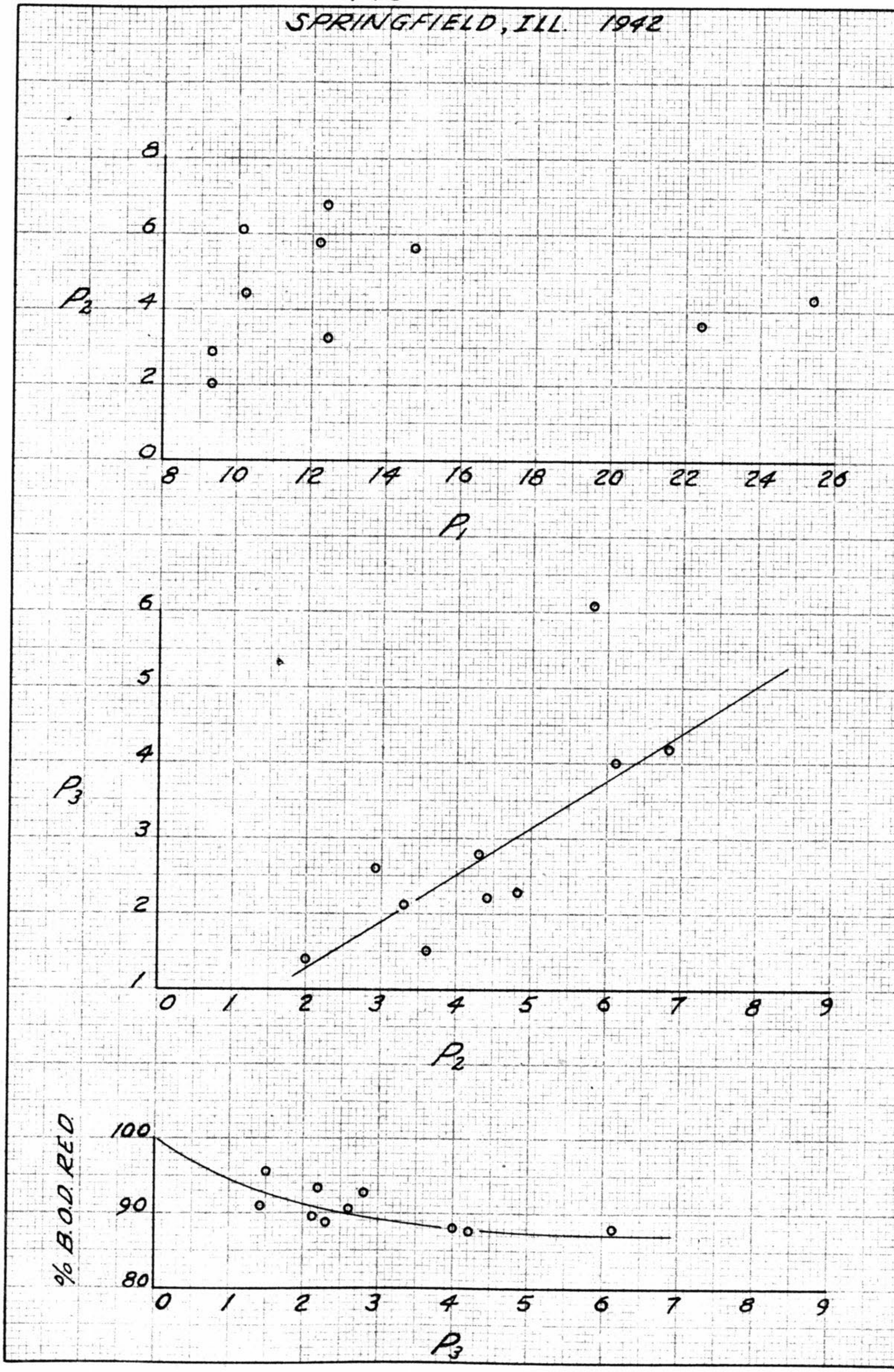
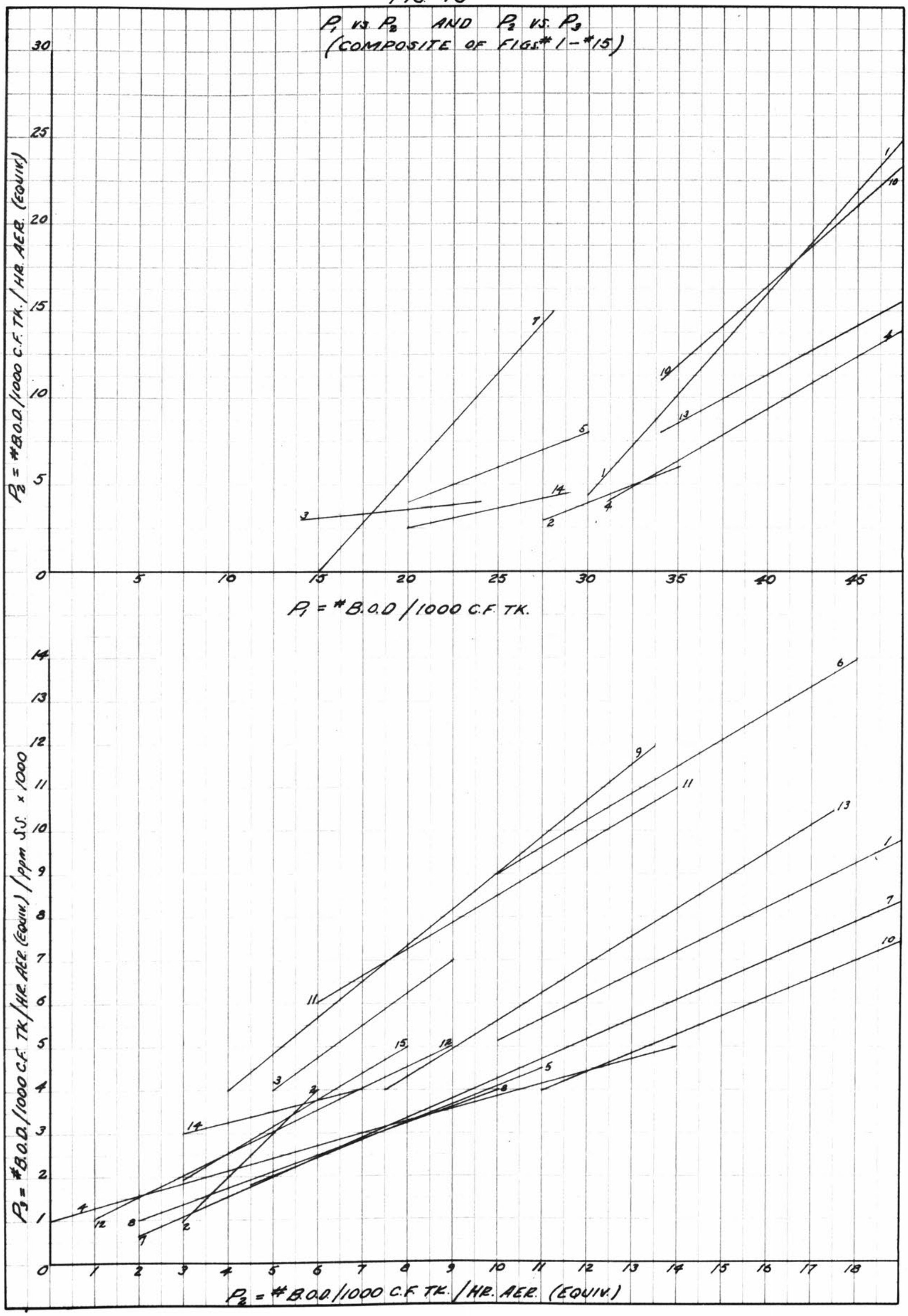


FIG. #16


P1 vs. P2 AND P2 vs. P3
(COMPOSITE OF FIGS. #1 - #15)
P2 = #B.O.D./1000 C.F. TK. / HR. AER. (EQUIV.)
P1 = #B.O.D./1000 C.F. TK.
P3 = #B.O.D./1000 C.F. TK / HR. AER. (EQUIV.) / ppm S.S. x 1000
P2 = #B.O.D./1000 C.F. TK. / HR. AER. (EQUIV.)

Studies Including All Plants

An all inclusive study of the loading parameters and their relation to plant performance is presented in Figures #17 thru #21.

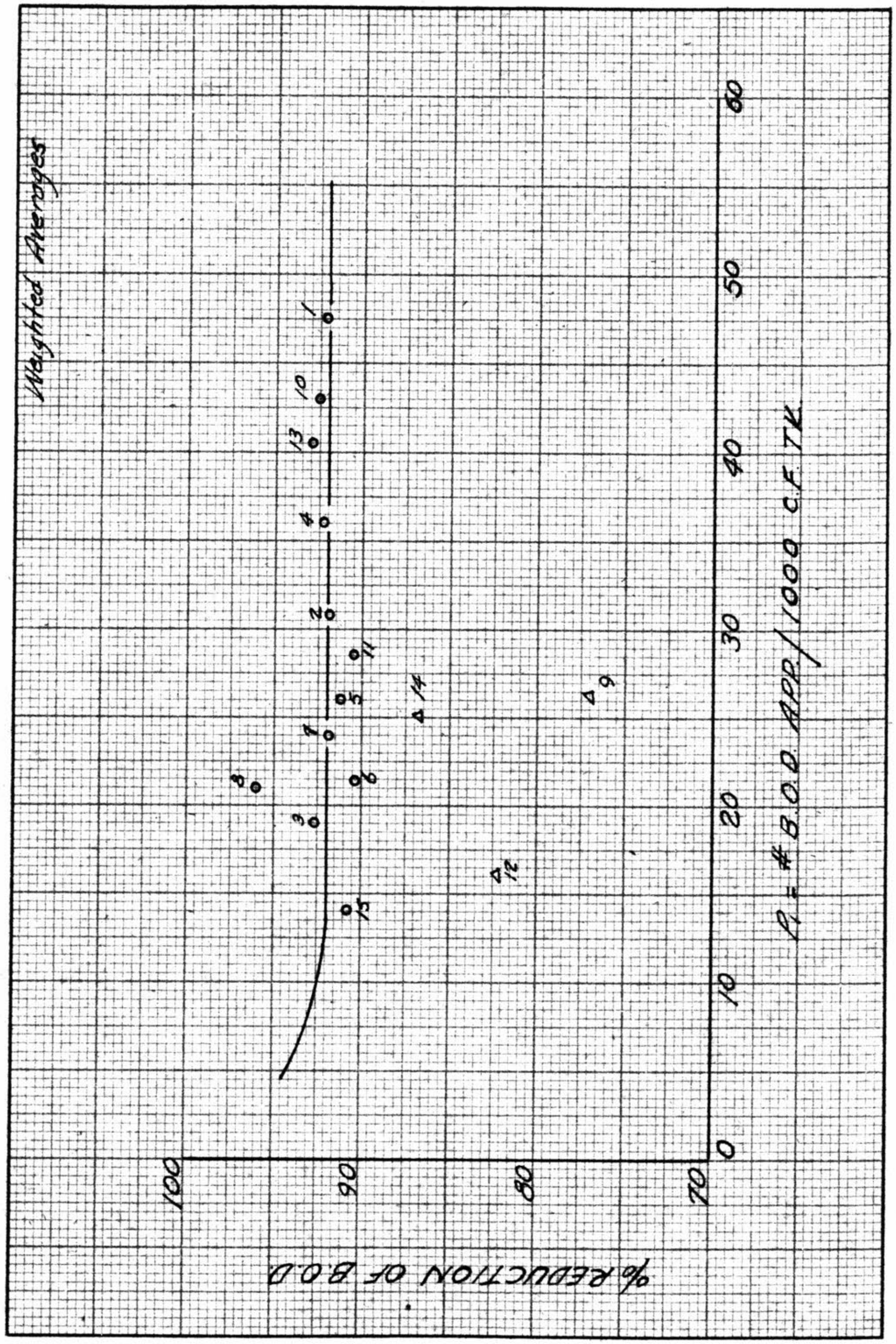
The parameters used in this study are as follows:

P_1 = Lbs. B.O.D. App./1000 C.F. Tk.

P_2 = Lbs. B.O.D. App./1000 C.F. Tk./Hr. Aer. Time (actual)

P_3 = Lbs. B.O.D. App./1000 C.F. Tk./Hr. Aer. Time/ ppm S.S. in Mixed Liquor x 1000

FIG. # 17


Weighted Averages
% REDUCTION OF B.O.D
L = # B.O.D APP./1000 C.F. TK
0
10
20
30
40
50
60
70
80
90
100

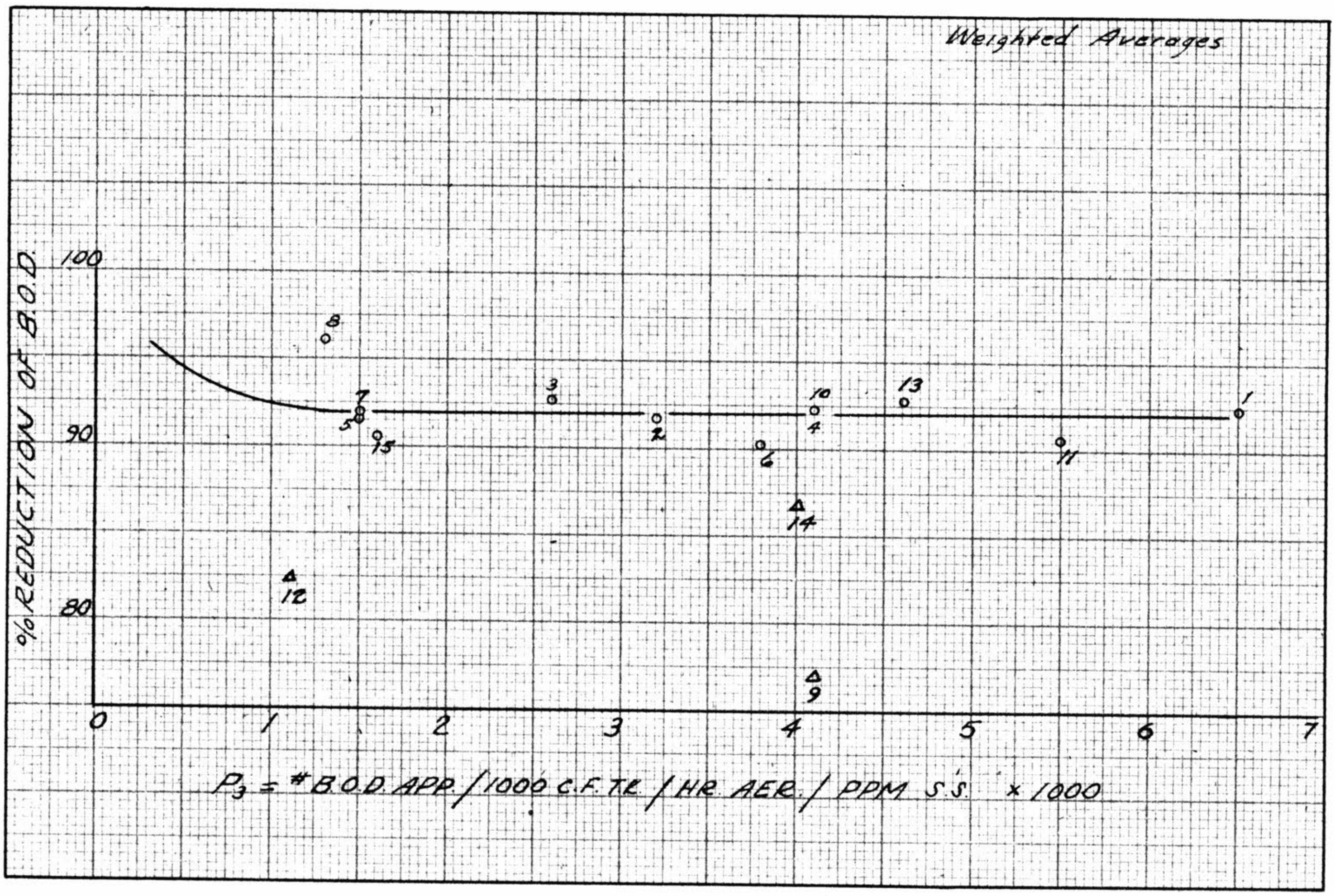
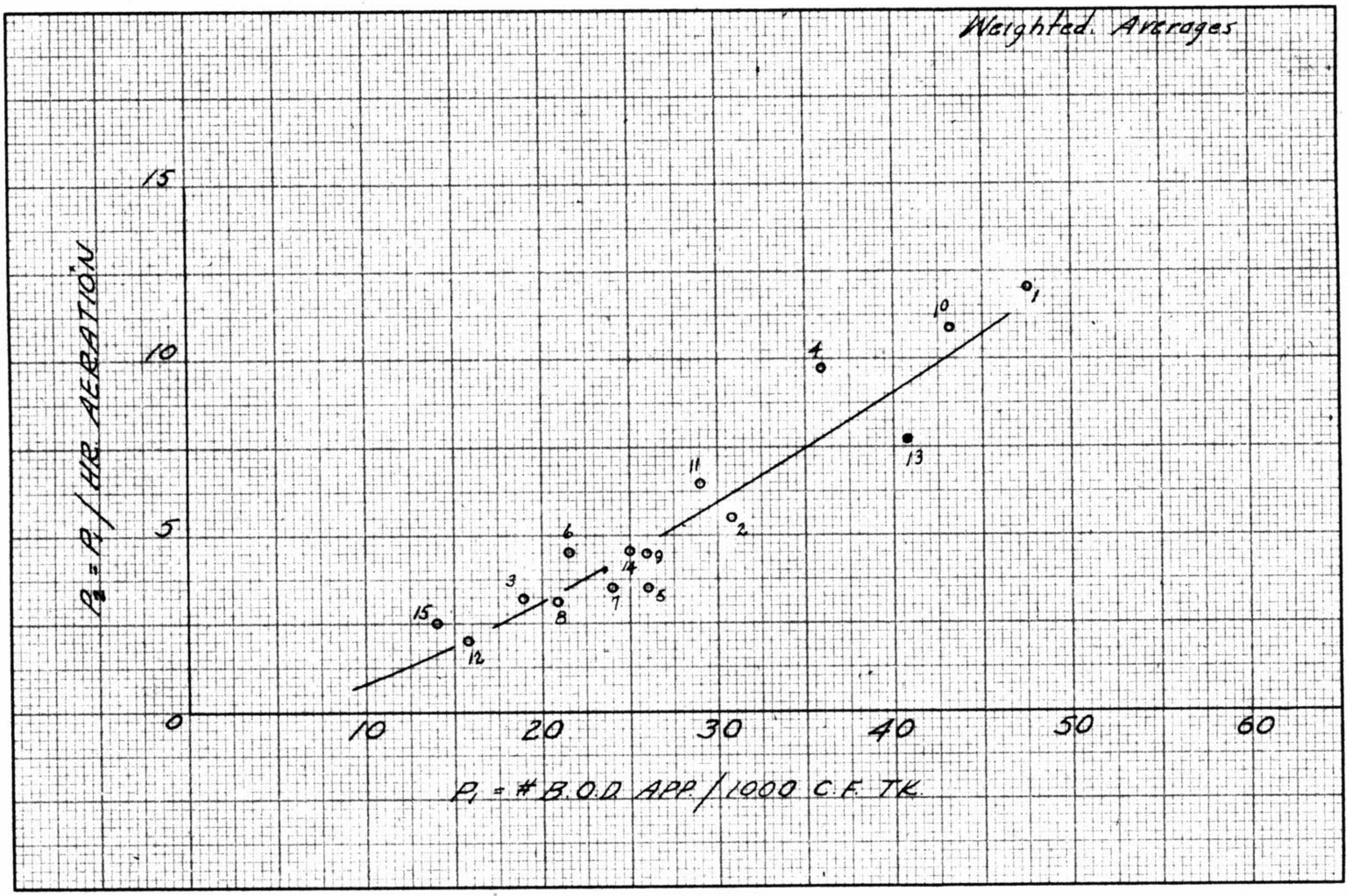

Weighted Averages
% REDUCTION OF B.O.D.
100
90
80
0
1
2
3
4
5
6
7
P3 = #B.O.D. APP. / 1000 C.F. TK. / HR. AER. / PPM S.S. x 1000
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15

FIG. #18



Weighted Averages
P2 - P1 / HR. AERATION
P1 = # B.O.D. APP. / 1000 C.F. TK.
0
5
10
15
10
20
30
40
50
60

FIG. #19

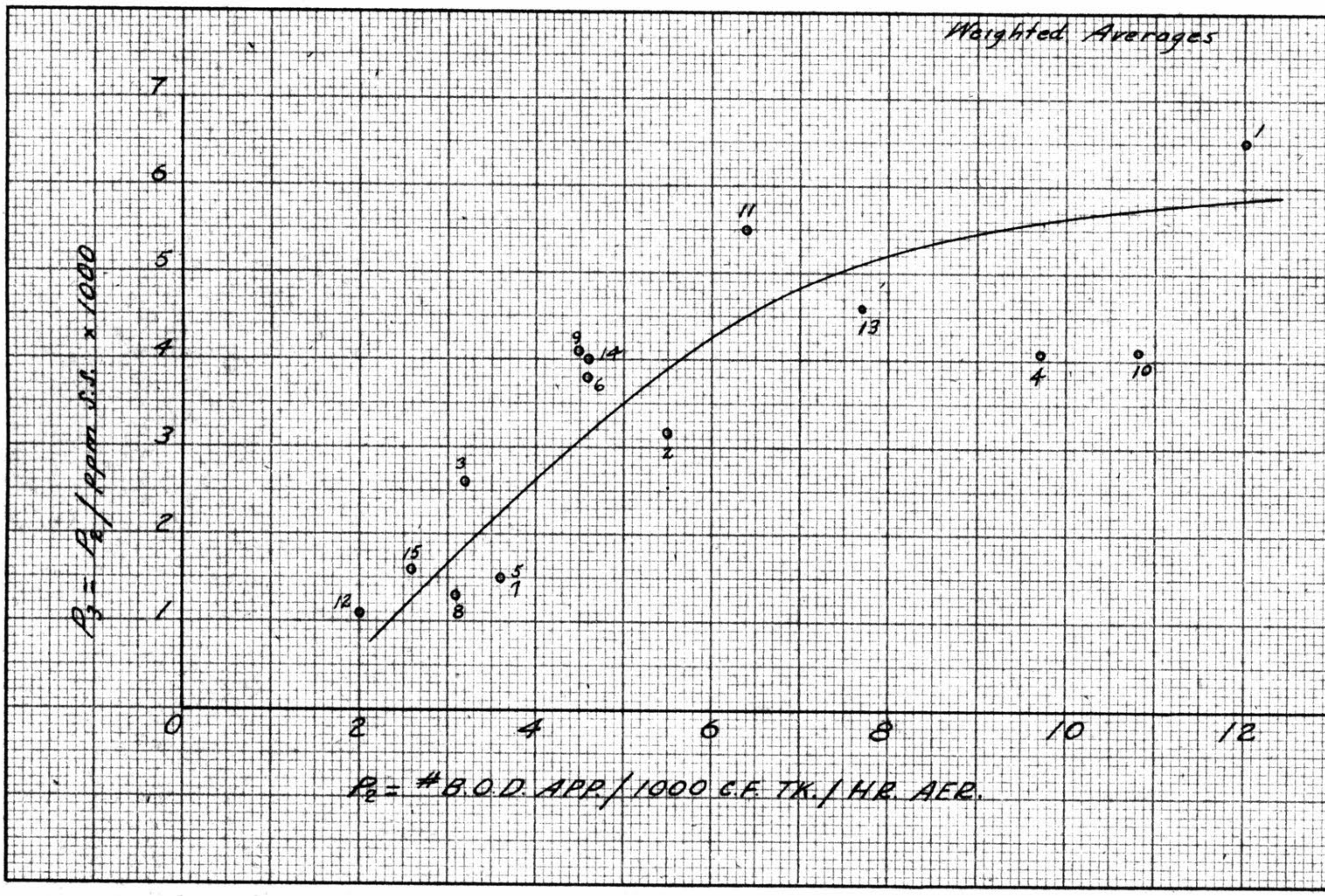
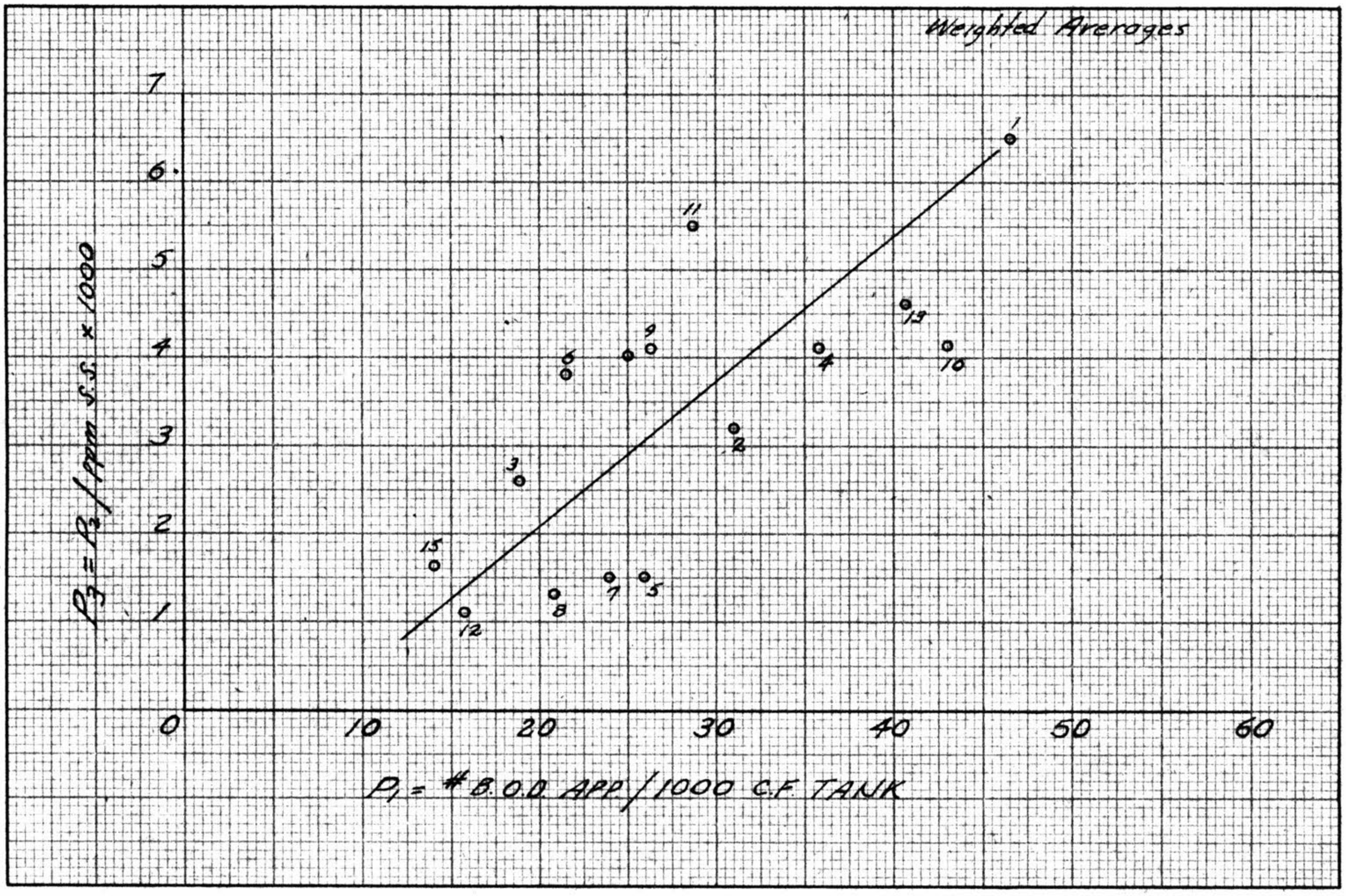

Weighted Averages
$P_3 = P_2 / \text{ppm S.S.} \times 1000$
P_2 = #B.O.D. APP./1000 C.F. TK./HR. AER.
0
2
4
6
8
10
12
1
2
3
4
5
6
7
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15

FIG. #20



Weighted Averages
P3 = P1 / ppm S.S. x 1000
P1 = # B.O.D APP / 1000 C.F TANK
0
10
20
30
40
50
60
1
2
3
4
5
6
7

FIG. # 21

VI DISCUSSION OF RESULTS

1 - Individual Plant Studies

Figures #1 thru #15 inclusive, except Figure #5, represent plottings of the three loading parameters P_1, P_2, and P_3 based on average monthly operation data. Figure #5 for Ft. Wayne, Ind., is unusual in that each of the seven plotted points represents the average of one year's operation.

The basic loading parameter, P_1, has been plotted against the more complex parameter, P_2, to show the relationship, if any, that exists between B.O.D. loading per unit volume of tank and B.O.D. loading per unit volume per unit of aeration time.

It seems logical to assume that a direct relationship should exist between these two functions for those plants operating at full capacity since an increase in flow of either sewage or returned sludge would increase the mixed liquor flow and necessitate a shorter detention period. On the other hand, plants having reserve aeration tank capacity may be able to proportion the available tank volume to the flow in order to maintain a desired detention period. This seems to have been done in the operation of the Marion, Indiana plant.

For a given loading, the detention period required will be inversely proportional to the ability of the process to clarify and oxidize the substrate. Since this ability is a function of the biological activity of the activated sludge, and the sludge activity is a function of the temperature, it seems reasonable to consider that the effect of temperature is one of lengthening or shortening the aeration contact time. Accordingly, in these individual plant studies, the values of parameters' P_2 and P_3 have been computed to include this effect as explained in the "Computation Methods" section.

The plottings of P_1 versus P_2 show that in most cases, a linear relationship exists between the two functions; that for increased loading there is an increase in the value of P_2. However, the plotted data for several of the plants are so erratic that no curve of best fit can be drawn while for other plants, a curved line seems to represent the curve of best fit.

The effect of suspended solids concentration in the mixed liquor related to B.O.D. loading per unit of aeration time is shown by parameter P_3. Parameter P_3 plotted against parameter P_2, in Figures #1 thru #15 inclusive, shows that for normal plant performance, a linear relationship exists between the suspended solids concentration in the mixed liquor and the unit B.O.D. load applied per unit of aeration time.

It is of interest to note that this relationship holds true for each of the fifteen plants even though in some plants the relation of P_1 to P_2 was linear, in others a curved line, and in some instances the values of P_1 and P_2 could not be correlated. Possibly the effect of the activated solids concentration in the mixed liquor is of such major effect that its variations over-shadow the effects of the other factors.

The effects of the all inclusive parameter, P_3, on plant performance shown in Figures #2, 5, 6, 8, and 11 which represent plants with loadings in the magnitude of 12 to 38 pounds of B.O.D. per 1000 cubic feet of aeration tank, show that the efficiency of each of these plants did not decrease with an increase in the value of P_3. This seems to indicate that these plants have not been operating at maximum capacity.

Figure #1, representing Ann Arbor, Mich., seems to indicate that B.O.D. loadings as high as 60 pounds per 1000 C.F. of aeration tank may be handled in this plant and still obtain B.O.D. removals of 89% and higher. These data in Figure #1 show that the plant efficiency has a definite tendency to decrease with increased values of the composite loading parameter P_3.

In contrast to the relative higher B.O.D. removals at Ann Arbor is the operating record of Madison, Wisc., shown by Figure #9. This plant, operating with B.O.D. loadings ranging from 23 tO 32 pounds per 1000 C.F. of aeration tank, has been able to obtain only 75 to 85% efficiencies, due, undoubtedly, to an excessive amount of slaughter house wastes being imposed upon the aeration process.

These nitrogenous materials are broken down by bacterial action with the consequent liberation of ammonia, which in turn is oxidized by the nitrifying flora to nitrites and nitrates. Hence, the apparent efficiency of the process, as measured by the B.O.D. removed, is low due to omitting the nitrification reactions. These nitrogenous wastes also cause considerable sludge bulking which further reduces the ability of the plant to stabilize the applied B.O.D..

The plants at Omaha and San Antonio, represented by Figures #12 and #14, also treat considerable amounts of slaughter house wastes and also show low B.O.D. removals.

These results, depicted by Figures #9, 12, and 14, seem to show that even though the proper relationship exists between the B.O.D. loads applied, the aeration period, and the concentration of suspended solids in the mixed liquor, the type of organic matter contributing the B.O.D. must also be considered. A careful review of the operation data from Omaha and San Antonio shows that high sludge indicies have been experienced resulting in suspended solids concentrations as low as 900 ppm in the mixed liquor.

Temperature undoubtedly has considerable effect on the performance of activated sludge plants. Some part of the temperature effect has been taken into account in computing the values of P_2 by using equivalent aeration periods.

However, the lower curves in Figures #1, 3, 4, 7, and 15, wherein the complex loading factor P_3 is related to percent B.O.D. reduction, seem to show an additional effect of temperature.

A study of the plotted points indicates that for the months of higher temperature, (1) the computed values of the composite loading parameter are lower due to the effect of lengthening the equivalent aeration period, and (2) the operating efficiencies are increased. The situation is reversed by lowering the temperature.

Thus, a constant purifying capacity can be maintained only by providing a greater concentration of activated solids in the mixed liquor during cold weather as compared to the concentrations required during warmer weather.

A composite of the several parameter curves plotted in Figure #16, taken from Figures #1 to #15, inclusive, indicates a rather wide range in plant loadings as represented by parameter P_3. Also, the slope and extent of the several inter-related curves varies considerably.

2 - Studies Including All Plants

Figure #17 seems to indicate that plant performance is independent of the magnitude of the B.O.D. load applied for values of P_1 less than 50.

In drawing in the curve of best fit, points #9, #12, and #14, representing the plants at Madison, Omaha, and San Antonio, respectively, were not considered in view of their low efficiencies which are readily attributed to the amount of slaughter house wastes they treat and not to the magnitude of the B.O.D. load applied.

A more complex parameter of loading to relate percentage B.O.D. removed to B.O.D. loading in terms of P_3 (lbs. B.O.D./1000 C.F./Hr./ppm S.S.) has been plotted in Figure #18. This plotting shows, as would be expected, the same trend as that of Figure #17. Again the results of plants #9, 12, and 14, have not been considered in plotting the curve in Figure #18. Time has not permitted a determination of the relation of loading versus percentage B.O.D. removal for these plants or an evaluation of the nitrification reactions.

The three loading parameters have been plotted against each other in consecutive order, from least complex to most complex, in Figures #19 and #20, in an attempt to determine the relationships existing between these several functions for a relatively constant degree of efficiency, i.e., the efficiency as depicted by the trend line of Figure #17.

Figure #19 shows good correlation between the B.O.D. load applied per unit volume and the same load applied per unit volume per unit of time. For the purpose of comparison, plants #9, #12, and #14 were plotted with the plants having average efficiencies above 90%. It can be seen that the same relationship exists between all plants regardless of the efficiency attained.

Therefore, it would appear that these two functions could not be used independently or together to determine the efficiency of a plant on the basis of the B.O.D. applied.

The relationship between parameters of second and third degree of complexity, shown in Figure #20, seems to have a definite trend for P_2 values ranging from 2.0 to 7.0 which correspond to B.O.D. loadings of 14 to 35 lbs/1000 C.F. of tank.

Thus, it appears that a ratio of suspended solids concentration to B.O.D. load may have to be increased for loadings in excess of 35 lbs. B.O.D./1000 C.F. of tank in order to maintain a constant degree of efficiency. However, the data presented herein are insufficient to prove this possibility.

The relationship between parameters of first and third degree of complexity, shown in Figure #21, indicates a definite trend toward a more or less linear relationship between the load applied and the time and activated solids concentration required to stabilize the load. However, the points are widely scattered which suggests that other factors, not yet determined, should be evaluated before full knowledge can be determined for the basic design and operating factors for aeration units.

VII CONCLUSIONS

The limited time has not permitted any comparison of the results of this study with work done by previous investigators. Accordingly, the following tentative conclusions are based upon the analysis of monthly operation data from fifteen carefully selected activated sludge type sewage treatment plants.

1 - This study, in which plant performance has been measured by the percent B.O.D. removed in the aeration and final tanks, has omitted the effect of B.O.D. reduction in the primary settling tank on the type and character of organic matter entering the aeration tank. Final conclusions as to basic design and operating factors should not be made until this effect is properly evaluated.

2 - The temperature of the sewage and activated sludge appears to have a definite effect on the performance of the activated sludge process. Conversion of aeration contact time to equivalent aeration time by application of the formula, $Y = 0.71 x^{1.54}$, in which Y is the relative activity of the microorganisms at X degrees centigrade, results in a spreading out of the computed values of the loading parameters for each plants. There is some uncertainty as to the validity of this correction. Additional adjustments may be

required to bring into harmony the results of the various plants.

3 - The efficiencies of the plants at Madison, Omaha, and San Antonio, which are much lower than those obtained by other plants with the same B.O.D. loadings, show fairly conclusively that the character of the organic matter materially affects the performance of the aeration process. It may be possible to increase the low efficiency figures of such plants to values comparable with the results obtained by other plants if the work done in stabilizing nitrogenous matter was properly evaluated.

4 - This study of 15 conventional type activated sludge plants in which loadings ranged up to 50 lbs. of B.O.D. per 1000 cubic feet of aeration tank, seems to show no decrease in efficiency for the higher loadings. Thus, it may be feasible to design activated sludge plants for substantially higher loadings than so far considered proper.

5 - A ratio of suspended solids concentration to B.O.D. load must be increased during periods of low temperature if the aeration process is to maintain a constant degree of purification.

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2. Schroepfer, G.J.,: "Economics of Sewage Treatment", Proc. A.S.C.E., 65, 1210 (1939)

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IX APPENDICES

APPENDIX A

This appendix contains the following information:

1) A list of the cooperating officials who furnished the basic data for this investigation.
2) Extracted operating data, Tables A-1 thru A-15, from each of the plants studied.

LIST OF COOPERATING OFFICIALS

Plant No.	Official
1.	Mr. C. Preston Witcher, Superintendent Ann Arbor Sewage Plant Ann Arbor, Michigan
2.	Mr. A. H. Ullrich, Superintendent Water and Sewage Treatment Austin, Texas
3.	Mr. J. W. Ellms Commissioner of Sewage Disposal Cleveland, Ohio (Easterly Plant)
4.	Dr. W. T. Hatfield Superintendent of Sanitary District Decatur, Illinois
5.	Mr. Paul L. Brunner, Chief Chemist Sewage Treatment Plant Fort Wayne, Indiana
6.	Mr. W. W. Mathews, Superintendent Gary Sanitary District Gary, Indiana
7.	Mr. Carl B. Carpenter Superintendent of Sanitary District Hammond, Indiana
8.	Mr. A. B. Cameron, Superintendent Sewage Treatment Works Jackson, Michigan
9.	Mr. H. O. Lord, Chief Engineer and Director Metropolitan Sewerage District of Madison, Wisconsin (Nine Springs)
10.	Mr. David Backmeyer, Superintendent Sewage Treatment Plant Marion, Indiana
11.	Mr. Paul R. White, Consulting Engineer 505 Alameda Avenue Muncie, Indiana
12.	Mr. William J. Provaznik Sewer and Sanitation Engineer Department of Public Improvements Omaha, Nebraska

13. Mr. L. S. Kraus, Chief Chemist
Peoria Sanitary District
Peoria, Illinois

14. Mr. E. J. M. Berg, Superintendent
Sewage Treatment Plant
San Antonio, Texas

15. Mr. C. C. Larson, Chemist
Springfield Sanitary District
Springfield, Illinois

- OPERATION DATA

s	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	YEARLY AVG.		
ge Flows - M.G.D.															
Raw - To plant (Total)	5.6	5.7	6.4	8.0	7.9	7.2	6.5	6.3	6.4	6.4	6.3	6.3	6.6		
Settled - To Aeration															
Mixed Liquor - in Aer.Tks.	7.8	7.7	8.1	9.5	9.7	9.2	8.5	8.3	8.4	8.3	8.2	8.2	8.5		
ytical Data (Laboratory)															
B.O.D. - ppm															
1. Raw Sewage	228	236	220	159	178	171	195	184	177	220	224	220	201		
2. Settled "	177	195	197	160	178	166	151	122	132	195	192	165	169		
3. Fin.Eff."	12	11	15	18	19	8	18	2	9	19	16	7	13		
Sus.Solids, ppm															
1. Raw Sewage	199	201	198	152	178	158	163	157	171	177	173	180	176		
2. Settled "	102	111	130	128	117	139	85	67	85	106	107	105	107		
3. Fin.Eff."	7	9	10	15	16	14	27	8	8	9	9	10	12		
4. Returned Sludge	5700	5700	5400	6050	5875	5400	4850	5000	5050	5500	5875	5500	5500		
5. Mixed Liquor - ppm	2175	2175	2100	1800	1575	1725	1650	1650	1650	1875	2000	1875	1850		
(a) % Volatile Sol.in Mix.Liq.															
D.O. ppm															
1. Aeration Tank Inlet															
Outlet															
2. Fin.Eff.Sewage	3.8	4.1	4.8	4.3	5.4	5.5	6.1	6.3	5.2	3.7	3.9	3.5	4.7		
Nitrogens - ppm (Fin.Eff.)															
1. NH_3															
2. NO_2															
3. NO_3															
Sewage Temp. (°F)	59	57	56	55	61	65	69	73	70	67	65	60	63		
pH (Raw or Settled ?)	9.3	9.1	8.6	8.2	8.0	7.8	7.5	7.2	7.2	7.5	8.0	8.2	8.1		
rned Sludge															
Sludge Index															
M.G.D. - Ret.Sludge	2.0	2.0	2.0	2.0	2.1	2.2	2.2	2.1	2.0	1.9	1.9	1.9	2.0		
% of Sewage	36	35	31	25	27	31	34	33	31	30	30	30	31		
Quantities															
Cu.ft./dy. (1000's)	4800	6100	6900	5600	4900	5500	6700	5300	5000	8100	5900	6600	5950		
Cu.ft./gal.	0.9	1.1	1.1	0.7	0.6	0.8	1.0	0.9	0.8	1.3	1.0	1.1	0.9		
Cu.ft.-lbs. BOD Removed															
tion Tanks (Liq.Vol.used)															
Mix Liq.Aer. - 1000 cf	194.4	194.4	194.4	194.4	194.4	194.4	194.4	194.4	194.4	194.4	194.4	194.4	194.4		
Pre and Reaer. - 1000 cf															
Aeration Per. - hrs.(Mix.Liq.)	4.4	4.3	4.2	3.5	3.4	3.6	4.0	4.0	4.0	4.0	4.1	4.1	4.0		
ling Tanks (~~Liq.Vol.used or~~ Detention Periods)															
Primary Settling	0.90	0.85	0.75	0.60	0.61	0.67	0.74	0.76	0.75	0.75	0.76	0.76	0.73		
Second Settling	1.48	1.50	1.43	1.22	1.19	1.26	1.36	1.40	1.38	1.40	1.41	1.41	1.36		

- OPERATION DATA

s	Jan. A	Feb. B	Mar. B	Apr. B	May B	June A	July A	Aug. A	Sept. A	Oct. A	Nov. B	Dec.	YEARLY AVG.	AVG. "A" 6 Mo.	AVG. 5 M
ge Flows - M.G.D.															
Raw - To plant (Total)	5.90	5.90	7.60	6.97	5.82	6.81	6.64	6.54	7.11	7.19	6.48	6.85	6.60	6.69	6.
Settled - To Aeration															
Mixed Liquor - in Aer.Tks.	7.62	7.31	9.52	8.33	7.75	9.47	9.28	8.23	8.83	8.92	8.35	8.65	8.47	8.73	8.
ytical Data (Laboratory)															
B.O.D. - ppm															
1. Raw Sewage	282	284	302	303	322	288	309	233	252	262	267	257	280	271	27
2. Settled "	112	163	136	175	159	157	172	162	141	149	154	169	154	149	15
3. Fin.Eff."	10	30	28	44	33	14	10	11	11	13	28	87	27	11.5	3
Sus.Solids, ppm															
1. Raw Sewage	239	274	289	272	292	282	253	251	245	229	270	249	262	250	27
2. Settled "	84	90	101	92	91	90	97	110	91	95	103	94	95	95	9
3. Fin.Eff."	10	6	12	12	5	4	4	7	6	10	17	72	14	6	1
4. Returned Sludge	6485	7720	3220	5110	5515	6570	4135	7980	8010	7185	5275	4530	6520	6727	53
5. Mixed Liquor - ppm	1645	1540	910	905	1430	2125	1480	1790	1790	1560	1400	1025	1470	1731	123
(a) % Volatile Sol.in Mix.Liq.	71	70	68	65	69	66	71	72	70	70	71	71	70	70	6
D.O. ppm															
1. Aeration Tank Inlet															
Outlet															
2. Fin.Eff.Sewage	1.0	2.2	1.9	0.5	1.0	1.0	1.1	1.4	1.2	1.3	0.9	0.9	1.2	1.1	1.
Nitrogens - ppm (Fin.Eff.)															
1. NH_3	18.8	3.5	13.8	12.1	14.0	6.0	11.8	20.7	14.2	15.9	20.9	18.8	14.2	14.6	12
2. NO_2	1.2	3.1	5.4	3.2	3.5	3.4	0.5	1.2	3.9	3.3	3.7	2.[illegible]	2.9	2.2	3.
3. NO_3	6.1	3.5	14.9	0.4	1.1	2.6	4.6	2.4	0.2	0.0	0.2	2.4	2.1	2.6	4.
Sewage Temp. (°F)	66	65	66	72	76	81	84	87	85	79	76	69	76	80	7
pH (Raw or Settled ?)															
ned Sludge															
Sludge Index (Mixed Liq.)	97	163	566	460	313	297	451	240	273	316	387	344	326	279	37
M.G.D. - Ret.Sludge	1.72	1.41	1.92	1.36	1.93	2.66	2.64	1.69	1.72	1.73	1.87	1.80	1.87	2.03	1.6
% of Sewage	29.9	23.0	26.0	20.6	33.7	39.8	39.9	26.1	24.5	24.6	29.0	26.7	28.3	30.8	26
uantities															
Cu.ft./dy. (1000's)	4803	5416	5406	4098	4832	5820	5504	6903	7373	6958	6448	7297	5909	6226	524
Cu.ft./gal.	0.82	0.92	0.72	0.62	0.84	0.87	0.84	1.07	1.05	0.98	1.00	1.10	0.90	0.94	0.8
Cu.ft.-lbs. BOD Removed															
ion Tanks (Liq.Vol.used)															
Mix Liq.Aer. - 1000 cf	253	253	253	253	253	253	253	253	253	253	253	253	253	253	25
~~Pre and~~ Reaer. - 1000 cf	18.8	18.8	18.8	18.8	18.8	18.8	18.8	18.8	18.8	18.8	18.8	18.8	18.8	18.8	18
Aeration Per. - hrs.(Mix.Liq.)	6.2	6.6	6.2	6.0	6.5	5.3	5.4	5.9	5.5	5.5	5.8	5.6	5.8	5.6	6.
ing Tanks (~~Liq.Vol.used or~~ Detention Periods)															
Primary Settling	1.6	1.6	1.3	1.4	1.6	1.4	1.4	1.5	1.3	1.3	1.5	1.4	1.4	1.4	1.5
Second Settling	2.5	2.6	2.5	2.3	2.5	2.0	2.1	2.2	2.1	2.0	2.2	2.1	2.3	2.1	2.
latile Solids in Mix. Liq. (ppm)	1170	1075	615	585	990	1400	1050	1290	1240	1090	1000	730	1020	1207	85

OMIT

- OPERATION DATA

s	Jan. B	Feb. B	Mar. B	Apr. B	May B	June A	July A	Aug. A	Sept. A	Oct. A	Nov. A	Dec. A	YEARLY AVG.	AVG. "A" 7 Mo.	AV... 5
ge Flows - M.G.D.															
Raw - To plant (Total)	92.9	103.2	104.0	101.6	104.4	103.2	95.3	91.1	98.6	86.0	79.3	94.1	96.1	92.5	[illegible]
Settled - To Aeration	83.7	84.7	81.6	100.5	100.0	103.1	93.3	89.0	91.8	82.9	78.1	92.9	90.1	90.2	[illegible]
Mixed Liquor - in Aer.Tks.	104.6	107.1	102.8	126.7	129.4	129.2	118.7	116.2	119.1	107.8	100.7	118.6	115.1	115.7	[illegible]
ytical Data (Laboratory)															
B.O.D. - ppm															
1. Raw Sewage	171	118	143	163	147	168	175	197	171	197	209	213	173	190	[illegible]
2. Settled "	120	71	77	72	72	84	99	109	78	92	83	116	89	94	[illegible]
3. Fin.Eff."	20.8	13.6	11.9	10.4	9.0	4.1	4.2	4.2	7.2	8.4	7.2	12.7	9.5	6.9	[illegible]
Sus.Solids, ppm															
1. Raw Sewage	247	282	248	293	253	260	232	218	215	190	236	203	240	222	[illegible]
2. Settled "															
3. Fin.Eff."	27.5	22.4	9.7	10.6	8.2	7.2	6.0	7.0	10.5	10.1	10.4	17.0	12.2	9.7	[illegible]
4. Returned Sludge	7190	7800	5250	6480	6190	5740	5480	5210	4400	3960	3510	5650	5570	4821	[illegible]
5. Mixed Liquor - ppm	1820	2030	1230	1450	1430	1310	1380	1440	1200	1120	1010	1280	1390	1248	[illegible]
(a) % Volatile Sol.in Mix.Liq.	68.6	65.5	64.2	63.0	63.8	61.5	62.6	63.7	58.9	62.4	63.5	67.3	64.1	62.8	
D.O. ppm															
1. Aeration Tank Inlet	2.3	3.4	3.9	2.1	1.5	0.9	0.6	0.5	1.5	1.6	1.5	1.9	1.8	1.2	[illegible]
Outlet															
2. Fin.Eff.Sewage	4.7	4.7	6.1	4.7	3.8	2.8	2.5	3.6	5.2	7.2	9.3	7.4	5.2	5.6	[illegible]
Nitrogens - ppm (Fin.Eff.)															
1. NH_3	7.1	5.2	4.8	6.0	6.7	5.5	3.0	1.2	1.3	0.5	0.6	4.6	3.9	2.4	
2. NO_2	0.3	0.5	0.7	0.4	0.3	0.4	0.5	0.2	0.8	0.9	1.4	0.9	0.6	0.7	
3. NO_3	3.4	2.9	2.5	2.8	3.0	2.3	2.0	4.8	5.9	8.2	7.1	4.1	4.1	4.9	
Sewage Temp. (°F)	59	56	57	62	64	69	76	79	76	70	67	61	66	71	
pH ~~Raw or~~ Settled ?)	7.1	7.1	7.1	7.1	7.1	7.1	7.2	7.2	7.3	7.3	7.4	7.3	7.2	7.2	
rned Sludge															
Sludge Index (Mix. Liq.)	100	87	89	78	81	87	112	111	67	81	83	82	88	89	
M.G.D. - Ret.Sludge	21.7	22.4	21.3	26.3	26.6	26.1	25.5	27.3	27.4	25.2	22.8	25.8	24.9	25.7	[illegible]
% of Sewage	25.9	26.4	26.1	26.2	26.6	25.3	27.3	30.7	29.8	30.4	29.5	27.9	27.6	28.7	[illegible]
Quantities															
Cu.ft./dy. (1000's)															
Cu.ft./gal.	1.09	1.05	1.03	1.01	0.98	0.88	1.01	1.04	1.01	1.05	1.12	0.79	1.01	0.99	[illegible]
Cu.ft./lbs. BOD Removed															
tion Tanks (Liq.Vol.used)															
Mix Liq.Aer. - 1000 cf	3780	3780	3780	3780	3780	3780	3780	3780	3780	3780	3780	3780	3780	3780	[illegible]
Pre and Reaer. - 1000 cf															
Aeration Per. - hrs.(Mix.Liq.)	6.60	6.34	6.60	5.36	5.25	5.25	5.72	5.84	5.70	6.30	6.80	5.73	5.90	5.90	[illegible]
ling Tanks (Liq.Vol.used or Detention Periods)															
Primary Settling 684,000	1.3	1.2	1.2	1.2	1.2	1.2	1.3	1.35	1.25	1.43	1.55	1.30	1.3	1.3	[illegible]
Second Settling 1,880,000	3.2	3.2	3.3	2.7	2.6	2.6	2.9	2.9	2.84	3.14	3.38	2.85	2.9	2.9	[illegible]
ATILE SOLIDS IN MIX. LIQ. - ppm	1250	1340	788	915	915	810	870	920	710	695	645	860	890	787	[illegible]

- OPERATION DATA

	Jan. A	Feb. A	Mar. A	Apr. A	May A	June	July A	Aug. A	Sept. A	Oct. A	Nov. A	Dec.	YEARLY AVG.	AVG. "A" 10 Mo.
e Flows - M.G.D.														
Raw - To plant (Total)														
Settled - To Aeration	3.60	3.70	3.98	5.58	6.38		5.03	4.52	5.43	4.13	4.62	4.26	4.66	4.70
Mixed Liquor - in Aer.Tks.	4.28	4.38	4.75	6.37	7.18		5.57	5.17	6.06	4.71	5.22	4.76	5.31	5.37
tical Data (Laboratory)														
B.O.D. - ppm														
1. Raw Sewage	283	289	286	229	183		196	229	175	171	202	193	221	224
2. Settled "	206	208	209	119	134		145	173	129	123	151	127	157	160
3. Fin.Eff."	21	13	9	8	10		14	12	11	10	15	18	13	12
Sus.Solids, ppm														
1. Raw Sewage	322	299	278	200	274		260	286	250	272	241	279	269	268
2. Settled "														
3. Fin.Eff."	43	43	41	35	36		43	33	37	28	42	34	38	38
4. Returned Sludge														
5. Mixed Liquor - ppm	2776	3033	2759	2890	3120		2080	2084	1518	1660	1495	1746	2287	2342
(a) % Volatile Sol.in Mix.Liq.														
D.O. ppm														
1. Aeration Tank Inlet														
Outlet														
2. Fin.Eff.Sewage	3-6	3-4	2-4	3-6	2-4		2-4	0.5-4	0.5-4	0.5-4	0.7-4	5-6		—
Nitrogens - ppm (Fin.Eff.)														
1. NH_3														
2. NO_2														
3. NO_3	1.7	0.7	0.4	1.1	0.6		0.5	0.6	0.4	0.5	0.4	0.7	0.7	0.7
Sewage Temp. (°F)	77	77	77	72	80	NO ANALYSES MADE	93	96	96	91	81	78	83	84
pH (Raw or Settled ?)													6.8-7.2	—
ned Sludge														
Sludge Index	39	38	46	38	29		32	82	84	82	98	61	57	57
M.G.D. - Ret.Sludge	0.68	0.68	0.74	0.80	0.71		0.54	0.65	0.63	0.59	0.59	0.50	0.65	0.66
% of Sewage														
uantities														
Cu.ft./dy. (1000's)	5080	5040	5120	4970	5330		5240	4550	4660	4520	5350	4820	4970	4986
Cu.ft./gal.	1.41	1.36	1.29	0.89	0.84		1.04	1.01	0.86	1.09	1.16	1.13	1.10	1.10
Cu.ft.-lbs. BOD Removed														
ion Tanks (Liq.Vol.used)														
Mix Liq.Aer. - 1000 cf	112.66	112.66	112.66	112.66	112.66		112.66	112.66	112.66	112.66	112.66	112.66	112.66	112.66
~~Pre and~~ Reaer. - 1000 cf	56.33	56.33	56.33	56.33	56.33		56.33	56.33	56.33	56.33	56.33	56.33	56.33	56.33
Aeration Per. - hrs.(Mix.Liq.)	4.67	4.56	4.21	3.14	2.78		3.59	3.87	3.30	4.25	3.83	4.20	3.85	3.82
ing Tanks (Liq.Vol.used ~~or Detention Periods~~)														
Primary Settling (Imhoff Tks.)	63,700													
Second Settling 128,600 C.F.														

- OPERATION DATA

	1941	1942	1943	1944	1945	1946	1947				7 Year Avg.				
e Flows - M.G.D.															
Raw - To plant (Total)	14.5	17.6	18.4	18.4	18.3	18.7	19.6				17.9				
Settled - To Aeration	12.7	14.0	15.4	16.6	15.9	17.8	18.1				15.8				
Mixed Liquor - in Aer.Tks.	16.8	18.8	20.2	20.7	20.9	22.4	23.4				20.5				
tical Data (Laboratory)															
B.O.D. - ppm															
1. Raw Sewage	208	190	191	214	219	198	229				207				
2. Settled "	174	155	152	163	163	167	187				166				
3. Fin.Eff."	15.5	13.1	13.5	17.9	15.8	15.7	12.0				14.8				
Sus.Solids, ppm															
1. Raw Sewage	284	199	192	234	269	235	234				235				
2. Settled "															
3. Fin.Eff."	15.2	14.8	19.8	17.4	15.7	11.3	12.0				15.2				
4. Returned Sludge	9800	9700	11,100	12,100	10,900	10,000	11,200				10,700				
5. Mixed Liquor - ppm	2280	2330	2417	2527	2547	2288	2398				2400				
(a) % Volatile Sol.in Mix.Liq.															
D.O. ppm															
1. Aeration Tank Inlet															
Outlet	4.9	5.2	5.1	5.2	5.3	4.4	5.1				5.0				
2. Fin.Eff.Sewage	4.8	5.2	5.2	5.0	5.0	4.6	5.0				5.0				
Nitrogens - ppm (Fin.Eff.)															
1. NH_3															
2. NO_2															
3. NO_3	22	13	—	—	—	19	10.				—				
Sewage Temp. (°F)	64	62	62	63	63	64	62				63				
pH (Raw ~~or Settled ?~~)	7.50	7.4	7.4	7.4	7.81	7.65	7.53				7.5				
ned Sludge															
Sludge Index	127	111	102	94	114	96	110				108				
M.G.D. - Ret.Sludge	4.1	4.8	4.8	4.1	5.0	4.6	5.3				4.7				
% of Sewage	32	34	32	25	32	26	29				30				
uantities															
Cu.ft./dy. (1000's)	14,700	13,700	13,400	14,300	14,800	14,600	13,900				14,200				
Cu.ft./gal.	1.16	0.98	0.87	0.86	0.93	0.82	0.77				0.91				
Cu.ft.-lbs. BOD Removed															
ion Tanks (Liq.Vol.used)															
Mix Liq.Aer. - 1000 cf	843	843	843	843	845	843	843				843				
Pre and Reaer. - 1000 cf															
Aeration Per. - hrs.(Mix.Liq.)	9.0	8.1	7.5	7.3	7.3	6.8	6.5				7.5				
ing Tanks (Liq.Vol.used ~~or Detention Periods~~)															
Primary Settling	128	128	128	128	128	128	128				128				
Second Settling	333	333	333	333	333	333	333				333				

- OPERATION DATA

	Jan. A	Feb. A	Mar. A	Apr. A	May A	June B	July B	Aug. B	Sept. A	Oct. B	Nov. B	Dec. B	YEARLY AVG.	AUG. "A" 6 Mo.	AUG. " 6 M
e Flows - M.G.D.															
Raw - To plant (Total)	20.82	19.44	21.70	18.96	19.75	21.19	21.42	22.10	21.17	18.84	19.59	19.41	20.38	20.31	20.
Settled - To Aeration															
Mixed Liquor - in Aer.Tks.	25.62	25.63	26.49	24.96	25.30	26.48	27.01	27.87	26.44	23.92	24.47	24.58	25.73	25.74	25.
tical Data (Laboratory)															
B.O.D. - ppm															
1. Raw Sewage	135.3	145.9	135.1	175.5	162.8	139.7	135.7	138.6	172.6	172.5	144.7	179.2	152.7	154.5	151.
2. Settled "	72.2	77.3	63.2	90.8	74.3	67.4	58.6	87.9	117.9	105.6	66.4	90.9	80.7	82.6	79.
3. Fin.Eff."	61	8.8	7.2	6.0	7.8	15.0	12.8	16.6	11.6	15.6	9.3	10.5	10.7	7.9	13.
Sus.Solids, ppm															
1. Raw Sewage	294	228	308	397	279	328	358	304	354	356	365	392	331	310	35
2. Settled "	91	87	93	110	98	85	79	111	120	116	98	112	100	100	10
3. Fin.Eff."	5	5	7	4	4	4	5	4	3	4	3	4	4	5	4
4. Returned Sludge	5116	4604	4489	3890	3345	3863	4062	4149	3464	2811	3748	4583	4010	4151	386
5. Mixed Liquor - ppm	1296	1285	1228	1143	1119	1086	1011	999	1166	876	1017	1236	1122	1206	103
(a) % Volatile Sol.in Mix.Liq.	71	74	66	69	67	64	63	65	64	68	65	66	67	69	6
D.O. ppm															
1. Aeration Tank Inlet															
Outlet	6.6	7.4	6.9	7.6	7.3	4.9	4.1	2.7	3.9	4.1	7.1	7.1	5.8	6.6	5.
2. Fin.Eff.Sewage	8.6	8.7	8.2	8.5	8.9	8.0	7.1	7.7	8.1	8.5	9.0	9.2	8.4	8.5	8.2
Nitrogens - ppm (Fin.Eff.)															
1. NH_3															
2. NO_2															
3. NO_3															
Sewage Temp. (°F)	50	49	50	53	56	59	61	64	64	62	59	53	57	54	60
pH (Raw ~~or Settled ?~~)	7.4	7.3	7.2	7.2	7.3	7.1	7.1	7.1	7.1	7.1	7.2	7.2	7.2	7.2	7.1
ned Sludge															
Sludge Index	92	103	110	128	113	86	83	113	108	110	92	87	102	109	95
M.G.D. - Ret.Sludge	6.47	6.19	6.62	7.05	6.76	6.11	6.02	6.60	6.21	6.47	6.45	6.82	6.48	6.55	6.4
% of Sewage	33.7	33.0	33.3	39.3	36.4	30.1	28.7	31.0	30.7	37.1	35.8	38.4	34.0	34.4	33.5
uantities															
Cu.ft./dy. (1000's)	8746	8855	8264	8508	8429	8195	8370	9067	9206	8666	8665	8727	8642	8668	861
Cu.ft./gal.	0.46	0.47	0.42	0.47	0.45	0.40	0.40	0.43	0.46	0.50	0.48	0.49	0.43	0.46	0.4
Cu.ft./lbs. BOD Removed	762	798	815	634	769	918	977	688	491	612	927	671	755	712	79
ion Tanks (Liq.Vol.used)															
Mix Liq.Aer. - 1000 cf	668	668	668	668	668	668	668	668	668	535	535	668	6.46	668	62
Pre and Reaer. - 1000 cf															
Aeration Per. - hrs.(Mix.Liq.)	4.68	4.81	4.83	4.57	4.74	4.61	4.69	4.30	4.55	4.21	3.93	4.36	4.52	4.70	43
ing Tanks (~~Liq.Vol.used or~~ Detention Periods)															
Primary Settling	1.93	2.00	2.03	2.15	1.99	1.91	1.89	1.85	1.91	2.10	2.14	2.07	2.00	2.00	1.9
Second Settling	3.19	3.28	3.07	3.27	3.21	3.10	3.03	2.93	3.11	3.33	2.96	2.23	3.06	3.19	2.9
ATILE SOLIDS IN MIX. LIQ. - PPM	920	950	810	790	750	695	637	650	745	595	660	815	750	827	67

- OPERATION DATA

s	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	YEARLY AVG.
ge Flows - M.G.D.													
Raw - To plant (Total)	22.94	20.08	24.29	20.18	18.42	19.46	19.60	17.70	15.52	16.35	18.52	21.00	19.42
Settled - To Aeration													
Mixed Liquor - in Aer.Tks.	34.01	31.00	35.09	30.91	29.23	30.45	30.56	28.61	26.50	28.10	30.27	32.82	30.63
ytical Data (Laboratory)													
B.O.D. - ppm													
1. Raw Sewage	261	291	218	214	231	164	170	230	299	230	148	182	220
2. Settled "	214	236	193	177	164	124	116	160	232	165	109	146	170
3. Fin.Eff."	17	24	19	17	13	7	8	12	13	6	11	16	14
Sus.Solids, ppm													
1. Raw Sewage	284	285	215	250	249	194	197	298	459	248	113	149	245
2. Settled "	246	203	194	185	156	119	105	170	401	148	78	103	177
3. Fin.Eff."	20	20	18	15	16	17	13	19	26	16	20	27	19
4. Returned Sludge	7750	6318	7010	6520	7460	6479	5851	7145	8460	5744	5088	5829	6637
5. Mixed Liquor - ppm	2591	2323	2280	2322	2418	2415	2137	2715	3420	2465	2066	2274	2477
(a) % Volatile Sol.in Mix.Liq.	69	76	66	66	66	61	61	60	62	65	73	72	66
D.O. ppm													
1. Aeration Tank Inlet													
Outlet	3.8	3.0	3.9	3.6	4.4	5.5	5.1	3.0	2.3	4.7	5.7	4.4	4.11
2. Fin.Eff.Sewage	2.6	1.4	3.3	2.4	3.5	4.7	4.2	1.9	1.1	3.9	4.9	3.7	3.13
Nitrogens - ppm (Fin.Eff.)													
1. NH_3													
2. NO_2													
3. NO_3	3.0	1.9	2.8	4.4	8.5	7.3	7.5	6.5	6.9	10.1	7.7	4.4	5.7
Sewage Temp. (°F)	50	49	50	54	58	65	70	72	72	69	52	56	61
pH (Raw ~~or settled ?~~)	7.5	7.4	7.3	7.5	7.3	7.3	7.4	7.4	7.3	7.3	7.6	7.6	7.4
ned Sludge													
Sludge Index (Mix. Liq.)	91	80	47	55	58	60	69	87	68	59	63	80	68
M.G.D. - Ret.Sludge	11.20	10.92	10.83	10.80	10.81	10.99	10.96	10.91	10.97	11.75	11.75	11.44	11.11
% of Sewage	48.8	54.3	44.5	53.5	58.3	56.5	56.0	61.7	70.5	71.9	63.4	54.5	57.8
uantities													
Cu.ft./dy. (1000's)	1296	1157	1145	1072	974	1020	1303	1174	1076	1175	1082	1135	1134
Cu.ft./gal.	0.60	0.71	0.55	0.78	0.66	0.79	0.79	0.78	1.00	0.90	0.68	0.60	0.75
Cu.ft./lbs. BOD Removed	364	403	377	579	685	612	855	633	550	675	625	556	610
ion Tanks (Liq.Vol.used)													
Mix Liq.Aer. - 1000 cf	1149	1149	1149	1149	1149	1149	1149	1149	1149	1149	1149	1149	1149
Pre ~~and Reaer~~. - 1000 cf	25	25	25	25	25	25	25	25	25	25	25	25	25
Aeration Per. - hrs.(Mix.Liq.)	6.29	6.93	6.14	6.96	7.40	7.15	7.05	7.53	8.12	7.65	7.12	6.57	7.07
ing Tanks (~~Liq.Vol.used or~~ Detention Periods)													
Primary Settling	1.10	1.26	1.05	1.26	1.38	1.31	1.30	1.44	1.64	1.56	1.38	1.21	1.30
Second Settling	2.42	2.66	2.33	2.67	2.82	2.71	2.70	2.89	3.10	2.94	2.72	2.52	2.70
LATILE SOLIDS IN MIX. LIQ — PPM	1790	1770	1505	1530	1800	1470	1300	1630	2120	1600	1510	1640	1645

- OPERATION DATA

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	YEARLY AVG.
e Flows - M.G.D.													
Raw - To plant (Total)	6.75	6.94	8.39	7.40	6.68	6.18	8.41	7.07	6.89	7.06	6.54	6.55	7.06
Settled - To Aeration	7.00	6.71	8.45	7.44	6.83	6.24	8.11	6.89	6.72	7.14	6.63	6.26	7.03
Mixed Liquor - in Aer.Tks.	7.85	7.42	9.25	8.35	7.96	7.66	8.90	7.84	7.44	8.09	7.30	7.26	7.93
tical Data (Laboratory)													
B.O.D. - ppm													
1. Raw Sewage	166	166	138	173	158	147	145	122	154	140	170	186	155
2. Settled "	125	124	111	125	109	102	85	68	93	107	115	124	107
3. Fin.Eff."	4	5	4	4	4	3	3	3	3	4	5	7	4
Sus.Solids, ppm													
1. Raw Sewage	231	216	204	266	249	237	243	191	224	206	221	266	229
2. Settled "	155	158	173	162	149	133	129	105	114	124	136	146	140
3. Fin.Eff."	14	16	14	16	15	15	15	13	14	13	16	18	15
4. Returned Sludge	16,000	16,000	18,000	16,000	16,000	14,000	15,000	14,000	14,000	15,000	14,000	15,000	15,000
5. Mixed Liquor - ppm	2522	2556	2456	2431	2500	2270	2017	2205	2215	2309	2130	2431	2337
(a) % Volatile Sol.in Mix.Liq.													
D.O. ppm													
1. Aeration Tank Inlet	4.4	4.4	3.9	2.9	2.5	1.2	1.1	0.9	0.6	2.9	2.9	3.3	2.6
Outlet													
2. Fin.Eff.Sewage	8.0	8.0	7.1	7.0	6.4	6.0	4.9	5.5	5.1	7.5	7.7	7.2	6.7
Nitrogens - ppm (Fin.Eff.)													
1. NH_3													13.7
2. NO_2													0.1
3. NO_3													0.0
Sewage Temp. (°F)	52	51	56	60	62	66	69	68	67	64	59	54	61
pH (Raw or Settled ?)													
ned Sludge													
Sludge Index	40	41	44	55	54	63	53	51	66	54	46	45	51
M.G.D. - Ret.Sludge	1.17	1.20	1.13	1.16	1.21	1.12	1.06	1.06	1.14	1.10	0.99	1.01	1.11
% of Sewage	17	18	14	16	18	22	13	15	17	15	16	16	16
uantities													
Cu.ft./dy. (1000's)	5110	5030	4300	4980	4450	3780	4000	3760	4130	5010	5060	5430	4586
Cu.ft./gal.	0.80	0.70	0.50	0.70	0.70	0.60	0.50	0.50	0.60	0.70	0.80	0.90	0.70
Cu.ft./lbs. BOD Removed													
ion Tanks (Liq.Vol.used)													
Mix Liq.Aer. - 1000 cf	300	300	300	300	300	300	300	300	300	300	300	300	300
Pre and Reaer. - 1000 cf													
Aeration Per. - hrs.(Mix.Liq.)	6.88	7.27	5.84	6.47	6.78	7.05	6.07	6.90	7.26	6.68	7.40	7.44	6.83
ing Tanks (Liq.Vol.used ~~or Detention Periods~~)													
Primary Settling 62,500 C.F.													
Second Settling 156,000 C.F.													
GANIC - N (PRIM. EFF.)	8.4	9.4	10.0	9.1	8.3	8.2	8.5	7.9	8.5	7.9	8.4	7.8	8.5

- OPERATION DATA

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	YEARLY AVG.		
e Flows - M.G.D.															
Raw - To plant (Total)	6.44	6.44	8.36	8.47	7.96	7.76	8.01	8.22	7.99	7.97	6.81	6.78	7.60		
Settled - To Aeration	6.44	6.44	8.36	8.47	7.96	7.76	8.01	8.22	7.99	7.97	6.81	6.78	7.60		
Mixed Liquor - in Aer.Tks.	10.00	11.49	12.60	12.12	12.05	11.93	12.07	12.03	11.58	11.01	10.94	10.46	11.52		
tical Data (Laboratory)															
B.O.D. - ppm															
1. Raw Sewage	253	242	238	210	237	218	232	207	203	223	261	230	229		
2. Settled "	196	199	171	159	156	135	135	125	129	154	171	152	157		
3. Fin.Eff."	41	51	39	33	38	36	29	24	24	26	57	39	36		
Sus.Solids, ppm															
1. Raw Sewage	250	218	218	195	207	191	213	195	205	207	209	217	210		
2. Settled "															
3. Fin.Eff."	21	31	16	16	20	22	17	17	13	11	28	25	19		
4. Returned Sludge	3480	2700	3050	3820	3140	3620	2970	3320	3330	2990	2400	2410	3044		
5. Mixed Liquor - ppm	1160	1160	1040	1180	1010	1120	990	1010	1080	1130	1140	1110	1094		
(a) % Volatile Sol.in Mix.Liq.															
D.O. ppm															
1. Aeration Tank Inlet															
Outlet	3.0	4.4	5.2	4.1	3.4	2.8	2.8	2.2	2.8	2.7	2.8	4.1	3.4		
2. Fin.Eff.Sewage	0.7	0.6	1.6	0.6	0.4	0.5	0.4	0.3	0.5	0.6	0.4	0.9	0.6		
Nitrogens - ppm (Fin.Eff.)															
1. NH_3															
2. NO_2															
3. NO_3	8.0	7.1	2.0	4.9	3.2	2.9	3.5.	2.0	3.7	4.4	3.9	8.8	4.5		
Sewage Temp. (°F)	61	56	58	60	64	68	73	74	72	70	66	60	65		
pH (Raw or Settled ?)											—				
ned Sludge															
Sludge Index	123	130	161	162	171	126	171	147	149	186	245	146	170		
M.G.D. - Ret.Sludge	3.56	5.05	4.24	3.65	4.09	4.17	4.06	3.81	3.59	3.04	4.13	3.68	3.75		
% of Sewage	55	78	51	43	51	54	51	47	45	38	61	55	52.4		
uantities															
Cu.ft./dy. (1000's)	5471	5940	6212	5743	5810	5864	5835	5288	5527	6481	5152	5031	5612		
Cu.ft./gal.	0.86	0.95	0.74	0.68	0.74	0.77	0.73	0.65	0.70	0.69	0.77	0.75	0.75		
Cu.ft.-lbs. BOD Removed															
ion Tanks (Liq.Vol.used)															
Mix Liq.Aer. - 1000 cf	376	376	376	376	376	376	376	376	376	376	376	376	376		
Pre and Reaer. - 1000 cf	0														
Aeration Per. - hrs.(Mix.Liq.)	6.8	5.8	5.4	5.6	5.6	5.7	5.6	5.6	5.9	6.2	6.2	6.5	5.9		
ing Tanks (Liq.Vol.used or Detention Periods)															
Primary Settling															
Second Settling															
GANIC - N (RAW)	12.5	11.3	—	7.0	10.4	10.6	—	—	8.2	12.9	—	8.5			

- OPERATION DATA

s	Jan. A	Feb. A	Mar. A	Apr. A	May A	June A	July A	Aug. A	Sept.	Oct. A	Nov.	Dec. A	YEARLY AVG.	AVG. "A" 10 Mo.
ge Flows - M.G.D.														
Raw - To plant (Total)	4.64	4.59	4.96	4.35	5.07	5.28	4.95	4.60	4.35	4.25	4.10	4.00	4.60	4.67
Settled - To Aeration														
Mixed Liquor - in Aer.Tks.	5.69	5.79	6.11	5.51	6.38	6.73	6.58	6.29	6.13	5.51	4.96	5.35	5.92	5.99
ytical Data (Laboratory)														
B.O.D. - ppm														
1. Raw Sewage	163	175	113	178	177	171	175	202	214	173	175	175	174	170
2. Settled "	138	141	96	145	148	130	147	202	214	153	156	153	152	145
3. Fin.Eff."	8	13	9	6	10	7	9	17	21	17	19	14	13	11
Sus.Solids, ppm														
1. Raw Sewage	189	196	150	187	200	214	177	202	232	185	149	167	187	187
2. Settled "	182	163	108	125	151	128	153	159	159	94	94	152	139	142
3. Fin.Eff."	10	17	16	7	12	10	7	9	20	11	11	21	13	12
4. Returned Sludge	13,950	11,000	11,270	9,656	10,720	9844	10834	11,145	11,269	12,563	10,826	9396	11,039	11,038
5. Mixed Liquor - ppm	2978	2384	2409	2288	2467	2436	2870	3260	3850	2620	1950	2520	2669	2625
(a) % Volatile Sol.in ~~Mix.Liq.~~ Ret. Sludge	64	66	56	69	67	64	62	69	71	69	74	71	67	66
D.O. ppm														
1. Aeration Tank Inlet														
Outlet														
2. Fin.Eff.Sewage														
Nitrogens - ppm (Fin.Eff.)														
1. NH_3														
2. NO_2														
3. NO_3														
Sewage Temp. (°F)	54	54	54	60	61	63	66	67	67	66	64	60	61	60.5
pH (Raw ~~or Settled ?~~)	7.7	7.7	7.7	7.6	7.5	7.4	7.5	7.4	7.3	7.5	7.5	7.5	7.5	7.5
ned Sludge														
Sludge Index	60	77	60	89	77	102	88	110	149	57	87	128	91	85
M.G.D. - Ret.Sludge	1.05	1.20	1.15	1.16	1.31	1.45	1.63	1.69	1.78	1.26	0.86	1.35	1.32	1.33
% of Sewage	22.7	26.1	23.0	26.7	25.9	27.4	33.0	36.7	40.8	29.6	21.0	33.9	28.9	28.5
uantities														
Cu.ft./dy. (1000's)														
Cu.ft./gal.	0.54	0.60	0.60	0.70	0.78	0.88	1.01	1.32	1.72	1.16	0.69	0.75	0.90	0.83
Cu.ft./lbs. BOD Removed	482	558	799	587	680	849	871	841	1066	1005	592	604	745	728
ion Tanks (Liq.Vol.used)														
Mix Liq.Aer. - 1000 cf	115	115	115	115	115	149	149	149	149	149	149	149	135	132
Pre and Reaer. - 1000 cf														
Aeration Per. - hrs.(Mix.Liq.)	3.65	3.64	3.48	3.79	3.63	4.12	4.21	4.40	4.53	4.98	4.20	3.99	4.04	3.99
ing Tanks (~~Liq.Vol.used or~~ Detention Periods)														
Primary Settling	1.29	1.61	1.40	1.66	1.42	1.36	1.45	1.56	1.67	1.71	1.78	1.87	1.57	1.53
Second Settling	2.59	2.46	2.44	2.62	2.26	2.18	2.20	2.29	2.40	2.64	2.88	2.73	2.48	2.44
TILE SOLIDS IN MIX. LIQ. - PPM	1910	1570	1350	1580	1650	1555	1780	2250	2740	1810	1440	1790	1785	1725

- OPERATION DATA

s	Jan. A	Feb. A	Mar. A	Apr. A	May A	June A	July B	Aug. A	Sept. A	Oct. B	Nov. B	Dec. B	YEARLY AVG.	Avg. "A" 8 Mo.	Av 4
ge Flows - M.G.D.															
Raw - To plant (Total)	9.41	9.56	9.46	9.56	10.03	9.66	8.79	8.89	9.18	8.89	8.87	9.34	9.30	9.47	8.
Settled - To Aeration															
Mixed Liquor - in Aer.Tks.	10.86	11.06	10.89	11.12	11.55	11.18	10.34	10.37	10.88	10.26	10.04	10.91	10.79	10.99	10
ytical Data (Laboratory)															
B.O.D. - ppm															
1. Raw Sewage	103	131	146	106	102	134	117	153	164	156	119	137	131	130	1
2. Settled "	108	108	149	91	89	109	110	115	124	130	125	127	115	112	12
3. Fin.Eff."	9	10	16	7	9	9	19	12	15	19	19	16	13	11	1
Sus.Solids, ppm															
1. Raw Sewage	175	198	207	179	170	181	171	246	226	241	211	211	201	198	2
2. Settled "	209	179	206	187	159	166	149	162	140	219	234	225	186	112	2
3. Fin.Eff."	9	7	10	5	11	11	21	11	18	24	19	17	14	10	
4. Returned Sludge	5280	5840	5800	4850	4620	5000	4370	3370	4500	5550	7070	6720	5250	4907	5
5. Mixed Liquor - ppm	1280	1260	1315	1090	1060	1250	990	1020	1095	1400	1440	1630	1235	1171	13
(a) % Volatile Sol.in Mix.Liq.	67	63	65	63	61	67	74	76	72	72	68	67	68	67	
D.O. ppm															
1. Aeration Tank Inlet															
Outlet	5.65	5.09	3.25	6.26	4.68	3.28	1.87	3.36	1.73	1.36	1.63	3.25	3.45	4.16	2.
2. Fin.Eff.Sewage	4.66	4.86	2.63	5.79	4.07	2.63	1.29	1.96	1.10	1.26	1.62	2.90	2.88	3.46	1.
Nitrogens - ppm (Fin.Eff.)															
1. NH_3															
2. NO_2															
3. NO_3															
Sewage Temp. (°F)	60	60	60	61	66	69	72	74	74	73	72	65	67	66	7
pH (Raw or Settled ?)															
rned Sludge															
Sludge Index (Mixed Liq.)	65	48	56	50	46	72	116	100	78	71	63	52	68	64	7
M.G.D. - Ret.Sludge	1.45	1.50	1.43	1.56	1.52	1.52	1.55	1.48	1.70	1.37	1.17	1.57	1.49	1.52	1.
% of Sewage	15.4	15.7	15.1	16.3	15.2	13.6	19.3	16.7	18.5	15.4	13.2	16.8	16.0	15.8	1.
Quantities															
Cu.ft./dy. (1000's)	4560	5750	4650	5280	5410	5400	4980	5720	5600	4890	3960	5320	5130	5296	47
Cu.ft./gal.	0.49	0.60	0.49	0.56	0.54	0.56	0.58	0.66	0.61	0.56	0.44	0.57	0.55	0.56	0
Cu.ft./lbs. BOD Removed	751	855	547	922	924	792	837	834	734	660	565	657	757	795	6
tion Tanks (Liq.Vol.used)															
Mix Liq.Aer. - 1000 cf	307												307	307	3
Pre and Reaer. - 1000 cf															
Aeration Per. - hrs.(Mix.Liq.)	5.10	5.11	5.09	4.83	5.16	5.14	4.97	4.84	4.96	5.34	5.55	5.30	5.12	4.41	5
ling Tanks (~~Liq.Vol.used or~~ Detention Periods)															
Primary Settling	0.80	0.79	0.79	0.79	0.75	0.78	0.87	0.85	0.82	0.85	0.86	0.81	0.81	0.80	0.
Second Settling	2.64	2.65	2.64	2.51	2.67	2.66	2.57	2.50	2.57	2.77	2.88	2.82	2.66	2.61	2.
ATILE SOLIDS IN MIX. LIQ. - PPM	860	795	855	685	645	840	735	775	790	1010	980	1090	840	785	9

OPERATION DATA

	Jan. A	Feb. A	Mar. A	Apr. A	May	June A	July A	Aug. A	Sept. A	Oct. A	Nov. A	Dec. A	YEARLY AVG.	Avg. "A" 11 Mo.
Flows - M.G.D.														
aw - To plant (Total)	2.54	2.56	2.35	2.18	2.78	2.19	2.94	2.69	2.61	2.22	2.92	2.46	2.54	2.51
ettled - To Aeration	2.54	2.56	2.35	2.18	2.78	2.19	2.94	2.69	2.61	2.22	2.92	2.46	2.54	2.51
ixed Liquor - in Aer.Tks.	4.29	4.19	3.87	3.66	4.35	3.47	4.49	4.28	4.24	3.72	4.48	4.00	4.09	4.06
ical Data (Laboratory)														
.O.D. - ppm														
1. Raw Sewage	280	296	292	340	312	250	297	322	298	275	266	320	296	294
2. Settled "	130	115	125	166	123	115	118	132	128	123	128	140	128	129
3. Fin.Eff."	20	26	34	34	52	22	17	22	30	22	13	20	25	23
us.Solids, ppm														
1. Raw Sewage	510	355	420	450	445	340	392	440	425	420	400	470	422	420
2. Settled "	160	150	145	150	150	125	150	145	150	145	165	150	149	149
3. Fin.Eff."	25	40	24	64	63	16	20	10	14	14	17	16	30	24
4. Returned Sludge	4190	3975	3605	2890	2720	1970	3200	4045	4227	4337	6840	4625	3885	3991
5. Mixed Liquor - ppm	2222	1725	1400	1235	1123	905	1260	1855	1915	2170	2670	2165	1720	1931
(a) % Volatile Sol.in Mix.Liq.														
.O. ppm														
1. Aeration Tank Inlet	3.3	3.2	3.5	3.3	3.4	3.4	3.0	2.2	1.6	2.8	1.5	1.2	2.7	2.6
Outlet	1.3	1.2	1.3	1.3	1.3	1.3	1.0	1.0	1.1	1.5	1.1	1.0	1.2	1.2
2. Fin.Eff.Sewage			Averages		1.0 – 1.5 (Ltr.)									
itrogens - ppm (Fin.Eff.)														
1. NH_3														
2. NO_2														
3. NO_3														
ewage Temp. (°F)	49	49	52	56	59	64	68	70	67	63	57	53	59	59
H (Raw or Settled ?)	7.5	7.4	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5
ed Sludge														
ludge Index	133	214	263	305	345	367	247	155	214	143	106	182	223	212
.G.D. - Ret.Sludge	1.75	1.63	1.52	1.48	1.57	1.28	1.55	1.59	1.63	1.50	1.56	1.54	1.55	1.55
of Sewage	69.0	63.7	64.6	67.7	56.6	58.6	53.1	59.0	62.3	67.6	53.5	62.6	61.5	62.0
antities														
u.ft./dy. (1000's)	2700	2530	2580	2771	3000	2390	2420	2490	2541	2680	2600	2900	2634	2600
u.ft./gal.	1.06	0.99	1.09	1.27	1.04	1.09	0.82	0.93	0.97	1.21	0.89	1.17	1.04	1.04
u.ft./lbs. BOD Removed														
on Tanks (Liq.Vol.used)														
ix Liq.Aer. - 1000 cf	172	172	172	172	172	172	172	172	172	172	172	172	172	172
re and Reaer. - 1000 cf														
eration Per. - hrs.(Mix.Liq.)	7.22	7.38	8.00	8.45	7.12	8.92	6.89	7.23	7.30	8.32	6.91	7.74	7.57	7.67
ng Tanks (Liq.Vol.used ~~or Detention Periods~~)														
rimary Settling 33,730 C.F.														
econd Settling 91,800 C.F.														

- OPERATION DATA

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	YEARLY AVG.		
e Flows - M.G.D.															
Raw - To plant (Total)	15.8	14.9	16.2	16.3	17.4	17.6	17.2	15.7	15.0	14.6	15.5	15.0	15.9		
Settled - To Aeration	15.8	14.7	16.2	16.3	15.1	17.4	17.2	15.6	15.0	14.6	14.8	15.0	15.6		
Mixed Liquor - in Aer.Tks.	21.2	19.8	21.1	20.2	19.9	22.1	21.9	20.8	20.3	19.0	18.3	18.4	20.3		
tical Data (Laboratory)															
B.O.D. - ppm															
1. Raw Sewage	335	416	343	350	288	289	310	286	306	308	317	317	322		
2. Settled "	261	331	269	262	233	220	217	213	215	226	234	247	244		
3. Fin.Eff."	19	31	17	21	14	20	17	10	16	14	16	18	18		
Sus.Solids, ppm															
1. Raw Sewage	272	322	275	247	244	252	227	265	258	260	267	288	265		
2. Settled "	153	180	160	127	117	111	103	108	95	112	126	138	128		
3. Fin.Eff."	14	22	11	12	8	12	10	8	11	8	9	9	11		
4. Returned Sludge															
5. Mixed Liquor - ppm	1710	1760	1690	1350	1560	1660	2020	1630	2030	1630	1720	1520	1690		
(a) % Volatile Sol.in Mix.Liq.	75.9	78.4	70.7	78.7	73.8	70.1	69.9	71.4	65.4	69.9	70.9	73.0	72.3		
D.O. ppm															
1. Aeration Tank Inlet	0	0	0	0	0	0	0	0	0	0	0	0	0		
Outlet															
2. Fin.Eff.Sewage	3.7	2.2	3.4	3.4	3.8	2.7	3.0	2.3	3.6	3.0	3.3	3.0	3.1		
Nitrogens - ppm (Fin.Eff.)															
1. NH_3	6.0	8.0	5.0	6.5	4.5	4.5	4.0	2.0	2.0	2.5	6.5	6.0	5.0		
2. NO_2 }															
3. NO_3 }	1.9	1.2	1.9	1.7	2.4	1.5	1.4	2.1	3.3	2.3	1.4	2.6	2.0		
Sewage Temp. (°F)	58	62	64	65	67	70	74	74	71	71	65	63	67		
pH (~~Raw or~~ Settled ?)	7.3	7.2	7.3	7.3	7.3	7.3	7.3	7.3	7.2	7.2	7.1	7.1	7.2		
ned Sludge															
Sludge Index (Mix. Liq.)	113	124	104	155	124	122	102	187	82	159	137	147	130		
M.G.D. - Ret.Sludge	5.4	5.1	4.9	3.9	4.8	4.7	4.7	5.2	5.3	4.4	3.5	3.4	4.6		
% of Sewage															
uantities															
Cu.ft./dy. ~~(1000's)~~ M.C.F.D.	16.7	16.9	16.2	16.7	15.0	17.9	18.2	18.2	18.0	19.1	19.0	20.3	17.7		
Cu.ft./gal.	1.08	1.16	1.03	1.04	1.04	1.06	1.07	1.17	1.22	1.33	1.31	1.37	1.16		
Cu.ft./lbs. BOD Removed															
ion Tanks (Liq.Vol.used)															
Mix Liq.Aer. - 1000 cf	595	595	595	595	595	595	595	595	595	595	595	595	595		
~~Pre and~~ Reaer. - 1000 cf	186.3	186.3	186.3	186.3	186.3	186.3	186.3	186.3	186.3	186.3	186.3	186.3	186.3		
Aeration Per. - hrs.(Mix.Liq.)	5.04	5.32	5.13	5.24	5.57	4.88	4.85	4.90	5.22	5.61	5.87	5.77	5.28		
ing Tanks (Liq.Vol.used or Detention Periods)															
Primary Settling	1.47	1.56	1.45	1.40	1.33	1.32	1.34	1.46	1.55	1.58	1.48	1.54	1.46		
Second Settling															
ATILE SOLIDS IN MIX. LIQ. — PPM	1300	1380	1200	1070	1150	1160	1410	1160	1330	1140	1220	1110	1220		

- OPERATION DATA

s	1945 June	July	Aug.	Sept.	4 Mo. Avg.	Yearly Avg.	1946 July	Aug.	Sept.	Oct.	Nov.	4 Mo. Avg.	Yearly Avg.		2 Ye Av
ge Flows - M.G.D.															
Raw - To plant (Total)								37.3	39.5	44.5			36.8		
Settled - To Aeration	22.5	22.1	24.0	22.5	22.7	24.4	24.3	25.4	27.1	28.6		27.4	25.5		24
Mixed Liquor - in Aer.Tks.	29.7	29.4	32.0	30.3	30.3	31.9	33.2	34.6	36.7	38.1		35.6	34.4		33
ytical Data (Laboratory)															
B.O.D. - ppm															
1. Raw Sewage	205	228	217	208	214	220	214	224	201	199		209	228		2
2. Settled "	125	144	131	127	132	130	127	144	124	107		125	128		1
3. Fin.Eff."	16	21	17	19	18	17	24	16	11	14		16	17		
Sus.Solids, ppm															
1. Raw Sewage	262	258	253	259	258	260	263	244	221	226		238	260		2
2. Settled "	172	175	172	135	163	161	168	160	144	163		158	163		1
3. Fin.Eff."	35	32	33	23	31	24	28	18	12	14		18	18		
4. Returned Sludge	2600	2900	3000	3800	3075	3700	3700	5000	5100	5600		4850	4600		4
5. Mixed Liquor - ppm	760	850	880	1100	895	1000	1110	1450	1500	1520		1395	1300		1
(a) % Volatile Sol.in Mix.Liq.															
D.O. ppm															
1. Aeration Tank Inlet															
Outlet															
2. Fin.Eff.Sewage	0.6	1.0	0.8	0.3	0.7	0.7	0.6	0.8	0.8	0.8		0.8	0.6		0
Nitrogens - ppm (Fin.Eff.)															
1. NH_3	13	12	13	13	13	12	10	9	4	6		7	9		
2. NO_2	0.1	0.5	0.2	0.3	0.3	0.8	0.4	0.8	3.8	1.9		1.7	1.3		
3. NO_3	0	0.1	0	0	0	0.1	0.	0	0.7	0.6		0.3	0.2		
Sewage Temp. (°F)	82	84	85	80	83	69	84	84	78	72		79	69		
pH (Raw ~~or Settled ?~~)	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3		7.3	7.3		
rned Sludge															
Sludge Index	210	214	246	310	245	190	182	136	93	80		122	138		1
M.G.D. - Ret.Sludge	7.2	7.3	8.0	7.8	7.6	7.5	8.9	9.2	9.6	9.5		9.3	8.9		
% of Sewage	32	33	33.3	35	33	31	36.6	36.0	35	33.2		35.2	34.8		
Quantities															
Cu.ft./dy. (1000's)	25,400	26,400	26,900	28,600	26,800	29,300	29,000	30,000	29,500	30,200		29,700	30,300		29,
Cu.ft./gal.	1.1	1.2	1.1	1.3	1.2	1.2	1.2	1.2	1.1	1.1		1.15	1.2		
Cu.ft./lbs. BOD Removed	1240	1170	1035	1350	1200	1270	1260	1110	1150	1365		1222	1285		12
tion Tanks (Liq.Vol.used)															
Mix Liq.Aer. - 1000 cf	1025	1025	1025	1025	1025	1025	1025	1025	1025	1025		1025	1025		10
~~Pre and~~ Reaer. - 1000 cf	48	48	48	48	48	48	48	48	48	48		48	48		
Aeration Per. - hrs.(Mix.Liq.)	6.2	6.1	5.7	6.1	6.1	5.8	5.5	5.3	5.1	4.8		5.2	5.3		5
ing Tanks (Liq.Vol.used or Detention Periods)															
Primary Settling	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.7		0.8	0.8		0
Second Settling	3.3	3.4	3.1	3.3	3.3	3.0	3.1	2.9	2.7	2.6		2.8	2.9		2
G. Nitrogen (Raw)	14	12	13	14	13.2	14	14	12	11	13		12.5	13		13
eaeration Period - Hrs.	1.2	1.1	1.0	1.1	1.1	1.1	0.9	0.9	0.9	0.9		0.9	0.9		1

A - OPERATION DATA

es	Jan.	Feb. A	Mar. A	Apr. A	May A	June A	July A	Aug. A	Sept. A	Oct.	Nov. A	Dec. A	YEARLY AVG.	AVG. "A" 10 MO.
age Flows - M.G.D.														
. Raw - To plant (Total)	10.6	10.5	9.5	9.4	10.2	9.2	9.2	8.0	7.3	6.8	9.2	10.3	9.2	9.3
. Settled - To Aeration														
. Mixed Liquor - in Aer.Tks.	14.3	13.9	12.9	12.9	13.2	13.0	12.7	11.9	11.1	9.9	12.7	13.6	12.7	12.8
lytical Data (Laboratory)														
. B.O.D. - ppm														
1. Raw Sewage	124	63	75	70	98	96	90	147	145	178	57	70	103	93
2. Settled "	83	42	57	47	63	59	44	139	134	131	44	51	74	68
3. Fin.Eff."	16	5	7	3	7	6	4	10	6	18	4	6	8	6
. Sus.Solids, ppm														
1. Raw Sewage	138	96	119	97	151	145	130	176	156	178	102	100	132	127
2. Settled "	75	64	63	53	70	74	56	136	170	103	57	53	81	80
3. Fin.Eff."	13	12	8	6	7	7	4	7	8	11	8	9	8	8
4. Returned Sludge	2668	5672	5700	4038	6606	4000	4396	3106	5138	3475	3588	2400	4230	4464
5. Mixed Liquor - ppm	1435	1528	1622	2000	2084	1606	1386	1548	2310	1366	1120	952	1580	1616
(a) % Volatile Sol.in Mix.Liq.														
. D.O. ppm														
1. Aeration Tank Inlet														
Outlet														
2. Fin.Eff.Sewage														
. Nitrogens - ppm (Fin.Eff.)														
1. NH_3														
2. NO_2														
3. NO_3	5.0	7.9	6.0	6.7	5.7	5.0	3.4	2.6	4.6	3.7	4.5	4.8	5.0	5.1
. Sewage Temp. (°F)	58	54	54	58	64	68	72	77	77	77	64	59	65	65
. pH (Raw ~~or Settled ?~~)	7.1	7.3	7.4	7.2	—	—	—	—	—	—	—	—	—	
urned Sludge														
. Sludge Index (Mix. Liq.)	77	56	56	65	104	93	123	194	113	101	98	84	97	99
. M.G.D. - Ret.Sludge	3.7	3.4	3.4	3.5	3.0	3.8	3.6	3.9	3.8	3.1	3.5	3.2	3.5	3.5
. % of Sewage	26	24	26	27	23	29	28	33	34	31	28	24	28	28
Quantities														
. Cu.ft./dy. (1000's)	5640	5070	5220	5370	6200	5650	4980	6700	6260	6690	5410	5480	5720	5634
. Cu.ft./gal.	0.53	0.48	0.56	0.57	0.61	0.61	0.54	0.89	0.86	0.98	0.59	0.53	0.64	0.62
. Cu.ft./lbs. BOD Removed	951	1564	1317	1557	1300	1388	1621	779	803	1044	1761	1509	1300	1360
ation Tanks (Liq.Vol.used)														
. Mix Liq.Aer. - 1000 cf	365	365	365	365	365	365	365	365	365	365	365	365	365	365
. Pre and Reaer. - 1000 cf														
. Aeration Per. - hrs.(Mix.Liq.)	4.7	4.9	5.4	5.4	5.2	5.3	5.5	5.9	6.3	7.0	5.5	4.5	5.5	5.4
tling Tanks (Liq.Vol.used ~~or Detention Periods~~)														
. Primary Settling 83,000 C.F.														
. Second Settling 96,000 C.F.														

APPENDIX B

This appendix contains Tables B-1 thru B-15 which summarize the computations for Figures #1 thru #16, respectively.

Table B-16 summarizes the computations for Figures #17 thru #21.

E B-I SUMMARY OF COMPUTATIONS ANN ARBOR, MICH. 194

h	Category	Equiv. Aer. Period.- Hrs.	#B.O.D. Applied	P_1	P_2	P_3	% B.O. Remove
	A	2.0	8,120	41.7	20.6	9.5	93.
	A	1.8	9,270	47.7	27.1	12.5	94.
	A	1.6	10,500	54.0	33.7	16.1	92.
	A	1.2	10,650	54.8	44.2	24.6	88.
	A	1.7	11,750	60.4	34.9	22.2	89.
	A	2.2	9,980	51.2	23.1	13.4	95.
	A	3.0	8,200	42.1	14.2	8.6	88.
	A	3.4	6,410	33.0	9.6	5.8	98.
.	A	3.1	7,050	36.3	11.8	7.2	93.
	A	2.7	10,400	53.5	19.8	10.6	90.
	A	2.5	10,100	51.9	20.6	10.3	91.
	A	2.0	8,670	44.6	22.4	11.9	95.8
age	A	2.3	9,260	47.6	23.5	12.7	92.

E B-12 SUMMARY OF COMPUTATIONS AUSTIN, TEXAS 194

n	Category	Equiv. Aer. Period - Hrs.	#B.O.D. Applied	P_1	P_2	P_3	% B.O. Remove
	A	4.0	5,610	20.7	5.2	3.1	89.5
	B	4.0	8,010	29.5	7.4	4.8	81.5
	B	4.0	8,610	31.7	7.9	8.7	80.6
	B	5.0	10,200	37.6	7.5	8.3	74.9
	B	6.2	7,730	28.5	4.6	3.2	79.0
	A	6.4	8,910	32.8	5.2	2.4	91.0
	A	6.7	9,520	35.0	5.3	3.6	94.2
	A	7.7	8,840	32.5	4.4	2.4	93.1
.	A	6.9	8,360	30.8	4.5	2.5	91.9
	A	5.8	8,940	32.9	5.7	3.7	91.0
	B	5.6	8,340	30.8	5.5	4.0	81.8
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age	A	6.2	8,360	30.8	5.0	3.0	91.8
age	B	6.2	8,580	31.6	6.6	5.8	79.6

E B-3 SUMMARY OF COMPUTATIONS CLEVELAND (E), OHIO 194

n	Category	Equiv. Aer. Period - Hrs.	#B.O.D. Applied	P_1	P_2	P_3	% B.O. Remove
	B	3.0	83,800	22.2	7.4	4.1	82.6
	B	2.4	50,100	13.3	5.5	2.7	80.8
	B	2.7	52,500	13.9	5.1	4.2	84.5
	B	2.9	60,100	16.0	5.6	3.8	85.5
	B	3.1	60,000	15.1	5.1	3.6	87.5
	A	3.9	72,000	18.9	4.9	3.7	95.0
	A	5.5	77,000	20.4	3.7	2.7	96.0
	A	6.1	81,000	21.5	3.5	2.4	96.0
.	A	5.5	59,700	15.9	2.9	2.4	91.0
	A	4.9	63,500	16.9	3.5	3.1	91.0
	A	4.6	54,100	14.4	3.1	3.1	91.1
	A	2.9	90,000	23.9	8.2	6.4	89.0
age	A	4.8	71,100	18.8	4.3	3.4	92.7
age	B	2.8	61,300	16.1	5.7	3.6	84.2

E B-4 SUMMARY OF COMPUTATIONS DECATUR, ILLINOIS 19

h	Category	Equiv. Aer. Period - Hrs.	#B.O.D. Applied	P_1	P_2	P_3	% B.O. Remove
	A	4.7	6,190	35.6	7.6	2.8	89.
	A	4.6	6,410	38.0	8.3	3.0	93.
	A	4.2	6,940	41.1	9.8	3.4	95.
	A	2.3	5,540	32.8	14.0	4.9	93.
	A	3.0	7,140	42.2	14.1	4.5	92.
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	A	5.6	6,090	36.0	6.4	3.1	90.
	A	6.5	6,510	38.6	6.0	2.9	93.
.	A	5.5	5,840	34.5	6.3	4.1	91.
	A	6.3	4,240	25.1	4.0	2.4	92.
	A	4.2	5,820	34.4	8.2	5.5	90.
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age	A	4.7	6,070	35.8	8.5	3.7	92.

E B-5 SUMMARY OF COMPUTATIONS FORT WAYNE, IND. 1941-1947

Category	Equiv. Aer. Period - Hrs.	#B.O.D. Applied	P_1	P_2	P_3	%B.O.D. Removed
A	5.3	18,500	21.9	4.1	1.8	91.1
A	4.4	18,100	21.5	4.9	2.1	91.5
A	4.1	19,500	23.1	5.6	2.3	91.1
A	4.1	22,600	26.8	6.6	2.3	89.0
A	4.1	21,600	25.6	6.3	2.5	90.3
A	4.0	24,800	29.8	7.5	3.3	90.6
A	3.5	28,200	33.4	10.0	4.0	93.6
ar Average	4.2	21,900	26.0	6.4	2.7	91.1

E B-6 SUMMARY OF COMPUTATIONS GARY, INDIANA 194

h	Category	Equiv. Aer. Period - Hrs.	#B.O.D. Applied	P_1	P_2	P_3	% B.O. Remove
	A	1.2	12,600	19.5	16.5	12.8	91.7
	A	1.1	12,600	19.4	17.7	13.8	88.5
	A	1.2	11,500	17.7	14.7	12.0	88.6
	A	1.5	14,400	22.2	15.1	13.2	93.5
	A	1.8	12,200	19.0	10.6	9.5	89.5
	B	2.1	11,900	18.5	8.8	7.9	77.5
	B	2.4	10,500	16.2	6.8	6.8	78.2
	B	2.5	16,200	25.1	10.0	10.0	81.1
.	A	2.7	20,700	32.1	12.0	10.3	90.3
	B	2.3	16,600	25.7	11.2	12.8	83.2
	B	1.8	10,900	16.8	9.3	9.1	86.0
	B	1.4	14,800	22.8	16.3	13.1	88.5
age	A	1.6	14,000	21.6	14.4	11.9	90.3
age	B	2.1	13,500	20.9	10.4	10.0	82.4

E B-7 SUMMARY OF COMPUTATIONS HAMMOND, IND. 194

n	Category	Equiv. Aer. Period - Hrs.	#B.O.D. Applied	P_1	P_2	P_3	% B.O. Remove
	A	1.6	41,000	35.7	22.6	8.7	92.1
	A	1.6	39,600	34.4	21.6	9.3	89.8
	A	1.5	39,100	34.1	22.2	9.7	90.1
	A	2.4	29,800	26.0	11.0	4.8	90.4
	A	3.2	25,200	22.0	6.9	2.5	92.1
	A	4.4	20,100	17.5	4.0	1.7	94.4
	A	5.4	19,000	16.6	3.1	1.4	93.1
	A	6.3	23,600	20.6	3.3	1.2	92.5
.	A	6.8	30,100	26.2	3.8	1.1	94.4
	A	5.7	22,500	19.6	3.5	1.4	96.4
	A	2.1	16,900	14.7	7.1	3.4	89.9
	A	2.5	25,600	22.2	8.9	3.9	89.0
age	A	3.6	27,700	24.1	9.8	4.1	91.8

E B-8 SUMMARY OF COMPUTATIONS JACKSON, MICH. 194

n	Category	Equiv. Aer. Period - Hrs.	#B.O.D. Applied	P_1	P_2	P_3	% B.O. Remove
	A	2.0	7,300	24.3	12.1	4.8	96.8
	A	2.0	6,950	23.2	11.8	4.7	96.0
	A	2.2	7,840	26.1	11.8	4.8	96.4
	A	3.1	7,750	25.9	8.2	3.4	96.8
	A	3.6	6,600	20.7	5.7	2.3	96.3
	A	4.6	5,200	17.4	3.8	1.7	97.1
	A	4.5	5,760	19.2	4.3	2.1	96.5
	A	4.9	3,900	13.0	2.7	1.2	95.6
.	A	4.9	5,200	17.4	3.5	1.6	96.8
	A	3.9	6,380	21.3	5.4	2.3	96.3
	A	3.4	6,360	21.2	6.2	2.9	95.7
	A	2.5	6,480	21.6	8.6	3.5	94.4
age	A	3.5	6,280	20.9	7.0	2.9	96.2

E B-9 SUMMARY OF COMPUTATIONS MADISON, WISC. 194

n	Category	Equiv. Aer. Period - Hrs.	#B.O.D. Applied	P_1	P_2	P_3	% B.O. Remove
	A	3.5	10,500	28.0	8.0	6.9	79.1
	A	2.2	10,700	28.4	12.9	11.1	74.4
	A	2.3	11,900	31.7	13.8	13.3	87.2
	A	2.7	11,250	29.9	11.1	9.4	79.2
	A	3.3	10,350	27.6	8.4	8.3	75.6
	A	4.0	8,750	23.3	5.8	5.2	73.4
	A	5.4	9,000	24.0	4.5	4.5	88.5
	A	5.0	8,600	22.8	4.6	4.5	80.8
	A	5.0	8,600	22.9	4.6	4.2	81.4
	A	4.8	10,200	27.2	5.7	5.0	83.1
	A	4.0	9,700	25.9	6.5	5.7	67.2
	A	3.2	8,600	22.9	7.2	6.5	74.4
ge	A	3.6	9,850	26.2	7.8	7.1	77.0

E B-10 SUMMARY OF COMPUTATIONS MARION, IND. 194

n	Category	Equiv. Aer. Period - Hrs.	#B.O.D. Applied	P_1	P_2	P_3	% B.O. Remove
	A	1.2	5,340	46.4	37.8	12.7	94.2
	A	1.2	5,400	47.8	38.9	16.3	90.8
	A	1.2	4,000	34.5	29.2	12.1	90.7
	A	1.8	5,300	45.7	24.8	10.8	95.8
	A	1.9	6,300	54.4	29.4	11.9	93.3
	A	2.3	5,700	38.4	16.7	6.8	94.7
	A	2.7	6,100	40.7	14.9	5.2	93.8
	A	3.0	7,800	52.1	17.6	5.4	91.5
	B	3.1	7,800	52.4	16.9	4.4	88.0
	A	3.2	5,430	36.4	11.2	4.3	88.8
	B	2.5	6,000	40.2	16.1	6.4	87.9
	A	1.9	5,100	34.2	17.6	7.0	91.0
age	A	2.1	5,630	43.1	23.8	9.3	92.5
age	B	2.8	6,800	46.3	16.8	5.4	88.0

E B-11 SUMMARY OF COMPUTATIONS MUNCIE, IND. 1946-

n	Category	Equiv. Aer. Period - Hrs.	#B.O.D. Applied	P_1	P_2	P_3	% B.O. Remove
	A	2.5	8,500	27.6	11.1	8.7	91.7
	A	2.5	8,640	28.2	11.3	9.0	90.7
	A	2.5	11,800	38.4	15.6	11.8	89.3
	A	2.5	7,300	23.7	9.6	8.8	92.3
	A	3.4	7,400	24.2	7.2	6.8	89.9
	A	3.8	8,800	28.7	7.6	6.1	91.8
	B	4.2	8,070	26.3	6.3	6.3	82.7
	A	4.4	8,530	27.8	6.4	6.3	89.6
.	A	4.5	9,500	31.0	6.9	6.3	87.9
	B	4.6	9,630	31.4	6.8	4.9	85.4
	B	4.7	9,250	30.0	6.4	4.5	84.8
	B	3.3	9,900	32.2	9.8	6.0	87.4
age	A	3.2	8,800	28.7	9.5	8.0	90.4
age	B	4.2	9,210	29.9	7.3	5.4	84.5

E B-12 SUMMARY OF COMPUTATIONS OMAHA, NEB. 194

h	Category	Equiv. Aer. Period - Hrs.	#B.O.D. Applied	P_1	P_2	P_3	% B.O. Remove
	A	1.7	2,760	16.0	9.7	4.4	84.4
	A	1.7	2,460	14.3	8.4	4.9	77.4
	A	2.3	2,460	14.3	6.1	4.4	80.8
	A	3.2	3,000	17.6	5.5	4.4	79.5
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	A	5.3	2,100	12.2	2.3	2.6	80.9
	A	4.9	2,900	16.9	3.5	2.7	85.6
	A	5.6	2,960	17.2	3.1	1.7	83.4
.	A	4.9	2,800	16.2	3.3	1.7	76.6
	A	4.7	2,280	13.3	2.8	1.3	82.1
	A	2.8	3,120	18.3	6.4	2.4	89.9
	A	2.5	2,880	16.7	6.7	3.1	85.7
age	A	3.6	2,700	15.7	5.3	3.1	82.4

E B-13 SUMMARY OF COMPUTATIONS PEORIA, ILL. 194

h	Category	Equiv. Aera. Period - Hrs.	#B.O.D. Applied	P_1	P_2	P_3	% B.O. Remove
	A	2.2	34,400	44.0	20.4	11.9	92.7
	A	2.9	40,600	52.0	18.3	10.4	90.5
	A	3.0	37,100	47.5	15.7	9.3	93.6
	A	3.2	35,400	45.4	14.1	10.4	92.3
	A	3.8	29,400	37.6	10.0	6.4	94.0
	A	3.8	31,900	40.8	10.9	6.6	90.8
	A	4.4	31,100	39.8	9.1	4.5	92.2
	A	4.4	27,600	35.4	8.0	4.9	95.4
.	A	9.2	26,900	34.4	8.3	4.1	92.5
	A	4.5	27,600	35.3	7.9	4.8	93.7
	A	3.6	28,800	36.9	10.3	6.0	93.1
	A	3.2	30,900	39.6	12.3	8.1	92.8
age	A	3.6	31,800	40.7	12.1	7.3	92.8

E B-14 SUMMARY OF COMPUTATIONS SAN ANTONIO, TEX. 1945-4

od	Category	Equiv. Aer. Period - Hrs.	#B.O.D. Applied	P_1	P_2	P_3	% B.O. Remove
	A	7.3	23,400	21.8	3.0	4.0	87.2
	A	7.5	26,600	24.8	3.3	3.9	85.4
	A	7.3	26,200	24.4	3.6	4.1	87.0
.	A	6.7	23,900	22.2	3.3	3.0	85.0
. Avg.	A	7.3	25,000	23.3	3.3	3.7	86.4
ly Avg.	A	4.3	26,500	24.7	5.7	5.7	86.9
	A	6.8	25,800	24.0	3.6	3.2	81.1
	A	6.5	30,600	28.5	4.4	3.0	88.9
.	A	5.2	28,000	26.1	5.0	3.4	91.1
	A	4.0	25,600	23.8	6.0	3.9	86.9
. Avg.	A	5.5	27,500	25.6	4.8	3.4	87.2
ly Avg.	A	3.9	27,300	25.4	6.5	5.0	86.7
ar Avg.	A	4.1	26,800	25.0	6.2	5.4	86.8

E B-15 SUMMARY OF COMPUTATIONS SPRINGFIELD, ILL. 194

n	Category	Equiv. Aer. Period - Hrs.	#B.O.D. Applied	P_1	P_2	P_3	% B.O. Remove
	B	2.0	7,350	20.1	10.0	6.9	81.0
	A	1.7	3,680	10.1	6.1	4.0	88.2
	A	1.8	4,530	12.4	6.8	4.2	87.7
	A	2.3	3,690	10.1	4.4	2.2	93.6
	A	3.1	5,360	14.7	4.8	2.3	88.9
	A	3.8	4,530	12.4	3.3	2.1	89.8
	A	4.6	3,380	9.3	2.0	1.4	90.9
	A	5.9	9,280	25.4	4.3	2.8	92.8
.	**A**	6.3	8,160	22.4	3.6	1.5	95.5
	B	7.0	7,740	20.4	2.9	2.1	86.3
	A	3.2	3,370	9.3	2.9	2.6	90.9
	A	2.1	4,390	12.1	5.8	6.1	88.2
ge	**A**	3.5	5,040	13.8	4.4	2.9	90.6
ge	**B**	4.5	7,545	20.2	6.5	4.5	83.6

E B-16 SUMMARY OF COMPUTATIONS FOR FIGURES #17 THRU #21

Plant	Length of Period	#B.O.D. Applied	P_1	P_2	P_3	% B.O.D Removed
nn Arbor, Mich.	1 yr.	9,260	47.6	12.0	6.5	92.3
ustin, Tex.	6 mo.	8,360	30.8	5.5	3.2	91.8
leveland, O.(E)	7 mo.	71,000	18.8	3.2	2.6	92.7
ecatur, Ill.	10 mo.	6,070	35.8	9.7	4.1	92.2
ort Wayne, Ind.	7 yr.	21,900	26.0	3.6	1.5	91.1
ary, Ind.	6 mo.	14,000	21.6	4.6	3.8	90.3
ammond, Ind.	1 yr.	27,500	24.1	3.6	1.5	91.8
ackson, Mich.	1 yr.	6,280	20.9	3.1	1.3	96.2
adison, Wisc.	1 yr.	9,850	26.2	4.5	4.1	77.0
arion, Ind.	10 mo.	5,630	43.1	10.8	4.1	92.5
uncie, Ind.	8 mo.	8,800	28.7	6.4	5.5	90.4
maha, Neb.	11 mo.	2,700	15.7	2.0	1.1	82.4
eoria, Ill.	1 yr.	31,700	40.7	7.7	4.6	92.8
an Antonio, Tex.	2 yr.	26,800	25.0	4.6	4.0	86.8
pringfield, Ill.	10 mo.	5,040	13.8	2.6	1.6	90.6

APPENDIX C

This appendix contains a brief description of each of the plants studied, their operating procedures, if unusual, and the type or characteristics of the wastes they treat.

1. Ann Arbor, Michigan

This plant employs preaeration for the removal of grease and oils, primary sedimentation, aeration thru fixed plate diffusers, and final sedimentation.

Chlorination is practiced during the summer months. Digestor supernatant is returned occasionally to the aerators instead of to the primary tanks. During 1947, this plant operated at 86% over its designed capacity on an average basis, and well over 100% overload on most week days. The Mallory System of operation is employed.

Phenolic wastes are reported occasionally.

2. Austin, Texas

The Austin plant has mechanically cleaned screens, a Dorr Detritor, primary sedimentation, aeration tanks with ridge and furrow fixed plate air diffusers and final sedimentation tanks. About 7% of the total aeration tank capacity is utilized for reaeration of sludge.

During 1945, the plant received all the wastes from the city owned abattoir and experienced considerable bulking in the final clarifiers. This situation became so bad in 1946 that operation was changed to straight aeration.

3. Cleveland, Ohio (Easterly)

This plant consists of 4 comminutors, detritors, primary tanks, conventional type diffused air aeration tanks and final clarifiers. Excess activated sludge is concentrated in two of the final clarifiers and then pumped to the Southerly plant. Chlorination of the effluent is practiced during the summer months for protection of bathing beachs.

Various types and large volumes of industrial wastes are treated with domestic sewage.

4. Decatur, Illinois

The Decatur plant is unusual in that it consists of Imhoff tanks which serve as primary sedimentation tanks for an activated sludge plant and for trickling filters. Aeration of mixed liquor plus reaeration of return sludge is normaly practiced but occasionally a portion of the aeration tank is used for preaeration of sewage.

Mechanical difficulties frequently necessitate the use of only one final clarifier. Large volumes of hot starch wastes, mixed with domestic, sewage, cause sewage temperatures as high as 96° F during the summer months.

5. Fort Wayne, Indiana

The main elements of this plant consist of screens, grit chambers, primary settling tanks, and aerators of the fixed plate spiral flow type followed by final sedimentation tanks.

Domestic sewage and wastes from 3 large breweries, 4 packing houses, and other small industries are treated at this plant.

6. Gary, Indiana

Preparatory devices consist of screens, comminutors, and grit chambers and are followed by 4 primary settling tanks, 10 aeration tanks designed for 5 hours detention, and 8 final settling tanks.

Although the sewage is relatively weak, it frequently contains heavy doses of pickling liquor wastes which upset the activated sludge.

7. <u>Hammond, Indiana</u>

This plant features a combination preaeration and grit removal tank which is provided with diffused air for spiral circulation of the sewage. The detention period ranges between 20 and 30 minutes. The plant proper is of the conventional type, employing fixed plate spiral flow type aeration tanks and circular final clarifiers.

8. <u>Jackson, Michigan</u>

Conventional type activated sludge plant treating sewage from a combined system of sewers. Small amounts of pickling liquors and gas house wastes are encountered at times.

9. <u>Madison, Wisconsin</u>

The sewage after being treated in a grease floculating tank, flows to a grease separator and then to primary sedimentation tanks which are followed by the activated sludge process.

Very low B.O.D. removals are obtained at this plant due to excessive amounts of slaughter house wastes being treated.

10. <u>Marion, Indiana</u>

This plant is also of the conventional type. Garbage, formerly ground at the plant and mixed with the sewage, is now being pumped directly to the digestors. Shock loads of milk wastes and cheese whey frequently upset the operation for short periods of time. During the canning season, corn and tomato wastes enter the plant and also make operation difficult.

11. Muncie, Indiana

Data other than operating data, not available.

12. Omaha, Nebraska

This is the usual type of activated sludge plant utilizing grit chambers and fixed diffusion plates.

The sewage has a very high B.O.D. due to large volumes of packing house wastes being discharged into the sewers. These wastes are composed of blood, paunch contents, and not infrequently, large chunks of meat which render effective treatment difficult.

13. Peoria, Illinois

The Peoria plant also utilizes spiral flow type aeration tanks. Operation is unusual in that digested sludge is added to return activated sludge for reaeration and is ultimately discharged into the mixed liquor. Reaeration capacity constitutes 24% of the total aeration tank volume.

Industrial wastes contribute half of the organic load imposed upon the plant. These wastes originate for the most part in breweries, packing houses, and paper mills.

14. San Antonio, Texas

On a volumetric basis, this plant is operating at 1.6 times its design capacity. It is of the conventional type and utilizes a portion of the aeration tank for reaeration of return sludge. In addition to handling excessive flows, slaughter house wastes add to the treatment problem. Chlorination of the oxidized effluent is practiced at this plant.

15. Springfield, Illinois

Preparatory devices at this plant consist of mechanically cleaned bar screens, grit basin, and grease removal basin. The aeration tanks are of the spiral flow diffused air type. Waste activated sludge and supernatant liquor from the digestion tanks are returned to the primary tanks for re-settling.

The plant treats sewage from a combined system. No industrial wastes are reported.

APPENDIX D

RELATIVE ACTIVITY FACTORS

FIG. # D-1

FROM S.W.J., 11, No. 6, 1939

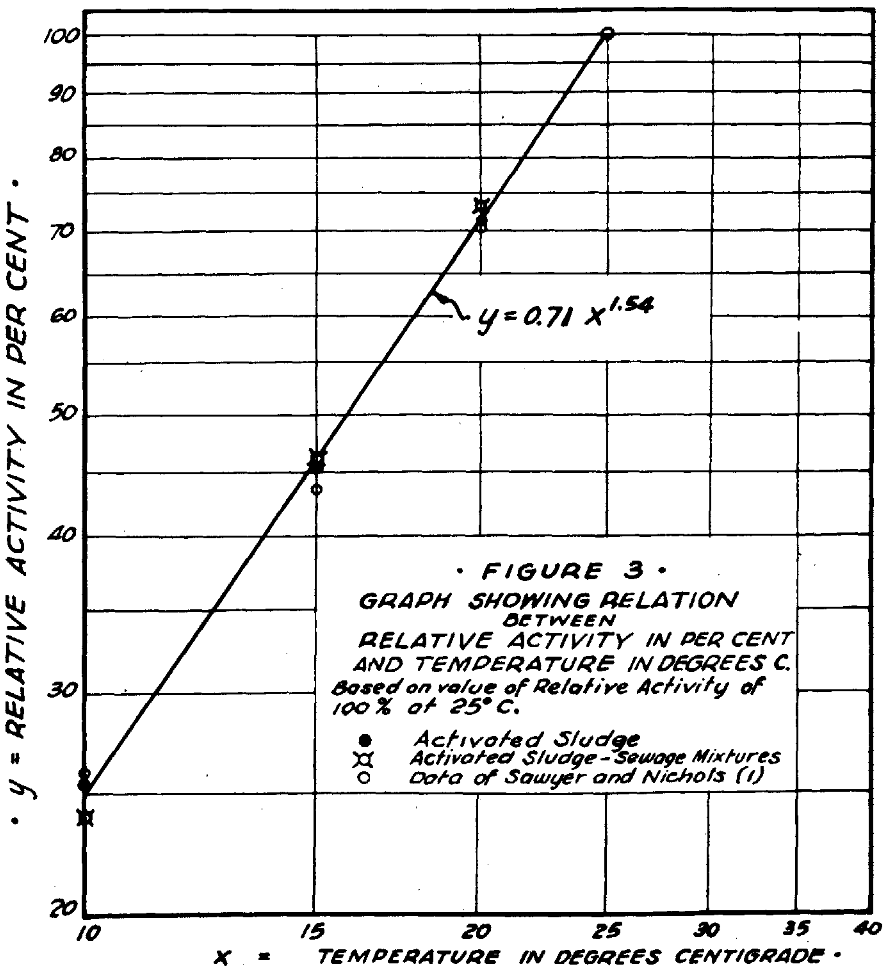

TABLE D-1

RELATIVE ACTIVITY FACTORS

FOR CALCULATING EQUIVALENT AERATION PERIODS

TEMPERATURE (X) °F	°C	RELATIVE ACTIVITY-PERCENT (Y)
48	8.9	21
49	9.4	23
50	10.0	25
51	10.5	27
52	11.1	29
53	11.7	32
54	12.2	34
55	12.7	36
56	13.3	38
57	13.8	41
58	14.4	43
59	15.0	46
60	15.5	49
61	16.0	51
62	16.6	54
63	17.1	56
64	17.7	59
65	18.2	62
66	18.8	65
67	19.3	68
68	19.9	71
69	20.5	74

TABLE D-1

RELATIVE ACTIVITY FACTORS (cont'd.)

TEMPERATURE (X) °F	°C	RELATIVE ACTIVITY-PERCENT (Y)
70	21.1	77
71	21.6	80
72	22.2	84
73	22.7	86
74	23.3	90
75	23.8	93
76	24.4	96
77	24.9	100
78	25.5	102
79	26.1	106
80	26.6	110
81	27.1	113
82	27.7	117
83	28.2	120
84	28.8	123
85	29.3	127
86	29.9	130
87	30.6	135
88	31.0	139
89	31.6	143
90	32.2	146
91	32.7	148
92	33.3	153
93.	33.8	157

TABLE D-1
RELATIVE ACTIVITY FACTORS (cont'd.)

TEMPERATURE (X) °F	°C	RELATIVE ACTIVITY-PERCENT (Y)
94	34.4	162
95	34.9	165
96	35.5	170