REPORT

On The

INVESTIGATION OF POLLUTION

OF THE

DES MOINES RIVER

From Fort Dodge to Farmington

June 1928 - March 1931

By The

BUREAU OF PUBLIC HEALTH ENGINEERING

STATE DEPARTMENT OF HEALTH

Des Moines, Iowa.

July, 1931

IN THE MATTER OF THE POLLUTION)
OF THE DES MOINES RIVER.) ORDER.

WHEREAS, at a hearing held by the State Department of Health on August 4, 1931, at which hearing representatives of the City of Ottumwa and the Morrell Packing Company of Ottumwa were present pursuant to a notice served upon them of such hearing and at which hearing evidence was introduced showing that the City of Ottumwa has been and is now disposing of raw, untreated sewage into the Des Moines River, to such an extent that the said river is rendered unwholesome and unfit for domestic use and as a public water supply and making the water in said river deleterious to fish life, and

WHEREAS, no evidence was produced or arguments offered on behalf of the City of Ottumwa, to show that the State Department of Health should not order the said City to cease from discharging raw sewage into the river, and

WHEREAS, the testimony so produced at the hearing shows that the Morrell Packing Company of Ottumwa is not discharging sewage into the Des Moines River directly but, in truth, is discharging its untreated sewage into the sewers of the city of Ottumwa, and

WHEREAS, the said City of Ottumwa has not taken any steps towards remedying the pollution of the Des Moines River by reason of the discharge of raw, untreated sewage into the Des Moines River by said City.

NOW, THEREFORE, IT IS HEREBY ORDERED, that the City of Ottumwa, Iowa shall submit to the State Department of Health certain progress reports in writing, which reports shall be filed on or before the following dates, to-wit: December 1, 1931; February 1, 1932; May 1, 1932. And each report shall show the work completed during the preceding quarter towards completion of the preliminary report.

AND IT IS FURTHER ORDERED, that the City of Ottumwa, Iowa, shall, on or before September 1, 1932, file with the State Department of Health a complete preliminary engineering report on the entire project, including the collection system and treatment works.

AND IT IS FURTHER ORDERED, that the City of Ottumwa, Iowa shall file not later than July 1, 1933 a complete detailed plan, together with specifications for a sewage treatment works, such plans to be approved by the State Department of Health.

AND IT IS FURTHER ORDERED, that on or before March 1, 1934, a written report shall be made to the State Department of Health by the City of Ottumwa, Iowa, setting out that a contract has been let for the construction and erection of the sewage treatment works as proposed under the completed plans and specifications previously submitted and approved by the State Department of Health.

AND IT IS FURTHER ORDERED, that in the event of the refusal or neglect of or by the City of Ottumwa to file any of the reports, drawings, plans or specifications as hereinbefore specified, or any of them, at or on the times herein ordered, that such neglect or refusal shall operate as a bar to any further time, being granted to the City of Ottumwa for the construction of intercepting sewers, or the erection of a sewage treatment plant, from and after the date set in this Order for the filing of said reports, drawings, plans and specifications.

This order is made subject to such further orders as may be made by the State Department of Health from time to time as the occasion may arise.

Dated at Des Moines, Iowa, this 14th day of August, 1931.

Commissioner of Health.

INDEX

INDEX
(Continued)

REPORT ON THE STUDIES OF THE POLLUTION
OF THE DES MOINES RIVER
1928-1931.

GENERAL SUMMARY.

In June, 1928 the Engineering Division of the Iowa State Department of Health began a study of the Des Moines River pollution from a point above Fort Dodge to a point below Farmington and the studies were continued until Summer of 1931.

The study was instituted as provided for under Sec. 2198 to 2208 of the Code of 1927 of Iowa which charges the State Department of Health with the duty of making investigation of streams for the purpose of determining the extent and effect of pollution.

The scope of the work included observation of the physical conditions of the stream, collecting samples, and making chemical and bacteriological determinations of both the stream water and the wastes discharged into the stream; collecting and compiling available pertinent data on stream flows, quantities and character of wastes discharged into the stream; compiling and interpreting the data from which conclusions were drawn.

The body of report contains in detail the data on tests and observations above referred to.

CONCLUSIONS

1. In the Des Moines river between Fort Dodge and Farmington three zones of heavy pollution are noted; namely, below the city of Fort Dodge, below the City of Des Moines, and below the city of Ottumwa.

2. Observations of the physical conditions of the stream indicate heavy pollution below Fort Dodge and Des Moines at normal dry weather flows in the form of sludge banks in the stream bed, floating solids, sewage odors, septic areas and occasional destruction of fish. The same conditions were noted below Ottumwa but to a somewhat lesser degree.

3. The average b. coli content in the steam water renders the water unsafe for bathing and other recreational purposes where contact with the water is required at all points in the steam included in this study. This is particularly the case at points of greatest b. coli contamination, below the three cities in question, and while recovery is noted, the organisms of the b. coli group in fairly high concentration persist at the sampling points farthest remote from the source of contamination.

4. The average b. coli content of the water was 145,000, 136,000, and 105,000per 100 cc. below Fort Dodge, Des Moines, and Ottumwa, respectively, and the lowest figure, 2900 per 100 cc. occurred above Des Moines. The average b. coli content above Ottumwa, the only point along the stream at which water from the stream is used for domestic purposes, exceeds the standard set by the United States Public Health Service (10,000 per 100 cc.) as a safe maximum b. coli content for raw water, which after the best type of treatment known will yield consistently safe palatable water.

   At other points in the river conditions are very much worse and the Des Moines River is unfit as a potential source of domestic water supply in its present condition throughout a great part of its course, even after adequate purification.

5. Oxygen determinations indicate frequent periods of low oxygen and negative oxygen balance at normally low flows and in a few instances almost complete depletion.

6. Average figures even at river stages considerably higher than normal low flows show oxygen resources below normal at points in the stream most remote from the source of pollution.

7. Study of the available flow records of the river indicates that low stages occur with sufficient frequency and over sufficiently

long durations of time so that the low flows must be considered normal conditions. During the three-year period of study the flow in the river at Des Moines was below 250 c.f.s. 32.6% of the time and below 600 c.f.s. 50% of the time.

8. Fish life has been destroyed on numerous occasions, particularly below Fort Dodge and Des Moines. While actual fish census were not taken, all evidence points to the fact that practically all game fish have been driven out of the zones of heavy pollution.

9. The free use of the stream for stock watering purposes is interfered with by pollution. Indications are that water heavily polluted with sewage is injurious to live stock. Access to heavily polluted water by dairy cattle constitutes a public health menace of the first magnitude unless the milk is pastuerized.

PURPOSE OF INVESTIGATION.

In 1924 the General Assembly passed a stream pollution law charging the State Department of Health with the duty of investigating the alleged pollution of streams. This law further provides for the calling of hearings and the issuing of orders by the department requiring the offenders to "desist in the practice found to be the cause of said pollution" as the condition is warranted. In 1925 the General Assembly added some minor amendments. A copy of the law will be found in the Appendix of this report.

In January, 1925 the department sent notices to Fort Dodge, Des Moines, Boone, and Ottumwa citing represenatitives of these cities to appear for a hearing to be held on January 15, 1925. The hearing was informal. The department had no bacteriological or chemical data bearing on the condition of the stream. The department did, however, have numerous complaints relative to the destruction of fish in the river below Fort Dodge and Des Moines, principally, and the department also had several petitions asking that steps be taken to prevent the further pollution of the Des Moines River.

As a result of this hearing, an order was issued to each city and major industry discharging wastes into the Des Moines River, requuiring them "to submit to the department detailed reports of the type of treatment plant or other devices and methods which they proposed to construct or adopt, together with tentative plans of their proposed installations for preventing the pollution of the Des Moines River."

The city of Boone shortly after the hearing prepared plans and specifications for a complete sewage treatment plant. This plant was constructed and placed in operation early in 1926. The other cities effected by the order have not filed reports or plans and specifications and nothing further has been done to date to relieve the pollution of the stream below the cities in question, with the exception of Boone. Since that time, several other petitions have been received complaining of the condition of the stream. In 1927 one petition having about 1500 signatures was sent to the Governor, requesting that some action be taken to abate the pollution of the river.

Since the amendments to the Stteam Pollution Law in 1925 requiring that "The department make full and complete investigations including bacteriological and chemical analyses of the water," the department has been engaged through the Sanitary Engineering Division in compiling data on the condition of the major streams in the state. With a very limited personnel it was impossible to conduct more than one survey at a time and consequently, it has taken considerable time to secure the data enclosed in this report.

Due to the fact that the personnel was busily engaged in stream pollution surveys elsewhere in the state, the Des Moines River study did not get under way until June 1928. During the winter of 1927-28 a few observations were made along the river but no routine sampling was begun at this time. In June, 1928 definite sampling stations were established and routine collection of samples was inaugurated. The sampling was continued until February, 1931, although there were frequent lapses of several weeks between collections due to the fact that the staff was engaged elsewhere or that weather and river conditions were such that the data gained would be worthless.

The purpose of the investigation was to determine the degree of pollution of the streams, the extent of such pollution, the sources of pollution under varying climatic and stream conditions. Obviously, samples collected during extremely high stream stages do not truly represent the condition of the stream. On the other hand, samples collected during extremely low stages of the stream are not representative, and in order to arrive at any definite and fiar conclusion, it was necessary to collect samples under all conditions of stream flow and under the different seasonal conditions. It was with this purpose in mind that the survey was spread over such an apparently lengthy period of time.

SCOPE OF THE INVESTIGATIONS.

Investigations of this type can be made very comprehensive and elaborate. Such investigations require a large staff and well-equipped central laboratory facilities. Many samples can be taken and the scope of tests can be very elaborate. Such investigations can run over several years time. On the other hand, as intensive study can be made over a short period of time using a few simple tests which can be made in the field. In this study a median policy was adopted. It was thought that a limited number of samples collected over an extended period of time would give a truer picture of the average condition of the stream than more frequent sampling over a short period of time.

The important tests were carried out on each sampling trip and these tests were augmented by special chemical determinations from time to time as the occasion arose.

T The investigator used a truck in which he could carry the necessary equipment for making the oxygen determinations in the field. A central laboratory was located at Des Moines for the B. O. D. determinations, while samples for ~~its~~ other determinations were shipped to the State Hygienic Laboratory at Iowa City.

The work was planned so that the maximum amount of information as to the condition of the river could be obtained with the limited personnel and facilities available. While limited personnel and facilities slowed up the work somewhat, the results obtained were over a sufficiently long period of time and the chemical and bacteriological data is complete enough so that a reliable picture of the average as well as the worst conditions of the streams during the period of study can be drawn.

THE DES MOINES RIVER.

The Des Moines River rises in Murray County, Minnesota and flows in a southerly direction, crossing the northern boundary of Iowa in the northwestern corner of Emmet County, and from there flows in a southeasterly direction across Iowa to the Mississippi River.

The east fork of the Des Moines River rises in the southwestern part of Martin County, Minnesota, and flows in a southeasterly direction to a point a few miles south of Humboldt, where it joins the main river.

The entire course of the river is across a region which was in past ages covered with continental glaciers. The mantle-rock in this region is therefore composed of loose material carried in by the glaciers and left there after they melted. Below Des Moines, the mantle-rock is somewhat different than that above and is known as loess. Beneath these glacial deposits there is bedrock which consists of layers of barious classes of stone. In the upper part of the valley, this bedrock has not been uncovered by the action of the river, but below Humboldt, it is quite common to find bedrock exposed.

Above Des Moines the valley is not very wide and at the extreme upper parts, the valley is shallow. From Humboldt on down the river the hills on either side of the river are high and steep, and below Des Moines the valley is also wide. The total fall of the river is about 1000 feet in its 535 miles of length. The total drainage area is 14,540 quare miles and its principal tributaries are East Fork, Raccoon River, Boone River, South River and Middle River.

The tributary drainage area is at the present time mostly farm land, intensively cultivated. In the upper reaches, much channel straightening and drainage work has been carried out. No doubt this work and the intensive cultivation of the land on the drainage areas has changed the nature of the stream. In times of heavy rains more silt is carried into the stream. The flood stages are higher than before the extensive drainage work, due to the more rapid run-off, and the average stages of the river are lower and the low stages of longer duration in the fall and early winter than they were prior to the extensive drainage operations.

With no water stored in sloughs and lakes and with the demand by the growing crop for most of the water that falls during the summer months, the run-off in the upper valley is small and as a result, low river stages over rather extended periods of time can usually be expected in the late summer and early fall and again in the winter.

For the most part, the river follows a fairly flat grade. Thus, in low states, the velocity is not great and opportunity for reaeration is not exceptionally good. There are numerous riffles and artificial dams throughout the course of the stream which create pools of relatively quiet water where sewage solids readily settle, there to undergo decomposition. Likewise, during an average winter, these pools of quiet water are covered with a solid coating of ice, thus cutting off the supply of atmospheric oxygen over relatively large portions of the river and for comparatively long periods of time.

SOURCES OF POLLUTION

In the principal cities discharging wastes into the Des Moines River, special studies were made to determine the strength and quantity of wastes entering the stream. In Des Moines, the Iowa Packing Co., and in Ottumwa, the Morrell Packing Co., are the principal industrial offenders. Due to the fact that both of these establishments discharge wastes into city sewers, it was impossible to obtain separate samples of each of these wastes. However, with the comprehensive data available on packing house wastes in other cities, a very close estimate of the oxygen demand of the packing house wastes can be obtained on the basis of their kill at the plants and from these figures a very close approximation of the population equivalent of the packing house wastes can be obtained.

In view of the numerous complaints of the oil pollution and of gas plant odors and of gas waste tastes in fish taken from the Des Moines River, special samples were taken of the gas plant wastes at Des Moines and analyzed for phenol content.

Accurate flow measurements are not available of the sewage discharged into the river from any of these cities, consequently estimates of quantity are based upon population served, water consumption and upon the flow records available.

The City of Fort Dodge installed a weir and recording gage on the main sewer outlet and have continuous flow records over a considerable period of time. There are two other sewer outlets into the river but this main sewer, it is estimated carries 90% of the sewage discharged into the streams and on the basis of these measurements it is estimated that the total dry weather flow of sewage from Fort Dodge is about 1,700,000 gallons. Average pumpage records at the water plant are also approximately this figure. The 1930 census shows a population of 21,895 for Fort Dodge.

The above figure would represent a per capita sewage flow of 78 gallons daily which is somewhat less than the average figures for the cities of similar size. This is probably accounted for by the fact that in Fort Dodge there are no large industries contributing large quantities of wastes to the city sewers.

In Des Moines measurements of flow are available for the main east and main west sewers. At the request of the department the city installed weirs and the department installed a recording gage on these two main outlets and flows were measured for several days. The average daily dry weather flow from these sewers was about 9,500,000. There are four other main sewers, namely the southwest sewer, the southeast 18th street sewer, the southeast 9th street sewer and the southeast 30th street sewer. It is estimated that the main east and main west sewers carry 60% of the total from the city. On this basis the total flow would be about 16,000,000 gallons daily. Records of water pumped by the water works for May, June, and December in 1930, indicate an average daily pumpage of 14,400,000 gallons. While some water pumped at the water works does not enter the sewer system, some water enters the sewer system from private supplies, infiltration, etc. The two will nearly compensate each other in dry weather.

The population of Des Moines in 1930 was 142,559. Using a figure of 15,000,000 gallons of sewage daily, the per capita daily sewage flow is 105 gallons, which is a reasonable figure for a city the size of Des Moines.

The principal offending industries in Des Moines are the Gas Company and the Iowa Packing Company. The former discharges only a small quantity of wastes but this waste is objectionable in small quantities due to its phenol content. The Iowa Packing Company contributes a considerable quantity of sewage to the city sewers, the exact figures on the amount are not available.

No data on the sewage flows in Ottumwa are available and no measurements were made.

Average daily pumpages at the water plant for January and June, 1931, are 3,200,000 gallons. The 1930 census gives Ottumwa a population of 28,075.

Using the water pumpage of 3,200,000 gallons per day as a basis the average per capita sewage flow would be 114 which is somewhat higher than the average for cities of similar size. In addition to this the Morrell Packing Company contributes a large quantity of the packing plant wastes to the city sewers, data on the exact quantity of which is not available. Ottumwa has eight separate sewer outlets into the river.

INDUSTRIAL WASTES

Fort Dodge has no industries which contribute large quantities of industrial wastes. A serum plant, creameries and laundries, etc., are connected to the city sewers, but since the quantities of these wastes are relatively small no attempt was made to estimate population equivalents.

The Iowa Packing Company plant is the principal industrial offender at Des Moines. Since this company discharges into the city dewers separate samples of packing house wastes could not be obtained. However, on the basis of comprehensive data from other meat packing establishments elsewhere in the state, a fairly accurate estimate of the population equivalent of packing house wastes can be obtained from the kill.

According to figures submitted by the packing house officials, the average kill in 1929 was 1,295. This is equivalent to domestic sewage from 16,900 people. The maximum kill was 1,945, which has a population equivalent of 25,300. The maximum kill usually extends over a period of about two months, and in the winter when the stream conditions are most critical.

The second greatest industrial offender in Des Moines is the Des Moines Gas Company. The quantity of wastes from this plant is small but the character is such that it contains high concentration of phenol and other tar derivatives which render such wastes very objectionable even in high dilutions. There are other minor industries, such as small packing establishments, rendering works, creameries, milk plants, laundries, etc., which contribute to the load but each of these are minor contributors compared with the whole and no separate data is available on these small establishments.

The only large industrial offender in Ottumwa is the Morrell Packing Company. On the basis of figures received from the company the population equivalent based upon average kills is 42,000 while the population equivalent based upon the maximum kills is 70,000.

SUMMARY.

The population equivalent of untreated sewage discharged into the Des Moines river at the three major cities is:

	1930 Pop.	Pop. Equiv. Aver. Kill	Total	Pop. Equiv. Max. Kill	Total
Fort Dodge	21,895		21,895		21,895
Des Moines	142,559				
Iowa Packing Company		16,900	159,459	25,300	167,859
Ottumwa	28,075				
Morrell Packing Co.		42,000	70,075	70,000	98,075

Following are the individual reports on the analyses of the sewage from Fort Dodge, Des Moines and Ottumwa. These reports are self explanatory.

FT. DODGE COMPOSITE SEWAGE SAMPLES-- May 21, 1929

STATION	ODOR	SEDIMENT	TURBIDITY	COLOR	ALKALINITY	CHLORINE AS CHLORIDES	OXYGEN CONSUMED	NITROGEN. AMMONIA	NITRITE	NITRATE	ALBUMINOID.
2	Chloroform	Decided Organic	Decided	Decided Gray	430	44	61.0	7.500	0.010	1.0	7.00
3	"	"	"	"	328	61	61.0	3.500	0.750	40.0	0.700
4	"	"	"	"	428	474	79.0	7.500	0.175	0.1	1.500

A COMPARISON OF B.O.D. FIGURES ON FT. DODGE SEWAGE.

Station	July 27, 1928 FRIDAY	Oct. 2, 1928 TUESDAY	May 21, 1929 TUESDAY	August 7, 1929 WEDNESDAY	Sepetember 10, 1929 TUESDAY
2	190	155	135	165	265
3		121	112	185	112
4	250	360	207	335	292
Ave.	220	212	151	228	223

Fort Dodge, Iowa. August 7, 1929

Composite Sewer Sampling

Wm. R. Mark.

Mr. A. H. Wieters,
Chief Engineer,
Office.

Dear Sir:

On August 7, 1929, Mr. McAllister and the writer collected composite sewer samples from the Fort Dodge sewers, viz:

#2 - West side sewer (12" pipe)
#3 - 16th St. Sewer (8" pipe)
#4 - Round House Sewer (28" Pipe)

The samples were collected over a period of 18 hours. The first sample was not 24 hours old by the time dilutions were made.

The pH of each sample was as follows:

#2 - 7.5
#3 - 7.3
#4 - 7.5

The average B.O.D. for Ft. Dodge sewage was 228 P.p.m. This is somewhat higher than the results obtained on May 21, 1929 over the same period of time.

Mr. John Pray, water superintendent, took gage readings of the 28" West side sewer during the past year. The readings for the period Nov. 17th to Dec. 1, 1928, can be found in the Des Moines River files. A drawing of the wier box was also obtained. Mr. Pray estimated that 98% of the town sewage is carried by the 28" East side sewer. He stated that in using the peak figures of a typical gage reading he obtained a daily sewage flow of 1,520,000 gallons which checks closely to the daily water consumption.

Respectfully submitted,

Wm. R. Mark
Asst. Sanitary Engineer.

WRM:M

FT. DODGE COMPOSITE SEWAGE SAMPLES - August 7, 1929.

STATION	ODOR	SEDIMENT	TURBIDITY	COLOR	ALKALINITY	CHLORINE AS CHLORIDE	OXYGEN CONSUMED	NITROGEN AMMONIA	NITRITE	NITRATE	ALBUMINOID
2	Chloroform	Decided Organic	Decided	Decided Gray	Acid	57	70	5.0	0.02	0.3	0.60
3	"	"	"	"	406	47	78	7.25	0.25	0.5	0.45
4	"	"	"	"	492	134	86	11.25	0.25	0.1	1.00

A COMPARISON OF B.O.D. FIGURES ON FT. DODGE SEWAGE (18 Hr. Composites)

Station	May 21, 1929 Tuesday	Aug. 7, 1929 Wednesday	Sept. 10, 1929 Tuesday
#2	135	165	265
# 3	112	185	112
#4	207	335	292
Average	151	228	223

Fort Dodge September 10th, 1929

Composite Sewer Sampling

R. B. McAllister

Mr. A. H. Wieters,
Chief Engineer,
Office.

Dear Sir:

On Sept. 10th, 1929, Mr. Mark and the writer collected samples from the Fort Dodge sewers, viz:

#2 - West side sewer (12" pipe)
#3 - 16th St. sewer (8" pipe)
#4 - Round House sewer (28" pipe)

The samples were collected over an 18 hour period. The first sample was about 30 hours old when the dilutions were made.

The pH of each sample was as follows:

#2 - 7.1
#3 - 7.1
#4 - 7.2

The average B.O.D. was 223 p.p.m., which is a little lower than the Aug. 7th samples, but higher than the May 21st samples.

At the time of the 12 o'clock and 2 o'clock sampling a bloody color was noticed at sewer outlet #4, which was probably caused by the waste from the Serum plant.

Respectfully submitted.

R. B. McAllister
Asst. Sanitary Engineer.

RBMcA:M

FT. DODGE COMPOSITE SEWAGE SAMPLES (Sept. 10, 1929).

STATION	ODOR	SEDIMENT	TURBIDITY	COLOR	ALKALINITY	CHLORINE AS CHLORIDE	OXYGEN CONSUMED	NITROGEN			
								AMMONIA	NITRITE	NITRATE	ALBUMINOID
2	Chloroform	Decided Organic	Decided	Decided Grey	490.0	56.0	63.0	3.500	0.002	0.1	1.000
3	"	"	"	"	448.0	53.0	34.4	3.500	0.002	0.1	1.000
4	"	"	"	"	566.0	229.0	135.0	12.500	0.002	0.1	3.000

A Comparison of Two Methods for Determining an Average Figure for the B.O.D. of Sewage

By M. J. Lonergan,
Assistant Sanitary Engineer,
State Department of Health,
Des Moines, Iowa.

In our stream pollution investigations, it becomes necessary for us to arrive at a figure, for the biochemical oxygen demand of the various domestic and industrial wastes, which are discharged into these streams. This figure, which is expressive of the oxygen consuming power of the waste, may be arrived at in different ways. During a recent study an attempt was made to determine the most practical method.

On May 3rd, (F riday) 1929 starting at 7 A.M. samples were taken every three hours, at six points on the five major sanitary sewers of Des Moines. This program involved making seven trips (94 miles) over an 18 hour period (from 7 A.M. to 1 A.M.) to collect 42 samples. Composites were made up for each sampling point (one-half pint taken from each sample) and several dilutions were made of each composite. Dilutions were also made up (4 of each) of each of the 42 samples collected. The five day B.O.D. was determined, in each case, and a very surprisingly close check resulted.

The data obtained show conclusively that the making up of dilutions of composite samples is the most practical method for determining the B.O.D. of sewage. The time and work involved in making dilutions of each sample is not warranted. In this instance it involved the making up of 170 dilutions, which we now know could have been eliminated, thereby lowering the time and expense involved. The only advantage of this method (evident in the accompanying graph) is, that it is interesting to know the hourly fluctuation in the strength of the sewage. Our mission, however, was to simply determine the average 18 hour B.O.D. figure for Des Moines sewage.

The accompanying figures, obtained by the two methods, show the final variation to be 5.6%. This variation is considered larger than it should be, because (as stated on the data sheet) the composite figure for Station No. 1 is not considered representative, since the depletion in each of the four dilutions made, was decidedly greater than 60%. For best results the depletion of oxygen in a dilution should be between 30 and 60%. By substituting 144 in place of 90 for Station No. 1, we find that the average figures then to be 188 and 189, which is a decidedly close check. The B.O.D. for Des Moines sewage is therefore taken to be 188 p.p.m.

Without the addition of the packing house waste the average B.O.D. figure for Des Moines domestic sewage over the 18 hour period would be 104 p.p.m. This figure probably is low for domestic sewage and is partly accountable for by the infiltration into the system. The ground water table was exceptionally high at this time.

Extreme care was taken in this work, which is reflected in the very comparable fesults. Past experiences have proven to us that careful technique and clean glassware are essentials for good results.

The pH was run on each sample taken from 1 P.M. and no particular variations were noted at any sampling point, and all samples were on the alkaline side of the scale.

CONCLUSION:

From henceforth to determine an average B.O.D. figure, dilutions will be made only of the composite sample.

STATION NUMBERS.

No. 1 Outlet of Main West Side Sewer
No. 2 Outlet of Main East Side Sewer
No. 3 Outlet of South West Sewer
No. 4 Outlet of Southeast 18th St. Sewer
(Below packing plant outlet.)
No. 5 Manhole at South East 20th & Scott St.
No. 6 Manhole on South East 18th Street.
(Above packing plant outlet.)
No. 6-A Difference between Sample No. 4 and No. 6, which gives the figures on the packing plant waste.

pH of Hourly samples - Des Moines Sewers - May 3, 1929.

Station	1 P.M.	4 P.M.	7 P.M.	10 P.M.	1 A.M.
1	7.6	7.6	7.5	7.4	7.4
2	7.5	7.6	7.5	7.6	7.5
3	7.4	7.3	7.3	7.2	7.2
4	7.1	7.0	7.2	7.3	7.4
5	7.2	7.2	7.3	7.4	7.4
6	7.6	7.6	7.6	7.6	7.6

May 3, 1929.

Des Moines.

Results of Sampling over an 18 hour Period to Determine the

5-day B.O.D. of Des Moines Sewage.

M. J. Lonergan.

Mr. A. H. Wieters,
Chief Engineer,
Office.

Dear Sir:

On May 3rd (Friday) 1929, we began taking sample at 7:00 A.M. at six points on the five major sanitary sewers of Des Moines. A sample was taken at each of these points every three hours thereafter up until 1:00 A.M. This procedure involved seven trips, a total of 94 miles, to collect the 42 samples. Composites were made up for each sampling point (one-half pint taken from each sample) and dilutions were made of these composites. Dilutions were also made up (4 of each) of each of the 42 samples. The object of making dilutions of each sample taken, as well as dilutions of the composite samples, was to definitely satify ourselves as to the most practical method of doing this sort of work in the future.

The data obtained show conclusively that the making up of dilutions of composite samples is the best practical method to determine the B.O.D. of sewage. The time and work involved in making dilutions of each sample is not warranted. In this instance some 170 dilutions were made up which (as we now know) could have been eliminated. We were pleased to learn of the very comparative figures obtained by the two methods, vi.: the results of the average B.O.D. of separate sample dilutions, and the average B.O.D. of the composite samples. As shown on the accompanying table this variation was 5.6%. This is considered larger than it should be, because, (as stated on the data sheet) the composite figure for Station No. 1 is not considered representative, since the depletion in each of the four dilutions made was decidedly greater than 60%. It is recalled that for best results the dilutions should be of such percentage that the depletion in oxygen in the sample should be between 30% and 60%. Had this been true, with regard to Sample No. 1, mentioned above, the comparative difference of the two methods of determining the B.O.D. would have been more nearly the same. By substituting 144 for 90 for Station No. 1, the comparative average B.O.D. would be about 166 p.p.m. in each case. The B.O.D. of Des Moines sewage is therefore taken to be 166 p.p.m.

Extreme care was taken in this work which, no doubt, is reflected in the very comparable results obtained.

The pH was run on each sample taken after 1:00 P.M., and the results are shown on an accompanying sheet. No particular variations were noted at any sampling point, and all were on the alkaline side of the scale.

CONCLUSION.

From henceforth we will only run dilutions on the composite samples.

Respectfully submitted.

M. J. Lonergan,
Asst. Sanitary Engineer.

MJL/M

NOTATIONS ON SAMPLES.

Sample No. 1

7 A.M.	-	Clear. Very heavy grease scum.	Temp.	10° C.
10 A.M.		Very concentrated, no grease now.	"	14
1 P.M.		" " " " "	"	14
4 P.M.		" " " " "	"	15
7 P.M.		Somewhat clearer than 4 P.M.	"	15
10 P.M.		Quite clear	"	13
1 A.M.		Very clear.	"	13

Sample No. 2.

7 A.M.	-	Dark color. B.O.D. will be high for 7 A.M.	Temp.	15 C
10 A.M.		Concentrated	"	21
1 P.M.		Large proportion of gas house waste Very decided gasoline odor.		18
4 P.M.		Still some gas house waste	"	18
7 P.M.		No gas house waste now. Clearer	"	17
10 P.M.		Clear.	"	17
1 A.M.		Very clear	"	19

Sample No. 3.

7 A.M.	-	Very clear, but sort of dye colored	Temp.	10 C
10 A.M.		Some stringy like material. Clear yet dye colored	"	10
1 P.M.		Some stringy like material. Clear yet dye colored	"	11
4 P.M.		Very clear. Clearest sample today.	"	11
7 P.M.		Very clear, yet dye colored	"	11
10 P.M.		" " " " "	"	11
1 A.M.		" " " " "	"	10

Sample No. 4.

7 A.M.	-	Very concentrated	Temp.	14 C.
10 A.M.		Very concentrated and greasy floating tallow	"	15
1 P.M.		Very concentrated and greasy	"	20
4 P.M.		Very concentrated	"	17
7 P.M.		Not as concentrated as 4 P.M.	"	14
10 P.M.		About same as 7 P.M.	"	21
1 A.M.		Very clear	"	21

Sample No. 5.

7 A.M.	-	Quite clear	Temp.	10 C
10 A.M.		Very milky color	"	14
1 P.M.		Same as 10 A.M.	"	13
4 P.M.		Concentrated	"	14
7 P.M.		Not so concentrated	"	11
10 P.M.		Quite clear	"	10
1 A.M.		Very clear	"	10

Sample No. 6.

7 A. M.	-	No sample taken		
10 A.M.		B.O.D. about 150	"	10
1 P.M.		About same as 10 A.M.	"	11
4 P.M.		About same as 10 A.M.	"	12
7 P.M.		Somewhat lighter	"	10
10 P.M.		Clear	"	10
1 A.M.		Very Clear	"	10

DES MOINES COMPOSITE SEWER SAMPLES May 3, 1929.

(Laboratory Data)

Station	Odor	Color	Sediment	Turbidity	Relative Stability	Alkalinity	Chlorine as Chlorides	Oxygen consumed	NITROGEN Ammonia	NITROGEN Nitrite	NITROGEN Nitrate	NITROGEN Albuminoid
1	Chloroform	Gray	Decided	Decided	90%	356	77	35.24	3.5	0.50	0.300	0.6
2	Gas Chloroform	Gray	Decided	Decided	90%	328	549	110.56	3.0	0.75	1.0	0.6
3	Chloroform	Slight Grey	Slight	Slight	90%	304	33	13.64	2.0	0.375	1.0	0.17
4	Chloroform	Grey Brown	Very Decided	Very Decided	37%	396	371	116.96	2.0	0.75	0.3	2.0
5	Chloroform	Gray	Slight	Decided	90%	306	48	61.04	5.0	0.175	0.3	1.5
6	Chloroform	Gray	Decided	Decided	90%	364	68	34.68	3.5	2.0	2.0	0.45
				Ave.	81%	342	191	62.02	3.3	.508	.81	.88

Comparison of Results of Separate Dilutions and Composite Samples
May 3, 1929.

Sta.	7 A.M.	10 A.M.	1 P.M.	4 P.M.	7 P.M.	10 P.M.	1 A.M.	Average of Separate Dilution	Average of Composite Samples	Percentage Difference
1	145	240	180	175	145	95	30	144	90*	60
2	145	240	285	220	110	--	12	167	170	1.8
3	50	110	90	45	18	20	2	42	--	--
4	540	1120	640	640	360	295	160	478	480	2.1
5	40	320	230	135	35	15	10	112	110	1.7
6	--	---	80	120	60	55	.32	54	50	7.9
6-A	--	---	560	520	300	240	---	424	430	1.4
							Average	188	178**	5.6

B. O.D. of Des Moines Sewers is therefore taken as 188 p.p.m.

*This figure (90) is not considered representative since the depletion in all four dilutions was greater than 90%. (It should not be greater than 60%.)

**A verage of Sts. 1,2,3,4 & 5. No. 4 includes packing plant Waste.

May 14, 1929.

Results of Sampling over 16 hour period to check B.O.D. of

Des Moines Sewers.

Mr. A. H. Wieters,
Chief Engineer,
Office.

Dear Sir:

On May 14, 1929 (Tuesday) another series of samples was collected from the Des Moines sewers. Samples were collected at 9 A.M., 12 M., 3 P.M., 6 P.M., 9 P.M. and 12 Midnight, and dilutions were made only of the composite samples. The average results of these determinations follow:

	B.O.D. May 14 - Tues	Friday May 3rd	Variation
Sewer No. 1	155 p.p.m.	144 p.p.m.	11
2	275 p.p.m.	167 p.p.m.	108
3	90 p.p.m.	42 p.p.m.	48
4	577 p.p.m.	478 p.p.m.	99
5	197 p.p.m.	112 p.p.m.	85
6	177 p.p.m.	54 p.p.m.	123
Average	258	188	

Leaving out the figure 177, (which is incorporated in Sewer No. 4) we obtain an average B.O.D. of 258 p.p.m. The average figure obtained on May 3rd (Friday) was 188 p.p.m. This gives us a variation of 70 p.p.m.. for which two possible explanations are offered, viz.:

(1) On May 3rd, there were seven collections made, as compared with six collections on May 14th. For a fair comparison of results there should have been seven collections made on May 14th, and it is believed that had another sample been taken at 6 A.M. it would lower our average figure of 258 p.p.m. Naturally the B.O.D. of any outlet at 6 A.M. would be quite low. As a matter of comparison, if we use the B.O.D. figures of 7 A.M. on May 3rd (since we have no 6 A.M. sample on May 14th) and average this figure, in each case with the results obtained on May 14th, we obtain the following figures:

5-14-29

Average Figures	May 14 Tues. 6 samples plus 7 A.M. May 3 Samp.	May 14 Tues. 6 samples	May 3rd Fri. 7 samples.	pH May 14th.
Sample 1	151	155	144	7.3
2	233	275	167	7.2
3	76	90	42	7.6
4	570	577	478	6.8
5	145	197	112	7.2
6	145	177	84	7.2
Average	220	258	188	

Thus, we see that, had 6 A.M. sample been collected our figure of 258 p.p.m. would have been reduced to at least 220 p.p.m. and probably more since the B.O.D. at 6 A.M. should be less than at 7 A.M.

(2) This still would give us a variation of 32 p.p.m., which can partially be accounted for by the fact that Tuesday is unlike Friday, in that it is a wash day, which reflects in the appearance and B.O.D. of a sample.

In conclusion, therefore, it would seem reasonable to average our two figures of 220 and 188, and call the B.O.D. of Des Moines Sewers 204 p.p.m.

Respectfully submitted,

M. J. Lonergan,
Asst. Sanitary Engineer.

MJL:M

NOTATION ON SAMPLES.

Sample No. 1

9 A.M.	Quite Clear	Temp. 15 deg. C.
12 M	Concentrated	" 15
3 P.M.	Concentrated	" 11
6 P.M.	Quite clear	" 10
9 P.M.	Quite clear	" 15
12 Mid.	Quite Clear	" 15

Sample No. 2.

9 A.M.	Concentrated	Temp. 22 Deg. C.
12 N.	Concentrated	" 12
3 P.M.	Concentrated	" 20
6 P.M.	Concentrated	" 22
12 P.M.	Quite Clear	" 24

Sample No. 3.

9 A.M.	Very Clear	Temp. 10 Deg. C.
12 N.	Very Cleark	" 11
3 P.M.	Clear	" 13
6 P.M.	Clear	" 10
9 P.M.	Very Clear	" 10
12 P.M.	Very Clear	" 11

Sample No. 4.

9 A.M.	Quite Cleark	Temp. 17 Deg. C.
12 N.	Very Red - bloody	" 18
3 P.M.	Still bloody	" 20
6 P.M.	" "	" 15
9 P.M.	Decidedly clearer	" 16
12 Mid.	Quite clear	" 14

Sample No. 5.

9 A.M.	Pink color	Temp. 13 Deg. C.
12 N.	Milky color	" 17
3 P.M.	Clear	" 12
6 P.M.	Clear	" 14
9 P.M.	Clear	" 15
12 P.M.	Very clear	" 11

Sample No. 6.

9 A.M.	Clear	Temp. 12 Deg. C.
12 N.	Concentrated	" 12
3 P.M.	Clear	" 20
6 P.M.	Clear	" 20
9 P.M.	Clear	" 15
12 Mid.	Clear	" 15

DES MOINES COMPOSITE SAMPLES - Tuesday May 14, 1929

Laboratory Data.

Station	Odor	Color	Sediment	Turbidity	Relative Stability %	Alkalinity	Chlorine as Chlorides	Oxygen Consumed	NITROGEN. Ammonia	Nitrite	Nitrate	Albuminoid
1	Chloroform	Decided Gray	Decided Organic	Decided	90 +	342	67	64	5.0	1.500	0.5	1.0
2	Chloroform	"	"	"	90 +	372	359	120	7.5	1.500	0.3	1.0
3	Chloroform	Slight Gray	Slight Organic	Slight	90 +	296	28	38	2.0	.375	2.0	2.5
4	Chloroform	Decided Brown	Decided Organic	Decided	60	334	518	61	7.5	1.875	0.1	3.0
5	Chloroform	Decided Gray	"	"	90 +	292	45	70	3.5	.500	.0	1.0
6 6	Chloroform	"	"	"	90 +	230	69	55	3.0	.875	1.0	7.0

June 10, 1929

sampling of the six Des Moines sewer outlets over a

period of 14 hours to determine the average B.O.D.

W. R. Mark

Mr. A. H. Wieters
Chief Engineer,
Office.

Dear Sir:

On Monday, June 10th, the writer collected composite samples of the Des Moines sewers. Samples were taken over a period of 14 hours from 6 A.M. until 8 P.M.

The following figures are the results of this work:

Station	B.O.D.	pH
No. 1	170	7.3
2	220	6.9
3	60	7.4
4	590	6.4
5	275	7.0
6	190	7.3

The average B.O.D. omitting results of No. 6, which is incorporated in No. 4, is 263 p.p.m.

For comparison previous results are here listed.

Station	B.O.D. Tues. May 14th	B.O.D. Fri. May 3rd	B. O.D. Mon. June 10th
1	155	144	170
2	275	167	220
3	90	42	60
4	577	478	590
5	197	112	276
6	177	54	190
Average	258	188	263

The increased B.O.D. can possibly be accounted for in that the samples were collected on a Monday, which is wash day. Wash water increased the B.O.D. considerably.

The average of the three (258, 188 and 263) would be 236 p.p.m., which I believe is a reasonable B.O.D. for the Des Moines Sewage.

Respectfully submitted,

W. R. Mark
Asst. Sanitary Engineer.

WRM/MM

NOTATIONS ON SAMPLES.

DES MOINES June 10, 1929.

Clear - Warm.

	Station No.	Temp.	Remarks.
6 A.M.	1	15.5° C.	Concentrated
	2	20.4	Fairly clear
	3	12.2	Clear
	4	26.2	Concentrated
	5	15.2	Clear
	6	15.0	Clear
8 A.M.	1	16.5	Concentrated
	2	17.5	Concentrated
	3	13	Clear
	4	24.2	Concentrated
	5	15.5	Concentrated
	6	15.0	Oily
10 A.M.	1	19	Concentrated
	2	23.8	Concentrated
	3	13.0	Clear
	4	27.0	Concentrated
	5	17.0	Concentrated
	6	14.0	Concentrated
12 Noon	1	19.0	Concentrated
	2	22.6	Concentrated
	3	13.0	Clear
	4	26.4	Concentrated
	5	18.5	Concentrated
	6	14.5	Concentrated
2 P.M.	1	18.6	Concentrated
	2	19.4	Concentrated
	3	14.0	Concentrated
	4	26.8	Concentrated
	5	19.8	Concentrated
	6	14.2	Concentrated

NOTATIONS ON SAMPLES.
Page. 2.

Des Moines June 10, 1929

	Station No.	Temp.	Remarks.
4 P.M.	1	13.8	Concentrated
	2	23.0	Concentrated
	3	13.8	Concentrated
	4	24.5	Concentrated
	5	19.5	Concentrated
	6	15.5	Concentrated
6 P.M.	1	19.5	Concentrated
	2	23.5	Concentrated
	3	13.0	Clear
	4	24.0	Concentrated
	5	18.0	Concentrated
	6	15.0	Concentrated
8 P.M.	1	19	Concentrated
	2	22	Concentrated
	3	13	Clear
	4	24	Concentrated
	5	17	Concentrated
	6	15	Concentrated

DES MOINES COMPOSITE SEWER SAMPLES Monday June 10, 1929.

Laboratory Data.

Station	Odor	Color	Sediment	Turbidity	Relative Stability %	Alkalinity	Chlorine as Chlorides	Oxygen Consumed	NITROGEN Ammonia	NITROGEN Nitrite	NITROGEN Nitrate	NITROGEN Albuminoid
1	Chloroform	Decided Grey	Decided Organic	Decided	90 +	360	161	61	5.0	0.30	.020	1.00
2	Chloroform	"	"	"	90 +	352	95	83	5.0	0.30	.020	1.00
3	Chloroform	"	slight organic	Slight	90 +	310	25	52	2.25	0.3	.07	0.45
4	Disagreeable	Decided Brown	Decided Organic	Decided	60	466	457	172	10.00	0.5	.02	1.25
5	Chloroform	Decided Grey	"	"	90 +	316	54	68	5.0	0.1	.01	1.00
6	Chloroform	"	"	"	90 +	464	75	95	3.5	0.3	.04	1.00
				Average	85	378	145	89	4.79	.20	.03	.95

Des Moines, Iowa.

March 11, 1930.

Composite Sewage Samples

N. E. McAllister

Mr. A. H. Wieters, Chief Engineer,
State Department of Health,
Office.

Dear Sir:

On March 5th and 6th, 1930 Mr. Fiala and the writer took samples on the six Des Moines sewer outlets. There was a total of eight sampling points. A sample was taken at each sampling point every hour. Due to the number of samples and the short time between samples, the work was divided between the two days.

Station Numbers.

1. Outlet of Main West Side sewer
2. " " " East " "
3. " " " South West Side sewer
4. " " " " East 18th St. Sewer
5. (below packing plant)
5. " " South East 20th St. sewer
6. Manhole South East 18th St. and Court. (above packing plant)
* 7. Gas plant waste
8. Outlet of South East 9th St. Sewer

* B.O.D. was not run on Station 7.

On the second day we were running short of sample bottles so we took composites over a three hour period instead of one full bottle for each sample. No samples were taken after 4 P.M. at the gas plant since the waste stopped flowing and all samples thereafter would have been the same.

Respectfully submitted

R. E. McAllister,
Asst. Sanitary Engineer.

RBM/MM

B. O. D. in P.P.M.

	1	2	3	4	5	6	7	8
7 A.M.	70	122.5	122.5	652.5	95.0	282.5		132.5
8	155	202.5	87.5					
9	342.5	352.5	55.0					
10	352.5	292.5	*242.5	532.5	262.5	172.5		692.5
11	280.0	330.0	82.5					
12 (Noon)	340.0	457.5	57.5					
1 P.M.	292.5	412.5	202.5	477.5	347.5	250.0		552.5
2	427.5	462.5	207.5					
3	385.0	360.0	197.5					
4	327.5	430.0	230.0	482.5	297.5	280.0		237.5
5	325.0	342.5	177.5					
6	325.0	425.0	102.5					
7	322.5	297.5	255.0	362.5	417.5	270.0		250.0
8	265.0	302.5	200.0					
9	287.5	297.5	187.5					
10	310.0	260.0	115.0	*187.5	280.0	*585.0		312.5
11	285.0	277.5	75.0					
12 (Midnite)	247.5	305.0	97.5					
Avg.	295.5	334.4	144.2	501.5	283.3	251.0		362.9

* Left out of averages.

Notations on Samples.

Time	Sta.	Temp.	
7 A.M.	1	9.0	Clear
	2	12.0	Fairly clear
	3	7.5	Clear
	4	18.0	Bloody
	5	9.0	Gray
	6	9.0	Light Gray
	7	30.0	
	8	7.0	Clear
8 A.M.	1	8.0	Gray
	2	12.0	Gray
	3	7.0	Clear
	4	18.0	Bloody
	5	9.0	Gray Oily
	6	9.0	Light gray
	7	20.0	
	8	7.5	
9 A.M.	1	13.0	Gray Oily
	2	14.0	" "
	3	8.0	Clear
	4	19.0	Bloody
	5	9.5	Grey
	6	9.0	Light Gray
	7	20.0	
	8	8.5	Dark grey
10 A.M.	1	15.0	Grey
	2	12.0	Grey - Gaseous odor
	3	8.0	Clear
	4	19.0	Bloody
	5	9.0	Gray oily
	6	9.0	Light gray
	7	22.0	
	8	8.5	Dark Gray
11 A.M.	1	15.0	Gray
	2	14.0	Lt.Gray Gaseous odor
	3	10.0	Clear
	4	20.0	Bloody
	5	13.0	Gray oily
	6	9.0	Light grey
	7	22.5	
	8	8.0	Dark grey

Time	Station	Temp.	
12 A.M.	1	15.0	Light gray
	2	14.0	" "
	3	9.0	Clear oily
	4	19.0	Bloody
	5	10.0	Gray
	6	8.5	Light gray
	7	22.0	
	8	8.0	Dark gray
1 P.M.	1	14.0	Gray
	2	15.0	"
	3	9.5	Clear Oily
	4	17.0	Gray
	5	14.0	Gray
	6	9.0	Gray
	7	22.0	
	8	8.5	Soapy
2 P.M.	1	15.0	Gray
	2	14.0	Black
	3	9.0	Gray
	4	18.0	Bloody
	5	13.0	Gray
	6	10.0	Gray
	7	22.0	
	8	8.5	Soapy
3 P.M.	1	15.5	Gray oily
	2	15.5	Gray
	3	9.5	Gray oily
	4	17.0	Slightly bloody
	5	12.0	Gray
	6	9.0	Gray
	7	22.0	
	8	8.0	Gray
4 P.M.	1	16.0	Gray
	2	16.0	Gray
	3	9.0	Clear
	4	15.0	Slightly bloody
	5	13.0	Gray
	6	10.0	Gray
	7	22.0	
	8	8.0	Gray
5 P.M.	1	15.0	Gray
	2	17.0	
	3	9.0	Clear
	4	13.0	Gray
	5	12.5	Gray
	6	10.0	Gray
	7		
	8	8.0	Gray

Time	Station	Temp	
6 P.M.	1	14.5	Gray
	2	16.0	Gray
	3	9.0	Clear
	4	16.0	Bloody
	5	13.0	Gray
	6	10.0	Clear
	7		
	8	7.0	Gray
7 P.M.	1	14.0	Gray
	2	15.0	Gray
	3	8.0	Gray
	4	15.0	Gray
	5	12.0	Gray
	6		
	7	10.0	Gray
	8	8.0	Gray
8 P.M.	1	13.5	Gray
	2	15.0	"
	3	8.5	"
	4	14.0	"
	5	11.0	"
	6	10.0	Clear
	7		
	8	9.0	Clear
9 P.M.	1	14.5	Gray
	2	15.0	"
	3	8.0	"
	4	13.0	"
	5	11.0	"
	6	8.0	Clear
	7		
	8	8.0	Gray
10 P.M.	1	13.0	Clear
	2	15.0	Gray
	3	8.0	Clear
	4	13.0	Gray
	5	10.0	"
	6	8.0	Clear
	7		
	8	8.0	Clear
11-P.M.	1	13.0	Gray
	2	14.0	"
	3	8.5	Clear
	4	13.0	Gray
	5	10.0	Gray
	6	8.0	Clear
	7		
	8	8.0	Clear

Time	Station	Temp	
12 P.M.	1	15.0	Clear
	2	13.0	"
	3	8.5	"
	4	12.0	Gray
	5	9.0	Gray
	6	8.0	Clear
	7		
	8	7.5	Clear

Des Moines Composite Sewage Samples - March 5 and 6, 1930

Laboratory Data

Station	Alkalinity	NITROGEN				Total Solids	Fixed Solids	Loss On Ignition	Suspended Solids	Fixed Suspended Solids	Loss on Ignition Suspended Solids	Phenol
		NH_3	NO_2	NO_3	Total Organic							
1	314	10.0	0.017	0.3	25.37	1212	861	351	261.6	108.8	152.0	
2	346	10.0	0.017	0.3	35.17	1208	804	404	208	67.0	14.0	353.0
3	282	7.5	0.007	0.3	15.33	743	499	244	27.2	11.1	16.1	
4	316	10.0	0.125	0.7	48.0	2334	1523	811	334	75	259.0	
5	348	11.25	0.004	0.3	26.92	1243	878	365	238	67	171.0	
6	350	15.0	0.125	0.5	37.52	1078	677	401	141	38	103	
7		20.0		0.7								*553.0 2823.5
8	302	7.5	0.085	0.5	50.98	1371	732	639	193	58	135	

* Sample held in Iowa City four months before reporting.

Ottumwa, Iowa. May 24, 1929.

Sampling of 8 Ottumwa Sewer Outlets over 18 hr. period to determine the average B.O.D.

Mr. A. H. Wieters,
Chief Engineer,
Office.

Dear Sir:

On May 17, 1929, composite samples were made up of eight major sanitary sewer outlets of Ottumwa. Samples were taken every two hours over an 18 hour period, from 2 P.M. to 12 P.M. and from 6 A.M. to 12 Noon, and the composite sample was brought to Des Moines where the dilutions were made. Under this plan the first sample taken was just about 25 hours old, and this may have had some effect upon our results. Yet when we consider that fresh sewage was added to this first sample, every two hours thereafter (with the exception of the six hours from 12 midnight to 6 A.M.) it hardly seems reasonable to assume that our composite sample should be considered anything but representative.

All samples upon arrival at Des Moines were on the alkaline side of the pH scale, with the exception of No. 3 and No. 9, which ran 6.8. These samples were affected by creamery waste in one instance, and by packing plant waste in the case of No. 9.

Care was exercised in making up these dilutions, yet the results of various dilutions did not check up as well as was the case with Des Moines samples, where none of our composites were over 18 hours old. By throwing out the results wherein the deplections of oxygen were not within the percentages of 20 and 60%, I believe we have some fairly good data, showing the kind of sewage, discharged by Ottumwa.

The following figures are the results of this work:

Station	B.O.D.	pH	
1	250	7.1	
2	165	7.2	
3	180	6.8	
4	185	7.6	
5	510	7.1	Includes creamery
6	160	7.3	
7	140	7.4	
8	130	7.1	
9	333	6.8	Includes packing Plant waste.

Sample No. 9 is the same as sample No. 8, with the exception of the packing plant waste. To arrive at an average figure therefore we should not include the No. 9 sample, nor the No. 5 sample. Under such plan for the 7 outlets, the average B.O.D. figure would be 172 p.p.m. for the domestic waste of Ottumwa. By including the waste from these two aforementioned sources, this figure would be raised to 240 p.p.m.

The waste from the Morrell Packing Plant (killing 2700 hogs and 300 cattle) amounts to the difference between the figures for Station 8 and Station 9, or 203 p.p.m. This seems to be the only way to arrive at a figure for their waste, since they have numerous outlets in the city sewer which are not available. This figure of 203 seems very low for this waste. The plant, however, is operating only 8 hours per day and not at full capacity. Therefore the samples collected after 6 P.M. were for the most part nothing but condenser water. The volume of flow was noticeably reduced after 10 P.M. We continued sampling over the 18 hour period, however, which of course would aid in lowering the B.O.D. of the composite sample.

It is suggested that, at the next time this work is done at Ottumwa, no samples be collected at 6 P.M. and that the sampling be started in the morning at such time when the plant is in full operation, which will be about 8-30 A.M. This should give us a representative B.O.D. figure.

Conclusions:

1. B.O.D. for Ottumwa Sewage - 172 p.p.m.
2. B.O.D. for Morrell Packing Plant - 203 p.p.m.
3. which is not considered representative.
3. An attempt should be made to collect samples at this creamery before it discharges into Sewer No. 5, to know the B.O.D. and the volume of this waste.
4. Another 18 hour period of collection is necessary.

Respectfully submitted,

M. J. Lonergan
Asst. Sanitary Engineer.

MJL M

OTTUMWA SEWER DESIGNATIONS.

No. 1 Large sewer outlet beside water plant.

No. 2 Washington Street outlet.

No. 3. Court Street outlet.

No. 4. Market Street outlet

No. 5 Union Street outlet (Swift creamery connection).

No. 6 Vine Street outlet.

No. 7 Finlay Avenue outlet.

No. 8 Iowa Avenue above packing plant.

No. 9 Iowa Avenue below packing plant.

OTTUMWA COMPOSITE SEWAGE SAMPLES (May 17, 1929) (Friday)
Laboratory Data.

STATION	ODOR	SEDIMENT	TURBIDITY	COLOR	ALKALINITY	CHLORINE AS CHLORIDES	OXYGEN CONSUMED	NITROGEN. AMMONIA	NITRITE	NITRATE	ALBUMINOID
1	Chloroform	Decided Organic	Decided	Decided Brown	254	69	45.0	10.000	0.800	6.0	1.000
2	"	"	"	Decided Gray	254	43	73.0	7.500	0.350	2.0	1.500
3	"	"	"	"	146	148	91.0	5.000	0.020	0.5	1.500
4	"	"	"	"	232	70	85.0	7.500	0.250	2.0	1.000
5	"	"	"	Decided Brown	242	199	97.0	3.500	2.000	0.3	3.500
6	"	"	"	Decided Grey	182	51	64.0	7.500	0.350	4.0	1.000
7	"	"	"	"	220	40	24.0	5.500	0.020	0.1	0.600
8	"	"	"	"	270	885	63.0	11.250	0.700	0.1	1.5000
9	"	"	"	Decided Brown	324	760	80	11.250	0.020	0.1	3.000

Ottumwa, Iowa. June 20, 1929.

Sampling of eight largest and most important sewer outlets

of Ottumwa.

W. R. Mark.

Mr. A. H. Wieters,
Chief Engineer,
Office.

Dear Sir:

On Thursday, June 20th, composite samples were again collected from the eight largest and most important sewer outlets of Ottumwa. They were collected over a period of twelve hours (6 A.M. to 6 P.M.) Samples were brought to Des Moines that evening and dilutions were made the following morning. By the time the dilutions were made the first sample was about twenty six hours old.

Samples No. 5 and No. 9 were on the acid side. The creamery and packing house respectively empty into these sewers. The pH table follows:

Station	pH
1	7.2
2	7.0
3	7.1
4	7.0
5	6.2
6	7.3
7	7.6
8	7.1
9	6.8

The results, wherein the depletion of oxygen was not within the percentage of 30 and 60%, were neglected.

The following figures are the results of this and the previous work (May 24th.).

Station	B.O.D. (May 24th)	B.O.D. (June 20th)
1	250	205
2	165	160
3	180	185
4	185	215
5	510	580 *
6	160	119

* Includes Swift Creamery.

Station	B.O.D. (May 24th)	B.O.D. (June 20th)
7	140	180
8	130	130
9	333	525**

** Includes packing plant.

By neglecting station No. 9, which includes packing house wastes, and station No. 5, which includes creamery wastes, the average B.O.D. for Ottumwa's domestic sewage is 170 p.p.m. The average including No. 9 and No. 5 is 271 p.p.m. The B.O.D. of the packing plant is considered the difference between No. 9 and No. 8 or 395 p.p.m. An effort will be made to get a sample of No. 5 sewer before the creamery turns their waste into it. The creamery waste B.O.D. can then be determined.

NOTATIONS ON SAMPLES.

Clear - Cool.

	Station No.	Temperature	Remarks.
6 A.M.	1	18°	Clear
	2	20	Clear
	3	25	Clear
	4	23	Clear
	5	21	Clear
	6	17	Clear
	7	16	Colored
	8	19	Clear
	9	35	Clear
9 A.M.	1	21	Concentrated
	2	22	Concentrated
	3	26	Concentrated
	4	27	Concentrated
	5	24	Clear
	6	17	Concentrated
	7	15	Fairly clear
	8	20	Clear
	9	34	Concentrated

	Station No.	Temperature	Remarks.
12 Noon	1	20°	Concentrated
	2	22	Concentrated
	3	28	Concentrated
	4	28	Concentrated
	5	24	Decidedly milky
	6	18	Concentrated
	7	17	Concentrated
	8	20	Concentrated
	9	35	Concentrated
3 P.M.	1	21	Concentrated
	2	22	Concentrated
	3	29	Concentrated
	4	28	Concentrated
	5	26	Concentrated
	6	18	Concentrated
	7	18	Concentrated
	8	20	Concentrated
	9	36	Concentrated
6 P.M.	1	20	Concentrated
	2	21	Concentrated
	3	26	Concentrated
	4	28	Concentrated
	5	24	Concentrated
	6	18	Concentrated
	7	18	Concentrated
	8	21	Concentrated
	9	34	Concentrated

OTTUMWA, COMPOSITE SEWER SAMPLES - June 20, 1929.
Laboratory Data.

STATION.	ODOR	COLOR	SEDIMENT	TURBIDITY	RELATIVE STABILITY	ALKALINITY	CHLORINE AS CHLORIDES	OXYGEN CONSUMED	NITROGEN. AMMONIA	NITROGEN. NITRITES	NITROGEN. NITRATES	NITROGEN. ALBUMINOID.
1	Chloroform	Decided gray	Decided Organic	Decided	90	276	68	43	7.5	0.35	0.30	0.70
2	Chloroform	"	"	"	90	262	50	51	7.5	0.20	0.3	1.00
3	Chloroform	"	""	"	90	210	36	41	2.25	0.25	0.3	0.70
4	Chloroform	"	"	"	90	228	77	38	3.00	0.01	0.0	0.60
5	Chloroform	Decided White	Decided White	"	60	116	189	580	3.5	0.02	0.0	1.4
6	Chloroform	Decided Gray	Decided Organic	"	90	264	63	43	10.00	0.35	0.3	0.7
7	Chloroform	"	"	"	90	266	46	42	5.0	0.01	0.1	0.45
8	Chloroform	"	"	"	90	270	599	45	10.00	0.01	0.1	1.00
9	Chloroform	"	"	"	60	394	740	170	10.00	0.01	0.1	1.50
	Average				83	254	208	117	6.5	0.15	0.15	0.89

In choosing sampling points, two facors largely governed the choice. The first and most important consideration was the securing of a representative sample and the sampling station was chosen with this consideration foremost. The second governing factor was the matter of accessibility. All of the tavel had to be accomplished by auto and the question of roads and bridges governed the choice of sampling stations. Even after a careful choice of sampling points some of the stations were inaccessible during very bad weather in winter.

The accompanying map of the Des Moines River shows the location of the sampling points designated by numbers. All data compilations and graphs used in this report refer to the sampling points by number, the map being the key to station numbers. For map see Chart 1, App. 1.

Following is a list of the sampling points giving a detailed description of each:

1. Station 1 is located above the municipal dam at Fort Dodge. This station is above all main sources of pollution.
2. Station 2 is located about two miles below station 1 and below all Fort Dodge sewer outlets. The samples were collected from a suspension foot bridge located at this point.
3. Station 3 is located at Kale about five miles below station 2. Samples were collected from a two span steel road bridge.
4. Station 4 is located about ten miles below station 3 at a two span steel road bridge in Lehigh.
5. Station 5 is located about sixteen miles below station 4 at a two span steel road bridge on the county road connecting Dayton and Stratford.
6. Station 6 is located about twenty miles below station 5 at a three span steel road bridge on national highway number 30, west of Boone.

7. Station 7 is located about fifteen miles below station 6 at a three span steel road bridge on the county highway connecting Madrid and Woodward.

8. Station 8 is located about twenty-three miles below station 7 at the Euclid Avenue bridge in Des Moines which is above all Des Moines sewer outlets.

9. Station 9 is located about eight miles below station 8 at a four span steel road bridge on state highway number 6. This station is on the road passing the Iowa Power and Light Company and is below all Des Moines sewer outlets.

10. Station 10 is located about eleven miles below station 9 at a three span steel road bridge north of Ford on a county road.

11. Station 11 is located about seventeen miles below station 10 at a four span steel road bridge on state highway number 14. The town of Red Rock is located here.

12. Station 12 is located about twenty-three miles below station 11 at a four span steel road bridge on state highway number 2.

13. Station 13 is located about fifteen miles below station 12 at a four span steel highway bridge on state highway number 59. The town of Eddyville is located at this point.

14. Station 14 is located about eight miles below station 13 at a three span steel bridge near Chillicothe. This station is just above Ottumwa.

15. Station 15 is located about fourteen miles below station 14 at a road bridge on a county road connection Ottumwa and Floris. This station is below all Ottumwa sewer outlets.

16. Station 16 is located about eight miles below station 15 at a five span steel road bridge in Eldon.

17. Station 17 is located about twenty-five miles below station 16 at a

four span steel road bridge on state highway number 1 in Keosauqua.

18. Station 18 is located about sixteen miles below station 17 at a five span steel road bridge on state highway number 3 in Farmington.

Because of the distances involved, it was obviously impossible for one man to collect all of the samples in one day. Hence, the river was divided in two portions for the sample collections, the upper portion extending from station 1 to 8, inclusive, and the lower portion from stations 9 to 18, inclusive. The upper and lower trips were made as nearly on consecutive days as was practicable, so that the record for the entire stream would be as nearly continuous as was possible.

SCOPE OF TESTS.

Those tésts were chosen which would give a reliable index of the conditions of the stream and at the same time could be practically applied to the conditions under which the survey had to be made.

Oxygen determinations and b. coli determinations were made for all sampling points during the survey. The oxygen determination consisted of dissolved oxygen and five day Biochemical oxygen demand tests. For a single test, this test will give more information as to the organic content in stream water and the ability of the water to support fish life than any other single test. Samples for these tests were collected in a special sampling can. The dissolved oxygen (D.O.) test gives an accurate measure of the dissolved oxygen that is actually present in the water at the time of sampling.

The Biochemical oxygen demand (B.O.D.) represents the actual amount of oxygen that is consumed by the organic material in the water for a specified time.

The initial dissolved oxygen content of the water is determined. The samples are incubated at 20° C. for 5, 10, or 20 days, after which the dissolved oxygen content is again measured. The difference between the initial dissolved oxygen and the final dissolved oxygen represents Biochemical oxygen demand for the period incubated.

Tests were made in conformity with standards described in Standard Methods of Water Analyses by the American Public Health Association. All B. O. D. results are expressed in terms of 5 day B. O. D.; that is, the incubation period was 5 days. To convert these results into 20 day B. O. D. the results should be divided by .68. Water temperatures were also made in the field.

Temperatures are important in computing the per cent saturation of dissolved oxygen.

The avove tests were all carried out in the field or completed in the Des Moines Laboratory. Central laboratory facilities for the bacteriological and sanitary chemical tests were not available at Des Moines, consequently samples were shipped to the State Hygienic Laboratory at Iowa City for B. coli determination throughout the survey. This determination gives a reliable index as to the bacterial condition of the water and its fitness for domestic and recreational purposes. During the latter part of the survey, samples were collected at each station for complete sanitary chemical analyses and shipped to Iowa City. The determinations included albuminoid nitrogen, ammonia nitrogen, nitrite nitrogen, nitrate nitrogen, alkalinity, and chlorides. A limited number of bacterial counts were also made at Iowa City, but due to the difficulty in getting the samples to the laboratory in good condition for these determinations, this was not carried out as a routine.

All analyses were made in accordance with standard methods of water analyses of the American Public Health Association.

INTERPRETATION OF DATA.

GENERAL:

The condition of a steam from a chemical and bacteriological standpoint will vary, depending upon several variable factors. Among these factors the important ones are:- 1. Quantity of wastes. 2. Character of wastes. 3. Steam flow or amount of diluting water available. 4. Nature of the steam; i.e. whether swift or sluggish, clear or turbid, obstructed with dams, riffles, etc., deep or shallow. 5. Temperature and weather conditions. 6. Presence or absence of an ice covering. In interpreting the results of chemical and bacteriological examinations, these factors must all be taken into consideration if conclusions are to be reliable. Some of the factors, such as quantity and character of wastes, quantity of steam flows, etc., can be measured quite accurately, whereas some of the factors of self purification cannot be so accurately determined. Consequently, a quantity of waste which might be tolerated without serious results in a stream under one condition, might become a serious nuisence or health menace under other conditions.

Likewise, a certain amount of sewage might be tolerated in one stream, whereas the same amount of sewage might result in serious pollution in other streams. Several important elements enter into the self purification of streams and unfortunately some of these are so variable for different streams and under different conditions that an exact figure for the carrying capacity of a stream cannot be predicted.

ELEMENTS IN THE SELF PURIFICATION OF STREAMS:

That any steam will purify itself in flowing a certain distance is a fallacy. On the other hand, were it not for the remarkable purification resulting from natural agencies in streams, the conditions would long since have become intolerable.

It is almost universally agreed that the greatest factor in the self purification of a stream is the biological activity. It is true that oxygen, sunlight, sedimentation and other chemical and physical factors play an important part, but on final anglyses, most of these factors are necessary aids to biological activities which bring about the purification. For instance, the orderly oxidation, or "burning up" of organic matter in sewage, is largely the result of bacterial action. These bacteria in turn are dependent upon oxygen for their very existence and without oxygen, this type of bacterial life is destroyed and the anaerobic bacteria gain the ascendency with resultant putrefaction and foul odors. Also chlorophyll bearing plants consume carbon dioxide and give off oxygen to the water, which in turn supports the aerobic bacterial life. This release of oxygen is absolutely dependent upon sunlight and ceases in darkness.

Since oxygen is so necessary in the self purification of streams, those factors which contribute the oxygen are of utmost importance in the purification. The principal sources of oxygen are the atmospheric oxygen and the oxygen given off by plants. Since both of these sources are effected by physiographical and weather conditions and are extremely variable, it is impossible to predict with any degree of accuracy the reaeration which will occur and from this, the capacity of a stream for oxidizing organic material without objectionable results. In a stream which is shallow and flows swiftly, thus exposing great surfaces of water to the air, conditions for atmospheric reaeration are ideal. On the other hand, in such a stream the suspended organic material does not settle, but is intimately mixed with the water and the oxygen demand in the water is greater than if the suspended material were settled out within a short distance below the sewer outlet.

In winter time, when a steam is frozen over long reaches, the opportunity for atmospheric reaeration is nil and therefore, under winter conditions, the capacity of a stream for purifying sewage is greatly reduced. On the other hand, winter temperatures greatly reduce biological activity and as a rule in winter the zones of heaviest pollution are usually farther remote from the source of pollution than under summer conditions.

Proper food, optimum temperatures and sunlight are necessary for the propagation of algae and other plants. Food conditions are usually satisfactory for algal development in moderately polluted streams. Optimum temperatures vary over a great range for different species, but as a general statement, few varieties can grow in winter. Thus we have another factor which favors the self purification of a steam in summer conditions as opposed to winter conditions.

Sunlight is necessary and as a result, cloudy weather, turbidity in water and other factors which prevent sunlight from penetrating the water, will have an inhibiting effect on the production of oxygen by plants. The effect of sunlight can best be illustrated by the results of several tests made in the Iowa lakes which will show 4 or 5 ppm. more of dissolved oxygen in a sample taken at 8 P.M. following a sunny day than there is in a sample taken from the same point at 4 A.M. the following day.

Presence of oxygen in the water is of utmost importance for two reasons. From 2 to 4 ppm. of dissolved oxygen is necessary to support fish and other aquatic life. Fish do not have the faculty of taking from the water the combined oxygen. Thus if the oxygen content falls below the above figures, fish are in distress from the lack of oxygen and if there is a further decrease in oxygen, the fish will die.

In the presence of oxygen, the organic matter in sewage is oxidized by so called aerobic bacterial action. The process is orderly, no foul odors occur, but large quantities of oxygen are consumed. If the oxygen is consumed faster than the water absorbs it, the aerobic bacteria will die and putrefactive organisms will gain the ascendency with accompanying foul odors and fish destruction.

Consequently, if foul odors are to be averted or if fish life is to be maintained, an oxygen balance must always be present in the water, and this balance should preferably be kept at 60 to 70 percent saturation.

All stream waters contain bacteria. In our Iowa streams, due to the incidental soil washings, the bacterial content is likely to be high, especially after periods of heavy surface run-off. Practically all of the soil bacteria are harmless and thus of no sanitary significance.

Presence of organisms of the b. coli group, however, are important from a sanitary standpoint, and the presence of these organisms in large numbers in a stream has a distinct public health significance. This is because these organisms normally inhabit the intestines of warm-blooded animals and their presence is indicative of pollution from this source. With b. coli may be associated specific organisms of intestinal diseases and water containing these organisms must be considered unfit for drinking and domestic purposes. Likewise, swimming, bathing and other contact with water having a high b. coli content is dangerous.

The nitrogen determinations are important indices of sewage pollution. Fresh sewage contains nitrogen in the form of albuminoid and ammonia nitrogen. Bacterial oxidize this ammonia and albuminoid nitrogen forming nitrites and ultimately nitrates, which is a stable form of nitrogen. Thus, if water contains nitrogen in the form of albuminoid and ammonia nitrogen, fresh, unstable, organic material is indicated, whereas if nitrates are present in the absence of the ammonia and albuminoid nitrogen, it indicates that complete purification has taken place.

Chlorides are of sanitary significance in that sewage usually contains chlorides in higher concentrations than river water in Iowa. An appreciable increase in chloride content of the river water below a sewer outlet is indicative of heavy sewage pollution.

BACTERIUM COLI FINDINGS: in Table 1 will be found the compilation of the determination of bacterium coli from samples collected at each sampling point on each day of the survey. The number of b. coli were determined from successive dilutions of the stream water and the results are expressed in the table numerically, according to the Phelps method, using the reciprocal of the smallest dilution in which organisms of the b. coli group were found.

Considerable difficulty was encountered in deciding upon the proper dilutions. To obtain an accurate index, it is necessary that the smallest dilution give a negative result. In a large number of the results, the lowest dilution which was innoculated showed the presence of organisms of the b. coli group, thus the esults are not absolutely reliable. Actually, the b. coli content would be greater than indicated in the table, since no doubt in some of the instances where the smallest dilutions indicated the presence of b. coli, a still smaller dilution would have also indicated the presence of these organisms.

Confirmation tests were run on all gas formers and the presence of aerogenes in the absence of b. coli was disregarded. The results as indicated by the table, therefore, will be the b. coli index as confirmed and not an index of the coli-aerogenes group. Results of tests indicate a concentration of b. coli as high as one million per 100 ml. using the Phelps index, or 2,310,000 per ml. using Reed's index, in individual samples.

Where no organism of this group is indicated in the table, it must be remembered that the greatest innoculations that were made were never greater than one ml. whereas in many instances the largest innoculation was 1/10 ml. Thus, where the table indicates no b. coli, the correct interpretation is that there were none present in one ml. of water. No doubt greater quantities of water would have invariably shown the presence of some organisms of this group.

In order to obtain a composite picture of the condition of the stream as regards the b. coli content, chart 2 App. C indicates the average number of b. coli per one hundred ml. of water for each sampling station. The chart is based upon average numbers throughout the period of the investigation. Reed's index, which is a modification of Phelps' index, was used in computing the most probably number of b. coli. This index is based upon the result of numberous determinations which indicate that the most probable number of b. coli is 2.31 times the reciprocal of the lowest dilution in which the organism is found. It is significant to note the tremendous number of organisms of this group below the three cities in question. It is rather surprising to find the index higher below Fort Dodge than any point on the river. However, it will be noted from the curve that the recovery is much more rapid below Fort Dodge than it is below Des Moines and Ottumwa and also that the recovery is more complete below Fort Dodge than it is below the other two cities.

It is further significant to note that immediately above Ottumwa the average b. coli content is 14,300 per 100 ml. This is particularly significant since Ottumwa derives its water supply from this point of the stream. The United States Public Health Service has made a study of numerous filter plants, and concludes that with the best type of treatment known 10,000 b. coli per 100 ml. is the maximum load which a water purification plant can carry if the final effluent from the purification works is to be consistently safe. There is little doubt but that the average b. coli content of the river renders the water unsafe for swimming and bathing in the entire course of the strem included in this study, and that the water is unsafe for recreational purposes where persons come in contact with the water.

It is also obvious that throughout a great part of its course the river is unfit as a potential source of water supply for domestic purposes, even though the river water first be treated using the best known methods available.

TOTAL BACTERIAL CONTENT: On Table 2 are recorded the total bacteria counts. The figures in column 1 indicate the total number of bacteria on litmus lactose agar at 37 degrees in 24 hours. Column 2 shows the total number of bacteria per ml. grown on nutrient agar at 20 degrees C. in 48 hours while the third column represents the number of acid colonies. It will be noted that total counts were not made throughout the entire survey. Due to the fact that so much time ordinarily elapsed between the collection of the samples and the arrival of the sample in the laboratory, it was thought that the total counts would not have a great deal of significance due to the possibility of great changes in number taking place while the sample was in transit. The few results obtained, however, do indicate fairly well the effect on the stream of the various sources of pollution, although the total counts as represented in the table throughout are probably lower than they would be had it been possible to get these samples to the laboratory in shorter time.

Table I

Des Moines River

B. Coli per ml.

Date	Stations. 9	10	11	12	13	14	15	16	17	18
July 19, 1928	100	100	100		100	100	100	100		100
Aug. 17, 1928	1000	1000				0	0	0	1000	0
Sept 6, 1928	1000	1000	1000	100	100	1000	100	100	10	10
" 27, 1928	1000	1000	100	100	10	0	10000	10	100	10
Oct. 5, 1928	1000	1000	0	10	10	10	10	100	10	10
Dec. 28, 1928	10	100	100	100	10	100	100	10	10	10
Jan. 9, 1929	1000		100	10	10	10	10		0	0
" 18, 1929	100		100		0	0	10	0	10	0
Feb. 7, 1929	100	100	100	100	100	100	100	100	1000	0
Aug. 3, 1929	100	10	0	0	0	0	0	0	0	0
Aug. 10, 1929	0	100	0	0	0	0	10	0	10	0
Sept 28, 1929	0	0	0	0	0	0	100	0	10	0
Nov. 8, 1929	1000	1000		10	1000	100	0	10	10	0
Nov. 27, 1929	1000	1000	1000	0	0	10	0	1000	1000	0
Dec. 4, 1929	1000		1000	0	0	0	10	0	0	0
" 28, 1929	1000	100	10	0	0	0	10	10	0	0
Jan. 8, 1930		1000	1000	0	10	0	0	0	0	0
" 29, 1930	1000		10		100	0	10	10	1000	100
Feb. 12, 1930	1000		1000	10	0	10	100	10	10	100
July 25, 1930	100	100	10	0	1	1	100	10	10	100
Sept.18, 1930	0	100		1	1	1	100	10	0	0
Dec. 3, 1930	10	1000	0	0	0	0	10	0	1	0
Jan. 21, 1931	1000	10	0	0	0	0	10	0	0	0
Fev. 12, 1931	1000	0	0	0	0	0	0	0	0	0

Table I (continued)

Des Moines River

B. coli per ml.

Date	Stations. 1	2	3	4	5	6	7	8
Aug. 7, 1928	100	100	100	100	100	100	10	100
" 14, 1928	10	100	1000	100	10	100	10	10
" 21, 1928	10	1000	1000	1000	10	0	10	10
Sept 8, 1928	100	10	100	100	1000	1000	100	100
Oct. 2, 1928	10	1000	10000	0	0	10	10	0
Jan. 4, 1929	0	100	100	0		0		10
" 15, 1929		100		10	100	10		100
July 30, 1929	10	100	100	100	10	10	10	10
Sept. 7, 1929	10	1000	100	10	10	10	0	0
" 24, 1929	0	1000	1000	10	0	10	0	10
Oct.18, 1929	10	10	100	0	0	1	10	0
Nov. 5, 1929	100	1000	100	0	0	0	0	0
" 23, 1929	0	1000	1000	0	0	0	0	0
" 30, 1929	0	1000	100	1000	10	0	0	0
Dec. 6, 1929	10	100	10	0	0	10	0	0
" 13, 1929	10	1000	0	1000	10	10	10	0
Jan 3, 1930	0	0	100	100	10	0	0	0
" 31, 1930	1	10	100	100	100	10	100	1
Feb. 7, 1930	100	1000	0	100	10	0	10	0
July 22, 1930	1	100	10	1	1	10	10	0
Sept.20, 1930	0	1000	100	100	1	1	10	1
Dec. 5, 1930	1	100	100	100	10	1	0	0
Jan. 13, 1931	0	100	0			0	0	
Feb. 10, 1931	0	100	0	10	10	0	0	0

Table 2.
Des Moines River
Bacteriological and Chemical Analysis.

Stations	37°C. L.L.	Bact. per ml. 20°C. N.A.	Acid Col.	B. Coli	Ammonia N.	Nitrogen As Album. N.	Nitrite N	Nitrate N	Alk. to Methyl Orange	Cl.
12-5-30.										
1	1,500	C.P.	0	1	0.070	0.070	0.001	0.7	274	11
2	1,000	9,000	10	10	0.400	0.200	0.001	0.7	282	14
3	9,000	12,000	140	100	0.400	0.200	0.000	0.7	268	12
4	12,000	6,000	80	10	0.400	0.200	0.001	0.5	270	16
5	1,500	12,000	0	10	0.250	0.140	0.000	0.5	298	14
6	120	4,800	0	0	0.070	0.200	0.000	0.0	274	14
7	1,000	4,800	0	0	0.070	0.200	0.000	0.0	282	15
8	700	6,000	0	0	0.030	0.140	0.000	0.0	286	13
12-3-30										
9	60,000	216,000	100	10	0.600	0.140	0.001	0.0	274	23
10	60,000	288,000	100	1000	0.700	0.200	0.001	0.0	278	30
11	30,000	276,000	100	0	1.500	0.200	0.004	0.3	268	27
12	26,000	150,000	100	0	1.000	0.140	0.000	0.1	260	21
13	36,000	240,000	100	0	0.700	0.120	0.000	0.1	248	21
14	60,000	204,000	100	0	0.600	0.200	0.000	0.1	244	22
15	48,000	150,000	100	10	0.600	0.300	0.001	0.3	238	28
16	3,800	54,000	100	0	0.600	0.200	0.001	0.1	322	32
17	2,200	90,000	100	1	0.300	0.300	0.000	0.1	162	26
18	1,200	42,000	100	0	0.250	0.200	0.000	0.1	168	29

TABLE 2.

Des Moines River

Bacteriological and Chemical Analysis

Stations.	Bact. per ml. 37°C L.L.	20°C. N.A.	Acid Col.	B. Coli.	Nitrogen As Ammonia N.	Album. N.	Nitrite N.	Nitrate N.	Alk. to Methyl Orange	Cl.
1-13-31.										
1	400	90,000	0	0	0.000	0.080	0.001	0.1	346	10
2	4,000	15,000	0	100	0.400	0.090	0.004	0.1	350	12
3	600	26,000	0	100	0.700	0.140	0.004	0.1	352	26
4										
5										
6	400	15,000	0	0	0.170	0.140	0.004	0.1	330	17
7	100	5,000	0	0	0.030	0.200	0.004	0.1	328	18
8										
1-21-31										
9	50,000	90,000	2700	1000	0.700	0.200	0.001	0.1	326	39
10	300	54,000	0	10	1.500	0.200	0.001	0.1	328	33
11	100	30,000	0	0	1.500	0.200	0.000	0.1	312	31
12	100	7,000	0	0	1.500	0.140	0.000	0.1	308	28
13	100	36,000	0	0	1.500	0.080	0.000	0.1	316	32
14	36,000		0	0	1.000	0.090	0.000	0.1	316	31
15	15,000	60,000	0	10	1.500	0.140	0.000	0.3	310	43
16	30,000	16,000	0	0	1.500	0.200	0.000	0.3	292	68
17	3, 000	15,000	0	0	1.500	0.140	0.001	0.3	274	55
18	10,000	10,000	0	0	1.500	0.140	0.001	0.3	276	61

TABLE 2
(Continued)

Des Moines River

Bacteriological and Chemical Analysis.

Stations	Bact. per ml. 37°C. L.L.	20°C. N.A.	Acid Col.	B. Coli	Nitrogen as Ammonia N	Album. N	Nitrite N	Nitrate N	Alk to Methyl Orange	Cl
2-10-21										
1	100	6,000	100	0	0.170	0.080	0.002	0.1	260	8
2	48,000	12,000	800	100	0.600	0.200	0.007	0.1	268	12
3	25,000	150,000	400	1000	0.600	0.200	0.007	0.1	274	12
4	2,500	30,000	100	10	0.450	0.140	0.007	0.1	276	13
5	100	8,000	100	0	0.250	0.140	0.007	0.1	262	10
6	200	8,000	100	0	0.140	0.140	0.007	0.1	260	11
7	200	10,000	100	0	0.140	0.140	0. 004	0.1	258	12
8	100	1,000	100	0	0.070	0.140	0.007	0.1	248	11

OXYGEN FINDINGS.

Table 3, shows the results of dissolved oxygen and biochemical oxygen demand determinations for the period. Charts 21, to 77, App. E, inclusive show the oxygen conditions at all stations for each day of sampling, and charts 3, to 20, App. D, show the oxygen condition at each individual station during the period of the survey.

The lowest D. O. below Fort Dodge occurred on September 30, 1930, when the oxygen content dropped to 2 p.p.m. or 19.4% saturation. At the same time the B. O. D. of the water was 24 p.p.m., which left a negative balance or deficiency of oxygen of 22 p.p.m. This also was the day of the highest B.O.D. noted below Fort Dodge, but on numerous occasions the B.O.D. exceeded 15 p.p.m.

The lowest oxygen content noted below Des Moines was on January 29, 1930, when the D. O. was .8 p.p.m. or 5.5% saturation with a B.O.D. of 9 p.p.m. Several times during the survey, D.O. contents of less than 3 p.p.m. were noted. The highest B. O. D. figures below Des Moines occured on February 27, 1929, when it reached 24.0 p.p.m. and again on January 21, when it reached 23.4 Figures in excess of 15 p.p.m. B. O. D. were not uncommon in low stream stages.

The lowest D. O. content below Ottumwa occured on January 29, 1930, when a figure of .8 p.p.m. or 5.5% saturation was reached. At this time the B. O. D. was 9 p.p.m. The highest figure for B. O. D. recorded below Ottumwa was 26. + p/p/m. on January 21, 1931.

The individual curves indicate a negative oxygen balance as follows: At the first sampling point below Fort Dodge in 8 of the 29 samples; at the first sampling station below Des Moines in 16 of the 27 samples; and at the first sampling station below Ottumwa in 7 of 26 samples, the negative balance exceeding 20 p.p.m. in one instance.

Charts 78, to 82, App. F, inclusive shows the average oxygen resources of the stream for various stream flows during the sampling period. The

B. O. D. is subtracted from the dissolved oxygen and the difference represents the oxygen resources of the stream in parts per million either negative or positive.

It must be remembered that the averaging of oxygen determinations does not give a true picture of conditions at the worst, since high results will compensate the low results and the average may thus be misleading. It is sufficient to point out, however, that the sewage from each of the cities has a marked effect upon the oxygen resources of the stream even for comparatively high flows.

Chart 78, App. F, shows average oxygen resources for flows less than 250 c. f. s. The average below Fort Dodge is + 2 p.p.m. whereas the average below Des Moines is -2.8 p.p.m. and is again negative at Station 11. Below Ottumwa the average figures show a positive blance of 1 p.p.m. with little improvement until Station 18 is reached. Recovery below Fort Dodge is more rapid and complete while below Des Moines the recovery is not complete at any point.

Chart 79, shows the oxygen resources at flows from 250 to 500 c.f.s. Oxygen resources are appreciably greater at these flows. In all instances the oxygen resources are higher below the points of greatest pollution than they were at these points during the lower flows. However, a sharp drop is noted below Des Moines with little recovery even above Ottumwa. Here again a drop occurs with slow but steady improvement to the last sampling point.

Chart 80, App. F, shows the average oxygen resources for flows ranging from 500 to 1000 c.f.s. Strangely enough the oxygen resources below both Fort Dodge and Ottumwa are both negative whereas at the lower flows both were positive. This may be accounted for by the fact that many of the samples that fall in this classification represent winter conditions when reaeration is at its lowest and in spite of more diluting water stream conditions are worse than at periods of lower flows in the summer time.

Chart 81, App. E. represents average oxygen resources at flows between 1,000 and 1,500 c.f.s. These results are rather erratic, probably for the reason that comparatively few samples fell within this classification. It is significant to note, however, that whereas Fort Dodge and Ottuma have little effect on the stream at these flows, Des Moines sewage causes a drop of more than 9 p.p.m. in oxygen resources and that this condition persists for 50 miles down stream even at these high flows.

Chart 82, App. F. shows the average oxygen resources for stream flows exceeding 1,500 c.f.s. Even at such flows the effect of sewage at Fort Dodge and Des Moines is noticeable. The stream, however, shows a gradual improvement below each point of heavy pollution as one progresses down stream.

In interpreting this data, it must be remembered that these charts are based on stream flow records at Des Moines. Fort Dodge, with a lighter sewage load than Des Moines or Ottumwa, also had stream flows considerably less than at Des Moines, whereas at Ottumwa the stream flows were considerably greater than at Des Moines.

It is significant to note from these charts that even at flows of 1,000 to 1,500 c.f.s. (exclusive of the discharge of the Raccoon which empties into the Des Moines just below Des Moines and which at times nearly equals the Des Moines river flows) the sewage discharged at Des Moines noticeably reduces the oxygen resources of the stream.

A second significant fact is that the worst oxygen conditions do not necessarily occur at the lowest stream stages but that weather, algae, and other conditions have a marked effect upon the carrying capacity of the stream.

A third significant fact is that the oxygen balance is seriously reduced at flows which do not represent extreme minimums but normal seasonal low flows which occur annually and over extended periods of time.

TABLE 3.

Sta.	Temp.	D.O.	% Saturation	B.O.D.	Temp.	D.O.	% Saturation	B.O.D.	Temp.	D.O.	% Saturation	B.O.D.	Sta.
	June 26, 1928								July 27, 1928				
1	23	5.1	58.8	1.6					28	8.9	112.0	2.4	1
2	23	5.7	65.6	3.7					28	6.5	82.0	4.0	2
3	23	---		---					28	8.1	102.4	6.1	3
4	23	6.4	78.8	2.4					28	9.7	122.5	6.4	4
5	23	7.0	80.7	3.8					28	8.4	106.0	6.5	5
6	23	10.4	120.0	6.9					28	6.4	80.8	6.1	6
7	23	9.4	108.2	6.3									7
8	23	5.1	58.8	---									8
	June 29, 1928				July 19, 1928								
9	22	11.7	132.5	15.0	28	5.0	63.4	2.2					9
10		---		---		---		---					10
11	22	3.2	36.2	2.1	28	2.8	35.4	4.8					11
12		---		---		---		---					12
13	22	4.1	46.5	3.6	28	4.4	55.5	2.8					13
14	22	4.1	46.5	3.3	28	5.1	57.3	8.8					14
15		---		---	28	3.7	46.7	5.2					15
16	22	6.4	72.5	4.6	28	5.0	63.4	8.4					16
17		[illegible]		---		---		---					17
18	22	6.0	68.0	5.6	28	5.7	72.0	2.7					18

TABLE 3 - Continued.

Sta.	Temp.	D.O.	% Saturation	B.O.D.	Temp.	D.O.	% Saturation	B.O.D.	Temp.	D.O.	% Saturation	B.O.D.	Sta.
					August 7, 1928				August 14, 1928				
1					26	6.3	76.6	3.2	28	5.8	73.3	4.4	1
2					27	6.6	81.9	4.6	27	6.4	79.3	10.0	2
3					26	5.5	68.9	4.8	27	6.0	74.4	8.4	3
4					26	---	---	---	28	6.5	82.0	8.0	4
5					27	4.5	55.8	3.5	28	---	---	---	5
6					26	5.5	66.9	3.5	28	---	---	---	6
7					26	5.0	60.8	3.8	28	---	---	---	7
8					26	5.9	71.8	4.8	28	6.1	77.1	5.1	8
	August 2, 1928								August 17, 1928				
9	28	7.5	94.7	---					27	---	---	---	9
10	28	6.8	85.9	---					27	---	---	---	10
11	28	4.9	61.9	4.4					27	---	---	---	11
12	27	5.1	63.2	2.6						---	---	---	12
13	28	4.7	59.4	2.1					27	---	---	---	13
14	28	6.2	78.3	2.8						---	---	---	14
15	28	5.0	63.2	3.0					31	12.5	167.5	7.6	15
16	28	5.3	67.0	2.9					30	10.9	141.5	7.0	16
17	27	---	---	---					30	8.8	115.0	6.4	17
18	27	5.9	73.1	3.0					31	8.0	107.0	5.2	18

Sta.	Temp.	D.O.	% Saturation	B.O.D.	Temp.	D.O.	% Saturation	B.O.D.	Temp.	D.O.	% Saturation	B.O.D.	Sta.
		August 21, 1928				September 8, 1928							
1	21	5.7	63.5	3.7	20	7.5	81.8	3.4					1
2	22	4.2	47.6	8.6	19	7.0	75.0	3.9					2
3	22	3.7	41.8	8.2	19	7.4	79.2	4.4					3
4	23	8.3	95.6	5.5	20	5.4	58.8	4.2					4
5	26	7.7	93.7	6.2	20	7.4	80.8	4.1					5
6	26	8.1	98.6	6.0	20	7.5	81.8	3.2					6
7	27	9.0	111.5	7.2	19	6.5	69.5	2.4					7
8	27	9.5	117.5	5.0	19	7.2	77.0	2.8					8
		September 6, 1928				September 12, 1928				September 27, 1928			
9	20	7.6	82.8	5.4	20	6.3	68.7	9.4	14	9.9	95.6	9.5	9
10	20	7.4	80.7	5.2	20	7.2	78.5	6.4	15	14.8	145.2	10.4	10
11	20	7.1	77.4	3.3	20	4.5	49.2	10.0	15	13.8	135.9	9.0	11
12	20	7.3	79.6	4.3	20	5.5	60.0	8.6	14	13.4	129.2	8.0	12
13	20	7.5	81.8	3.6		---	---	---	15	12.6	124.0	7.4	13
14	19	7.4	80.0	3.5		---	---	---	15	12.5	123.0	6.7	14
15	20	7.9	86.2	4.2		---	---	---	15	10.5	103.4	2.8	15
16	21	7.7	85.6	3.8		---	---	---	15	10.7	105.2	3.5	16
17	21	6.2	69.0	1.4		---	---	---	15	10.3	101.2	3.1	17
18	20	8.4	91.6	3.2		---	---	---	15	10.1	99.7	2.8	18

Sta.	Temp.	D.O.	% Satura-tion	B.O.D.	Temp.	D.O.	% Satura-tion	B.O.D.	Temp.	D.O.	% Satura-tion	B.O.D.	Sta.
		October 2, 1928								December 18, 1928			
1	13	9.1	85.7	8.5					1	11.2	78.6	5.6	1
2	16	11.8	118.7	10.8					1	11.6	81.5	7.7	2
3	16	11.8	118.7	11.5					1	11.8	82.7	6.8	3
4	14	13.0	125.5	11.7					2	11.9	85.0	7.3	4
5	14	11.4	110.0	8.6					2	8.4	60.7	4.1	5
6	18	15.3	116.5	11.7					2	12.0	86.6	6.4	6
7	16	15.4	115.0	11.9					2	10.5	75.8	3.5	7
8	16	16.5	116.7	12.0					2	10.1	73.0	3.6	8
		October 5, 1928				October 10, 1928				December 28, 1928			
9	19	---		13.1	21	7.6	84.7	12.0	2	10.5	75.8	3.4	9
10	18	---		15.7	21	---	---	---	2	9.4	67.7	2.5	10
11	17	---		12.8	21	11.3	125.6	13.5	2	10.3	74.3	3.2	11
12	17	---		11.3	21	9.0	100.0	12.3	2	9.3	67.2	1.0	12
13	17	---		9.7	20	9.2	101.2	6.8	2	10.5	75.8	1.0	13
14	17	---		9.3	21	8.0	89.1	8.5	1	12.7	89.2	2.8	14
15	21	9.5	105.6	12.2	21	8.4	93.5	9.3	1	13.3	93.4	3.1	15
16	22	9.1	103.2	8.6	21	8.8	98.0	8.3	2	14.0	101.2	2.2	16
17	20	10.1	110.3	10.3		---	---	---	2	14.2	102.4	3.0	17
18	20	9.8	107.0	11.0		---	---	---	3	9.0	62.0	2.1	18

TABLE 3-Continued.

Sta.	Temp.	D.O.	% Saturation	B.O.D.	Temp.	D.O.	% Saturation	B.O.D.	Temp.	D.O.	% Saturation	B.O.D.	Sta.
		January 4, 1929				January 15, 1929							
1	2	15.4	111.3	3.2	0	9.3	63.5	3.3					1
2	1	10.7	75.5	0.1	0	11.2	77.7	4.1					2
3	2	14.1	102.0	3.1	0	10.4	71.1	4.7					3
4	1	13.6	95.5	2.2	0	7.6	51.8	3.0					4
5	1	---		---	0	9.0	61.5	3.0					5
6	1	12.5	87.7	2.3	0	10.5	71.7	2.0					6
7	1	---		---	0	@--		---					7
8	2	13.5	97.5	3.1	0	12.9	88.2	3.7					8
		January 8, 1929				January 18, 1929				February 7, 1929			
9	0	12.2	83.3	5.0	1	10.1	70.8	6.4	1	8.0	56.2	24.0	9
10	0	---		---		---		---	1	8.0	56.2	2.9	10
11	0	12.5	85.4	4.9	1	5.1	35.8	5.1	1	7.5	52.7	0.8	11
12	0	9.8	62.0	4.3		---		---	1	7.0	49.2	0.4	12
13	0	9.2	61.6	1.9	1	7.7	55.4	1.1	1	8.0	56.2	2.6	13
14	0	11.2	76.7	1.3	1	9.0	63.5	2.8	1	8.8	61.7	2.5	14
15	0	7.7	52.5	2.2	1	10.2	71.5	7.7	1	7.4	52.0	13.7	15
16	0	10.7	73.0	3.5	2	8.6	62.0	2.9	1	6.5	45.7	---	16
17	0	12.7	86.7	2.6	2	---		---	1	8.3	58.3	3.0	17
18	0	11.0	75.2	2.4	2	9.5	68.6	3.8	1	7.7	54.0	0.7	18

TABLE 3 - Continued.

Sta.	Temp.	D.O.	% Saturation	B.O.D.	Temp.	D.O.	% Saturation	B.O.D.	Temp.	D.O.	% Saturation	B.O.D.	Sta.
	February 15, 1929				February 22, 1929				July 30, 1929.				
1	1	5.3	37.2	1.1	1	6.4	45.0	2.7	25	6.3	75.1	---	1
2	1	8.5	59.7	11.0	1	7.4	52.0	16.7	25	6.9	82.5	16.0	2
3	1	7.0	49.5	2.7	1	7.2	50.5	3.6	25	4.7	56.1	---	3
4	1	5.0	35.1	1.0	1	5.5	38.6	3.8	25	7.3	87.1	---	4
5	1	5.2	36.5	1.5	1	5.2	36.5	5.1	25	6.6	78.7	4.2	5
6	1	7.6	49.7	---	1	4.6	32.3	4.5	27	11.0	136.2	10.3	6
7	1	8.0	56.2	0.8					26	11.2	125.0	---	7
8	1	8.0	56.2	1.4	1	6.6	46.3	3.8	26	13.3	162.0	---	8
					February 27, 1929				August 3, 1929				
9	1	10.4	73.2	14.4		10.1		[illegible]6.7	25	10.1	120.2	---	9
10						---		---	24	12.0	140.1	10.4	10
11						7.3		3.9	24	11.1	130.1	---	11
12						---		---	24	9.2	108.0	9.0	12
13						11.3		4.6	24	7.3	85.7	---	13
14						8.5		3.7	24	6.8	79.8	---	14
15									24	7.2	89.3	6.1	15
16									24	7.8	91.5	5.4	16
17									23	7.9	91.0	4.6	17
18									23	8.4	96.7	5.7	18

TABLE 3 - Continued.

Sta.	Temp.	D.O.	% Saturation	B.O.D.	Temp.	D.O.	% Saturation	B.O.D.	Temp.	D.O.	% Saturation	B.O.D.	Sta.
									September 7, 1929.				
									22	14.3	162.0	9.5	1
									24	11.2	131.3	9.5	2
									23	11.8	13.6	6.0	3
									23	13.0	150.00	6.7	4
									22	9.2	104.2	6.8	5
									18	10.1	106.0	5.2	6
									18	10.2	107.0	4.5	7
									19	10.4	111.6	5.1	8
	August 10, 1929				September 4, 1929								
9	27	14.0	173.4	12.2	22	8.5	96.3	5.9					9
10	26	9.1	110.5	15.6	22	8.8	100.0	5.7					10
11	26	7.9	96.0	3.4	21	11.0	122.3	6.4					11
12	26	7.8	96.0	---	20	8.5	92.7	8.7					12
13	27	13.2	163.5	12.7	19	8.4	90.0	6.0					13
14	27	13.7	170.0	12.2	19	7.6	81.3	7.8					14
15	28	12.5	158.0	16.8	19	8.1	86.8	4.1					15
16	27	13.5	167.5	10.2	25	9.8	117.0	4.5					16
17	26	10.6	128.8	9.0	25	7.3	87.2	2.0					17
18	26	9.1	110.5	8.4	24	7.8	91.5	2.5					18

TABLE 3 - Continued.

Sta.	Temp.	D.O.	% Saturation	B.O.D.	Temp.	D.O.	% Saturation	B.O.D.	Temp.	D.O.	% Saturation	B.O.D.	Sta.
	September 12, 1929				September 24, 1929				October 13, 1929				
1	19	9.4	100.5	3.3	18	9.7	101.8	3.1	13	8.5	80.4	3.5	1
2	21	10.8	120.4	4.0	18	10.8	113.3	7.5	13	8.2	77.4	6.8	2
3	21	9.6	107.0	4.8	18	7.8	81.8	6.0	13	7.9	74.5	4.2	3
4	20	12.0	131.0	5.3	19	10.5	112.3	5.5	13	10.8	102.0	5.0	4
5	20	12.8	139.6	6.1	20	10.4	113.5	10.0	13	11.4	107.5	6.3	5
6	20	13.2	146.0	8.0	21	9.6	105.8	10.1	15	10.5	91.5	5.8	6
7	20	11.5	128.0	5.9	21	10.1	112.4	9.8	15	10.6	92.5	6.1	7
8	19	9.5		---	20	10.9	119.0	9.2	15	10.3	89.6	5.5	8
	September 16, 1929				September 28, 1929								
9	20	9.4	104.5	12.2	27	7.7	95.6	6.2					9
10	19	---		---	23	11.4	131.2	8.4					10
11	19	11.7	125.0	10.6	22	10.1	114.6	9.5					11
12	19	9.4	100.6	---	22	8.7	98.6	8.6					12
13	20	12.1	132.0	---	22	7.3	82.8	7.1					13
14	20	---		---	22	7.1	80.5	7.0					14
15	19	12.6	135.0	11.2	23	11.2	129.3	8.6					15
16	19	12.6	135.0	---	23	10.8	124.7	10.4					16
17	19	10.0	107.0	9.4	24	11.0	128.8	10.7					17
18	19	8.5	90.7	8.0	25	10.0	119.3	9.8					18

TABLE 3 - Continued.

Sta.	Temp.	D.O.	% Saturation	B.O.D.	Temp.	D.O.	% Saturation	B.O.D.	Temp.	D.O.	% Saturation	B.O.D.	Sta.
		November 5, 1929				November 23, 1929				November 30, 1929			
1	4	13.0	91.5	5.0	1	18.0	126.5	10.5	.5	15.2	105.5	8.1	1
2	4	13.7	96.6	9.3	.5	14.6	101.6	9.6	.5	15.2	105.5	7.9	2
3	4	12.5	95.0	6.8	0	14.2	97.2	10.7	.5	10.0	69.5	5.8	3
4	3	12.7	94.5	6.1	0	15.4	105.4	9.6	0	---		---	4
5	4	13.2	100.6	7.1	2	14.4	104.0	8.5	0	17.5	120.0	8.3	5
6	5	13.4	104.7	6.7	.5	15.2	105.5	6.9	.5	13.5	93.8	3.7	6
7	4	13.5	102.7	8.3	0	15.1	103.2	8.4	0	9.7	66.7	1.3	7
8	3	14.0	104.0	6.0	.5	14.8	102.7	7.3	0	17.5	120.0	7.2	8
		November 8, 1929				November 27, 1929				December 4, 1929			
9	6	10.5	84.4	5.1	3	13.8	1037	5.4	1	10.0	70.3	12.2	9
10	5	11.2	87.5	7.1	4	10.5	80.0	8.1	1	12.5	87.7	4.9	10
11	5	11.5	89.8	4.9	2	8.3	61.5	5.9	.5	14.3	99.3	7.7	11
12	5	12.7	99.4	5.2	1	8.7	61.3	2.1	0	10.0	68.4	---	12
13	5	11.9	93.0	3.4	1	9.3	65.4	3.8	0	14.2	97.1	6.3	13
14	5	12.1	94.5	4.9	1	8.0	56.5	1.5	0	12.5	86.2	4.8	14
15	5	11.5	90.0	4.3	2	16.3	117.7	16.0	0	10.6	72.5	2.8	15
16	4	13.0	98.7	3.9	3	12.1	89.8	8.6	.5	11.6	80.5	4.0	16
17	4	11.6	88.3	4.3	1	12.4	87.0	4.3	.5	17.0	118.0	9.2	17
18	5	12.0	93.8	3.8	1	15.0	105.5	6.5	0	11.5	78.8	0.6	18

TABLE 3 - Continued.

Sta.	Temp.	D.O.	% Saturation	B.O.D.	Temp.	D.O.	% Saturation	B.O.D.	Temp.	D.O.	% Saturation	B.O.D.	Sta.
	December 6, 1929				December 13, 1929				January 3, 1930				
1	1	12.6	88.6	6.1	.5	12.9	89.5	5.6	0	14.2	97	2.6	1
2	.5	14.6	101.7	7.0	1	12.8	89.8	4.9	0	14.8	101.5	6.5	2
3	.5	11.7	81.4	5.3	.5	13.1	90.8	8.3	0	12.0	82.3	3.8	3
4	0	12.6	86.2	6.4	.5	12.4	85.3	5.2	0	13.3	90.7	4.5	4
5	0	13.5	92.4	7.6	.5	13.5	93.6	5.9	0	13.2	90.3	4.8	5
6	1	8.2	57.5	0.9	.5	13.2	91.5	3.2	0	9.2	62.8	---	6
7	1	12.1	85.0	2.0	.5	15.8	109.5	6.5	.5	9.9	68.7	---	7
8	1	16.4	115.0	7.0	.5	16.0	111.0	7.8	0	16.3	111	5.8	8
9					December 28, 1929				January 8, 1930.				
9					1	13.5	94.8	13.3	1	9.8	68.7	4.6	9
10					.5	11.7	81.2	11.4	0	10.8	74.0	3.8	10
11					.5	8.6	59.7	8.4	0	9.6	65.5	1.7	11
12					1	8.3	58.4	3.9	0	8.8	60.3	0.2	12
13					1	9.8	68.7	4.1	0	13.6	93.0	3.9	13
14					1	11.9	83.5	5.5	0	13.7	93.6	3.8	14
15					1	14.7	103.2	6.4	0	16.4	112.3	2.2	15
16					1	15.8	111.0	7.6	0	13.8	94.2	7.7	16
17					1	13.5	94.8	10.1	0	16.5	112.7	6.5	17
18					.5	16.2	112.5	8.9	0	16.2	110.6	7.2	18

TABLE 3 Continued.

Sta.	Temp.	D.O.	% Saturation	B.O.D.	Temp.	D.O.	% Saturation	B.O.D.	Temp.	D.O.	% Saturation	B.O.D.	Sta.
		January 11, 1930				January 31, 1930				February 7, 1930			
1	0	15.6	106.8	7.0	0	3.4	23.2	1.4	.5	3.6	24.9	1.5	1
2	0	16.5	113.0	5.3	0	6.7	45.8	2.4	0	11.9	81.4	3.7	2
3	0	12.6	86.5	6.6	0	2.0	13.6	1.3	0	8.5	58.2	1.6	3
4	0	10.0	68.4	6.3	0	3.0	20.5	1.8	0	2.8	19.3	1.2	4
5	0	12.5	85.5	11.7	0	1.8	12.3	1.3	0	4.2	28.6	1.9	5
6	0	14.0	95.7	7.3	0	7.1	48.5	2.0	0	11.8	80.5	2.2	6
7	0	10.5	71.7	9.7	0	4.9	33.5	1.7	0	12.0	82.0	2.5	7
8	0	12.7	86.9	5.9	0	4.7	32.2	1.6	0	12.0	82.0	8.0	8
		January 29, 1930								February 12, 1930.			
9	5	---	---	---					2	10.3	79.5	---	9
10	0	---	---	---					1	---	---	---	10
11	0	---	---	---					1	---	---	---	11
12	0	.8	5.45	6.3					1	10.9	76.5	10.3	12
13	0	1.4	9.55	4.7					1	10.5	73.7	10.2	13
14	0	---	---	---					1	6.0	42.2	5.8	14
15	0	2.6	17.5	13.0					1	10.0	70.3	9.5	15
16	0	---	---	---					1	10.2	71.6	9.3	16
17	0	.8	5.45	9.0					1	7.5	52.6	999	17
18	0	---	---	---					1	7.9	55.5	7.6	18

TABLE 3 - Continued.

Sta.	Temp.	D.O.	% Saturation	B.O.D.	Temp.	D.O.	% Saturation	B.O.D.	Temp.	D.O.	% Saturation	B.O.D.	Sta.
	January 13, 1931				February 10, 1931.								
1	0	18.7	127.8	8.4	1	15.4	108.2	5.4					1
2	0	12.9	88.4	5.2	2	11.7	84.5	7.5					2
3	0	10.4	71.2	9.8	1	12.4	87.3	12.2 +					3
4		---	---	---	1	13.7	96.3	6.7					4
5		---	---	---	1	14.1	99.2	5.8					5
6	0	14.2	97.2	7.9	1	15.8	111.0	8.0					6
7	0	17.9	122.4	9.8	1	15.2	106.8	8.0					7
8		---	---	---	0	17.7	124.2	10.0					8
	January 21, 1931				February 12, 1930								
9	0	8.6	58.8	23.4	2	13.4	97	13.2 +					9
10	0	4.5	30.6	---	1	11.0	77.4	10.7 +					10
11	0	3.0	20.4	19.5	2	12.0	86.8	9.9					11
12	0	5.5	37.6	4.0	2	12.6	91.0	5.8					12
13	0	9.0	61.5	3.9	2	12.4	87.3	5.5					13
14	0	11.5	78.7	9.6	1	12.0	84.5	5.5					14
15	0	12.7	86.8	26.1 +	1	15.8	111.0	8.1					15
16	0	7.2	49.4	6.2	1	13.4	94.4	11.2					16
17	0	14.2	92.0	13.9	2	13.6	98.3	7.8					17
18	0	16.8	115.0	16.4 +	1	14.0	98.3	8.6					18

Sta.	Temp.	D.O.	% Saturation	B.O.D.	Temp.	D.O.	% Saturation	B.O.D.	Temp.	D.O.	% Saturation	B.O.D.	Sta.
		July 22, 1930				September 20, 1930				December 5, 1930			
1	26	5.5	67.0	1.2	17	8.0	82.3	4.0	3	15.4	114.8	5.6	1
2	25	4.5	53.6	6.2	15	2.0	9.4	24.0	1	12.5	87.7	8.1	2
3	25	7.3	82.2	4.2		6.5		5.9	.5	12.6	87.3	8.2	3
4	25	9.4	112.0	4.7	15	8.1	79.6	4.6	1	12.6	88.5	6.9	4
5	25	9.3	111.0	4.8	15	7.6	74.8	3.9	1	13.7	96.2	7.3	5
6	26	8.9	108.0	5.1	17	9.5	97.8	4.8	1	13.7	96.2	6.0	6
7	27	8.7	107.8	4.5	18	9.3	97.6	5.3	1	10.8	76.0	3.5	7
8	27	9.0	111.5	4.4	19	9.9	105.7	4.9	1	9.1	64.0	1.3	8
		July 25, 1930				September 17, 1930				December 3, 1930			
9	31	7.7	182.2	7.6 +	23	3.1	35.8	11.6	.5	10.7	74.2	10.7 +	9
10	31	13.4	180.0	13.2 +	20	7.5	82.7	6.6	1	9.2	64.6	9.2 +	10
11	29	12.2	187.7	12.1 +	17	11.6	116.0	9.5	1	11.8	83.0	8.9	11
12	29	9.5	122.0	9.4 +	17	8.5	87.4	6.2	1	13.5	95.0	8.3	12
13	28	7.9	99.9	7.9 +	17	8.2	84.4	5.8	1	15.4	108.2	8.1	13
14	28	9.4	118.5	8.8	16	8.0	80.5	5.0	1	14.1	99.0	6.1	14
15	27	9.2	114.0	7.6	20	7.0	76.4	6.6 +	1	13.4	94.2	13.4 +	15
16	28	9.2	116.0	8.5	19	9.3	99.6	8.9 +	1	14.5	102	8.0	16
17	27	9.5	117.6	9.2 +	20	10.0	109.0	6.5	1	14.6	102.5	11.0	17
18	25	8.3	99.2	6.1	19	9.6	102.5	8.1	1	15.5	109.0	9.5	18

TABLE 3 Continued.

Sta.	Temp.	D.O.	% Saturation	B.O.D.	Sta.
			June 6, 1931.		
1	21	3.4	37.8	3.4 +	1
2	20	4.3	46.8	14.0	2
3	19	2.7	29.2	6.0	3
4	20	7.6	67.3	13.0	4
5	22	9.2	104.0	7.3	5
6		---	---	---	6
7	22	8.0	90.6	5.9	7
8	19	6.1	65.3	3.7	8

OTHER CHEMICAL DATA.

During the latter period, samples were collected and shipped to Iowa City for complete sanitary chemical data. These data do not add greatly to the information already given, but simply substantiate and check the results.

Determinations for ammonia nitrogen, albuminoid nitrogen, nitrite nitrogen, nitrate nitrogen, methyl orange alkalinity and chlorine as chlorides were made. Results of these analyses are tabulated in table 2.

Ammonia nitrogen shows a great increase below Fort Dodge and then a gradual decrease but not complete recovery at Station 8 above Des Moines. At Station 9 below Des Moines there is again a great increase with little improvement all the way to Ottumwa. Below Ottumwa there is again a slight increase with no improvement noted, farther down stream.

Albuminoid nitrogen shows the same general trend. Albuminoid and ammonia nitrogen indicate fresh sewage pollution. Nitrite nitrogen is present in very minute quantities at all stations. This indicates that at no point in the stream has oxidation of the nitrogen reached the nitrite stage. As would be expected, the nitrate content is uniformly low and shows no increase below the points of pollution, again indicating that the nitrogen oxidation is not taking place.

These results show more than any other results, the failure of the stream to recover from its pollutional load, even at the points farthest from the sources of pollution.

A significant increase in chlorides is noted below Fort Dodge, a further increase below Des Moines, and a still further increase below Ottumwa. At Staion 1 the chloride content is 10 ppm., whereas at Station 18 it has increased to 61 ppm. A casual glance at the table will show that the chlorides show sudden increases at the points of pollution and are the result of the sewage discharged into the stream at these points. The sewage contains chlorides in greater quantities than the unpolluted stream water.

These results of chemical analyses simply augment the evidence previously discussed, showing the polluted condition of the stream.

PHENOL DETERMINATIONS.

Due to the many complaints of gas house odors in the stream water below Des Moines, special phenol determinations were made on both the wastes from the gas plant and also on samples of river water downstream as far as station 13 (Eddyville).

The phenol determinations were made in the State Hygienic Laboratory at Iowa City and since this determination is laborious and difficult, only two samples of the gas house wastes and one set of samples from the river below Des Moines were analyzed.

Reports of the results of phenol determinations are as follows:

DATE	SOURCE	PPM.	PPB
3-8-30	Gas plant sewer	553	553,000
7-1-30	Gas plant sewer	2823.5	2,823,500
1-21-30	River water station 9	0.008	8
1-21-30	" " " 11	0.004	4
1-21-30	" " " 12	0.002	2
1-21-30	" " " 13	0.002	2

Actual measurements of the quantities of gas house wastes discharged into the river are not available; however, the quantities are small. Gas plant officials estimate that about 2000 gallons per day are discharged into the stream. The flow is not continouous, nor is the character of the waste uniform as noted by the two results of analyses.

However, with only 2000 gallons of wastes with a phenol content of 2823 ppm. at a steam stage of 100 c.f.m., it is computed that 75 ppb. of phenol would be present in the river below the gas plant. Since 50 ppb. will impart serious tastes and odors to the water, the complaints seem to be justified and the gas plant is contributing measurably to the pollution of the stream. It is also significant to note that phenols persist as far down stream as Eddyville, about sixty-five miles. In addition to phenols, oily wastes and other coal tar by-products are present in gas house wastes in objectionable amounts.

PHYSICAL CONDITIONS.

On the trips along the river, the physical conditions were noted. During the summer months, the Des Moines River is usually turbid and floating solids are not as noticeable as they would be in a clear water. In the winter when the water is very clear, ice usually covers the stream and it is impossible to see the solids. Even with the turbid water and the ice, physical evidences of pollution may be seen at several places.

Above station one there is very little pollution entering the stream and the river usually appears to be in fair condition. At times, however, there is a scum on the water surface and on June 6, 1931 an oil scum was very noticeable. This is the only time an oil scum has been noted.

At station 2, about one mile below the Fort Dodge sewer outlets, the river is in very bad condition. The river bed is made up almost entirely of rock and on top of the rock there is a deposit of sludge in places and in other places there is a heavy growth of algae. At low stages the river at this point is so shallow that it is hard to find a place deep enough to submerge the sampling can. Floating solids may be seen at this point almost any time a person may choose to look.

Station 3, located about 6 miles below the Fort Dodge sewer outlets, shows some improvement in the amount of floating solids, but the algae and weed growth is getting worse. Another thing to consider here is the turbidity caused by a brick and tile factory located about one mile above the station.

At Lehigh, Station 4, floating solids may still be seen. The river here is much deeper and as the water is usually turbid the investigator could not see the condition of the river bed.

From station 4 to Des Moines, stations 5, 6, 7 and 8, the river looks pretty good most of the time. At these stations floating solids are seldom seen because of the natural turbidity of the water.

Station 9 is located a few miles below the Des Moines sewer outlets and the stream at this point looks bad. Floating solids may be seen any time and the bed of the river near the banks shows a heavy sludge deposit. The river near the center is too deep and turbid to see the condition of the river bed there.

At station 10, about 11 miles below station 9, very much the same conditions are found. There are less floating solids and the sludge deposits are not so thick, but both are there.

Stations 11, 12, 13, 14 show a great improvement in the physical condition of the stream. The water is not so turbid and the stream bed seems to be in a much better condition. The investigator has seen live fish at all of these stations.

Below Ottumwa at Station 15 about the same conditions as those below Fort Dodge and Des Moines are found. Floating solids are not uncommon and it is almost impossible to tell by observation whether or not there is a sludge deposit because of the depth and turbidity of the water.

At stations 16, 17 and 18 the stream has the appearance of an ordinary turbid stream. There are no floating solids and no sludge deposits are visable.

EFFECT OF SEWAGE SLUDGE ON THE STREAM BED.

During extended periods of low flow, the velocity of the river is low and this aggravates the settling of sewage sludge within comparatively short distances below the source of pollution. The settling of this decomposable material, which has a high oxygen demand has a temporary salutary effect upon the supernatant waters farther down stream in that it relieves these waters of much of its oxygen-consuming, organic load. The decomposition of this material in the stream bed is not rapid. Under conditions of summer temperatures, complete digestion or neutralization may take place in five or six months, but under winter condition, the bacterial action responsible for the digestion virtually ceases.

As a basis for design in sludge digestion compartments in sewage plants, engineers are agreed that 2.5 to three cubic feet per capita must be allowed for sludge storage for the complete digestion of the sludge, where the sludge tanks are not artificially heated. There is no doubt but that digestion in controlled tanks is more rapid than in a stream bed, since the temperatures are more nearly uniform.

However, using the figure of 2.5 cubic feet per capita for sludge in a stream bed in various stages of digestion, the effect of the sludge on a stream bed in periods of dry flow can be appreciated from the following figures.

There would be in some portions of the stream at all times, sludge in various stages of digestion in the following quantities:

	Pop. Equiv. of Sewage	Cu. Ft.	Cu. Yds.
From Fort Dodge	21,891	55,000	2,040
From Des Moines	167,859	419,648	15,540
From Ottumwa	98,075	245,187	9,080

During times of frequent high stream stages, this material would, of course, be spread over long distances of the stream bed. During protracted periods of low flow, however, most of this material would be deposited within a short distance below the sewer outlets.

This settled sewage sludge has several effects on the stream. The familiar ebullition of gas bubbles accompanied by the rising to the surface of black, foul smelling solids is one of the effects on the stream.

The deoxidization of the overlying water by the accumulated sludge is another effect. This is one reason why, in certain parts of the stream, a lower oxygen balance will be noted at high river stages than at low river stages.

The actual destruction of fish has been noted on several occasions as an indirect result of the sludge deposits. The following conditions were found: Sludge had accumulated in the stream bed due to prolonged low velocities. A sudden rise in the stream dislodged the sludge and mixed it intimately with the water and as a result so lowered the oxygen content of the water that fish were destroyed by the thousand for miles below the source of pollution.

DESTRUCTION OF FISH

Reports of dead fish in the stream below Fort Dodge and Des Moines have been frequent, and on a few occasions at Ottumwa. The winter months, with the low flows accompanied by heavy ice formation have been the most critical times for fish life, altho several times dead fish have been reported below Fort Dodge in late summer.

A fish census has not been attempted but from the best information available there are apparently no game fish in the zones of heavy pollution during the lower river stages. With the low oxygen balance and the organic filth in the streams this is to be expected. Carp and other less sensitive fish are present at times in the zones of pollution.

In all of the cases of where the death of fish was investigated, the cause of the death was apparently due to lack of oxygen. Much complaint has been received by the department of the destruction of fish by gas-house wastes below Des Moines, and it is probable that at low stages when a slug of gas house wastes is discharged into the stream, the concentration of phenol is sufficient to destroy fish. Phenol is known to be toxic to fish in very dilute solutions and the presence of phenols in the river water as far down as Eddyville will give some indication of the extent of the phenol pollution. There is no doubt but that the gas-house wastes when present in amounts too small to kill the fish, still have a toxic effect upon the fish, and furthermore impart to the fish a taste which renders them unfit for human consumption.

For the most part the stream of pollution entering the river at the cities concerned in this report is rather constant in character and amount. Sudden large discharges of extremely heavily concentrated wastes which would destroy large numbers of fish before they could get away, are absent in these cities. Consequently, the stream condition becomes slowly and gradually worse with each period of lowering river stages. Fish ordinarily have ample time to migrate from the zones of heavy pollution before the conditions become so bad that fish life cannot exist. In the studies many examples of the migration of fish to cleaner waters has been noted during periods of lowering stream stages and the resultant heavier concentration of pollution.

The accumulation of sludge on the stream beds destroys breeding grounds which of course would have a deleterious effect on fish life. There is ample evidence that even when the oxygen content of a stream is sufficient to support fish live, lowered oxygen content has a devitalizing effect and this is deleterious to fish life, making them less resistant to disease, high temperatures, etc.

EFFECT OF POLLUTION ON LIVE STOCK.

The exact effect of polluted waters on live stock is not definitely known, although leading veterinarians are agreed that live stock cannot thrive if the drinking water is heavily polluted with sewage, and in several instances the department has investigated conditions in Iowa where the death of live stock was attributed to drinking sewage polluted waters.

Access to polluted waters by dairy cows has a direct and serious public health significance. Cows wading in polluted waters may collect pathogenic bacteria on teats, udders and other parts of the body. The bacteria in turn are mechanically transferred to milk during the milking process. Such milk is an excellent medium for the growth of the common intestinal bacteria. Milk thus infected can readily become a focus of infection unless the milk is adequately pasteurized.

There is also the question of the spread of undulant fever to animals drinking water polluted with wastes from meat packing plants altho as far as the writer knows this possibility has not been definitely established.

Charts 83, 84, 85 show the records of stream flow measurements at Des Moines, Ottumwa and Keosauqua, respectively.

Dicharge records at Des Moines were obtained from the Weather Bureau of the United States Department of Agriculture at Des Moines. This station is located on the Des Moines River above the junction with the Raccoon River.

Records for the Ottumwa station were furnished by the United States Geological Survey and the Mississippi River Power Company furnished the records at Keosauqua. From September 30, 1930 to February 28, 1931 the flows at Ottumwa are estimated from the Des Moines and Keosauqua data. Changes in the river bed at Ottumwa rendered the Ottumwa readings inaccurate.

Unfortunately, no flow records were available for the Des Moines River at Fort Dodge nor for the Raccoon River at Des Moines. The discharges at Fort Dodge are considerably less than at Des Moines; however, no attempt will be made to estimate the discharge at Fort Dodge.

The Raccoon River discharges into the Des Moines at Des Moines and at a short distance below the sewer outlets, The water from both streams is available for dilution. While no records are available for the Raccoon River it is fair to assume that the discharges of the Raccoon are less than the Des Moines for the low stages.

A study of the flow records revealed several rather startling facts. The low flow recorded at Des Moines during the period was 42 c.f.s. for both the Des Moines and Raccoon Rivers, which is less than .3 c.f.s. per 1000 population.

Chart 86 shows the flow record of the stream for the period of the survey showing the percentages of time during this period when flows were less than a stated figure. For 7.6% of the time, the discharge was less than 100 c.f.s.; for 32.6% of the time, it was less than 250 c.f.s.; and for 50% of the time, it was less than 600 c.f.s.

Leading authorities in the United States have recommended stream discharge of from 4 to 10 c.f.s. as the minimum flows which are necessary to dilute the sewage from 1000 persons without causing undue pollution. Using the minimum figure, Fort Dodge with a population equivalent of 25,000 would require a minimum flow of 100 c.f.s. Des Moines with a population equivalent of 165,000 would require a minimum flow of 660 c.f.s. and Ottumwa with a population equivalent of 95,000 would require a minimum flow of 380 c.f.s.

Using an average of the figures cited above, namely 7 c.f.s. per 1000 population, the minimum requirements would be: for Fort Dodge, 175 c.f.s., for Des Moines, 1155 c.f.s., and for Ottumwa, 665 c.f.s.

Study of these stream flow records as well as records of previous years reveals that low flows are of almost annual occurrence in the late summer and again in the winter. During the summer months there is little run-off from the cultivated lands, as even with normal rainfall, the growing crops and evaporation consume most of the water that falls. With the extensive drainage operations in the upper drainage area of the river, storm waters run off rapidly, thus leaving no stored water to sustain the stream flow during the periods when there is little run-off. In winter, when the ground is frozen, percolation and seepage is at a minimum and thus, again, a sustained flow of water between the infrequent periods of run-off is not a usual occurrence.

A study of the stream flow records indicates that low flows occur with sufficient frequency and over a sufficiently long period of time so that these conditions cannot be considered abnormal. Periods of low discharges may be expected for two or three months out of the year, even during a normally wet year.

ACKNOWLEDGEMENTS.

The investigations reported herein were conducted by the Bureau of Public Health Engineering, State Department of Health, under the direction of A. H. Wieters, Director.

The writer is grateful for and acknowledges the field investigations and chemical determinations, the compilation of data and the preparation of charts by the Assistant Engineers of the Staff, especially R. B. McAllister and W. R. Mark who carried out most of the work. Assistant Engineers P. J. Houser and E. G. Fiala and former assistant engineers M. J. Lonergan and N. W. Towne also assisted in the work.

The writer acknowledges and is grateful for the bacteriological and chemical determinations made in the Iowa State Hygienic Laboratories at Iowa City by Gilbert Kelso, Mr. Matthews and S. Pearch, under the direction of Jack J. Hinman, Jr.

Grateful acknowledgement is further made as follows: To the U. S. Weather Bureau Station at Des Moines; the U. S. Geological Survey and the Mississippi Light and Power Co., for stream flow records; to the City of Fort Dodge for sewer gaging records; to the City of Des Moines for sewer gaging records and the use of space in the laboratory in the City Hall; to the Ottumwa Water Works for space in their laboratory.

APPENDIX INDEX.

- APPENDIX A -

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IOWA STREAM POLLUTION LAW

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2198. Investigation of pollution of water. The department may upon its own initiative investigate the alleged pollution of corruption of any stream or body of water which is rendering the same unwholesome or unfit for domestic use, or as a public water supply, or which is rendering it deleterious to fish life, and the department shall make such investigation upon the written petition of:

1. The council of any city or town.
2. Any local board of health.
3. The trustees of any township.
4. Twenty-five residents of the state.

The power vested by this section in the department shall not apply, however, to the lower five thousand feet of any stream flowing into a river at a place where such river forms a part of the boundary line of the state.

2199. Time and place of hearing. After a full and complete investigation including bacteriological and chemical analysis of the water and location of the source of contamination, the department shall make an order fixing the time and place for a hearing which shall not be less than ten days thereafter. Such hearing shall be public and shall be carried on as far as possible in the same manner as a court hearing and every alleged offender shall have the right to appear by counsel, present testimony, and examine witnesses.

2200. Notice. Notice of the time and place of hearing shall be served upon each alleged offender at least ten days before said hearing in the manner required for the service of notice of the commencement of an ordinary action in a court record.

2201. Order. After such hearing the department may, if it believes the alleged offender is guilty of the charges, enter an order directing such Person to desist in the practice found to be the cause of such pollution or corruption, or it may order a change in the method of passing waste materials into the water so that the same will be rendered innocuous and harmless. No order shall be issued under the provisions of this section that will require the expenditure of more than five thousand dollars (5000.00) without the written approval of a majority of the members of the state executive council.

2202. Reasonable time for compliance. If any such change is ordered, unless such practice is rendering such water dangerous to the public health, a reasonable time shall be granted to the offender in which to put in use the method ordered.

2203. Record. The department shall keep a complete record of such proceedings, including all the evidence taken, and such record shall be open to public inspection.

2204. Appeal. An appeal may be taken by the aggrieved party from any order entered in such proceeding to the district court of the county in which the alleged offense was committed. Such appeal shall be perfected by serving a written notice on the commissioner of public health within thirty days of the entry of such order.

2205. Transcript. Within thirty days after an application for appeal is filed with the commissioner, he shall make, certify, and file in the office of the clerk of the court to which the appeal is taken, a full and complete transcript of all documents and papers relating to the case.

2206. Trial term--precedence. The first term after the appeal is taken shall be the trial term, and if the appeal is taken during a pending term, it shall be triable during such term at any time after ten days from the date that the transcript is filed by the commissioner. The hearing on appeal shall be tried as a suit in equity and shall be de novo.

2207. Violation of order--contempt. Failure to obey any order made by the department with reference to matters pertaining to the pollution of streams shall constitute contempt. In such event the department may certify to the district court of the county in which such disobedience shall occur, or to the district court of Polk County, the fact of such failure. The distirct court shall then proceed to hear and determine the matter and to punish for contempt to the same extent as though such failure were in connection with an order made by the district court which is made punishable by contempt.

2208. Penalty. Any party found guilty of contempt under the preceding section shall be fined not to exceed one thousand dollars or be imprisoned for failure to pay such fine. The penalties provided in this section shall be considered as additional to any penalty which may be imposed under the law relative to nuisances or any other statute relating to the pollution of streams and a conviction under the preceding section shall not be a bar to prosecution under any other penal statute.

- APPENDIX B -

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CHART #1

SHOWING SAMPLING STATIONS

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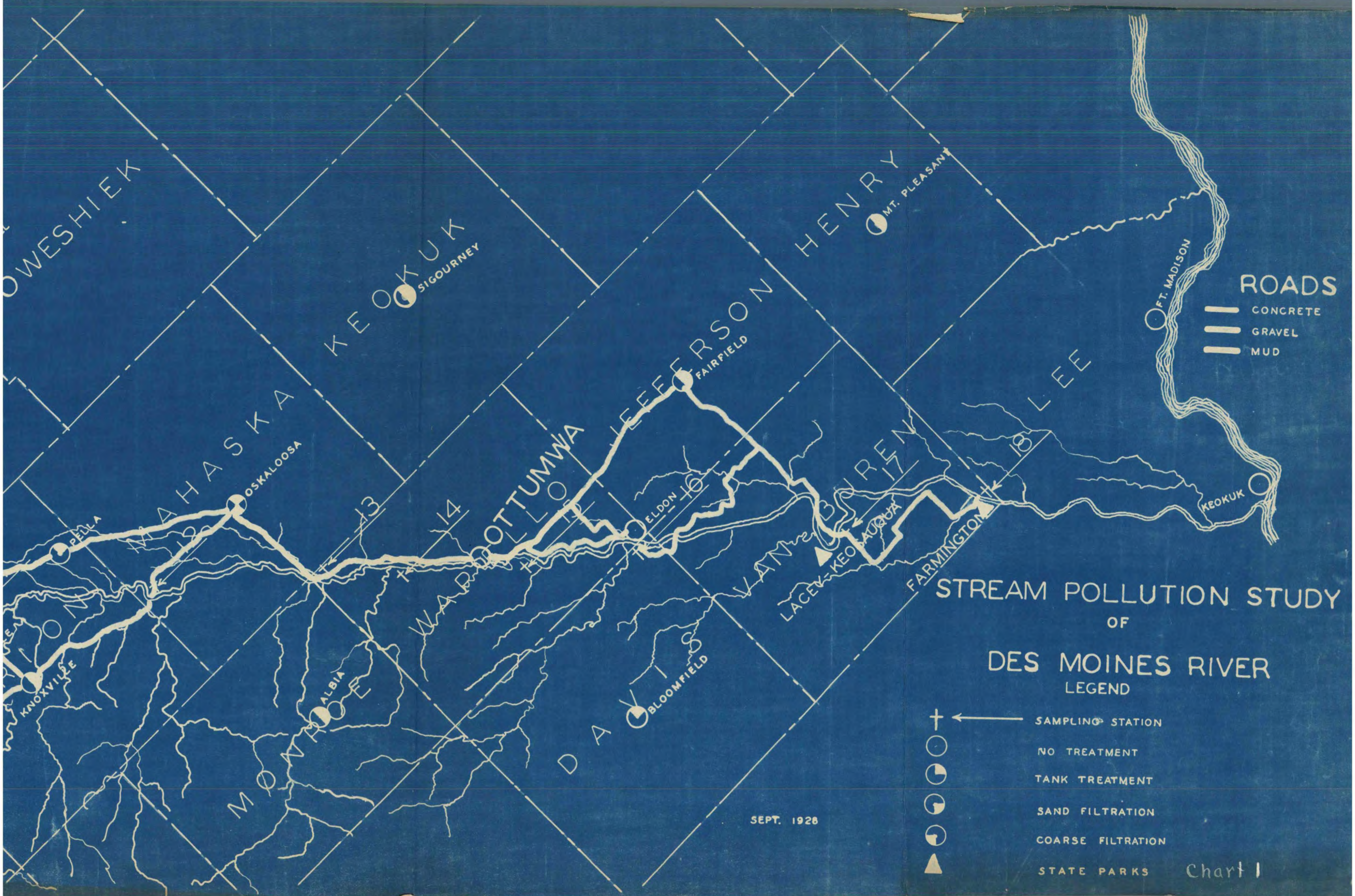
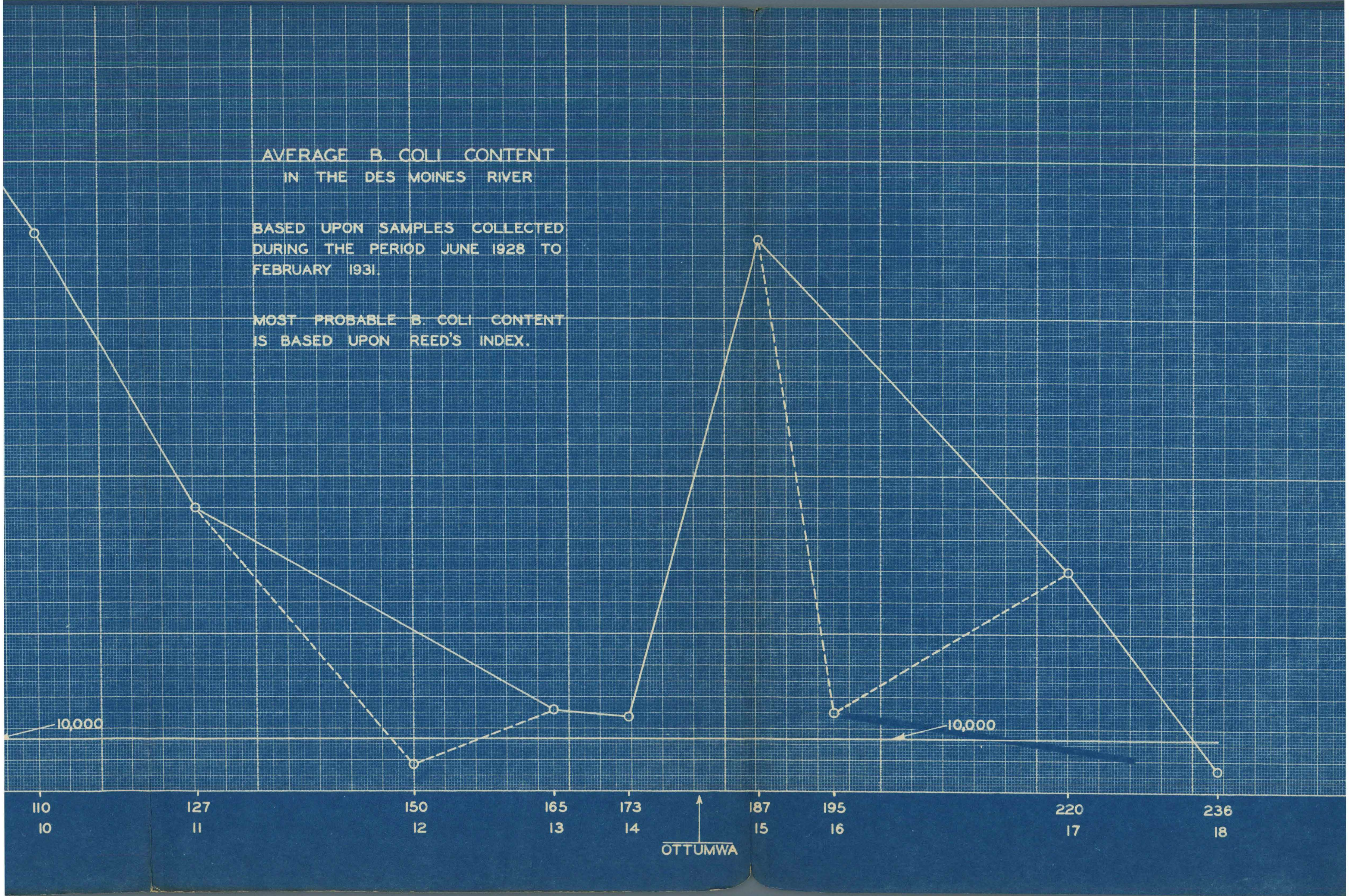
-



OWESHIEK
KEOKUK
SIGOURNEY
HENRY
MT. PLEASANT
JEFFERSON
FAIRFIELD
MAHASKA
OSKALOOSA
PELLA
KNOXVILLE
OTTUMWA
WAPELLO
ELDON
13
14
16
17
18
MONROE
ALBIA
DAVIS
BLOOMFIELD
VAN BUREN
LACEY-KEOSAUQUA
FARMINGTON
LEE
KEOKUK
FT. MADISON
ROADS
CONCRETE
GRAVEL
MUD
STREAM POLLUTION STUDY
OF
DES MOINES RIVER
LEGEND
SAMPLING STATION
NO TREATMENT
TANK TREATMENT
SAND FILTRATION
COARSE FILTRATION
STATE PARKS
SEPT. 1928
Chart 1



AVERAGE B. COLI CONTENT
IN THE DES MOINES RIVER
BASED UPON SAMPLES COLLECTED DURING THE PERIOD JUNE 1928 TO FEBRUARY 1931.
MOST PROBABLE B. COLI CONTENT IS BASED UPON REED'S INDEX.
10,000
10,000
110
10
127
11
150
12
165
13
173
14
OTTUMWA
187
15
195
16
220
17
236
18

APPENDIX D

--0--

CHARTS #3 TO #20 - INCLUSIVE

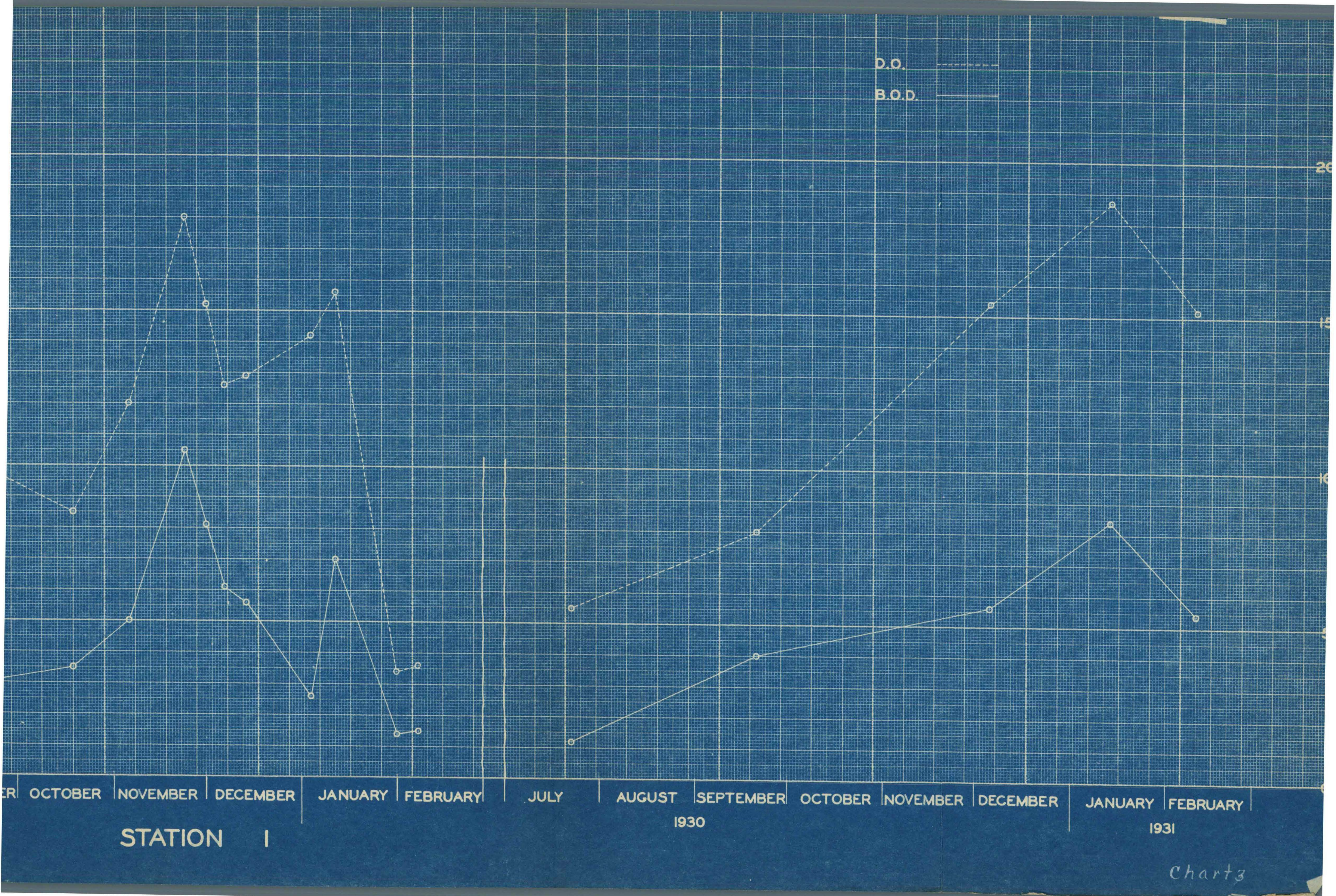
SHOWING D. O. AND B. O. D.

FOR

EACH SAMPLING STATION

FOR THE PERIOD OF THE SURVEY.

--0--


D.O.
B.O.D.
20
15
10
5
ER
OCTOBER
NOVEMBER
DECEMBER
JANUARY
FEBRUARY
JULY
AUGUST
SEPTEMBER
OCTOBER
NOVEMBER
DECEMBER
1930
JANUARY
FEBRUARY
1931
STATION I
Chart 3

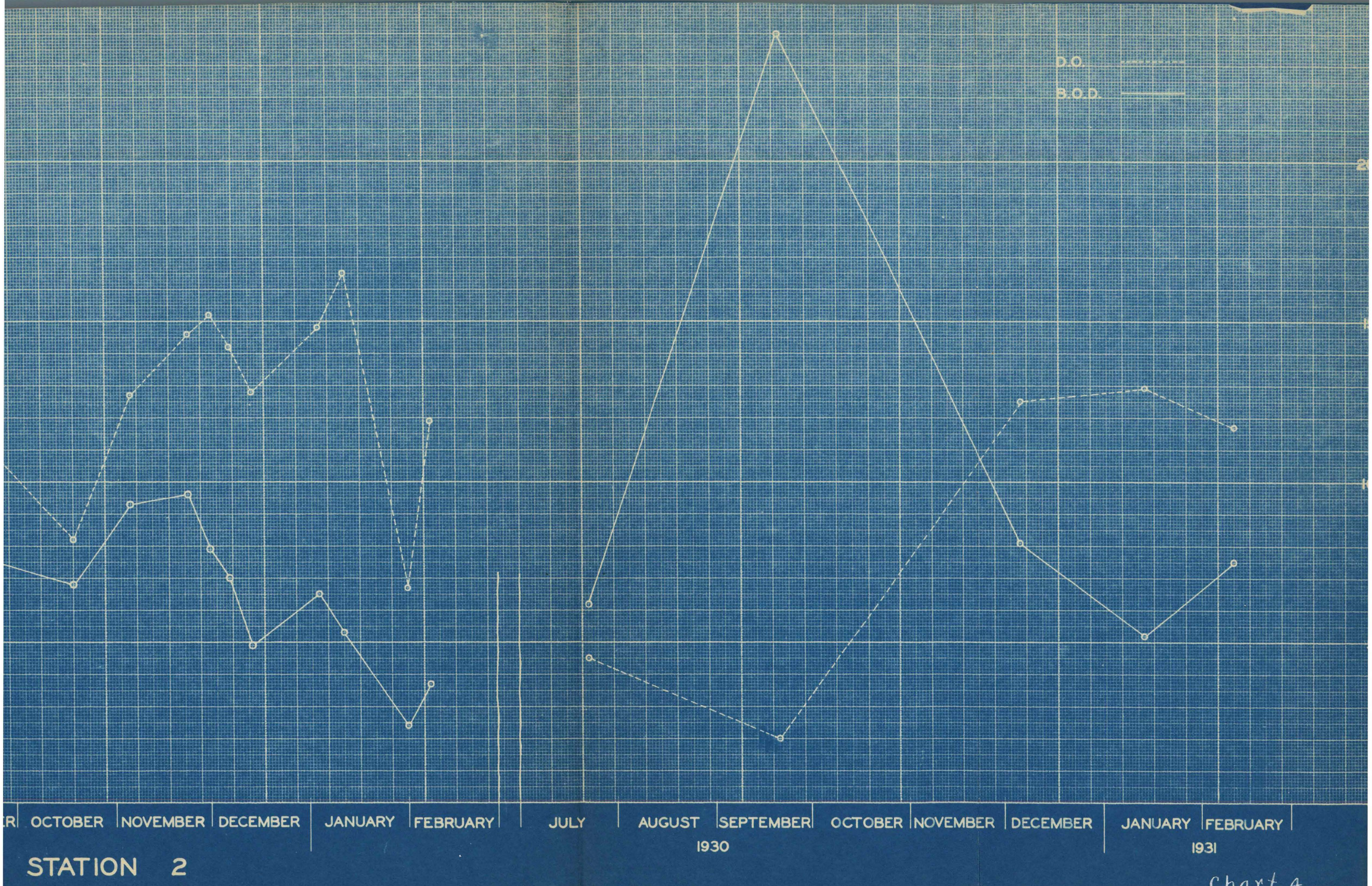
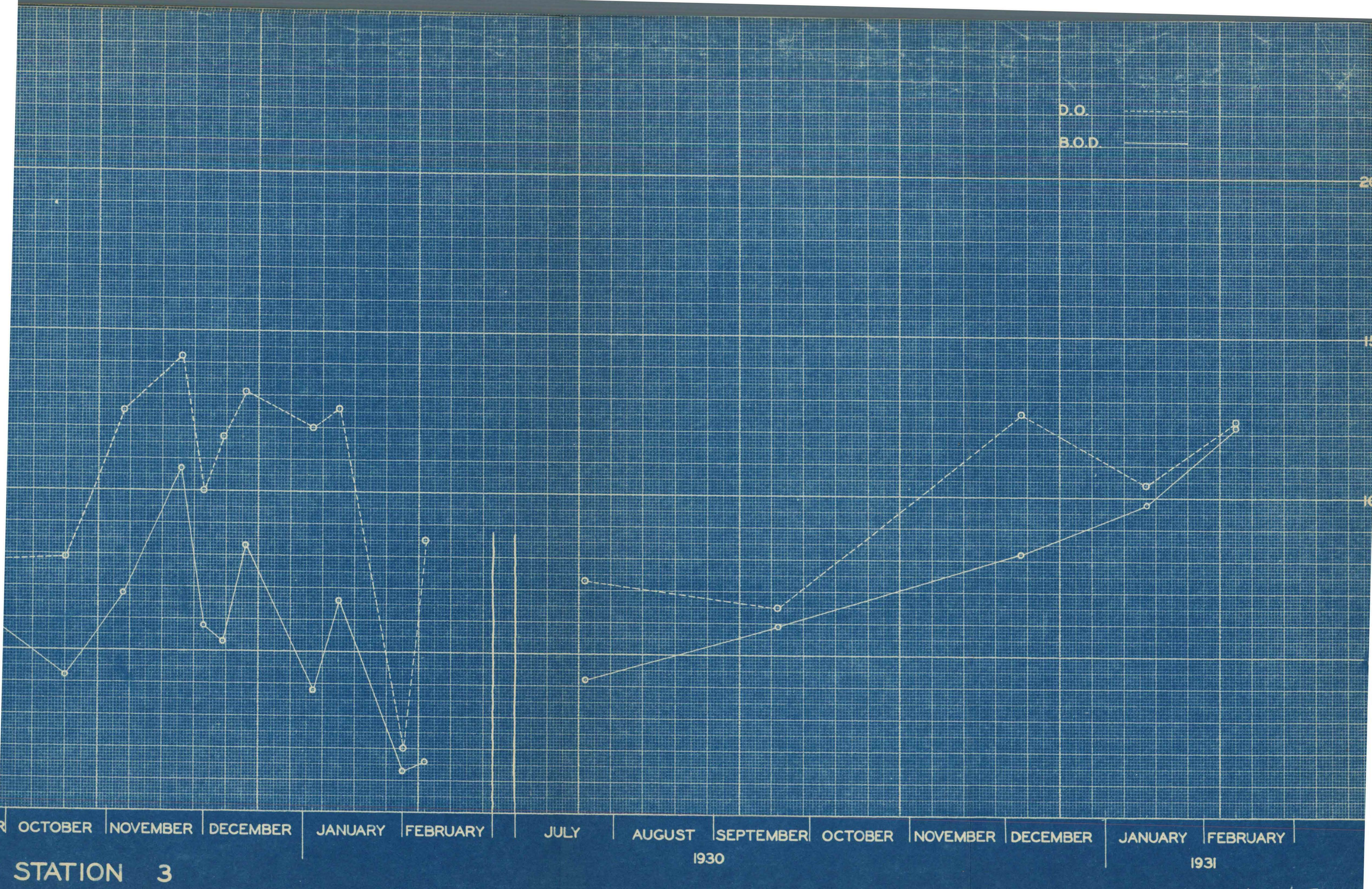
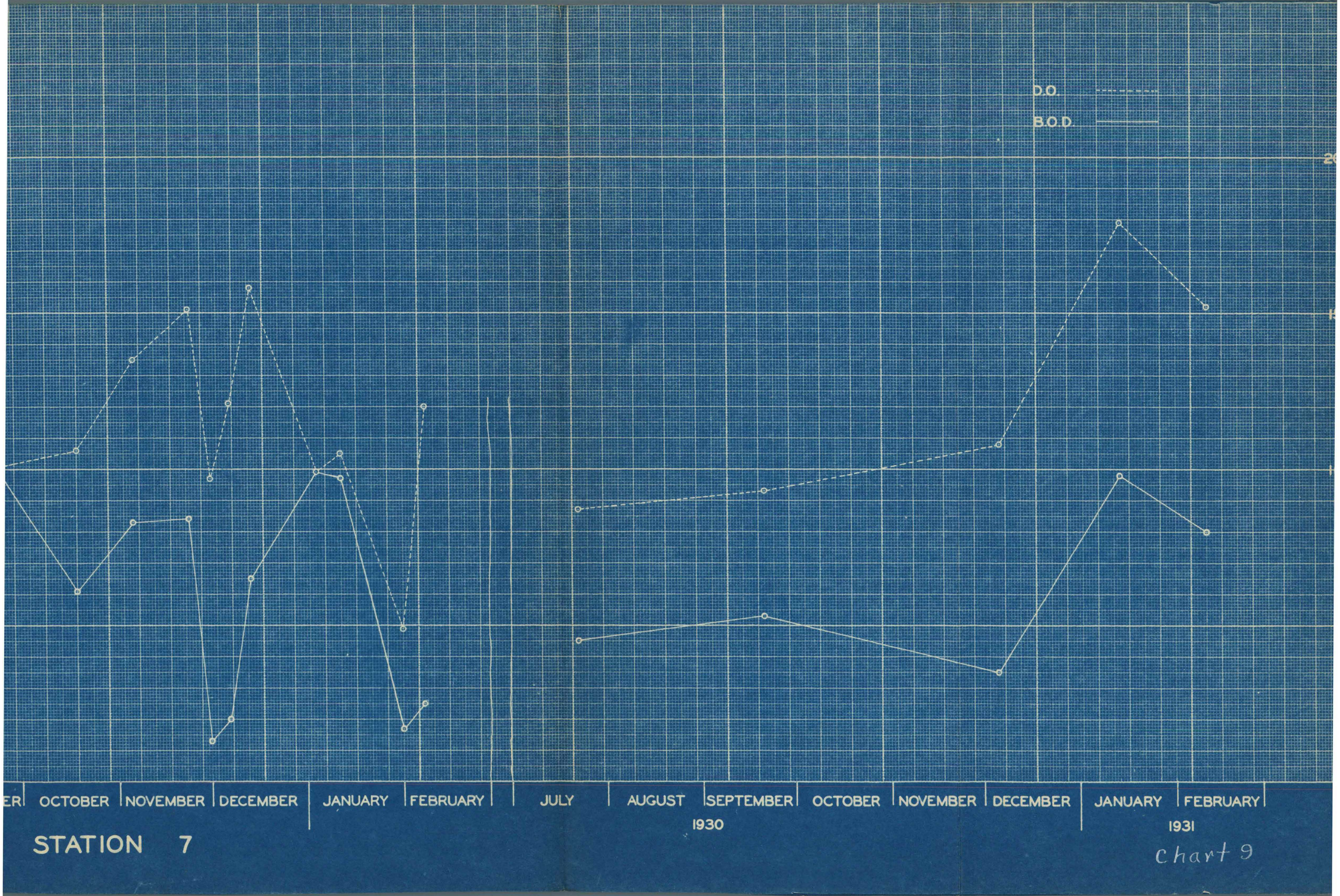

D.O.
B.O.D.
ER OCTOBER NOVEMBER DECEMBER JANUARY FEBRUARY
JULY AUGUST SEPTEMBER OCTOBER NOVEMBER DECEMBER JANUARY FEBRUARY
1930
1931
STATION 2

Chart 4

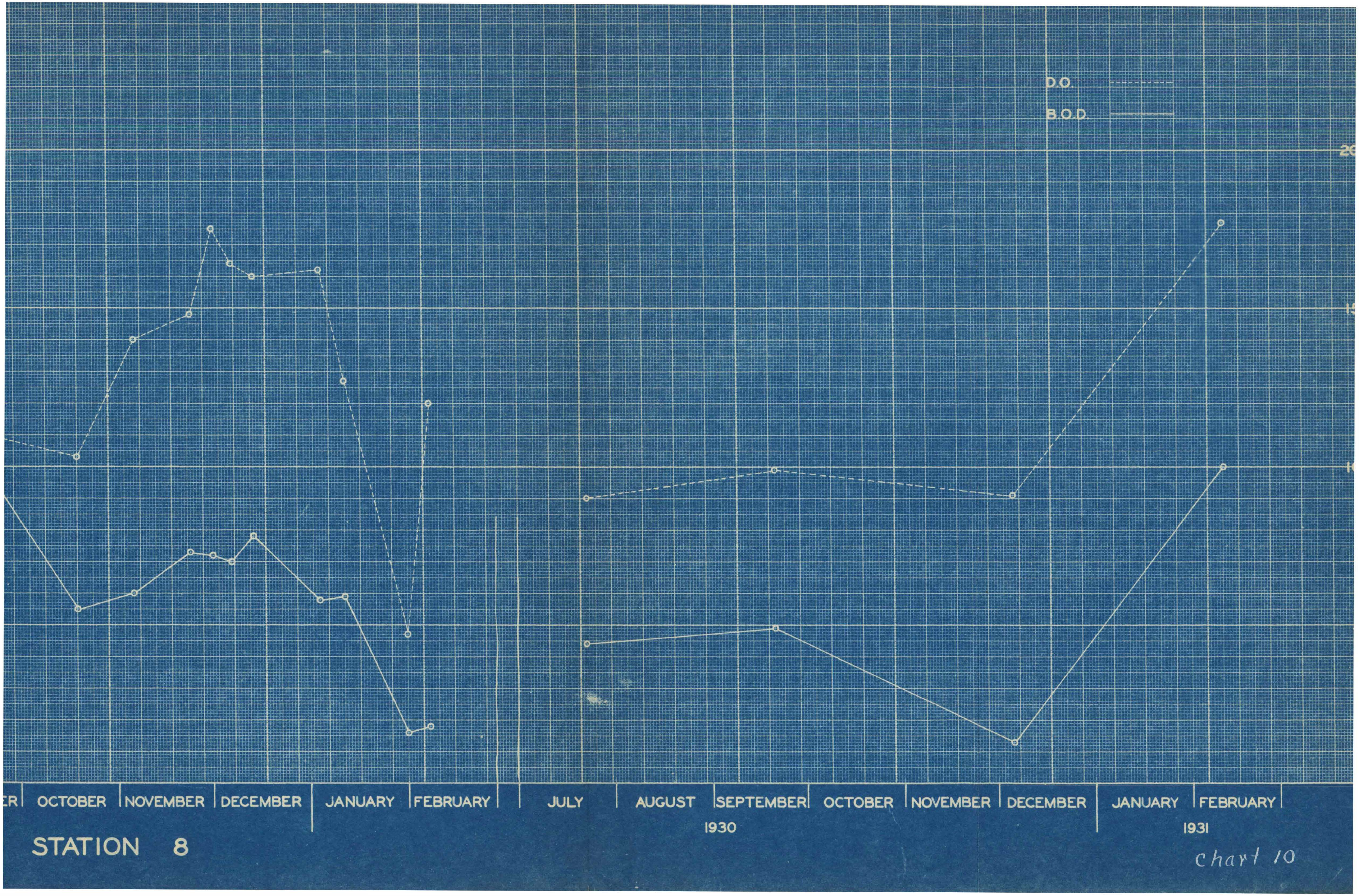


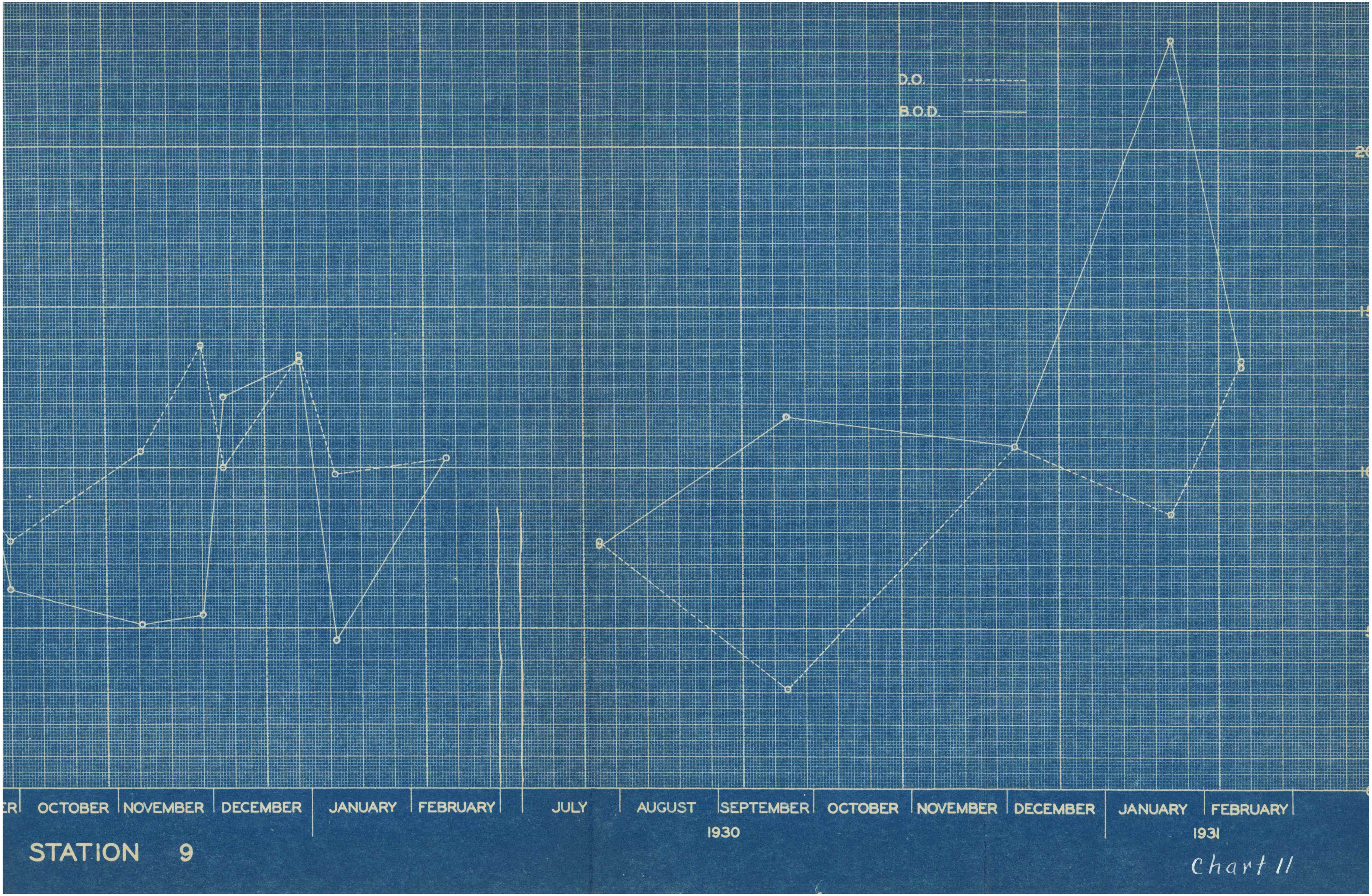
D.O.
B.O.D.
20
15
10
OCTOBER
NOVEMBER
DECEMBER
JANUARY
FEBRUARY
JULY
AUGUST
SEPTEMBER
OCTOBER
NOVEMBER
DECEMBER
JANUARY
FEBRUARY
1930
1931
STATION 3

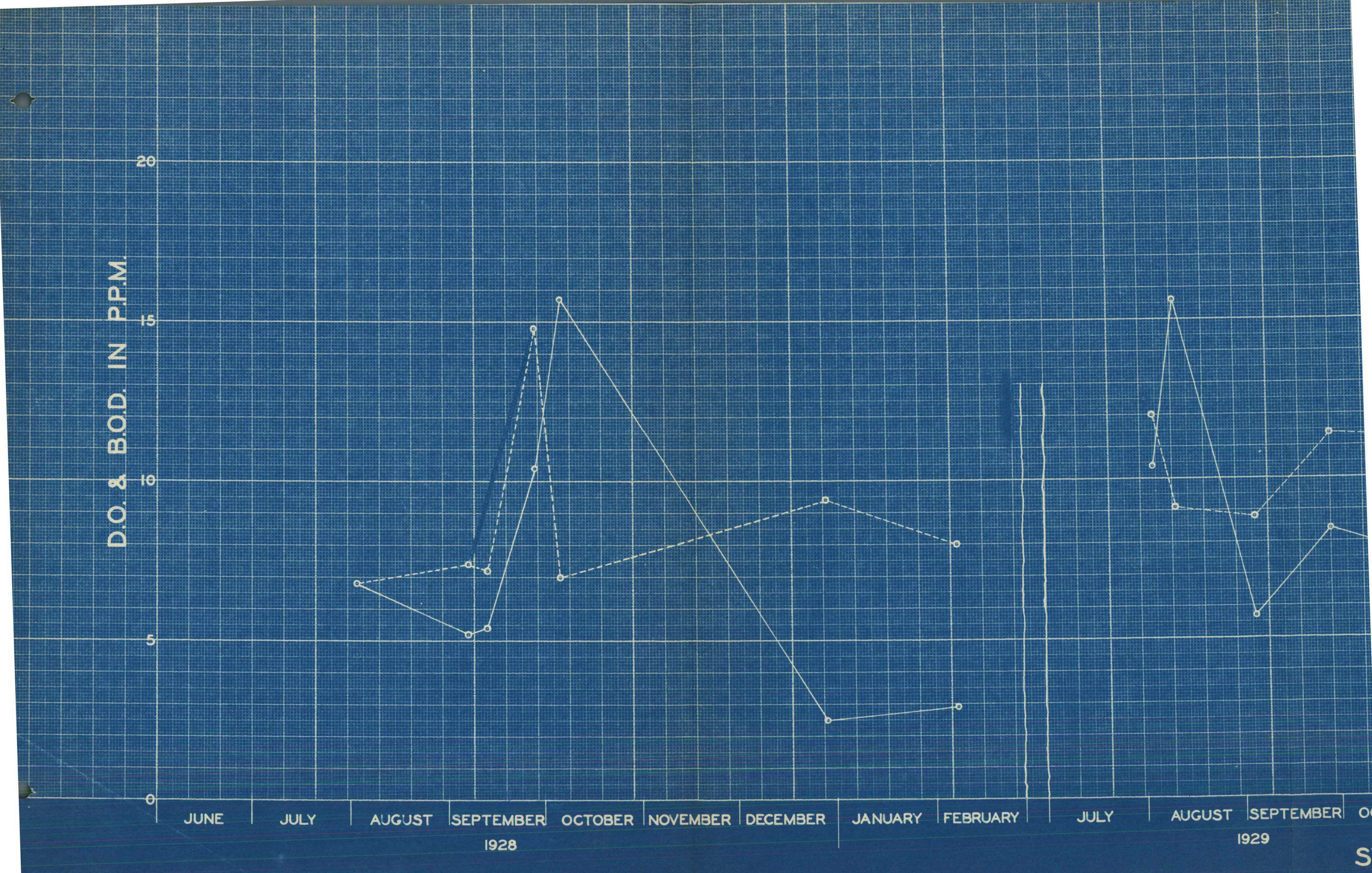
Chart 5



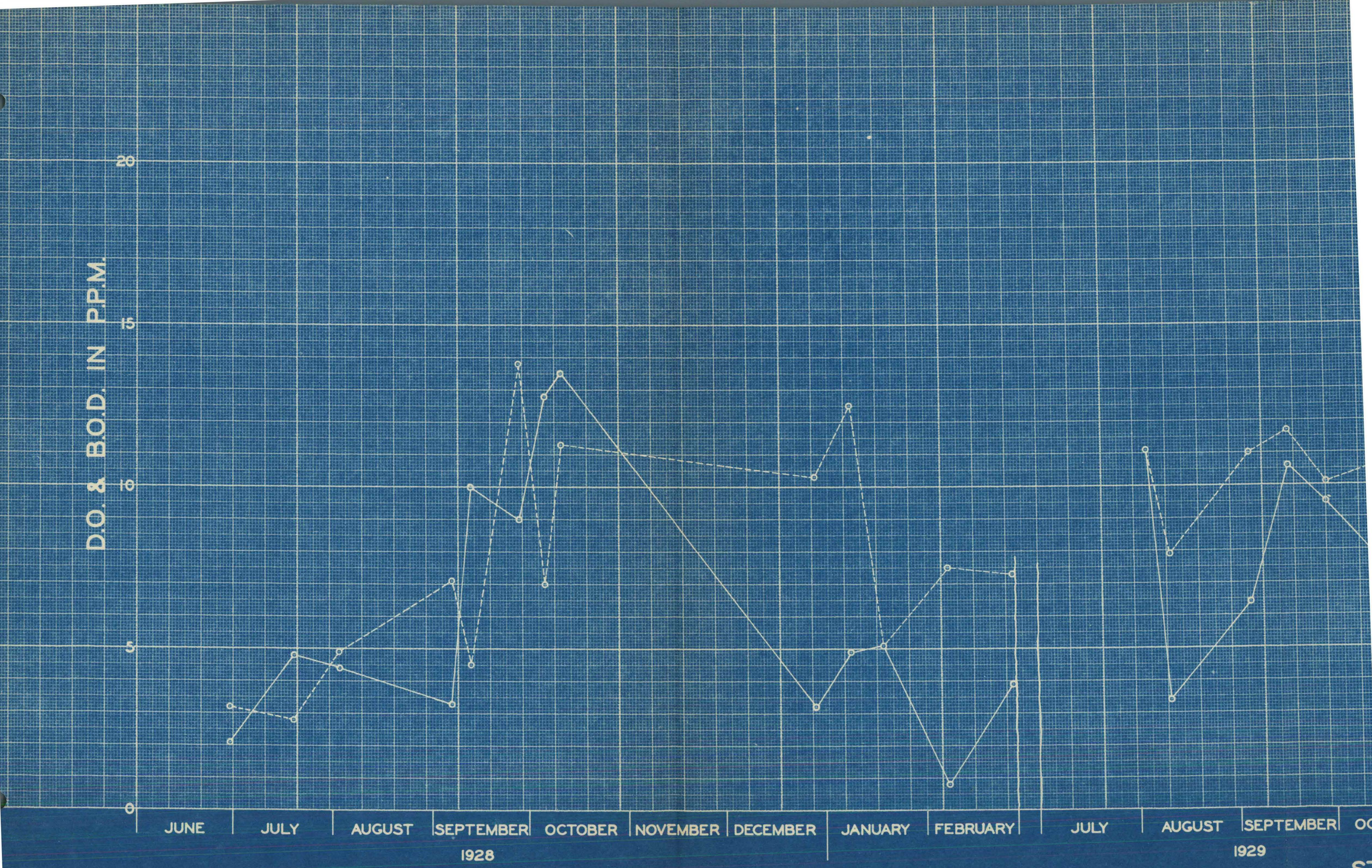
D.O.
B.O.D.
ER
OCTOBER
NOVEMBER
DECEMBER
JANUARY
FEBRUARY
JULY
AUGUST
SEPTEMBER
OCTOBER
NOVEMBER
DECEMBER
JANUARY
FEBRUARY
1930
1931
STATION 7
Chart 9


D.O.
B.O.D.
20
15
10
ER
OCTOBER
NOVEMBER
DECEMBER
JANUARY
FEBRUARY
JULY
AUGUST
SEPTEMBER
OCTOBER
NOVEMBER
DECEMBER
JANUARY
FEBRUARY
1930
1931
STATION 8
Chart 10

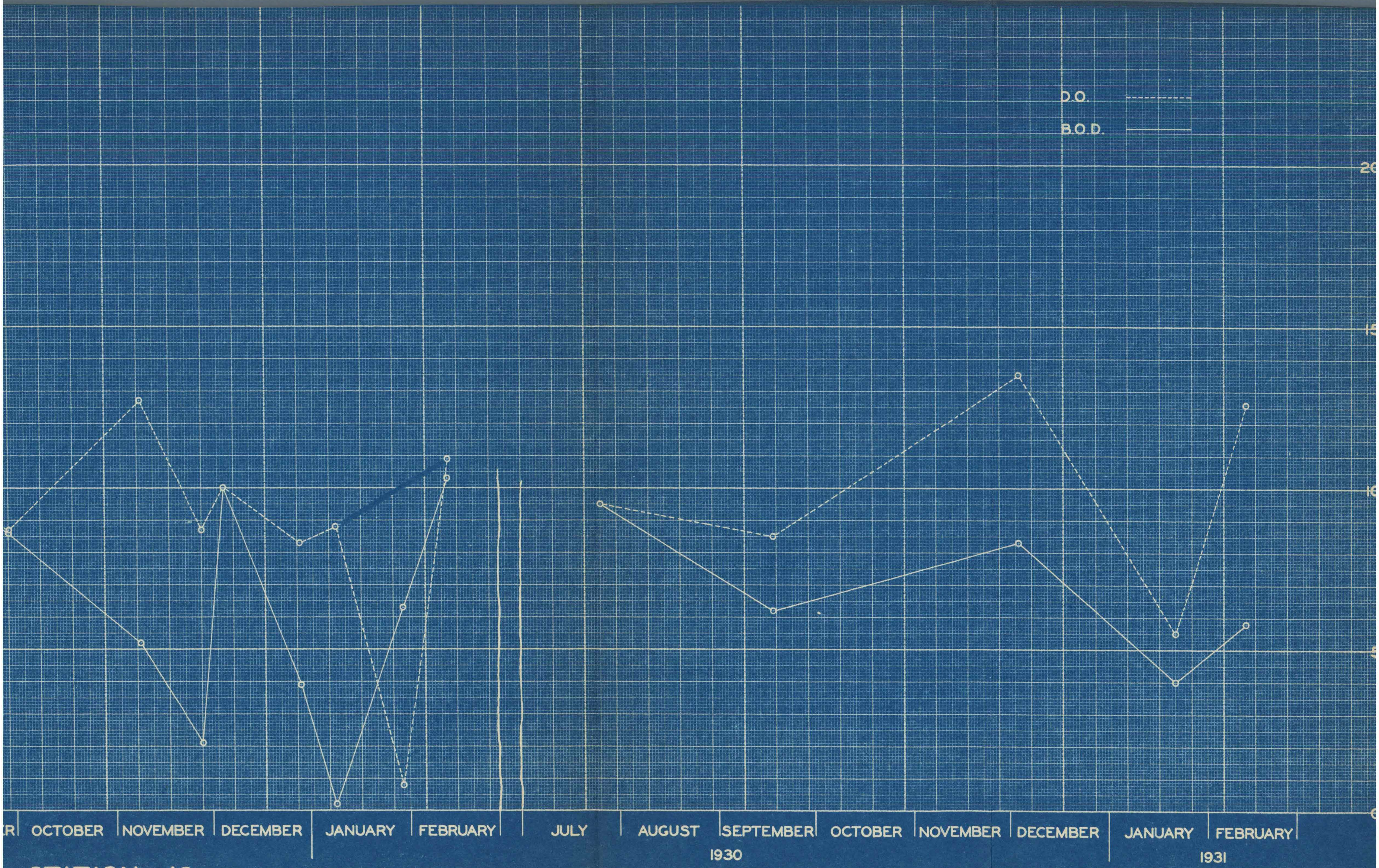

D.O.
B.O.D.
ER
OCTOBER
NOVEMBER
DECEMBER
JANUARY
FEBRUARY
JULY
AUGUST
SEPTEMBER
OCTOBER
NOVEMBER
DECEMBER
JANUARY
FEBRUARY
1930
1931
STATION 9
Chart 11



D.O. & B.O.D. IN P.P.M.
0
5
10
15
20
JUNE
JULY
AUGUST
SEPTEMBER
OCTOBER
NOVEMBER
DECEMBER
JANUARY
FEBRUARY
1928
JULY
AUGUST
SEPTEMBER
1929

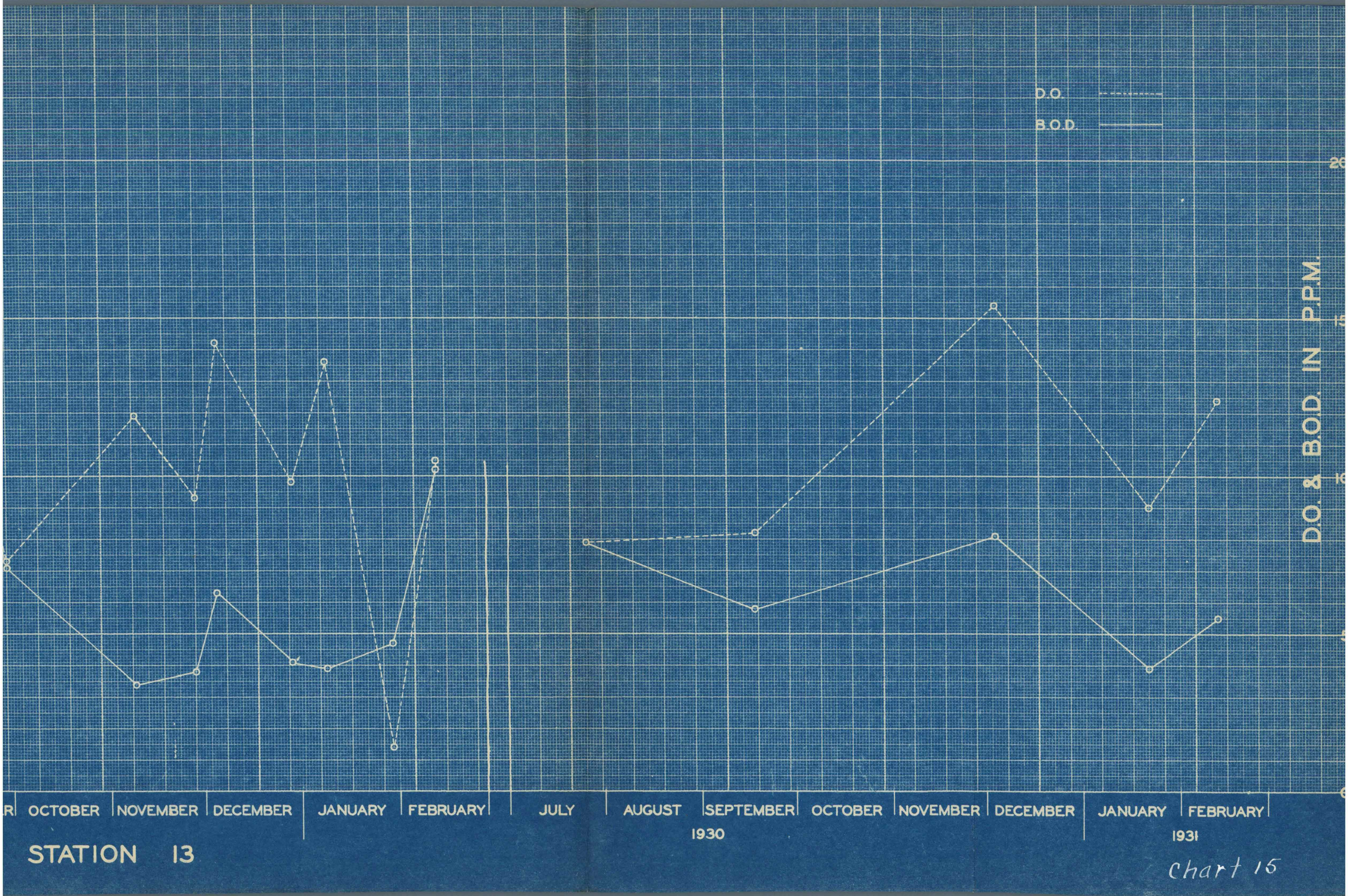


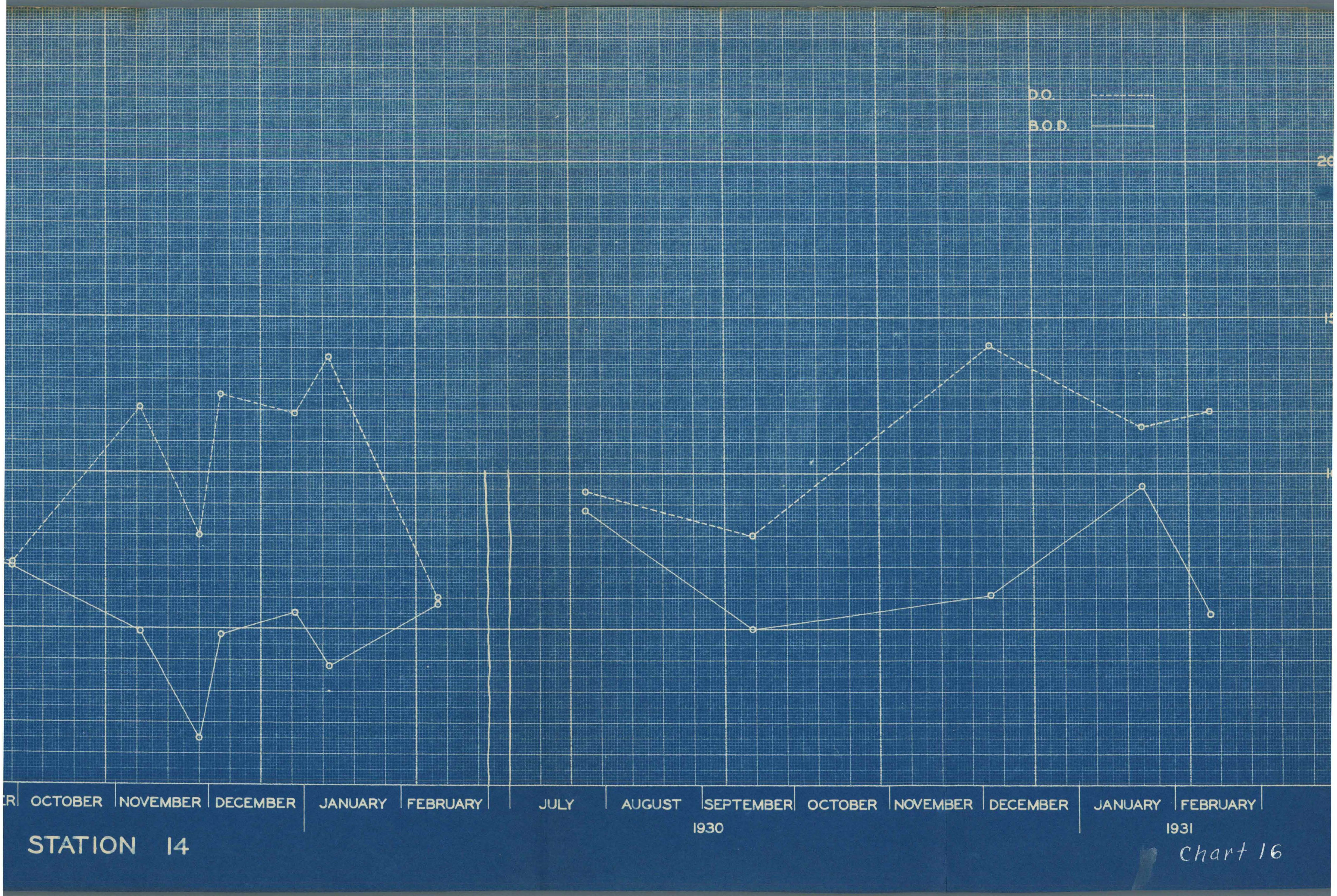
D.O. & B.O.D. IN P.P.M.
20
15
10
5
0
JUNE
JULY
AUGUST
SEPTEMBER
OCTOBER
NOVEMBER
DECEMBER
JANUARY
FEBRUARY
1928
JULY
AUGUST
SEPTEMBER
OC
1929
ST



STATION 12

Chart 14


D.O.
B.O.D.
D.O. & B.O.D. IN P.P.M.
20
15
10
5
0
R
OCTOBER
NOVEMBER
DECEMBER
JANUARY
FEBRUARY
JULY
AUGUST
SEPTEMBER
OCTOBER
NOVEMBER
DECEMBER
JANUARY
FEBRUARY
1930
1931
STATION 13
Chart 15


D.O.
B.O.D.
20
15
10
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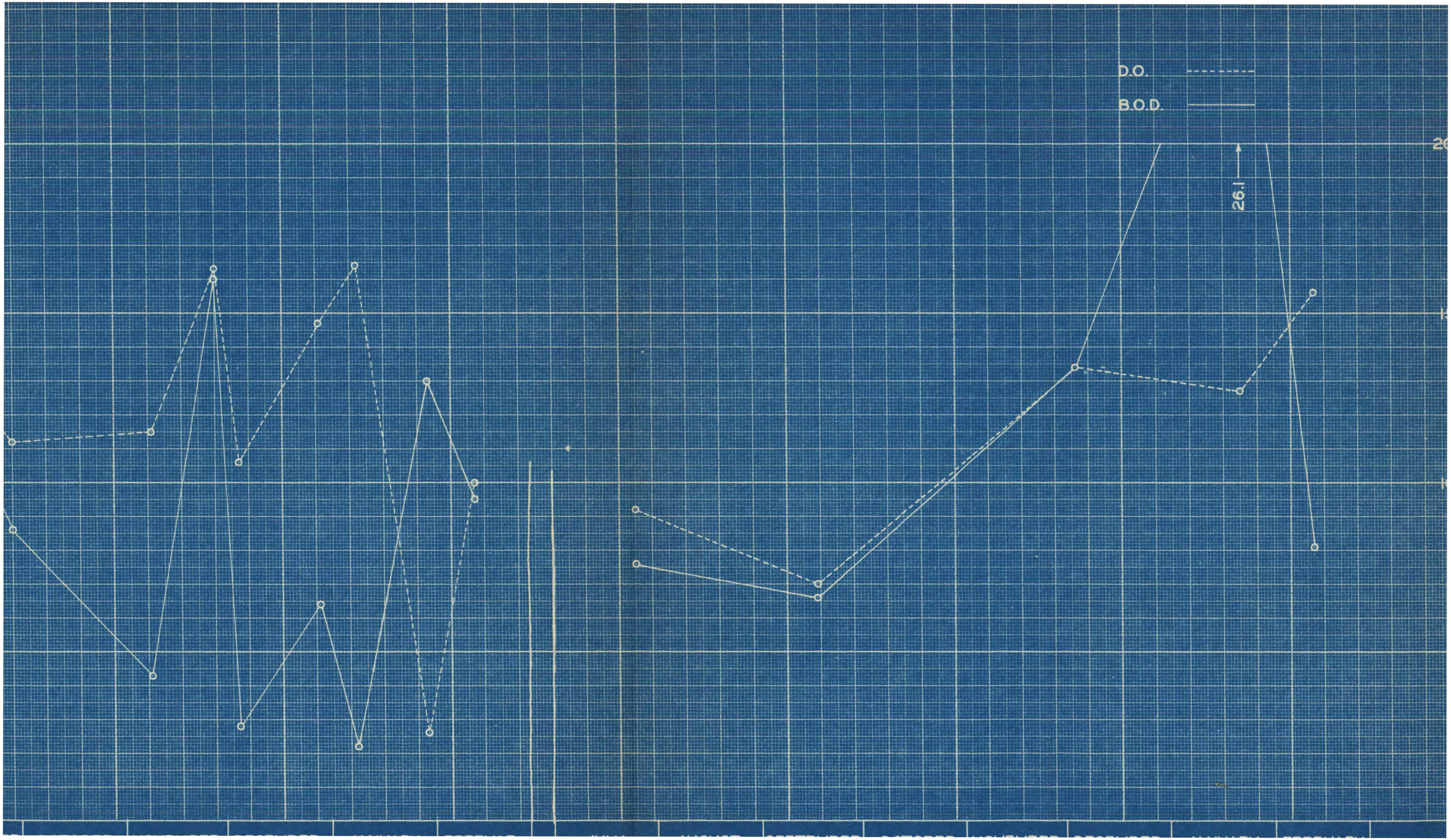
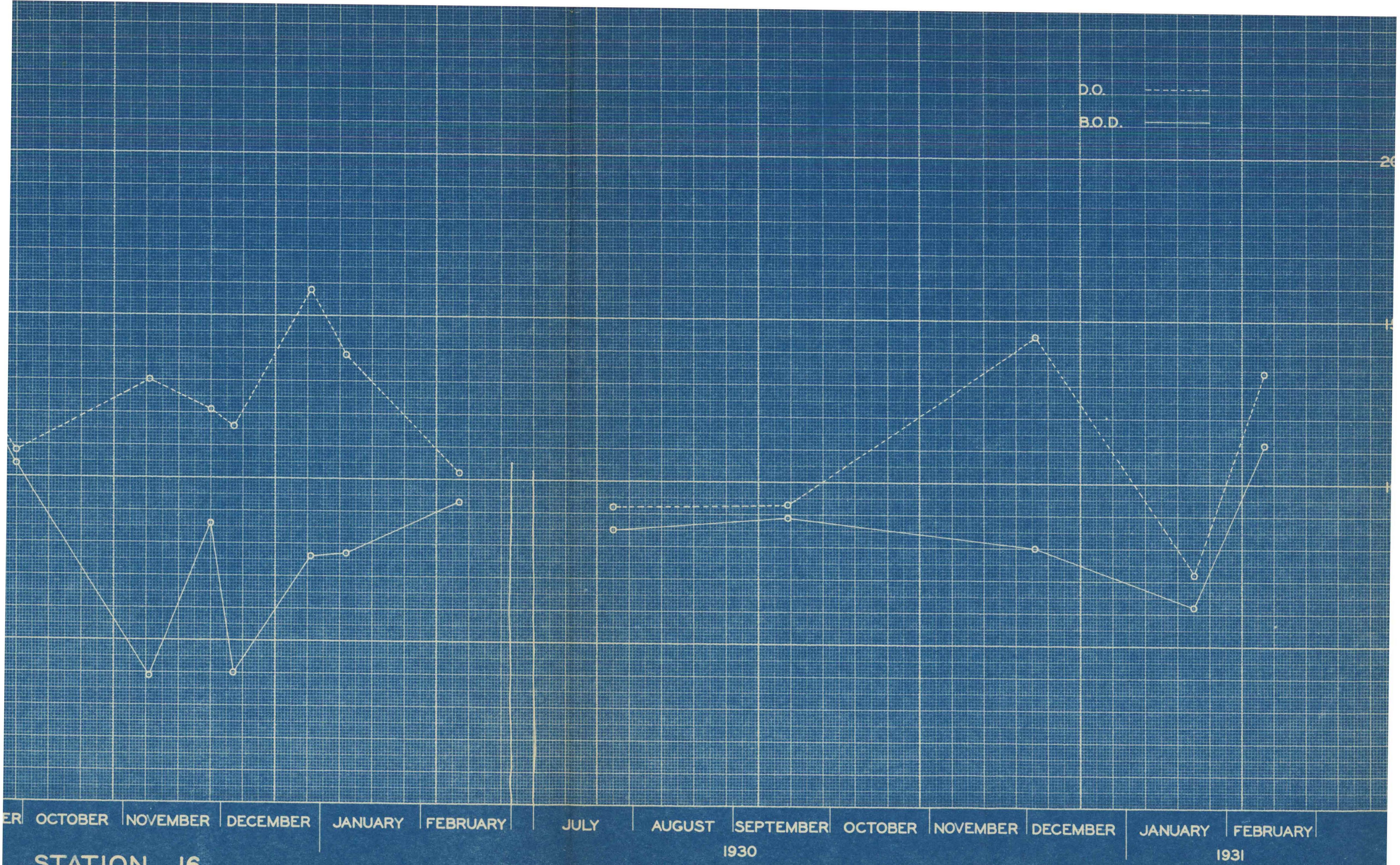
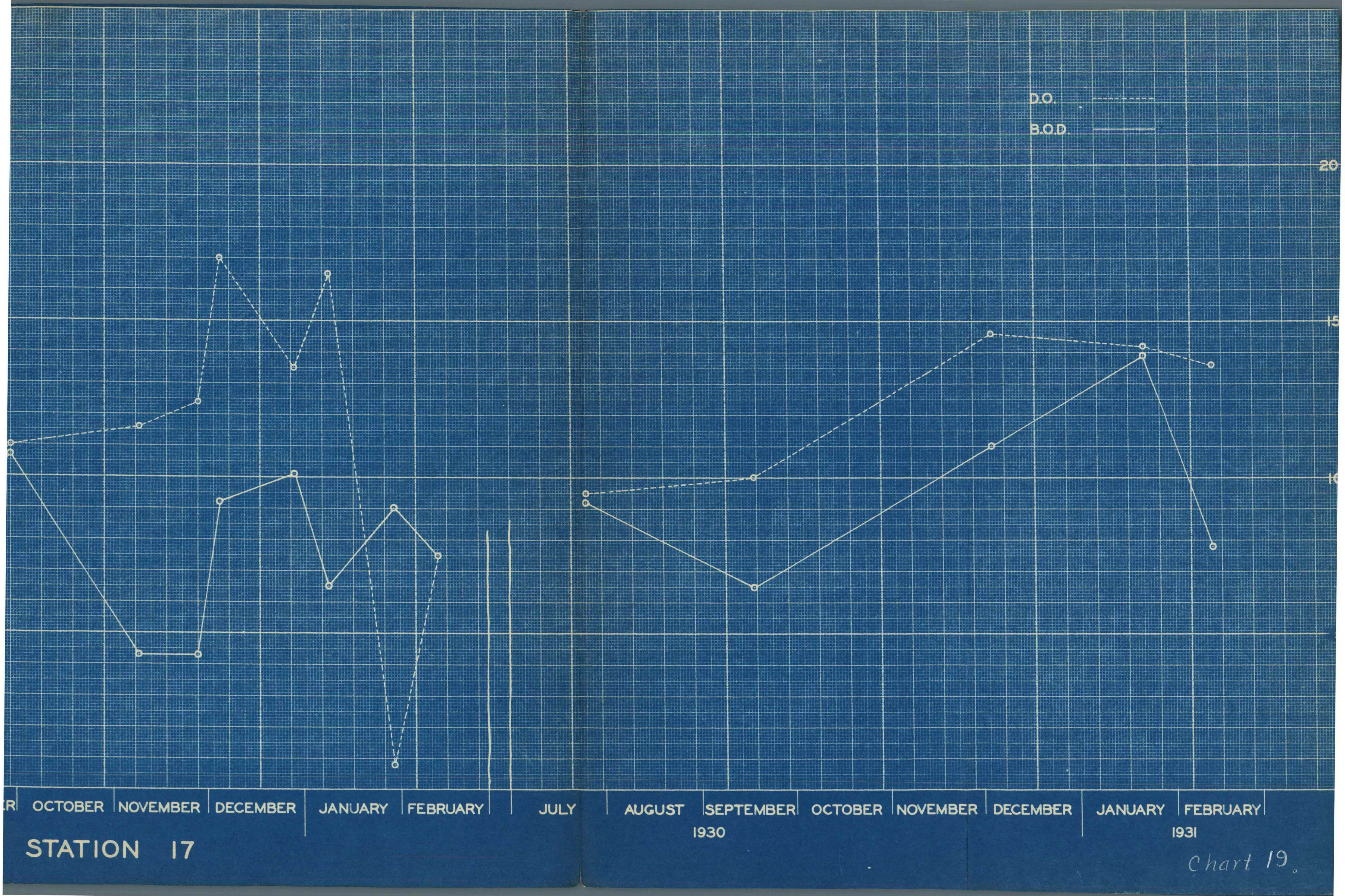
OCTOBER
NOVEMBER
DECEMBER
JANUARY
FEBRUARY
JULY
AUGUST
SEPTEMBER
OCTOBER
NOVEMBER
DECEMBER
JANUARY
FEBRUARY
1930
1931
STATION 14
Chart 16

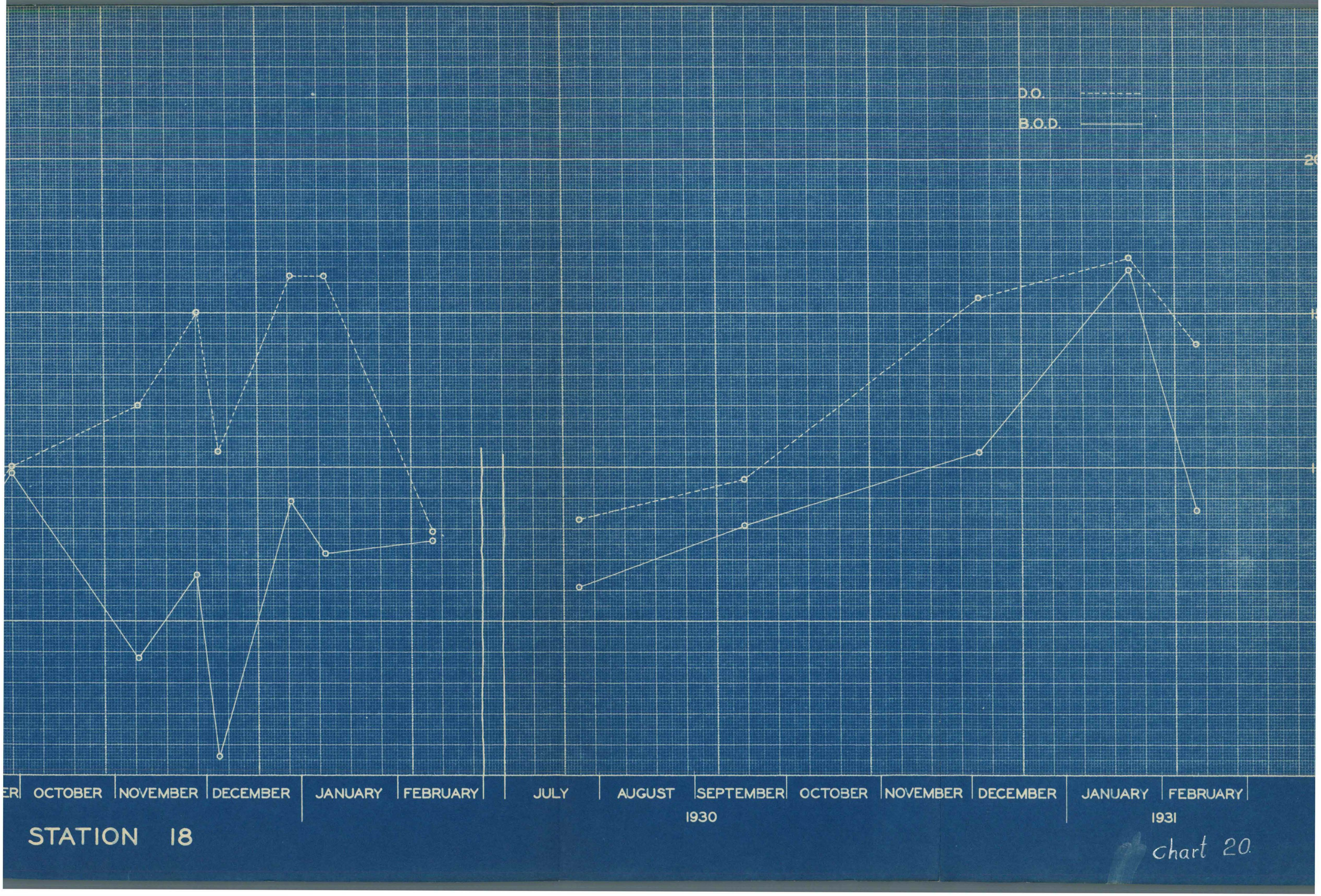

D.O.
B.O.D.
26.1



STATION 16

Chart 18


D.O.
B.O.D.
20
15
10
R
OCTOBER
NOVEMBER
DECEMBER
JANUARY
FEBRUARY
JULY
AUGUST
SEPTEMBER
OCTOBER
NOVEMBER
DECEMBER
JANUARY
FEBRUARY
1930
1931
STATION 17
Chart 19.



D.O.
B.O.D.
ER
OCTOBER
NOVEMBER
DECEMBER
JANUARY
FEBRUARY
JULY
AUGUST
SEPTEMBER
OCTOBER
NOVEMBER
DECEMBER
JANUARY
FEBRUARY
1930
1931
STATION 18
Chart 20.

APPENDIX E

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CHARTS #21 to #77

INCLUSIVE

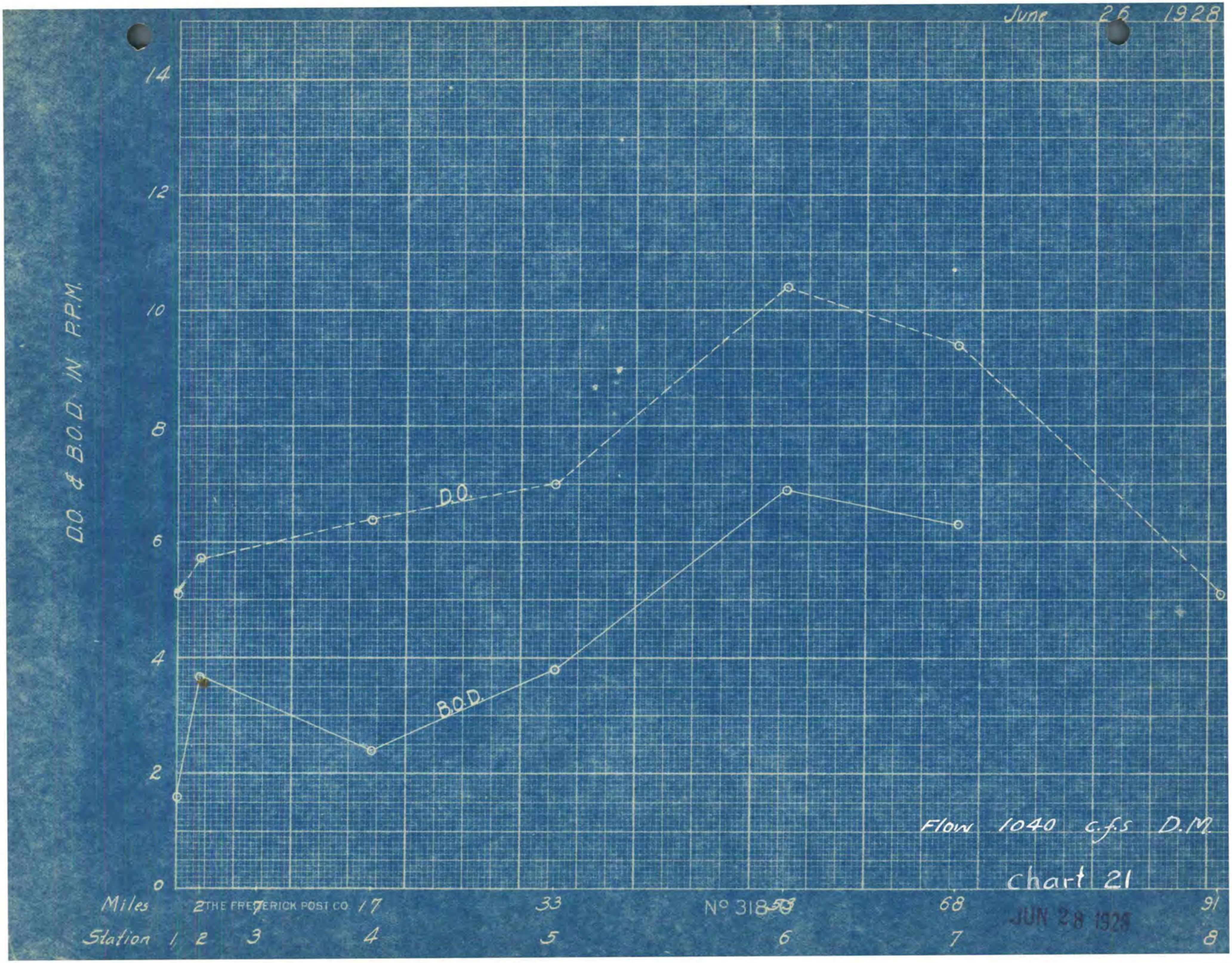
SHOWING D. O. AND B. O. D.

AT ALL SAMPLING STATIONS

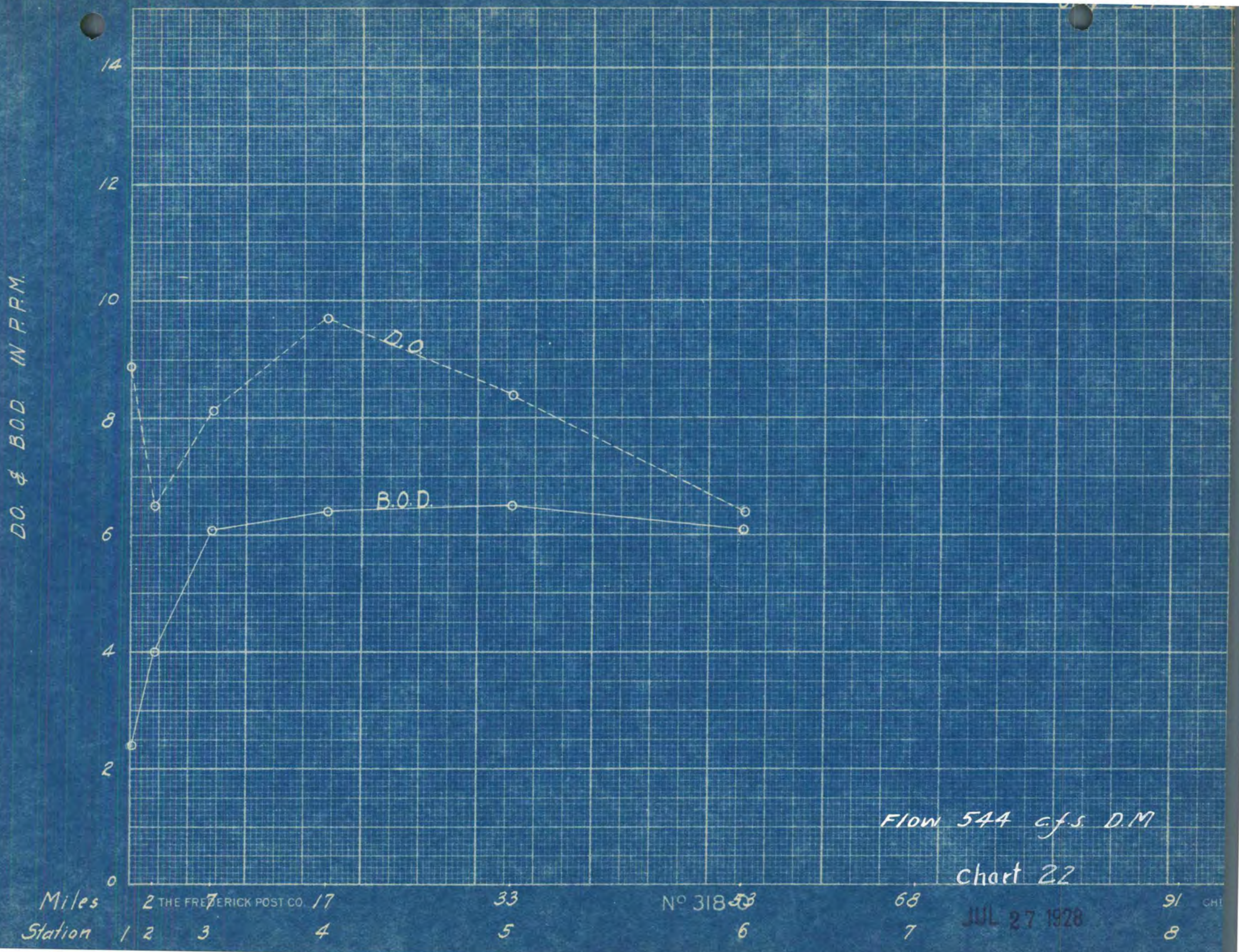
FOR EACH

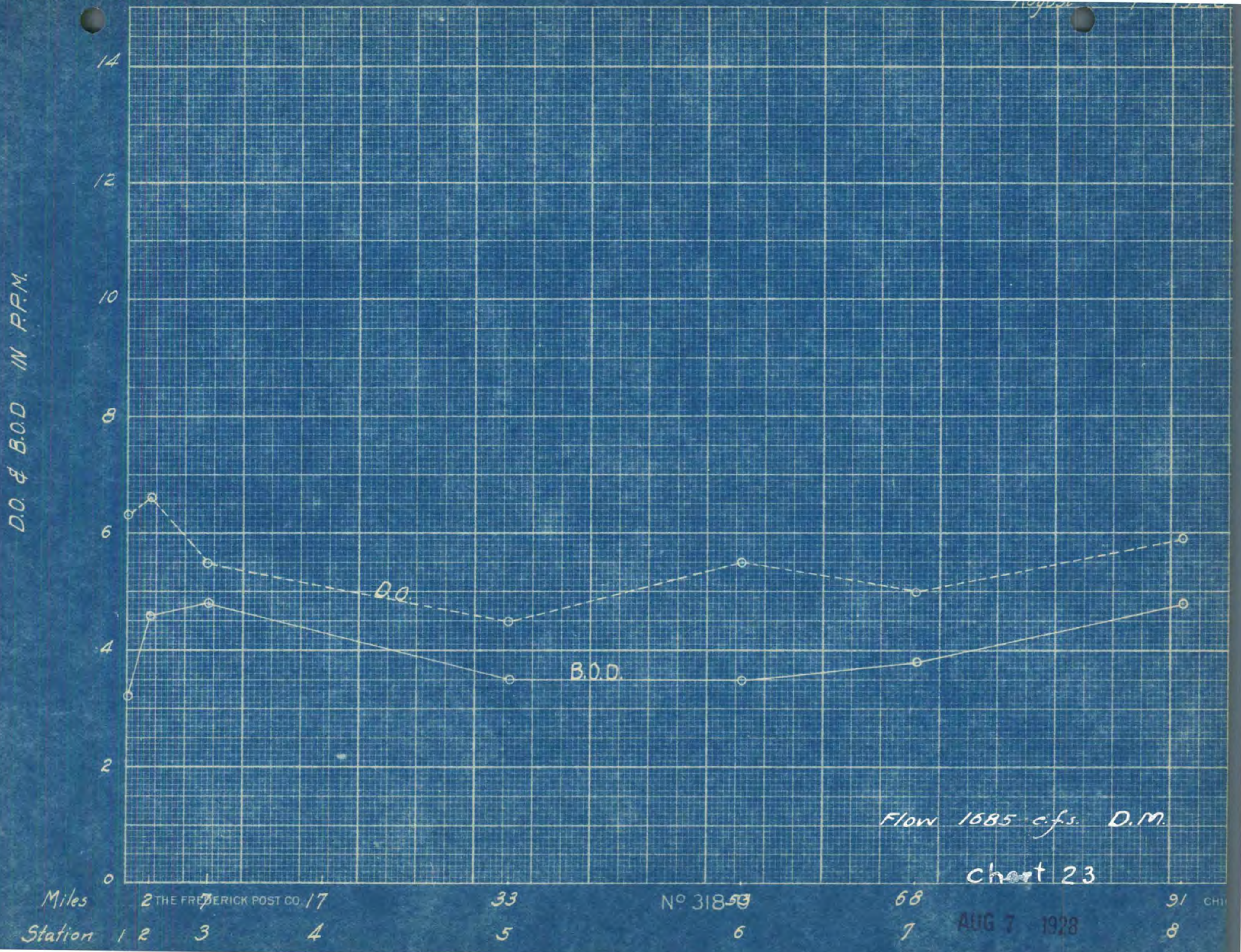
DATE OF SAMPLING.

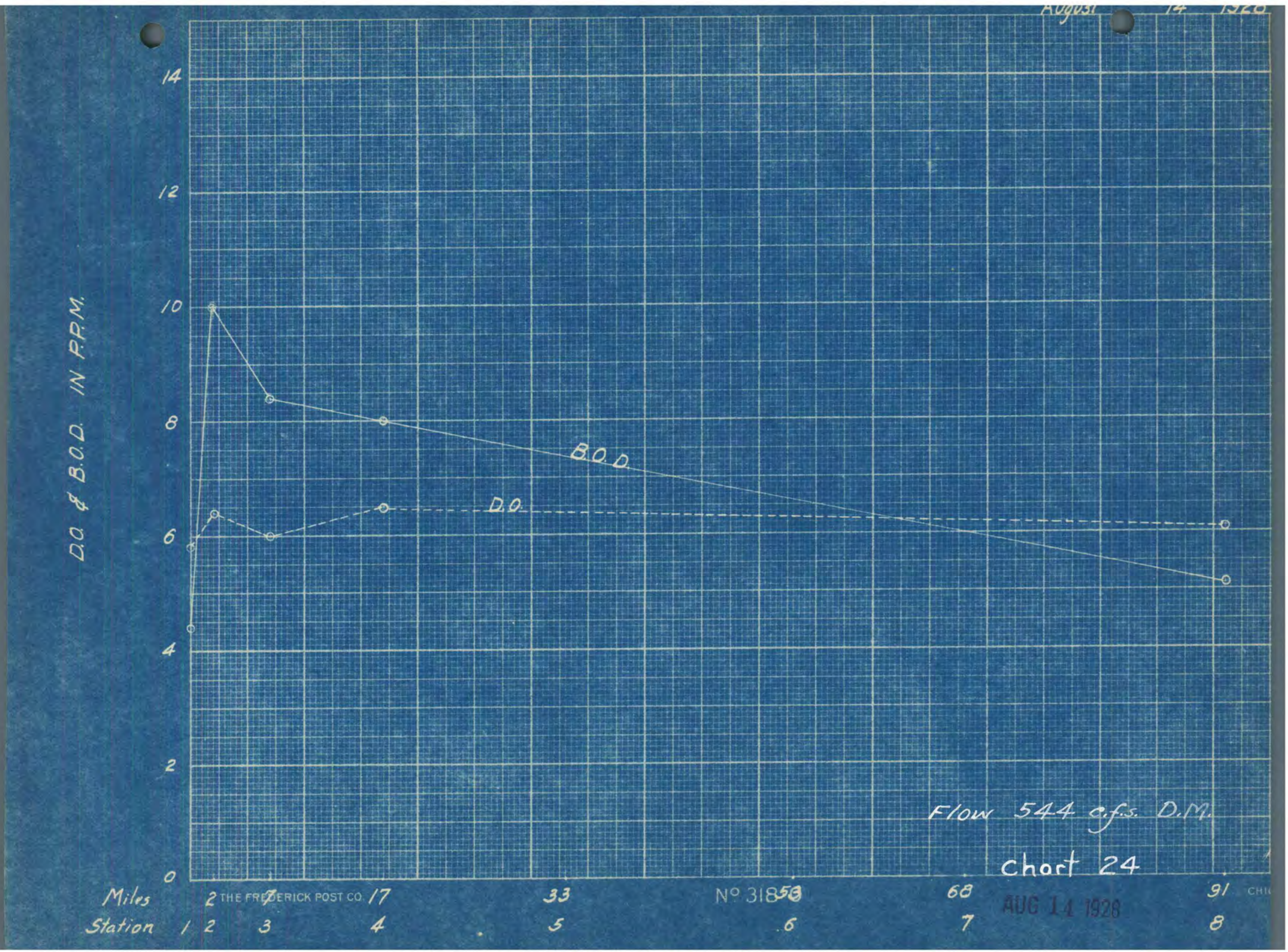
---0---

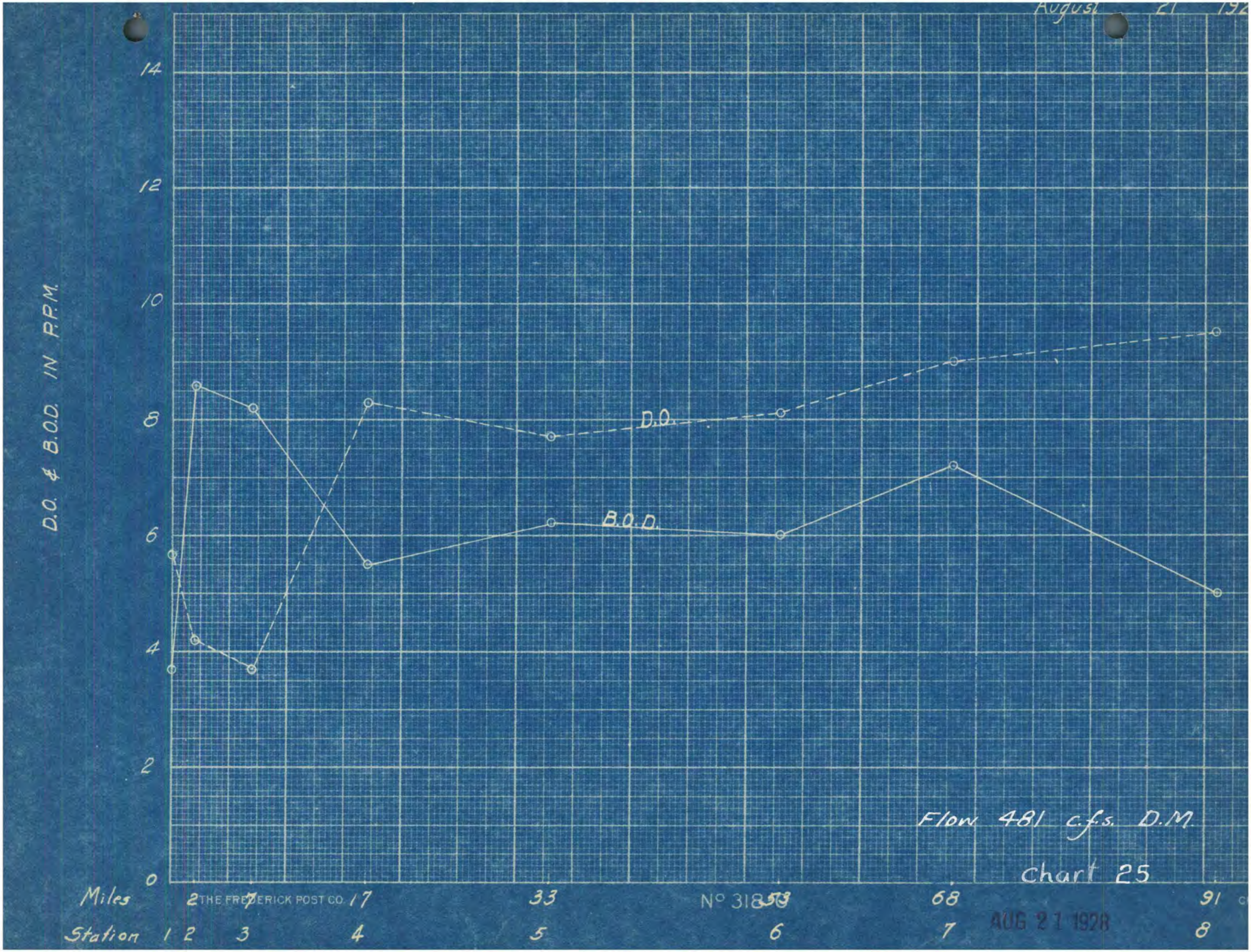


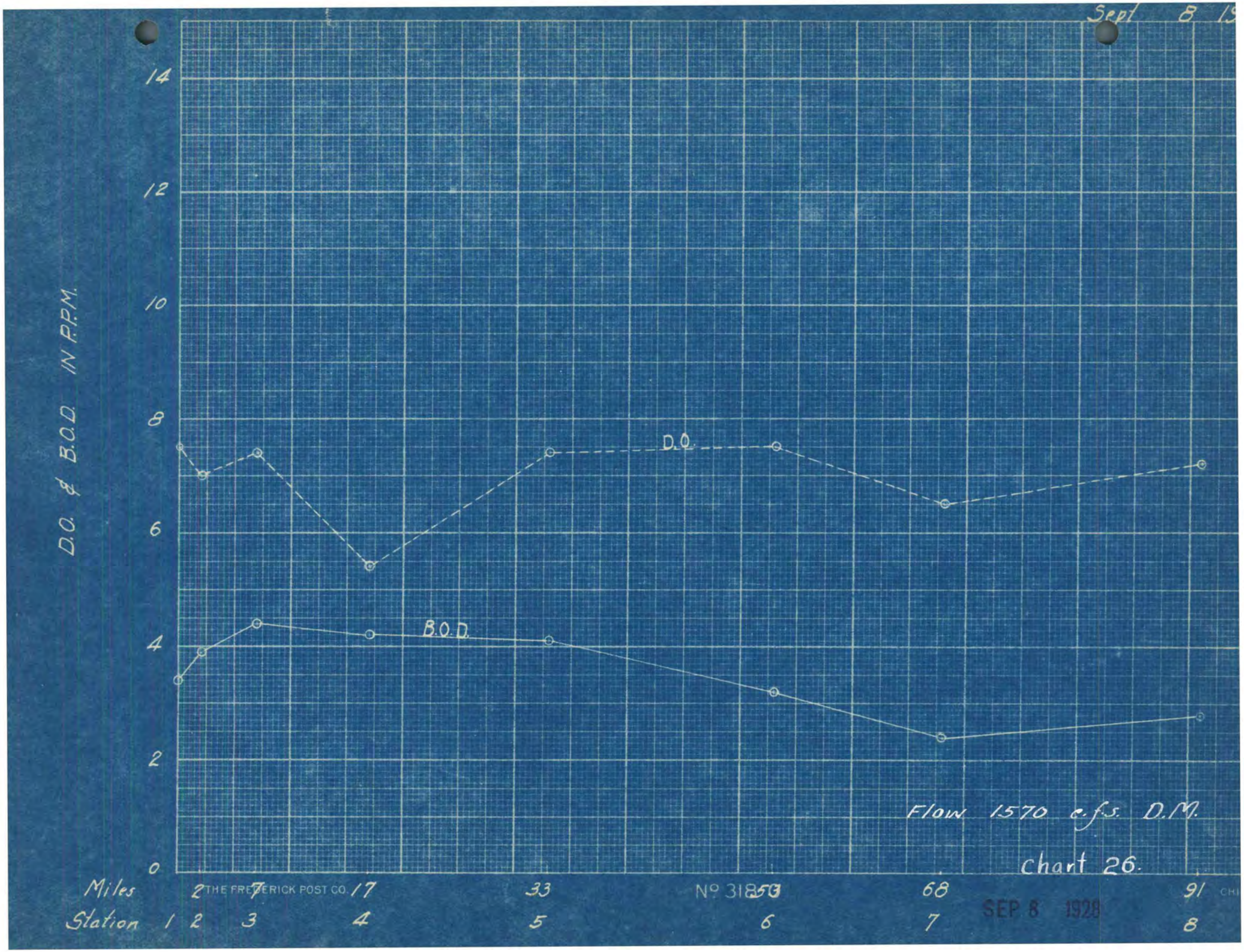
June 26 1928
D.O. & B.O.D. IN P.P.M.
14
12
10
8
6
4
2
0
D.O.
B.O.D.
Flow 1040 c.f.s D.M.
Chart 21
Miles 2 7 17 33 58 68 91
Station 1 2 3 4 5 6 7 8
THE FREDERICK POST CO.
No 318
JUN 28 1928


D.O. & B.O.D. IN P.P.M.
14
12
10
8
6
4
2
0
D.O.
B.O.D.
Flow 544 c.f.s. D.M
Chart 22
Miles 2 7 17 33 53 68 91
Station 1 2 3 4 5 6 7 8
THE FREDERICK POST CO.
No 318-53
JUL 27 1928

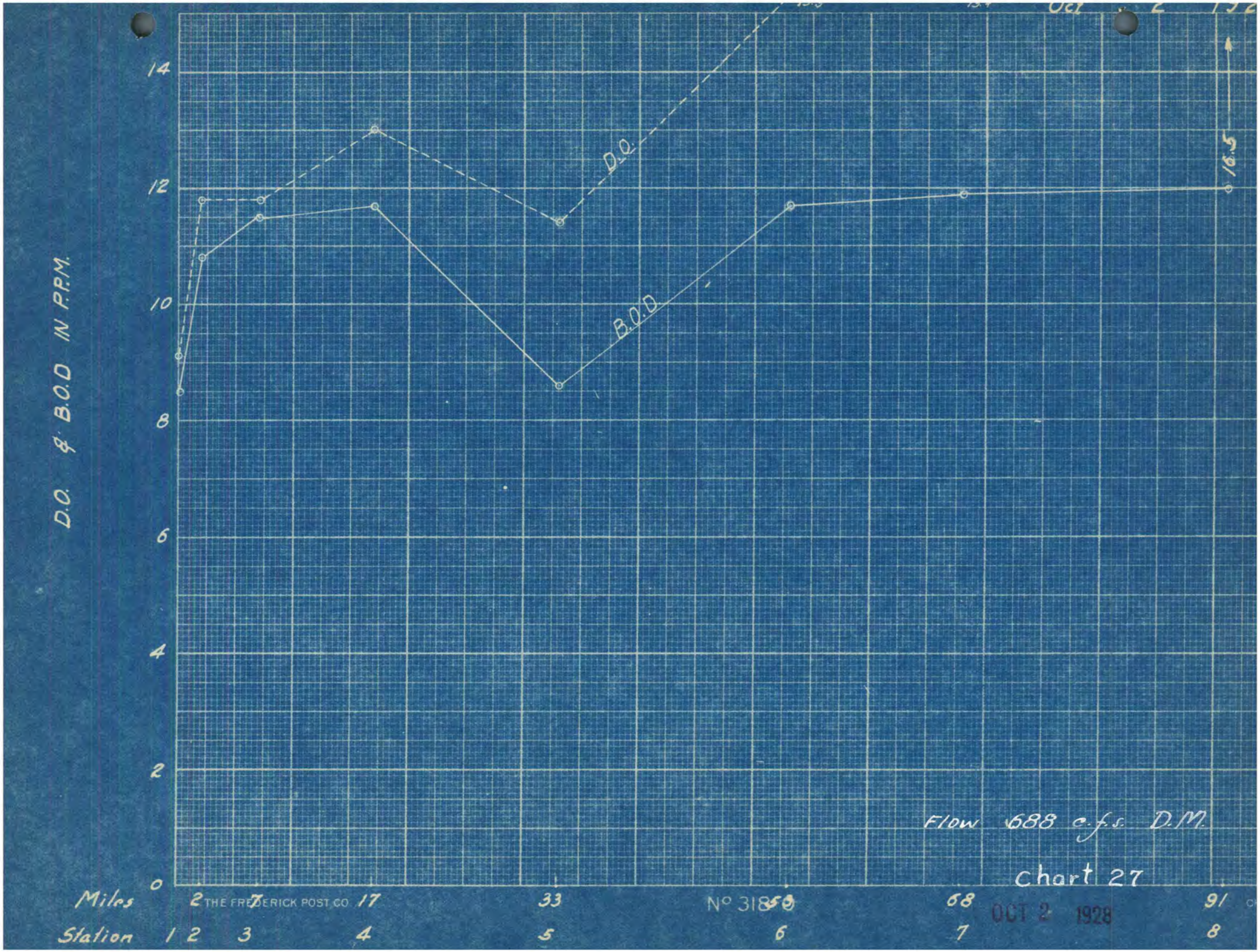

D.O. & B.O.D IN P.P.M.
14
12
10
8
6
4
2
0
D.O.
B.O.D.
Flow 1685 c.f.s. D.M.
Chart 23
Miles 2 7 17 33 53 68 91
Station 1 2 3 4 5 6 7 8
THE FREDERICK POST CO.
Nº 318
AUG 7 1928


August 14 1928
D.O. & B.O.D. IN P.P.M.
14
12
10
8
6
4
2
0
B.O.D.
D.O.
Flow 544 c.f.s. D.M.
Chart 24
Miles 2 7 17 33 58 68 91
Station 1 2 3 4 5 6 7 8
THE FREDERICK POST CO.
AUG 14 1928


August 21 192
D.O. & B.O.D. IN P.P.M.
14
12
10
8
6
4
2
0
D.O.
B.O.D.
Flow 481 c.f.s. D.M.
Chart 25
Miles 2 7 17 33 53 68 91
Station 1 2 3 4 5 6 7 8
THE FREDERICK POST CO.
Nº 318
AUG 21 1928

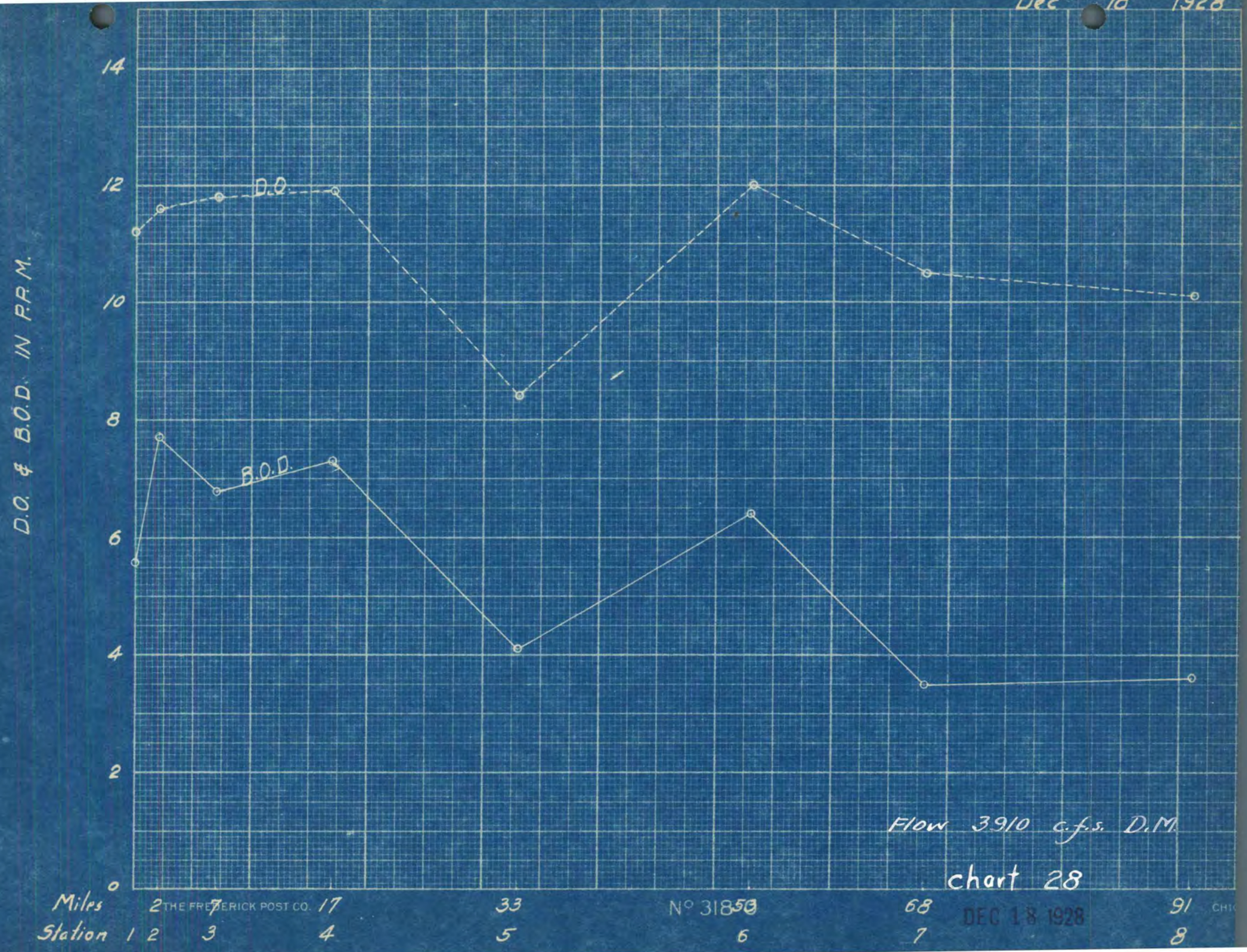


Sept 8 19
D.O. & B.O.D. IN P.P.M.
14
12
10
8
6
4
2
0
D.O.
B.O.D.
Flow 1570 c.f.s. D.M.
Chart 26.
Miles 2 7 17 33 68 91
Station 1 2 3 4 5 6 7 8
THE FREDERICK POST CO.
Nº 318
SEP 8 1928

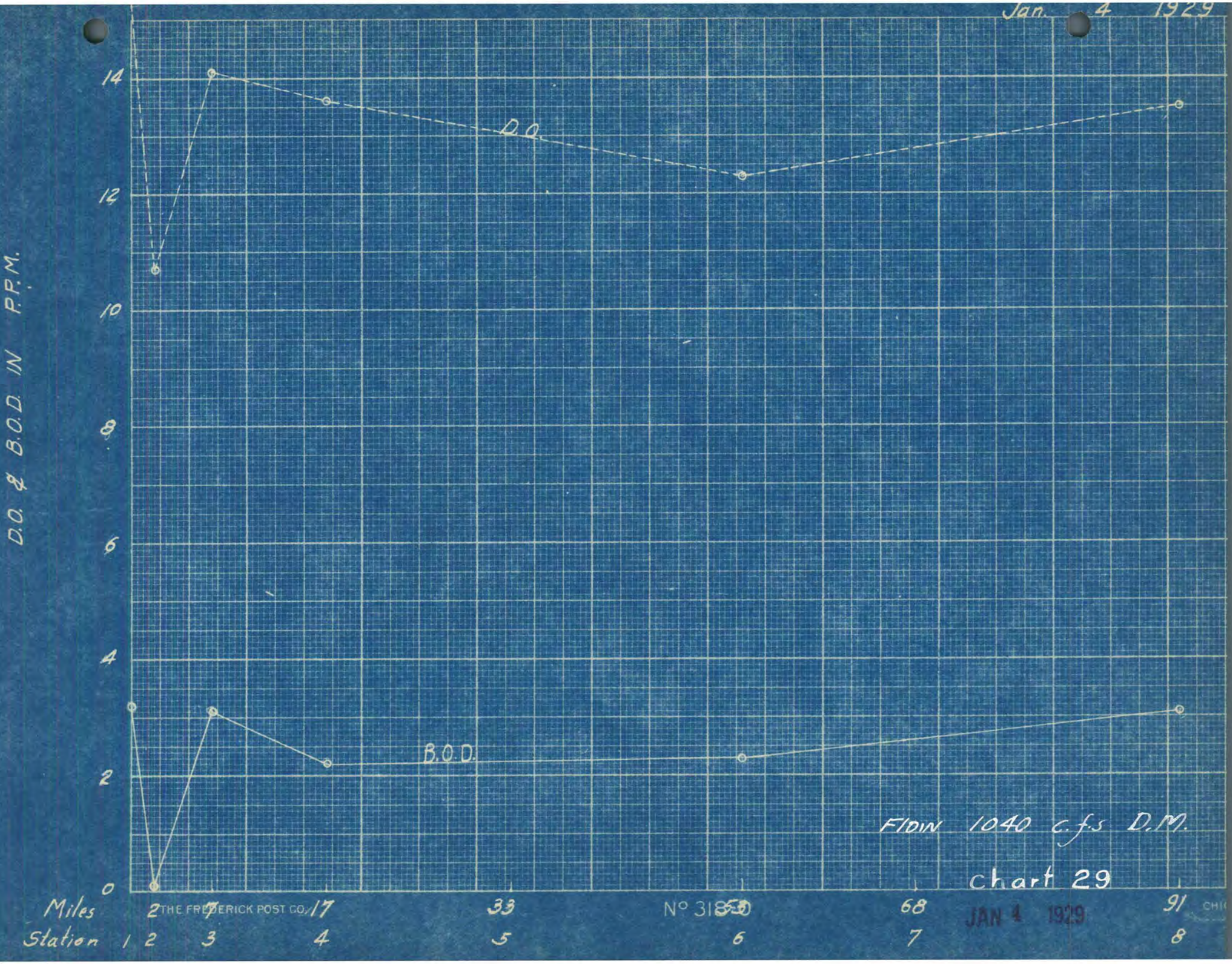


Oct 2 192
D.O. & B.O.D IN P.P.M.
14
12
10
8
6
4
2
0
D.O.
B.O.D.
16.5
Flow 688 c.f.s. D.M.
Chart 27
Miles 2 7 17 33 68 91
Station 1 2 3 4 5 6 7 8
THE FREDERICK POST CO.
OCT 2 1928

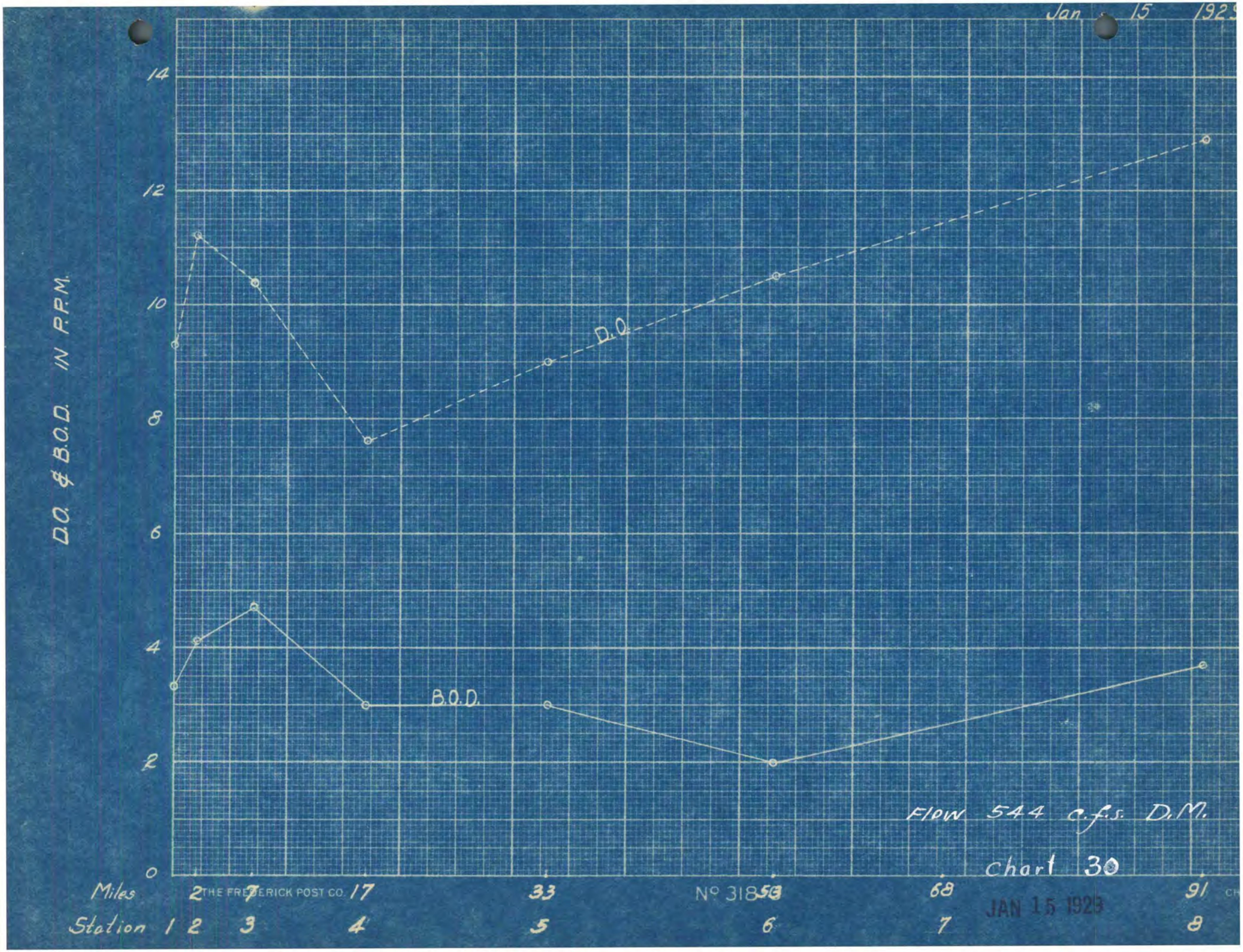
Dec 18 1928

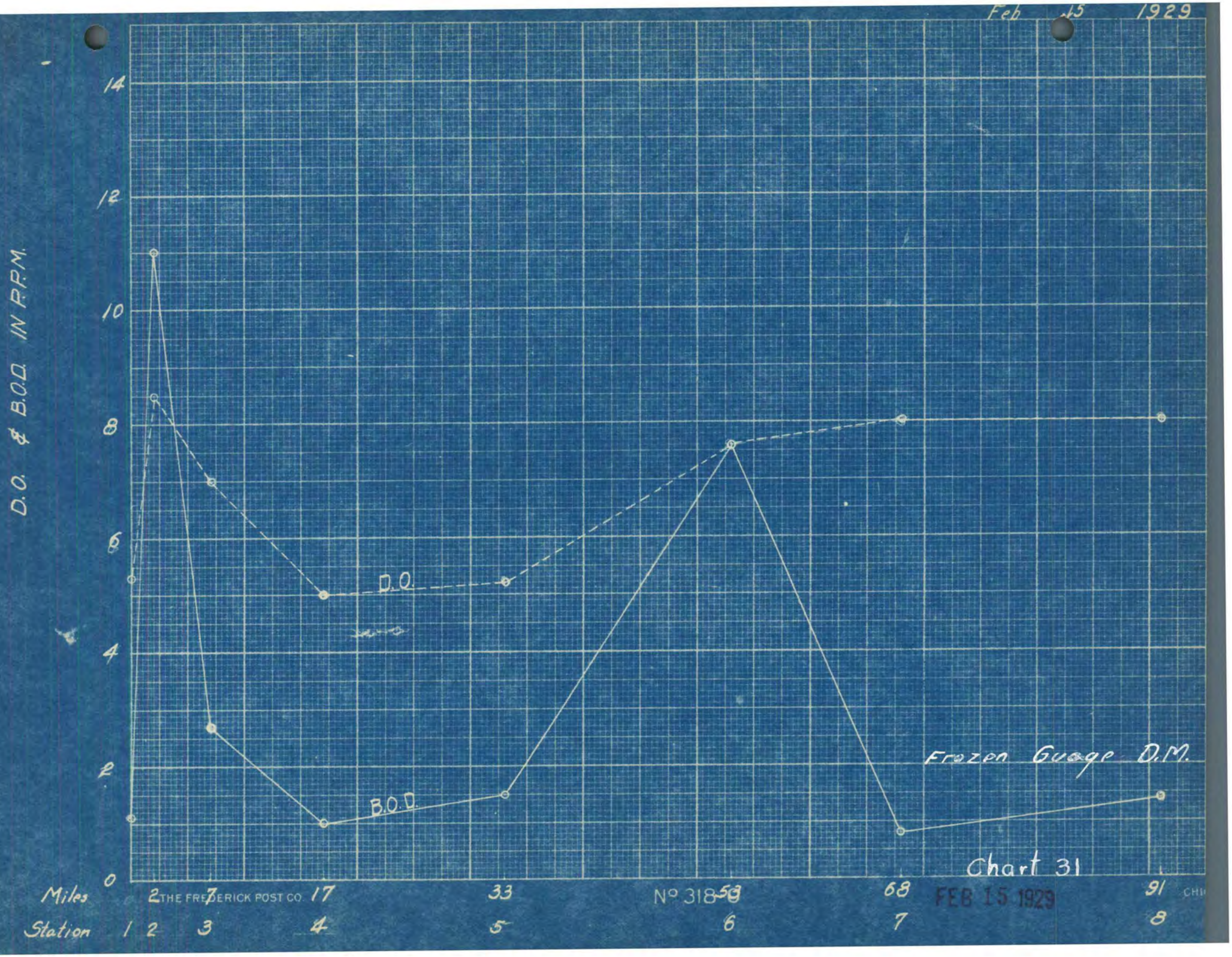


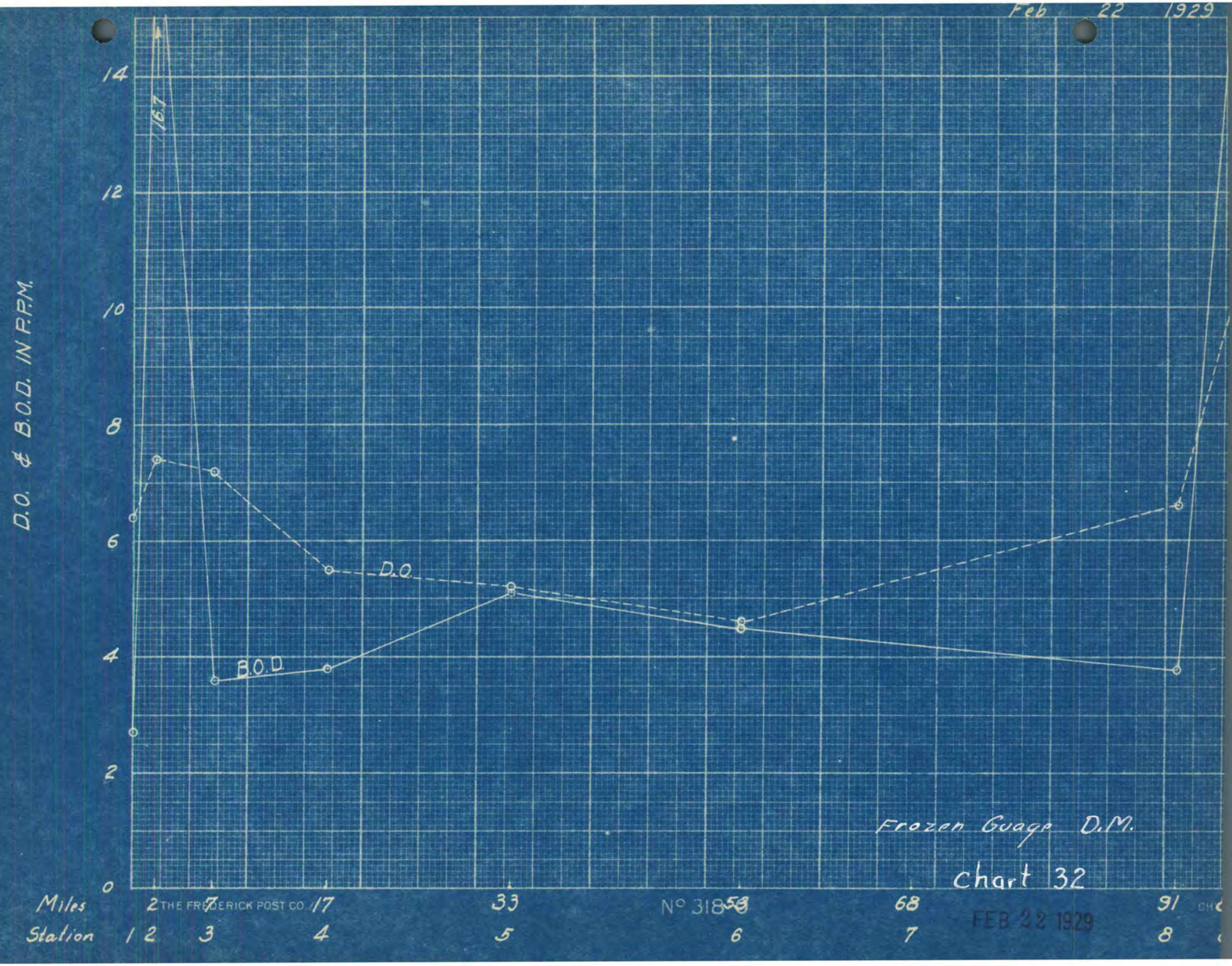
14
12
10
8
6
4
2
0
D.O. & B.O.D. IN P.P.M.
D.O.
B.O.D.
Flow 3910 c.f.s. D.M.
chart 28
Miles 2 7 17 33 56 68 91
Station 1 2 3 4 5 6 7 8
THE FREDERICK POST CO.
Nº 318
DEC 18 1928

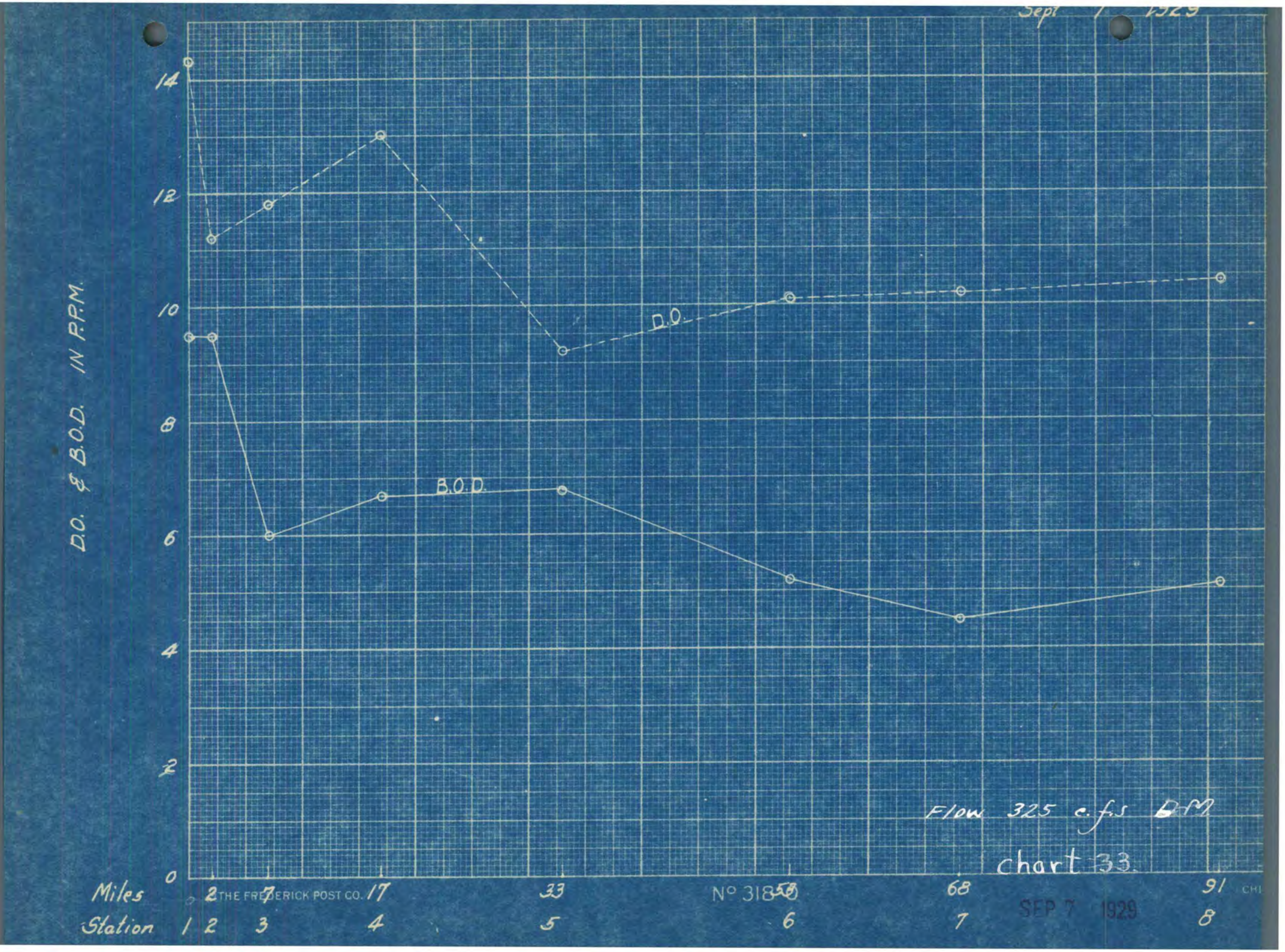


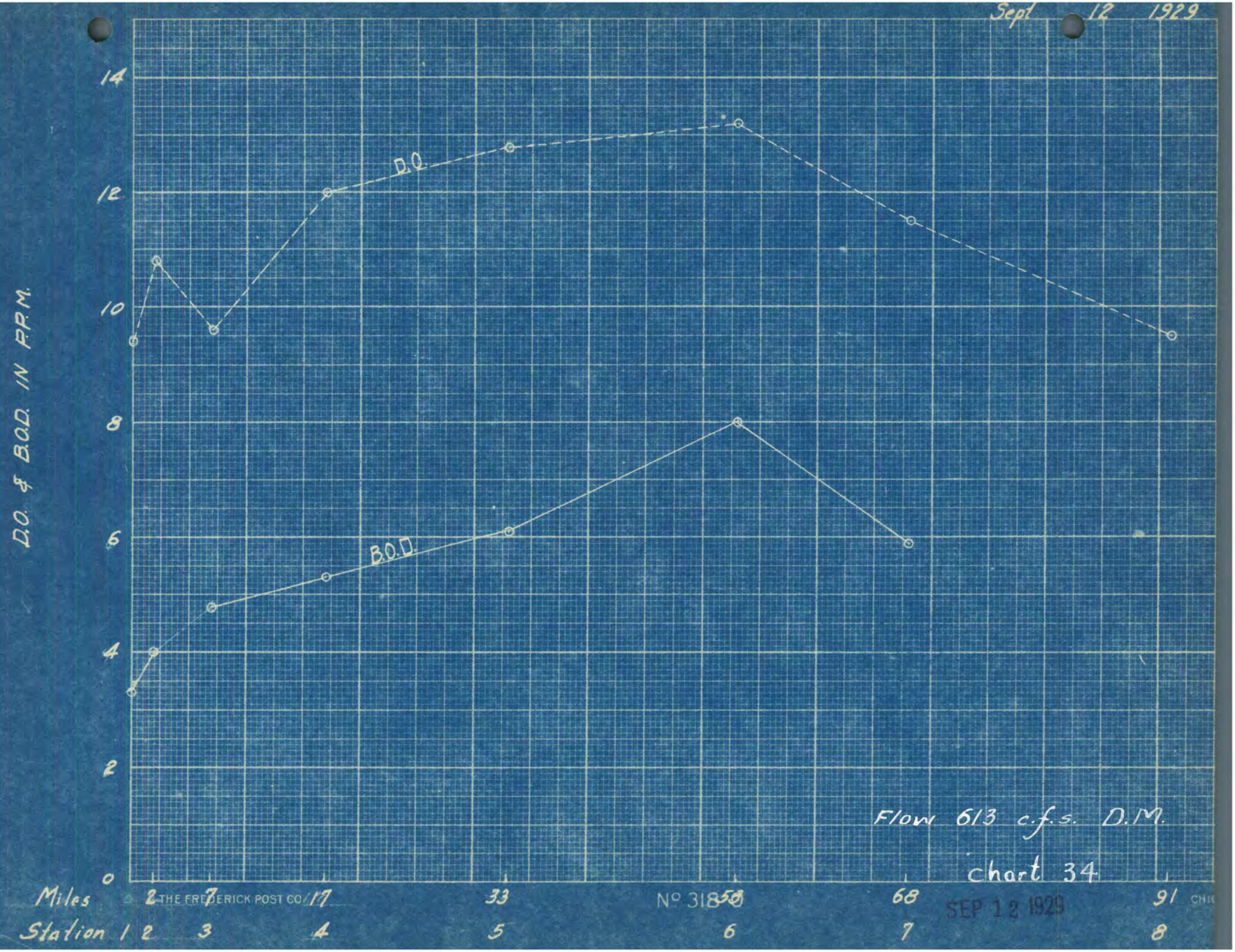
Jan. 4 1929
D.O. & B.O.D. IN P.P.M.
14
12
10
8
6
4
2
0
D.O.
B.O.D.
Flow 1040 c.f.s D.M.
Chart 29
Miles 2 7 17 33 50 68 91
Station 1 2 3 4 5 6 7 8
THE FREDERICK POST CO.
Nº 318
JAN 4 1929


Jan 15 1929
D.O. & B.O.D. IN P.P.M.
14
12
10
8
6
4
2
0
D.O.
B.O.D.
Flow 544 c.f.s. D.M.
Chart 30
Miles 2 7 17 33 53 68 91
Station 1 2 3 4 5 6 7 8
THE FREDERICK POST CO.
Nº 318
JAN 15 1929

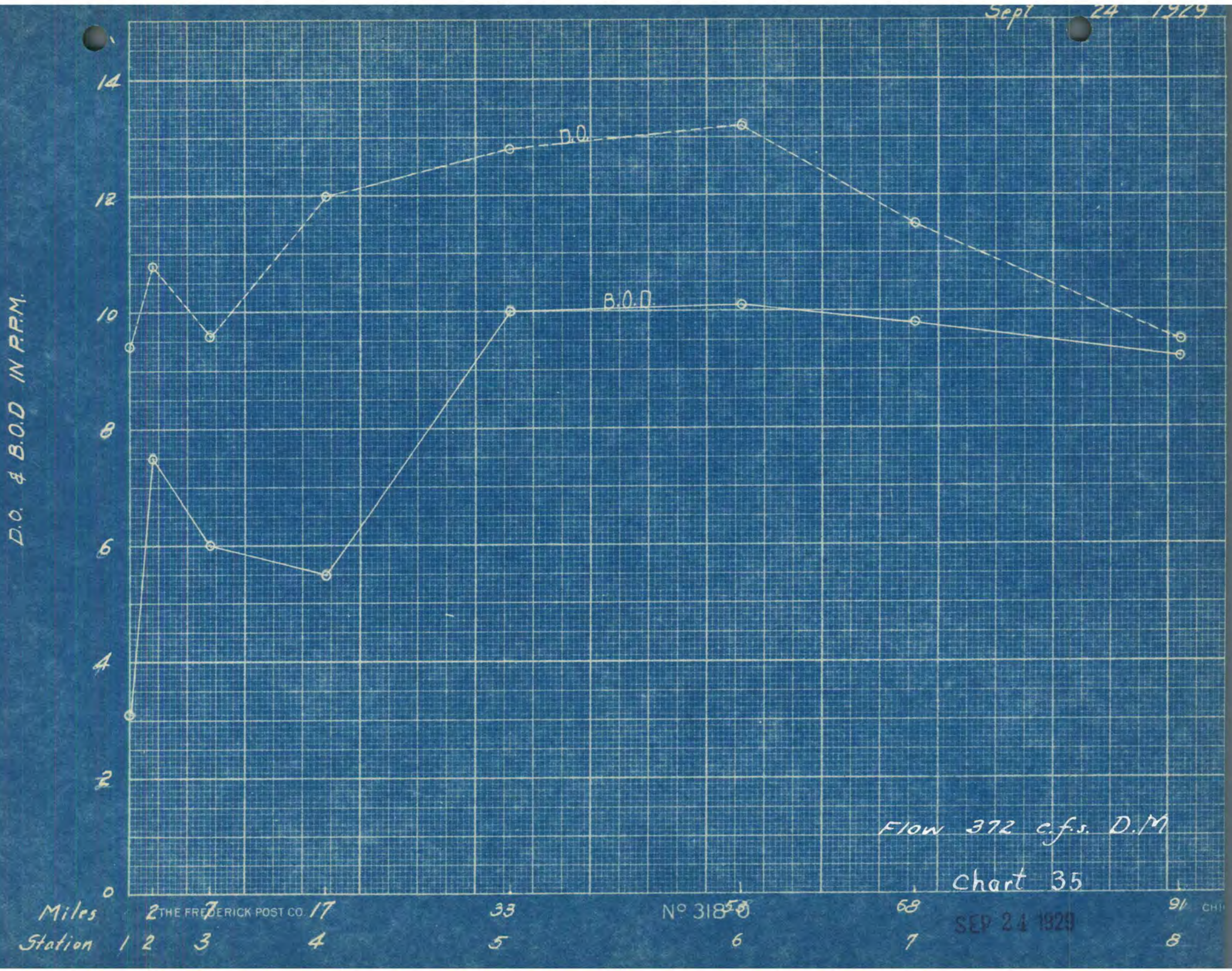

Feb 15 1929
D.O. & B.O.D. IN P.P.M.
14
12
10
8
6
4
2
0
D.O.
B.O.D.
Frozen Guage D.M.
Chart 31
Miles 2 7 17 33 58 68 91
Station 1 2 3 4 5 6 7 8
THE FREDERICK POST CO.
Nº 318
FEB 15 1929

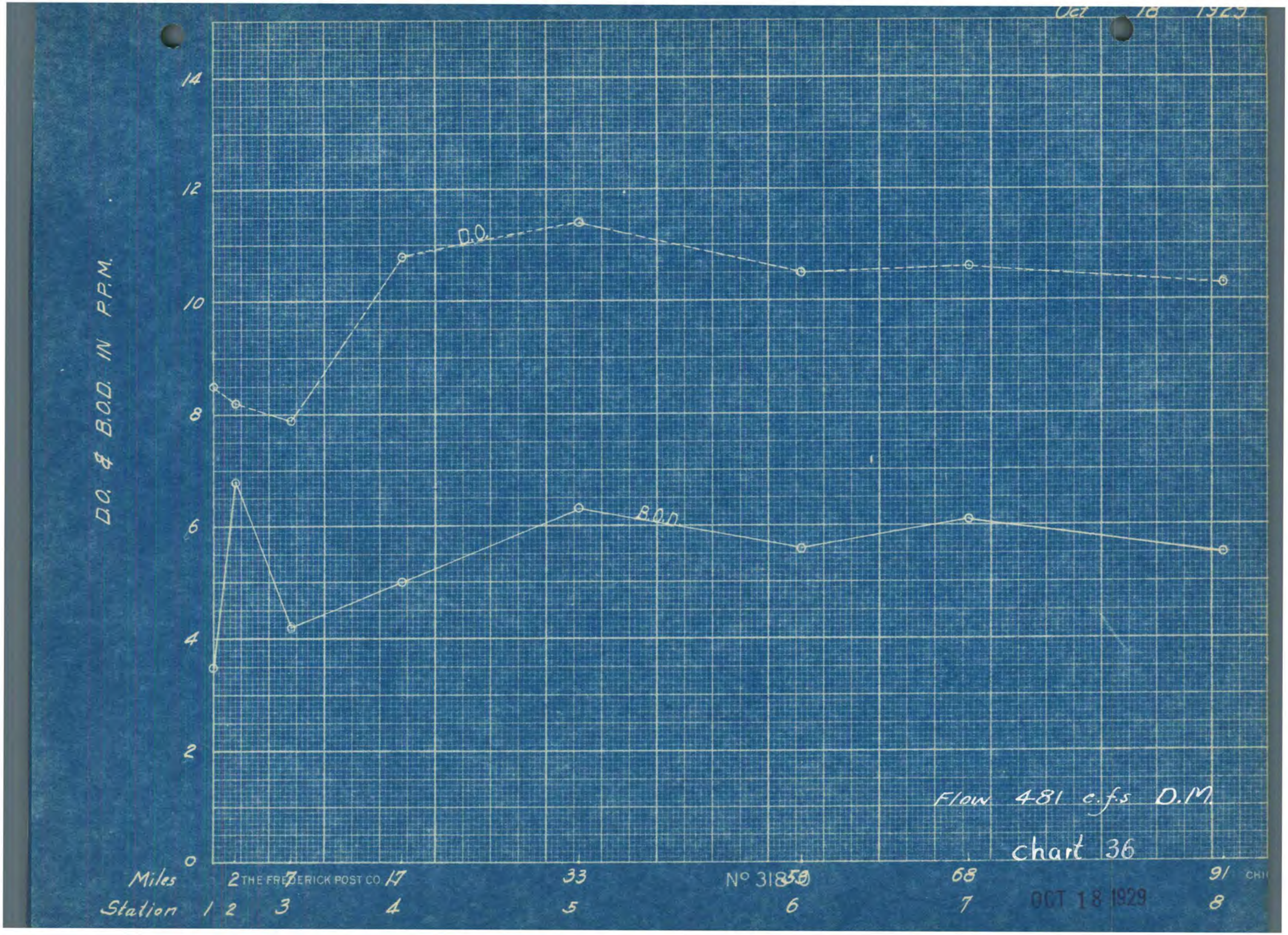

Feb 22 1929
D.O. & B.O.D. IN P.P.M.
14
12
10
8
6
4
2
0
16.7
D.O.
B.O.D.
Frozen Guage D.M.
Chart 32
Miles 2 7 17 33 53 68 91
Station 1 2 3 4 5 6 7 8
THE FREDERICK POST CO.
FEB 22 1929

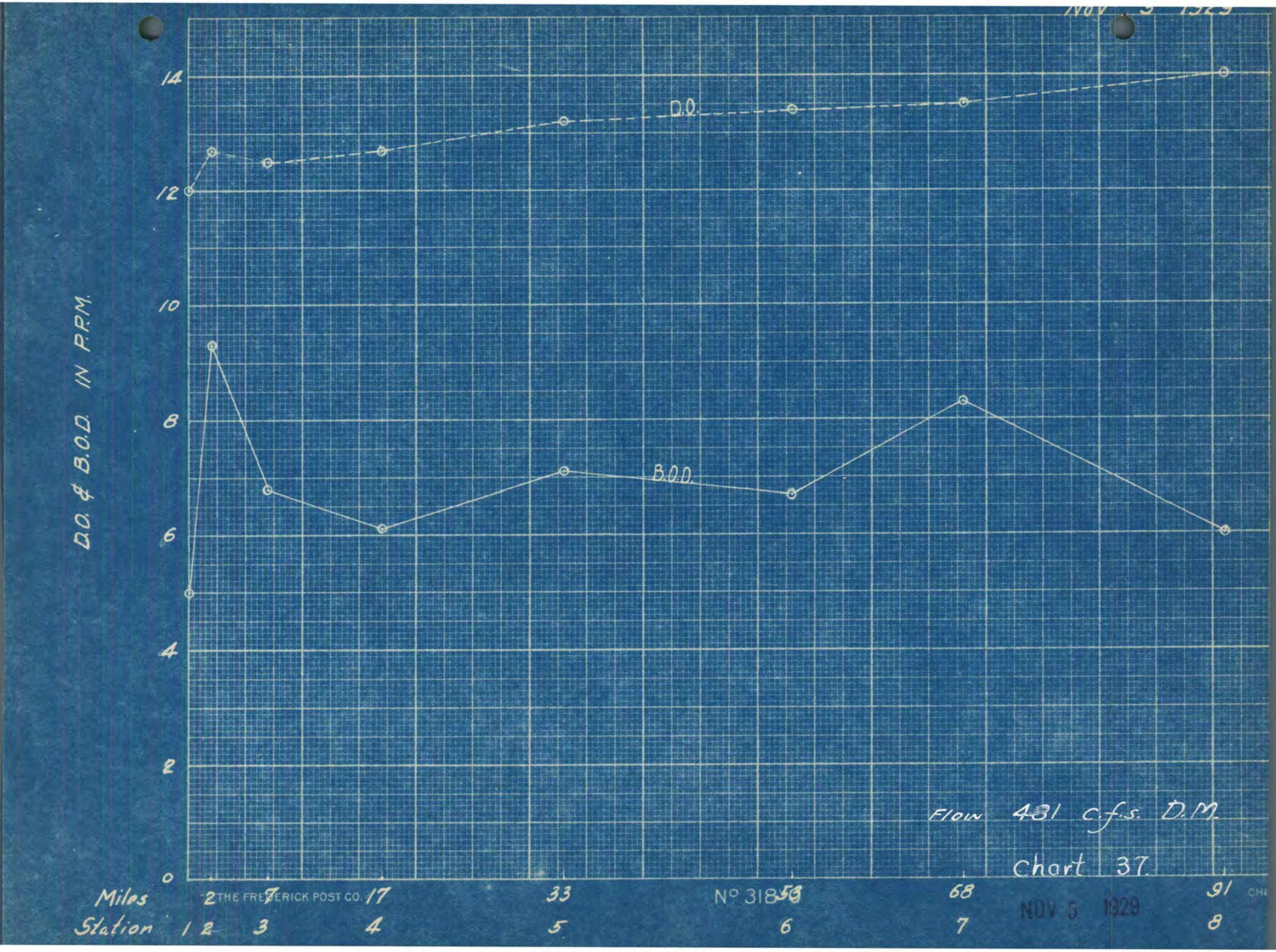

Sept 7 1929
D.O. & B.O.D. IN P.P.M.
14
12
10
8
6
4
2
0
D.O.
B.O.D.
Flow 325 c.f.s.
Chart 33.
Miles 0 2 7 17 33 50 68 91
Station 1 2 3 4 5 6 7 8
THE FREDERICK POST CO.
Nº 318
SEP 7 1929

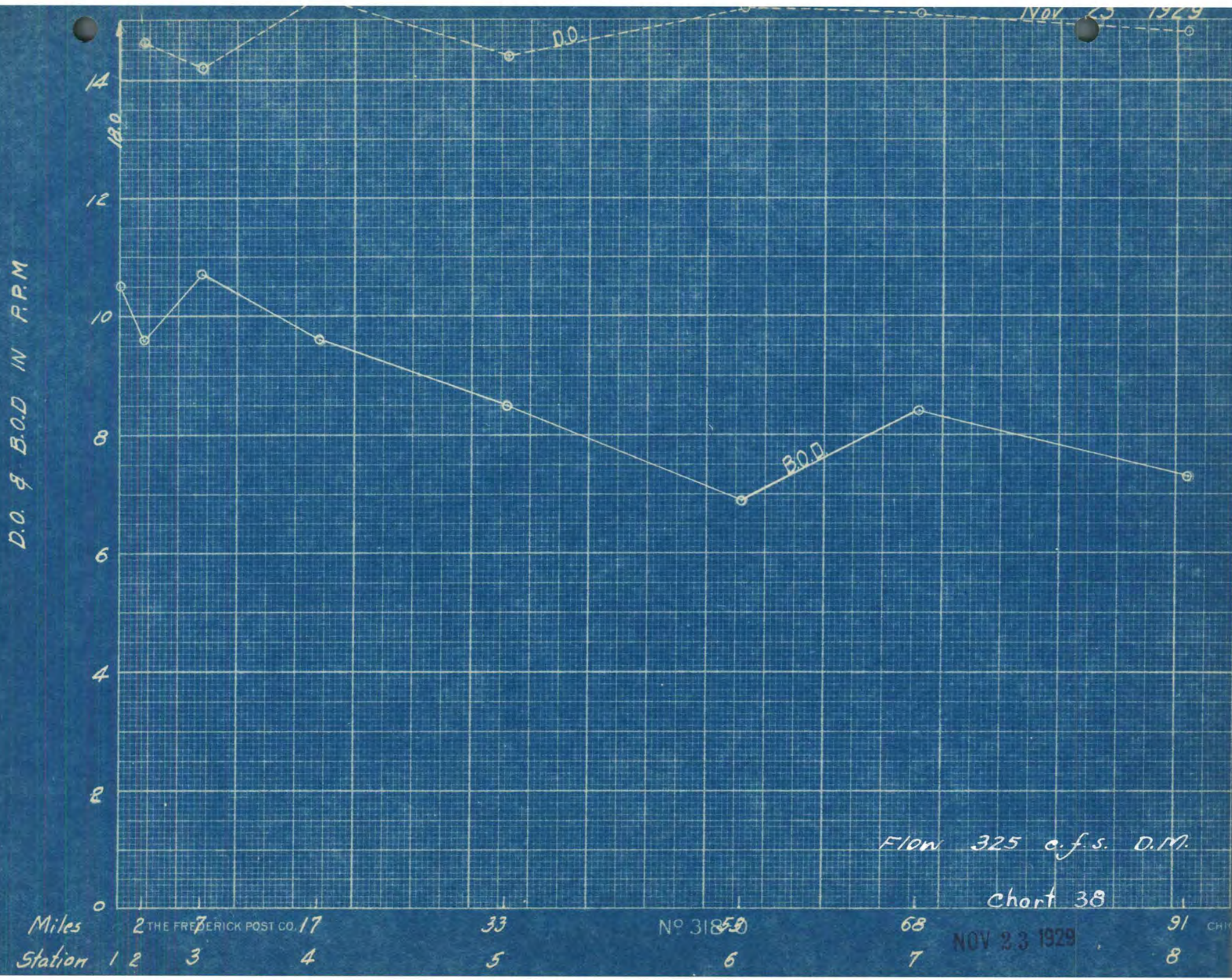


Sept 12 1929
D.O. & B.O.D. IN P.P.M.
14
12
10
8
6
4
2
0
D.O.
B.O.D.
Flow 613 c.f.s. D.M.
Chart 34
Miles 0 2 7 17 33 58 68 91
Station 1 2 3 4 5 6 7 8
THE FREDERICK POST CO.
SEP 12 1929

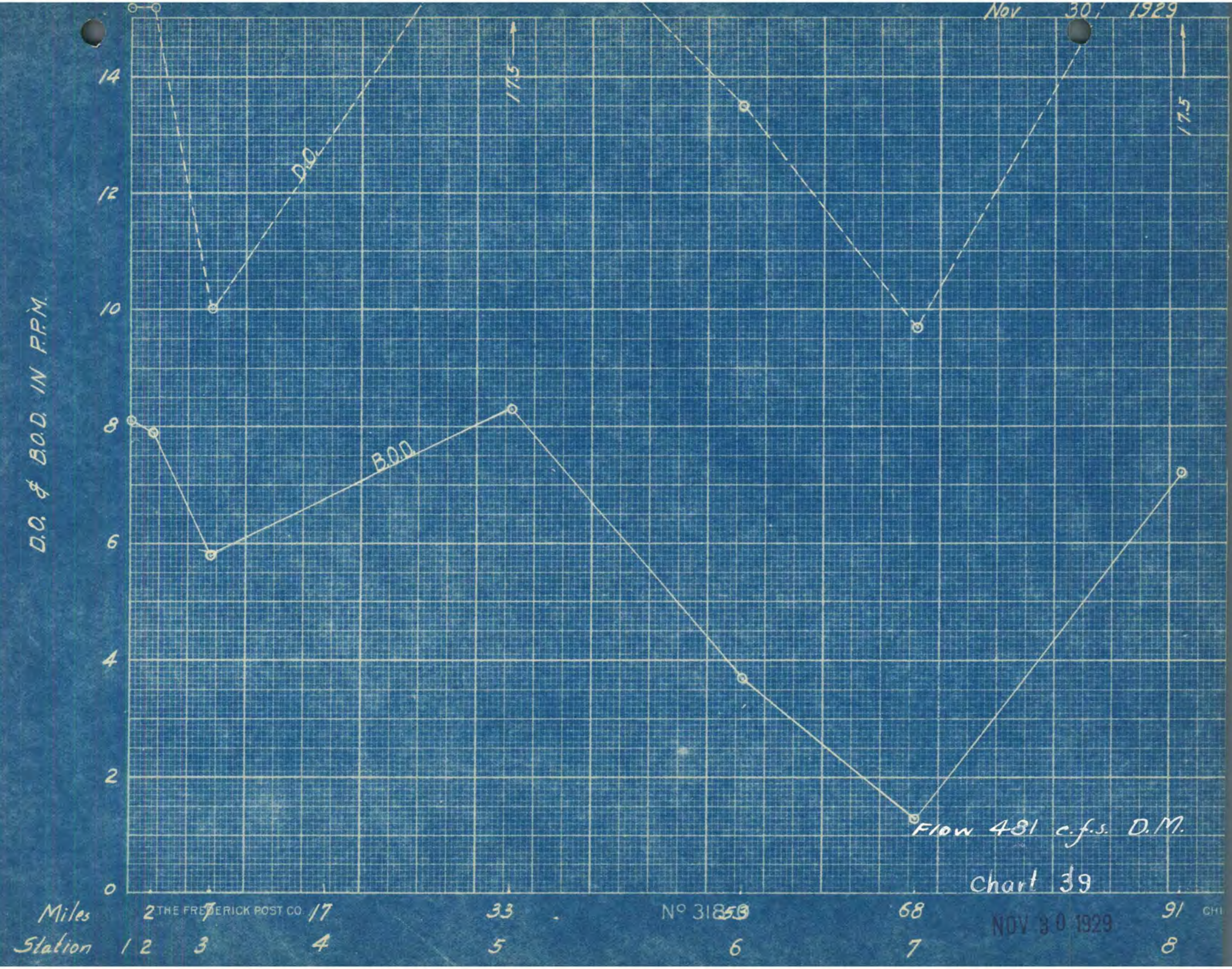

Sept 24 1929
D.O. & B.O.D IN P.P.M.
14
12
10
8
6
4
2
0
D.O.
B.O.D.
Flow 372 c.f.s. D.M
Chart 35
Miles 2 7 17 33 56 68 91
Station 1 2 3 4 5 6 7 8
THE FREDERICK POST CO.
Nº 318-G
SEP 24 1929

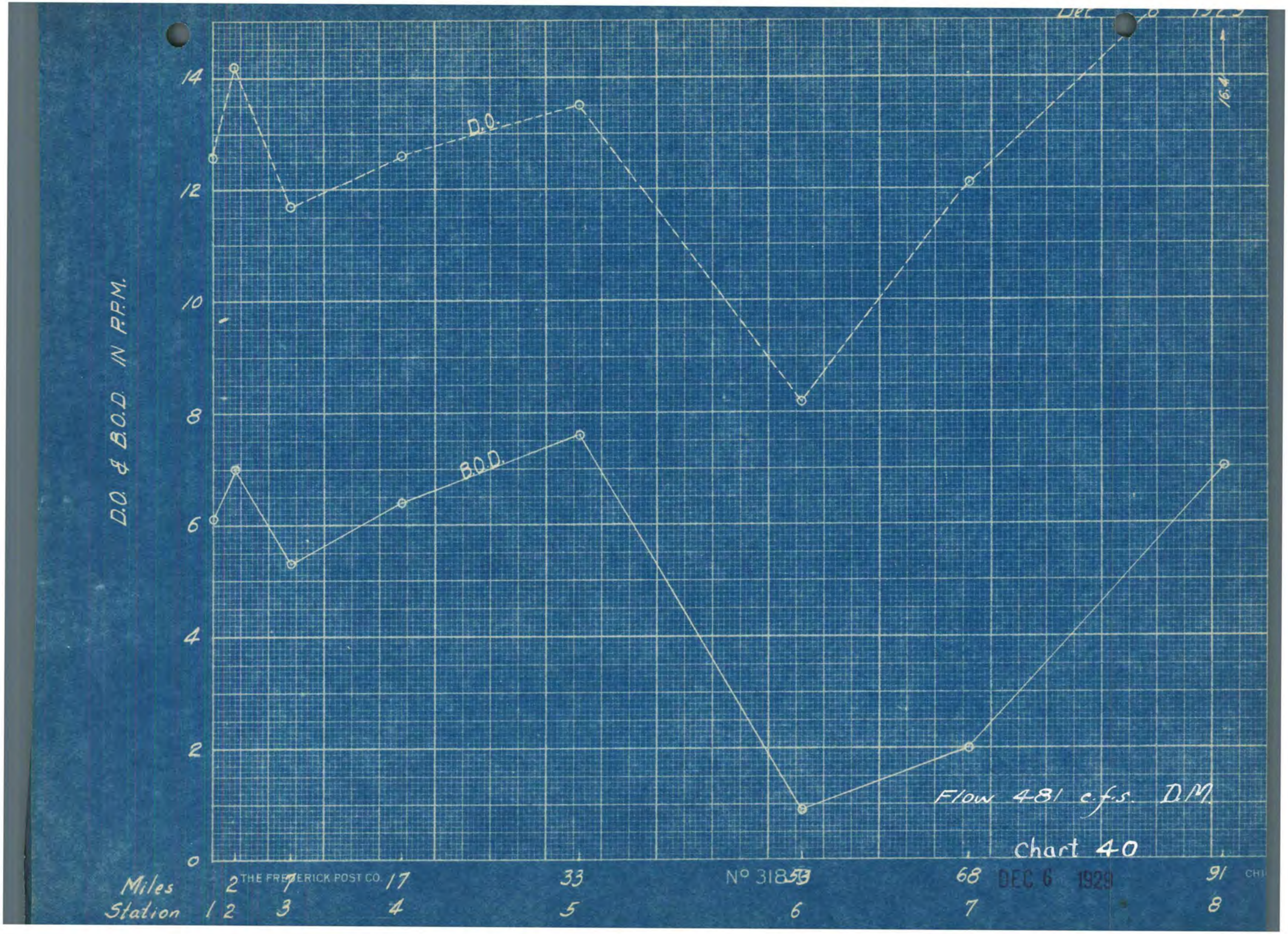

Oct 18 1929
D.O. & B.O.D. IN P.P.M.
14
12
10
8
6
4
2
0
D.O.
B.O.D.
Flow 481 c.f.s D.M.
Chart 36
Miles 2 7 17 33 50 68 91
Station 1 2 3 4 5 6 7 8
THE FREDERICK POST CO.
OCT 18 1929

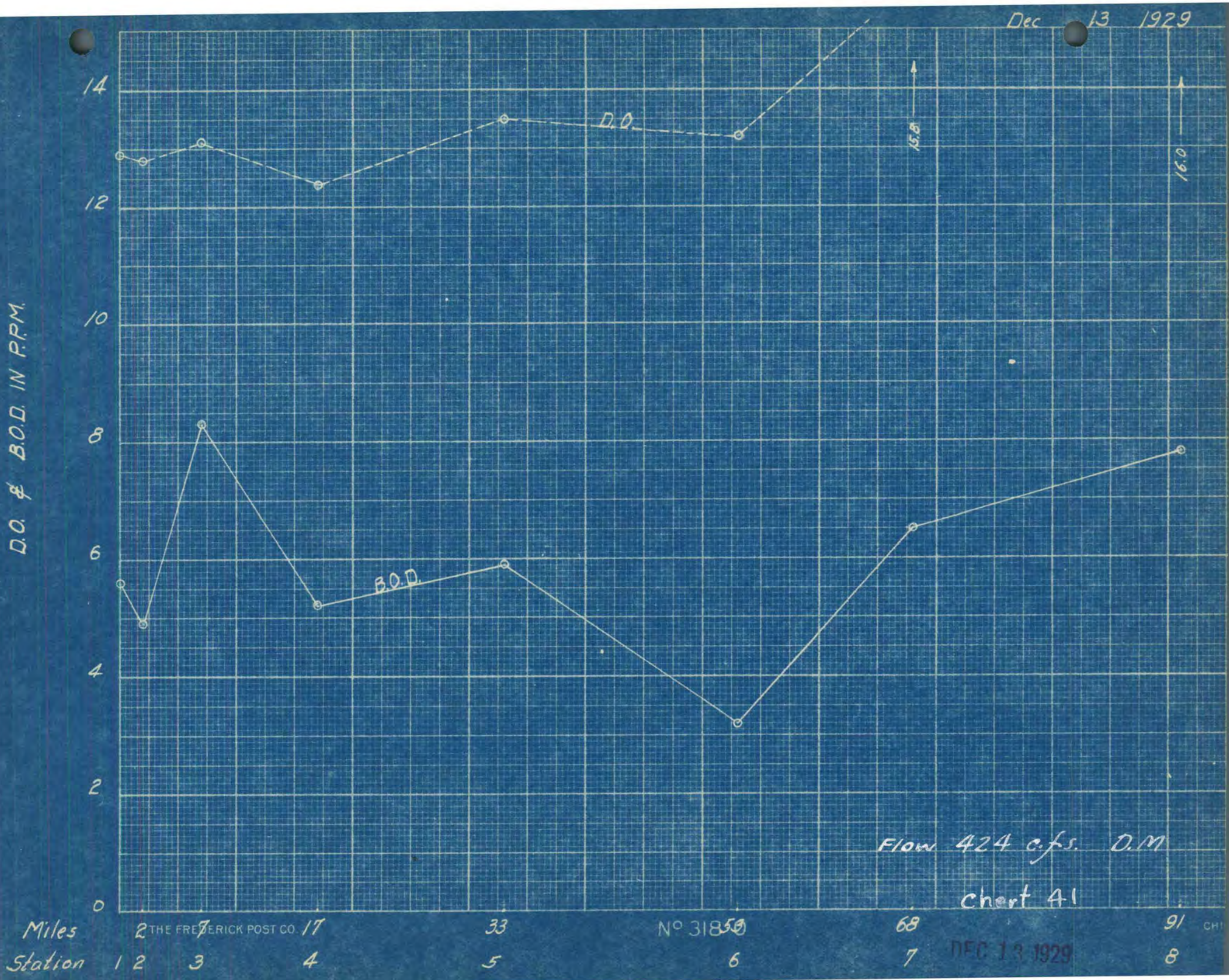

NOV 5 1929
D.O. & B.O.D. IN P.P.M.
14
12
10
8
6
4
2
0
D.O.
B.O.D.
Flow 481 c.f.s. D.M.
Chart 37
Miles 2 7 17 33 56 68 91
Station 1 2 3 4 5 6 7 8
THE FREDERICK POST CO.
No 318
NOV 5 1929

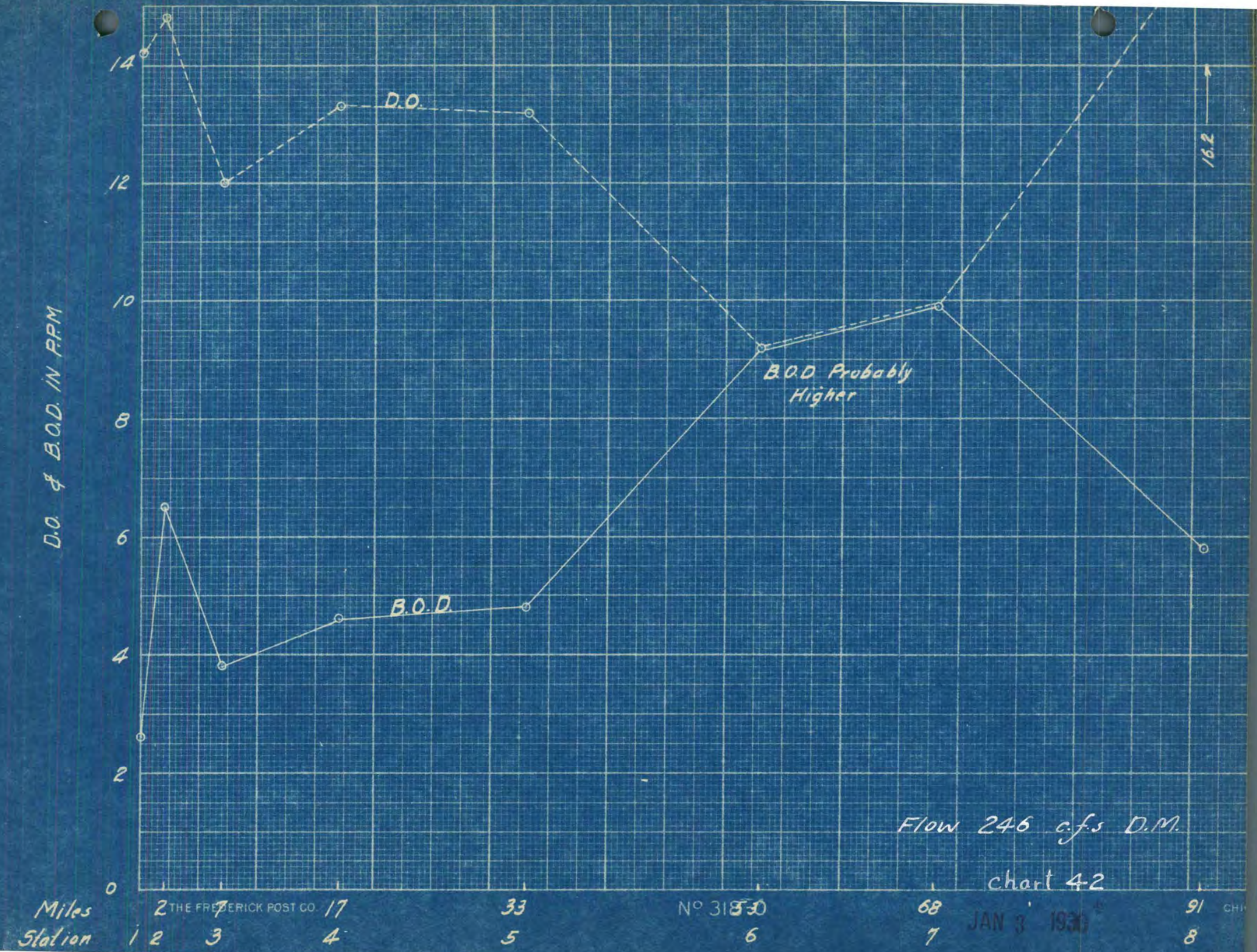

Nov 23 1929
D.O.
B.O.D
D.O. & B.O.D IN P.P.M
14
12
10
8
6
4
2
0
Miles 2 7 17 33 50 68 91
Station 1 2 3 4 5 6 7 8
Flow 325 c.f.s. D.M.
Chart 38
THE FREDERICK POST CO.
Nº 318

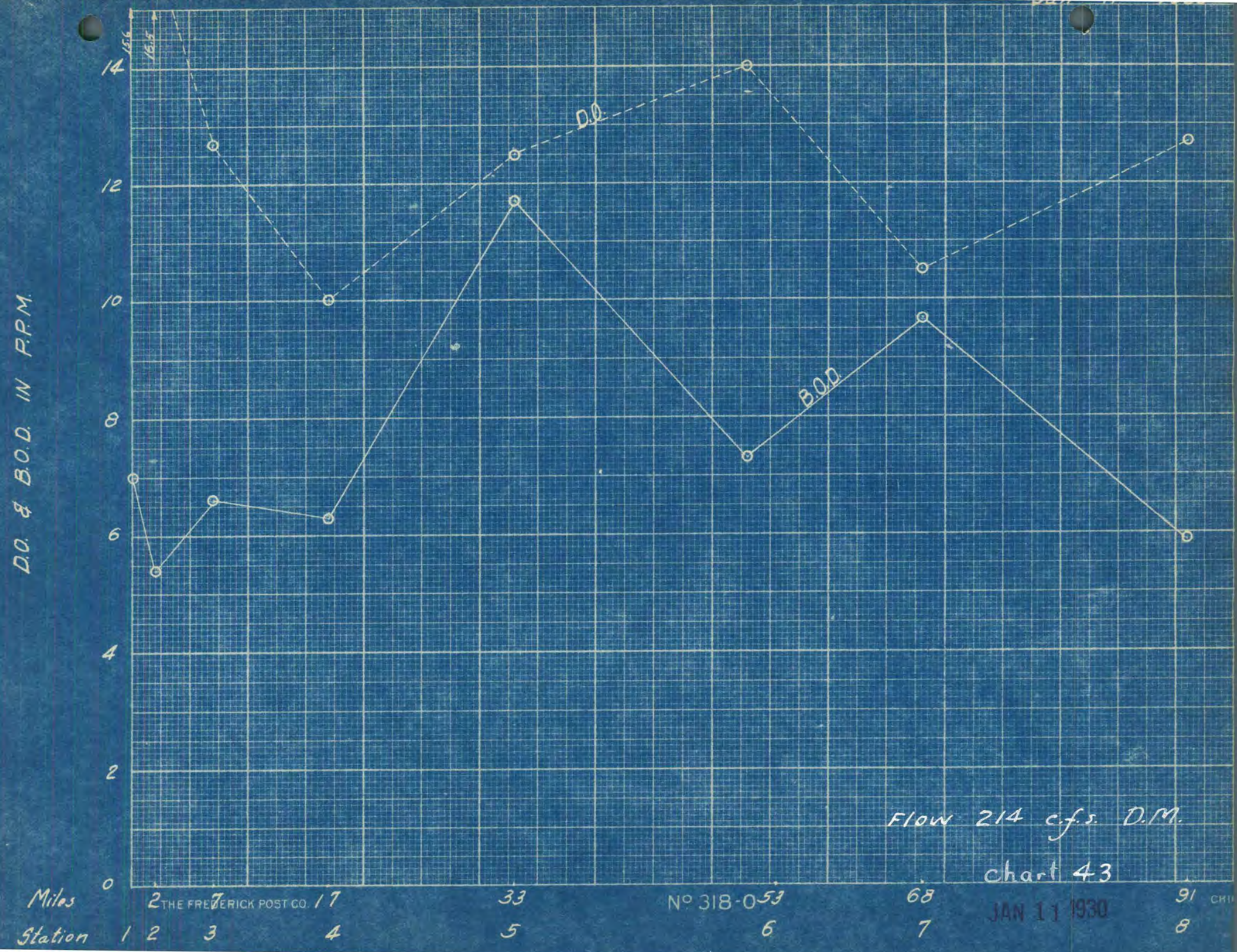
NOV 23 1929

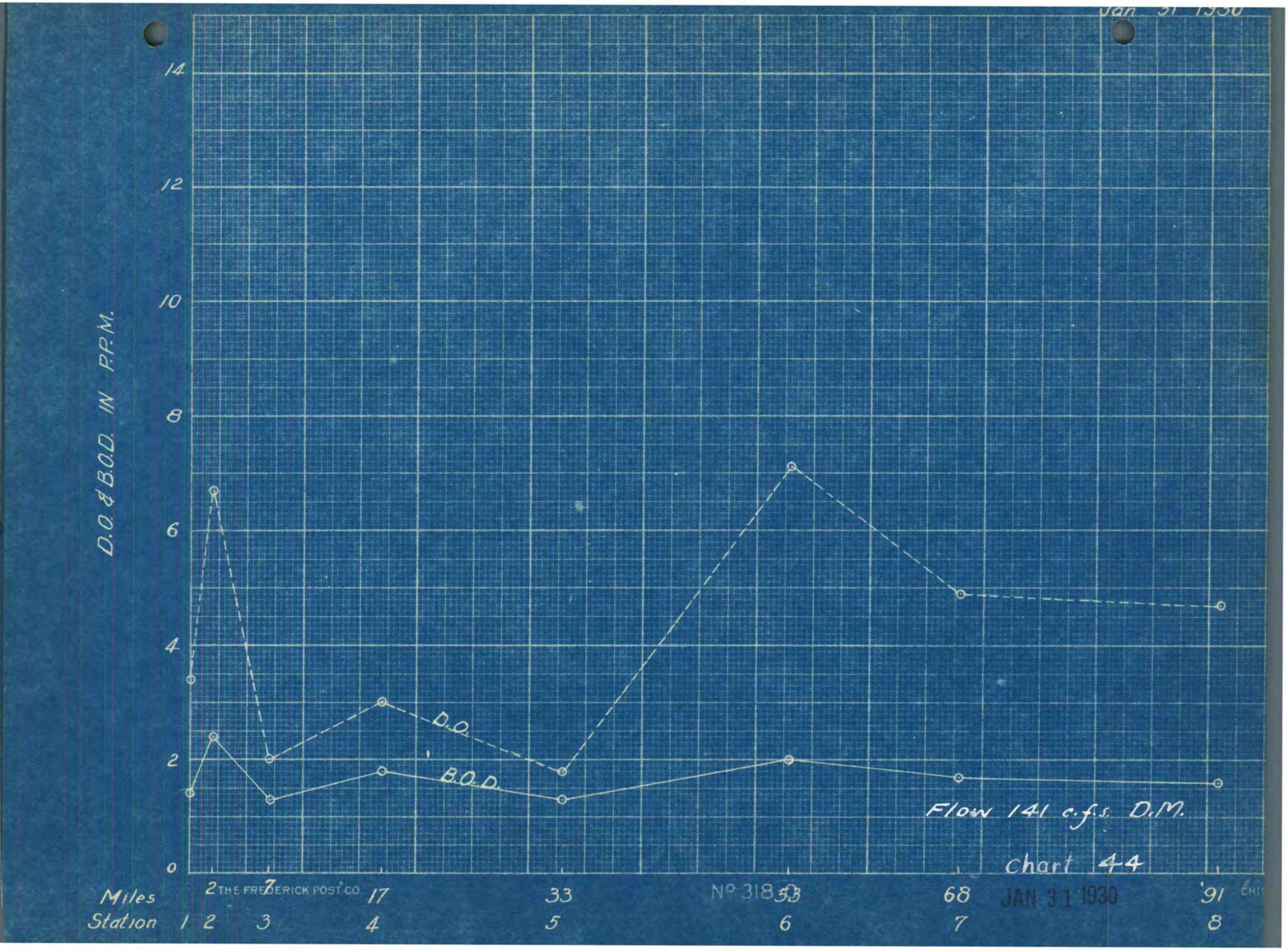

Nov 30, 1929
D.O. & B.O.D. IN P.P.M.
D.O.
B.O.D.
17.5
17.5
14
12
10
8
6
4
2
0
Flow 481 c.f.s. D.M.
Chart 39
Miles 2 7 17 33 53 68 91
Station 1 2 3 4 5 6 7 8
THE FREDERICK POST CO.
NOV 30 1929


D.O. & B.O.D. IN P.P.M.
14
12
10
8
6
4
2
0
D.O.
B.O.D.
16.4
Flow 481 c.f.s. D.M.
Chart 40
Miles 2 7 17 33 53 68 91
Station 1 2 3 4 5 6 7 8
THE FREDERICK POST CO.
DEC 6 1929

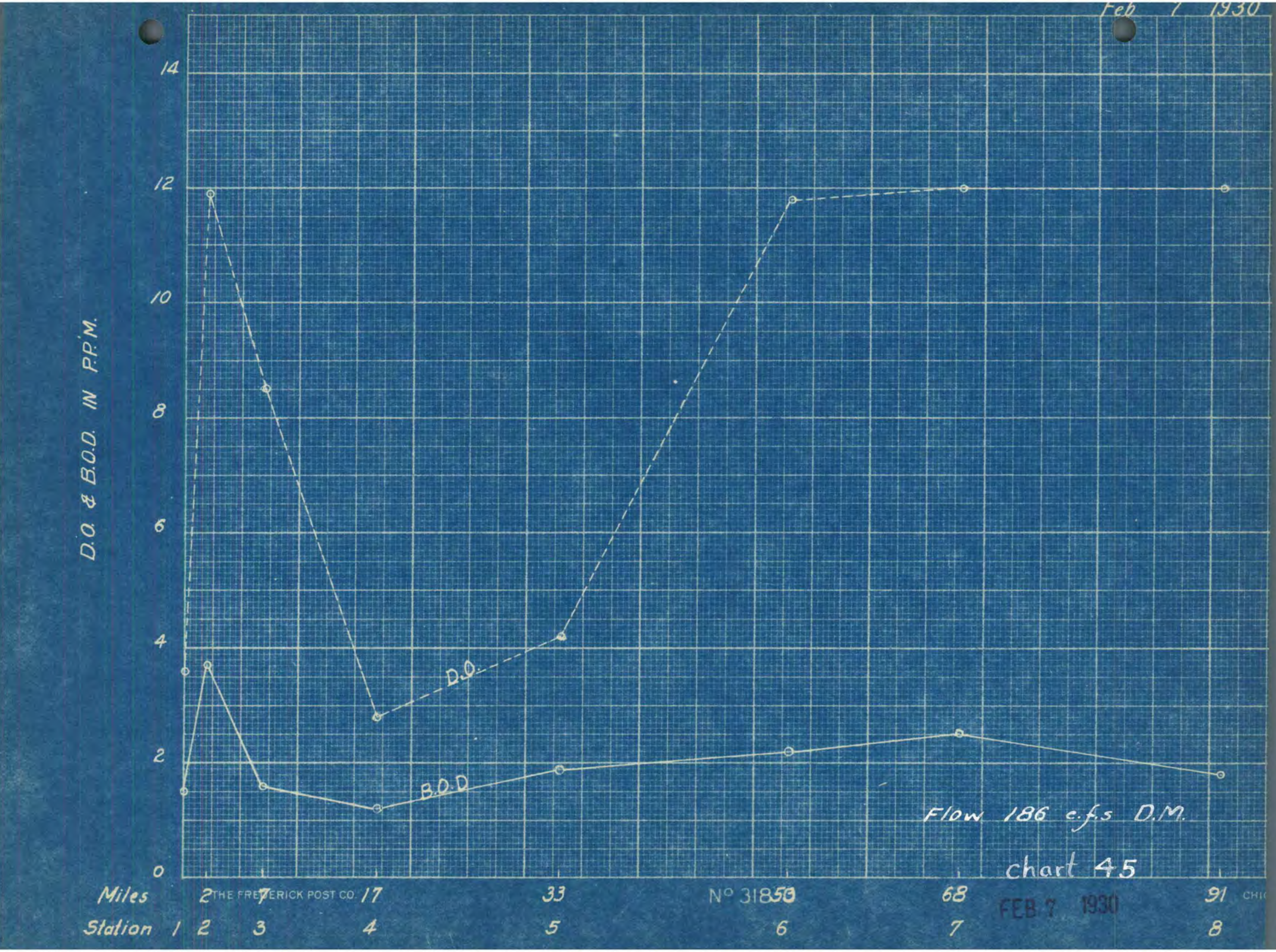

Dec 13 1929
D.O. & B.O.D. IN P.P.M.
14
12
10
8
6
4
2
0
D.O.
B.O.D.
15.8
16.0
Flow 424 c.f.s. D.M
Chart 41
Miles 2 7 17 33 50 68 91
Station 1 2 3 4 5 6 7 8
THE FREDERICK POST CO.
DEC 13 1929

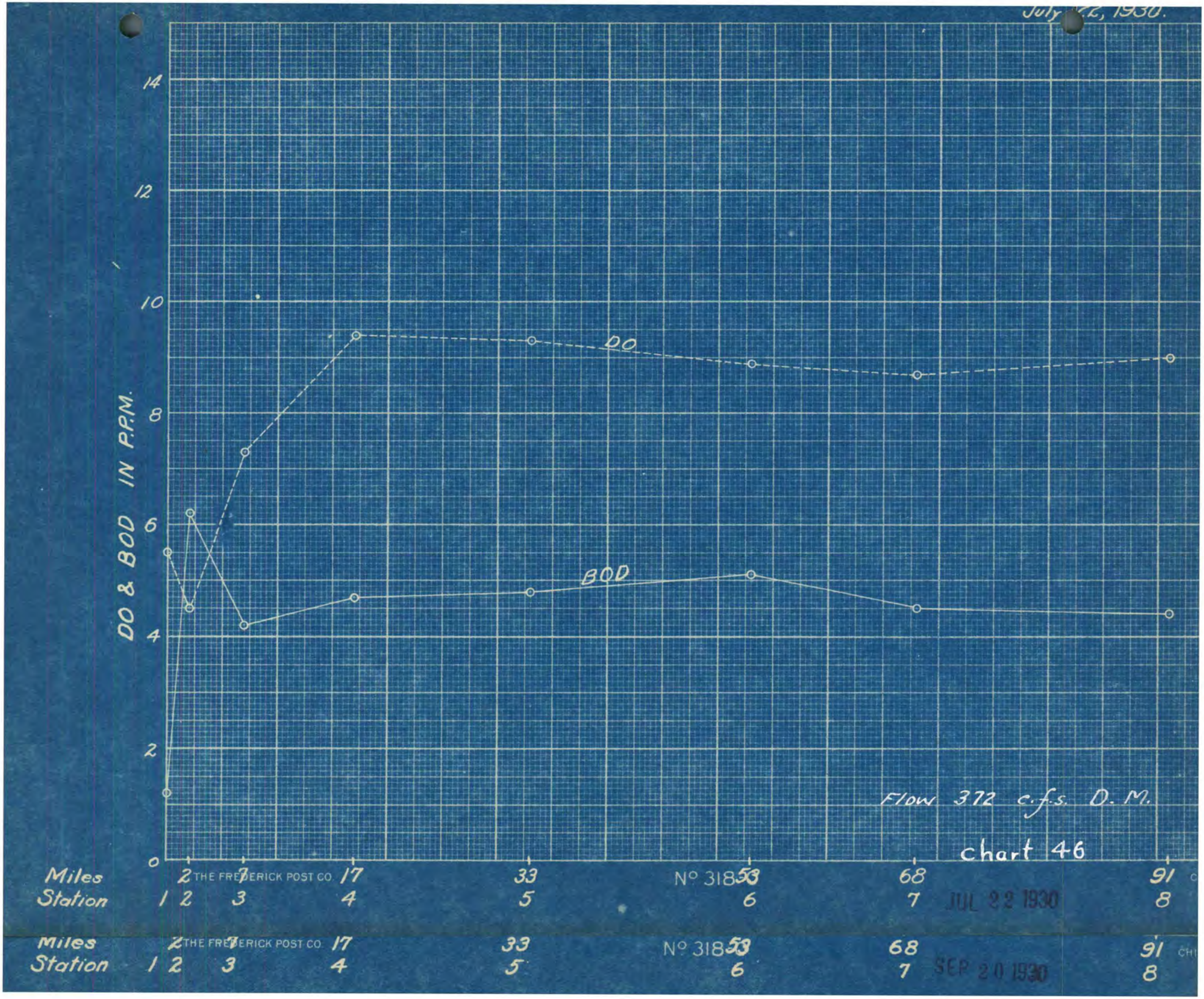

D.O. & B.O.D. IN P.P.M.
D.O.
B.O.D.
B.O.D. Probably Higher
16.2
Flow 246 c.f.s. D.M.
Chart 4-2
Miles 2 7 17 33 50 68 91
Station 1 2 3 4 5 6 7 8
THE FREDERICK POST CO.
No 318-30
JAN 3 1930


D.O. & B.O.D. IN P.P.M.
0
2
4
6
8
10
12
14
15.6
16.5
D.O.
B.O.D.
Miles 2 7 17 33 53 68 91
Station 1 2 3 4 5 6 7 8
Flow 214 c.f.s. D.M.
Chart 43
THE FREDERICK POST CO.
N° 318-0
JAN 11 1930

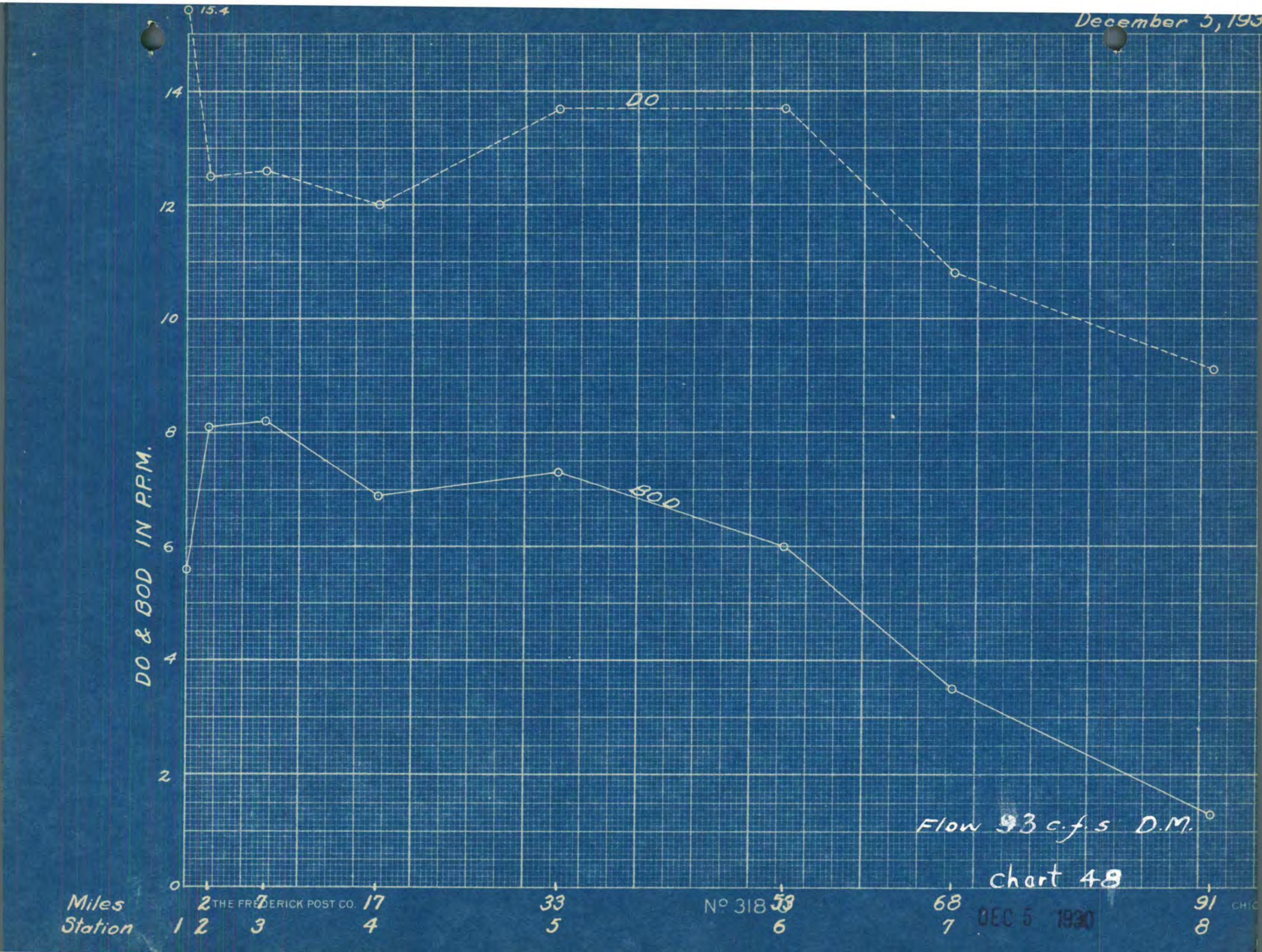


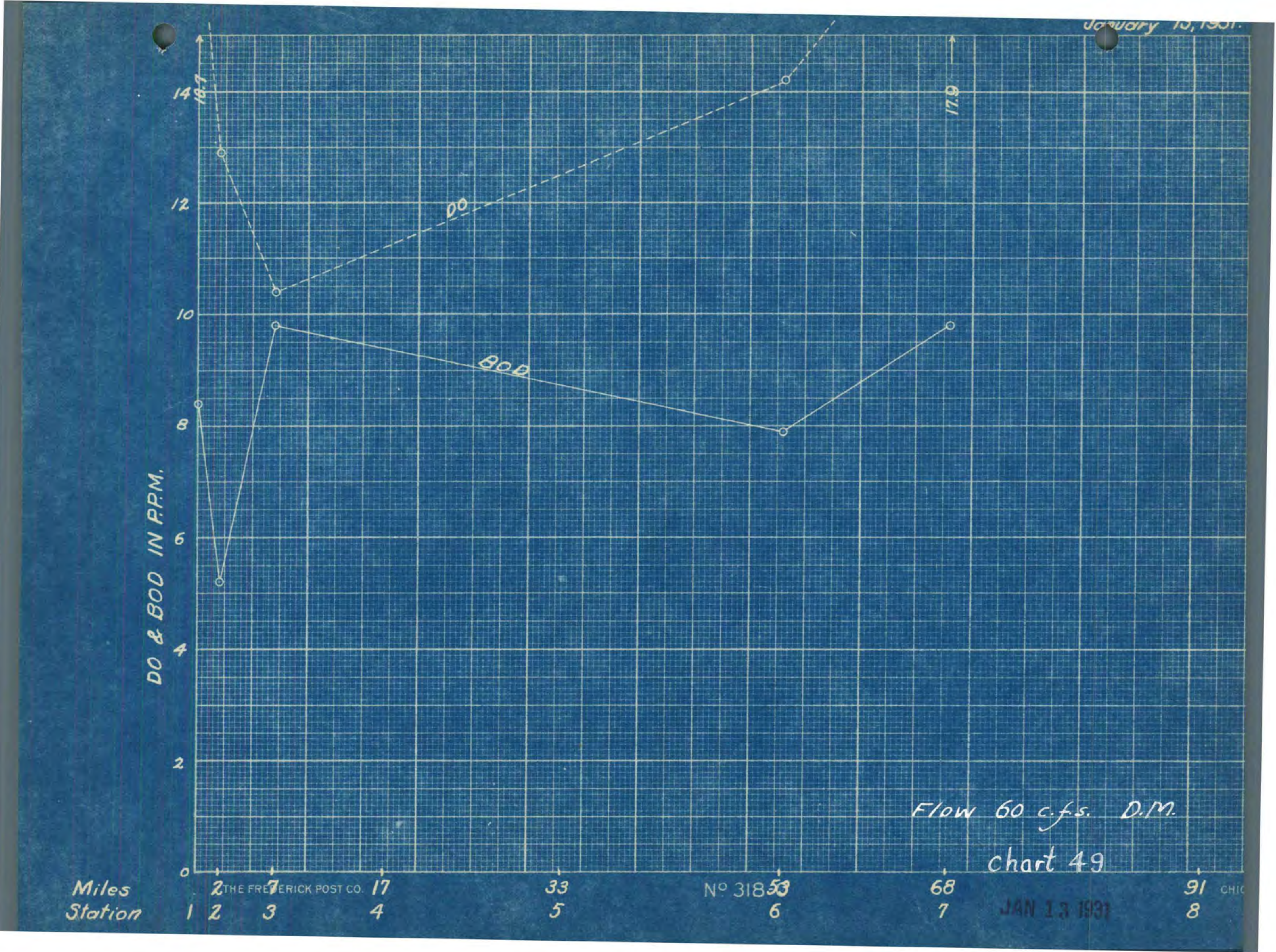
Jan 31 1930
D.O. & B.O.D. IN P.P.M.
14
12
10
8
6
4
2
0
D.O.
B.O.D.
Flow 141 c.f.s. D.M.
Chart 44
Miles 2 7 17 33 53 68 91
Station 1 2 3 4 5 6 7 8
THE FREDERICK POST CO.
Nº 318
JAN 31 1930

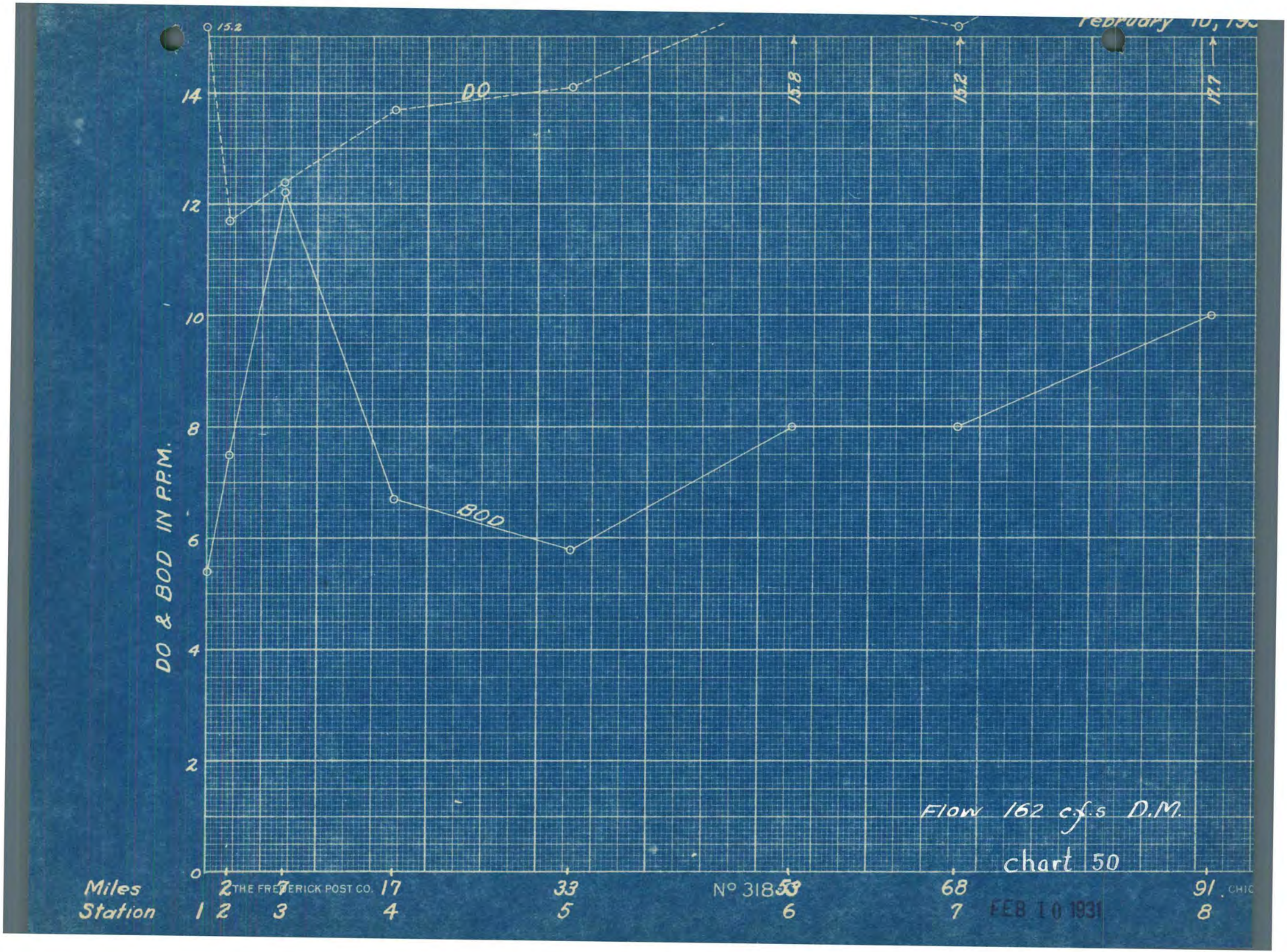

Feb 7 1930
D.O. & B.O.D. IN P.P.M.
14
12
10
8
6
4
2
0
D.O.
B.O.D.
Flow 186 c.f.s D.M.
Chart 45
Miles 2 7 17 33 50 68 91
Station 1 2 3 4 5 6 7 8
THE FREDERICK POST CO.
Nº 3185
FEB 7 1930



July 22, 1930.
14
12
10
8
6
4
2
0
DO & BOD IN P.P.M.
DO
BOD
Flow 372 c.f.s. D. M.
Chart 46
Miles 2 7 17 33 53 68 91
Station 1 2 3 4 5 6 7 8
THE FREDERICK POST CO.
Nº 318
JUL 22 1930
Miles 2 7 17 33 53 68 91
Station 1 2 3 4 5 6 7 8
THE FREDERICK POST CO.
Nº 318
SEP 20 1930


December 5, 193
15.4
DO
BOD
DO & BOD IN P.P.M.
0
2
4
6
8
10
12
14
Miles 2 7 17 33 53 68 91
Station 1 2 3 4 5 6 7 8
Flow 93 c.f.s D.M.
Chart 48
THE FREDERICK POST CO.
Nº 318
DEC 5 1930


January 13, 1931.
DO & BOD IN P.P.M.
14
12
10
8
6
4
2
0
18.1
17.9
DO
BOD
Flow 60 c.f.s. D.M.
Chart 49
Miles 2 7 17 33 53 68 91
Station 1 2 3 4 5 6 7 8
THE FREDERICK POST CO.
Nº 318
JAN 13 1931


February 10, 193
15.2
DO
15.8
15.2
17.7
14
12
10
8
6
4
2
0
DO & BOD IN P.P.M.
BOD
Flow 162 c.f.s D.M.
Chart 50
Miles 2 7 17 33 53 68 91
Station 1 2 3 4 5 6 7 8
THE FREDERICK POST CO.
Nº 31853
FEB 10 1931

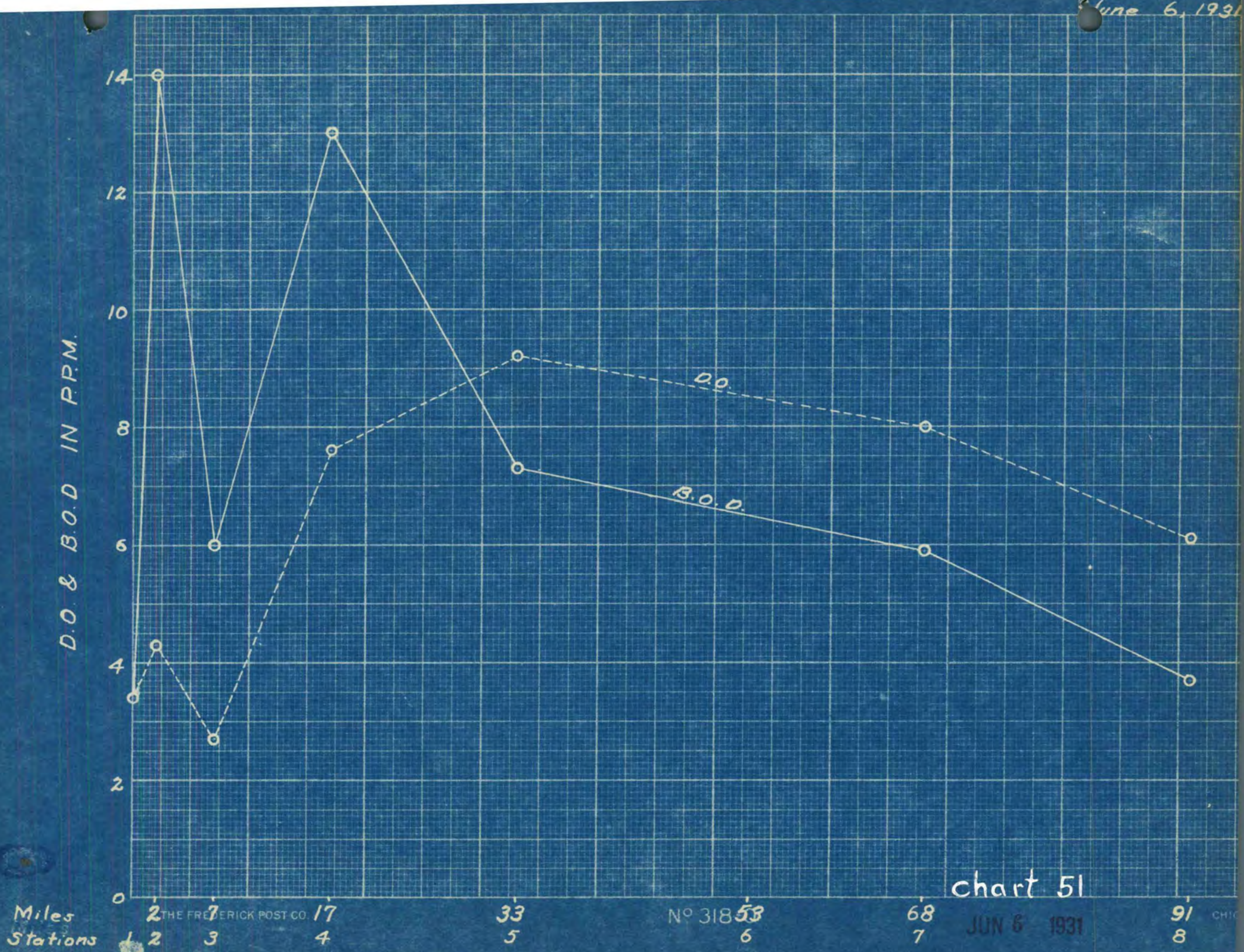
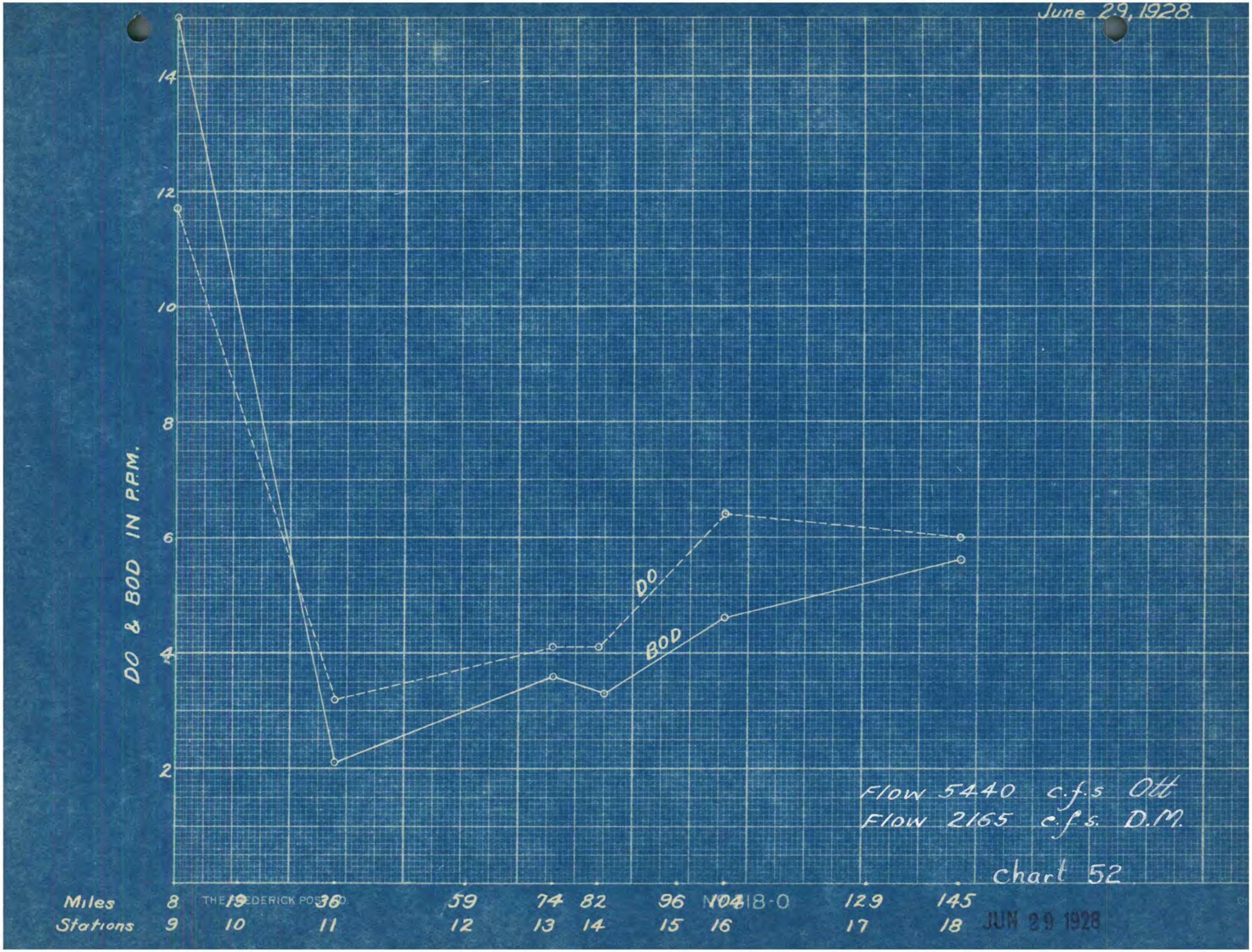
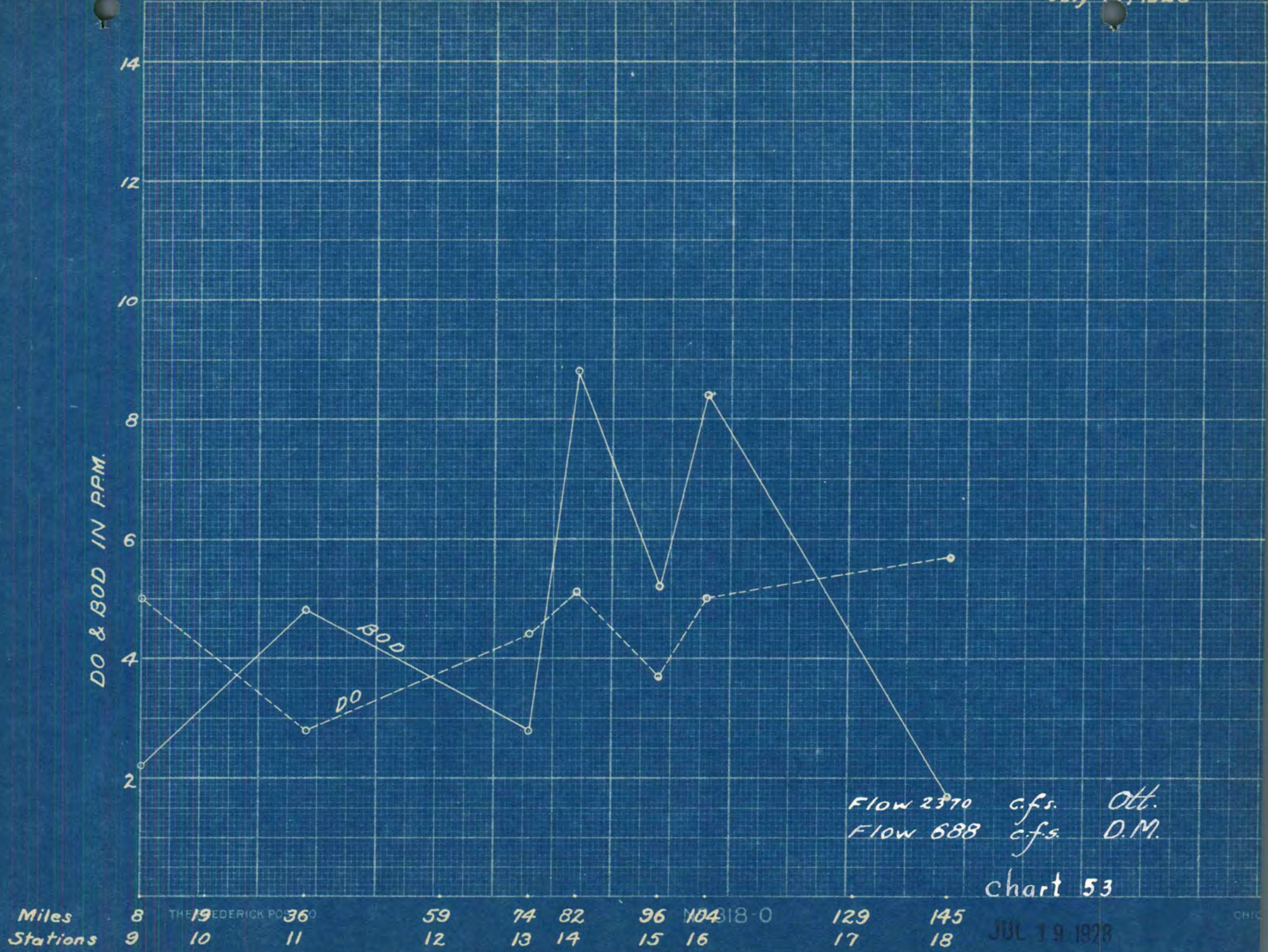

June 6, 1931
D.O. & B.O.D IN P.P.M.
14
12
10
8
6
4
2
0
D.O.
B.O.D.
Miles 2 7 17 33 53 68 91
Stations 1 2 3 4 5 6 7 8
THE FREDERICK POST CO.
Nº 318
JUN 6 1931

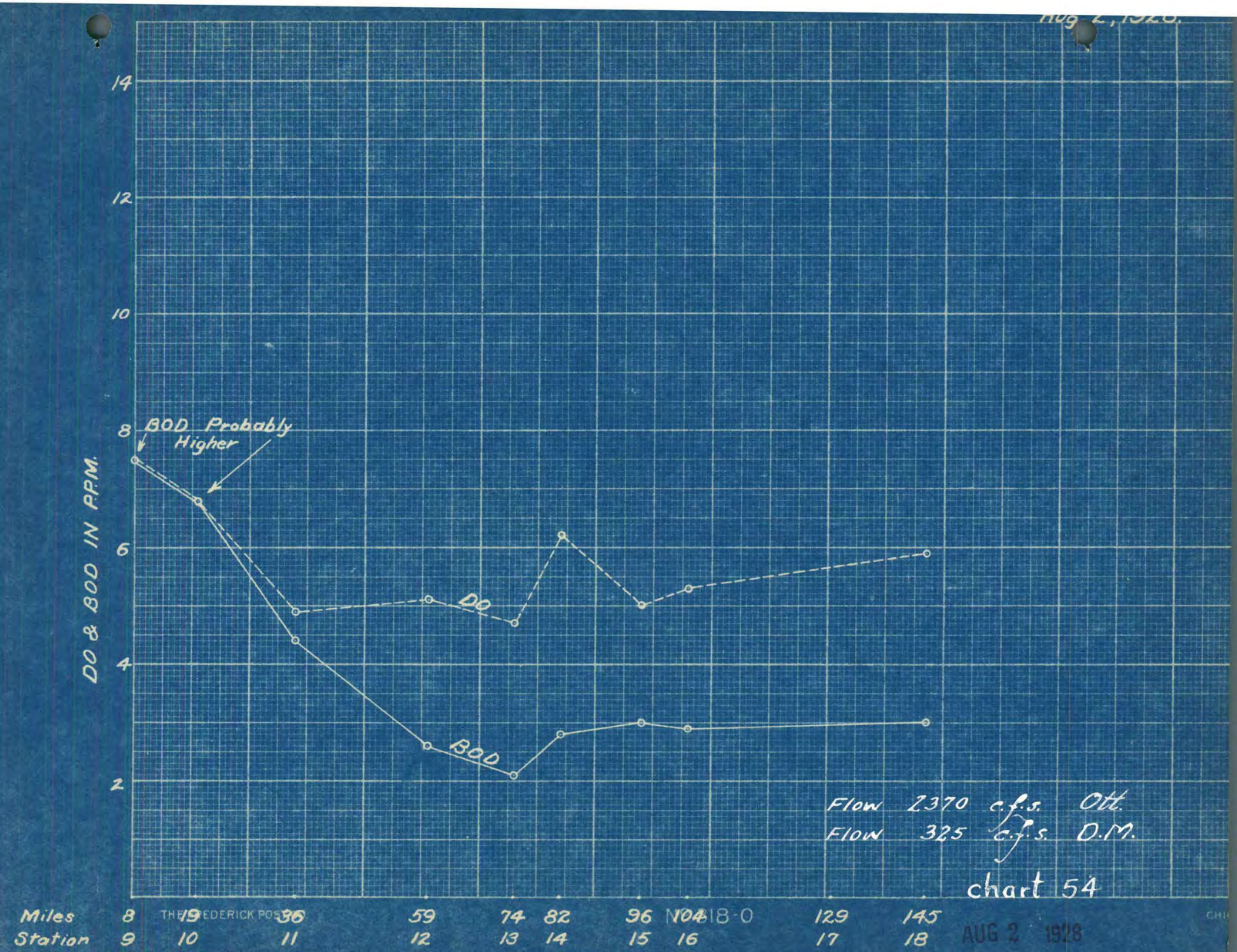
Chart 51


June 29, 1928.
DO & BOD IN P.P.M.
14
12
10
8
6
4
2
DO
BOD
Flow 5440 c.f.s Ott
Flow 2165 c.f.s. D.M.
Chart 52
Miles 8 19 36 59 74 82 96 104 129 145
Stations 9 10 11 12 13 14 15 16 17 18
JUN 29 1928

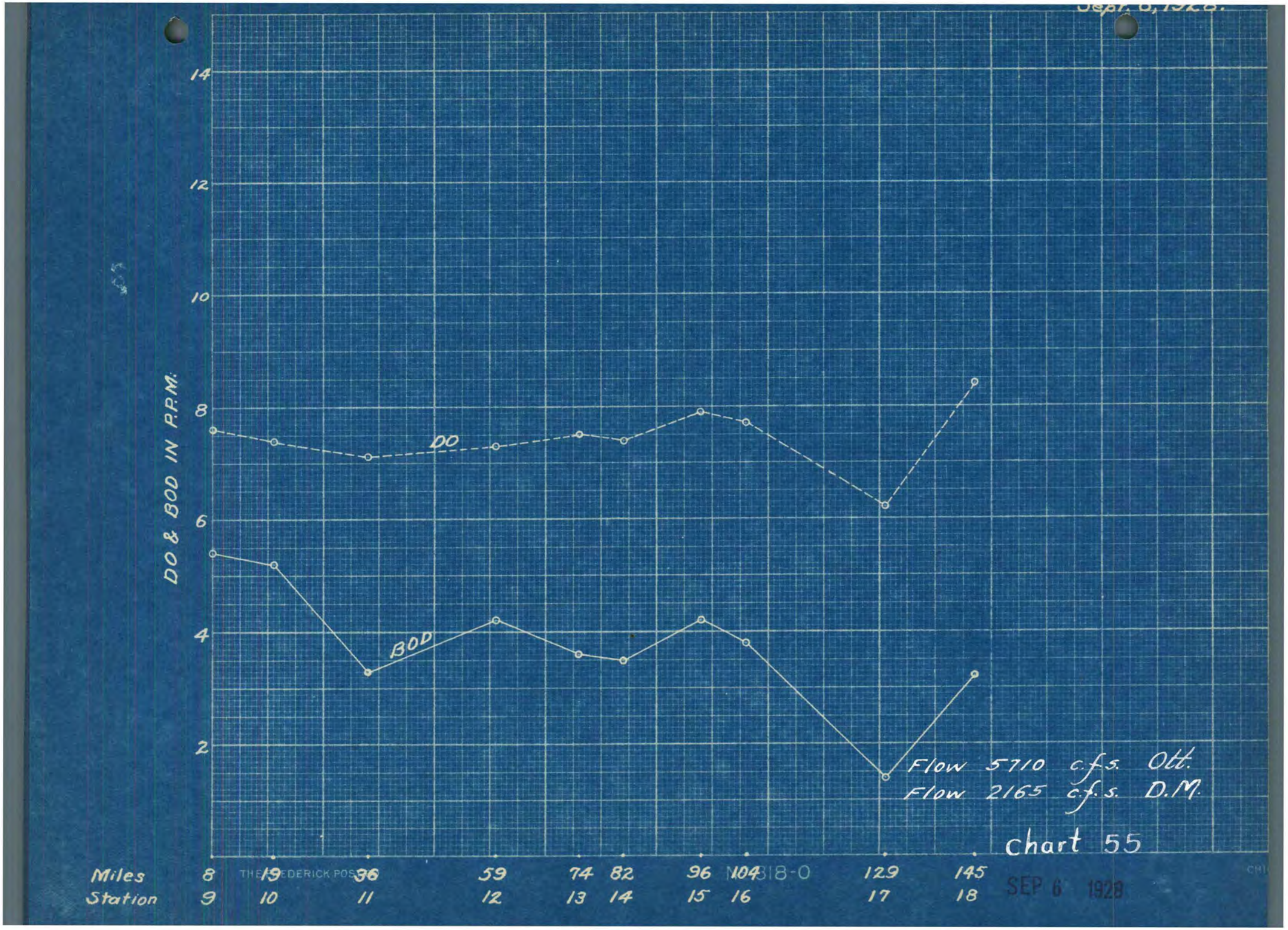
July 19, 1928

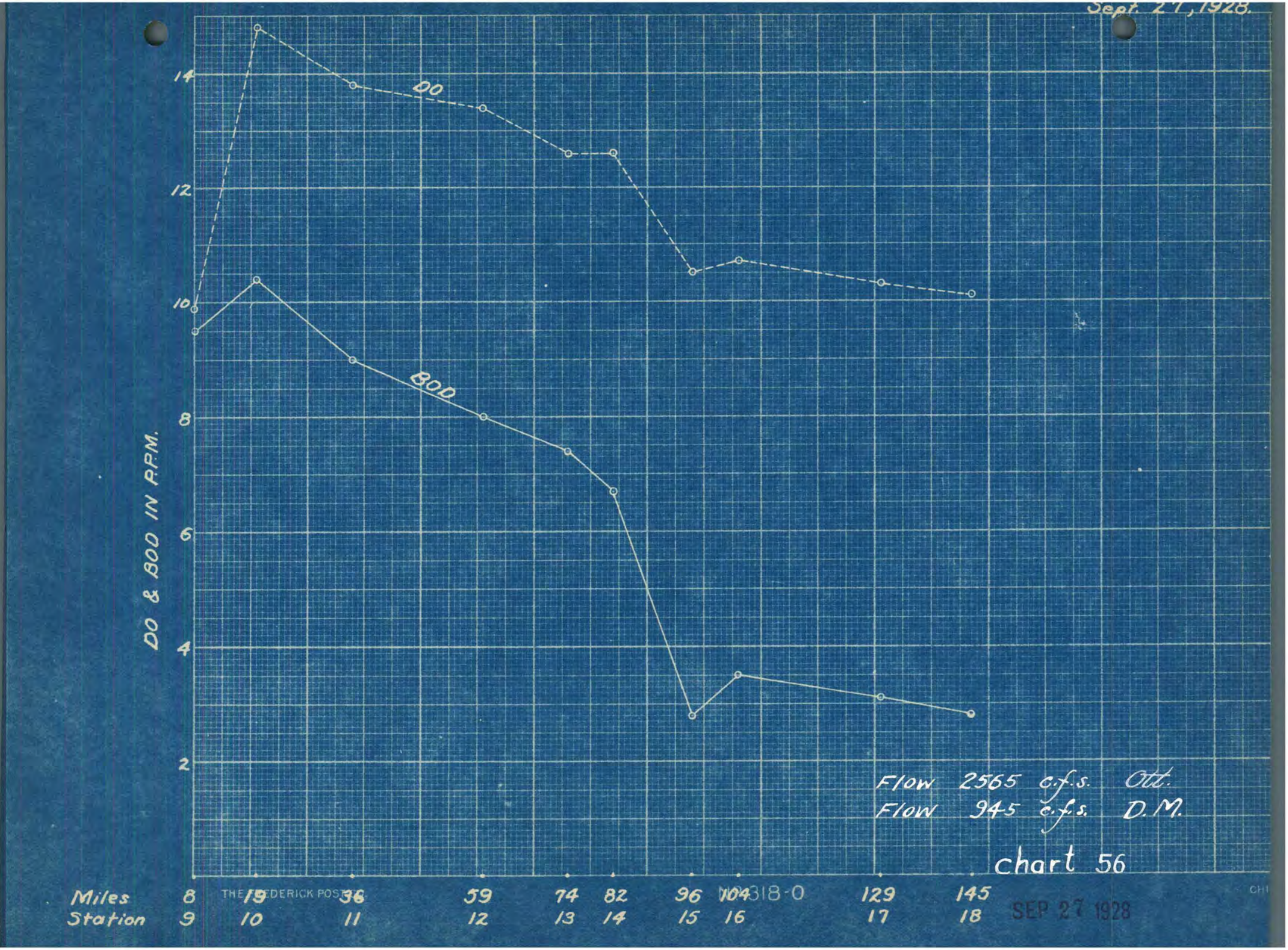


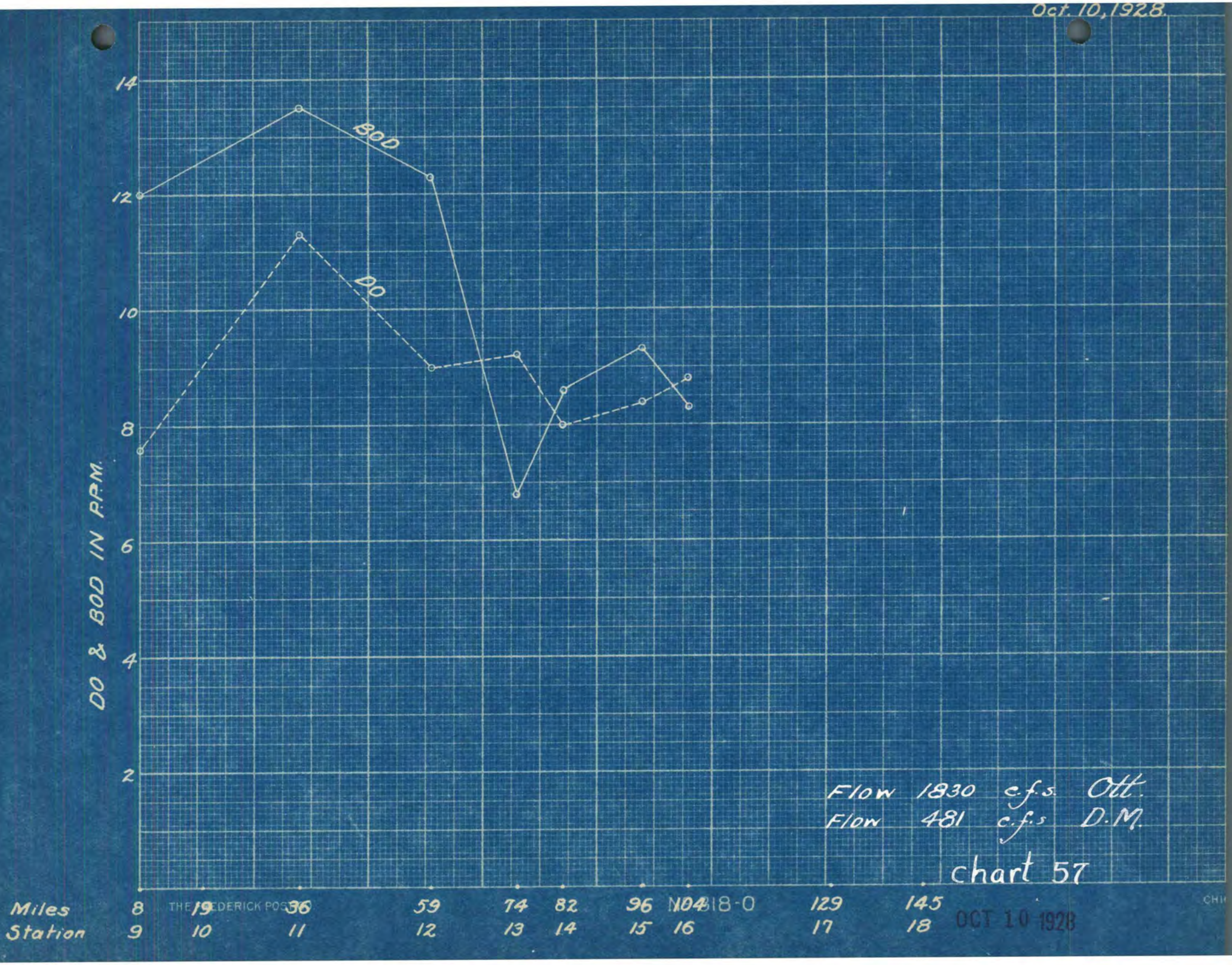
JUL 19 1928

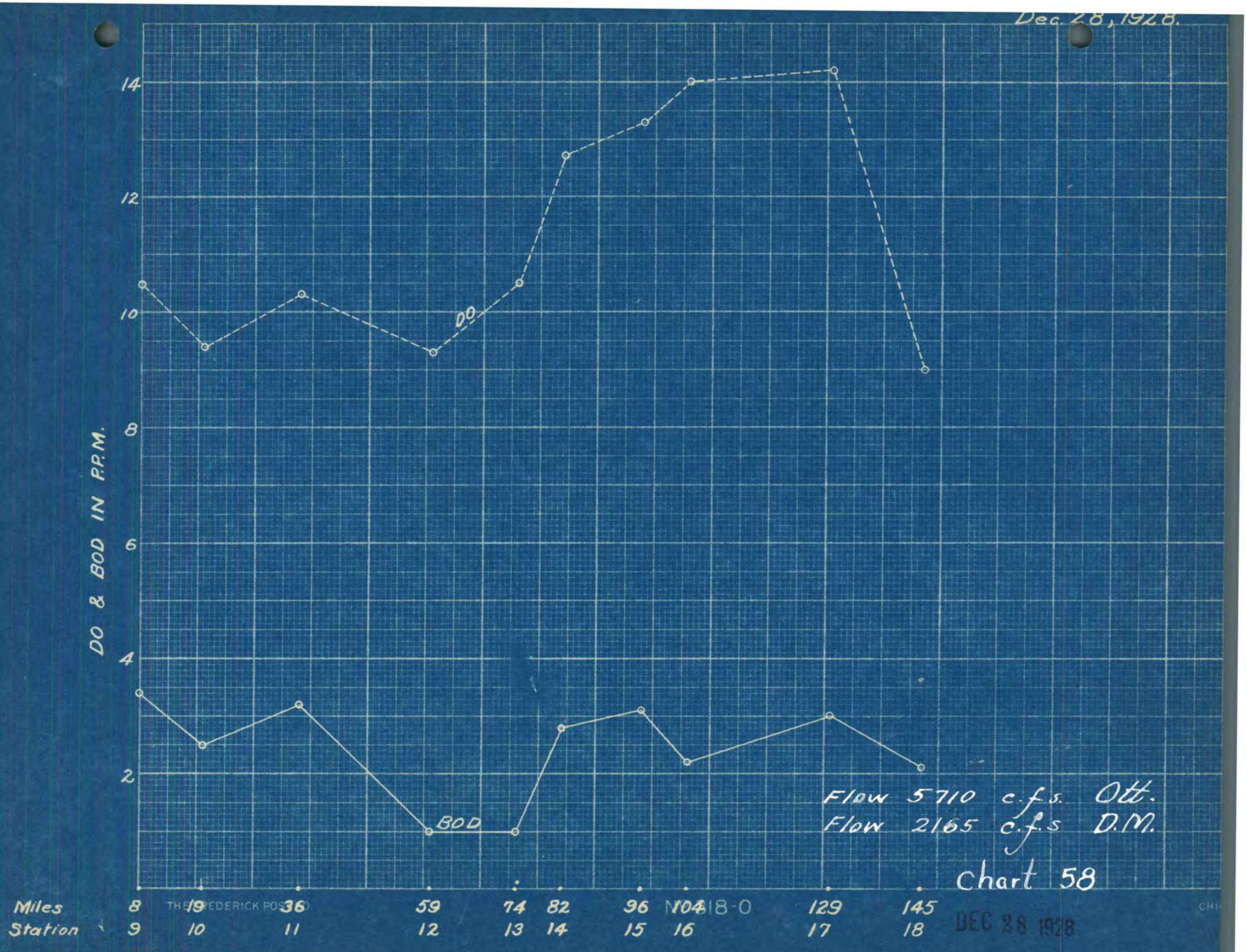


Aug 2, 1928.
DO & BOD IN P.P.M.
14
12
10
8
6
4
2
BOD Probably Higher
DO
BOD
Flow 2370 c.f.s. Ott.
Flow 325 c.f.s. D.M.
chart 54
Miles 8 19 36 59 74 82 96 104 129 145
Station 9 10 11 12 13 14 15 16 17 18

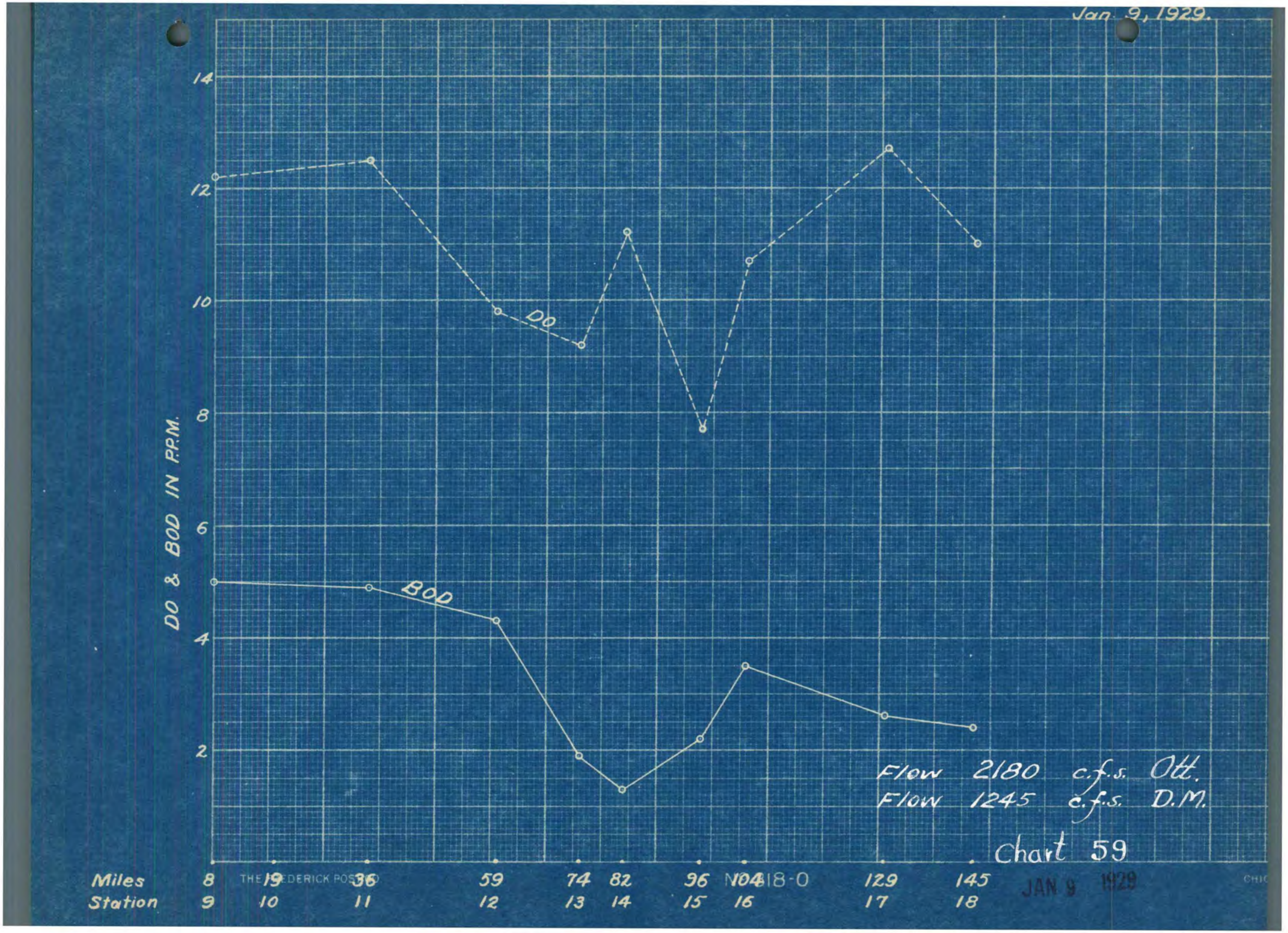

Sept. 6, 1928.
14
12
10
8
6
4
2
DO & BOD IN P.P.M.
DO
BOD
Flow 5710 c.f.s. Ott.
Flow 2165 c.f.s. D.M.
Chart 55
Miles 8 19 36 59 74 82 96 104 129 145
Station 9 10 11 12 13 14 15 16 17 18
SEP 6 1928

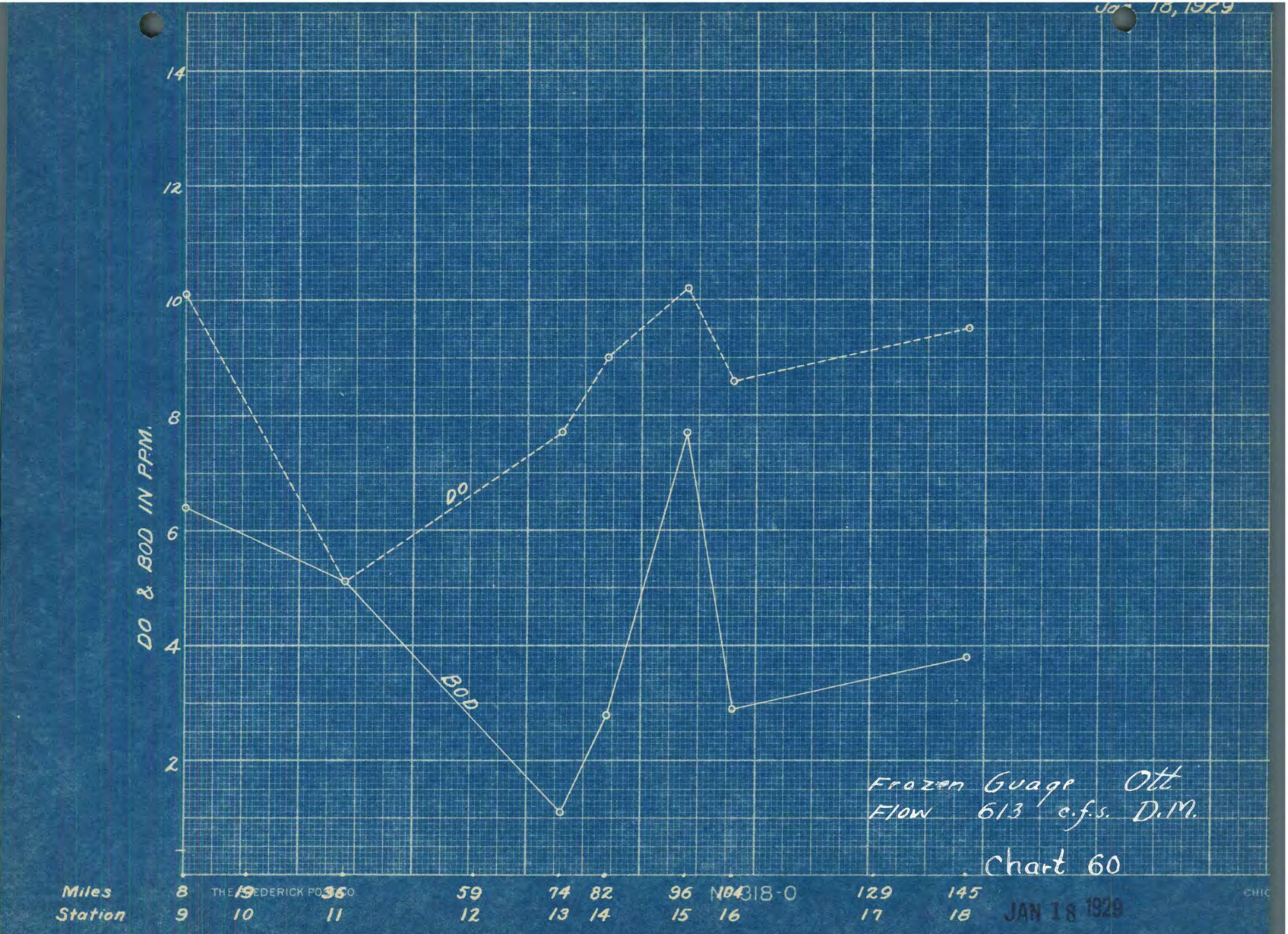

Sept. 27, 1928.
DO
BOD
DO & BOD IN P.P.M.
14
12
10
8
6
4
2
Flow 2565 c.f.s. Ott.
Flow 945 c.f.s. D.M.
chart 56
Miles 8 19 36 59 74 82 96 104 129 145
Station 9 10 11 12 13 14 15 16 17 18
SEP 27 1928


Oct. 10, 1928.
DO & BOD IN P.P.M.
14
12
10
8
6
4
2
BOD
DO
Miles 8 19 36 59 74 82 96 104 129 145
Station 9 10 11 12 13 14 15 16 17 18
Flow 1830 c.f.s. Ott.
Flow 481 c.f.s D.M.
chart 57
OCT 10 1928

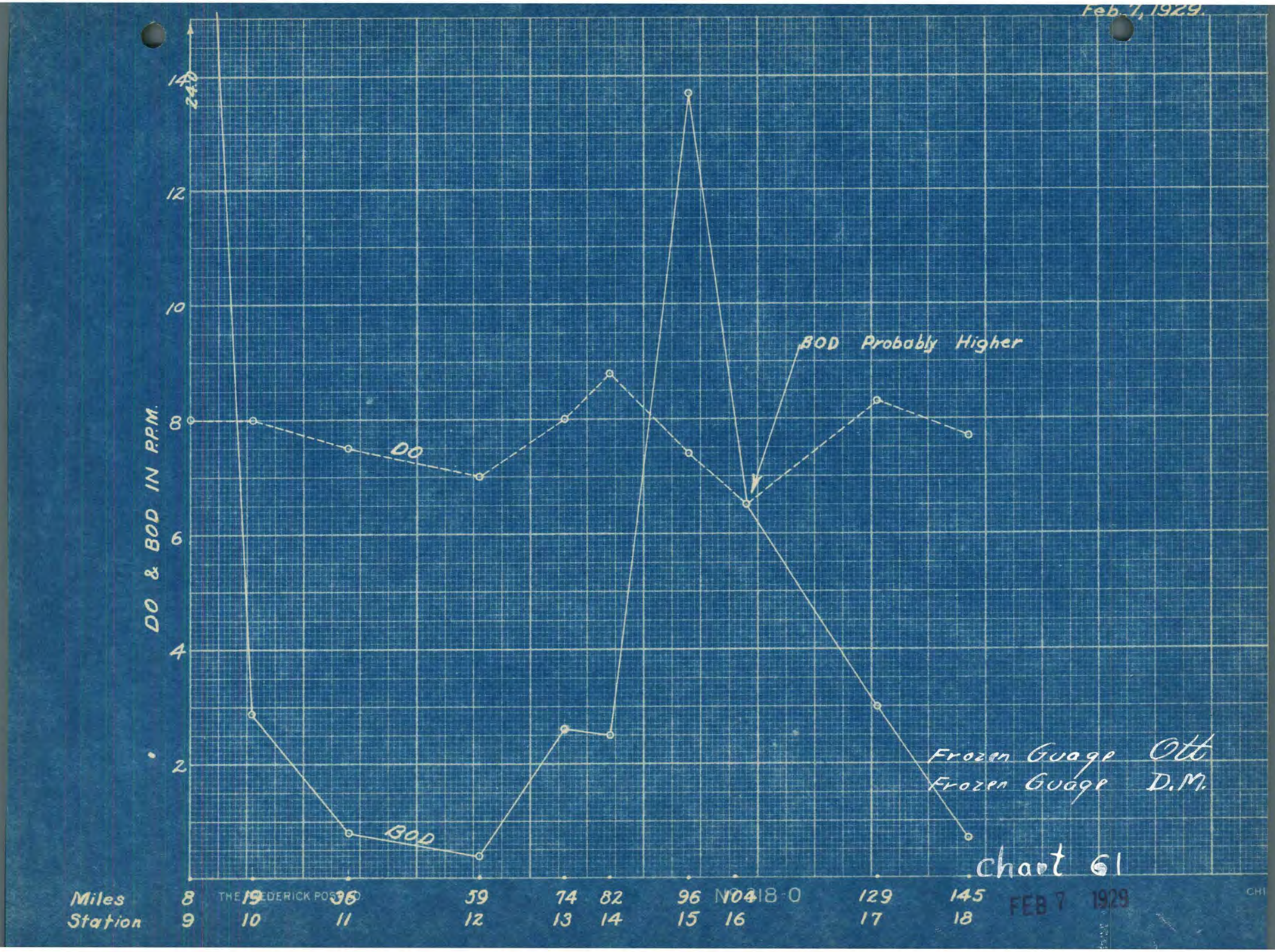


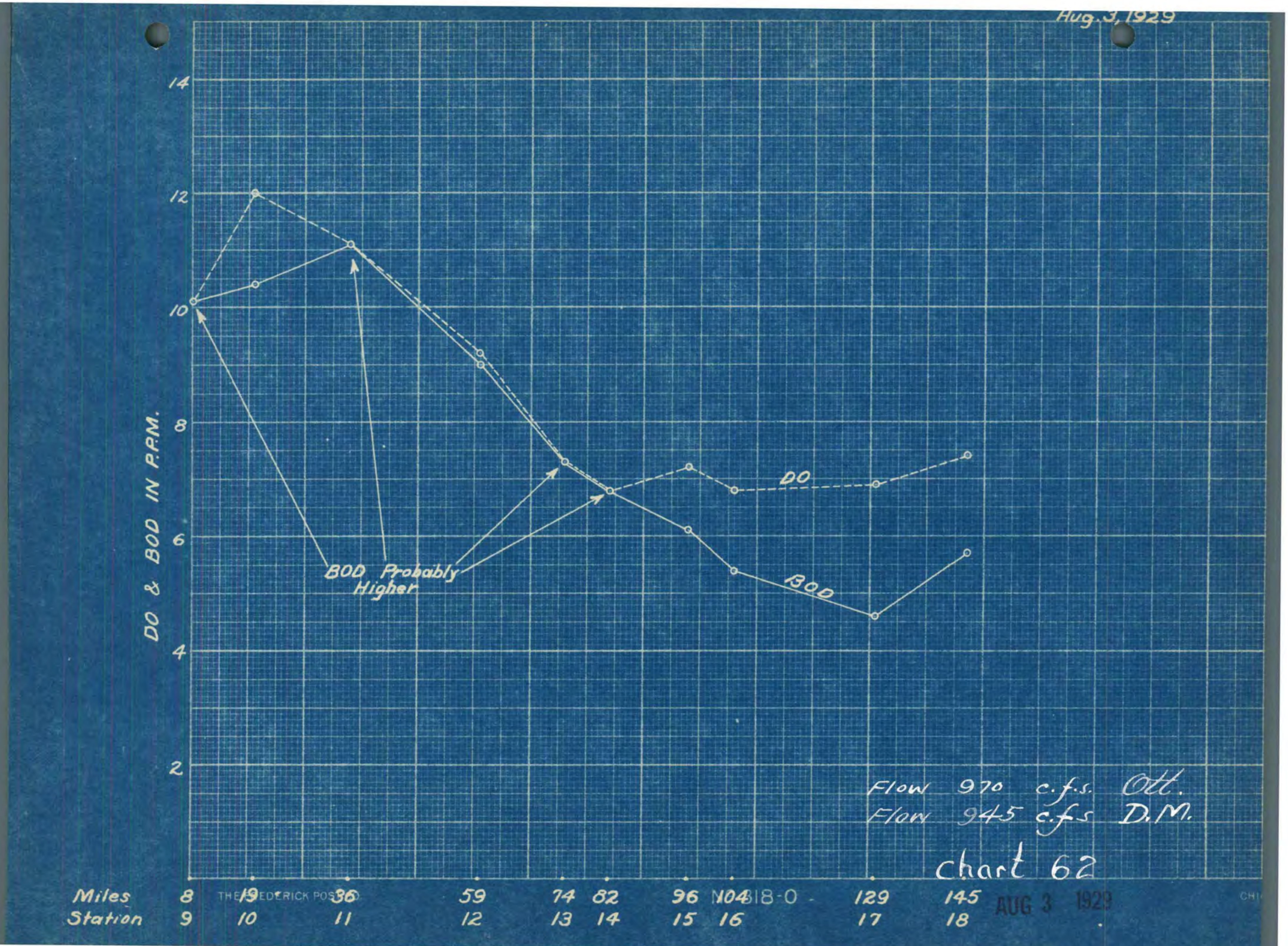
Dec. 28, 1928.
DO & BOD IN P.P.M.
14
12
10
8
6
4
2
DO
BOD
Flow 5710 c.f.s. Ott.
Flow 2165 c.f.s D.M.
Chart 58
Miles 8 19 36 59 74 82 96 104 129 145
Station 9 10 11 12 13 14 15 16 17 18

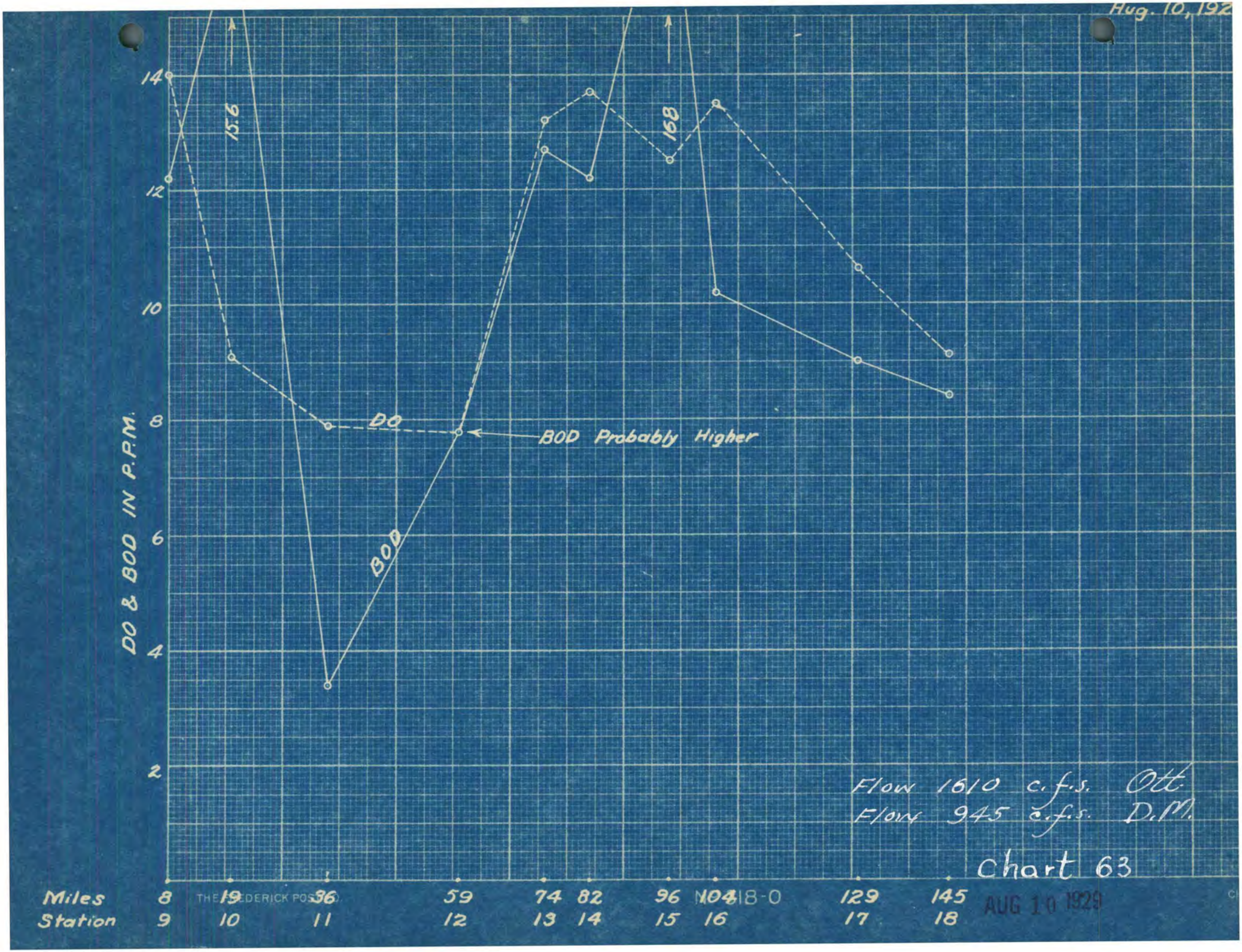

Jan. 9, 1929.
DO & BOD IN P.P.M.
14
12
10
8
6
4
2
DO
BOD
Flow 2180 c.f.s. Ott.
Flow 1245 c.f.s. D.M.
Chart 59
Miles 8 19 36 59 74 82 96 104 129 145
Station 9 10 11 12 13 14 15 16 17 18
JAN 9 1929



Jan 18, 1929
14
12
10
8
6
4
2
DO & BOD IN P.P.M.
DO
BOD
Frozen Guage Ott
Flow 613 c.f.s. D.M.
Chart 60
Miles 8 19 36 59 74 82 96 104 129 145
Station 9 10 11 12 13 14 15 16 17 18
THE FREDERICK POST CO
NO 318-0
CHIC
JAN 18 1929


Feb. 7, 1929.
DO & BOD IN P.P.M.
14
24.0
12
10
8
6
4
2
DO
BOD
BOD Probably Higher
Frozen Guage Ott
Frozen Guage D.M.
Chart 61
Miles 8 19 36 59 74 82 96 104 129 145
Station 9 10 11 12 13 14 15 16 17 18
FEB 7 1929


Aug. 3, 1929
DO & BOD IN P.P.M.
14
12
10
8
6
4
2
DO
BOD
BOD Probably Higher
Flow 970 c.f.s. Ott.
Flow 945 c.f.s. D.M.
Chart 62
Miles 8 19 36 59 74 82 96 104 129 145
Station 9 10 11 12 13 14 15 16 17 18
AUG 3 1929


Aug. 10, 192
DO & BOD IN P.P.M.
14
12
10
8
6
4
2
15.6
168
DO
BOD
BOD Probably Higher
Flow 1610 c.f.s. Ott.
Flow 945 c.f.s. D.M.
Chart 63
Miles 8 19 36 59 74 82 96 104 129 145
Station 9 10 11 12 13 14 15 16 17 18
AUG 10 1929

Sept. 4, 1929

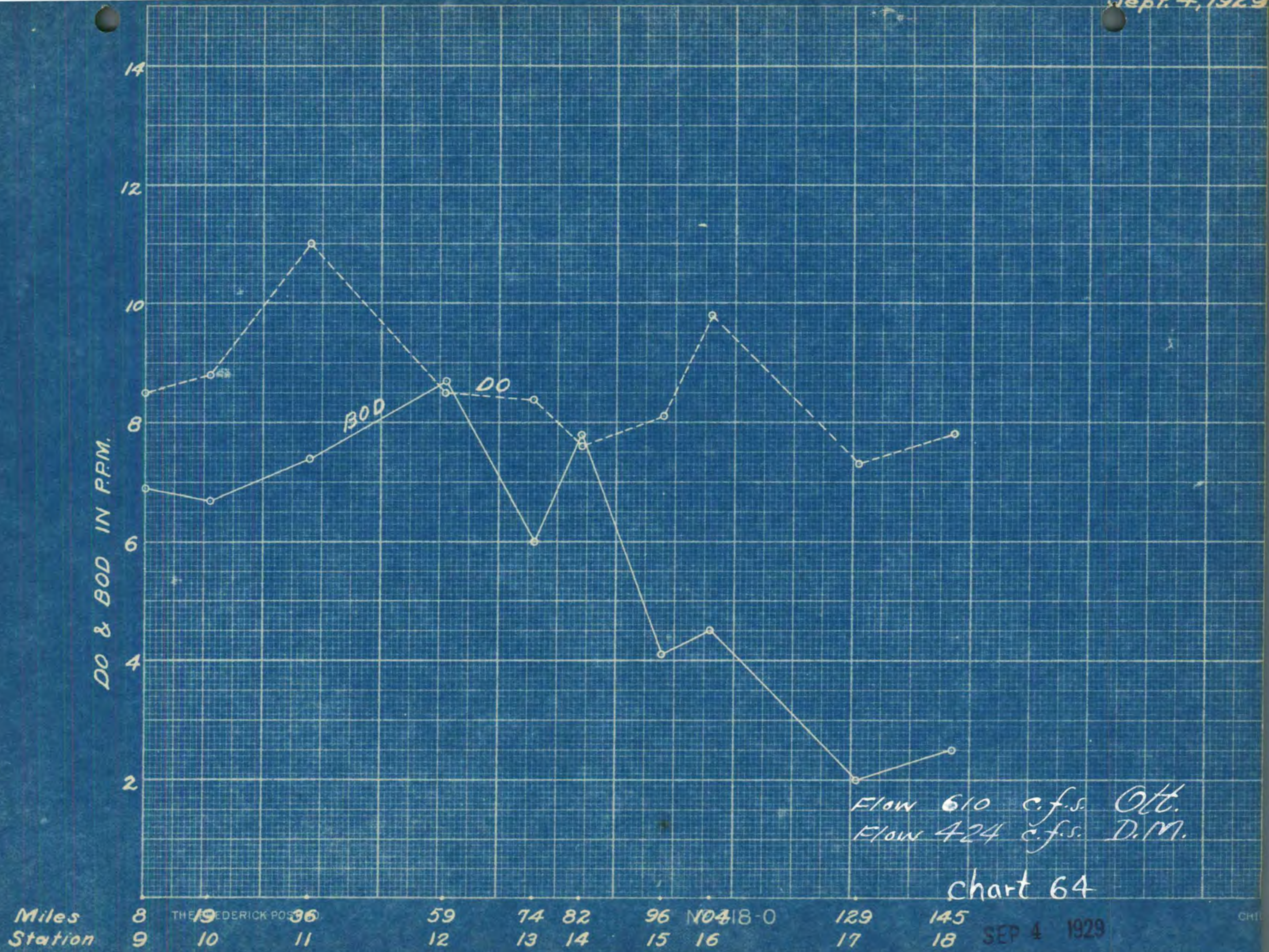
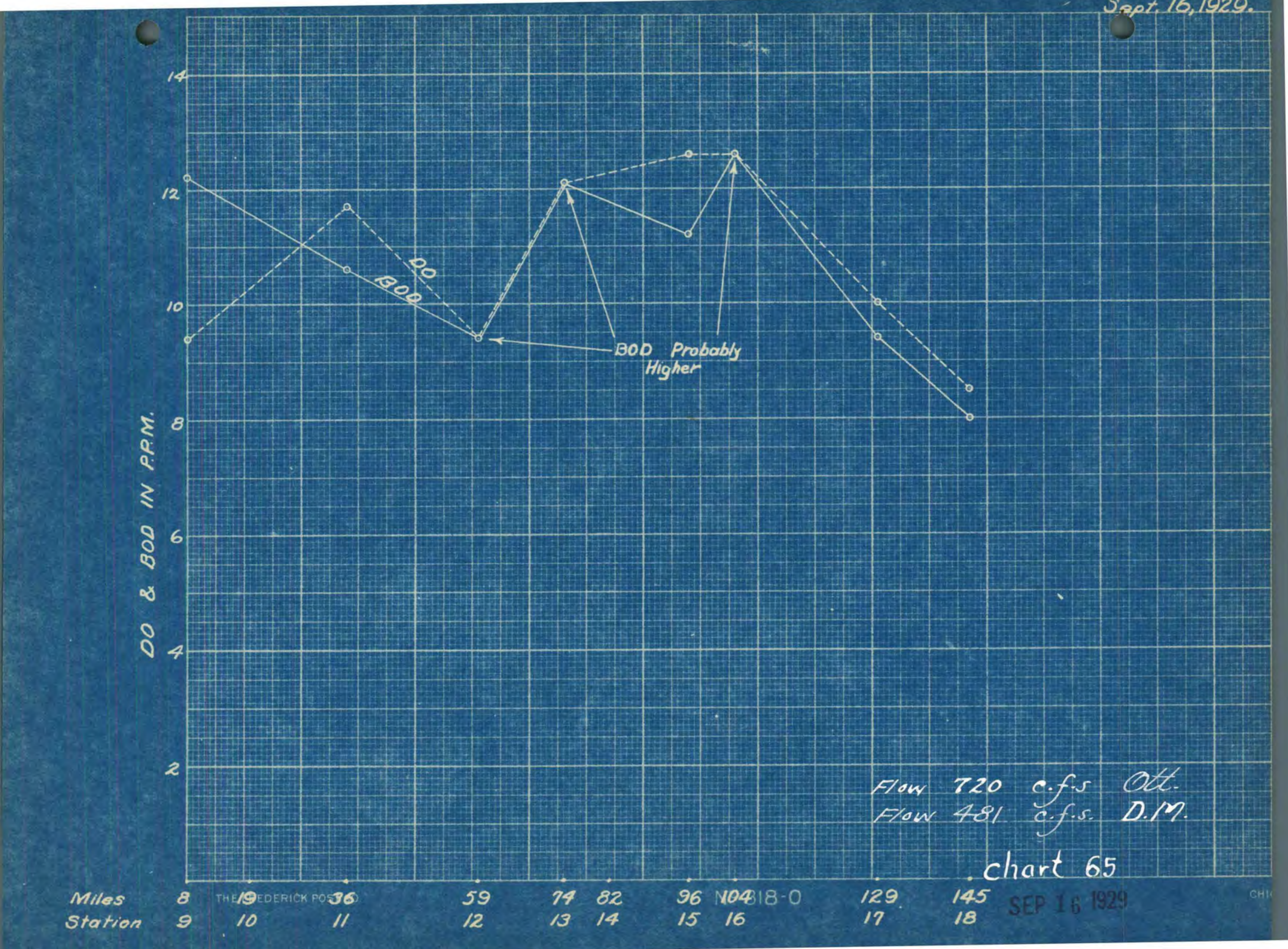


Chart 64



Sept. 16, 1929.
DO & BOD IN P.P.M.
14
12
10
8
6
4
2
DO
BOD
BOD Probably Higher
Flow 720 c.f.s Ott.
Flow 481 c.f.s. D.M.
chart 65
Miles 8 19 36 59 74 82 96 104 129 145
Station 9 10 11 12 13 14 15 16 17 18
SEP 16 1929

Sept. 28, 1929.

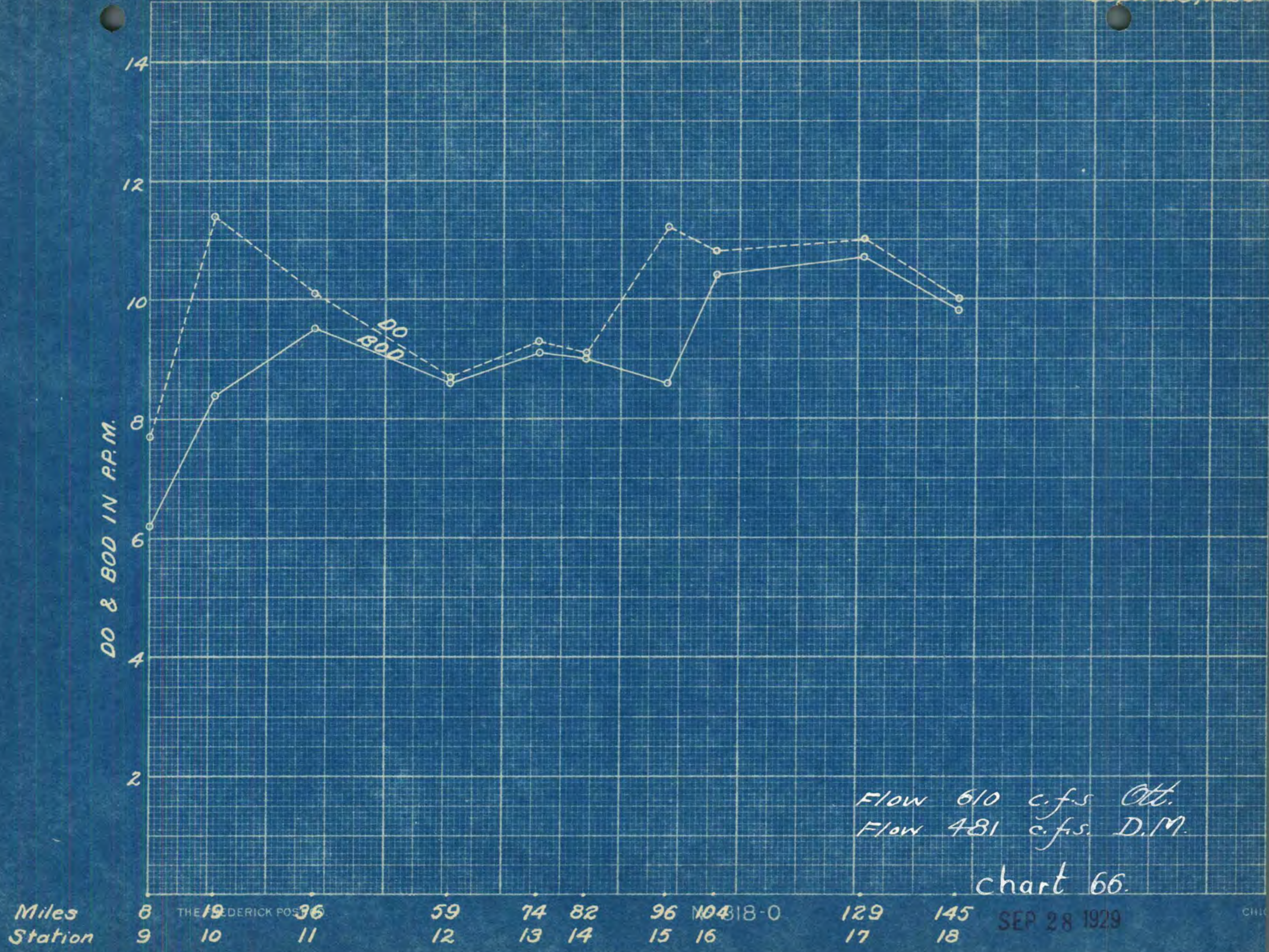
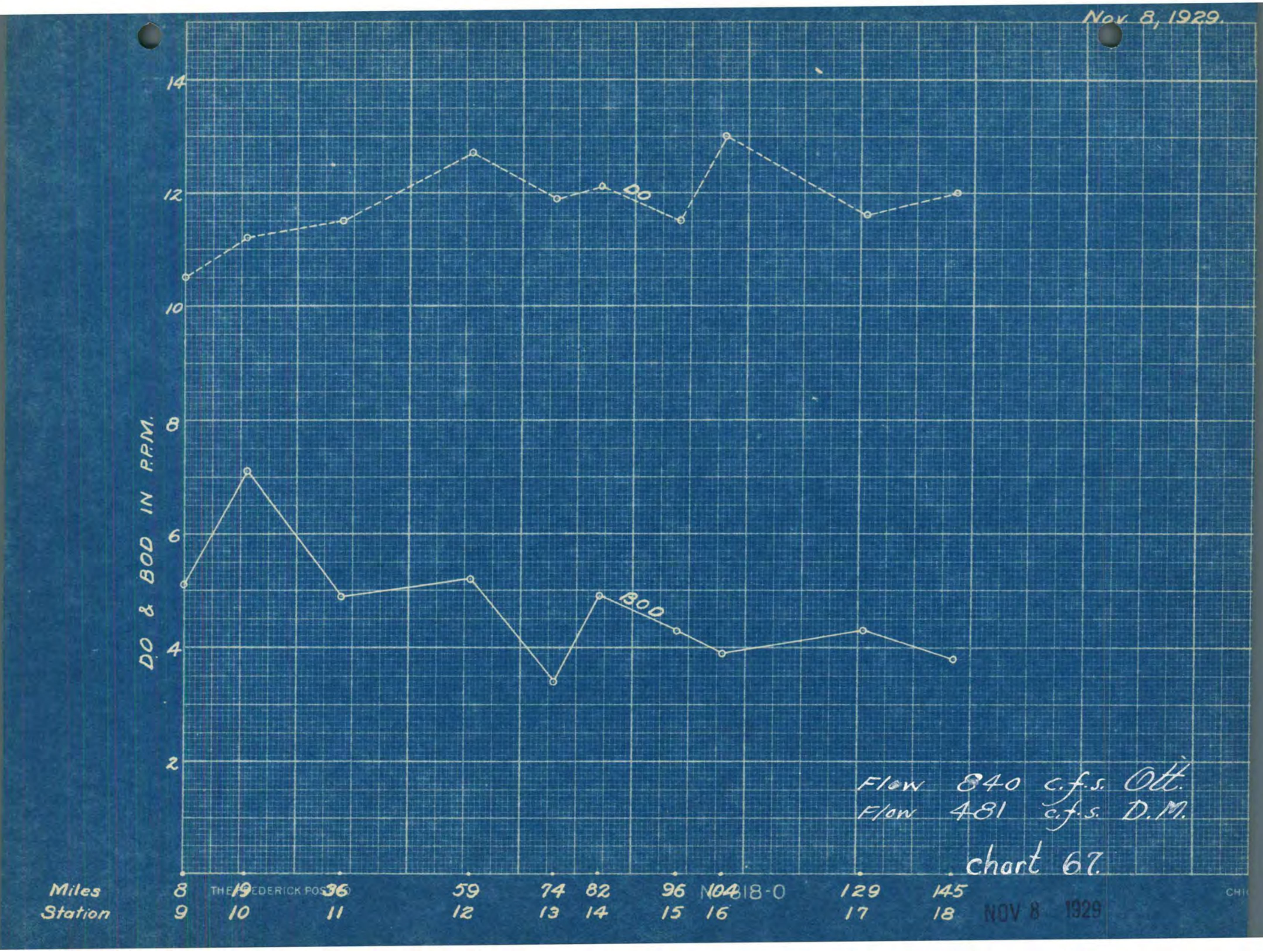
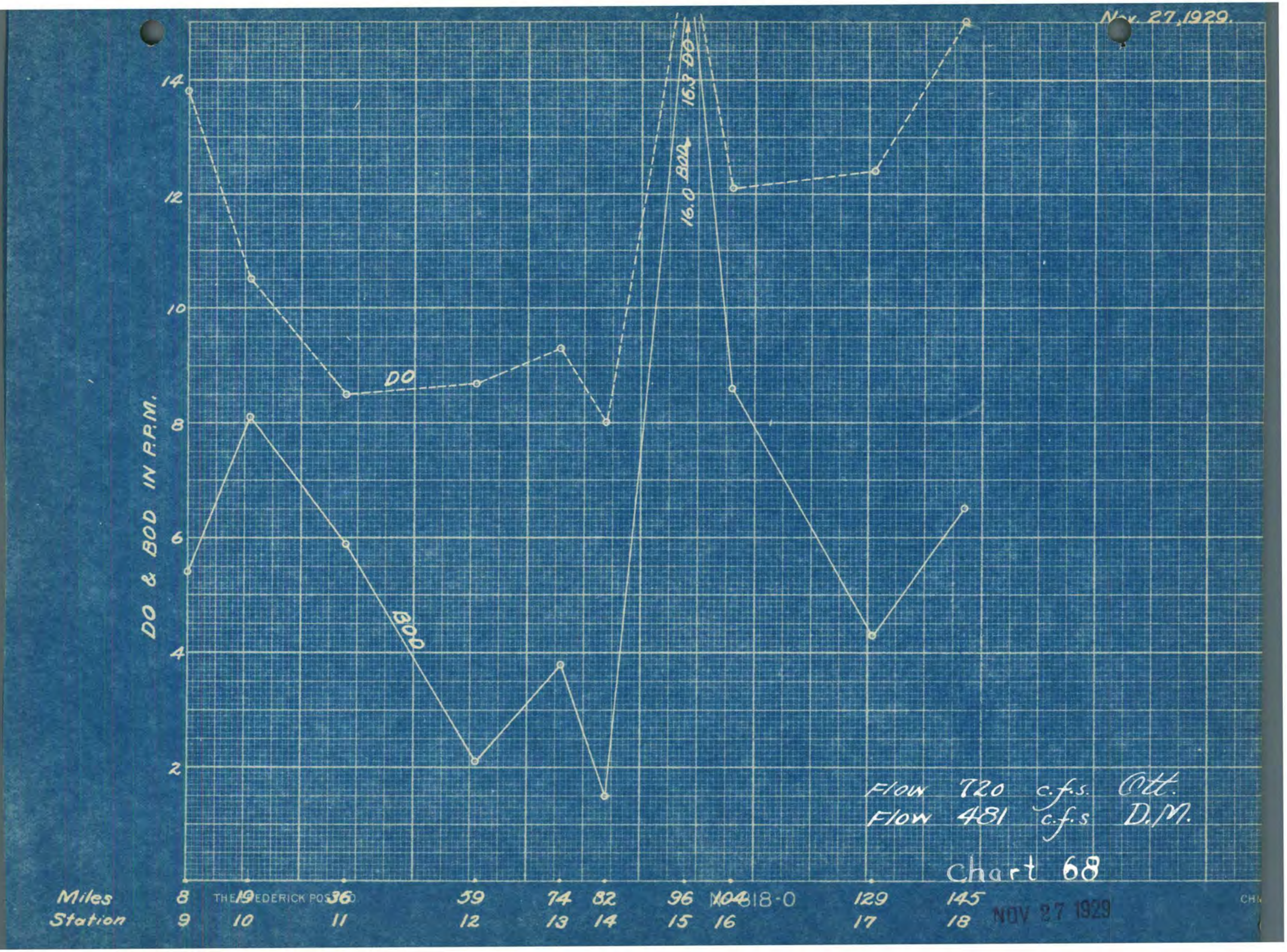


chart 66.


Nov. 8, 1929.
DO & BOD IN P.P.M.
14
12
10
8
6
4
2
DO
BOD
Flow 840 c.f.s. Ott.
Flow 481 c.f.s. D.M.
Chart 67.
Miles
Station
8 19 36 59 74 82 96 104 129 145
9 10 11 12 13 14 15 16 17 18
NOV 8 1929



Nov. 27, 1929.
DO & BOD IN P.P.M.
14
12
10
8
6
4
2
DO
BOD
16.0 BOD
16.3 DO
Flow 720 c.f.s. Ott.
Flow 481 c.f.s D.M.
Chart 68
Miles 8 19 36 59 74 82 96 104 129 145
Station 9 10 11 12 13 14 15 16 17 18
THE FREDERICK POST CO.
1818-0
NOV 27 1929

Dec. 4, 1929.

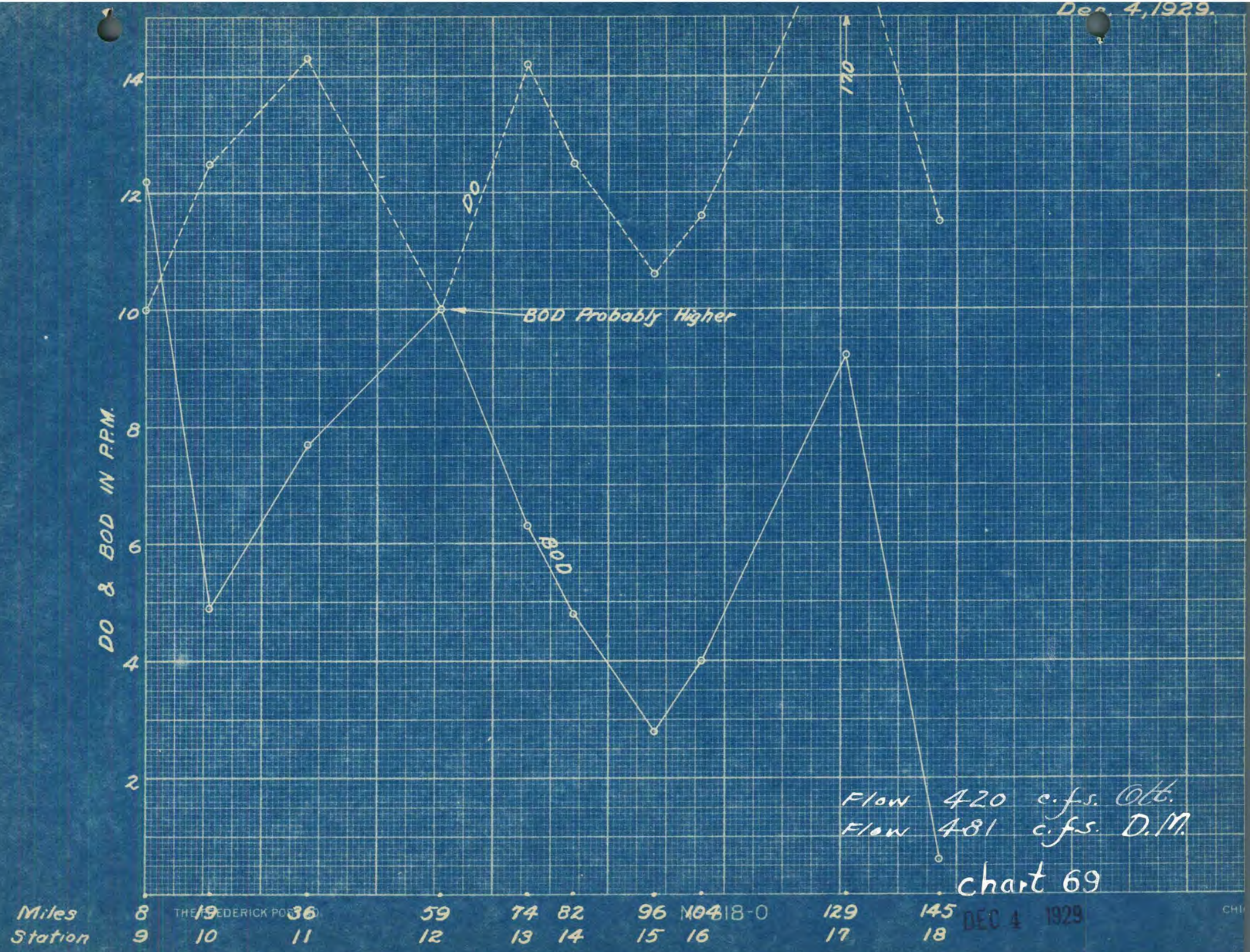
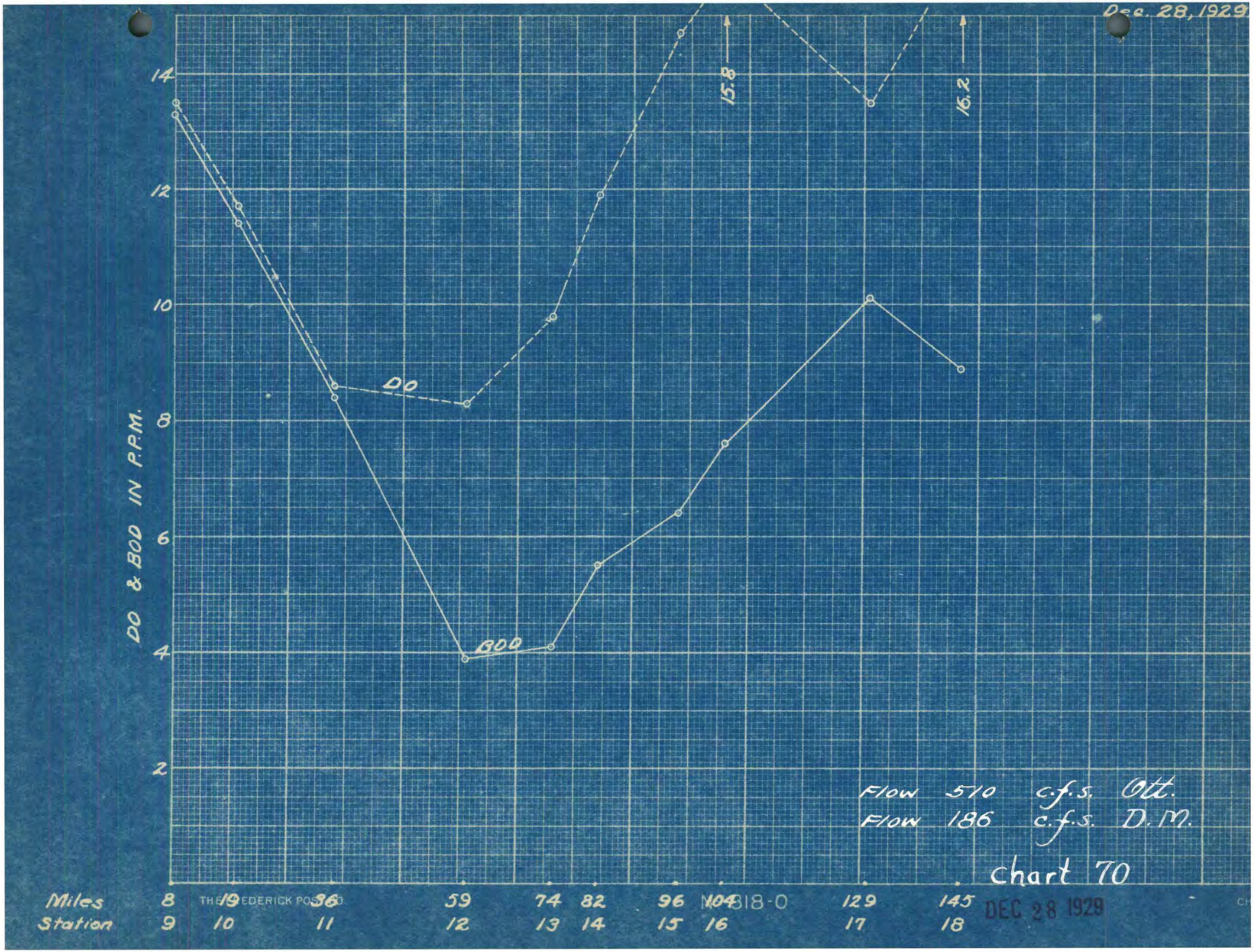
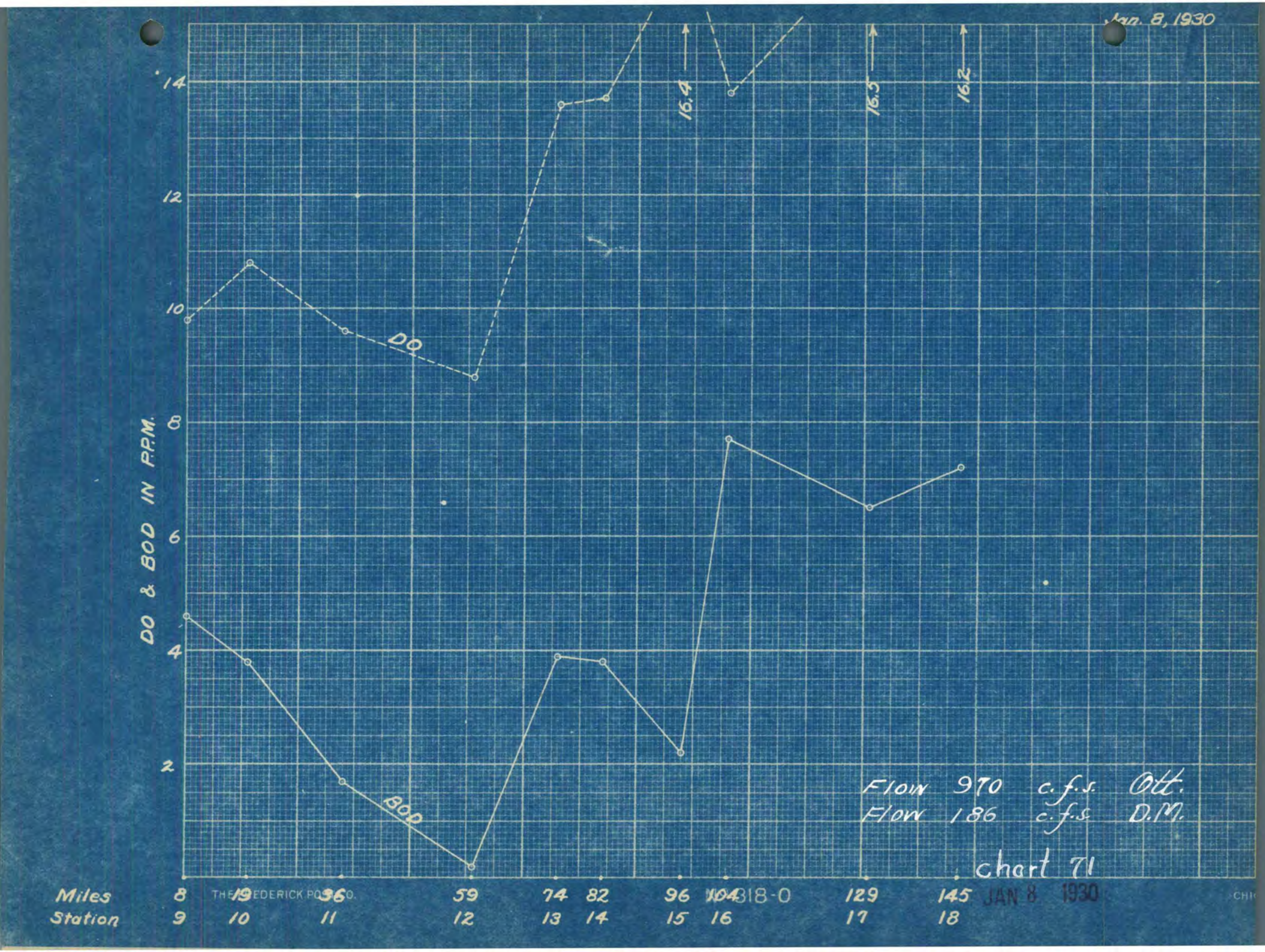
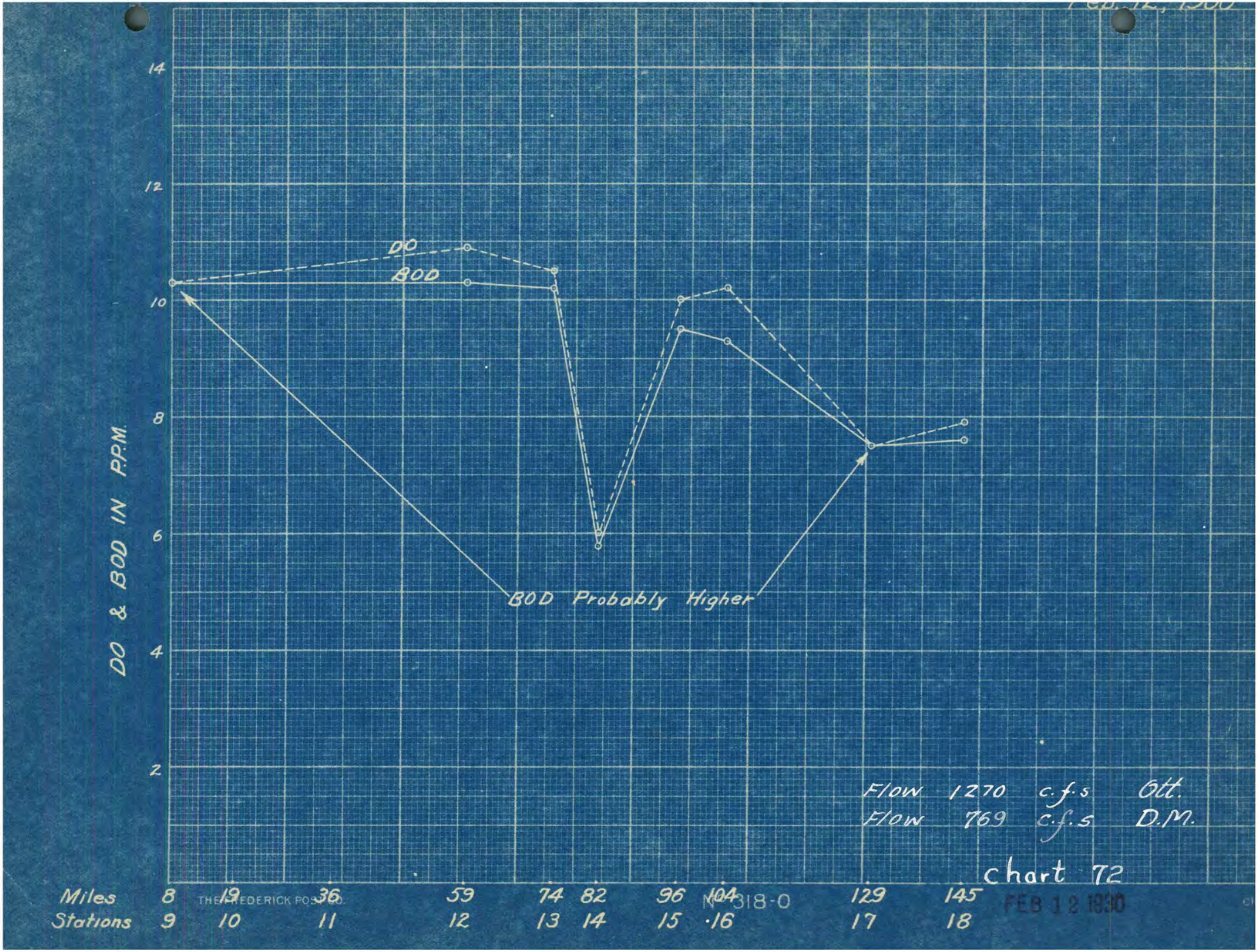


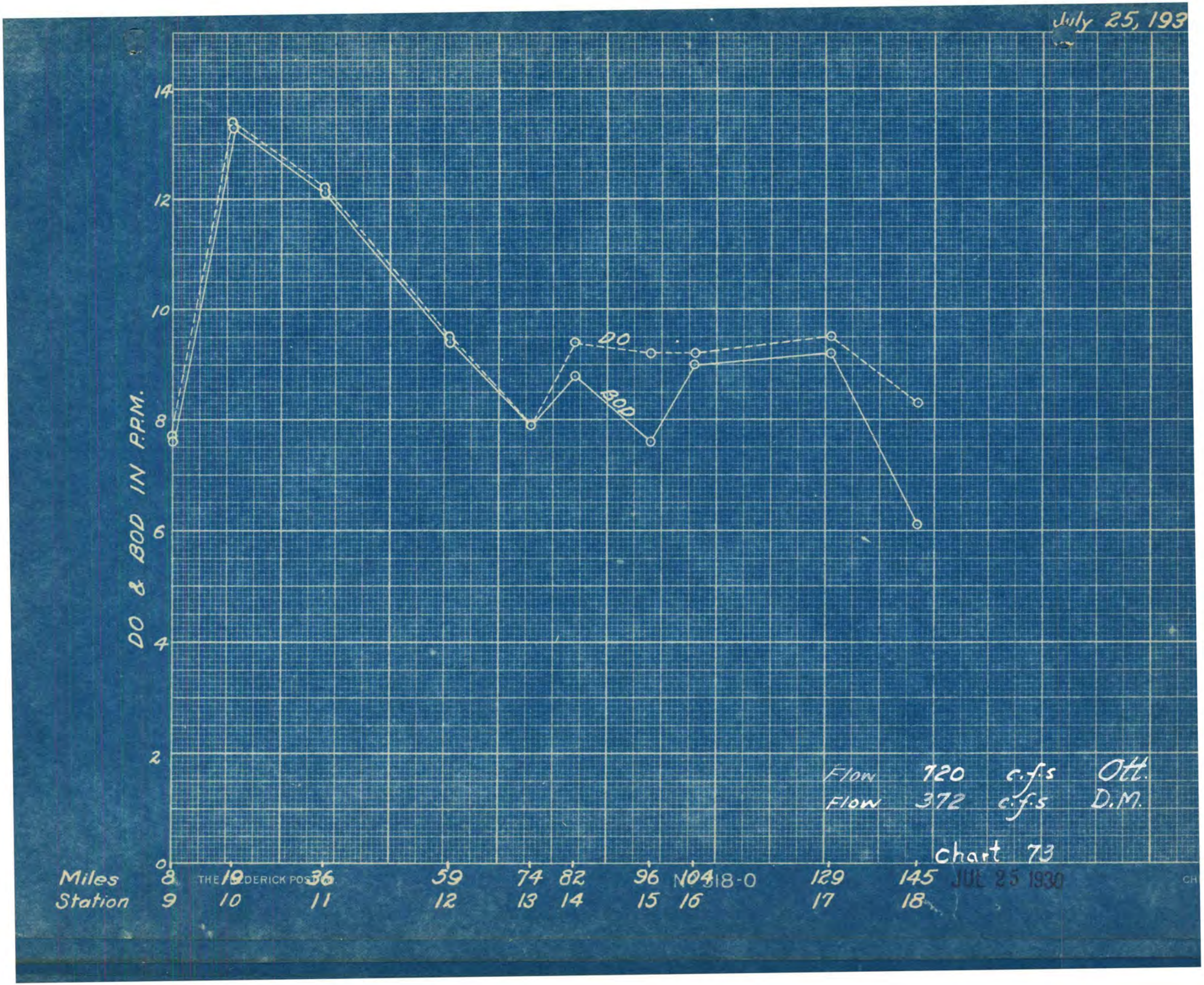
Chart 69

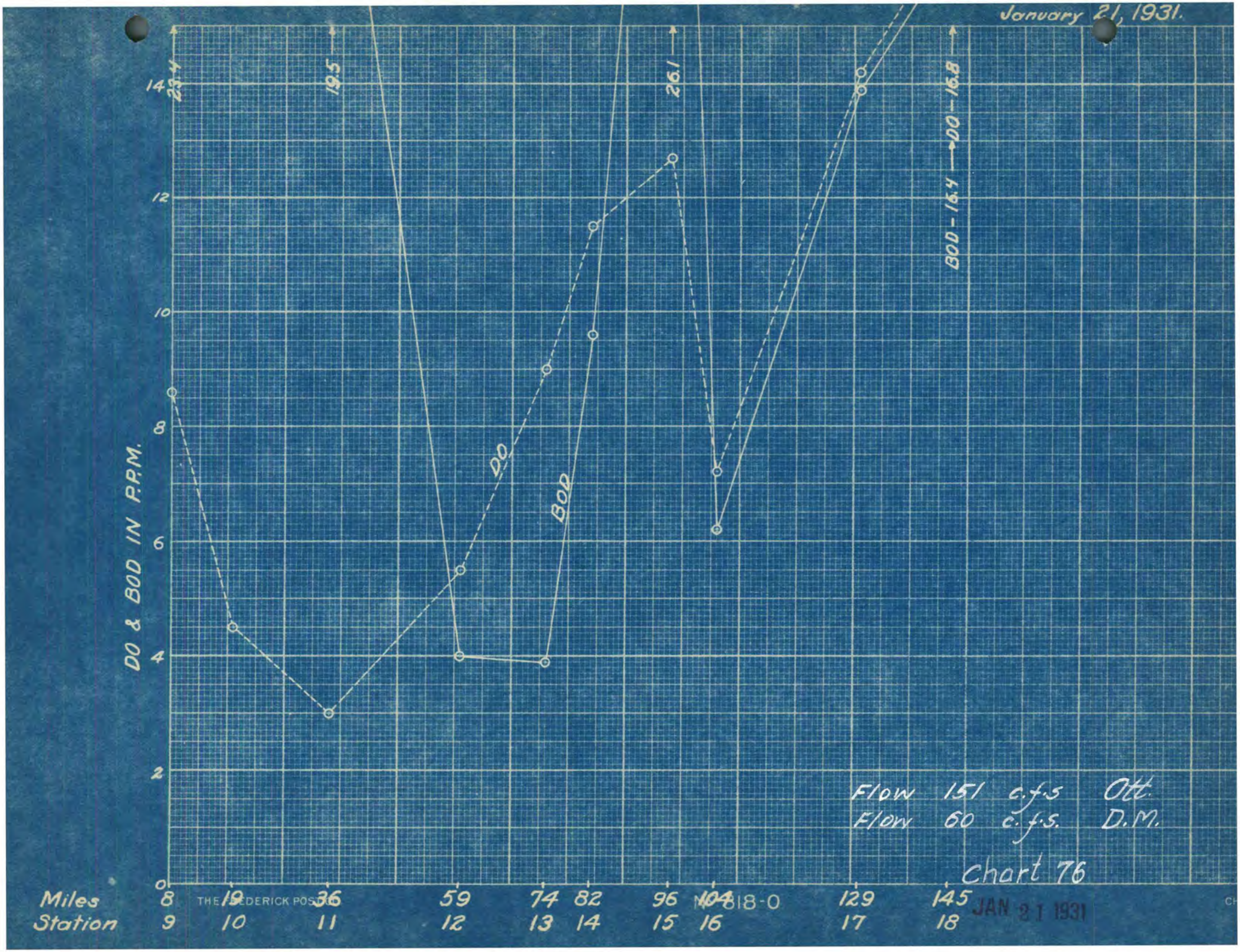


Dec. 28, 1929
DO & BOD IN P.P.M.
14
12
10
8
6
4
2
DO
BOD
15.8
16.2
Flow 510 c.f.s. Ott.
Flow 186 c.f.s. D.M.
Chart 70
Miles 8 19 36 59 74 82 96 104 129 145
Station 9 10 11 12 13 14 15 16 17 18
DEC 28 1929


Jan. 8, 1930
DO & BOD IN P.P.M.
14
12
10
8
6
4
2
DO
BOD
16.4
16.5
16.2
Flow 970 c.f.s. Ott.
Flow 186 c.f.s. D.M.
Chart 71
JAN 8 1930
Miles 8 19 36 59 74 82 96 104 129 145
Station 9 10 11 12 13 14 15 16 17 18


DO & BOD IN P.P.M.
14
12
10
8
6
4
2
DO
BOD
BOD Probably Higher
Flow 1270 c.f.s Ott.
Flow 769 c.f.s D.M.
Miles 8 19 36 59 74 82 96 104 129 145
Stations 9 10 11 12 13 14 15 16 17 18
THE FREDERICK POST CO.
No 318-0
FEB 12 1930
Chart 72


July 25, 193
DO & BOD IN P.P.M.
14
12
10
8
6
4
2
0
DO
BOD
Flow 720 c.f.s Ott.
Flow 372 c.f.s D.M.
Chart 73
Miles 8 19 36 59 74 82 96 104 129 145
Station 9 10 11 12 13 14 15 16 17 18
THE FREDERICK POST CO.
No 318-0
JUL 25 1930


January 21, 1931.
DO & BOD IN P.P.M.
23.4
19.5
26.1
BOD - 16.4 → DO - 16.8
DO
BOD
Flow 151 c.f.s. Ott.
Flow 60 c.f.s. D.M.
Chart 76
Miles 8 19 36 59 74 82 96 104 129 145
Station 9 10 11 12 13 14 15 16 17 18
THE FREDERICK POST CO.
JAN 21 1931

APPENDIX F

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CHARTS #78 TO #82

INCLUSIVE

SHOWING AVERAGE OXYGEN RESOURCES

AT DIFFERENT RIVER STAGES.

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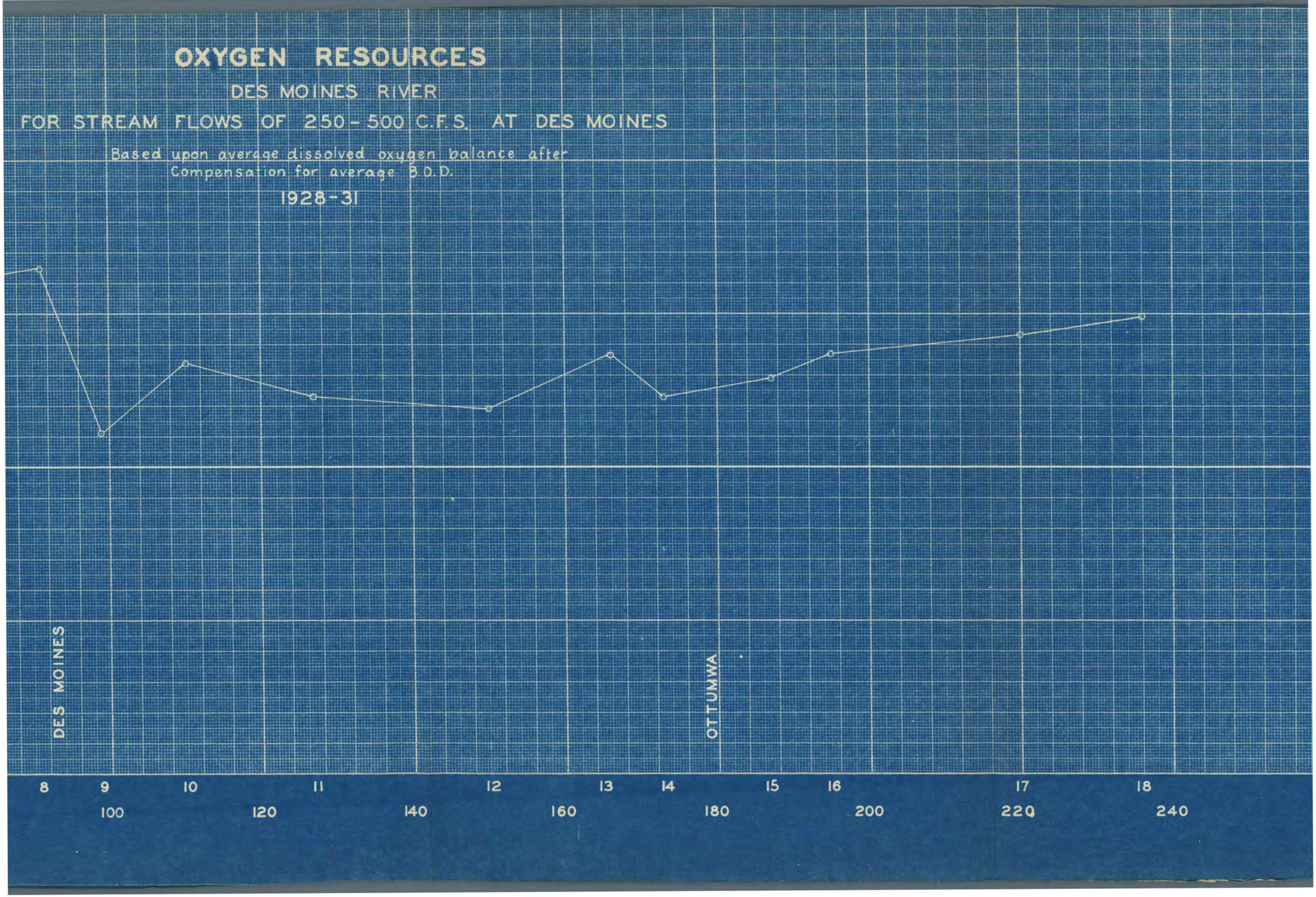
OXYGEN RESOURCES
DES MOINES RIVER
FOR STREAM FLOWS LESS THAN 250 C.F.S. AT DES MOINES
Based upon average dissolved oxygen balance after compensation for average B.O.D.
1928 - 31
DES MOINES
OTTUMWA
8
9
10
11
12
13
14
15
16
17
18
100
120
140
160
180
200
220
240


OXYGEN RESOURCES
DES MOINES RIVER
FOR STREAM FLOWS OF 250-500 C.F.S. AT DES MOINES
Based upon average dissolved oxygen balance after
Compensation for average B.O.D.
1928-31
DES MOINES
OTTUMWA
8
9
10
11
12
13
14
15
16
17
18
100
120
140
160
180
200
220
240

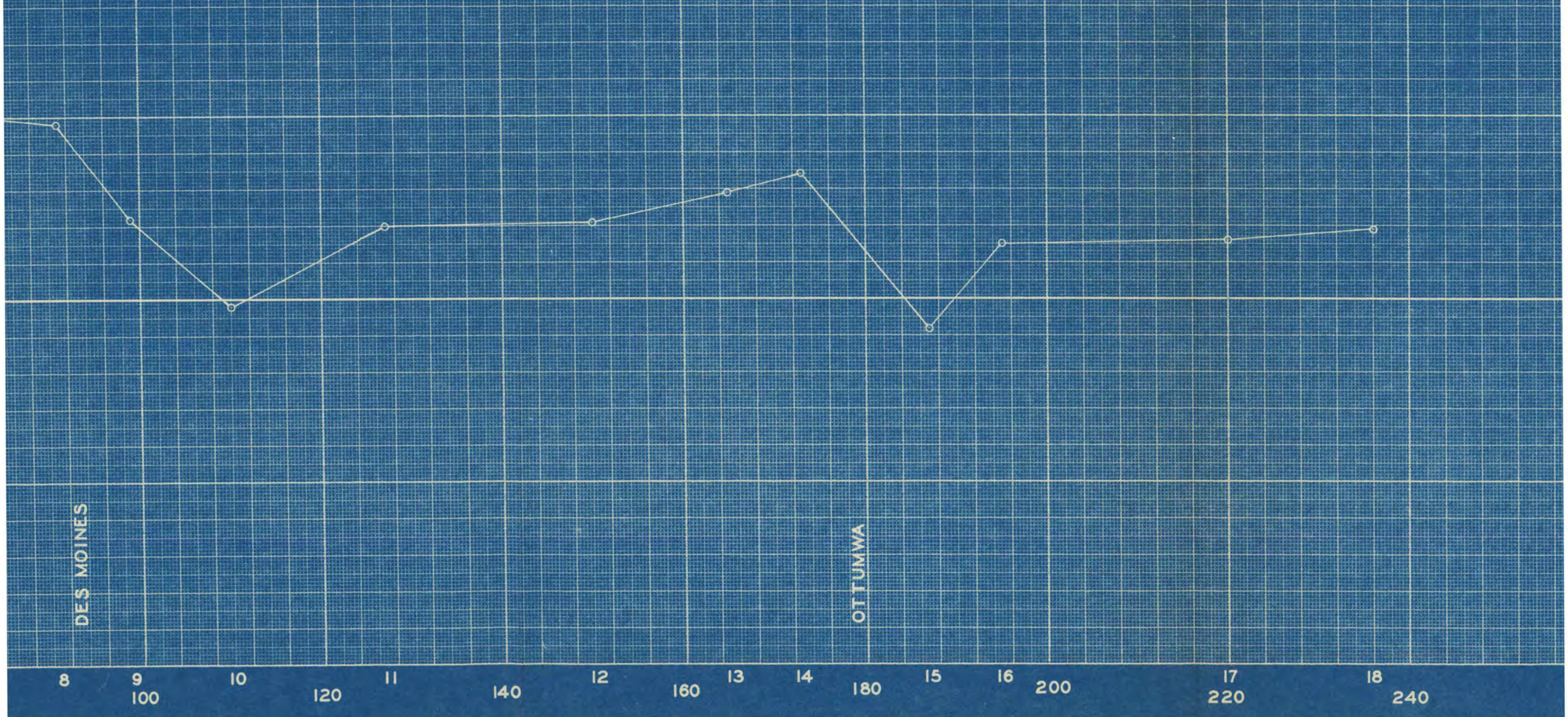
OXYGEN RESOURCES

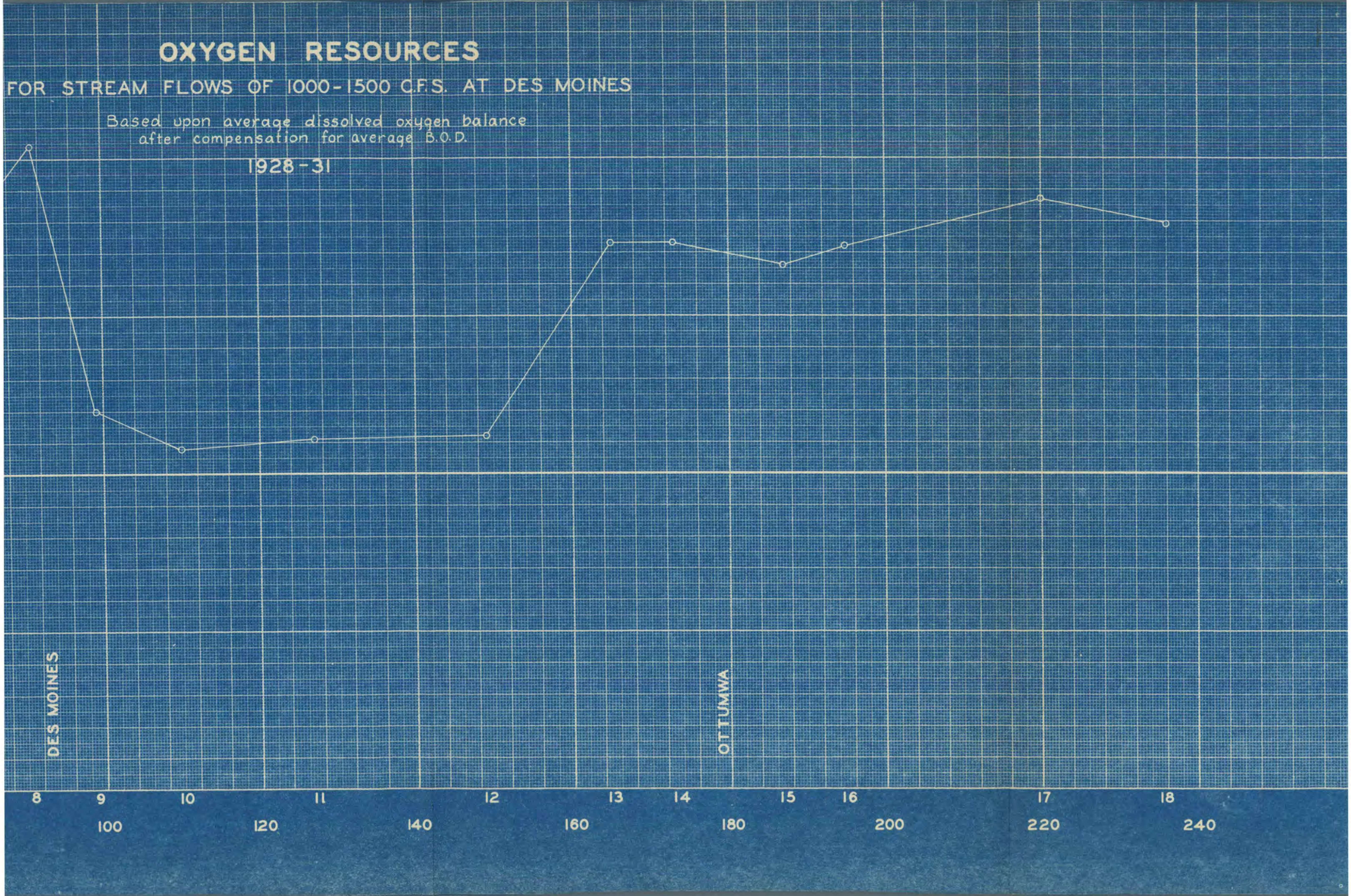
DES MOINES RIVER

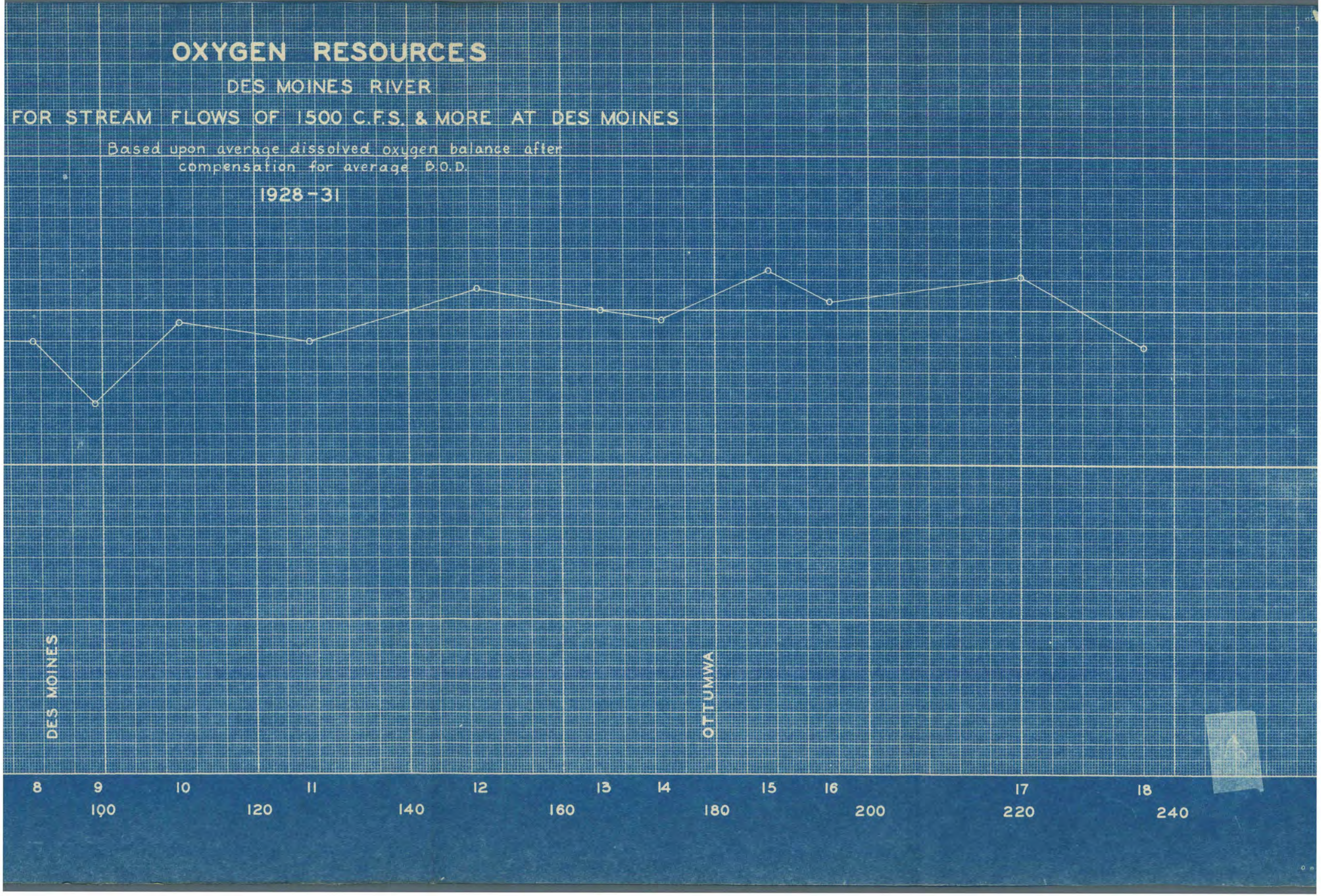
FOR STREAM FLOWS OF 500-1000 C.F.S. AT DES MOINES

Based upon average dissolved oxygen balance after compensation for average B.O.D.

1928-31




OXYGEN RESOURCES
FOR STREAM FLOWS OF 1000-1500 C.F.S. AT DES MOINES
Based upon average dissolved oxygen balance
after compensation for average B.O.D.
1928-31
DES MOINES
OTTUMWA
8
9
10
11
12
13
14
15
16
17
18
100
120
140
160
180
200
220
240


OXYGEN RESOURCES
DES MOINES RIVER
FOR STREAM FLOWS OF 1500 C.F.S. & MORE AT DES MOINES
Based upon average dissolved oxygen balance after
compensation for average B.O.D.
1928-31
DES MOINES
OTTUMWA
8
9
10
11
12
13
14
15
16
17
18
100
120
140
160
180
200
220
240