MONTANA STATE BOARD OF HEALTH

and

MONTANA STATE FISH AND GAME DEPARTMENT

THREE FORKS AREA WATER QUALITY STUDY

Progress Report Number 1

October 1959 to September 1960

Introduction

Investigations concerned with water quality must be conducted over a long period of time if the normal variations in the chemical and physical aspects of a body of water are to be determined. This study, concerned with water quality of the main upper Missouri River streams, is scheduled to be conducted over a three or possibly four-year period. This report is concerned with water quality data collected during the first year of the study - - October 1959 to September 1960.

The upper Missouri River Drainage, more commonly referred to as the Three Forks Drainage area, consist of some 16,000 square miles located in Southwestern Montana. A map of the Three Forks Drainage area is shown on Figure 1. The main streams in this drainage, and those with which this study is concerned are the Beaverhead, Big Hole, Jefferson, Madison and Gallatin Rivers. The Jefferson, Madison and Gallatin Rivers flow together at Trident, Montana, (a short distance northeast of Three Forks, Montana), to form the Missouri River. The Beaverhead and Big Hole Rivers flow together near Twin Bridges, Montana to form the Jefferson River. For a description of the Three Forks Drainage area the reader is referred to a 1958 report by the U. S. Fish and Wildlife Service entitled Three Forks Division, Montana.

The primary use of the waters within the area is for irrigation and recreation. Several streams serve as municipal water supplies, and some receive small amounts of sewage and mine wastes. In general, few streams in the Three Forks Drainage area are polluted. The Montana State Board of Health has conducted an extensive pollution survey of the Missouri River Drainage, which includes the Three Forks area. The results of this survey are presented in a report entitled Water Pollution in the Missouri River Drainage, Report 60-1, 1960.

Many streams within the area undergo severe irrigation drawdown, but evidence indicates that the larger streams are never completely de-watered, except a 2-3 mile stretch of the West Gallatin River which is dried up each summer. Severe irrigation drawdown greatly lessens available fish habitat, creates conditions favorable to higher water temperatures, and return irrigation water often carries a high silt load. Fishing is the primary outdoor recreation in the area, and several of the main streams, viz. the Madison and Big Hole Rivers, are world renowned for their large trout and excellent fishing.

Man could not for long leave such a vast supply of water untouched. The Bureau of Reclamation has proposed a number of development projects for the Three Forks Drainage area. These projects are designed to re-distribute water from one area to another, and take the form of impoundments, ditches, flumes, canals and, in one case, wells. The ultimate objective is to supply irrigation water for dry benchlands, and to produce hydro-electric power. A discussion of these projects and their anticipated effect upon the present fishery resource is discussed in the above U. S. Fish and Wildlife Service Report.

Design and Purpose of Study

There are two main reasons for this study. The most important at this time is to establish a "yardstick" of water quality with which to measure future changes due to proposed development projects. That is, to determine what the water quality is before any projects are initiated so that changes can be noted. The second reason is to establish water quality information for industry and other agencies wishing to use the waters within the area in future years.

Samples were collected at various locations (see Figure 1) from the Beaverhead, Big Hole, Jefferson, Madison and Gallatin Rivers. One sample (Station 17), was collected in the Missouri River about one-half mile downstream from where this river is formed at Trident, Montana by waters of the Jefferson, Madison and Gallatin Rivers. Incomplete mixing was noted at this station, and future samples taken on the Missouri River will be collected at Toston, Montana, a considerable distance below Trident, Montana. In addition to the samples collected in these rivers, a sample (Station 18), beginning in December 1959, was collected monthly in Ten Mile Creek west of Helena, Montana. Ten Mile Creek is out of the Three Forks Drainage area and thus serves as a control stream to which water quality data from the streams within the Three Forks Drainage area can be compared.

Sampling stations are designated either primary or secondary. Primary stations are located at or near the mouth of the stream under consideration, and secondary stations are located along their length. Sampling at the primary stations was conducted once a month, and during the first year's study before the middle of each month. The secondary stations were sampled four times a year - - during late fall, before spring runoff, during spring runoff, and at late summer during the period of irrigation drawdown and low stream flows. For a descriptive location of the sampling stations see Table 1.

At each primary station the water samples collected were analyzed for pH, total dissolved solids (T.D.S.), Turbidity (Turb.), Hardness as $CaCO_3$ (Hard), bicarbonates (HCO_3), sulfates (SO_4), Calcium (Ca), Magnesium (Mg), and Carbonates (CO_3). At the secondary stations water samples were analyzed only for pH, total dissolved solids and turbidity. Temperature (Temp.) were taken each time a water sample was collected. Future samples collected at the primary stations will also be analyzed for chlorides.

Whenever possible water samples were collected at the stream center, or wherever the flow appeared the greatest. A Kemmerer water bottle, a device for collecting water samples, was often employed when sampling from a bridge crossing. The determination of pH was conducted at streamside using a Hellige Color Comparator. Water samples were collected in one-liter polyethylene bottles and transported to the Montana State Board of Health Chemistry Laboratory at Helena. All chemical determinations, except total dissolved solids, were made in accordance with Standard Methods for the Examination of Water, Sewage, and Industrial Wastes 10th Edition, 1955. The approximation of total dissolved solids was determined with a National Aluminate Corporation Nalcometer, an electrical device for measuring conductivity in water. The readings given for total dissolved solids are probably slightly lower than actually present in the streams sampled. A high bicarbonate content is present in the streams sampled, and bicarbonates have lower conductivity values than sulfate and chloride salts. The factor used with the Nalcometer considers the presence of all these salts. During the 1960-1961 sampling year total dissolved solids will be determined using both the Nalcometer (conductivity) and gravimetric methods. When this is done a comparison between the two methods can be made.

During some winter months water samples were not obtained because of ice-cover on the streams. Such was the case for every primary station during March 1960 except the Madison River at Three Forks (Station 7). Ice-cover prevented sampling on the Jefferson River (Station 16), during the months of January, February and March 1960.

In conducting a water quality study such as this it is, of course, desirable to have relative flow data of the streams being sampled. Unfortunately flow data were not available for every stream station, and the flow-measuring equipment we have is not applicable for large streams. Flow data for five of the streams sampled were available from the Helena, Montana office of the U. S. Geological Survey. These available flow data are tabulated in cubic feet per second on Table 2, and represent flows of the Gallatin, Big Hole, Beaverhead, Jefferson and Missouri Rivers. For the Gallatin, Beaverhead and Jefferson Rivers flow data were available at the primary sampling stations. Flow data for the Big Hole River at its primary station (Station 10) were not available, therefore, flow measurements collected at Melrose, Montana (Secondary Station 9) are presented. Flow data for the Missouri River were not available at its primary station, and thus flows collected at Toston, Montana, the site of the new sampling station, are presented. The only flows available for the Madison River were those collected just below Ennis Lake. These flows are not included in this report, because measurements collected at this location would not be applicable at the mouth of the river. There are no monthly flow measurements available for Ten Mile Creek. Sporadic flow measurements taken on this stream with a velocity headrod ranged from 5 to 36 cubic feet per second. The author has not measured it during spring runoff, but would estimate it flows about 70 cubic feet per second. Plans are made to measure its high water flow during the spring of 1961.

The high and low water periods for the streams sampled within the Three Forks area are quite similar. Some variations are noted in the Beaverhead River, and doubtless the same is true for the Madison River. These variations are brought about by changes in water releases from headwater impoundments. In general we can say that the high water period for streams considered in this study is during June, and the low water period is during August. River flows are, however, influenced by a variety of factors, such as ice, irrigation drawdown, water needs for electrical power generation, precipitation and drought. Thus, the flows listed on Table 2 are accurate only for the day of the month in which the sample was collected.

Results of First Year's Sampling

Results of the study for the first year are tabulated on Table 3 for the secondary stations, and Table 4 for the primary stations. A graphic presentation of these data are presented on Figures 2 and 3; the former being the secondary stations, and the latter being the primary stations. All values listed except pH and temperature are in parts per million, that is one part chemical agent to one-million parts of water. These data for the first year must stand alone because there are no previous data in which to compare. They must also be analyzed for exactly what they are - - the chemical and physical (in the case of temperature) aspects of the river water at the month, day and time the sample was collected.

In briefly analyzing the chemical results collected during the first year of the study, only comparisons to some general expectations can be made. For example, the highest turbidity readings would be expected to occur during the period of peak flow, which in this drainage was during the month of June. This was not the case, as an examination of Figures 3 and 4 show that the highest turbidity readings occured during April and May. Apparently the larger amounts of suspended solids (turbidity causing agents) are washed into streams when the snow first begins to melt, and by the time the streams have reached their highest flows the amount of suspended solids reaching them is much lower in proportion to the volume of flow. The Madison River showed high turbidity readings during October 1959. These higher-than-normal readings were due to emergency excavation work on the face of Quake Lake Dam by the Army Corps of Engineers. Thus, these turbidity readings for October 1959 are by no means normal for the Madison River. Turbidity readings for the Beaverhead River show some monthly variations. Water from this stream is heavily used for irrigation, and combined releases from Lima Reservoir plus irrigation return water probably account for this.

Ordinarily one would expect the chemical agents in a stream to decrease in amount during the period of peak flow because of the high dilution factor present. Such was the case with the chemical agents analyzed in this study except the sulfates (SO_4). The sulfates showed an unexplainable increase during the periods of peak flow, and especially during the month of June. The author can offer no explanation for this rise, and prefers to wait until additional data are collected before discussing it further.

Any further discussion concerning the analysis of the first year's data should be postponed until additional data are collected.

No comment has been made in this report concerning the effect these chemicals have upon the various uses of water. There is a host of literature available concerning this subject and a few of the more important publications are mentioned here. For information relative to drinking water the reader is referred to a report by the U. S. Public Health Service (1946) entitled Public Health Service Drinking Water Standards. For information concerning chemicals and their effects upon drinking water, industrial use, livestock use and aquatic life, a publication by the California Water Pollution Board (1952) entitled Water Quality Criteria, and Aspects of River Pollution by Klein (1957) are quite useful. For information concerning the effects of chemicals on aquatic life the reader is referred to Tarzwell (1957), Hynes (1960) and Sylvester (1958). There are, of course, other important publications that could be listed, but space does not permit there entry at this time.

Acknowledgments

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Fishery Management Biologist, Montana Fish and Game Department, for their review of the study plan and for their encouragement. Mr. Don Willems, Sanitary Engineer, Montana State Board of Health, made suggestions and reviewed the manuscript and data. Mr. Edward LeFebvre, Chemist, Montana State Board of Health, analyzed the water samples for all the chemicals reported except pH. The Helena, Montana office of the U. S. Geological Survey provided flow measurements as reported on Table 2. J. M. Stubbs, formerly of Missoula, Montana, assisted with the collection of water samples during the summer of 1960.

Robert C. Averett
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TABLE 1. Location and Description of Sampling Stations.

LOCATION	NUMBER	DESCRIPTION
East Gallatin River above the West Gallatin River	1	North on Broadway Street at Belgrade, to Dry Creek Church. Then go past church one-half mile and turn left (south). Station is first bridge crossing on this road.
West Gallatin River above the East Gallatin River	2	Sixty yards upstream from bridge crossing on Highway 10 south of Manhattan.
Gallatin River at Logan	3	One-half mile below Logan.
Gallatin River at Trident	4*	One-Hundred yards above bridge crossing at Missouri Headwaters State Park.
Madison River at Indian Creek	5	South of Cameron, cross Indian Creek and turn south at first gravel road. Follow gravel road to first county bridge crossing. Station is at this bridge crossing.
Madison River at Ennis	6	Cross Madison River at Ennis and turn right (west) at first road. Sample is taken at Fish and Game Department Access Site.
Madison River at Three Forks	7*	At first bridge crossing on Highway 10 below Three Forks.
Big Hole River below the North Fork of the Big Hole River	8	At the Squaw Creek Bridge about 15 miles northeast of Wisdom. (Authors note: a new bridge has been constructed near this site since sampling began.)
Big Hole River at Melrose	9	Turn west at Melrose at the Canyon Creek-Hecla Road. Sampling station is at first bridge crossing on this road.
Big Hole River above Twin Bridges	10*	Turn right(north) at first road on Highway 91. Sampling station is at first bridge crossing on this road.
Beaverhead River at Lima	11*	Turn east at first road five miles south of Dell. Sampling Station is at first bridge crossing Beaverhead River on this road.
Beaverhead River above Dillon	12	First bridge crossing Beaverhead River on Highway 91 southeast of Dillon.

TABLE 1. (Continued)

LOCATION	NUMBER	DESCRIPTION
Beaverhead River at Twin Bridges	13*	At Bridge Crossing Beaverhead River in City of Twin Bridges.
Jefferson River below Twin Bridges	14	At first bridge crossing Jefferson River on Highway 10 north of Twin Bridges.
Jefferson River at LaHood Park	15	About one mile below (south) of LaHood Park on Highway 10.
Jefferson River above Three Forks	16*	At bridge crossing near junction of Highways 90 and 12, north of Three Forks.
Missouri River at Trident	17*	About one mile above the Ideal Cement Company Plant north of Trident.
Ten Mile Creek west of Helena	18*	One-half mile below bridge crossing on Highway 12 west of Helena.

* Denotes Primary Station.

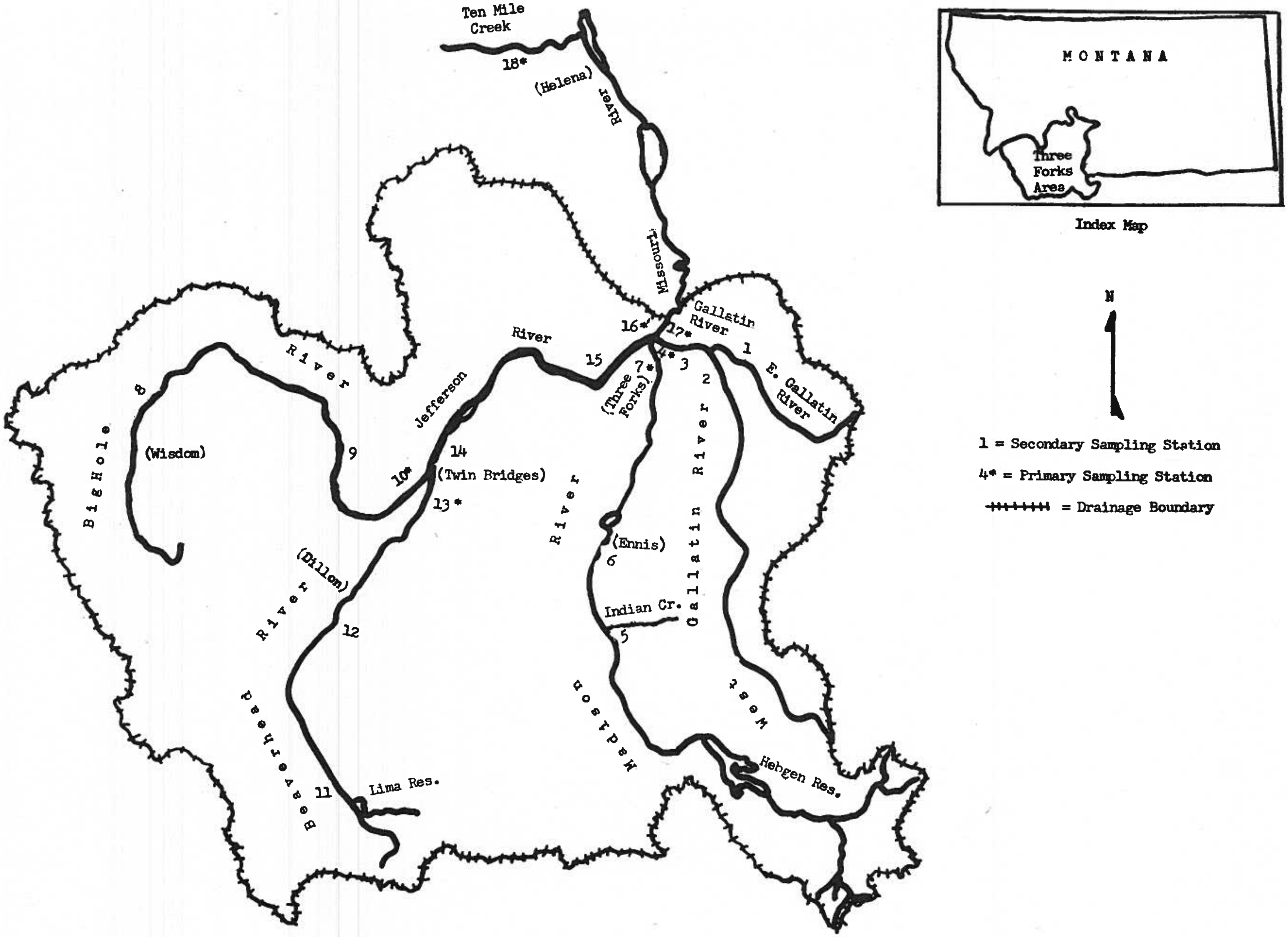

Figure 1. Upper Missouri Drainage Area (Three Forks Area) Showing Relative Location of Sampling Stations.

TABLE 2. Available Stream Flows in Cubic Feet Per Second. See Text for Explanation of Flows Not Recorded.

Gallatin River at Trident

Date	Flow
Oct. 6	950
Nov. 4	1070
Dec. 5	1000
Jan. 7	870
Feb. 4	800
Mar.	----
Apr. 12	1780
May 10	1920
June 14	2050
July 7	435
Aug. 4	370
Sept. 9	650

Big Hole River at Melrose

Date	Flow
Oct. 8	750
Nov. 4	1000
Dec. 5	500
Jan. 7	290
Feb. 4	410
Mar.	----
Apr. 12	2400
May 10	2150
June 15	3700
July 7	725
Aug. 4	570
Sept. 9	320

Missouri River at Toston

Date	Flow
Oct. 6	4870
Nov. 4	7510
Dec. 6	5200
Jan. 7	3470
Feb. 4	4090
Mar.	----
Apr. 12	9120
May 11	6920
June 14	7200
July 7	1980
Aug. 4	1130
Sept. 9	2460

Beaverhead River at Twin Bridges

Date	Flow
Oct. 8	485
Nov. 4	600
Dec. 5	530
Jan. 7	450
Feb. 4	450
Mar.	- - - -
April 12	560
May 11	200
June 15	46
July 7	75
Aug. 4	135
Sept. 9	235

Jefferson River Above Three Forks

Date	Flow
Oct. 6	1620
Nov. 4	2330
Dec. 5	1730
Jan.	- - - -
Feb.	- - - -
Mar.	- - - -
April 12	4280
May 10	3060
June 14	4120
July 7	918
Aug. 4	470
Sept. 9	850

Table 3. Tabulation of Chemical Data Collected at Secondary Stations. Except for pH and Temperatur all results are in Parts Per Million.

Station 1. East Gallatin River Above the West Gallatin River.

Mo.	Date	Hour	pH	T.D.S.	Turb.	Temp. °F.
Oct.	6	1600	7.8	239	4	48
May	11	1105	7.8	145	90	52
June	14	1420	8.2	154	4	64
Aug.	4	1215	8.2	214	2	62

Station 2. West Gallatin River Above the East Gallatin River.

Mo.	Date	Hour	pH	T.D.S.	Turb.	Temp. °F.
Oct.	6	1630	7.6	171	0.5	48
May	11	1030	7.8	145	30	50
June	14	1600	7.6	86	16	58
Aug.	4	1150	7.8	180	0	60

Station 3. Gallatin River at Logan, Montana.

Mo.	Date	Hour	pH	T.D.S.	Turb.	Temp. °F.
Oct.	6	1415	8.0	214	8	48
May	11	1015	7.8	171	53	50
June	14	1540	8.0	120	27	60
Aug.	4	1125	8.2	248	3	65

Station 5. Madison River at Indian Creek.

Mo.	Date	Hour	pH	T.D.S.	Turb.	Temp. °F.
Oct.	7	1030	7.8	145	96	48
May	11	1330	8.2	137	21	58
June	15	0925	7.8	94	10	52
Aug.	4	1000	8.4	145	3	68

Station 6. Madison River at Ennis, Montana.

Mo.	Date	Hour	pH	T.D.S.	Turb.	Temp. °F.
Oct.	7	1000	7.8	154	152	48
May	11	1300	8.4	154	6	60
June	15	0900	8.0	103	8	54
Aug.	4	1530	8.4	145	4	72

Station 8. Big Hole River below the North Fork of the Big Hole River.

Mo.	Date	Hour	pH	T.D.S.	Turb.	Temp. °F.
Oct.	7	1720	7.8	60	9	46
May	11	0915	7.2	85	12	52
June	15	1630	7.3	53	9	58
Aug.	5	1210	7.4	75	6	68

Station 9. Big Hole River at Melrose, Montana.

Mo.	Date	Hour	pH	T.D.S.	Turb.	Temp. °F.
Oct.	7	1630	8.0	86	4	50
May	11	0800	7.4	85	12	54
June	15	1515	7.4	57	6	56
Aug.	5	1110	8.2	103	4	63

Station 11. Beaverhead River at Lima, Montana.

Mo.	Date	Hour	pH	T.D.S.	Turb.	Temp. °F.
Oct.	7	1430	8.4	231	40	50
May	11	1720	8.0	239	27	57
June	15	1400	8.0	214	10	58
Aug.	5	0930	8.2	222	36	61

Station 12. Beaverhead River Above Dillon, Montana.

Mo.	Date	Hour	pH	T.D.S.	Turb.	Temp. °F.
Oct.	7	1330	8.2	342	8	48
May	11	1630	8.4	308	8	60
June	15	1300	8.0	316	17	56
Aug.	5	0845	7.8	342	2	57

Station 14. Jefferson River below Twin Bridges, Montana.

Mo.	Date	Hour	pH	T.D.S.	Turb.	Temp. °F.
Oct.	7	1200	7.8	274	8	48
May	11	1310	8.0	128	10	58
June	15	1100	7.4	77	8	58
Aug.	4	1730	8.2	248	4	72

Station 15. Jefferson River at LaHood Park, Montana.

Mo.	Date	Hour	pH	T.D.S.	Turb.	Temp. °F.
Oct.	8	1030	8.2	274	9	46
May	11	1130	7.8	137	20	58
June	15	1700	7.6	94	9	62
Aug.	4	1000	8.0	282	5	66

Table 4. Tabulation of Chemical Data Collected at Primary Stations. Except for pH and Temperature all results are in Parts Per Million.

Station 4. Gallatin River at Trident, Montana.

Mo.	Day	Hour	pH	T.D.S.	Turb.	Hard.	Ca	Mg	HCO_3	CO_3	SO_4	Temp.°F.
Oct.	6	1315	8.2	239	6	231	69	14	189	12	43	48
Nov.	4	1305	8.2	231	3	218	52	21	201	6	49	38
Dec.	5	0930	8.0	180	7	246	54	27	207	0	53	34
Jan.	7	0920	8.0	171	9	206	50	20	201	0	53	34
Feb.	4	1230	8.0	231	15	245	50	29	207	0	54	36
Mar.		Ice Cover	- - -	- - -	Could Not Sample							
Apr.	12	1330	8.0	120	36	186	47	17	201	0	43	36
May	10	1000	8.0	171	57	167	44	14	183	0	41	52
June	14	1500	7.8	120	35	146	32	16	146	0	140	58
July	7	1330	8.4	214	1	218	48	24	189	18	37	74
Aug.	4	1100	8.4	257	8	229	53	23	226	8	43	70
Sept.	9	0900	8.2	205	6	250	55	28	232	0	41	53

Station 7. Madison River Below Three Forks, Montana.

Mo.	Day	Hour	pH	T.D.S.	Turb.	Hard.	Ca	Mg	HCO_3	CO_3	SO_4	Temp.°F.
Oct.	6	1330	7.8	171	27	115	28	11	122	6	29	46
Nov.	4	1245	8.0	162	106	100	23	10	165	0	35	38
Dec.	5	0915	8.0	145	9	155	25	23	146	0	31	34
Jan.	7	0900	8.0	188	7	88	22	8	153	0	21	34
Feb.	4	1220	7.8	197	7	137	25	18	159	0	23	36
Mar.	4	1000	8.0	205	10	108	25	11	165	0	18	34
Apr.	12	1345	8.2	171	17	108	24	12	140	0	29	48
May	10	0930	7.8	171	22	108	25	11	146	0	25	54
June	14	1500	8.2	137	4	114	25	13	128	6	66	66
July	7	1320	8.2	137	3	146	28	18	134	6	21	74
Aug.	4	1100	8.4	162	8	135	27	17	159	0	23	68
Sept.	9	0900	8.2	171	8	114	28	10	153	0	21	53

Station 10. Big Hole River Above Twin Bridges, Montana.

Mo.	Day	Hour	pH	T.D.S.	Turb.	Hard.	Ca	Mg	HCO_3	CO_3	SO_4	Temp.°F.
Oct.	8	1000	7.6	111	3	115	28	11	116	0	18	44
Nov.	4	1450	7.8	77	8	91	20	10	85	0	16	38
Dec.	5	1115	8.0	86	5	127	28	14	110	0	21	34
Jan.	7	1000	7.6	77	2	98	25	9	122	0	23	34
Feb.	4	1420	7.6	103	2	118	24	14	116	0	21	36
Mar.		Ice Cover	- - -	- - -	Could Not Sample							
Apr.	12	1530	7.2	75	16	59	11	8	67	0	14	48
May	10	1330	7.6	90	12	59	12	7	61	0	14	58
June	15	1130	7.4	67	9	73	15	9	73	0	45	58
July	7	1130	8.0	111	4	125	27	14	128	0	18	68
Aug.	4	1750	8.4	120	6	146	30	17	146	6	21	73
Sept.	9	1115	8.2	137	2	135	35	12	159	0	19	58

Station 13. Beaverhead River at Twin Bridges, Montana.

Mo.	Day	Hour	pH	T.D.S.	Turb.	Hard.	Ca	Mg	HCO_3	CO_3	SO_4	Temp.°F.
Oct.	8	0930	8.2	228	12	394	74	51	281	12	156	48
Nov.	4	1445	8.4	376	17	355	73	42	281	0	144	40
Dec.	5	1100	8.2	325	7	373	84	40	281	0	136	38
Jan.	7	1130	8.0	393	5	314	74	31	281	0	132	36
Feb.	4	1410	8.2	393	15	314	45	49	287	0	132	36
Mar.		Ice Cover	- - -	- - -	Could Not Sample							
Apr.	12	1520	8.0	342	44	304	101	13	250	0	99	48
May	11	1325	8.0	342	18	284	61	32	250	0	132	60
June	15	1120	8.2	291	9	260	62	26	214	0	280	59
July	7	1140	8.0	376	3	343	76	37	287	0	144	66
Aug.	4	1740	8.2	393	11	343	73	39	250	12	144	70
Sept.	9	1105	8.2	376	7	354	80	38	281	0	144	53

Table 4. Continued

Station 16. Jefferson River Above Three Forks, Montana.

Mo.	Day	Hour	pH	T.D.S.	Turb.	Hard.	Ca	Mg	HCO_3	CO_3	SO_4	Temp. °F.
Oct.	6	1345	8.2	282	9	260	62	26	201	12	93	48
Nov.	4	1230	8.2	265	9	255	54	29	201	0	80	40
Dec.	5	0900	7.6	222	7	282	52	37	220	0	88	34
Jan.		Ice Cover - - - - - - - Could Not Sample										
Feb.		Ice Cover - - - - - - - Could Not Sample										
Mar.		Ice Cover - - - - - - - Could Not Sample										
Apr.	12	1315	7.8	154	31	147	40	11	128	0	49	48
May	10	0915	7.8	154	12	137	27	17	128	0	47	54
June	14	1435	7.6	94	17	104	25	10	98	0	83	63
July	7	1250	8.0	231	1	229	48	26	183	6	62	72
Aug.	4	1030	8.2	291	6	260	55	30	232	12	82	68
Sept.	9	0850	8.4	308	9	270	60	29	238	0	93	54

Station 17. Missouri River at Trident, Montana.

Mo.	Day	Hour	pH	T.D.S.	Turb.	Hard.	Ca	Mg	HCO_3	CO_3	SO_4	Temp. °F.
Oct.	6	1300	8.0	231	5	231	49	26	201	6	45	48
Nov.	4	1300	8.2	180	9	237	52	26	207	0	45	38
Dec.	6	1200	8.0	197	12	255	58	27	214	0	58	34
Jan.	7	0930	8.2	239	7	206	46	22	207	0	60	36
Feb.	4	1230	8.0	231	10	215	35	31	207	0	58	33
Mar.		Ice Cover - - - - - - - Could Not Sample										
Apr.	12	1335	8.0	188	39	186	45	18	183	0	41	48
May	11	1000	8.0	171	54	167	41	16	195	0	4	54
June	14	1525	8.0	120	28	146	32	16	140	0	135	59
July	7	1330	8.4	214	0	208	46	22	177	18	43	74
Aug.	4	1120	8.2	239	6	208	48	21	195	12	41	68
Sept.	9	0900	8.2	231	5	218	52	22	226	0	43	52

Station 18. Ten Mile Creek West of Helena, Montana.

Mo.	Day	Hour	pH	T.D.S.	Turb.	Hard.	Ca	Mg	HCO_3	CO_3	SO_4	Temp. °F.
Oct.		No Samples Collected										
Nov.		No Samples Collected										
Dec.	6	1200	7.8	85	2	146	34	15	110	0	47	34
Jan.	11	0815	7.4	103	2	127	33	11	140	0	41	34
Feb.	4	1100	7.8	154	0	235	31	38	153	0	41	38
Mar.		No Samples Collected										
Apr.	12	0915	7.2	85	10	59	11	8	49	0	29	48
May	11	1315	7.2	85	32	59	10	9	37	0	29	48
June	17	1325	7.4	70	4	73	13	10	55	0	70	53
July	8	1115	7.8	137	1	125	32	11	128	0	39	60
Aug.	4	0820	8.2	173	0	156	38	15	165	0	39	55
Sept.	8	1400	8.2	180	8	166	38	17	165	0	41	58

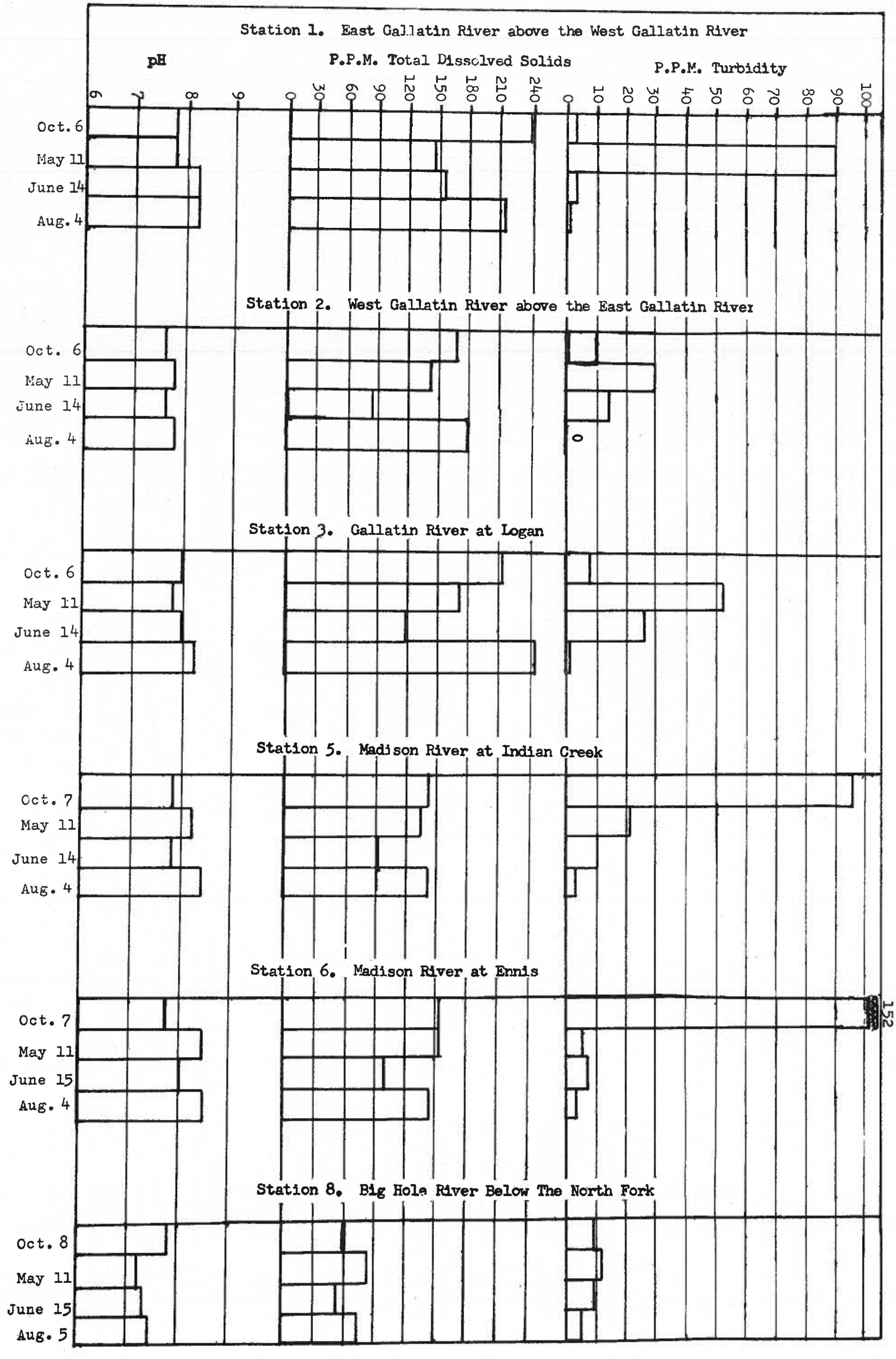

Figure 2. Graphic Presentation of Chemical Results Collected at Secondary Stations 1959 - 1960.

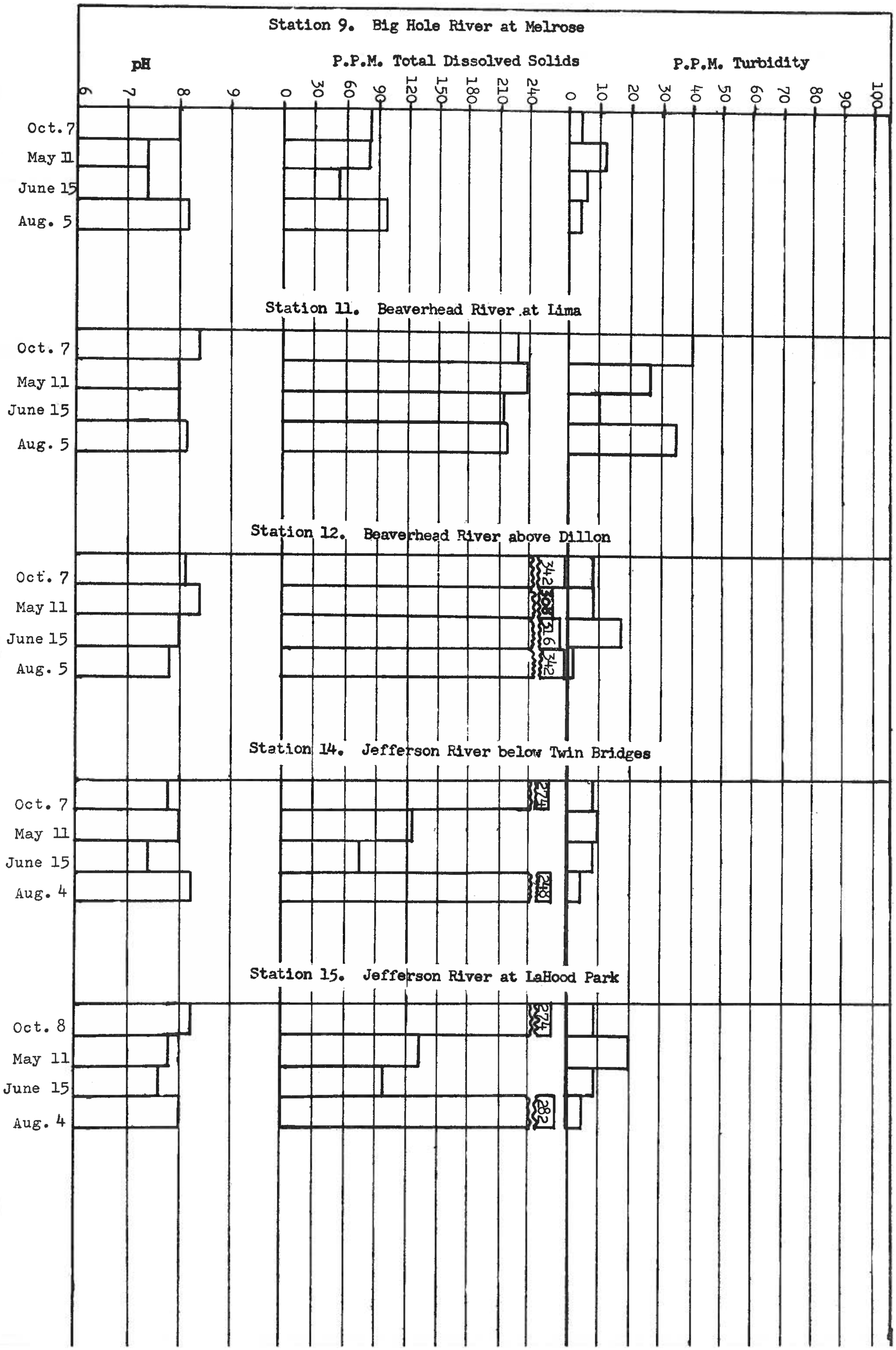

Figure 2. Continued.

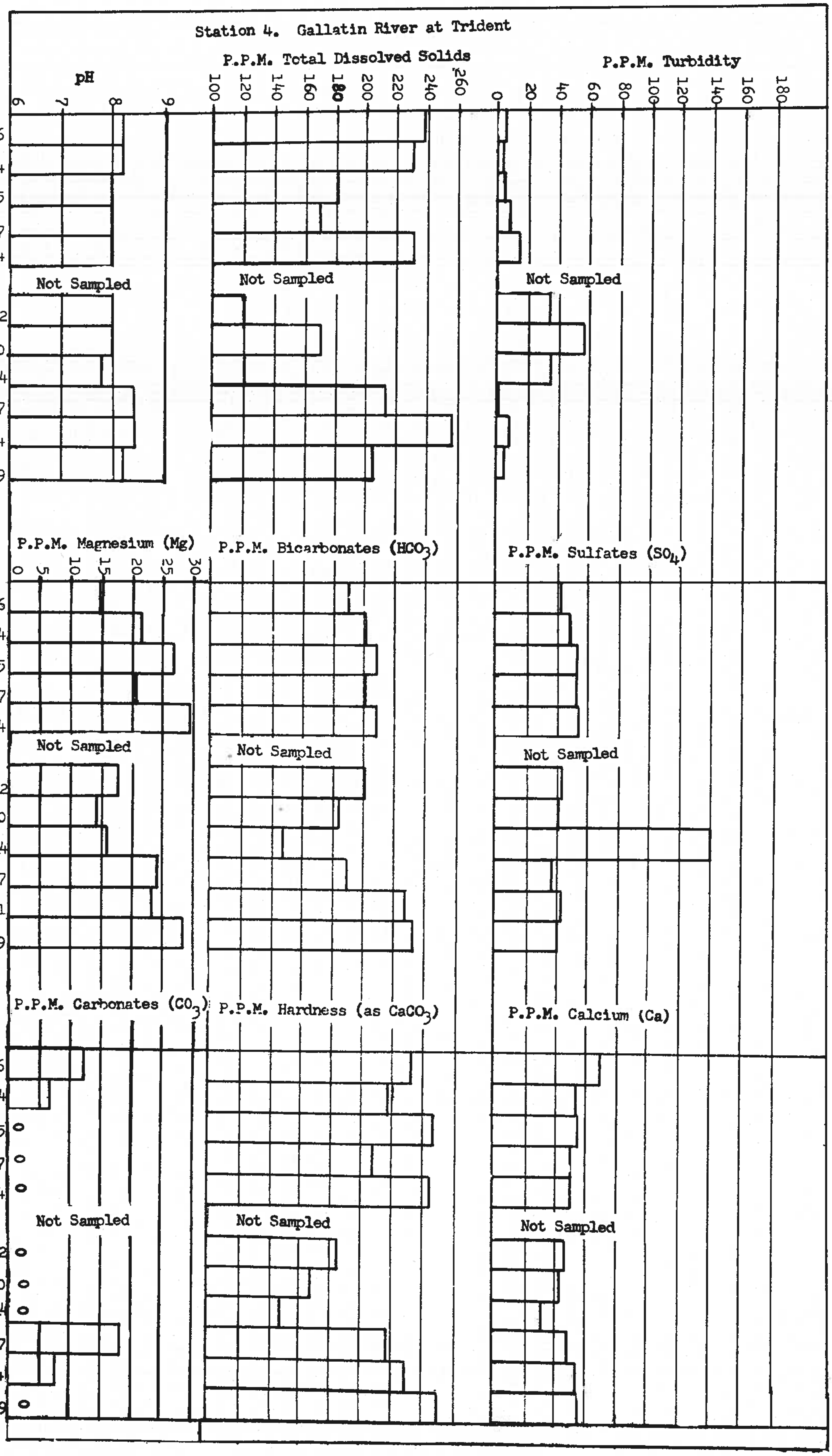

Figure 3. Graphic Presentation of Chemical Results Collected at Primary Stations 1959-1960.

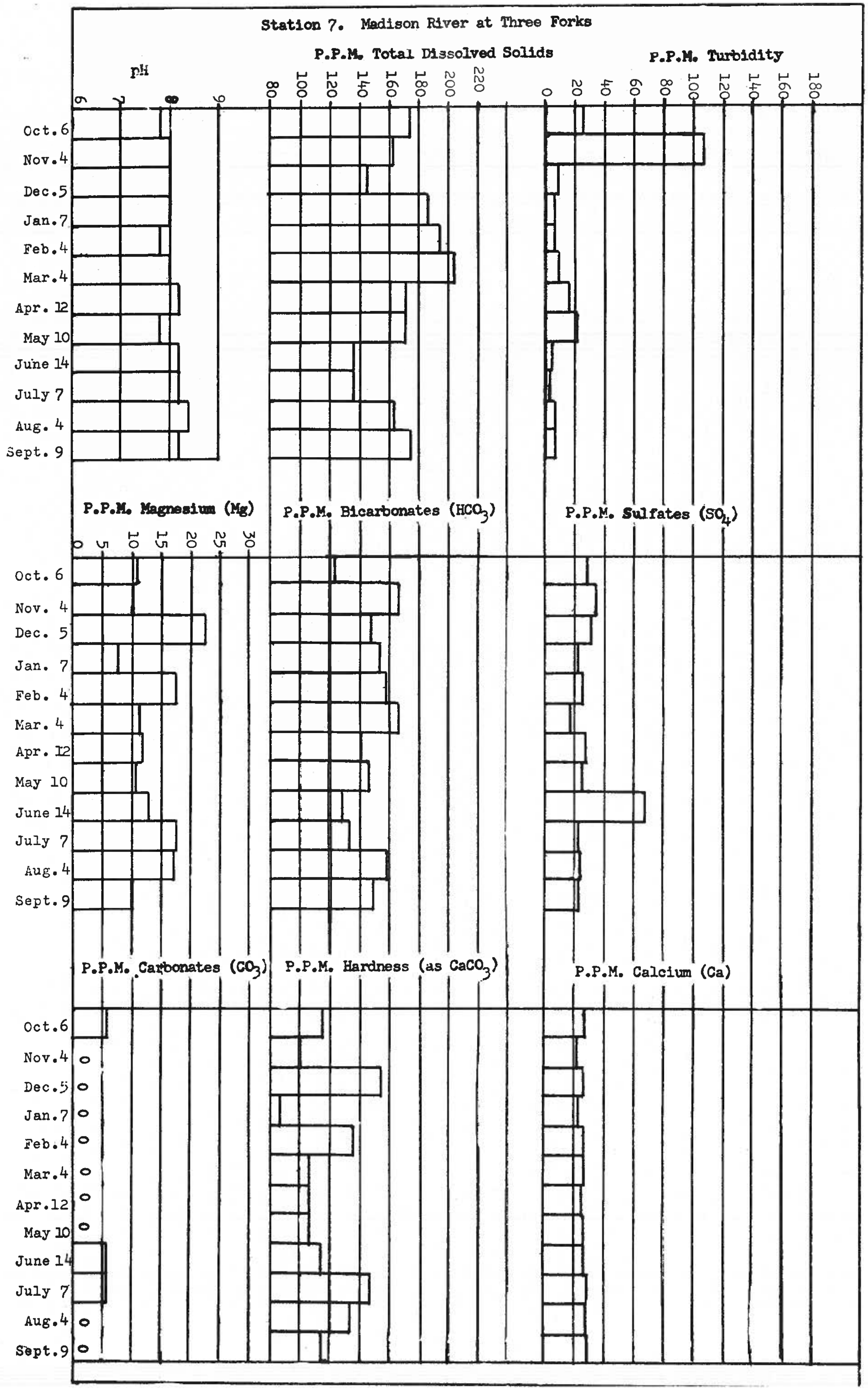

Figure 3. Continued.

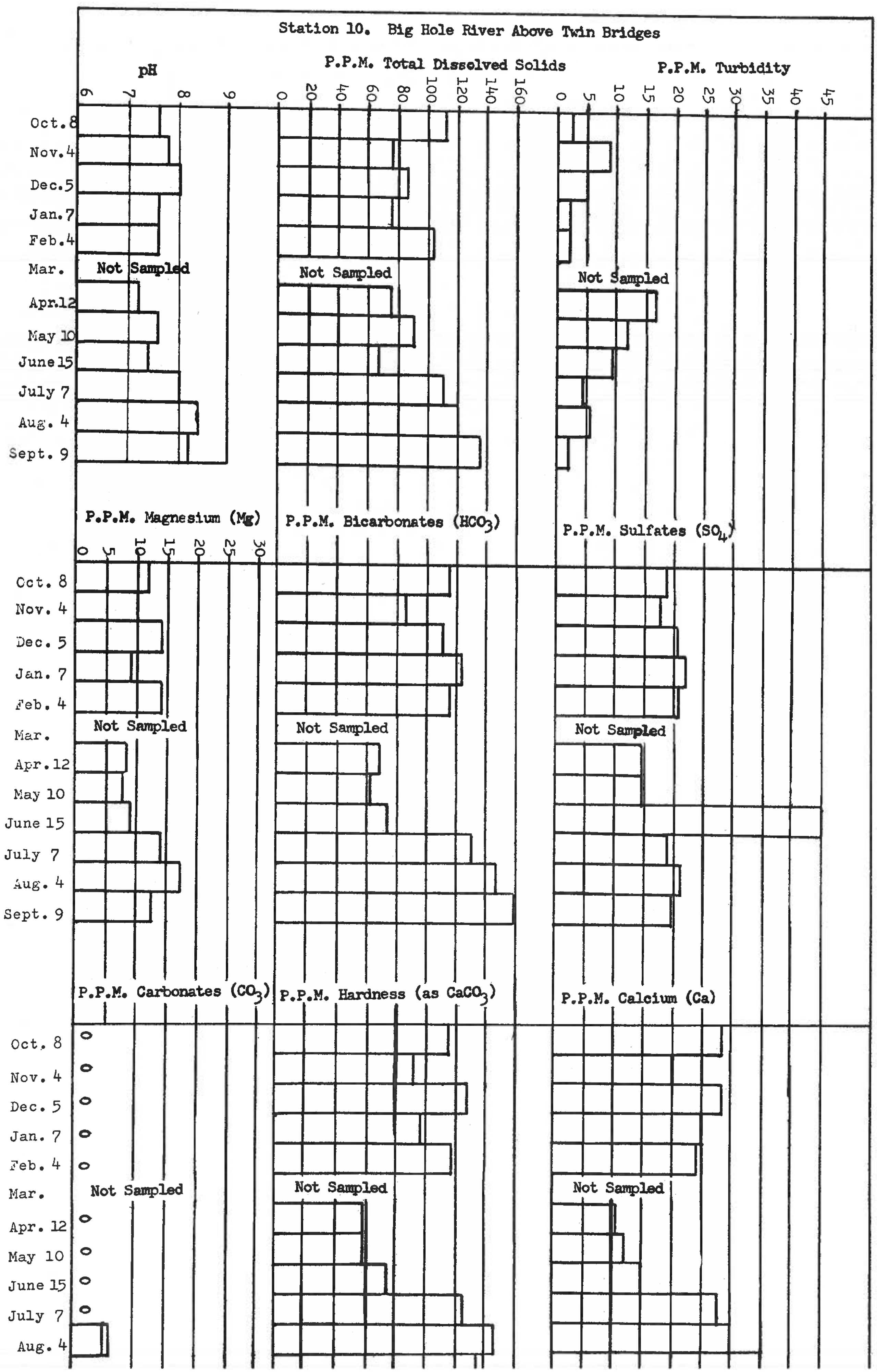

Figure 3. Continued.

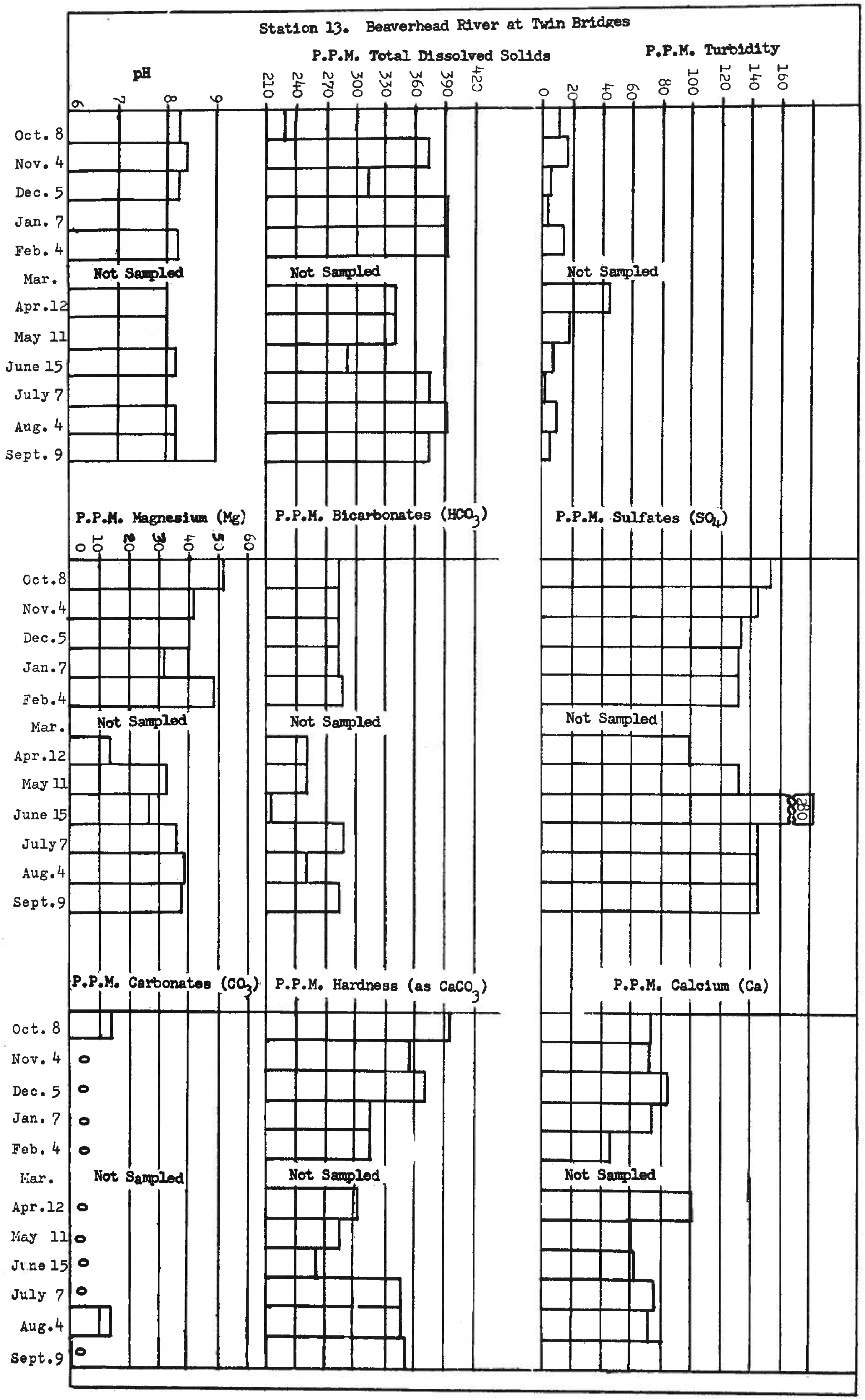

Figure 3. Continued.

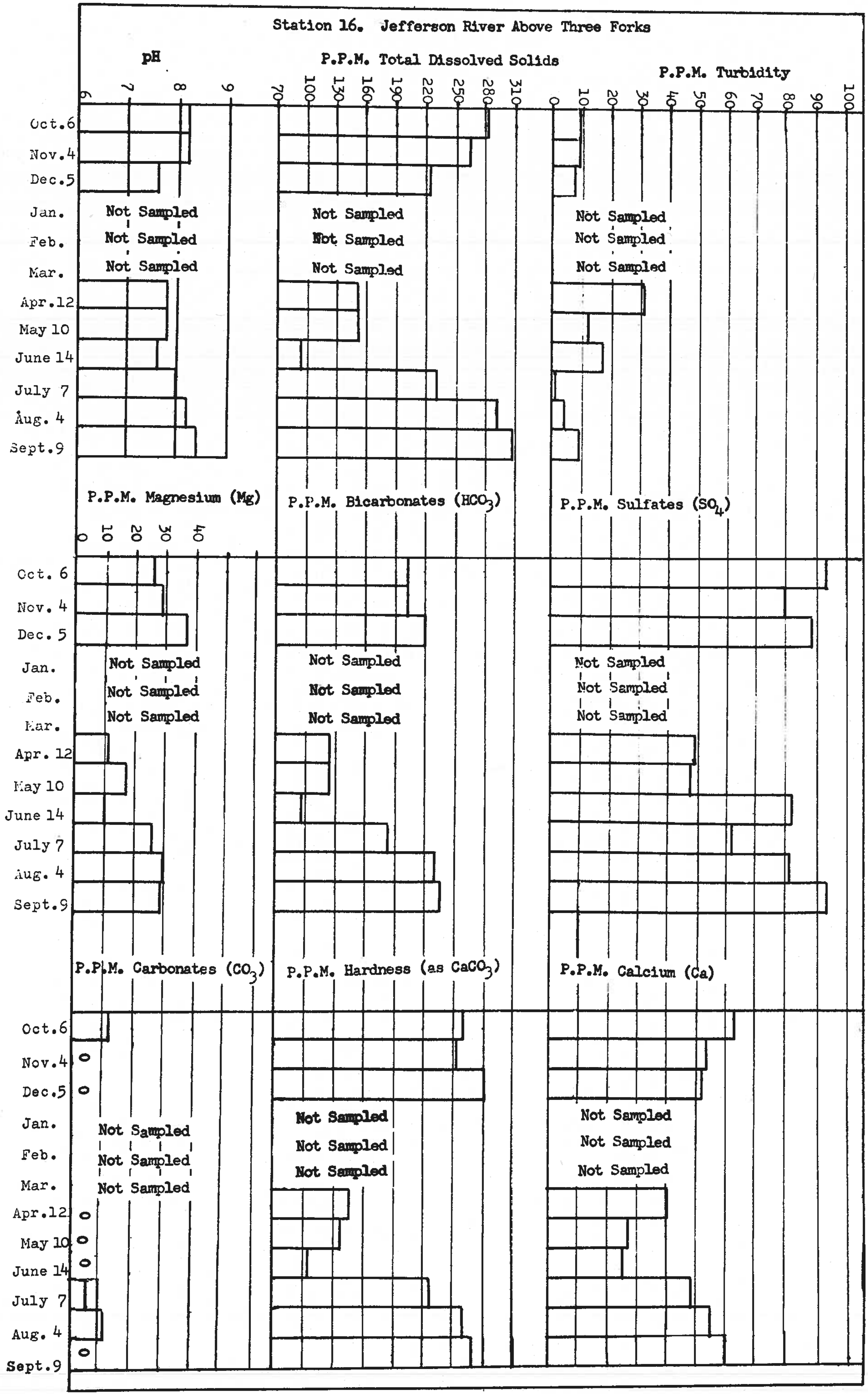

Figure 3. Continued.

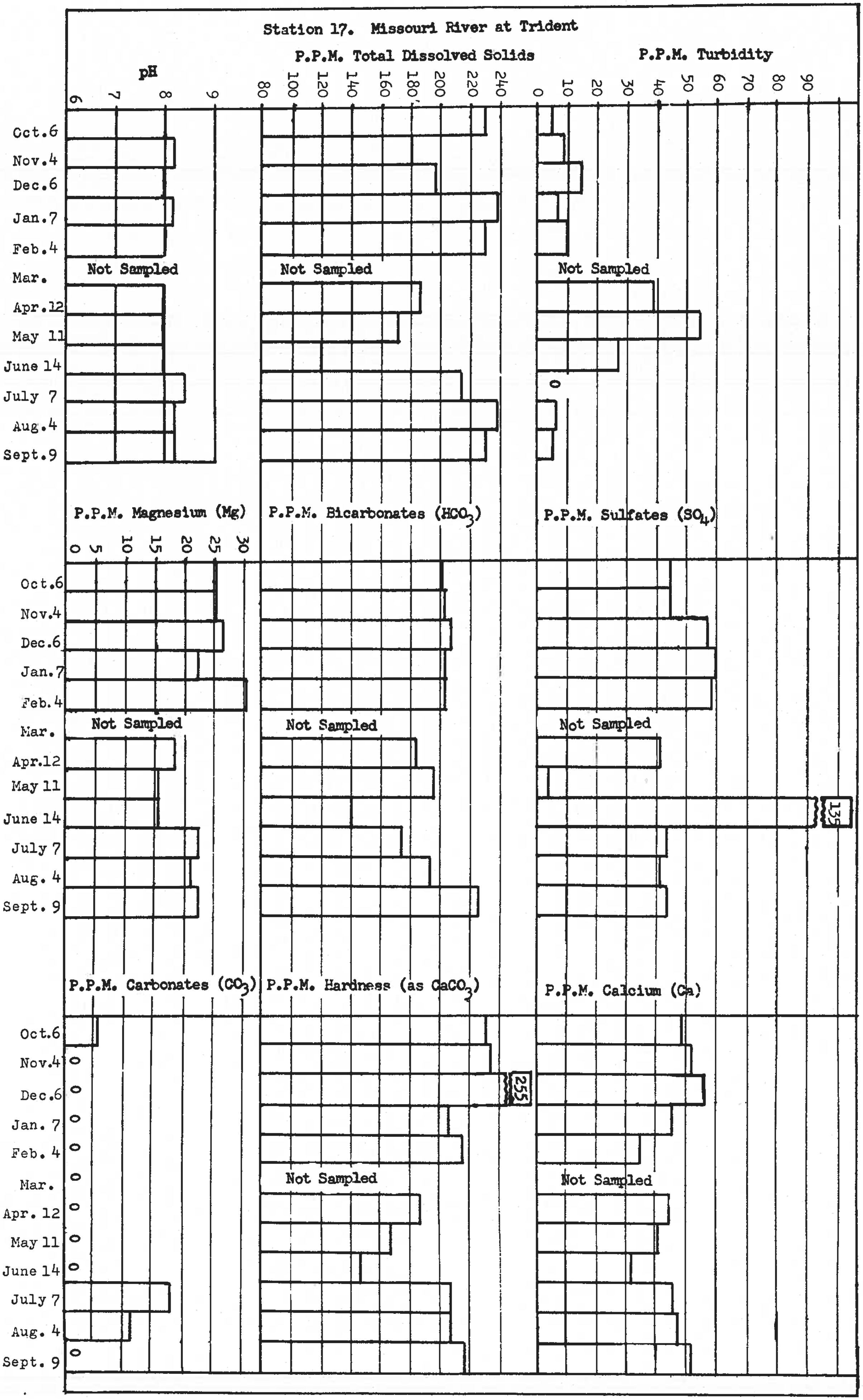

Figure 3. Continued.

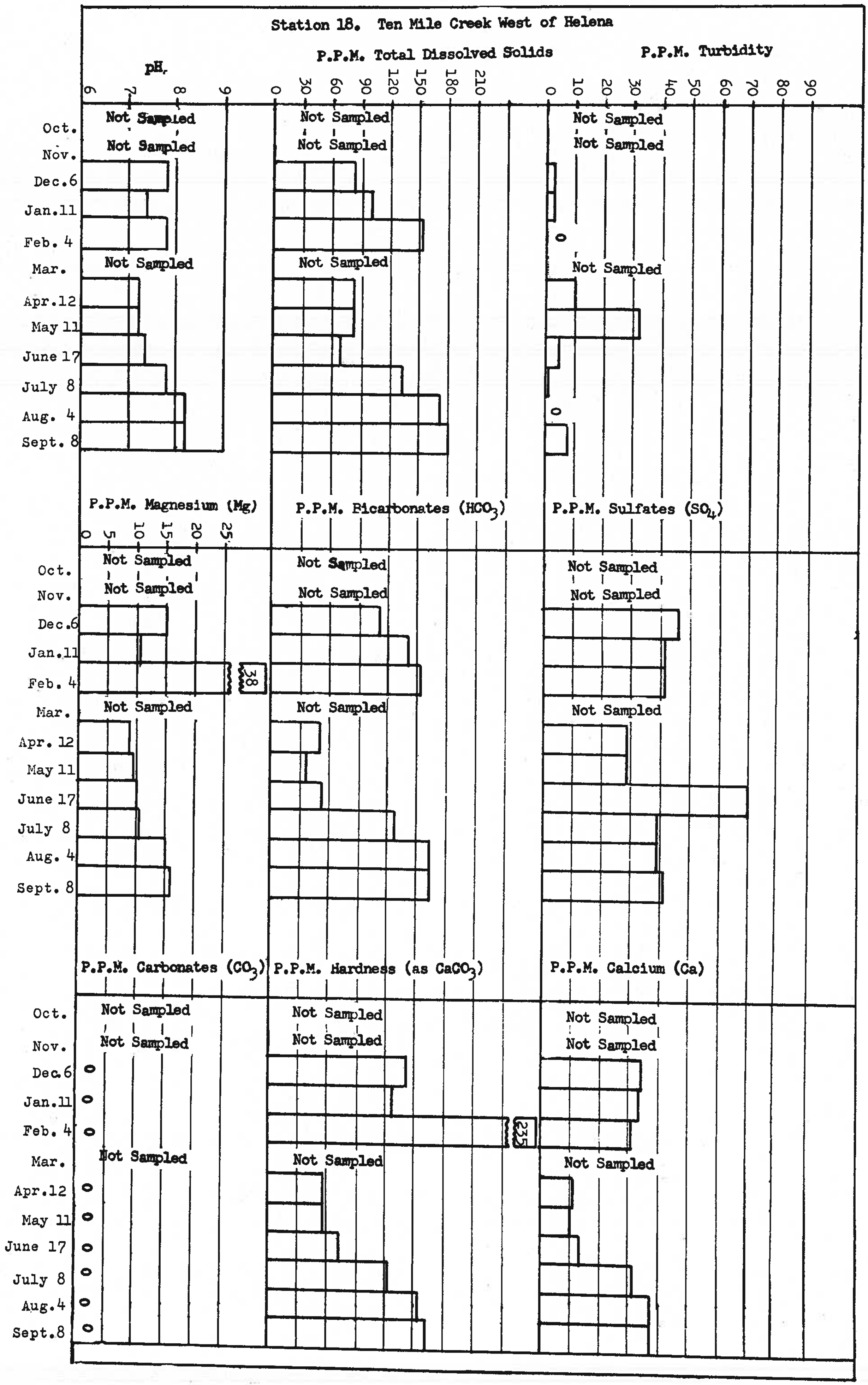

Figure 3. Continued.