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CHEMICAL SURVEY of the WINNIPEG RIVER, FORT ALEXANDER, MANITOBA (POWERVIEW TO MOUTH)

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CHEMICAL SURVEY

of

WINNIPEG RIVER,

FORT ALEXANDER, MANITOBA

(POWERVIEW TO MOUTH)

JUNE, 1972

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WINNIPEG RIVER SURVEY

Introduction

This report contains the results of a survey and study of the Winnipeg River in the vicinity of the Fort Alexander Indian Reserve. The study was requested by the Department of Indian Affairs and Northern Development on behalf of the Fort Alexander Indian Band.

The initial survey, which was a survey of the chemical conditions in the river, was carried out in September of 1970. The results of this survey were inconclusive in that the chemical and biochemical parameters which are customarily used in water quality surveys, and which were, in fact, used for this particular survey, indicated that there was a general deterioration of water quality within the reach of the river under study but could not accurately pinpoint a specific source or sources of pollution.

It was thought necessary to carry on further chemical sampling the following summer, but, in addition, to carry out a biological survey of the benthic (bottom dwelling) organisms. The results of the additional chemical samples yielded results much similar to those of the previous year's sampling program, however, the biological survey of benthic organisms proved to be much more fruitful and an accusing finger has been pointed at wood fibers. The river bottom was found to be covered with wood fibers for a distance of at least two miles downstream from the Abitibi Paper Company outfall. The wood fiber deposits interfere with the egg hatching success of various fish species in the river. Pollution of varying degrees of severity was identified in the four mile stretch downstream of the papermill outfall which was attributable chiefly to wood fiber loss from the mill operation.

Various chemical pollutants were identified in the mill effluent, however, very high dilution ratios result when the effluent is discharged to the river and changes in the levels of chemical pollutants in the water are statistically insignificant as it passes the mill, or for that matter, any other point along the river.

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Conclusions

The chemical survey of the Winnipeg River from Great Falls to the mouth indicates that it is not chemically polluted to any significant degree. There is no question that the Abitibi Paper Company is discharging an undesirable effluent containing high levels of chemical pollutants, however, the effects of these pollutants are minimal due to the very large flows in the Winnipeg River and the high resulting dilutions. The survey does indicate that a large amount of biochemical oxygen demand material is being discharged into the river by the papermill.

The bacteriological survey of the river indicates that the effluent from the papermill is a significant source of bacterial contamination but again the large dilution resulting from the high flows reduces the severity of the effect on the river.

The benthic survey indicates that the fauna of the river is adversely affected by the mill effluent and that a pollution problem does exist due to the mill's operation. The chief offender is identified as wood fiber from the mill discharge.

Aesthetic and biological pollution problems along the lower reaches of the Winnipeg River are more severe than chemical pollution.

Recommendations

It is recommended that the quality of the mill effluent should be substantially improved to reduce the pollutional load discharged into the Winnipeg River. Wood, bark and other wood fiber should be eliminated from the discharge. The effluent should be treated with a disinfectant to reduce the bacterial count. The existing fiber pile at the outfall should be removed.

DESCRIPTION OF STUDY AREA

A detailed description of the immediate study area is given on Page 3 of the accompanying report on the benthos survey. More generally, the Winnipeg River drains a portion of the Canadian Shield (or Precambrian Shield, as it is known). The area under consideration is located at the southern edge of this Shield.

The entire watershed area of some 53,500 square miles, is quite sparsely populated as a large portion of it offers little opportunity for agricultural use. Those portions best suited for such use lie in southern Manitoba and Minnesota and extend northward on the Canadian side from the Rainy River. The remainder of the drainage basin consists, for the most part, of a forest covered Laurentian highland formation, with many granite outcroppings interspersed with lakes, muskeg and a few areas of arable land. The forest cover is composed largely of spruce, poplar, jack pine and oak. Due to the relatively short growing season and marginal fertility of the soils, the growth is not prolific and has little lumber value but in many of the sheltered valleys the timber is better developed and makes excellent pulpwood material. Several papermills have been built along the Winnipeg - Rainy - English Rivers system to take advantage of this resource.

In recent years, the area has found great popularity as a recreational area for such activities as cottage building, camping, boating and hiking.

The climate of the Winnipeg River Basin varies from extreme cold in winter to a short hot summer. Mean annual temperature for

Description of Study Area (continued)

the basin is 39° with variations in monthly means ranging from -14.5° to 72.3°F. Extremes of -50°F to 110°F have been recorded. Mean annual precipitation is about 20 inches with variations from 14 to 34 inches.

The Winnipeg River is part of an international waterway system and is a major source of electrical energy. Its flow is controlled quite closely with minimum flows in the order of 20,000 c.f.s. with a long term average annual flow of 29-30,000 c.f.s.

In time past, the Winnipeg River served as part of a water route between the Western Plains and Eastern Canada and was used by the fur trade for over 100 years. With the advent of the railway, however, the waterway had been abandoned as a means of transportation.

The present economic value, besides its recreational function, of the Winnipeg River, lies in the fact that it is a major source of hydro-electric energy for the Province. Within the Manitoba boundaries there is a total generating capacity of 736,000 h.p. on the river. In addition, Atomic Energy of Canada Ltd., uses the waters of the Winnipeg River for cooling its atomic research reactors.

Results of Previous Surveys

In 1957, the then Provincial Sanitary Control Commission carried out a study on the Winnipeg River as part of a series of studies on the major watercourses of Manitoba. These studies were carried out to determine the sanitary conditions of the rivers and to point out the steps to be taken in safeguarding the quality of the water and the health of its users.

Results of Previous Surveys (continued)

The Winnipeg River study was carried out specifically to investigate complaints from the Indian Affairs Branch that the wastes being discharged into the Winnipeg River upstream of the Fort Alexander Residential School were contaminating the water in the river used as a potable water source by the school.

Among the findings, it was reported that the bacteriological contamination was more severe downstream of Fort Alexander than upstream and that the overall picture of industrial waste pollution from the papermill did not appear to be critical because of the high dilution ratio. The mill was identified as a source of a pollutant, namely: bark and wood fiber wastes. The report concluded:

> "The calculated combined quantity of these wastes is approximately 80 tons per day. Although these wastes are not toxic in themselves, they have far reaching effects on a stream and on its normal balance of life.
>
> Cellulose fibers in particular are slow in disintegrating and therefore accumulate on the stream bottom. They are detrimental to fish because they effectively blanket the stream beds, smothering the food organisms of the fish, covering the spawning beds and collect and hold other organisms and detritus that are harmful to fish life. Fish may also become entangled in fiber mats and consequently may suffer from impaired gill action.
>
> The report further states in reference to the papermill that wastes come in such great quantities that the resultant accumulation at the outfall and at the dock is at times of concern to the company. The bark must be removed from the

Results of Previous Surveys (continued)

area around the outfall to permit the flow of effluent to the river and from around the dock where it may interfere with navigation, where an estimated six foot layer of bark has accumulated on the river bottom."

A second survey carried out by the Manitoba Department of Health, Environmental Sanitation Section, studied the Winnipeg River between Pointe du Bois and its mouth at Traverse Bay. The specific aim of this survey was to document the quality of the river with respect to chemical, sanitary and biological conditions. Among the main findings, it was stated that the Winnipeg River shows few signs of pollution with the exception of that stretch between Pine Falls and the mouth. In this area, pollution is evident in the form of changes in composition of fish life accompanied by variations in abundance, the appearance of pollution tolerant organisms, the disappearance of intolerant organisms, a rise in bacterial contamination and somewhat high B.O.D. figures with depressed dissolved oxygen levels.

The current study, in effect, confirms the findings of the previous studies but points out that likely due to resort development along the Winnipeg River and its tributaries and the concomitant demands on the river of increased population, conditions have generally deteriorated slightly during the past decade.

The Present Survey

The current survey, which was started in 1970 by the then Public Health Engineering Division of the Department of National Health and Welfare, now part of the Environmental Protection Service of the Department of Environment, investigated the water quality and sanitary condition of the Winnipeg River from a point just above the Great Falls power dam to the mouth of the river and into Traverse Bay.

In the latter part of August and early September of 1970, seven cross sections, or transects of the river were established (described later), the first one being in the forebay of the Great Falls dam. During the 1970 study, these transects were referred to as ranges and are designated on the figures and tables of this report as "R". At each range, four sampling points were established and designated by the letters A, B, C and D; A being nearest the south and/or west bank of the river.

Samples were collected daily from August 31st to September 4th inclusive. On August 31st the Abitibi Paper Company mill at Pine Falls was not in operation. On the morning of September 1st, the mill started operating and remained operating during the rest of the survey. The samples for bacteriological examination were analysed by the Bacteriology Laboratory of the Department of Mines, Resources and Environmental Management of the Province of Manitoba. A series of 144 samples were sent to the laboratory in Ottawa for nitrite, nitrate, orthophosphate and total phosphate analyses. Water samples from each range were sent to that laboratory for complete chemical analyses with regard to drinking water standards.

The Present Survey (continued)

Chemical Oxygen Demand analyses were carried out on series of samples submitted on September 1st and September 3rd by the chemical laboratory of the Environmental Division of the Province of Manitoba. All other tests and analyses were carried out in the Winnipeg laboratory of Public Health Engineering Division.

After the results of the sampling were analysed, it became apparent that the entire survey was rather inconclusive in that no definite trends could be established. It was decided, therefore, to repeat some of the chemical sampling program and to carry out a biological examination of the benthic (bottom dwelling) organisms of the river. This proved to be a fortuitous decision as very definite results were obtained from this study. The survey was carried out by Mr. John Loch, Biologist, of the Resources Development Branch, Fisheries Service, Department of the Environment.

For this survey, five transects, differing from those of the previous year's study, were selected over a shorter stretch of the river in the vicinity of the Abitibi Paper Company, Pine Falls, mill. These same transects were also used for the chemical analyses sampling program. At each transect, or station, three sub-stations A, B and C were established, lettering from the south or west bank. For the purposes of this report, the transects used in the 1970 study are called ranges whereas those used in the 1971 study are called stations. This is surely a convenience for distinguishing the two. It should be noted that the 1970 study ranges are numbered downstream whereas the 1971 study stations are numbered upstream.

current is quite fast and the surface is turbulent. It is likely that some aeration occurs at this point in the river. There is bedrock on both shores and both banks are clean in appearance.

Range 4. This range is 7.4 miles above the mouth and just above the rapids between the towns of Pine Falls and Powerview, near the Pine Falls water intake. The water is not more than 15 feet deep and fairly fast moving at this range. The banks are rocky and gradually sloping. They are clean in appearance. The water still is relatively clear.

Range 5. This range is at Abraham Point and is 5.8 miles above the mouth and about 1.1 miles below the Abitibi Paper Company outfall. The river is nearly half a mile wide at this point. The water is fairly fast moving near the north side where the maximum depth is 50 feet. The north shore has low, gently sloping sandy banks. There were some logs and an accumulation of wood debris on this shore. The water near the south side was much slower moving and shallower. There were large rocks near the shore and some wood deposits downstream of this range.

Range 6. This range is located at Courchenes Point, a mile above the river mouth. Both banks are steep and some erosion is occurring due to wave action. There is little current but much surface turbulence due to wind action in this area. The water is more turbid in appearance. Logs were observed on both shores together with some wood chips and debris. There was also evidence of wood, bark and "mush" consisting of wood chips, etc., in several locations in this area along the river, particularly where the banks are flat.

The Present Survey (continued)

For the 1970 sampling program, seven transects, or ranges, were selected over a twenty-three mile stretch of the river. They were selected for their significance as being representative of different sets of conditions along the river. It was felt that these ranges would reflect some of the effect of effluents on the river. Accessibility, depth of water and current were all considered in their selection. A description of each range follows:

Range 1. This range is located 21.8 miles above the mouth of the Winnipeg River (taken to be between Bruyère's Point and Two Hearts Point), some five hundred feet above the Great Falls power dam. Above the dam, the water elevation is 812 feet± and the lowest bottom elevation in the forebay is 735 feet. At this point the water is clear and has a very low velocity. The river banks are low and wooded and the shore is generally clean.

Range 2. This range is located 10.6 miles from the mouth immediately below the Maskwa (Bear) River. The surface elevation is 755 feet and the deepest bottom elevation is 692 feet. The river channel at this range is less than 1,000 feet wide. The 10-foot high banks on the south west side are wooded while those on the north east side are gradual and are cultivated. The water is still quite clear and slow moving. There is no noticeable change in the colour or clarity of the water between this point and upstream of the confluence of the Maskwa River.

Range 3. This range is 8.8 miles above the mouth, immediately below the Powerview dam. The surface elevation is about 715 feet and the deepest bottom elevation is 695 feet. The

The Present Survey (continued)

Range 7. This range is located in Traverse Bay, a mile away from the mouth of the river. Wood chips and bark were observed in large quantity on the beach on the north side just north of Sharp Point.

The stations used for both the biological and chemical surveys in 1971 are described in the "Benthos Survey" report starting on Page 3 and will not be repeated here. There are six stations, five of which were used for the Benthos Survey, which lie between Range 3 and Range 6 of the 1970 survey.

GENERAL COMMENTS ON CONDITIONS ALONG THE WINNIPEG RIVER

Along the Winnipeg River there are several communities including Fort Alexander, Pine Falls, Powerview, St. George, Silver Falls, Great Falls, McArthur Falls, Lac du Bonnet, Pinawa, etc., all of which discharge wastes into the river. Sewage treatment ranges from none at all to lagooning or primary sedimentation. Although none of these towns are particularly large and likely not major polluters of the river, (a study was not made, however) each contributes to some degree to the pollutional load of the river. Generally speaking, the flow in the river is sufficient to handle the load without significant impairment of the water quality, however, gradual deterioration does occur as is evident by examination of the level of pollutants, even at Range 1. Each time a lagoon is discharged, the river receives some bacteria, suspended solids, algae and chemical nutrients.

Above Pine Falls the river is relatively clear (although by no means like the proverbial mountain stream) and the shores are free from debris. Below the Abitibi Paper Co. Mill, bark, wood chips, etc., are in evidence along the shores of the river in many places. At the outfall, from the mill itself, large piles of bark and wood chips line both sides of the ditch through which effluent from the mill is discharged. These sites in places are eight to ten feet above the water level and much of the wood and related material finds its way into the river. Fishermen at Fort Alexander have complained of slime coating their nets. Slime, a filamentous bacterial (Sphaerotilus) growth is associated with suspended wood fiber.

The effluent from the papermill is just off-white in colour and can be observed in the river for up to 1,000 feet as a separate flow.

GENERAL COMMENTS ON CONDITIONS ALONG THE WINNIPEG RIVER (continued)

Beyond that distance, mixing becomes complete and the effluent is diluted sufficiently to become indistinguishable from the rest of the river.

CHEMICAL ANALYSIS OF WATER QUALITY

On September 13, 1970, grab samples were taken at mid-stream for water quality analyses. The results are included as Appendix 3 and summarized in Table A 3. Examination of this Table shows that with the exception of iron, there is no significant change in the levels of the parameters analysed along the stretch of river under study. In addition, with the exception of iron and manganese, this water meets the acceptable limits for these parameters set out in the Canadian Drinking Water Standards by quite a long margin. The water is very soft and if filtered and treated by an iron removal unit (which also removes manganese) should prove to be excellent as a domestic supply.

RESULTS OF THE SURVEY

Following are presented the Tables of the information extracted from the results of analyses. The original data is presented in the Appendices. Tables and figures 1 to 17 were compiled as follows. Each Table, or figure, represents only one parameter. When the sampling program was carried out in 1970, the papermill was not operating on August 31st, the first day of the survey. The results of that day's sampling are shown and plotted individually in order to act as a comparison for when the mill was in operation. Samples taken from September 1st to September 4th, inclusive, were taken when the mill was in operation. The individual values for each parameter are presented in the Appendices. The values appearing in the Tables and figures are the arithmetic mean of the samples taken during the four days of operation. By comparing the 1970 figures and graphs, a comparison of conditions in the river with the mill operating and not operating are obtained. In most cases, there is no significant difference and those slight differences that exist can be attributed to variation due to the randomness of sampling.

An additional series of samples was taken on August 4th and August 5th of 1971. The arithmetic mean of these two samples is shown in the Tables and plotted separately. On these two days, the papermill was in operation. A comparison of these values with those obtained on September 1 - 4, 1970, should indicate any changes in conditions from one year to the next. Again, in most instances there is little significant change and differences are largely attributable to the variation due to randomness of sampling.

DISCUSSION OF CHEMICAL PARAMETERS

All chemical and physical tests carried out in this survey were done in accordance with the methods outlined in "Standard Methods for the Examination of Water, Sewage and Industrial Wastes", current edition. The parameters selected are those generally accepted for use in surveys of water quality in rivers and are discussed individually. The significance of each parameter, as an indicator of pollution, is considered and an estimate of the significance of that variable is made as it relates to the current survey.

Alkalinity - represents the contents of carbonates, bicarbonates, hydroxides and occasionally, silicates present in water. Alkalinity is commonly found in natural waters in the form of carbonates of soda or bicarbonate of calcium and magnesium. Too low (below 10 mg/1 litre) a level of alkalinity is undesirable in water as such water tends to be acidic and corrosive. Alkalinity above 100 mg/1 litre is not desirable as high levels of alkalinity are concomitant with high levels of hardness. Within the above limits, the exact amount of alkalinity found in sewage or natural waters has little significance. Examination of Table 1 and Figure 1 shows that there is a slight, though not significant, drop in alkalinity from September, 1970, to August, 1971. There is, however, virtually no change in alkalinity along the river. The alkalinity of the river 100 feet downstream of the papermill outfall, is the same as that along the entire length of river under study. The level of alkalinity is within the desirable range.

Bacteriological Analyses - The coliform group of bacteria is used as an indicator group for pollution because these bacteria are normal inhabitants of the intestinal tract. When found in

Discussion of Chemical Parameters (continued)

water, coliform bacteria indicate that the water may have been contaminated with human or animal excreta. There are members of the coliform group which are found in non-animal organic matter. Faecal coliform and total coliform tests are carried out if a distinction between the two is desired. If the coliform group is present, it is assumed that various pathogenic (harmful to man) bacteria are also present. Raw sewage generally contains 10 to 25 million coliform organisms per 100 ml.

Examination of Table 2 indicates that when the papermill is operating, the level of coliform bacteria increases significantly below the mill outfall. Samples of the mill effluent also contain high coliform counts as indicated at the bottom of Table 2. The high dilution resulting when the mill effluent enters the river causes a reduction in the coliform count of water samples. The mill effluent is definitely a source of bacterial contamination of the river and chlorination of final effluent should be considered prior to discharge to the river.

BIOCHEMICAL OXYGEN DEMAND

Aerobic decomposition of organic matter requires oxygen. The amount of organic matter can be deduced by determining the rate and amount of oxygen utilization. It is an indicator of the metabolism of living organisms as they utilize organic matter for food. This determination is called the biochemical oxygen demand (B.O.D.) and is generally based on a five day incubation period at a constant temperature of 20°C. A British Royal Commission on sewage disposed to river systems suggested, with respect to B.O.D. levels, the following river classification based on the standard five day B.O.D. test:

B.O.D.	- 1 ppm	-	'very clean'
	2 ppm	-	'clean'
	5 ppm	-	'doubtful'
	10 ppm	-	'dirty'

The 1970 survey, with respect to B.O.D. (see graphical representation in Table and figure 3) shows a gradual increase in the mean B.O.D. values from 0.7 to 1.1 from Range I above Great Falls to Range 7 in Traverse Bay. The limited number of samples collected and analysed in 1971 indicated somewhat higher B.O.D. values over those of 1970.

The analyses indicate a slight increase in B.O.D. at the site of the papermill and townsite of Pine Falls and a further slight increase in the vicinity of Fort Alexander. Comparing the graph of September 1 - 4, 1970, and September, 1971, (when the mill was operating) with that for August 31st, 1970, when the mill was not operating, it is evident that there is an increase in B.O.D. downstream of the mill during periods of operation. This change represents on the average a 40% increase when the mill is operating and must be considered as significant. The levels of B.O.D. in the river cannot be regarded as being indicative of a heavy pollutional

Biochemical Oxygen Demand (continued)

load, particularly in view of the significantly higher levels of dissolved oxygen, however, Table 3 indicates quite high levels of B.O.D. in the mill effluent which average 87 mg/1 litre. Levels above 30 mg/1 litre are generally considered unacceptable. The low B.O.D. levels in the river result primarily from the high dilution which occurs.

Consideration should be given to preliminary treatment of the mill effluent to lower the B.O.D. before discharge.

Chemical Oxygen Demand - is the inorganic counterpart of biochemical oxygen demand. C.O.D. tests have been devised in an attempt to overcome objections to the B.O.D. test, such as, the time required, uncertainties concerning the reaction velocity constant and the total first stage oxygen demand. There is usually a close ratio between C.O.D. and B.O.D. in industrial wastes which are fairly constant in composition and contain no toxic materials. Figure and Table 4 show an almost constant C.O.D. along the stretch of river under study on September 1, 1970, just as the mill had started operating and a rise in C.O.D. over a four mile stretch upstream of the mill on September 3, 1970, after the mill had been operating. The general level of C.O.D. is relatively high throughout the river, but an examination of the laboratory report on C.O.D. (see Appendix 4) shows a random distribution of C.O.D. values throughout the river with no marked increase which can be attributed to effluent from the mill or to any other source.

Chlorides - in waters, are not to be confused with free residual chlorine resulting from the addition of free chlorine gas. Chlorides are inorganic substances commonly found in the urine of man and animals. The amount of chlorides above the normal chloride

Biochemical Oxygen Demand (continued)

content of waters in an area can be used as an index of the degree of pollution. The chloride content may be affected by certain trade wastes. Since chlorides are inorganic substances in solution, they are not affected by biological processes or by sedimentation.

The September, 1970, results indicate chloride levels less than 0.5 part per million throughout the length of river surveyed with a slight decrease in the vicinity of the papermill. The August, 1971, values show an increase to 2.0 to 2.6 parts per million with a very slight decrease immediately downstream of the mill and a larger increase farther downstream. The Canadian Drinking Water Standards, published by Department of National Health and Welfare, give an acceptable limit of chlorides in drinking water as 250 mg/1 litre so that the level of chlorides in the Winnipeg River is two orders of magnitude lower than allowable limits and cannot be regarded as in any way impairing the quality of the water for drinking or other uses.

Colour - in water is usually derived from leaves, peat, logs and other organic matter but it may be caused by iron or manganese combined with organic matter. Swamps are perhaps the principal source of coloured water. True colour is caused by material in solution, whereas apparent colour may be due to very fine particles carried in suspension in the water. The size, shape and light scattering properties also have a strong bearing on apparent colour. Large particles of relatively opaque material, such as wood fibers, do not have a great effect on the colour but increase the turbidity significantly. Colour limits on drinking water are developed primarily to meet aesthetic satisfaction and secondarily

Biochemical Oxygen Demand (continued)

to prevent the possible staining of clothes and fixtures. For drinking water, a colour below 5 True Colour Units is generally acceptable. There is no correlation between true and apparent colour in excess of 40 would have to be filtered anyway to remove the turbidity to be aesthetically acceptable.

Examination of Table and figure 6 shows that although the colour level is somewhat lower in the 1971 samples there is no significant colour level change along the length of the Winnipeg River under study.

Conductivity - or specific conductance, is a measure of a water's capacity to convey an electric current. This property is an indication of the total concentration of the ionized substances, particularly dissolved metallic salts, in the water. Most raw and finished drinking waters in Canada exhibit a conductivity from about 50 to 500 micromhos per cm. Examination of Table 7 indicates that the conductivity of the river remains effectively constant over the length of river under study and over the duration of the survey. The conductivity of the mill effluent is somewhat higher and can be said to be adding ions to the river but the level of conductivity of the river and even of the effluent is well within the limits accepted for municipal supplies in Canada.

Dissolved Oxygen

Oxygen is used in the bio-oxidation process which decomposes organic wastes. A measurement of the dissolved oxygen established the influence of organic pollution to the waters of a stream.

Adequate dissolved oxygen is necessary for the life of fish and other aquatic organisms. Suffocation of fish will result from drastic reduction of dissolved oxygen. Under average stream conditions 3.0 mg/1 or less of dissolved oxygen should be regarded

Dissolved Oxygen (continued)

as hazardous, and to maintain the varied fish fauna in good condition the dissolved oxygen content should remain 5.0 mg/l or higher. A drop in dissolved oxygen content indicates the presence of organic pollution. The point of maximum de-oxygenation may be some distance down river from the point of pollution because the de-oxygenation process of water by industrial wastes and sewage is a comparatively slow process.

Another significant consideration in determining the role of oxygen in the water with regard to pollution, is the relative level of dissolved oxygen to biological oxygen demand. The B.O.D. should not exceed the D.O. for any substantial distance along the river. Generally speaking, there should be a cushioning zone of 5 mg/l litre between the maximum B.O.D. and the minimum D.O. content at the same point.

Examination of Table and figure 8 indicates that the average dissolved oxygen level is very high, ranging in the order of 90% saturation during the 1970 survey and at saturation during the 1971 survey. Also, there is no significant difference between the dissolved oxygen levels when the mill is operating and when it is not. The oxygen levels are high and nowhere along the stretch of river under study is there evidence of oxygen depletion. In addition, in comparing the dissolved oxygen levels with B.O.D. levels, it is evident that everywhere there is at least 5 mg/l litre more dissolved oxygen than B.O.D. material

Lignin and Tannic Acid

Wood is made up of cellulose combined with lignin and tannic acid similar organic substances which are related to carbohydrates and which degenerate very slowly. It is a common constituent of

Lignin and Tannic Acid (continued)

water flowing through wooded and swampy areas and in areas where there are pulping processes which liberate lignin and tannic acid from wood fibres.

The concentration of lignin and tannic acid above the Great Falls Hydro Power Plant of 1.0 mg/l may be compared with that of 1.1 mg/l immediately downstream from the confluence of the Maskwa River. After complete mixing in the stream above Pine Falls, the average levels were reduced to 1.0 mg/l. Downstream from Pine Falls, the concentration of lignin and tannic acid increased to 1.1 mg/l and persisted at that level to Traverse Bay on Lake Winnipeg. (See figure and Table 9)

Lignin and tannic acid concentrations for the two day survey in August, 1971, exhibited a somewhat parallel pattern, namely, a slight increase below Pine Falls. In that survey, however, a slight decrease in concentration was recorded as the stream approached Traverse Bay.

The slight increase in lignin and tannic acid in the stretch of the river studied is not significant.

Nitrates and Nitrites

There are five nitrogen determinations that may be used in the analyses of waters or wastewaters: albuminoid ammonia, free ammonia, organic nitrogen, nitrates and nitrites. The last four constitute total nitrogen. Nitrates and nitrites are found in fresh sewages only, in very low concentrations. Nitrites are not stable and usually oxidize to nitrates. Their presence indicates that change is in progress, that a wastewater is fresh or the addition of diluting water so recently as to allow insufficient time for the reduction of the nitrates and nitrites. The presence of

Nitrates and Nitrites (continued)

nitrates in waters may be undesirable because of the promotion of algal and macroscopic plant growth.

Examination of Table 10 shows a level of nitrates consistently below 0.01 part per million which is the limit of sensitivity of the standard method of nitrate determination. Levels in this order do not pose any pollutional threat to the river. Table II shows the identical pattern for nitrites and this level of nitrite nitrogen indicates that there is an abundance of oxygen in the water for oxidization purposes. At present, these low levels of nitrogen are not promoting aquatic growth.

Phosphates

Phosphorous occurs in natural waters and in wastewaters almost solely as various types of phosphates. The various forms of phosphates find their way into wastewaters, effluents and polluted waters from a variety of sources, including laundering and cleaning operations and agricultural fertilizers which are carried into rivers by storm runoff and snow melt. Organic phosphates are formed primarily in biological processes and are contributed to sewage in body wastes and food residues or they may be formed from orthophosphates in biological treatment processes or by bio-organisms in the receiving water. In instances where phosphorous is a growth-limiting nutrient, the discharge of raw or treated sewage, agricultural drainage or certain industrial wastes may stimulate the growth, in nuisance quantities, of photosynthetic aquatic micro and macro-organisms.

Examination of tables and figures 12 and 16 indicates that the levels of both orthophosphates and total phosphates is slightly higher when the mill is not operating than when it is. The difference is not significant, however. There is also a drop in the

Phosphates (continued)

total level of orthophosphates in the 1971 samples as compared to the 1970 samples. There is also no significant change in levels above and below the mill outfall in these two parameters. No excessive algal growth was observed to indicate high rates of phosphorous utilization by aquatic organisms.

Orthophosphates are common in commercial fertilizers and often find their way into bodies of water by way of rain or snow melt runoff from agricultural lands.

pH - is a mathematical index relating to the degree of ion concentration in a water or in other words, whether a water is basic or acidic. It also has significance in controlling the corrosion and scaling tendency of the water. The Canadian Drinking Water Standards promulgated by the Department of National Health and Welfare state that water in the pH range of 6.5 to 8.3 is acceptable as treated drinking water. Examination of Table 13 shows that all samples at all locations and at all times, including the mill effluent, have a pH well within this range.

Sulphates - Sulphate is widely distributed in nature and may be present in concentrations ranging from a few to several thousand mg/l litre. Because sodium and magnesium sulphate exert a cathartic action, the acceptable limit of sulphate in potable water is 250 mg/ litre. Reference to Table and figure 14 shows that during the 1970 sampling program, sulphates were uniformly and surprisingly low along the entire portion of the river under study. The 1971 sampling program indicates a general increase in sulphate level with a slight peak just downstream of the papermill outfall. This is not unexpected as sulphates are usually by-products of paper manufacturing, however, a sample taken 100 feet downstream of the outfall had a

Sulphates (continued)

lower sulphate content than those taken in the ranges, above and further below the papermill. Generally, however, the sulphate content of the river is very low and is not detrimental to the flora and fauna of the river. It is suspected that the low sulphate levels in the river can be attributed to the high dilution ratios.

Suspended Solids

The concentration of suspended solids is a fair indication of the extent of pollution due to the discharge of solids into a river. Settleable solids are suspended solids until they have settled on the bottom of the watercourse. Dissolved or colloidal solids, such as sulphite waste liquors, may be synthesized by bacteria in the stream to form suspended and settleable sludge. The analytical data on suspended solids excludes floating masses and bottom deposits. Suspended solids contribute to both turbidity and apparent colour.

Examination of Table 15 indicates that while the mill was not in operation on August 31, 1970, there were no suspended solids observed in the samples, both above and below the papermill outfall. When the mill started operations on September 1, 1970, the level of suspended solids remained virtually zero above the papermill outfall but increased below the mill. This pattern continued with increasing levels of suspended solids below the mill outfall but surprisingly the suspended solids level also increased above the mill outfall. There seems to be no reasonable explantion for this. The 1971 sampling program indicates a slightly higher overall suspended solids level in the river with a definite increase immediately below the papermill outfall and a gradual decline to ambient levels

Suspended Solids (continued)

farther downstream where the solids have had a chance to settle out. As indicated in Table 15, the suspended solids level of the effluent from the papermill is relatively high, averaging 258 mg/litre in the 1970 survey and 81 in the 1971 survey. There is no doubt that the papermill is discharging suspended solids, primarily as wood fiber. Not only does wood fiber settle out and smother benthic organisms, it also acts as a substrate for slime producing bacteria which results in the coating by slime of most materials under the water. It is desirable to remove substantially all suspended solids from the papermill's effluent.

Turbidity

Turbidity in water is caused by the presence of suspended matter, such as clay, silt, finely divided organic and inorganic matter, plankton and other microscopic organisms. Turbidity is a measure of the light scattering and absorbing ability of a liquid and does not identify specific material in the water. To correlate turbidity with weight concentration of suspended matter is impractical as the size, shape and refractive and reflective indices of the particulate materials are of great importance optically but bear little direct relationship to the concentration and specific gravity of the suspended matter. In the present survey, turbidity in the water is due, at least in part, to the presence of fibrous materials.

Examination of Table and figure 17 shows an increase in turbidity downstream of the mill. The 1971 survey shows a sharp increase immediately downstream of the mill, then a slight decline as suspended material settles out, then a further increase towards

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Turbidity (continued)

the mouth of the river. It should be noted that the Winnipeg River widens out near its mouth and water from the relatively shallow Traverse Bay is driven upstream by the prevailing northwest winds so that the high turbidity at the river mouth is likely due to very fine clay particles held in suspension in the turbulent waters. The sharp peak in turbidity, indicated in the 1971 figures, points out the need to remove suspended solids from sources discharging to the river. Table 17 indicates that the turbidity of effluent from the papermill is on the average about five times as high as of the river water.

AVERAGE FLOWS IN WINNIPEG RIVER

Date	Average Flow C.F.S.
August 31, 1970	27,490
September 1, 1970	29,030
September 2, 1970	30,780
September 3, 1970	29,820
September 4, 1970	30,120
August 4, 1971	32,810
August 5, 1971	32,740

MONTHLY AVERAGE FLOW RATES

Month	Average Flow C.F.S.
August, 1970	34,200
September, 1970	32,480
August, 1971	25,400

All values were recorded just below Pine Falls

ALKALINITY - TOTAL AS $CaCO_3$

TABLE I

OUTFALL ↓ → FLOW

RANGE	I	II	III	IV	V	VI	VII
Sept.5/70	38.0	38.0	37.2	38.3	38.3	39.0	

STATION	I	II	III	IV	VI	VI	100' downstream of outfall
Aug.4/71	45*	44	43	44	44	44	44
Aug.5/71	40	43	43	45	43	42	--
AVERAGE							
Aug.4th & 5th	42	43	43	44	43	43	44

* All values are given as milligrams per litre, or the equivalent-parts per million

BACTERIOLOGICAL ANALYSIS

TOTAL COLIFORMS

MPN per 100 ml

TABLE 2

FLOW → OUTFALL

RANGE	I	II	III	IV	V	VI	VII	Papermill Outfall
Aug.31/70	56	19	218	<240	<240	240	87	900
Sept.1	119	209	41	2600	940	240±	125	110,000
Sept.2	100	310	45	<240	1540	1380	401	46,000
Sept.3	507	87	141	<350	675	240±	193	24,000
Median Sept. 1-3	68	43	68	<240	605	<300	43	

AVERAGE

Sept. 1-3	242	202	176		1052		240

STATION	I	II	III	IV	V	VI
Sept.8/71	540	2250	1750	4000	-	240
Sept.21/71	<240	240+	<240	240I	<240	

Papermill outfall - coliform bacteria

August 31, 1970	-	900
September 1, 1970	-	110,000
September 2, 1970		46,000
September 3, 1970	-	24,000

* Outfall refers to effluent from the papermill

BIOCHEMICAL OXYGEN DEMAND

TABLE 3

RANGE	I	II	III	IV	V	VI	VII	Papermill Outfall
1970								
Aug.31	0.7*	0.7	0.6	0.8	0.5	1.0	0.9	--
Sept.1	0.6	0.7	1.3	1.2	1.1	0.7	0.7	117.3
Sept.2	0.6	0.8	1.2	1.0	1.2	1.0	1.5	--
Sept.3	0.8	0.7	0.7	0.6	1.1	1.1	1.1	44.1
Sept.4	0.6	0.9	0.8	1.1	1.6	1.2	1.3	100.8
AVERAGE								
Sept.1-4	0.7	0.8	1.0	0.9	1.2	1.0	1.1	87

STATION	I	II	III	IV	V	VI	100' from outfall
1971							
Aug.4	2.8	1.7	1.7	1.6	1.6	2.0	--
Aug.5	1.3	1.3	1.9	1.4	1.1	1.3	797
Average Aug. 4th & 5th	2.1	1.5	1.8	1.5	1.3	1.6	

* All values are parts per million or milligrams per liter.

CHEMICAL OXYGEN DEMAND

TABLE 4

RANGE	I	II	III	IV	V	VI	VII
Sept.1/70							
	7.9*	7.2	7.3	7.9	8.6	8.4	8.2
Sept.3/70							
	13.3	12.4	15.3	17.8	13.7	14.0	15.2

On September 1, when the samples were taken the mill had just started operation. On September 3rd, the mill had been operating for two days when these samples were taken.

* All values in milligrams per liter, or parts per million.

CHLORIDES

TABLE 5

RANGE	I	II	III	IV	V	VI	VII
Sept.5/70							
	0.5*	0.5	0.4	0.2	0.2	0.5	

STATION	I	II	III	IV	VI	VI	100' of outfall
Aug.4/71							
	2.0	2.0	1.7	1.5	1.5	1.5	2.0
Aug.5/71							
	2.2	2.3	3.5	2.5	3.0	3.2	--
AVERAGE							
Aug. 4th & 5th							
	2.1	2.2	2.6	2.0	2.2	2.4	2.0

* Values in milligrams per liter or parts per million.

COLOUR

TABLE 6

RANGE	I	II	III	IV	V	VI	VII	Papermill Outfall
1970								
Aug.31	56*	56	58	59	56	58	53	--
Sept.1	50	51	54	51	51	52	54	70
Sept.2	50	55	55	55	55	54	55	--
Sept.3	51	51	45	61	54	55	61	70
Sept.4	48	45	45	51	52	46	49	70
AVERAGE								
Sept.1-4								
	50	51	49	55	53	52	52	70

STATION	I	II	III	IV	V	VI	100' from outfall
1971							
Aug.4	40	40	40	38	38	40	55
Aug.5	39	40	39	42	41	39	
Aug. 4th & 5th							

* All values in milligrams per liter.

CONDUCTIVITY

MICROMHOS PER CM

TABLE 7

RANGE	I	II	III	IV	V	VI	VII	Papermill Outfall
1970								
Aug.31	84	85	86	86	87	83	84	--
Sept.1	85	87	89	87	86	82	83	136
Sept.2	84	84	84	85	85	82	85	--
Sept.3	86	84	85	85	87	81	84	147
Sept.4	80	83	83	86	90	81	80	170
AVERAGE								
Sept.1-4	83	84	85	86	87	82	83	151

STATION	I	II	III	IV	V	VI	100' from outfall
1971							
Aug.4	89	89	87	86	87	85	86
Aug.5	83	90	90	89	86	85	200
AVERAGE							
Aug.4th & 5th	86	89	88	88	87	85	143

DISSOLVED OXYGEN

TABLE 8

RANGE	I	II	III	IV	V	VI	VII	Papermill Outfall
1970								
Aug.1	8.3*	8.2	8.2	8.2	8.4	8.2	8.2	--
Sept.1	8.3	8.2	8.4	8.1	8.0	8.0	8.1	4.0
Sept.2	8.2	8.1	8.4	8.2	8.0	8.0	8.1	--
Sept.3	8.3	8.2	8.2	8.3	8.0	7.9	7.9	5.4
Sept.4	8.1	8.2	8.0	8.2	8.1	7.9	7.9	4.8
AVERAGE								
Sept.1-4	8.2	8.2	8.3	8.2	8.1	8.0	8.1	4.7
Percent Saturation	91%	91%	92%	91%	90%	89%	90%	58%

STATION	I	II	III	IV	V	VI	100' from outfall
1971							
Aug.4	8.5	9.1	9.0	9.0	8.9	8.9	--
Aug.5	8.7	9.1	9.2	9.2	9.3	9.4	8.9
AVERAGE							
Aug.4th & 5th	8.6	9.1	9.1	9.1	9.1	9.2	8.9
Percent Saturation	96%	101%	101%	101%	101%	102%	106%

* All values are in parts per million or milligrams per liter.

LIGNIN & TANNIC ACID

TABLE 9

RANGE	I	II	III	IV	V	VI	VII	Papermill Outfall
1970								
Aug.31	1.1*	1.2	1.1	1.1	1.1	1.1	1.1	--
Sept.1	1.1	1.1	1.0	1.0	1.1	1.0	1.0	19
Sept.2	1.0	1.1	1.0	1.1	1.0	1.1	1.0	125
Sept.3	1.0	1.1	1.1	1.1	1.2	1.1	1.1	7.0
Sept.4	1.1	1.1	1.1	0.9	1.2	1.1	1.1	23.5
AVERAGE								
Sept.1-4	1.1	1.1	1.1	1.0	1.1	1.1	1.1	44

STATION	I	II	III	IV	V	VI	100' from outfall
1971							
Aug.4	1.0	1.0	1.0	1.0	1.0	1.0	1.1
Aug.5	1.0	1.0	1.1	1.3	1.0	0.8	--
AVERAGE							
Aug.4th & 5th	1.0	1.0	1.0	1.1	1.0	0.9	1.1

*Values in milligrams per liter or parts per million.

NITRATE NITROGEN (NO_3)

TABLE 10

RANGE	I	II	III	IV	V	VI	VII
1970							
Aug.31	.01*	.01	.01	.01	.01	.01	.01
Sept.1	.01	.01	.01	.01	.01	.01	.01
Sept.2	.01	.01	.01	.01	.01	.01	.01
Sept.3	.01	.01	.01	.01	.01	.01	.01
Sept.4	.01	.01	.01	.01	.01	.01	.01
AVERAGE							
Sept.1-4	.01	.01	.01	.01	.01	.01	.01

No nitrate analysis was carried out during the 1971 sampling program

* Values are in parts per million or milligrams per liter.

NITRITE NITROGEN (NO_2)

TABLE 11

RANGE	I	II	III	IV	V	VI	VII
1970							
Aug.31	.003*	.003	.003	.003	.003	.003	.003
Sept.1	.003	.003	.003	.003	.003	.003	.003
Sept.2	.003	.003	.003	.003	.003	.003	.004
Sept.3	.003	.003	.003	.003	.003	.003	.003
Sept.4	.002	.003	.003	.003	.003	.003	.003
AVERAGE							
Sept.1-4	.003	.003	.003	.003	.003	.003	.003

No Nitrite analysis was carried out during the 1971 sampling program.

* Values in milligrams per liter or parts per million.

ORTHOPHOSPHATES

TABLE 12

RANGE	I	II	III	IV	V	VI	VII
1970							
Aug.31	.05*	.06	.06	.06	.05	.06	.06
Sept.1	.06	.05	.06	.05	.05	.06	.06
Sept.2	.04	.04	.07	.04	.05	.05	.05
Sept.3	.06	.04	.06	.05	.05	.04	.06
Sept.4	.05	.05	.05	.05	.05	.05	.07
AVERAGE							
Sept.1-4	.05	.04	.06	.05	.05	.05	.06

STATION	I	II	III	IV	VI	VI	100' from outfall
1971							
Aug.4	.02	.03	.02	.01	.02	.02	.01
Aug.5	None done						
AVERAGE							
Aug.4th & 5th	.02	.03	.02	.01	.02	.02	.01

* Values in milligrams per liter.

pH

TABLE 13

RANGE	I	II	III	IV	V	VI	VII	OUTFALL
1970								
Aug. 31	7.8	7.6	7.7	7.4	7.5	7.8	7.7	--
Sept. 1	7.6	7.6	7.6	7.5	7.5	7.5	7.5	6.8
Sept. 2	7.7	7.7	7.4	7.4	7.7	7.8	7.7	--
Sept. 3	7.6	7.5	7.5	7.6	7.5	7.5	7.5	6.8
Sept. 4	7.6	7.5	7.6	7.6	7.7	7.6	7.7	6.8
AVERAGE								
Sept. 1-4	7.6	7.6	7.6	7.5	7.6	7.6	7.6	6.8

STATION	I	II	III	IV	V	VI	100' downstream of outfall
1971							
Aug. 4	7.8	7.9	8.0	7.9	8.0	7.9	7.9
Aug. 5	7.8	7.8	7.9	7.9	7.9	7.9	7.0
AVERAGE							
Aug. 4 & 5	7.8	7.9	7.9	7.9	7.9	7.9	7.5

SULPHATES

TABLE 14

RANGE	I	II	III	IV	V	VI	VII
1970							
Sept. 5	0.5*	0.4	0.5	0.4	0.5	0.5	

STATION	I	II	III	IV	V	VI	100' downstream of outfall
1971							
Aug. 4	7.9	9.2	9.2	9.3	8.9	8.5	8.8
Aug. 5	8.0	8.1	9.1	12.0	9.6	8.3	-
AVERAGE							
Aug. 4th & 5th	7.9	8.6	9.2	10.7	9.3	8.4	8.8

* Values in milligrams per liter or parts per million.

SUSPENDED SOLIDS

TABLE 15

RANGE	I	II	III	IV	V	VI	VII	Outfall
1970								
Aug. 31	0*	0	0	0	0	0	0	--
Sept. 1	0	1	0	.5	3	4.5	0	170
Sept. 2	1.8	2	3.8	153	5.3	5.8	8.8	170
Sept. 3	7.3	87.8	774	343	543	165	14	547
Sept. 4	0	310	16	0	3.5	469	15	147
AVERAGE								
Sept. 1-4	2.3	100	498	124	139	161	10	258

STATION	I	II	III	IV	V	VI	100' from Outfall
1971							
Aug. 4	12.7	11	10.3	8.7	10.3	11	11
Aug. 5	14	18.3	17.7	31	15	13.5	151
AVERAGE							
Aug. 4th & 5th	13.3	14.7	14.0	19.9	12.7	12.3	81

* Values in milligrams per liter or parts per million.

TOTAL PHOSPHATES

TABLE 16

RANGE	I	II	III	IV	V	VI	VII
1970							
Aug. 31	0.10*	0.10	0.11	0.10	0.14	0.12	0.10
Sept. 1	0.09	0.09	0.08	0.09	0.09	0.11	0.10
Sept. 2	0.10	0.11	0.10	0.10	0.09	0.10	0.11
Sept. 3	0.10	0.10	0.10	0.10	0.10	0.11	0.12
Sept. 4	0.10	0.10	0.10	0.09	0.11	0.10	0.11
AVERAGE							
Sept. 1-4	0.10	0.10	0.10	0.10	0.10	0.10	0.11

No total phosphate analysis was carried out during the 1971 sampling program.

* Values in milligrams per liter or parts per million.

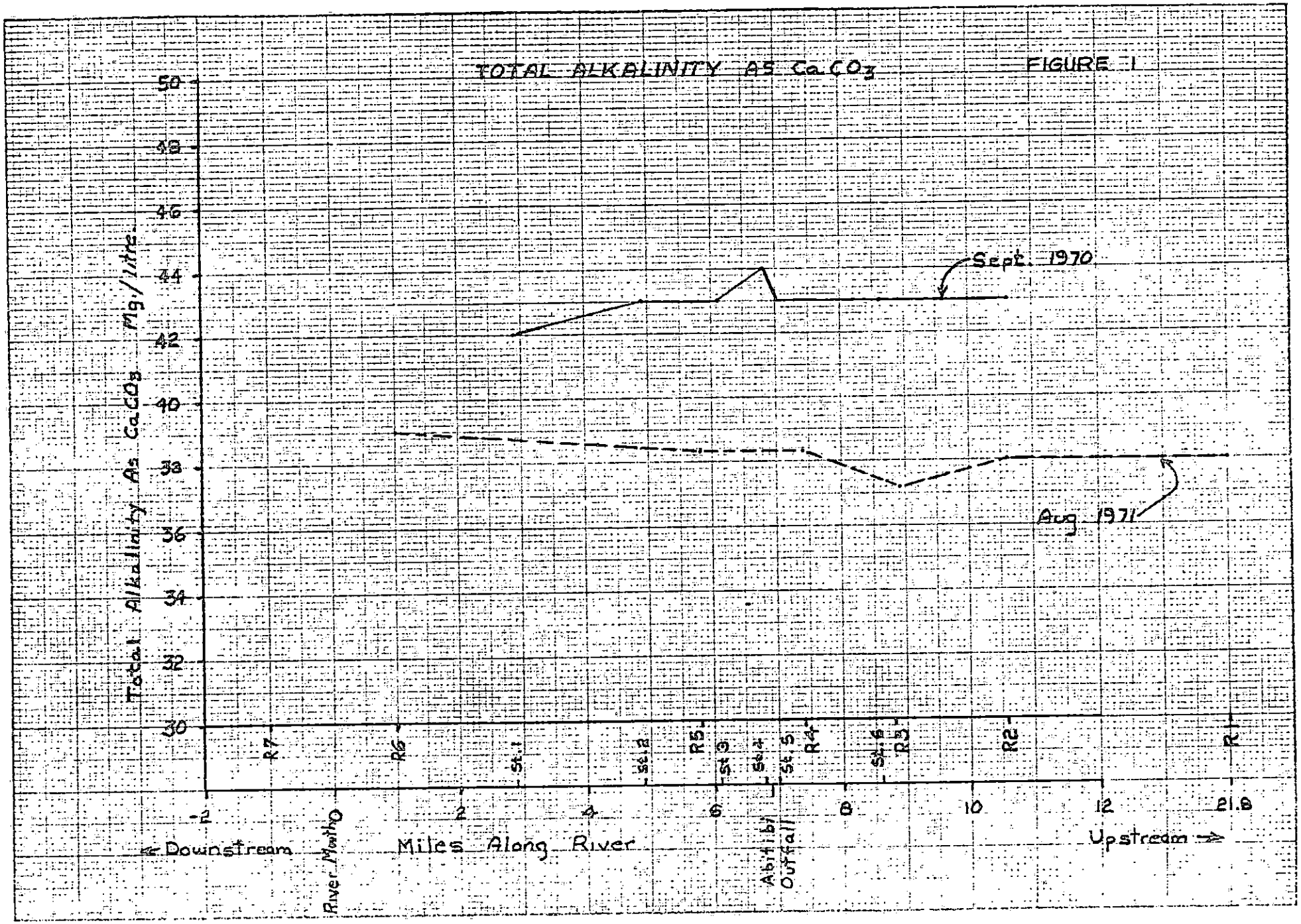
TURBIDITY J.T.U.

TABLE 17

RANGE	I	II	III	IV	V	VI	VII	Outfall
1970								
Aug. 31	8.5*	9	9.5	8.2	8.8	12	13	--
Sept. 1	10.8	10.2	8.8	7.8	8.8	12.2	12.5	67
Sept. 2	7.0	8.0	7.3	8.0	9.0	11.8	12.2	--
Sept. 3	7.8	8.0	7.0	8.2	9.5	12.0	12.8	64
Sept. 4	8.0	8.2	8.0	8.0	9.5	11.8	22.5	91
AVERAGE								
Sept. 1-4	8.6	8.6	8.1	8.0	9.2	11.9	14.7	74

STATION	I	II	III	IV	V	VI	100 feet from Outfall
1971							
Aug. 4	13	10	10	9	8	8	8
Aug. 5	10	10	12	15	10	9	>85
AVERAGE							
Aug. 4th & 5th	11.3	10.3	10.8	12.0	8.7	8.5	

* Values in Jackson Turbidity Units.



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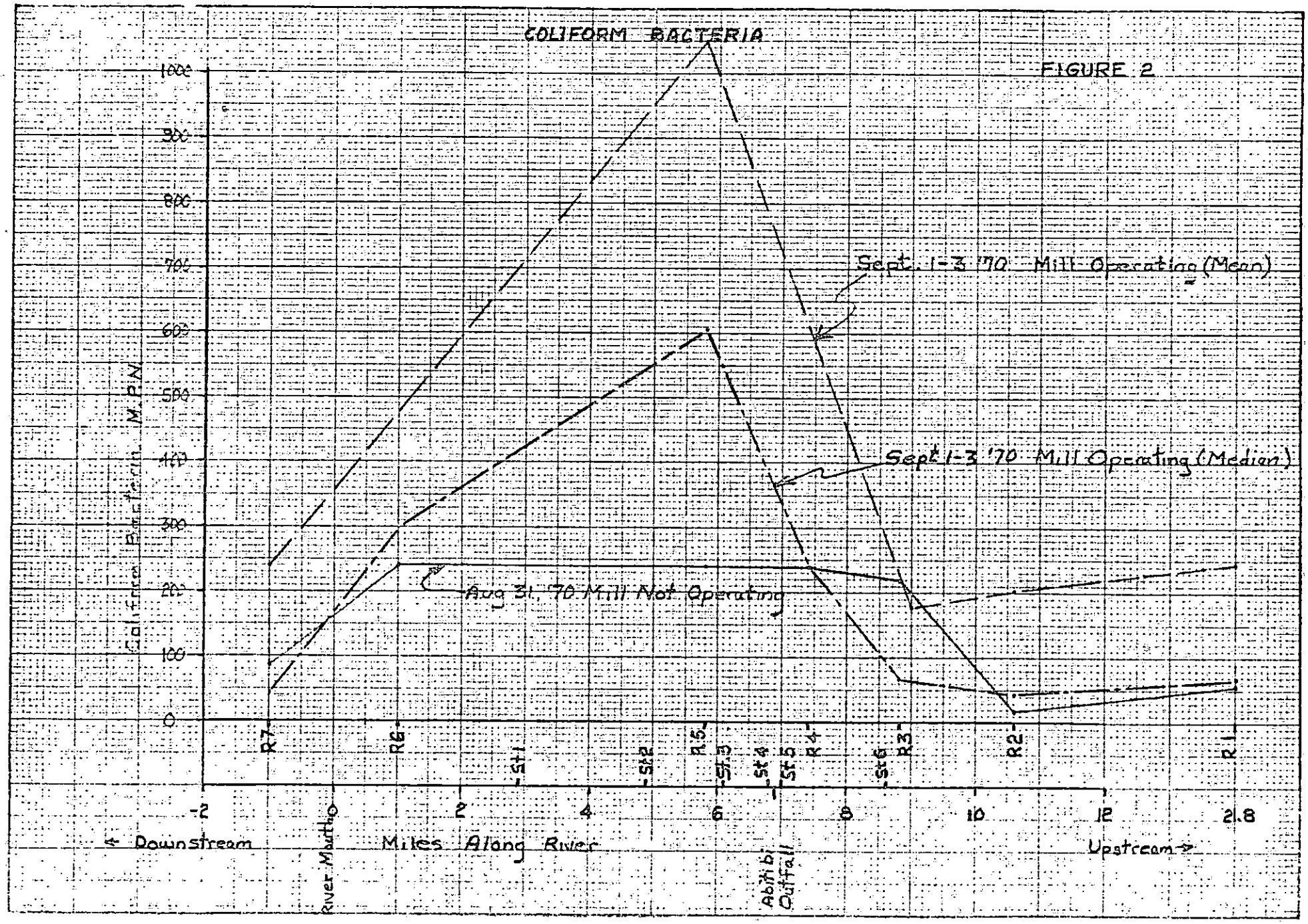

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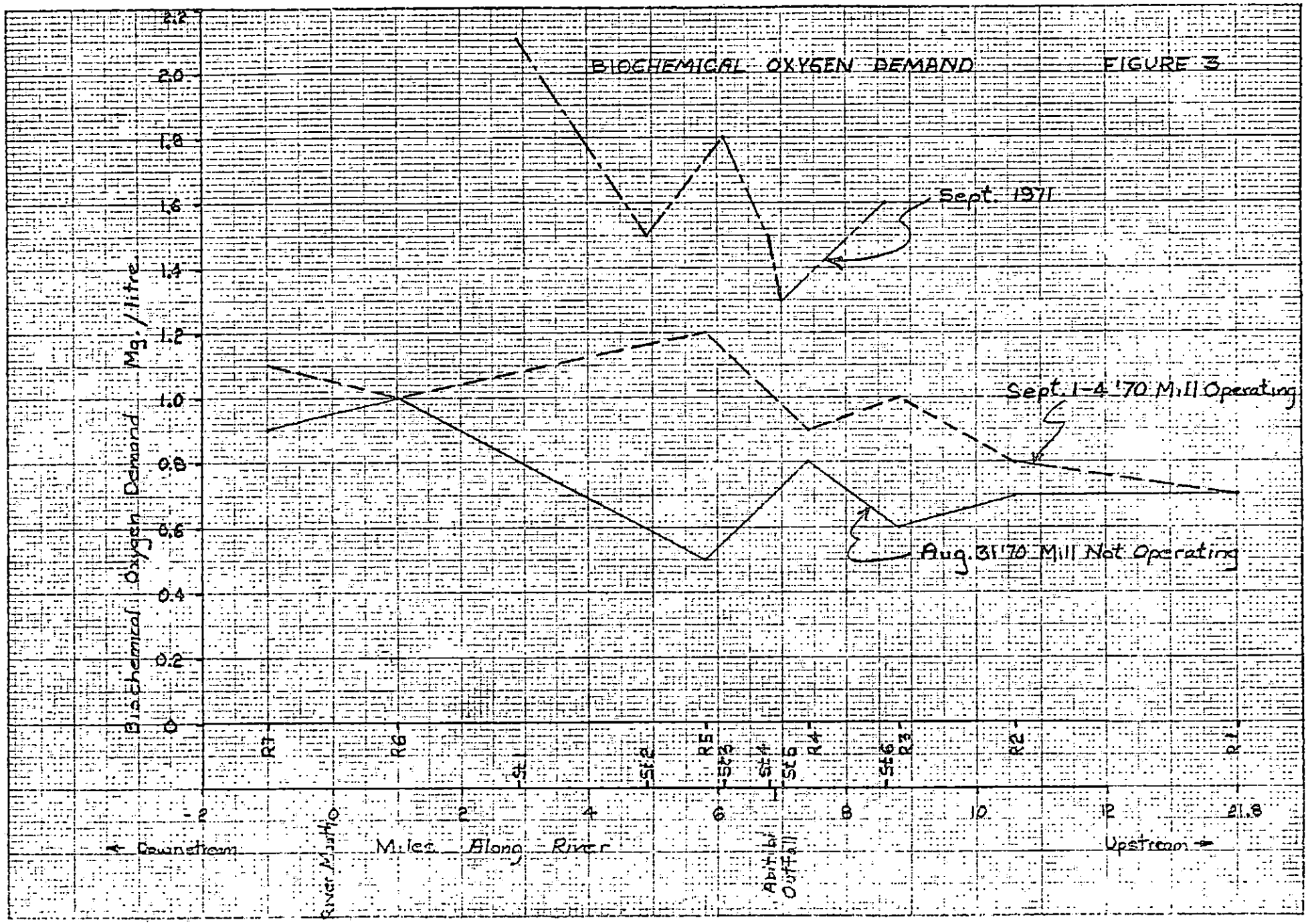
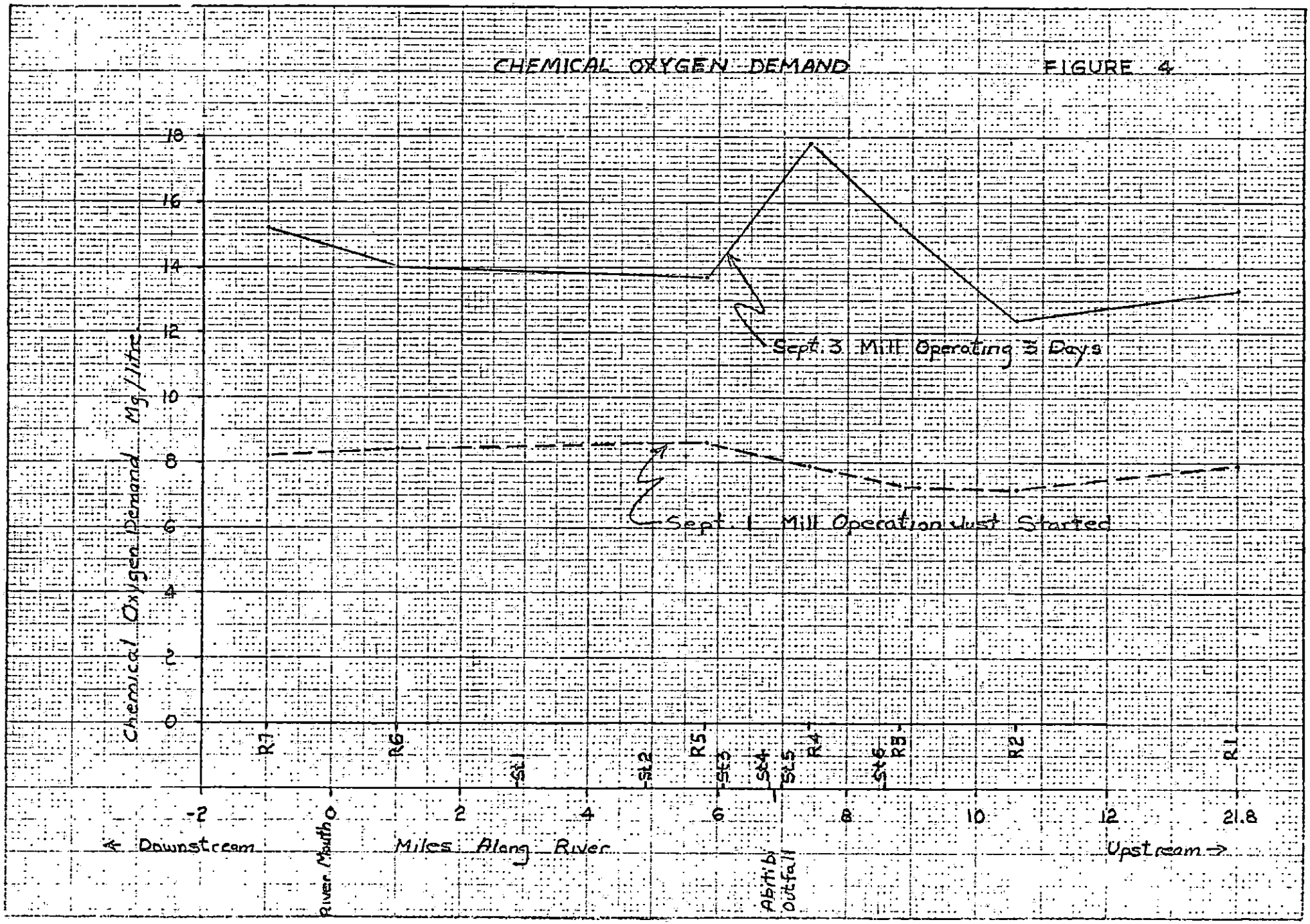

BIOCHEMICAL OXYGEN DEMAND
FIGURE 3
Biochemical Oxygen Demand Mg./litre
2.2
2.0
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0
Sept. 1971
Sept. 1-4 '70 Mill Operating
Aug. 31 '70 Mill Not Operating
R7
R6
St 1
St 2
R5
St 3
St 4
St 5
R4
St 6
R3
R2
R1
-2
River Mouth 0
2
4
6
8
10
12
21.8
← Downstream
Miles Along River
Abitibi Outfall
Upstream →



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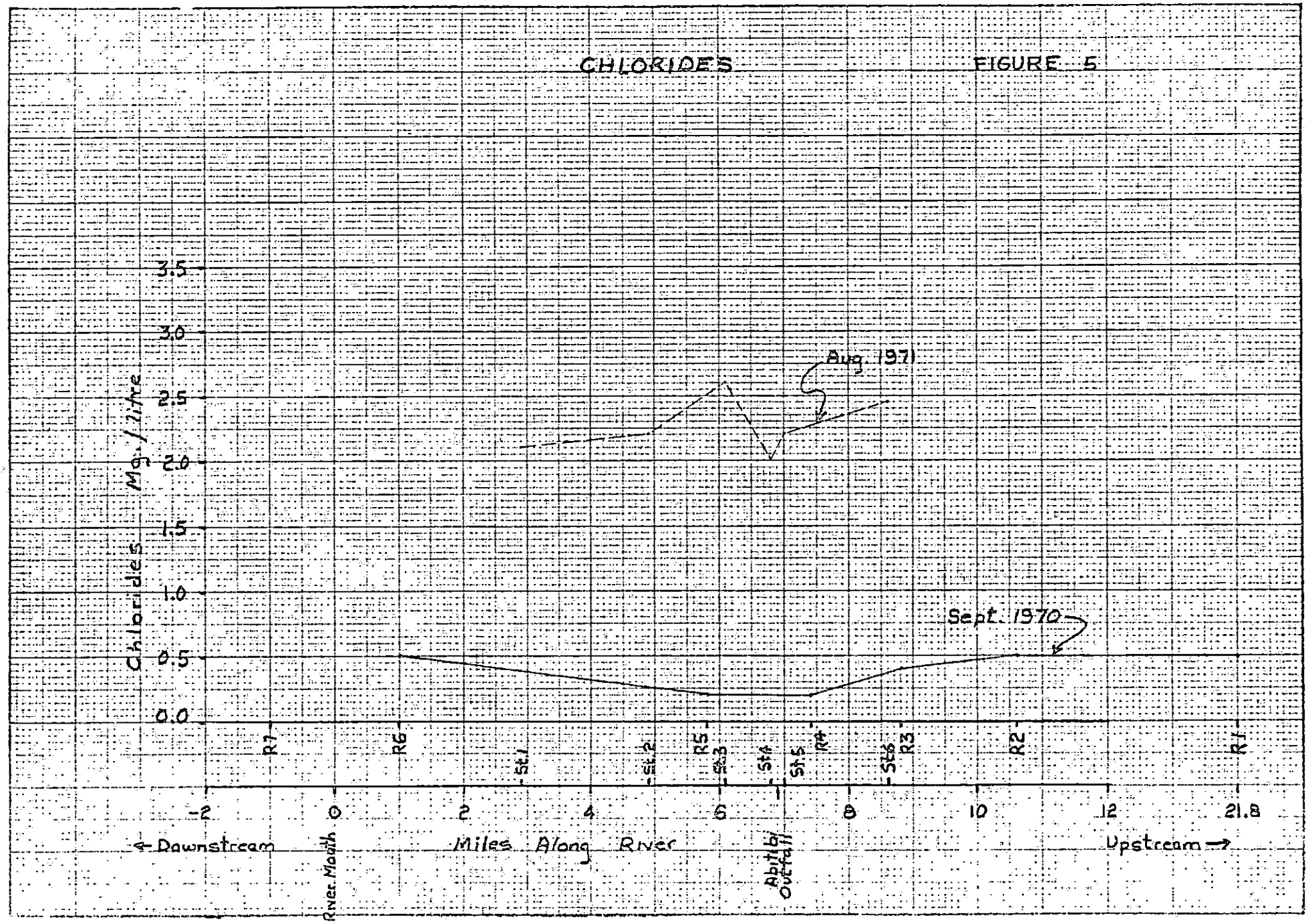

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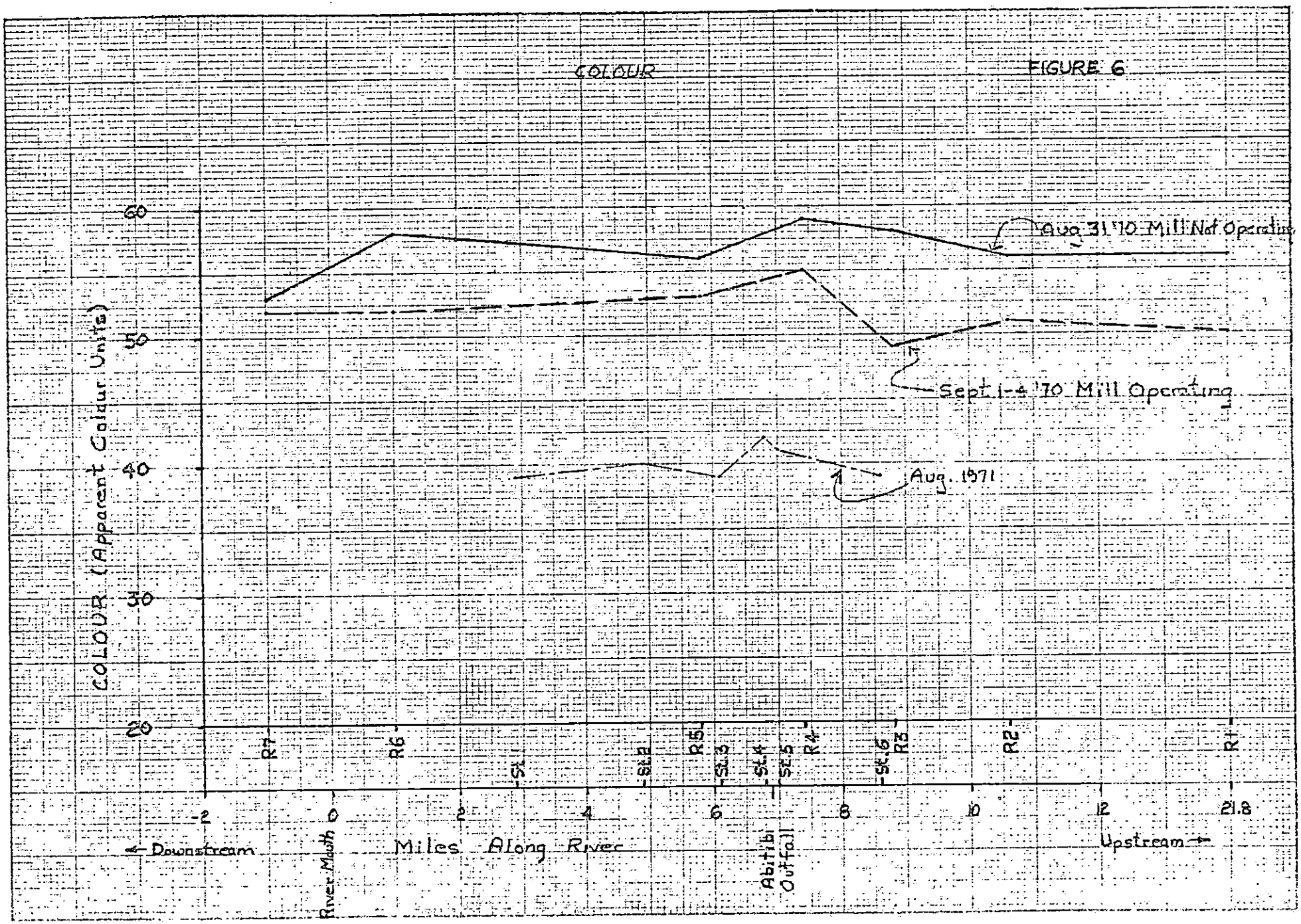

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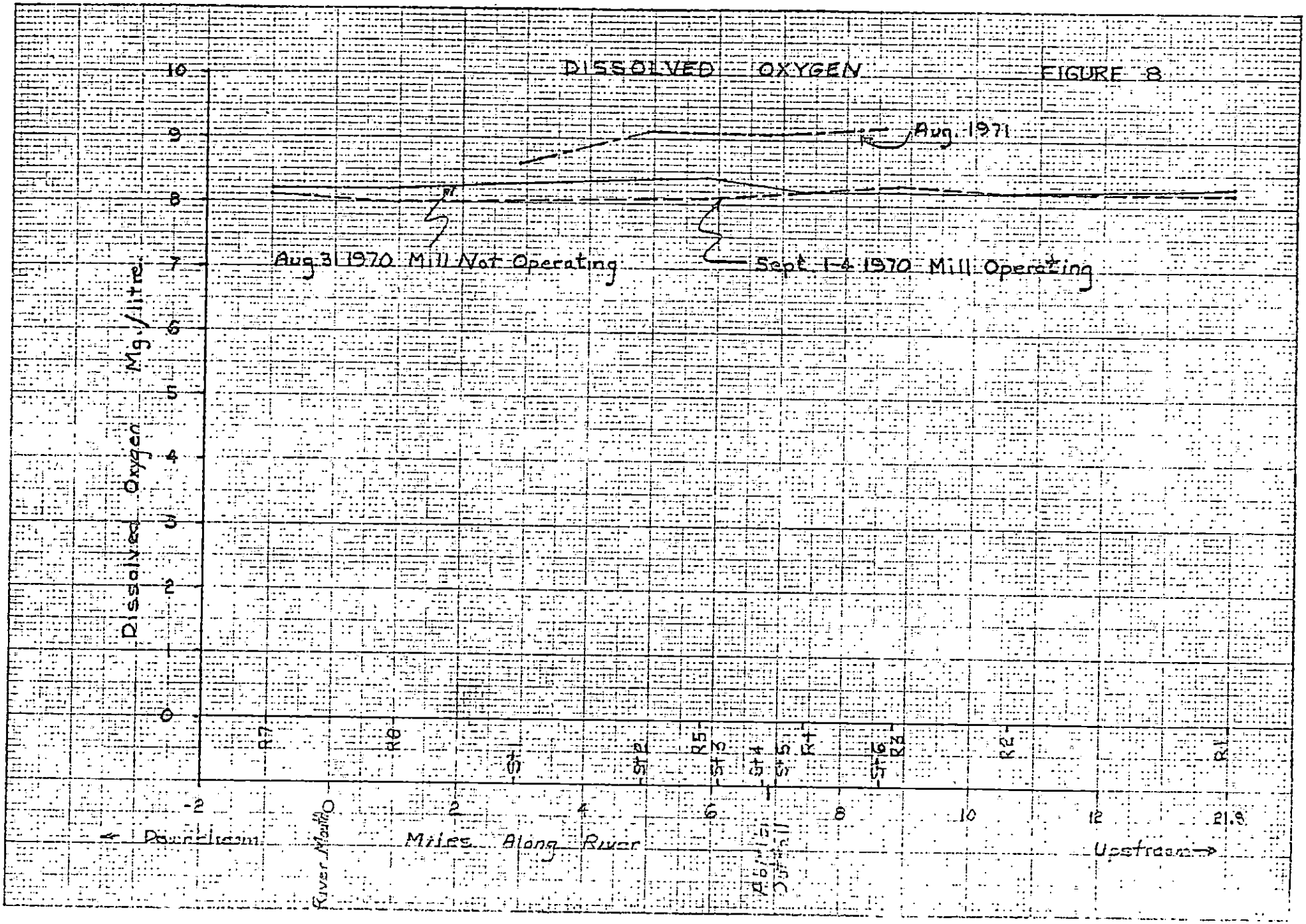

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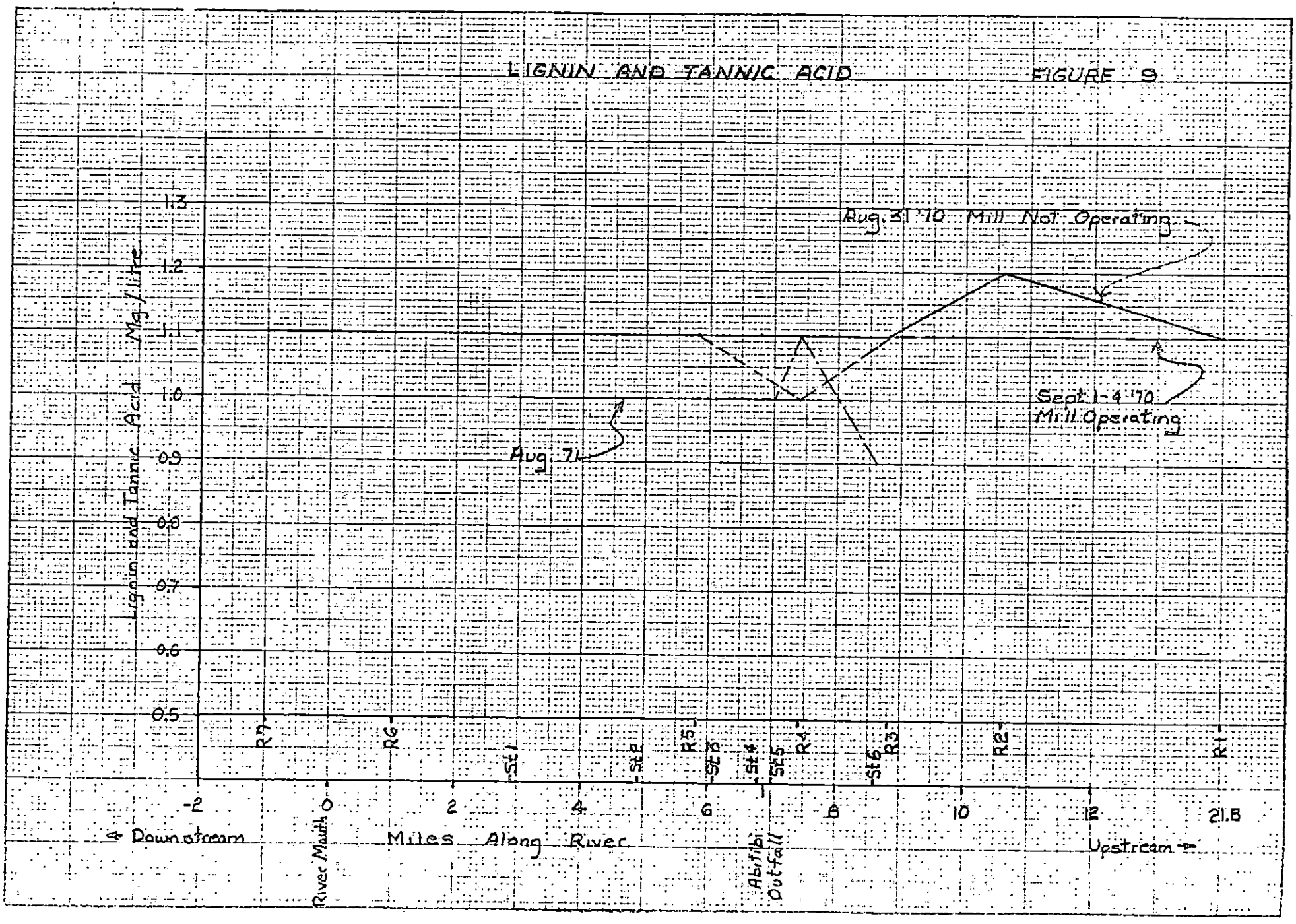

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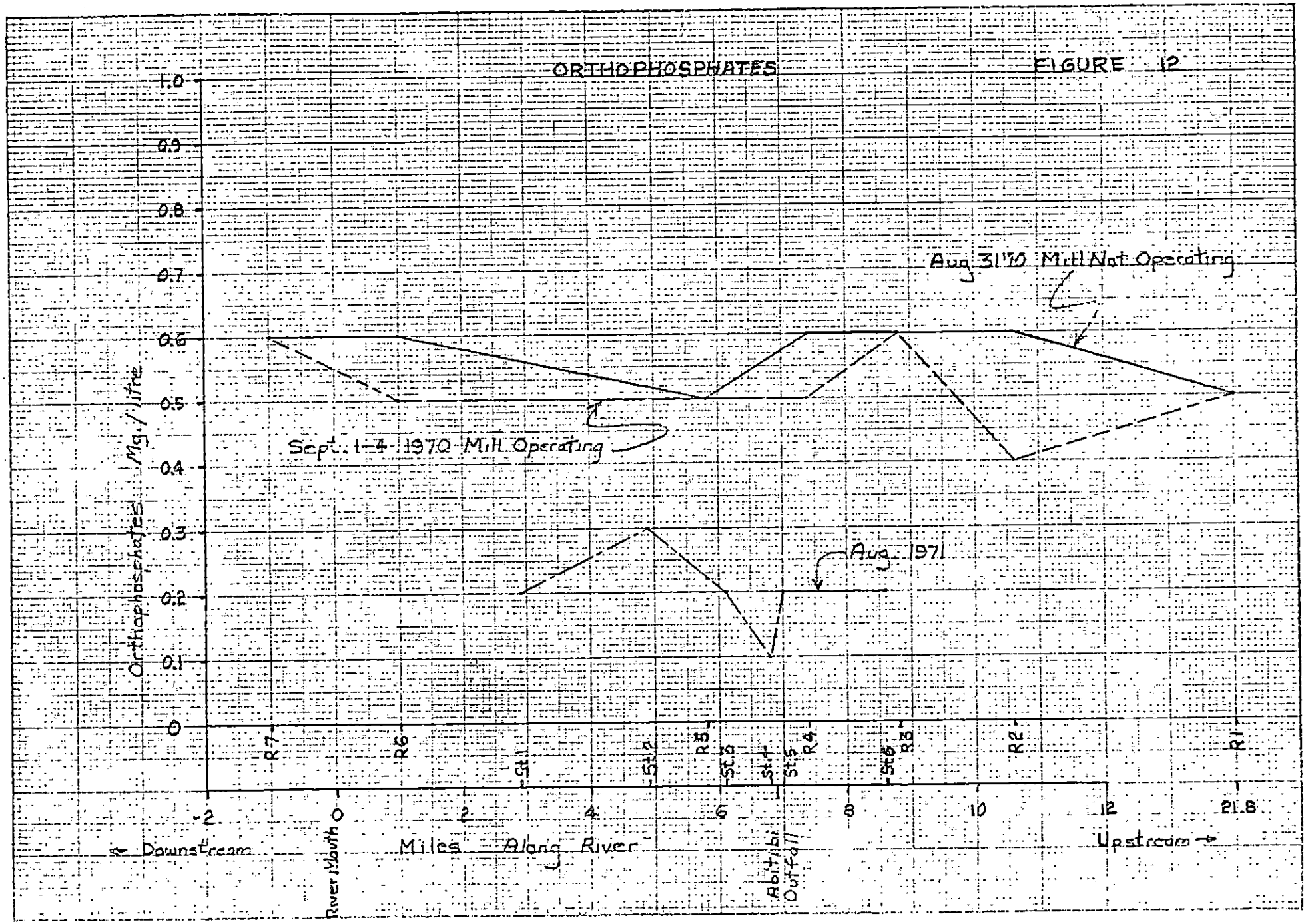

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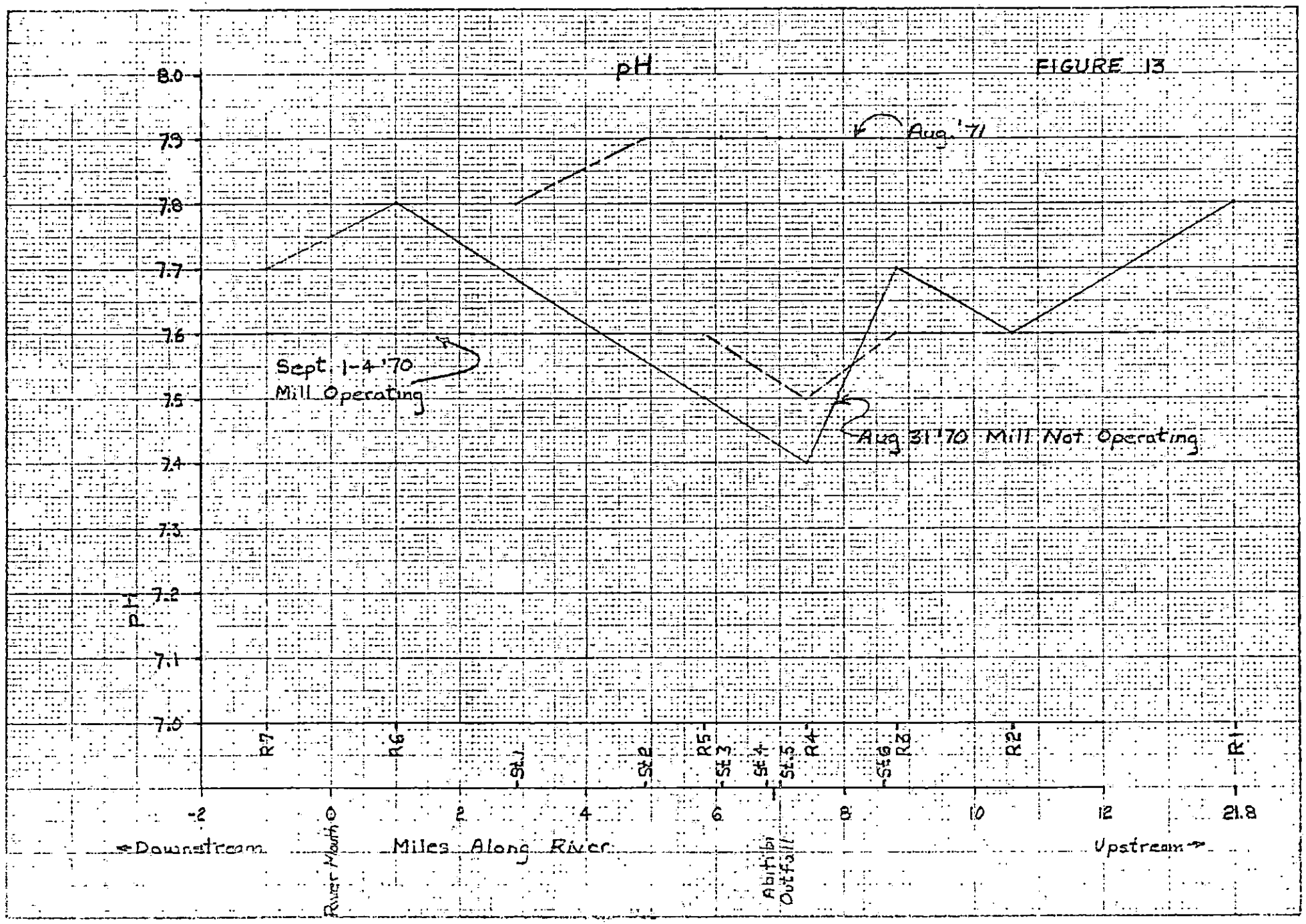

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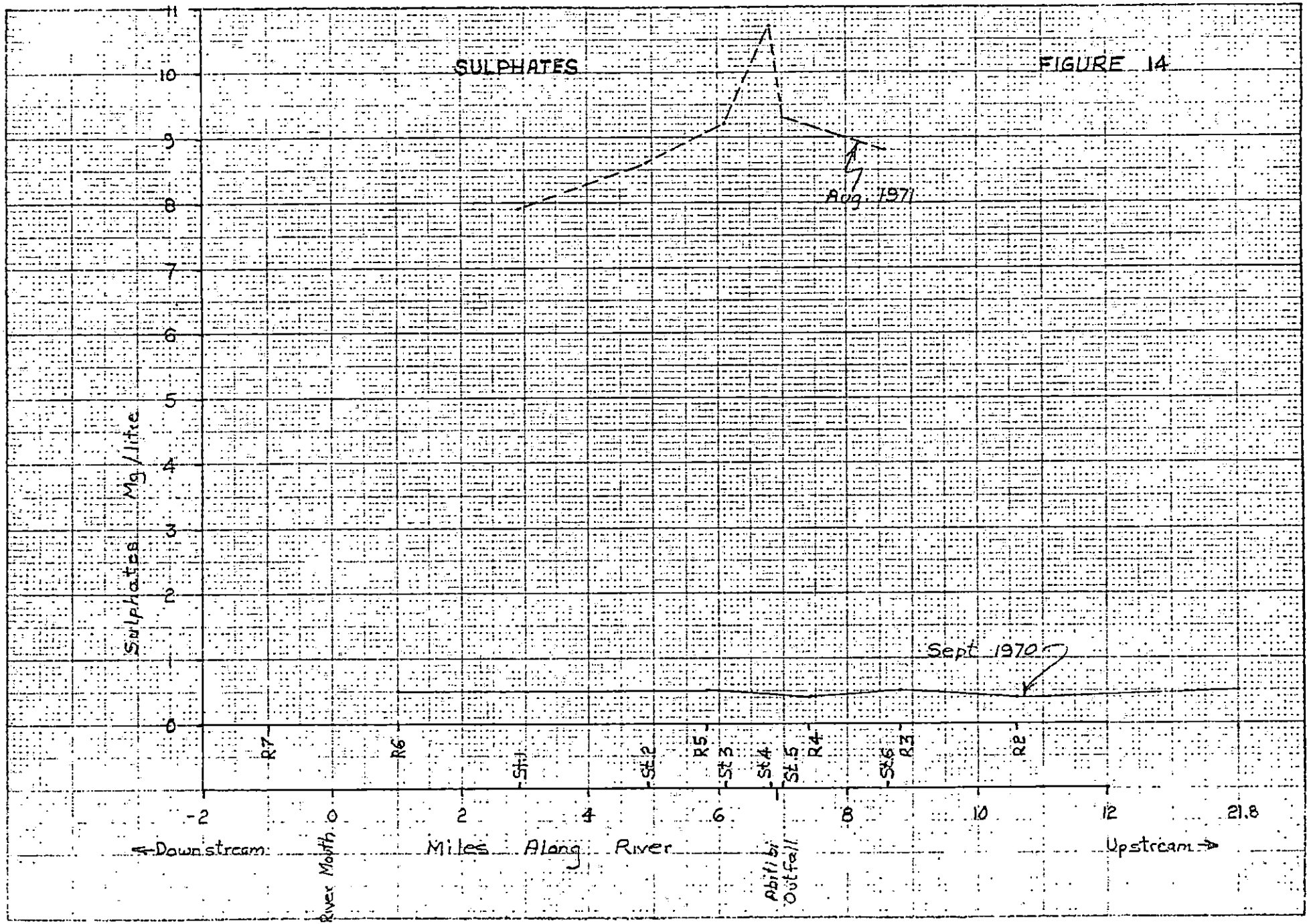

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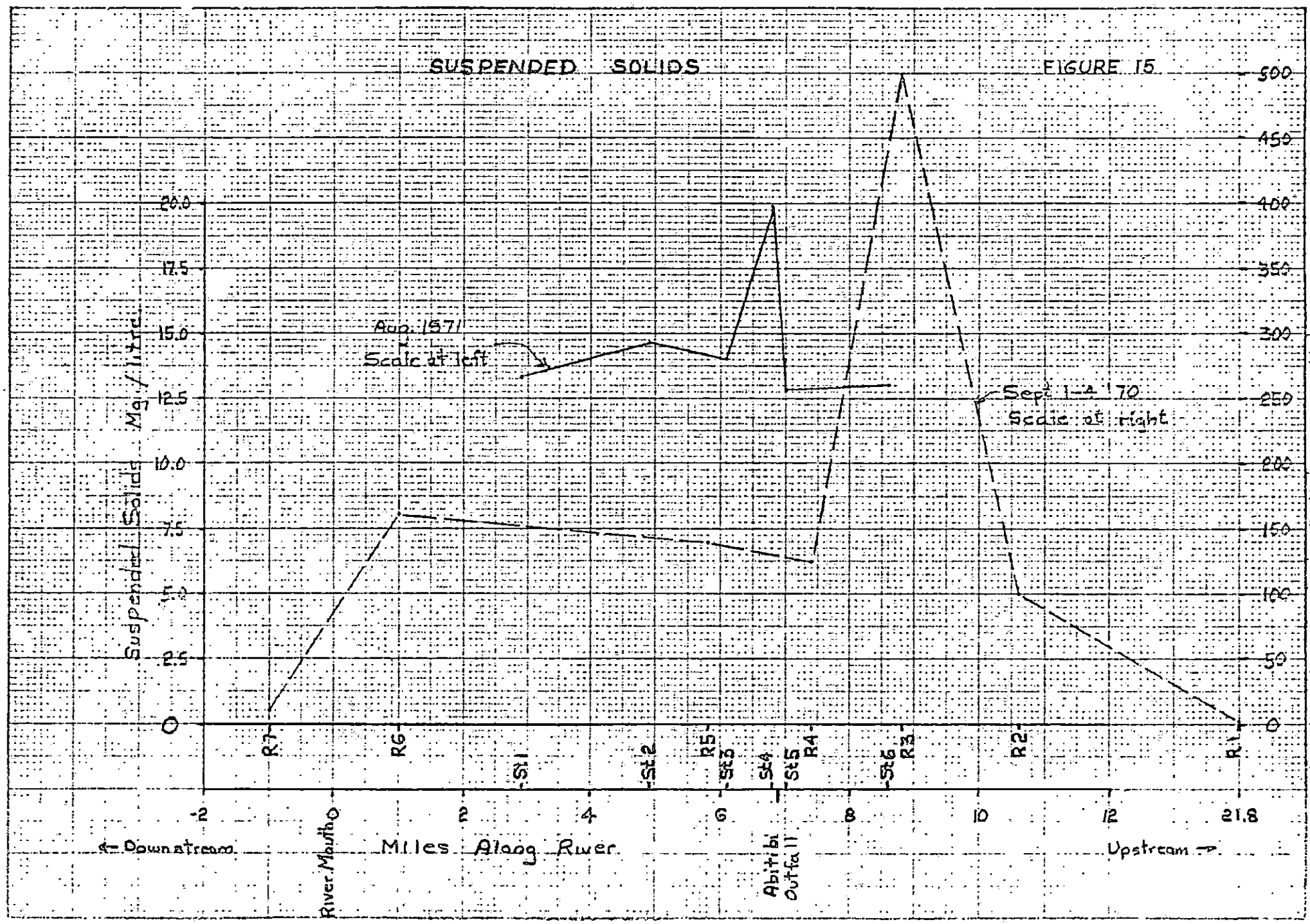

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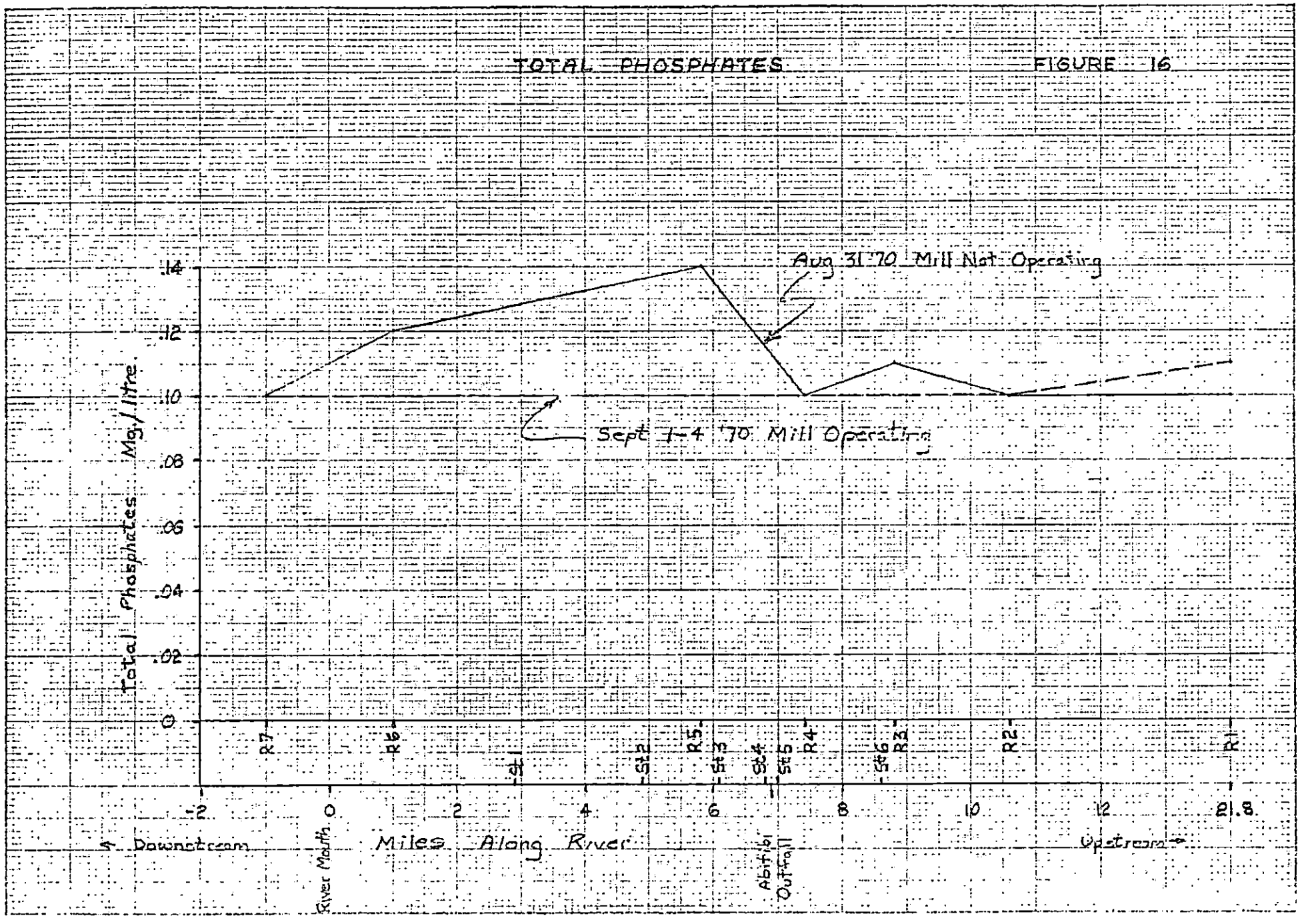

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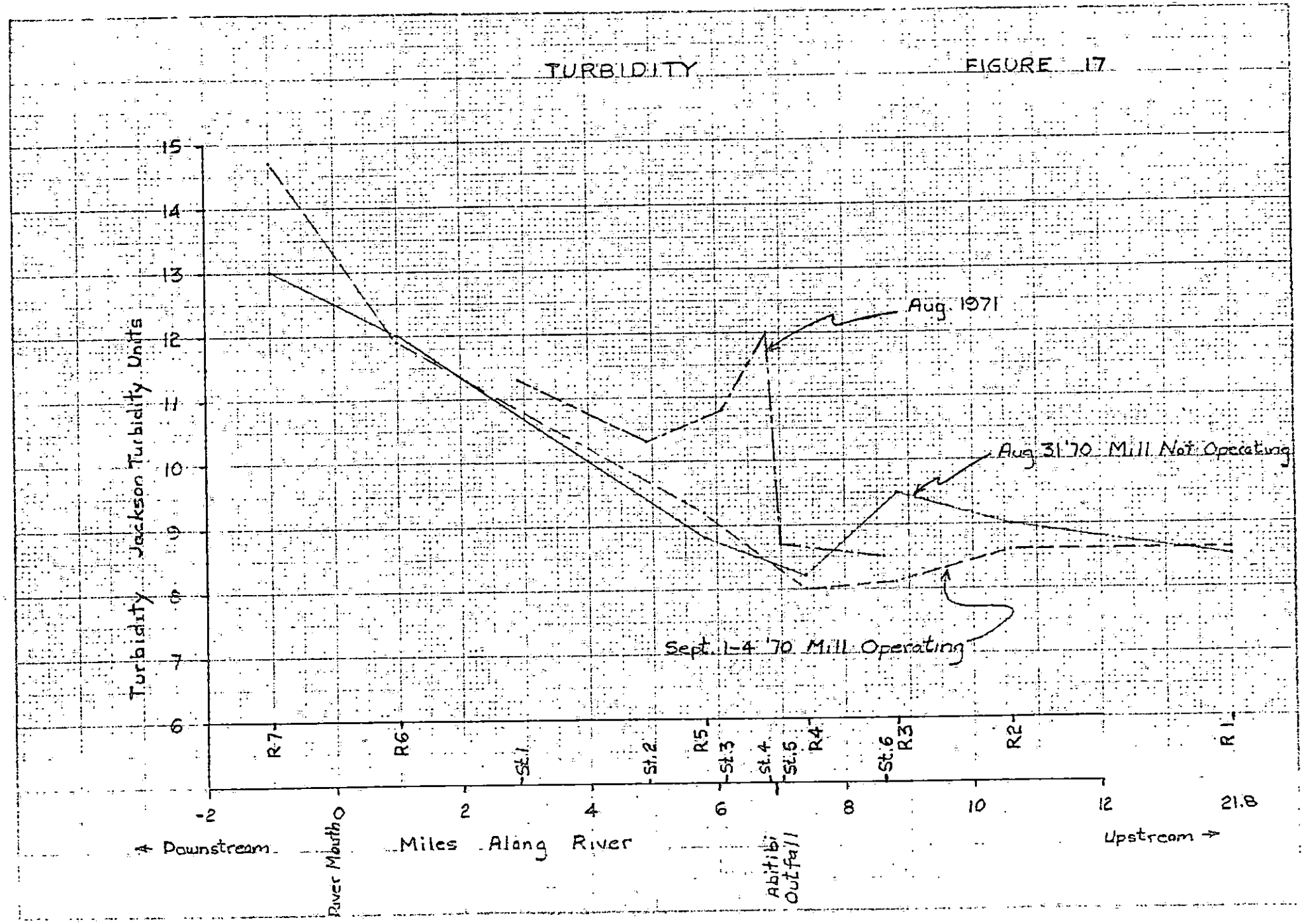

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APPENDIX I

WINNIPEG RIVER

at

Fort Alexander, Manitoba.

PHYSICAL AND CHEMICAL QUALITY DATA

September, 1970

ANALYTICAL DATA - WINNIPEG RIVER

FORT ALEXANDER, MANITOBA

AUGUST 31, 1970

	D.O. (mg/1)	pH	Temp°C.	Conductivity µS	Turbidity	Color	B.O.D. (mg/1)	Suspended Solids (mg/1)	Lignin & Tannic Acid (mg/1)
Range I									
A	8.3	7.8	18	85	8	60	0.8	0	1.3
B	8.2	7.7	18	84	10	50	0.6	0	1.0
C	8.3	7.8	18	85	9	55	0.8	0	1.0
D	8.3	7.7	18	82	7	60	0.7	0	1.0
Range II									
A	8.3	7.6	19	92	9	60	1.0	0	1.0
B	8.2	7.8	19	83	10	45	0.8	0	1.0
C	8.1	7.4	19	83	8	60	0.5	0	1.2
D	8.1	7.6	19	82	8	60	0.6	0	1.4
Range III									
A	8.1	7.7	19	90	10	50	0.7	0	1.1
B	8.2	7.6	19	84	9	60	0.8	0	1.0
C	8.2	7.7	19	85	9	60	0.5	0	1.0
D	8.2	7.8	19	84	10	60	0.5	0	1.0
Range IV									
A	8.2	7.3	19	90	8	60	1.1	0	1.0
B	8.0	7.3	19	90	8	55	0.5	0	1.0
C	8.4	7.3	19	84	9	60	0.8	0	1.2
D	8.2	7.5	19	80	8	60	0.8	0	1.2
Range V									
A	8.5	7.5	19	90	10	50	0.7	0	1.2
B	8.5	7.6	19	90	9	60	1.1	0	1.0
C	8.0	7.4	19	85	8	55	.2	0	1.2
D	-	7.5	19	84	8	60	0	0	1.0
Range VI									
A	8.1	7.8	19	82	12	60	0.9	0	1.2
B	8.3	7.8	19	83	13	56	1.0	0	1.0
C	8.3	7.7	19	82	12	60	1.0	0	1.2
D	8.2	7.8	19	83	11	55	1.0	0	1.0
Range VII									
A	8.1	7.7	19	90	13	60	1.2	0	1.0
B	8.3	7.8	19	82	14	45	0.8	0	1.0
C	8.2	7.7	19	82	12	50	0.8	0	1.5
D	8.2	7.7	19	83	13	55	0.8	0	1.0

ANALYTICAL DATA - WINNIPEG RIVER

FORT ALEXANDER, MANITOBA

SEPTEMBER 1, 1970

	D.O. (mg/1)	pH	Temp°C	Conductivity µS	Turbidity	Color	B.O.D. (mg/1)	Suspended Solids (mg/1)	Lignin & Tannic Acid (mg/1)
Range I									
A	8.2	7.6	19	85	11	50	0.4	0	1.0
B	8.2	7.7	19	86	11	50	0.3	0	1.0
C	8.2	7.6	19	86	10	50	0.5	0	1.2
D	8.5	7.5	19	84	11	50	1.0	0	1.0
Range II									
A	8.1	7.7	19	90	13	55	0.8	2	1.0
B	8.2	7.6	19	88	9	50	0.7	2	1.0
C	8.4	7.6	19	85	10	50	1.0	0	1.0
D	8.0	7.6	19	86	9	50	0.4	0	1.2
Range III									
A	9.0	7.5	19	90	9	55	0.9	0	1.1
B	8.8	7.6	19	90	9	55	2.0	0	1.1
C	8.4	7.6	19	85	8	50	1.0	0	0.8
D	8.3	7.7	19	90	9	55	1.2	0	1.0
Range IV									
A	8.1	7.6	19	90	8	50	1.3	1	1.0
B	8.2	7.4	19	80	6	50	1.0	1	1.0
C	8.2	7.55	19	86	8	55	1.0	0	1.0
D	7.9	7.4	19	90	9	50	1.7	0	1.0
Range V									
A	7.9	7.7	19	90	9	55	1.1	4	
B	7.9	7.5	19	85	9	50	1.4	2	1.0
C	8.0	7.5	19	85	8	50	0.7	2	1.0
D	8.2	7.5	19	85	9	50	1.2	4	1.2
Range VI									
A	8.2	7.5	19	83	12	50	1.1	2	1.0
B	8.0	7.5	19	80	13	55	0.5	6	1.0
C	8.0	7.5	19	82	12	50	0.5	2	1.0
D	8.0	7.55	19	83	12	55	0.7	8	1.0
Range VII									
A	8.0	7.5	19	82	11	50	0.6	0	1.0
B	7.0	7.5	19	83	13	55		0	1.0
C	9.0	7.5	19	82	11	55	1.7	0	1.0
D	8.2	7.5	19	84	15	55	0.7	0	1.0
Papermill Sewer Outlet	4.0	6.8	--	136	67	≥70	117.3	170	19.0

ANALYTICAL DATA - WINNIPEG RIVER

FORT ALEXANDER, MANITOBA

SEPTEMBER 2, 1970

	D.O. (mg/l)	pH	Temp°C.	Conductivity µS	Turbidity	Color	B.O.D. (mg/l)	Suspended Solids (mg/l)	Lignin & Tannic Acid (mg/l)
Range I									
A	8.2	7.6	19.5	85	7	50	0.7	2	1.0
B	8.3	7.7	19.5	81	7	50	0.9	2	1.0
C	8.3	7.7	19.5	85	7	50	--	2	1.0
D	8.2	7.7	19.5	84	7	50	0.3	1	1.0
Range II									
A	7.4	7.7	19.5	83	8	55	--	2	1.0
B	8.2	7.7	19.5	84	8	55	0.6	2	1.2
C	8.2	7.7	19.5	84	8	55	0.8	2	1.0
D	8.4	7.6	19.5	85	8	55	1.0	2	1.0
Range III									
A	8.5	5.8	19.5	415	110	--	1.4	5	1.0
B	8.3	7.4	19.5	84	7	55	1.0	3	1.0
C	8.4	7.5	19.5	84	8	55	1.2	7	1.0
D	8.4	7.4	19.5	85	7	55	--	0	1.0
Range IV									
A	8.2	7.4	19.5	86	8	55	1.0	3	1.1
B	8.3	7.5	19.5	84	8	55	1.0	0	1.0
C	8.1	7.4	19.5	85	8	55	0.5	--	1.1
D	8.4	7.4	19.5	85	8	55	1.4	61	1.0
Range V									
A	7.9	7.5	19.5	85	11	55	1.9	5	--
B	8.1	7.7	19.5	85	9	55	1.2	5	1.0
C	8.1	7.8	19.5	85	8	55	--	5	1.0
D	7.5	7.8	19.5	84	8	55	0.4	6	--
Range VI									
A	8.0	7.7	19.5	82	12	50	--	8	1.1
B	7.9	7.75	19.5	82	12	55	0.2	4	1.0
C	8.2	7.8	19.5	81	11	55	1.4	6	1.1
D	8.0	7.7	19.5	82	12	55	1.5	5	1.0
Range VII									
A	8.0	7.7	19.5	86	9	55	1.3	3	1.0
B	8.0	7.7	19.5	85	11	55	1.0	10	1.0
C	8.2	7.65	19.5	85	14	55	1.1	9	0.8
D	8.1	7.7	19.5	86	15	55	1.0	12	1.0
Papermill Sewer Outlet									
	--	--	--	--	--	--	--	170	125.0

ANALYTICAL DATA - WINNIPEG RIVER

FORT ALEXANDER, MANITOBA

SEPTEMBER 3, 1970

	D.O. (mg/l)	pH	Temp°C	Conductivity µS	Turbidity	Color	B.O.D. (mg/l)	Suspended Solids (mg/l)	Lignin & Tannic Acid (mg/l)
Range I									
A	8.2	7.4	19	87	7	45	0.9	2	1.0
B	8.2	7.6	19	86	7	50	0.8	1	1.0
C	8.3	7.5	19	86	12	55	0.7	23	1.0
D	8.4	7.7	19	84	8	55	1.0	3	1.0
Range II									
A	8.4	7.4	19	86	8	55	1.0	0	1.0
B	8.3	7.6	19	84	8	45	0.8	0	1.2
C	8.0	7.4	19	83	8	45	0.6	8	1.2
D	8.0	7.6	19	82	8	60	0.5	341	1.1
Range III									
A	8.3	7.5	19	85	8	40	0.6	837	1.1
B	8.2	7.5	19	85	8	45	0.7	963	--
C	8.2	7.4	19	85	8	45	0.7	1033	--
D	8.2	7.6	19	85	8	50	0.7	264	--
Range IV									
A	8.4	7.5	19	84	8	55	0.9	3	1.0
B	8.3	7.6	19	86	8	55	0.6	350	1.0
C	8.2	7.6	19	84	9	70	0.6	296	1.1
D	8.2	7.6	19	86	8	65	0.4	723	1.1
Range V									
A	7.7	7.4	19	87	12	55	1.3	681	1.3
B	7.9	7.5	19	89	10	55	1.5	459	1.5
C	8.3	7.6	19	85	8	55	1.0	485	0.8
D	8.1	7.6	19	85	8	50	0.6	548	1.0
Range VI									
A	7.7	7.5	19	80	12	55	1.1	509	1.1
B	7.8	7.35	19	83	13	55	1.2	131	1.2
C	8.1	7.6	19	81	12	55	1.3	7	1.1
D	7.9	7.4	19	81	11	55	1.0	13	1.0
Range VII									
A	7.8	7.5	19	81	10	55	1.1	2	1.2
B	7.9	7.5	19	85	11	60	1.2	4	1.0
C	7.8	7.5	19	86	18	70	1.1	42	1.2
D	8.1	7.5	19	85	12	60	1.2	9	1.1
Papermill Sewer Outlet									
	5.4	6.8	--	147	64	>70	44.1	547	7.0

ANALYTICAL DATA - WINNIPEG RIVER

FORT ALEXANDER, MANITOBA

SEPTEMBER 4, 1970

	D.O (mg/1)	pH	Temp°C	Conductivity µS	Turbidity	Color	B.O.D. (mg/1)	Suspended Solids (mg/1)	Lignin & Tannic Acid (mg/1)
Range I									
A	8.1	7.5	19.5	80	8	55	0.4	0	1.0
B	8.2	7.5	19.5	78	8	50	0.8	0	1.0
C	8.1	7.7	19.5	80	8	40	0.7	0	1.1
D	8.1	7.6	19.5	80	8	45	0.7	0	1.0
Range II									
A	8.3	7.6	19.5	82	8	45	1.4	0	1.1
B	8.3	7.6	19.5	82	9	40	0.8	394	1.0
C	8.3	7.6	19.5	80	8	55	0.7	663	1.0
D	7.9	7.3	19.5	86	8	40	0.9	782	1.0
Range III									
A	8.1	7.6	19.5	81	8	50	0.7	5	1.3
B	7.6	7.6	19.5	83	8	45	--	1	1.0
C	8.2	7.8	19.5	83	8	45	0.9	4	1.1
D	8.3	7.6	19.5	84	8	40	0.9	53	1.0
Range IV									
A	8.2	7.7	19.5	87	8	50	0.9	0	0.8
B	8.2	7.5	19.5	86	8	50	0.9	0	1.0
C	8.2	7.7	19.5	86	8	50	0.8	0	0.8
D	8.2	7.6	19.5	86	8	55	0.7	0	1.0
Range V									
A	--	7.5	19.5	91	12	55	--	13	1.1
B	8.0	7.8	19.5	90	9	55	2.0	0	1.5
C	8.1	7.7	19.5	86	8	45	1.4	0	1.0
D	8.2	7.6	19.5	92	9	55	1.4	1	1.0
Range VI									
A	7.9	7.5	19.5	82	12	40	1.2	2	1.0
B	7.9	7.6	19.5	80	13	45	1.1	1014	1.2
C	7.9	7.7	19.5	80	11	50	1.1	2	1.1
D	7.9	7.6	19.5	80	11	50	1.4	859	1.1
Range VII									
A	--	7.9	19.5	85	50	--	--	46	1.1
B	8.1	7.7	19.5	80	11	55	1.6	5	1.1
C	7.8	7.6	19.5	78	12	40	1.2	8	1.1
D	7.9	7.7	19.5	78	13	50	1.0	3	1.0
Papermill Sewer Outlet									
	4.8	6.8	--	170	91	≥70	100.8	147	23.5

Remarks

(1) No significant change in D.O., pH, Conductivity, Lignin & Tannic Acid and Color is noted.

(2) Turbidity slightly increases towards the lower part of the river.

(3) A slight but definite trend of B.O.D. increase is noted towards the lower part of the river.

(4) Suspended solids are higher at the latter part of the survey.

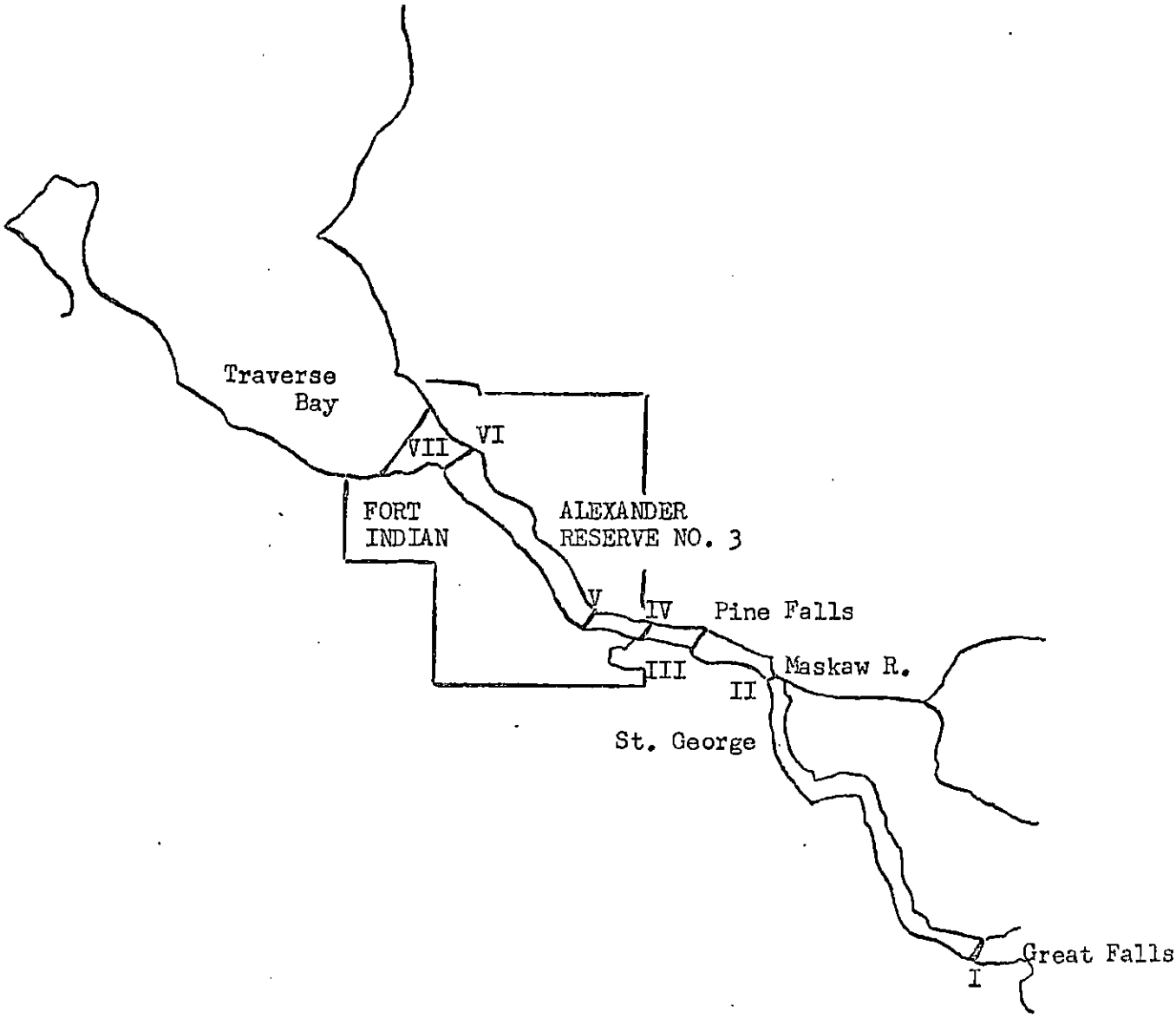
(5) Data obtained for September 2, Range III, Station A should be considered non-representative.

(6) Analytical data for the Papermill Outlet are self-explanatory.

V. T. Chacko,
Chemist,
Western Region.

WINNIPEG RIVER AT FORT ALEXANDER

SAMPLING STATIONS I - VII



APPENDIX 2

WINNIPEG RIVER

at

FORT ALEXANDER, MANITOBA

PHYSICAL AND CHEMICAL

WATER QUALITY DATA

AUGUST, 1971

Public Health
Engineering Division,
Department of the
Environment,
Winnipeg, Manitoba.

Prepared by:

V. T. Chacko,
Chemist,
Western Region

ANALYTICAL DATA - WINNIPEG RIVER

FORT ALEXANDER, MANITOBA

AUGUST 4, 1971

D.O. mg/1	pH	Temp°C	Conductivity µS	Color A.C.U.	Turbidity J.T.U.	B.OD. mg/1	Suspended Solids mg/1	Lignin & Tannic Acid mg/1	Alkalinity mg/1	Chlorides mg/1	Sulfates as SO_4 mg/1	Orthophosphate as PO_4 mg/1
Station I												
A 8.1	7.8	19	90	40	12	2.9	17	1.0	48	2	8.8	0.03
B 8.7	7.8	19	88	40	12	3.9	11	1.0	44	2	6.0	0.01
C 8.6	7.8	19	88	40	14	1.7	11	1.0	44	2	8.8	0.01
Station II												
A 9.1	7.8	19	90	40	11	1.1	12	1.0	44	2	8.8	0.03
B 9.1	7.9	19	90	40	10	2.2	11	1.1	44	2	10.0	0.03
C 9.1	8.0	19	86	40	10	1.7	10	1.0	44	2	8.8	0.03
Station III												
A 9.0	7.8	19	87	40	9	2.0	10	1.1	44	1.5	8.8	0.01
B 9.0	8.0	19	86	40	9	--	8	1.0	42	1.5	8.8	0.01
C 8.9	8.1	19	87	40	11	1.3	13	0.9	44	2	10.0	0.03
Station IV												
A 8.9	7.8	19	86	35	10	3.1	9	1.0	44	1.5	11.0	0.01
B 9.0	7.9	19	86	40	9	0.8	8	0.9	44	1.5	8.0	0.01
C 9.0	7.9	19	86	40	8	1.0	9	1.0	44	1.5	8.8	0.01
Station V												
A 8.9	8.0	19	90	40	8	0.6	10	1.0	44	1.5	10.0	0.01
B 8.9	7.9	19	86	35	8	1.4	11	1.0	44	1.5	8.0	0.01
C 8.9	8.0	19	85	40	7	2.8	10	1.0	44	1.5	8.8	0.03
Station VI												
A 8.8	7.9	19	85	40	8	--	10	1.0	44	1.5	8.8	0.03
B 8.9	7.9	19	85	40	8	2.5	12	1.0	44	1.5	8.0	0.01
C 9.0	7.9	19	85	40	8	1.5	11	1.1	44	1.5	8.8	0.01
Papermill effluent (100' downstream)												
	7.9	19	86	55	8	--	11	1.1	44	2	8.8	0.01

ANALYTICAL DATA - WINNIPEG RIVER

FORT ALEXANDER, MANITOBA

AUGUST 5, 1971

D.O. mg/1	pH	Temp°C	Conductivity µS	Color A.C.U.	Turbidity J.T.U.	B.O.D. mg/1	Suspended Solids mg/1	Lignin & Tannic Acid mg/1	Alkalinity mg/1	Chlorides mg/1	Sulfates as SO_4 mg/1
Station I											
A 8.6	7.8	19	80	40	10	1.4	15	1	38	2.0	8.8
B 8.7	7.8	19	84	35	10	1.3	13	1	40	2.0	8
C 8.7	7.8	19	84	40	10	1.1	14	1	42	2.5	7.2
Station II											
A 9.1	7.8	19	90	40	10	1.3	19	1	44	2.5	7.2
B 9.3	7.8	19	90	40	10	1.2	17	1	42	1.5	8
C 9.0	7.8	19	90	40	11	1.4	17	1	44	3.0	9
Station III											
A 9.0	7.8	19	90	40	12	2.5	18	1	42	4.0	7.2
B 9.2	7.8	19	90	35	12	2.2	19	1.3	42	2.5	10
C 9.3	8.0	19	90	40	12	1.0	16	1	46	4.0	10
Station IV											
A 9.1	7.8	19	90	35	12	2.0	22	1.3	44	3.0	10
B 9.3	7.9	19	90	40	10	1.0	16	1.3	42	2.0	8
C 9.2	7.9	19	88	60	23	1.3	55	1.3	48	2.5	18
Station V											
A 9.3	7.9	19	88	40	10	1.1	17	1	42	4.0	10
B 9.4	7.9	19	86	50	10	1.1	14	1	44	2.0	10
C 9.3	7.9	19	85	40	9	1.2	14	1	42	3.0	8.8
Station VI											
A 9.4	7.9	19	85	40	9	1.0	13	0.7	42	3.5	8
B 9.4	7.9	19	85	35	9	1.2	14	0.7	44	3.5	8.8
C 9.4	7.9	19	85	40	9	1.6	--	0.9	40	2.5	8
Papermill effluent at the river											
8.9	7.0	19	200	>70	>85	>97	151	--	--	--	--

CHEMICAL DATA

All samples are collected from three feet above bottom at the indicated stations on page 2.

No significant change in pH, conductivity, turbidity, lignin and tannic acid, sulfate and ortho-phosphate is noted from the September, 1970, levels.

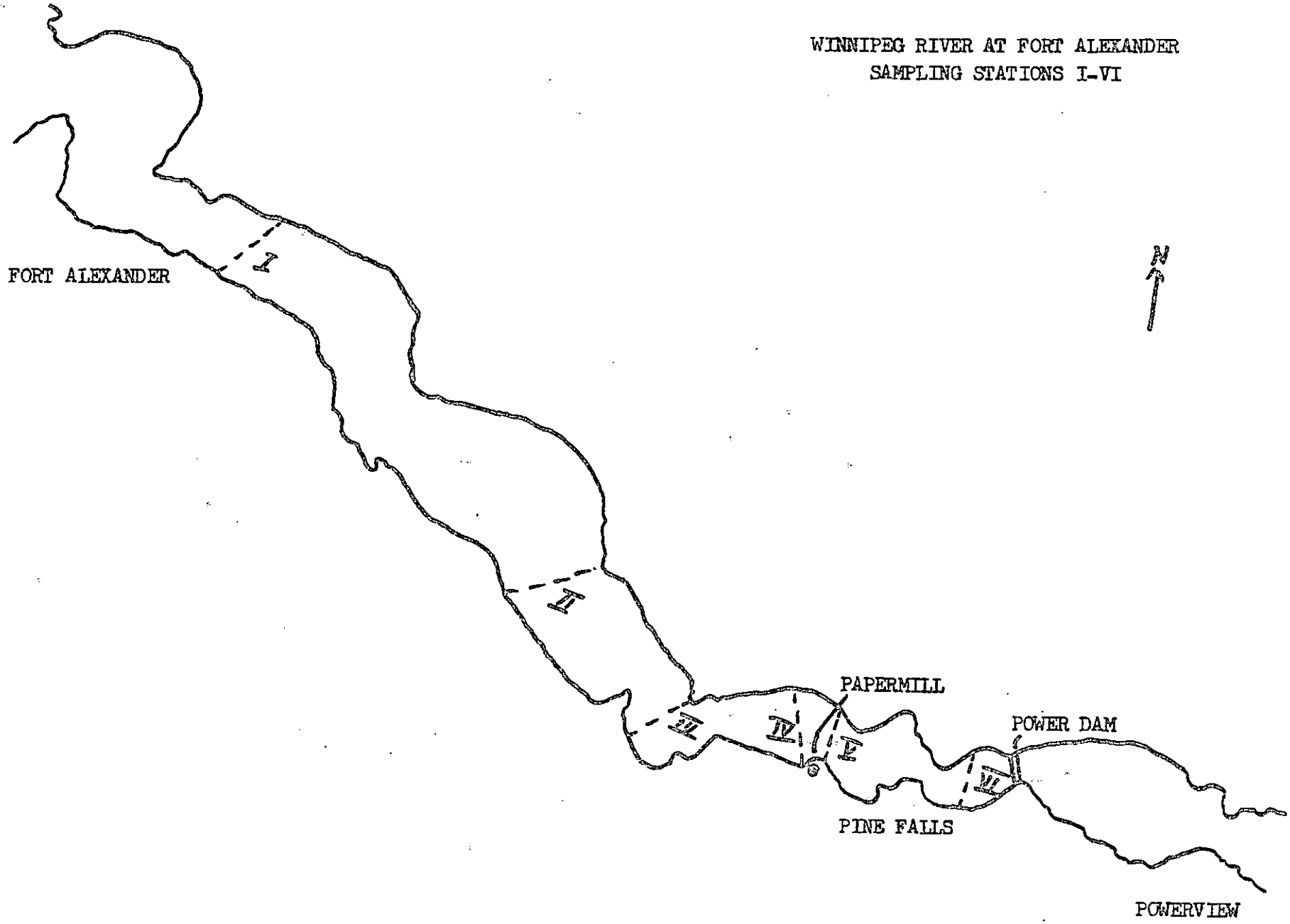
The most significant change is in suspended solids. Stations above and below the papermill show higher suspended solids than the 1970 level.

B.O.D. is slightly higher than the 1970 level but stations below and above the papermill do not vary significantly.

The effluent from the papermill contains excessive amounts of B.O.D. and suspended solids but the data indicate their effect on the river is not significant.

V. T. Chacko,
Chemist,
Western Region.

WINNIPEG RIVER AT FORT ALEXANDER
SAMPLING STATIONS I-VI



APPENDIX 3

WINNIPEG RIVER
at
FORT ALEXANDER, MANITOBA

CHEMICAL ANALYSES

SEPTEMBER, 1970

DEPARTMENT OF NATIONAL HEALTH AND WELFARE
PUBLIC HEALTH ENGINEERING DIVISION

CHEMICAL ANALYSIS OF WATER

LOCATION: Fort Alexander, Man. Winnipeg River
DATE SAMPLED:
IDENTIFYING MARKS: #107 Range I B
SAMPLED BY:
SUBMITTED BY: V.T. Chacko
DATE RECEIVED IN LAB.: 5.9.70

IONS, ETC., IN PARTS PER MILLION		IONS, ETC., IN PARTS PER MILLION	
pH Value	7.6	Calcium (Ca)	
Hardness (EDTA) as $CaCO_3$	4.8	Magnesium (Mg)	
Alkalinities—Phenolphthalein as $CaCO_3$	NIL	Sodium (Na)-Calculated	
Total as $CaCO_3$	38.0	Bicarbonate as CO_3	23.0
Iron (Fe) (Total)	0.19	Carbonate (CO_3)	
Manganese (Mn) (Total)	0.07	Sulphate (SO_4)	0.5
Color (Units)		Chloride (Cl)	0.5
Turbidity (Units)		Nitrate (NO_3)	
Nitrate Nitrogen (N)	<0.01	Fluoride (F)	0.05
Nitrite Nitrogen (N)	0.003	Silica (SiO_2)	
Free Ammonia Nitrogen (N)		Total Dissolved Solids—Determined	57
Albuminoid Nitrogen (N)		Specific Conductance (Micromhos/cm)	90
SULPHITE	1.1		

REMARKS:

DATE: Sept. 30, 1970
CHEMIST: [illegible]

W.S. 37 Rev. 5-64.

DEPARTMENT OF NATIONAL HEALTH AND WELFARE
PUBLIC HEALTH ENGINEERING DIVISION

CHEMICAL ANALYSIS OF WATER

LOCATION: Fort Alexander, Man. DATE SAMPLED:

IDENTIFYING MARKS: Winnipeg River #104 Reg. II B SAMPLED BY:

SUBMITTED BY: V.T. Chacko DATE RECEIVED IN LAB.: 5.9.70

IONS, ETC., IN PARTS PER MILLION		IONS, ETC., IN PARTS PER MILLION	
pH Value	7.5	Calcium (Ca)	
Hardness (EDTA) as $CaCO_3$	4.7	Magnesium (Mg)	
Alkalinities—Phenolphthalein as $CaCO_3$	NIL	Sodium (Na)-Calculated	
Total as $CaCO_3$	38.0	Bicarbonate as CO_3	23.0
Iron (Fe) (Total)	0.90	Carbonate (CO_3)	
Manganese (Mn) (Total)	0.08	Sulphate (SO_4)	0.4
Color (Units)		Chloride (Cl)	0.5
Turbidity (Units)		Nitrate (NO_3)	
Nitrate Nitrogen (N)	<0.01	Fluoride (F)	0.05
Nitrite Nitrogen (N)	0.004	Silica (SiO_2)	
Free Ammonia Nitrogen (N)		Total Dissolved Solids—Determined	58
Albuminoid Nitrogen (N)		Specific Conductance (Micromhos/cm)	90
SULPHITE	0.8		

REMARKS:

DATE: Sept. 30, 1970 CHEMIST: C. McHolton.

W.S. 37 Rev. 5-64.

DEPARTMENT OF NATIONAL HEALTH AND WELFARE
PUBLIC HEALTH ENGINEERING DIVISION

CHEMICAL ANALYSIS OF WATER

LOCATION: Fort Alexander, Man DATE SAMPLED:

IDENTIFYING MARKS Winnipeg River #101 = Range III B SAMPLED BY:

SUBMITTED BY: V.T. Chacko DATE RECEIVED IN LAB.: 5.9.70

IONS, ETC., IN PARTS PER MILLION		IONS, ETC., IN PARTS PER MILLION	
pH Value	7.5	Calcium (Ca)	
Hardness (EDTA) as $CaCO_3$	4.6	Magnesium (Mg)	
Alkalinities—Phenolphthalein as $CaCO_3$	NIL	Sodium (Na)-Calculated	
Total as $CaCO_3$	37.2	Bicarbonate as CO_3	22.2
Iron (Fe) (Total)	0.40	Carbonate (CO_3)	
Manganese (Mn) (Total)	0.06	Sulphate (SO_4)	0.5
Color (Units)		Chloride (Cl)	0.4
Turbidity (Units)		Nitrate (NO_3)	
Nitrate Nitrogen (N)	<0.01	Fluoride (F)	0.05
Nitrite Nitrogen (N)	0.003	Silica (SiO_2)	
Free Ammonia Nitrogen (N)		Total Dissolved Solids—Determined	61
Albuminoid Nitrogen (N)		Specific Conductance (Micromhos/cm)	87
SULPHITE	1.0		

REMARKS:

DATE: Sept. 30, 1970 CHEMIST: [illegible]

W.S. 37 Rev. 5-64.

DEPARTMENT OF NATIONAL HEALTH AND WELFARE
PUBLIC HEALTH ENGINEERING DIVISION

CHEMICAL ANALYSIS OF WATER

LOCATION: Fort Alexander, Man DATE SAMPLED:

IDENTIFYING MARKS: Winnipeg River #102 Range IV B SAMPLED BY:

SUBMITTED BY: V.T. Chacko DATE RECEIVED IN LAB.: 5.9.70

IONS, ETC., IN PARTS PER MILLION		IONS, ETC., IN PARTS PER MILLION	
pH Value	7.6	Calcium (Ca)	
Hardness (EDTA) as $CaCO_3$	4.7	Magnesium (Mg)	
Alkalinities—Phenolphthalein as $CaCO_3$	NIL	Sodium (Na)-Calculated	
Total as $CaCO_3$	38.3	Bicarbonate as CO_3	23.0
Iron (Fe) (Total)	0.40	Carbonate (CO_3)	
Manganese (Mn) (Total)	0.06	Sulphate (SO_4)	0.4
Color (Units)		Chloride (Cl)	0.2
Turbidity (Units)		Nitrate (NO_3)	
Nitrate Nitrogen (N)		Fluoride (F)	0.05
Nitrite Nitrogen (N)	0.003	Silica (SiO_2)	
Free Ammonia Nitrogen (N)		Total Dissolved Solids—Determined	55
Albuminoid Nitrogen (N)		Specific Conductance (Micromhos/cm)	86
SULPHITE	1.2		

REMARKS:

DATE: Sept. 30, 1970 CHEMIST: W C Holton

W.S. 37 Rev. 5-64.

DEPARTMENT OF NATIONAL HEALTH AND WELFARE
PUBLIC HEALTH ENGINEERING DIVISION

CHEMICAL ANALYSIS OF WATER

LOCATION: Fort Alexander, Man DATE SAMPLED:

IDENTIFYING MARKS: Winnipeg River, #105 Range V B SAMPLED BY:

SUBMITTED BY: V.T. Chacko DATE RECEIVED IN LAB.: 5.9.70

IONS, ETC., IN PARTS PER MILLION		IONS, ETC., IN PARTS PER MILLION	
pH Value	7.4	Calcium (Ca)	
Hardness (EDTA) as $CaCO_3$	4.8	Magnesium (Mg)	
Alkalinities – Phenolphthalein as $CaCO_3$	NIL	Sodium (Na)-Calculated	
Total as $CaCO_3$	38.3	Bicarbonate as CO_3	23.0
Iron (Fe) (Total)	0.32	Carbonate (CO_3)	
Manganese (Mn) (Total)	0.07	Sulphate (SO_4)	0.5
Color (Units)		Chloride (Cl)	0.2
Turbidity (Units)		Nitrate (NO_3)	
Nitrate Nitrogen (N)	<0.01	Fluoride (F)	0.05
Nitrite Nitrogen (N)	0.003	Silica (SiO_2)	
Free Ammonia Nitrogen (N)		Total Dissolved Solids – Determined	56
Albuminoid Nitrogen (N)		Specific Conductance (Micromhos/cm)	88
SULPHITE	1.3		

REMARKS:

DATE: Sept. 30, 1970 CHEMIST: [illegible]

W.S. 37 Rev. 5-64.

DEPARTMENT OF NATIONAL HEALTH AND WELFARE
PUBLIC HEALTH ENGINEERING DIVISION

CHEMICAL ANALYSIS OF WATER

LOCATION: Fort Alexander, Man DATE SAMPLED:

IDENTIFYING MARKS: Winnipeg River, #106 SAMPLED BY: Range V. B.

SUBMITTED BY: V.T. Chacko DATE RECEIVED IN LAB.: 5.9.70

IONS, ETC., IN PARTS PER MILLION		IONS, ETC., IN PARTS PER MILLION	
pH Value	7.5	Calcium (Ca)	
Hardness (EDTA) as $CaCO_3$	4.8	Magnesium (Mg)	
Alkalinities—Phenolphthalein as $CaCO_3$	NIL	Sodium (Na)-Calculated	
Total as $CaCO_3$	39.0	Bicarbonate as CO_3	23.4
Iron (Fe) (Total)	0.62	Carbonate (CO_3)	
Manganese (Mn) (Total)	0.07	Sulphate (SO_4)	0.5
Color (Units)		Chloride (Cl)	0.5
Turbidity (Units)		Nitrate (NO_3)	
Nitrate Nitrogen (N)	<0.01	Fluoride (F)	0.05
Nitrite Nitrogen (N)	0.004	Silica (SiO_2)	
Free Ammonia Nitrogen (N)		Total Dissolved Solids—Determined	57
Albuminoid Nitrogen (N)		Specific Conductance (Micromhos/cm)	90
SULPHITE	1.5		

REMARKS:

DATE: Sept. 30, 1970 CHEMIST: [illegible]

W.S. 37 Rev. 5-64.

TABLE A-3

CHEMICAL ANALYSES - OTTAWA LAB

	R 1 (B)*	R 2 (B)	R 3 (B)	R 4 (B)	R 5 (B)	R 6 (B)
pH	7.6	7.5	7.5	7.6	7.4	7.5
Hardness $CaCO_3$	4.8	4.7	4.6	4.7	4.8	4.8
Alkal. Phen.	nil	nil	nil	nil	nil	nil
Total	38.0	38.0	37.2	38.3	38.3	39.0
Iron	0.19	0.90	0.40	0.40	0.32	0.62
Manganese	0.07	0.08	0.06	0.06	0.07	0.07
Nitrite Nit.(N)	<0.01	<0.01	<0.01	----	<0.01	<0.01
Nitrite	0.003	0.004	0.003	0.003	0.003	0.004
Sulphite	1.1	0.8	1.0	1.2	1.3	1.5
Bicarbonate	23.0	23.0	22.2	23.0	23.0	23.4
Sulphate (SO_4)	0.5	0.4	0.5	0.4	0.5	0.5
Chloride	0.5	0.5	0.4	0.2	0.2	0.5
Fluoride	0.05	0.05	0.05	0.05	0.05	0.05
T D S	57	58	61	55	56	57
Spec. Cond.	90	90	87	86	88	90

Note:

(B)* - refers to the second sub range of four i.e., the samples were taken near the middle of the river in each case

APPENDIX 4

WINNIPEG RIVER

at

FORT ALEXANDER, MANITOBA

CHEMICAL OXYGEN DEMAND RESULTS

SEPTEMBER, 1970

ENVIRONMENTAL HEALTH LAB

Report On: Winnipeg River at Pine Falls, Manitoba

Identification:

Grab samples were collected by National Health & Welfare staff from the Winnipeg River between Pine Falls and Fort Alexander on September 1 and September 3, 1970. These samples were taken to determine the quality of the Winnipeg River when the Abitibi Pulp and Papermill was not operating (September 1, 1970) and when they were discharging (September 3, 1970) effluent to the river.

Lab. Nos.: A1407 series - September 1, 1970
A1483 series - September 3, 1970

ANALYSIS

Station	Bottle No.	Date (Sept/70)	C.O.D. (mg/1)
1A	20	1	7.6
	29	3	14.9
2A	17	1	7.0
	12	3	11.7
3A	25	1	6.9
	9	3	16.8
4A	6	1	7.9
	26	3	21.6
5A	3	1	9.8
	8	3	15.6
6A	27	1	9.3
	10	3	14.3
7A	30	1	8.6
	19	3	13.9

Station	Bottle No.	Date (Sept/70)	C.O.D. (mg/1)
1C	9	1	8.1
	13	3	11.7
2C	29	1	7.4
	4	3	13.1
3C	14	1	7.6
	17	3	13.7
4C	28	1	7.8
	5	3	13.9
5C	1	1	7.3
	28	3	11.7
6C	19	1	7.5
	24	3	13.7
7C	24	1	7.8
	20	3	16.4
Sewer	13	1	>13.5
(Abitibi Outfall)	1	3	155.

A grid was established along the Winnipeg River downstream from the Pulp Mill at Pine Falls such that: numbers indicate stations along the grid 1 (farthest south) to 7 (farthest north) and letters A, B, C, and D indicate a grid across the river west to east

Sept.1/70 - Mill not operating
Sept.3/70 - Mill discharging effluent to river

APPENDIX 5

BENTHOS SURVEY IN THE WINNIPEG RIVER IN THE VICINITY OF THE ABITIBI MANITOBA PAPER COMPANY PINE FALLS, MANITOBA

BY J. S. LOCH

SEPTEMBER, 1970

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BENTHOS SURVEY IN THE WINNIPEG RIVER IN THE VICINITY OF THE ABITIBI MANITOBA PAPER COMPANY PINE FALLS, MANITOBA

by

J. S. Loch

Resource Development Branch
Fisheries Service
Department of the Environment
Winnipeg, Manitoba

January, 1972

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INTRODUCTION

The Abitibi Manitoba Paper Company operates a pulp and paper mill at the town of Pine Falls, Manitoba ($50^{o}34'$ lat., $96^{o}13'$ long.). This is an integrated newsprint mill; the newsprint is made from 75 percent groundwood pulp, 20 percent sodium-based sulphite pulp, and 5 percent kraft pulp. A study was conducted to determine the effect of the mill's effluent on the bottom-dwelling organisms ('benthos' or 'bottom fauna') of the receiving waters, the Winnipeg River.

According to a Winnipeg River Survey by the Provincial Sanitary Control Commission (Kay, 1957), the industrial waste pollution from the mill "is not critical." The potential source of pollution appeared to be bark and fibre waste and the 1957 study stated, "these effects are not noticeable along the Winnipeg River, as the current is sufficient to move the materials out into the lake." However, Cober (1966) found in a benthic survey below the mill's outfall that samples contained considerable quantities of woodchips and bark for a six-mile stretch of river below the pulp mill outfall. A Winnipeg River Pollution Survey (Dickson, 1961) by the Manitoba Department of Health found that the total number of benthic invertebrate species decreased, while the numbers for the pollution tolerant species increased downstream from the mill.

Such studies of the bottom dwelling organisms in the area of a discharge can provide a biological assessment of the effects of waste discharges on an aquatic system. There are a number of reasons why benthic organisms specifically are used in such pollution studies. The food potential of bottom fauna for fish is one reason: if the bottom fauna are destroyed, the fish will ultimately suffer. However, there are several

other reasons why bottom fauna are studied: first, many species are extremely sensitive to pollution and respond quickly to it; second, bottom fauna usually have a complex life cycle of a year or more, and if at any time during their life cycle environmental conditions are outside their tolerance limits, they die; third, since they have an attached, or sessile, mode of life and are not subject to rapid migrations (as fish are), they serve as natural monitors of water quality.

DESCRIPTION OF STUDY AREA

The Winnipeg River has its sources in the English River system and the Lake of the Woods. It extends approximately 320 kilometers (200 miles) from Kenora on Lake of the Woods to Traverse Bay on Lake Winnipeg.

The area of the Winnipeg River sampled is located in Township 19, Range 9, East in the east-central part of Manitoba. This study area extends from the Pine Falls power dam to the village of Fort Alexander on the Winnipeg River (Figure 1). The pulp mill in question is situated 1.6 km. (1 mile) downstream from this power dam. Fort Alexander is 3.2 km. (2 miles) upstream from the mouth of the river.

There are a series of power installations on the Winnipeg River and the flow is thereby regulated at an average of 8,500 m^3/sec (30,000 cfs).

Five transects (stations) were selected in the vicinity of the pulp mill (Figure 1). These stations were selected for their strategic importance, that is, at locations that would reflect some stage of effect of discharge. One station was located above the point of discharge (outfall) the other four below the outfall. Three substations were set up along each transect. Similar ranges of depth and current were considered in final positioning of the stations and substations. A description of each station follows:

Station One:

This station was located 6.4 km. (4 miles) downstream from the mill's outfall. The channel is 0.8 km. (½ mile) wide at this point and the current was moderate at all three substations. The river depths at the substations were: (a) 11.4 m. (37'); (b) 13.9 m. (45'); (c) 7.4 m. (24').

The river bottom (substrate) was comprised entirely of mud at these substations.

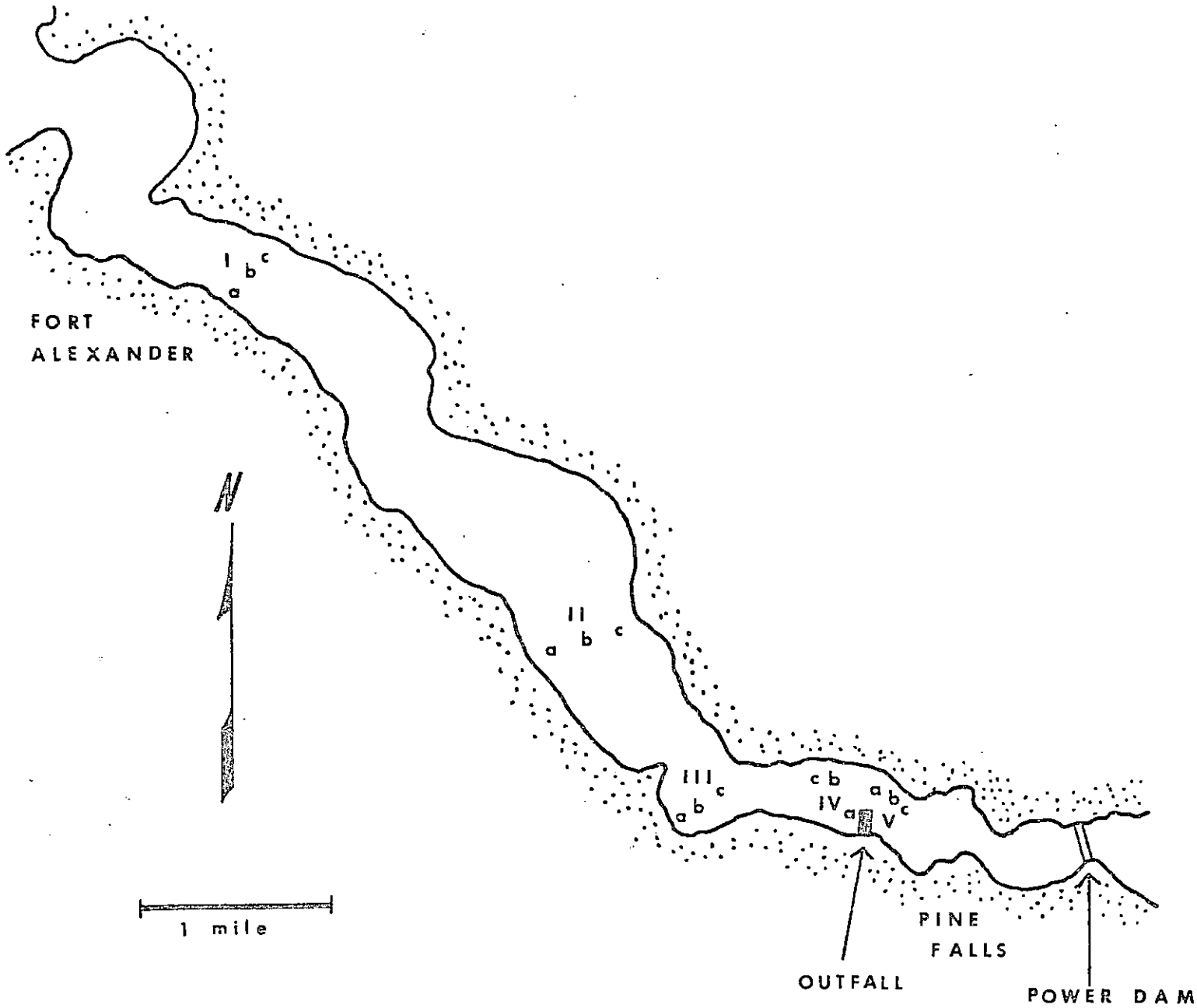
Station Two

This station was located 3.2 km. (2 miles) downstream from the outfall. The channel is 0.8 km. (½ mile) wide at this point and the current moderate at all three substations. The river depths at the substations were: (a) 8.0 m. (26'); (b) 7.4 m. (24'); (c) 12.3 m. (40'). The substrate at all three substations consisted of approximately 50 percent wood fibre and 50 percent mud.

Station Three

This station was located 1.3 km. (0.8 mile) downstream from the outfall. The channel is 0.6 km. (0.4 mile) wide at this point. The current was quite fast near the north shore and substations were located in slower waters towards the south shore as the substrate in the area of the strong current could not be sampled due to its rocky nature. The river substrate at these substations consisted of 50 - 100 percent wood fibre, the rest being mud. The river depths at the substations were: (a) 4.9 m. (16'); (b) 13.3 m. (43'); (c) 15.4 m. (50').

Figure 1. Benthos survey stations in the Winnipeg River.


FORT
ALEXANDER
I
a
b
c
II
a
b
c
III
a
b
c
IV
a
b
c
V
a
b
c
N
1 mile
OUTFALL
PINE
FALLS
POWER DAM

Station Four

This station was located immediately below the outfall, Substation (a) was located in 6.2 m. (20') of water in an area of little current. The substrate sampled consisted entirely of wood pulp and fibre; gas bubbles were being evolved from the substrate in this region. Substations (b) and (c) were located on the north shore of the river along the edge of a permanent log boom in 12.9 m. (42') and 10.5 m. (34') of water respectively. The substrate here consisted mostly of mud and gravel with some pieces of bark and sticks also being present. There was no wood fibre. The current at Station Four followed the centre of the river, hence substation (a) would feel the full effect of the outfall, while substations (b) and (c) should not be effected. Substations (b) and (c) were located near the north shore as the centre of the river, where the current was strong, could not be sampled due to the rocky nature of the substrate.

Station Five

This station was located immediately above the outfall and all three substations were situated along the edge of a log boom on the north shore due to the rocky nature of the substrate in other areas along the transect. The substrate was the same as that of Station 4 (b), 4 (c), that is, mud and gravel with some large sticks and pieces of bark. The depths of the river at the substations were: (a) 8 m. (26'); (b) 6.5 m. (21'); (c) 6.5 m. (21').

These stations were selected for their strategic importance, that is, at locations that would reflect some stage of effect of discharge.

Similar ranges of depth and current were considered in final positioning of the stations and substations.

METHODS AND MATERIALS

Benthic samples were taken using a Ponar grab. This device was felt to be the most suitable for a deep, fast moving river with a bottom that would vary from mud to gravel to rock. Flannagan (1970) suggests the Ponar is the "closest to being an all sediment sampler but in no sediment ...(is it)... entirely satisfactory."

Duplicate samples were taken at the substations mentioned above. The river was sampled on August 4, September 6 and October 12, 1971.

The grab sample was emptied into a conical net of Nitex nylon (602 micron opening), washed and then preserved in a solution of ethyl alcohol and rose bengal (100 mg/litre 95 percent ethyl alcohol) diluted to 70 percent. Rose bengal is a vital stain (stains living matter) and enhances the ability to perceive small organisms. Lackey et al. (1971) recommend this stain. The samples were then returned to the lab, spread out in white enamelled trays and picked through by hand. All organisms visible were removed and preserved in vials in 70 percent ethyl alcohol. Flotation methods were not employed due to the presence of wood fibre which had the same specific gravity as the organisms. The vital stain proved to be invaluable in finding organisms in the large masses of wood fibre. Figure 2 shows the sampling gear used in this study.

A multiple plate sampler (Hester and Dendy, 1962) was also used in this study. One sampler was placed at each substation. However, the majority of these disappeared over a month's duration. Some samplers were washed away due to poor fastening to the anchor rope, others due to the

Figure 2. Sampling equipment used in benthic survey.

fluctuating water levels in the river, while still others were removed by passersby or destroyed by river barges. Therefore, this sampling method was abandoned.

All benthic fauna were identified to genus with the exception of aquatic Oligochaeta which were left at the taxonomic level of 'class' due to the difficulty in identification of these organisms. Subsamples of the various genera were examined by authorities for confirmation of identification. Identifications of the Chironomidae were done using a provisional key of Hamilton and Saether of the Freshwater Institute, Winnipeg.

The organisms collected were separated into major taxonomic 'groups' (family, order or class) and an average number per station for each group was calculated by division of the total per station by the number of substations. In the case of Station Four, this was separated into Station IV (a) and Station IV (b) - (c) the former having one substation, the latter two. Similar calculations were made for the various genera of the Chironomidae family.

Quantitative analysis was performed through a species diversity index as described by Wilhm and Dorris (1966, 1968) and Wilhm (1970). This index is based on the premise that diversity is equivalent to the uncertainty that exists as to the species of an individual that might be selected at random from a community. The more species in a community and the more equal their abundance, the greater would be the uncertainty as to the type of the individual selected. In a polluted situation, the more sensitive species would not survive, while pollution-tolerant organisms would flourish

absence of inter-specific competition and in the presence of optimum living conditions. Therefore, a decrease of diversity is expected in a polluted environment and this would be reflected in the species diversity index.

Wilhm and Dorris (1968) use the formula:

$$\bar{d} = - \ (n_i/n) \ . \ \log_2 \ (n_i/n)$$

Where n is the total number of individuals in the sample,

n_i is the number of individuals in the $\underline{i}$ th species

d is the species diversity index

A low value for $\bar{d}$ indicates low diversity, while a high value would indicate a high degree of diversity. Diversity indices can be calculated at the generic level rather than the species level as the mathematical theory of the index is not dependent on the level of taxonomic classification, except in order of magnitude (Pielou, 1966). Indices were calculated for each substation and also for each station. Duplicate samples were pooled for these calculations.

RESULTS

The major components of the benthic community as determined by the Ponar grab sample method are shown in Figure 3. Midge fly larvae (Chironomidae) and aquatic worms (Oligochaeta) predominated. Other benthic organisms that were present in considerable numbers included: fingernail clams (Sphaeridae), mayfly nymphs (Ephemeroptera), leeches (Hirudinea), scuds (Amphipoda) and caddis fly larvae (Trichoptera).

Chironomidae and Oliogochaeta were found at all stations but were the only groups at Station IV (a) directly below the outfall. Mayfly nymphs appeared in increasing numbers with distance from the point of discharge. They also were present in Station V above the outfall. Caddis fly larvae and the fingernail clams appeared to follow a similar trend. No discernable relationships were seen for leeches and scuds.

Figure 3 also shows the average representation of these various benthic groups at the selected stations. Station V appears to have the most diverse fauna - more groups and relatively equal numbers within each group. Station IV (a) has the least diversification with only Chironomidae and Oligochaeta being represented. Among the Chironomidae only one genus (*Chironomus*) is present in significant numbers at all times at this sub-station (Figure 4). Station IV (b) (c) shows a similar diversification to that of Station V. This is to be expected as Station IV (b) (c) is on the opposite side of the river, facing the outfall and the current keeps the discharge to the near side of the river affecting Station IV (a) but not IV (b) (c). Stations III, II, I show increasing diversity as would be expected from an increase in distance from the point of discharge.

These observations on diversity are substantiated by the calculation of the diversity index (Figure 5). Maximum diversity is seen in Station V, IV (b) (c), and I. Substation IV (a) shows very little diversity and Station III has improved on this but is not at the level of other stations.

Among the Chironomidae, certain genera appeared to be more prevalent at stations near the outfall. These included *Tribelos*, *Sergentia*, *Polypedilum* and especially *Chironomus* (See Figure 4). Two other genera were present in significant numbers in areas removed from the outfall: *Ablabesmyia* and *Procladius*.

Qualitative observations on the composition of the dredge samples showed that the bottom was covered extensively with wood fibre in the vicinity of Substation IV (a), Station III and to a lesser extent Station II. Samples at IV (a) and III consisted entirely of wood fibre, while wood fibre comprised approximately 30 - 40 percent of the samples at Station II. Station V, IV (b) (c) and I did not have any wood fibre present in their samples. There was a considerable amount of bark and branches, as well as gravel and mud in samples taken at Station V and IV (b) (c). Station I samples consisted entirely of mud.

A complete list of organisms taken at each station and month is found in the Appendix.

Figure 3. Average composition by bottom-faunal group at each station of benthic survey in the Winnipeg River. (Station IV (a) is indicated with a solid line, Station IV (b) (c) with a dotted line).

C	Chironomidae
O	Oligochaeta
S	Sphaeridae
E	Ephemeroptera
T	Trichoptera
H	Hirudinea
A	Amphipoda

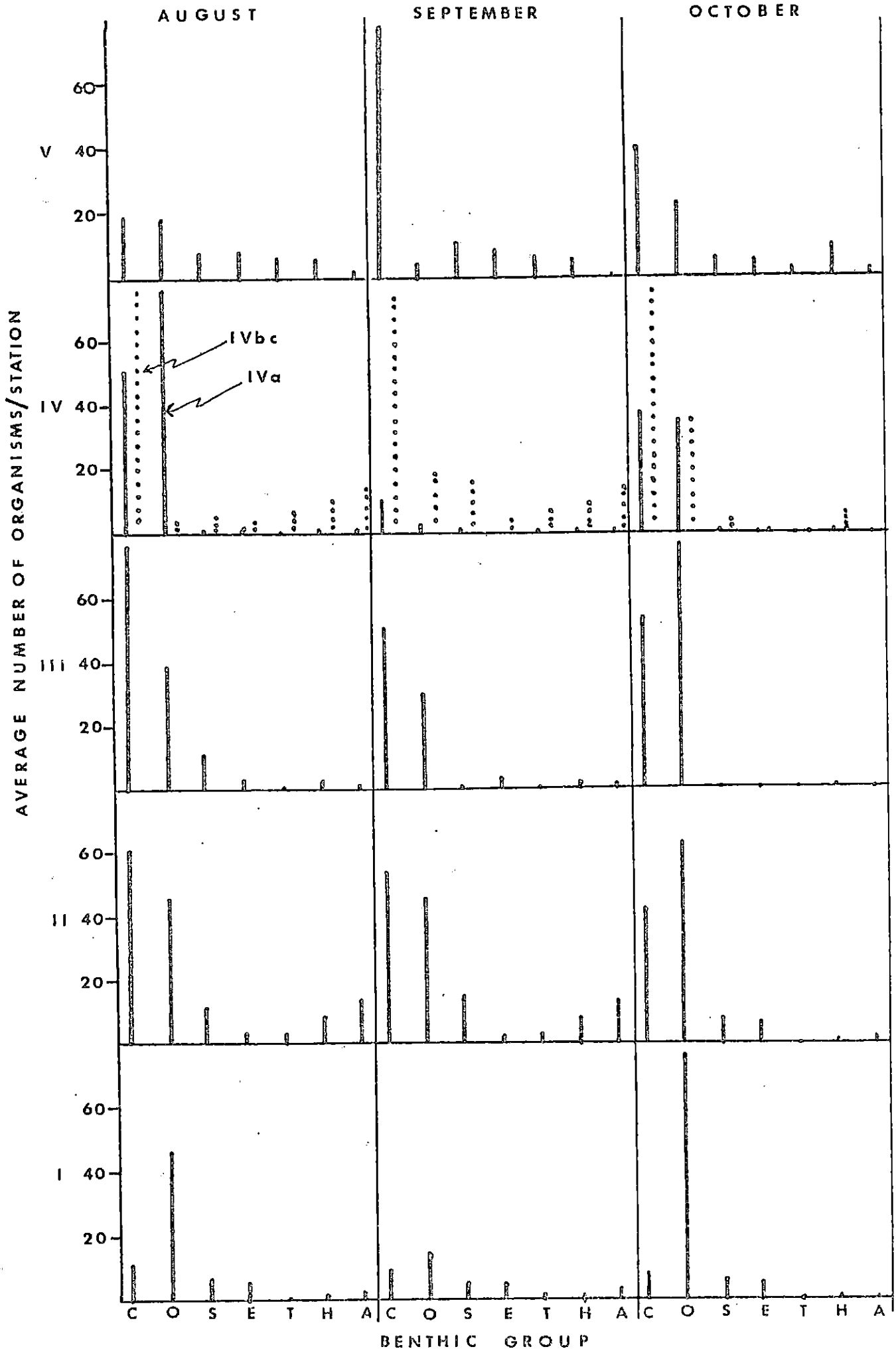

AUGUST
SEPTEMBER
OCTOBER
AVERAGE NUMBER OF ORGANISMS/STATION
V
IV
III
II
I
60
40
20
IVbc
IVa
C O S E T H A
BENTHIC GROUP

Figure 4. Average composition (by genus) at each station of Chironomidae in benthic survey of the Winnipeg River (showing major genera only).

A	*Ablabesmyia*
Pr	*Procladius*
Ch	*Chironomus*
T	*Tribelos*
S	*Sergentia*
Po	*Polypedilum*
Cr	*Cryptochironomus*

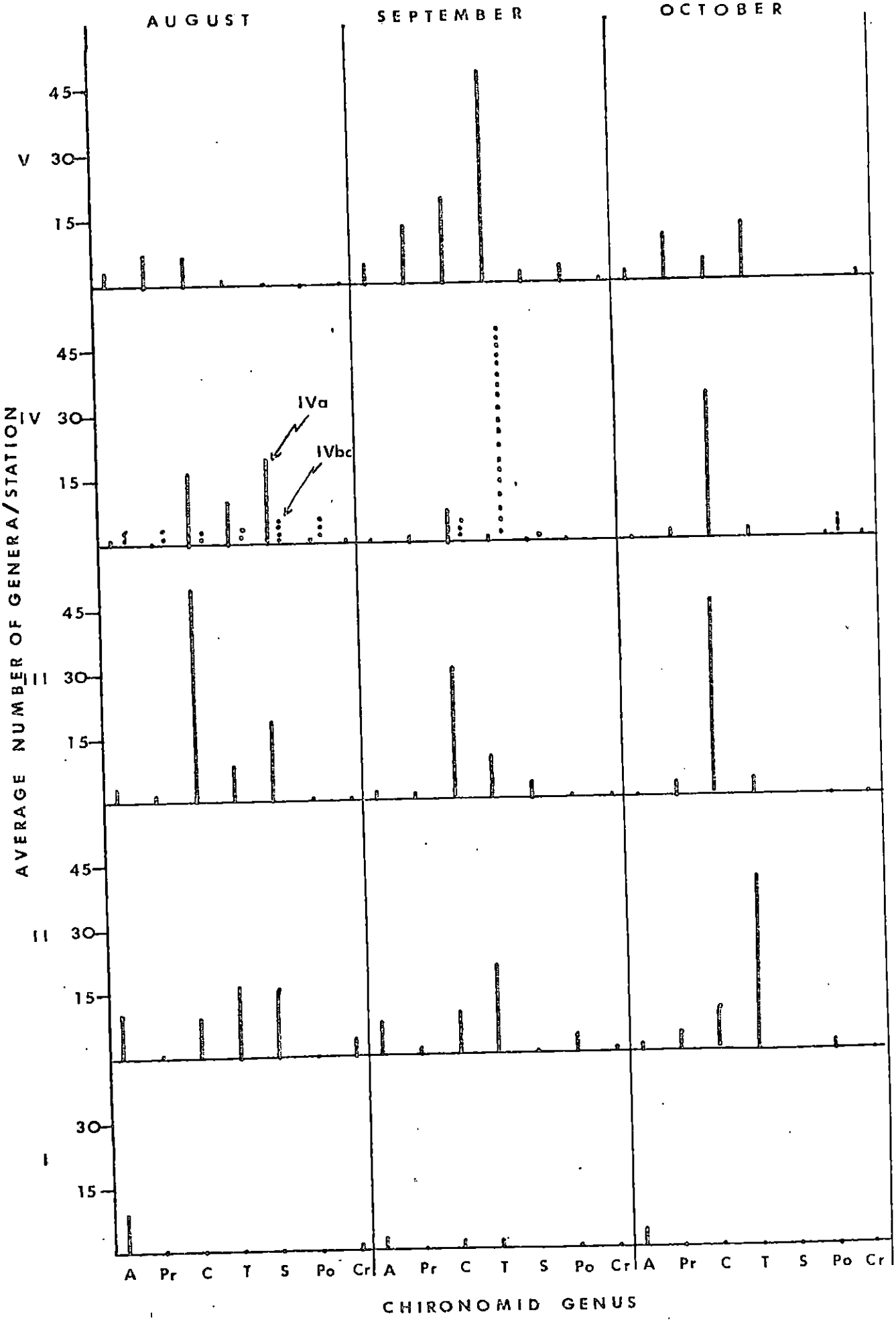
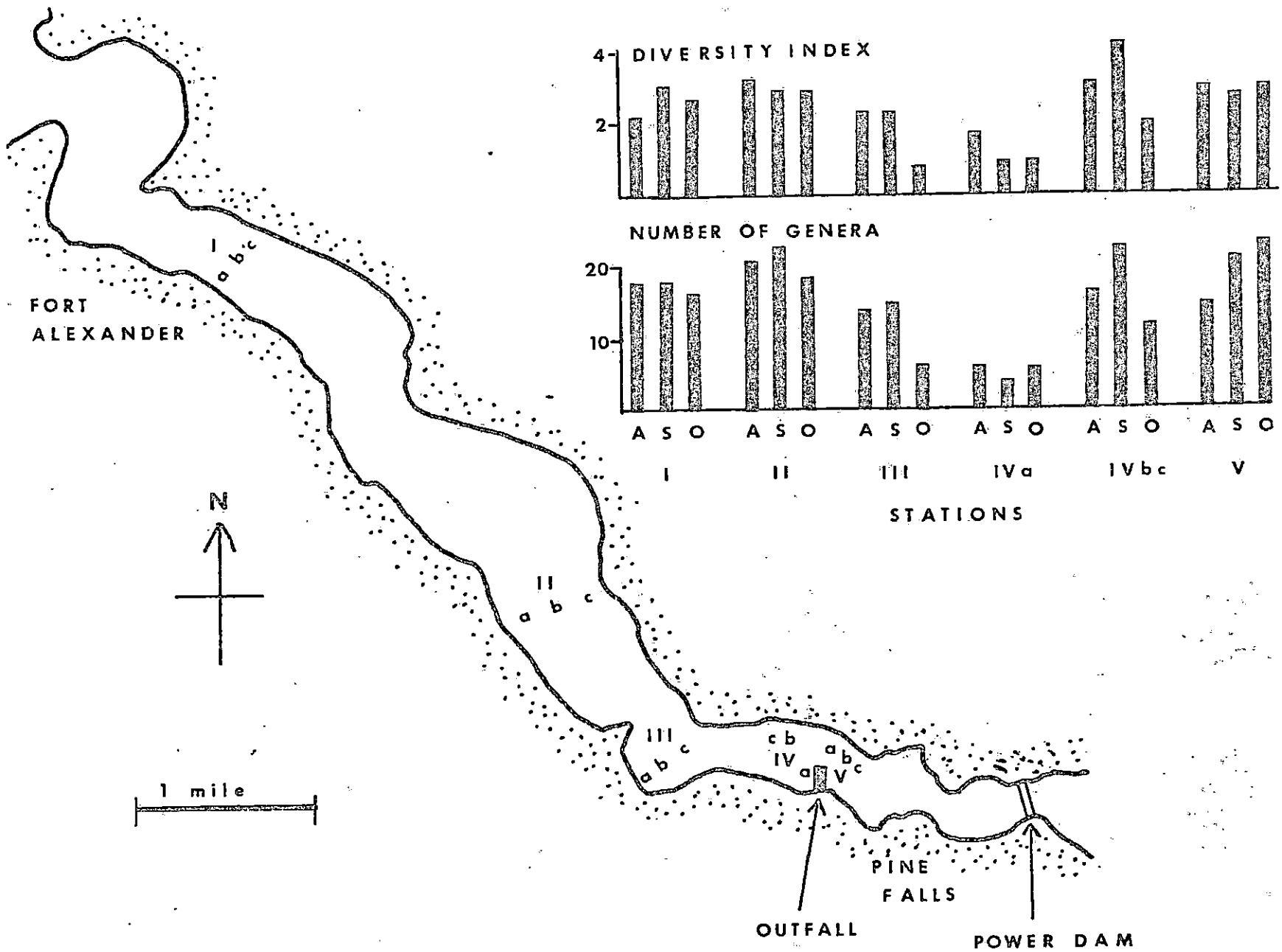

AUGUST
SEPTEMBER
OCTOBER
AVERAGE NUMBER OF GENERA/STATION
V
IV
III
II
I
45
30
15
IVa
IVbc
A
Pr
C
T
S
Po
Cr
CHIRONOMID GENUS

Figure 5. Benthos survey sampling results in terms of a diversity index and number of genera of benthic organisms per station.

A August

S September

O October


DIVERSITY INDEX
4
2
NUMBER OF GENERA
20
10
A S O A S O A S O A S O A S O A S O
I II III IVa IVbc V
STATIONS
FORT ALEXANDER
I a b c
II a b c
III a b c
IV a b c
V a b c
N
1 mile
OUTFALL
PINE FALLS
POWER DAM

DISCUSSION

Certain groups of organisms have been found to be intolerant of various types of pollution. Immature or larval stages of mayflies and caddisflies are quite sensitive to environmental changes and as such serve as good pollution indicators (Richardson, 1928; Gaufin and Tarzwell, 1954). The decrease in abundance of these organisms at stations progressively closer to the outfall would appear to indicate that these groups have been affected by the pulp mill discharge. Chironomidae and Oligichaeta are regarded as pollution-tolerant organisms. These organisms predominate at all stations and especially so at Stations IV (a) and III which are immediately downstream from the outfall. The midge fly genus *Chironomus* is especially abundant at these two stations and Hynes (1960) and various other authors have found this genus to be quite pollution-tolerant. The fingernail clams (Sphaeriidae) are regarded as intermediate in tolerance and their presence at most stations would appear to indicate that this entire stretch of river could not be classified as "clean water."

Wilhm and Dorris (1968) suggest that a diversity index value of less than one indicates heavy pollution; values between one and three indicate moderate pollution and values above three indicate clear water areas. These numbers are somewhat arbitrary and the index calculated in this study is at the generic level rather than the species level. Pielou (1966) suggests a modification might be made to compensate for this change in level of classification. However, the values obtained in this study appear to follow Wilhm and Dorris's categorizations. Stations I and II have intermediate values between two and three indicating perhaps that these

stations have been moderately affected by the mill discharge. Station III has an index around two and from the observations concerning the amount of wood fibre present in samples from this area, this station appears to have been seriously affected by the mill discharge. Substation IV (a) has an index value of one and it certainly is in a state of gross pollution. Station V and IV (b) (c), both of which are outside the area of influence of the mill discharge, have diversity values of three or greater indicating relatively clean water. However, there was a considerable amount of bark and sticks in these samples likely due to abrasion of logs kept in the booms beside which these stations were located.

The wood fibre accumulation is seen most dramatically at the outfall. Here an extensive conglomeration of bark, fibre and flotsam stretches from shore 60 m. (200') out into the river (Figures 5, 6, & 7). This "pier" is 6 - 12 m. (20' - 40') wide, 2 - 3 m. (8' - 10') above the water line and 6 - 12 m. (20 - 40') below the water surface. The effluent flows through this mass creating a channel. To the west of this pier there is a small bay (Figure 8), its bottom is covered with fibre and slime and the evolution of gases from the bottom was seen. Minimal foaming occurred only due to the waste diffusing through the channel bulk before emptying into the river proper.

Smith and associates published a series of papers on the effect of wood fibre on walleye eggs and fry (Smith and Kramer, 1963; Colby and Smith, 1967; Smith et al., 1965). They found that groundwood fibres from the paper mill at International Falls, Minnesota, coated the bottom of the Rainy River. This mat stimulated the growth of slime bacterium *Sphaerotilus*

which prevented the walleye from emerging from the eggs. They also found that these fibre beds are toxic to eggs and fry and other benthis organisms because of dissolved sulphides. These fibre beds were found to a distance of 62 miles downstream from the mill. Benthic surveys revealed that only Oligochaetes and Chironomids were found frequently on these wood fibre deposits. Conifer groundwood was found to be the most toxic, followed by kraft pulp, sulphite pulp and aspen groundwood.

The groundwood used at the Abitibi mill is from black spruce and jack pine, both conifers. Walleye *(Stizostedion vitreum)* inhabit the Winnipeg River and no doubt could be affected by the mill's discharge, as could spawning runs of whitefish *(Coregonus clupeaformis)* and tulibee *(Coregonus artedi)*, although there have been no studies on this problem.

At the time of the survey, a considerable discharge of fibre, bark and wood chunks was observed at the outfall. The Abitibi mill is intending to install a fine bark clarifier which should alleviate much of the fibre discharge problem. However, this will not solve the problem of existing fibre accumulations at the outfall and downstream nor the likely problem of toxicity to fish. The mill has not suggested any remedies for this. The size of the fibre/flotsam/debris accumulation at the outfall could insure continued fibre dosing into the river for many years to come, regardless of future pollution abatement programs.

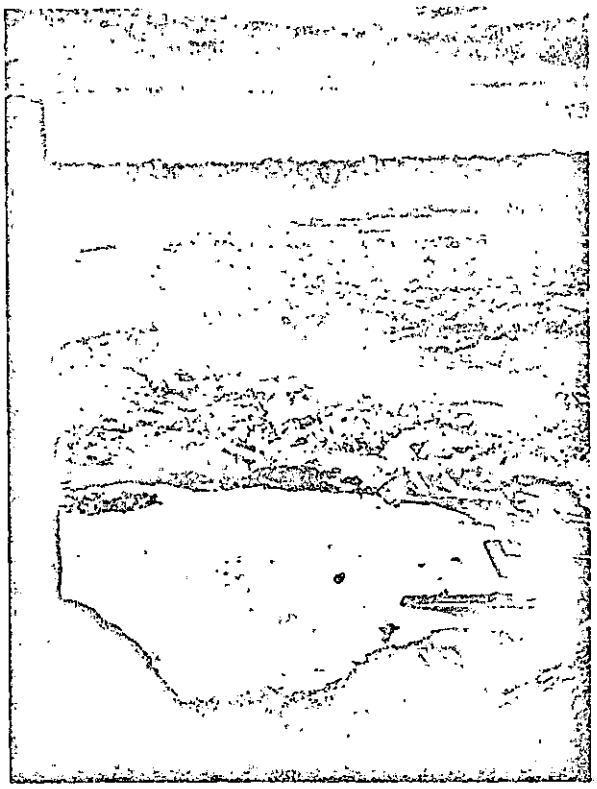


Figure 6. View of outfall and 'pier' from water level.

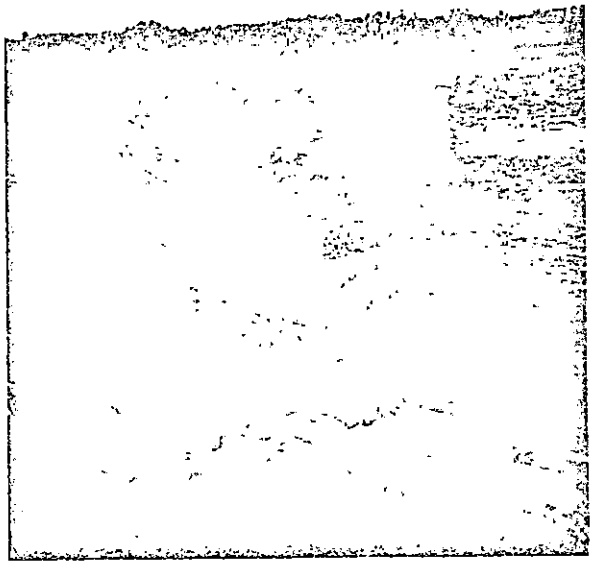


Figure 7. Wood accumulation at outfall.

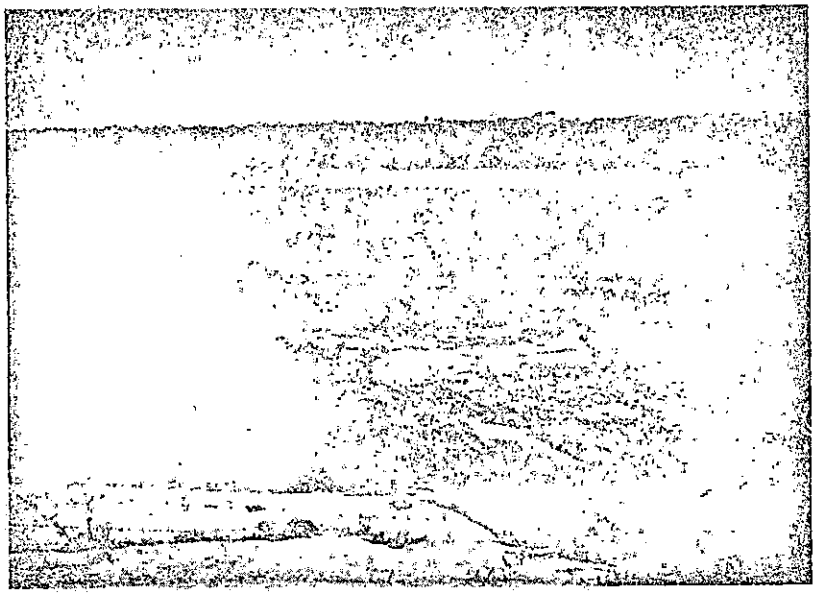


Figure 8. View of outfall from south shore.

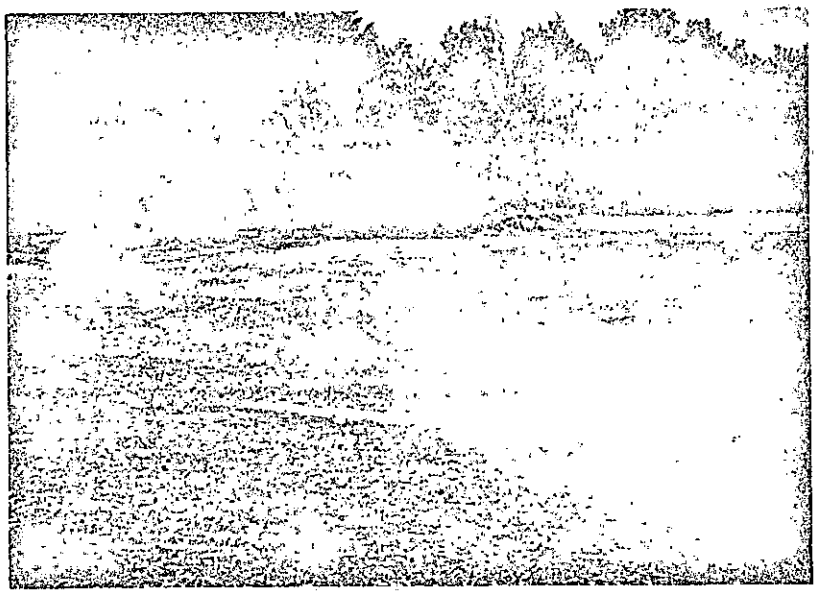


Figure 9. Wood accumulation in bay ½ mile downstream from outfall. (The Winnipeg River is at a low level at time of photograph).

CONCLUSIONS

A benthic survey of the Winnipeg River has shown it to be moderately to severely polluted by the discharge of the Abitibi Manitoba Pulp and Paper Company, which has adversely affected the diversity of the benthic community. Massive losses of wood fibre from the mill discharge have caused large accumulations of this fibre on the river bottom and even above the water surface. The existing fiber pile at the outfall should not be permitted to "gradually disappear into the river" but should be removed.

An aesthetic and biological pollution problem exists in the Winnipeg River as a result of the effluent discharged by the Abitibi Manitoba Paper Company.

SUMMARY

1. Substrate analysis at stations located downstream from the pulp mill discharge indicate that there is a considerable wood fibre loss from the mill operation. There are large accumulations of wood fibre at the outfall in the form of a flotsam/fibre/debris pier. The river bottom is covered with a wood fibre layer for a distance of at least two miles downstream in areas where the current does not wash the bottom clean. The wood fibre may affect the egg hatching success of various fish species in the river.

2. Benthic fauna studies indicate that organisms normally associated with a polluted environment (Oligochaeta, *Chironomus*) are found in large numbers for a mile downstream from the discharge.

3. Diversity indices indicate that moderate to heavy pollution exists at least for a four-mile stretch downstream.

4. The Winnipeg River is aesthetically and biologically polluted in terms of the degree of wood fibre accumulation and the effects this has on the benthic community.

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Miss Susan Bates assisted in the collection of samples, sorted them and provided tentative identifications for all groups of organisms except the Chironomidae. Her assistance is much appreciated.

Jo-Anne Crowe of the Manitoba Department of Mines, Resources and Environmental Management provided invaluable advice on setting up the survey and assisted in identification of Trichoptera, Hiludinea and Chironomidae.

Dr. R. H. Green, Department of Zoology, University of Manitoba, verified the snail and clam identifications; Drs. A. L. Hamilton and O.E. Saether verified the chironomid identifications. Dr. Hamilton also provided useful advice on sampling gear. Mr. Gian Vascotto, Department of Zoology, University of Manitoba assisted in identification of other miscellaneous insect larvae.

LITERATURE CITED

Colby, P.J., and L.L. Smith, Jr. 1967. Survival of walleye eggs and fry on paper fibre sludge deposits in Rainy R., Minnesota. Trans. Amer. Fish. Soc., 96(3): 278-296.

Dickson, I. 1961. Winnipeg River pollution survey. Bureau of Public Health Engineering. Manitoba Department of Health. 62 pp.

Flannagan, J.F. 1970. Efficiencies of various grabs and corers in sampling freshwater benthos. J. Fish. Res. Bd. Canada, 27(1): 1691-1700.

Gaufin, A.R., and C.M. Tarzwell. 1956. Aquatic macroinvertebrate communities as indicators of organic pollution in Lytle Creek. Sewage and Industrial Wastes, 28(7): 906-924.

Hester, F.E., and J.S. Dendy. 1962. A multiple plate sampler for aquatic invertebrates. Trans. Amer. Fish Soc., 91: 420-421.

Hynes, N.B. 1960. The biology of polluted waters. Liverpool University Press, Liverpool. 202 pp.

Kay, L.A. 1957. Winnipeg River survey. Provincial Sanitary Control Commission. Dept. of Mines and Natural Resources. Manitoba. 20 pp.

Lackey, R.T., and B.E. May. 1971. Use of sugar flotation and dye to sort benthic samples. Trans. Amer. Fish. Soc., 100(4): 794-797.

Pielou, E.C. 1969. An introduction to mathematical ecology. Wiley and Sons, Toronto. 286 pp.

Richardson, R.E. 1928. The bottom fauna of the Middle Illinois River, 1913-1925; its distribution, abundance, evaluation and index value in the study of stream pollution. Bull. Ill. State Nat. Hist. Survey, Vol. 17, Art XII, 86 pp.

Smith, L.L., Jr., and R.H. Kramer, 1963. Survival of walleye eggs in relation to wood fibres and *Sphaerotilus natans* in the Rainy River, Minnesota. Trans. Amer. Fish. Soc., 92(3): 220-234.

Smith, L.L., Jr., R.H. Kramer, and J.C. MacLeod. 1965. Effects of pulpwood fibres on fathead minnows and walleye fingerlings. J. Water Poll. Control Fed., 37(1): 130-140.

Wilhm, J.L., and T.C. Dorris. 1966. Species diversity of benthic macroinvertebrates in a stream receiving domestic and oil refinery effluents. Amer. Midl. Nat., 76: 427-449.

Wilhm, J.L., and T.C. Dorris. 1968. Biological parameters for water quality criteria. Bioscience, 18(6): 477-481.

Wilhm, J.L. 1970. Range of diversity indexes in benthic macroinvertebrate populations. J. Water Poll. Control Fed., 42(5): 221-224.

PERSONAL COMMUNICATION CITED

Cober, Jo-Anne, M.E. 1966. Survey of the benthic fauna of the Winnipeg River below Pine Falls area in July, 1966. Department of Mines and Natural Resources, Manitoba. 12 pp.

Appendix

Bottom fauna sampled in the benthic survey of the Winnipeg River

	August						September						October					
Station	I	II	III	IVa	IVbc	V	I	II	III	IVa	IVbc	V	I	II	III	IVa	IVbc	V
Gastropoda																		
Amnicola	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Physea	-	-	-	-	1	-	-	1	-	-	-	-	-	-	-	-	-	2
Campeloma	8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
others	-	2	1	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-
Pelcopoda																		
Sphaeridae																		
Pisidium	15	72	29	-	6	30	11	64	-	-	41	55	16	33	-	1	16	30
Sphaerium	22	21	26	-	9	17	21	24	-	-	21	4	4	10	-	-	-	4
Unionidae																		
Lampsilis	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-
Proptera	-	-	-	-	-	-	-	1	-	-	3	-	1	-	-	-	-	-
Leptodea	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
Annelida																		
Oligochaeta	274	270	194	226	17	99	71	269	149	5	75	24	518	378	886	71	138	37
Hirudinea																		
Helobdella	3	50	9	-	30	26	1	20	15	-	25	19	-	1	-	-	24	48
Nephelopus	1	3	-	-	-	2	-	-	-	-	2	4	-	-	-	-	-	5

continued .....

Appendix (continued)

Bottom fauna sampled in a benthic survey of the Winnipeg River

	August						September						October					
Station	I	II	III	IVa	IVbc	V	I	II	III	IVa	IVbc	V	I	II	III	IVa	IVbc	V
Arthropoda																		
Amphipoda																		
Hyalella	9	69	2	–	43	4	4	1	23	–	23	9	1	3	–	–	3	10
Insecta																		
Odonata	–	–	–	–	–	–	–	–	–	–	2	–	–	–	–	–	–	–
Megaloptera	–	–	–	–	–	–	–	–	–	–	–	3	–	–	–	–	1	2
Ephemeroptera																		
Hexagenia	32	15	24	–	–	–	25	145	4	–	154	28	30	35	–	5	–	28
others	–	–	–	–	–	–	1	3	1	–	–	–	–	2	–	–	–	–
Trichoptera																		
Cheumatopsyche	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–
Neureclipsis	–	1	1	–	–	38	1	1	–	–	5	30	–	–	–	–	3	19
Chironomidae																		
Ablabesmyia	53	59	17	2	8	20	18	47	12	–	15	23	24	11	2	–	8	11
Procladius	2	2	8	–	13	44	3	12	11	–	2	74	1	32	18	3	45	66
Coelotanypus	–	–	–	–	–	1	–	–	–	–	–	3	–	–	–	–	–	2
Clinotanypus	–	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–
Thienemannyia gp....	–	1	–	–	2	–	–	–	1	–	–	–	1	10	–	–	–	8
Chironomus	5	54	243	33	8	36	11	58	189	14	20	118	1	57	275	68	40	30
Cryptochironomus ...	6	28	3	–	5	3	7	7	4	–	2	4	8	5	1	1	5	4

continued .....

Appendix (concluded)

Bottom fauna sampled in a benthic survey of the Winnipeg River

Station	August						September						October					
	I	II	III	IVa	IVbc	V	I	II	III	IVa	IVbc	V	I	II	III	IVa	IVbc	V
Tribelos	-	99	43	19	9	5	8	144	60	2	201	286	1	111	25	4	258	76
Sergentia	-	95	97	46	14	-	-	4	18	1	4	11	4	1	-	-	-	-
Polypedilum	-	-	-	2	17	1	4	28	4	-	39	23	2	15	1	-	18	34
Paratendipes	-	-	-	-	1	-	-	-	-	-	-	2	-	-	-	-	-	-
Endochironomus	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
Glyptotendipes	-	1	1	-	-	-	-	3	-	1	2	3	-	-	-	-	-	-
Dicrotendipes	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Stictochironomus	-	-	-	-	-	-	-	14	2	-	4	1	-	7	-	-	-	1
Demicryptochironomus	-	-	-	-	-	-	-	5	3	-	6	1	3	3	-	-	6	3
Micropsectra	-	10	-	-	6	1	-	-	-	-	1	-	-	-	-	-	-	-
Caleposectra	-	3	-	-	1	-	-	2	-	-	3	4	1	-	-	-	-	-
Epiococladius	3	1	-	-	1	1	-	-	1	-	3	-	3	-	-	-	-	1
Heterotrissocladius	-	7	-	-	-	-	-	1	3	-	-	-	-	-	-	-	-	-
Potthastia	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-