THE ONTARIO WATER RESOURCES COMMISSION

WATER RESOURCES SURVEY

DISTRICT OF SUDBURY

PART 2

A SURVEY OF INDUSTRIAL WATER USE AND WASTE DISPOSAL

1960 to 1963

THE

ONTARIO WATER RESOURCES

COMMISSION

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PART II

A SURVEY OF INDUSTRIAL WATER

USE AND WASTE DISPOSAL

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ABBREVIATIONS

ENGINEERING TERMS

BOD	BIO-CHEMICAL OXYGEN DEMAND
GPD	GALLONS PER DAY
USGPD	UNITED STATES GALLONS PER DAY
GPM	GALLONS PER MINUTE
MGD	MILLION GALLONS PER DAY
NO.	NUMBER
PPB	PARTS PER BILLION
PPM	PARTS PER MILLION
SUSP.	SUSPENDED
DISS.	DISSOLVED

COMPANIES

INCO - INTERNATIONAL NICKEL COMPANY OF CANADA LIMITED

KVP - KALAMAZOO VEGETABLE PARCHMENT COMPANY

CIL - CANADIAN INDUSTRIES LIMITED

CHAPTER I

SUMMARY AND RECOMMENDATIONS

SUMMARY

This report comprises Part II of the survey conducted by the Ontario Water Resources Commission staff during 1960 to 1963. It deals with the water supply and waste disposal practices of industries located in the District of Sudbury. For information regarding municipal water supply and waste disposal practices in the district, as well as a description of the geology, ground water, and surface water in the area, the reader is referred to Part I of this report issued at an earlier date.

In this report the various industries considered in the survey are dealt with in separate chapters. Hence, there is a chapter on each of the following industries: International Nickel Company of Canada Limited; Falconbridge Nickel Mines Limited; Canadian Industries Limited; Lowphos Ore Limited, Moose Mountain Mine; and KVP. In order to avoid confusion in dealing with the two large mining complexes in the area, the International Nickel Company and Falconbridge Nickel Mines, each installation of these companies is dealt with as a separate entity in the company chapters.

Information on each installation or industry involved in the survey was gathered to provide enough data to present an understanding of the position of the industries in the field of water supply and waste disposal. This included the following background information; a brief introduction, an indication of the number of persons involved, a brief description of the process with stress being placed on operations requiring large volumes of water, an outline of the major sources of waste and their quantities, and a statement of how and to where these wastes are disposed. This information was collected by consultation with technical personnel involved in the operations and by observation.

As well as the above, the format provided for the inclusion of the analytical results obtained from samples taken in the field. These results were then discussed in the report and conclusions and recommendations were made.

The results of the survey can be summarized as follows:

1) The major portion of the industry located in the District of Sudbury is involved in the mining and processing of ores found in the area which contain copper, nickel and iron. Most other industries located in the area are service industries and depend on the mining industry for their livelihood. Exceptions to this are the plants of KVP, which produces pulp and paper, and CIL which produces sulphuric acid and sulphur dioxide. At the present time CIL uses waste gases from INCO as its sole source of raw material and, hence, in this respect, is also dependent on the mining industry.

2) The waste discharges from International Nickel Company and Falconbridge Nickel Mines are characterized by the same components. These components are suspended solids, copper, nickel and iron, and they appear in varying concentrations depending on the discharge.

3) Waters pumped from mines and discharged to streams in the area contain varying concentrations of suspended solids, copper, nickel and iron, and generally exhibit a low pH. Preliminary studies of the analytical results indicate that waste waters from mines operated by INCO contain much higher levels of copper and nickel than do waste waters from mines

operated by Falconbridge Nickel Company. It has not been determined if this is the result of different procedures used in mining or if it is dependent on the composition of the ores being mined.

4) The disposal of tailings in the area is in keeping with standard practice in the industry. The disposal methods are effective in reducing suspended solids, copper, and nickel in the effluent. However, high iron concentrations and depressed pH conditions have been observed. It was illustrated that weather conditions could adversely affect the efficiency of the tailings disposal basins, particularly when high winds prevailed.

5) Effluents in the area, other than mine water and tailings discharges, which are associated with the mining industry, vary from satisfactory to unfavourable, and no generalization can be made. Of particular note is the discharge from INCO's Copper Cliff smelter which was shown to carry very high concentrations of copper and nickel over intermittent periods of time. Also of note was a discharge from the mill operated by Lowphos Ore Limited which, at the time of the survey, transported a large quantity of suspended solids to the Roberts River. Plans have been proposed which should alleviate the latter problem in the immediate future.

6) The discharges from the Canadian Industries Limited plants in the area exhibit a very low pH on a continuous basis. Although these discharges are low in volume, the effects on the receiving watercourse could be quite pronounced.

7) The waste discharge from the KVP Company transports suspended solids and bio-degradable organic material in quantities generally considered undesireable for discharge to a watercourse. Analysis of samples obtained during the 1963 survey indicates that approximately 9 tons

of BOD and 25 to 30 tons of suspended solids are discharged to the Spanish River each operating day. The wastes from the mill also contain relatively small quantities of substances arising from the pulping process which are felt to adversely affect the value of the river and the estuary at Lake Huron as a commercial and sport fishery, by imparting a characteristic taste to the flesh of some species of fish. The company has altered its method of disposal of waste from the crude sulphate turpentine decanter and the new method of disposal should somewhat alleviate the taste and odour problem in the river although it will not necessarily eliminate it.

RECOMMENDATIONS

1) All mine water discharges in the area should be disposed of in such a manner as to conform with the Ontario Water Resources Commission objectives presented in Chapter II. This may involve the establishment of treatment to reduce concentrations of suspended solids, copper, nickel and iron and to adjust the pH to an acceptable value.
2) The disposal of tailings in the area is in keeping with what is considered good practice. However, efforts should be made to control the pH of tailings area effluents (i.e. Levack, Fecunis Lake, and the Falconbridge Old Tailings area effluents all exhibit depressed pH conditions). Research should also be initiated to determine the effects of weather conditions on tailings settling basin efficiency with the purpose in mind to overcome or minimize adverse effects.
3) The waste discharge from INCO's Copper Cliff smelter should be treated to reduce concentrations of suspended solids, copper, and nickel. The

nature of the wastes involved indicate that segregation of wastes followed by settling in an impounded area may be of benefit in reducing the amount of polluting material reaching the receiving watercourse.

4) The wastes from INCO's iron ore recovery plant and Copper Cliff copper refinery are, in general, handled in a satisfactory manner. However, efforts should be made to insure that suspended solids in the iron ore recovery plant wastes discharging to the holding ponds on the premises do not reach a watercourse. Close control on the pH and suspended solids concentrations in the copper refinery discharges should be maintained. The combining of discharges may result in better pH control, whereas, impoundment of the wastes may be required to reduce the suspended solids content.

5) The pyrrhotite storage basin located at the Hardy mill, operated by Falconbridge Nickel Mines, gives rise to a discharge which, at times, carries quantities of suspended solids and nickel considered undesirable for discharge to a watercourse. Efforts should be made to reduce the level of these contaminants, either by increasing the retention time in the basin or by some form of chemical treatment of the effluent. Since this discharge proceeds directly to the Onaping River, it is felt that rigid control of the discharge is warranted.

6) The slimes from the sand plants located at East mine and the Fecunis Lake mine, operated by Falconbridge Nickel mines, should be disposed of to a tailings disposal area. Slimes at East mine are presently handled in this manner although temporary measures sometimes require a portion of these wastes to be discharged to Emery Creek. At Fecunis Lake mine, these wastes should be re-routed so that they are disposed of with Fecunis Lake mill tailings. (Plans are presently underway to return these wastes to the mill circuit.)

7) The tailings area receiving wastes from the pyrrhotite plant, operated by Falconbridge Nickel mines, gives rise to a discharge which has a low pH and carries high concentrations of iron and suspended solids to Emery Creek, a tributary of the Wanapitei River. This problem is much more pronounced during periods of high winds. It is recommended that the company take the necessary steps to remedy this situation. Such steps may involve the increasing of retention time in the basin by raising the level of the overflow weir, and by providing overflow control to guard against the effects produced by adverse weather conditions. Chemical treatment may be necessary to reduce the iron concentration in the effluent and elevate the pH to an acceptable range. Control of the iron concentration may reduce hydrolysis reactions and hence provide the necessary pH control to render the wastes satisfactory for discharge.

8) The waste discharges from both plants operated by Canadian Industries Limited should be treated in a manner which insures that they conform with Commission objectives. Neutralization of the wastes, followed by settling to remove suspended solids, is likely to provide the

necessary treatment, although other alternatives could be investigated.

9) The installation operated by Lowphos Ore Limited is presently responsible for placing a heavy load of suspended solids on the Roberts River due to dyke leaks and intermittent mill sump pump failures. It is recommended that the company eliminate these problems in the immediate future as the river cannot assimilate these wastes. (Since the time of field survey work these problems have been rectified.)

10) The KVP Company should provide for automatic sampling and flow recording of the main sewer discharge from the mill just prior to the lagoon on the Spanish River to permit closer surveillance of the main waste discharge to the river. The company should also undertake studies into the provision of primary treatment for either all their waste discharge or segregated waste streams known to contribute heavily to the pollution of the river. Studies should be undertaken to seek practical means of providing secondary treatment of wastes subsequent to primary treatment.

CHAPTER II

CONDUCT OF SURVEY

FIELD SURVEY METHODS

The field survey work necessary for the preparation of this report was carried out from 1960 to 1963. During this period all of the major industries in the District of Sudbury were contacted and an evaluation of their waste disposal practices was made. Industries visited, which are dealt with in this report, include: International Nickel Company of Canada, Limited; Falconbridge Nickel Mines Limited; Canadian Industries Limited; Lowphos Ore Company Limited; and KVP Company, Limited.

Due to the magnitude and complexity of the operations of International Nickel Company and Falconbridge Nickel Mines, these industries were treated in a different manner than other industries involved. Thus, each installation of these companies was treated as a separate entity in the survey even though it may have been closely coupled to operations at another installation.

During the initial stages of the survey, International Nickel Company and Falconbridge Nickel mines were contacted and information was gathered on their operations and waste handling procedures. This was accompanied by the sampling of all major waste discharges. At this time sampling was confined to obtaining single grab samples of each waste discharge.

In the final stages of the survey the companies were revisited and information which had been obtained previously was up-dated. At this time a more extensive sampling programme was carried out. Discharges carrying contaminants in concentrations which appeared to fluctuate, or were suspected of fluctuating a great deal, were sampled on a composite basis over a period of up to eight hours. Other wastes, such as mine water and tailings area discharges, which were suspected of carrying relatively stable concentrations of contaminants over a reasonable period of time, were grab sampled on three consecutive days where possible. It was felt that since operations at the various types of installations were generally quite similar, sampling of this nature would provide the information necessary to determine the waste disposal problems that existed.

Samples taken at the Falconbridge and INCO installations in the late stages of the survey were checked in the field to determine the pH. This determination was repeated in the laboratory at a later date.

Both plants of Canadian Industries, Limited, located in the District of Sudbury were surveyed. This company was in the process of altering operations at the time of the survey. However, as the proposed alterations were not likely to change the characteristics of the wastes to any great extent, the plants were surveyed as they existed at that time. In the early stages of the survey, grab samples were obtained from the final discharges, and, in the final stages of the survey, the discharges were sampled on a composite basis for about eight hours. pH determinations were made at regular intervals during the composite sampling period.

The operations of Lowphos Ore Company, Moose Mountain Mine, were also surveyed for this report. Data on the operation of the company were gathered and grab samples of all waste discharges were obtained. Sampling of the watercourse receiving these wastes was also carried out to determine the effects of the waste.

The KVP Company was surveyed in 1961 and 1963. During the surveys operational information was obtained and sewers in the plant were sampled. An attempt was made to obtain all in-plant samples from automatic samplers maintained by the company. This procedure was supplemented by grab samples when composite samples from automatic samplers were not available. The Spanish River was also sampled at various locations to supplement information obtained at the mill. During the 1963 survey the main mill discharge to the Spanish River was sampled on a composite basis.

ANALYTICAL PROCEDURES

All samples obtained in the field were analyzed in the Ontario Water Resources Commission laboratory located in Toronto. Analytical procedures followed are contained in the book entitled "Standard Methods for the Examination of Water and Waste Water", 11th Edition, published by the American Public Health Association, Inc. A short discussion on each type of determination follows to assist in the interpretation of results.

Bio-Chemical Oxygen Demand (BOD):

The BOD is reported in ppm (parts per million) and is an indication of the amount of oxygen required for the stabilization of decomposable organic matter present in sewage, polluted waters, or industrial wastes. Consequently, the BOD present in the waste water discharge reduces, and may eliminate, the dissolved oxygen content of the receiving stream. Laboratory tests are conducted over a period of controlled incubation. The time and temperature commonly used for the test are five days at 20°C. These conditions were used for all BOD analyses included in this report. The validity of the results of this test are questionable if toxic materials are present at the time of analysis.

A desirable upper limit in naturally occurring water is 4 ppm.

Total, Suspended, and Dissolved Solids:

The analyses for solids usually include tests for total, suspended and dissolved solids. Suspended solids determinations indicate the amount of undissolved solids of organic or inorganic nature; whereas, the dissolved solids are a measure of material in solution. Land erosion, sewage, and industrial wastes are significant sources of suspended solids. The effect of suspended solids in water is reflected in the difficulties associated with water purification, deposition in streams, and injury to the habitat of fish.

Where suspended solids values approach 20 ppm (parts per million) or less, analytical difficulties are experienced and, except for samples from sewage treatment works, the values of suspended matter are usually determined as turbidity.

Ignited Suspended Solids:

The test for ignited suspended solids is often used to determine the amount of suspended organic material present which is not amenable to bio-chemical oxidation. Due to the nature of the test it is often used on pulp and paper mill wastes as it gives an indication as to what portion of the total solids measured is bark, fibre, etc.

Nickel:

The test for nickel is a colorimetric test which determines the amount of nickel, in ppm (parts per million), in solution. Since it is customary to first digest the sample with an HNO_3 - H_2SO_4 solution, it is conceivable that the results represent both the nickel incorporated in the solids contained in the sample and the nickel in solution, or in other words, the total nickel content of the sample.

As nickel is toxic to the biological life found in naturally occurring waters at very low concentrations, a suggested maximum upper limit for the nickel concentration in a waste discharge is 8 ppm.

Copper:

The analysis for copper is carried out in a manner similar to that for nickel. Results are again reported in ppm (parts per million) and represent the total copper concentration in the sample. As copper is very toxic to the biological life found in naturally occurring watercourses, a maximum upper limit of 3 ppm (parts per million) should be observed in all wastes discharging to a watercourse.

Iron:

The analytical method used to determine the concentration of iron in a sample is based on colorimetry. Again the sample is treated in such a way to insure complete dissolution of the iron in the sample and therefore, the results represent the total concentration of iron in the sample. Very small quantities of iron will adversly affect a water supply and, in larger quantities, it will affect the aesthetic qualities of a watercourse and may, if present in the form of certain compounds, produce acidic conditions on hydrolysis. Concentrations should not exceed 17 ppm (parts per million) in wastes discharging to watercourses.

Acidity and Alkalinity:

The acidity of a water is usually caused by the presence of uncombined carbon dioxide, mineral acids, and salts of strong acids and weak bases. Iron and aluminum salts of mine and industrial origin fall into the last category. The analysis for acidity is carried out by neutralizing a given volume of the sample with a strong base of known concentration. At the Commission laboratory the test determines the total acidity of the water. Results of the test are reported in terms of ppm $CaCO_3$ as this provides an estimate of the lime application which may be required to make water supplies satisfactory for general use and protect watercourses from acidic wastes.

Water which is high in acidity becomes aggressive and may result in corrosion problems as well as being unfavourable for most biological life.

Alkalinity is usually imparted to water by the bicarbonate, carbonate, and hydroxide components contained in it. The degree of alkalinity is determined by titration with a standard solution of a strong mineral acid. Values given in this report represent total alkalinity although procedures can be followed to determine the alkalinity resulting from the individual components given above.

If waters contain a high degree of caustic (hydroxyl) alkalinity, the pH of such waters become high, and an unfavourable environment for biological life will result.

A highly alkaline water which contains ammonia may also result in toxic conditions being formed.

pH:

The pH is an index of the acidity or alkalinity of the solution as represented by the instantaneous hydrogen ion concentration. The practical pH scale extends from 0, very acid, to 14, very alkaline, with the middle value of pH 7 corresponding to exact neutrality (at 25° C.).
The Commission objectives indicate that no material should be discharged to a water course if it has a pH lower than 5.5 or higher than 9.5 or if the pH becomes lower than 5.5 or higher than 9.5 on dilution.
The pH meter used in the laboratory was a radiometer made in Denmark. Field pH's were determined with a Beckman portable pH meter.

Turbidity:

Turbidity is an optical measure of the fine suspended solids, such as silt and finely divided organic matter, in water. Where suspended solids values approach 20 ppm or less, the results are usually reported as turbidity in silica or Jackson units. High turbidity levels in watercourses interfere with light penetration and hence will affect photosynthetic reactions and the biological life cycle.

Phenols:

Phenol and phenolic equivalents are reported in ppb (parts per billion) and those values included in this report were measured.

by the Gibbs method with modifications.

Phenolic compounds are present in the waste flows from many industrial processes. Dependent on the concentration, the presence of these materials may be toxic to fish or may taint the flesh of fish. Phenols in very minute concentrations will combine with chlorine to produce intense tastes and odours in water.

As an objective, the concentration of phenols or phenol equivalents should not exceed 5 ppb at any point in receiving waters subsequent to initial dilution.

Ether Solubles:

Ether solubles may contain grease, fat, oil or other material soluble in ether and should not exceed 15 ppm in a discharge. Such material if present in a waste discharge will affect the aesthetic qualities of a receiving stream and may result in taste, odours and other problems.

Sulphates (SO_4):

The values of sulphate concentrations contained in this report were determined by gravimetric methods. Sulphates, if present in large quantities, may result in extreme hardness of the water or even the establishment of toxic conditions. Objectives of the Commission indicate that sulphate concentrations in a waste discharge should be maintained below 1,500 ppm.

Calcium:

Determinations for calcium in pulp and paper mill waste samples were made in order to help in the classification of the nature of suspended solids and to estimate chemical losses from the process. As analytical procedures used did not provide analyses for total calcium in each case the usefulness of the results in drawing conclusions is limited.

Sodium:

Determinations for sodium were made on pulp and paper mill wastes to assist in determining the magnitude of chemical loss from the process.

Lignin:

The analyses of samples for lignins as tannic acid was intended to indicate sources of non-cellular organic waste material. It is quite reasonable to assume that some of the taste and odor-producing substances are closely related to lignins as complex compounds.

Resin Acid Soaps:

Analyses for resin acid soaps were made to determine the efficiency of recovery of this highly toxic material.

C H A P T E R I I I

INTERNATIONAL NICKEL COMPANY

The International Nickel Company of Canada, Limited was organized as a subsidiary of the American corporation in 1916 to consolidate the mining interests within the Dominion, and in 1928, this company became the parent corporation. By the year 1963, the company had expanded its operations to where it operated five underground mines, one open pit, three mills, two smelters, a copper refinery, and an iron ore recovery plant in the District of Sudbury. The mines are: the Murray mine, Frood-Stobie mine, Garson mine, Creighton mine, Levack mine and Clarabelle Open Pit. A sixth mine, the Copper Cliff North Mine, was in the initial stage of development. The mills are located at Copper Cliff, Creighton and Levack and the smelters at Copper Cliff and Coniston. The copper refinery is also located in Copper Cliff and the Iron Ore Recovery plant is in Waters Township.

In the remainder of this chapter, each installation mentioned above is considered as a separate entity as far as possible. Topics discussed will include personnel, processes, operation, description of waste survey and sampling, results, conclusions and recommendations.

Information necessary for the preparation of this report and assistance in the survey was provided by the following personnel:

Mr. N. H. Kearns, Chief Engineer, Copper Cliff

Mr. A. D. Finlayson, Assistant Chief Draftsman, Copper Cliff

Mr. R. Snitch, Smelter Superintendent, Coniston

Mr. V. H. Ritzel, Mine Superintendent, Levack

Mr. J. C. Bischoff, Works Metallurgist, Copper Refining Division

Mr. W. Los, Mechanical Foreman, Clarabelle Open Pit

Mr. F. Pentney, Master Mechanic, Creighton

Mr. A. Simon, Mechanical Foreman, Frood-Stobie

Mr. R. Beach, Master Mechanic, Garson.

MURRAY MINE

Murray mine is situated in the City of Sudbury adjacent to the Chelmsford Highway. This ore body was first discovered in 1883.

PERSONNEL

Approximately 200 persons are employed at the mine which operates one shift per day, five days per week.

DESCRIPTION OF PROCESS

The production capacity of the mine is 6,000 tons of raw ore per day. The mine is serviced by one shaft, number 2 shaft. Operations at the mine site are confined to mining and crushing only, the ore being transported to Copper Cliff for further processing.

The surface plant is located at number 2 shaft and consists of a headframe, crushing plant, collarhouse, combined office and change-house, hoist and compressor building, warehouse, general shops, carpenter shop, heating plant, powder magazine and fuse house.

WATER SUPPLY

Water is drawn from Pump Lake, chlorinated, and pumped about one mile to a 160,000 gallon storage tank on the distribution system.

It is estimated that water is consumed at the rate of 380,000 US gpd. The greater portion of this water is utilized in the mine (about 217,000 US gpd) while 73,000 US gpd are used at the surface plant, 7,000 US gpd at the townsite and 82,000 US gpd flow to the storage tank and the overflow.

The use of a cooling pond on compressor cooling water greatly reduces the quantity of water necessary to support operations.

SOURCES OF WASTE

The most significant waste originating at the mine is mine water pumpage resulting from sand fill operations and infiltration. This waste is drained to sumps on the 1,650 and 3,000 foot levels and is pumped to the surface for disposal. The average discharge at the surface has been measured at 400,000 US gpd.

WASTE DISPOSAL

Mine water pumped to the surface is discharged to a swampy area which is a tributary to Nolin Creek, an upper tributary of Junction Creek. Sanitary wastes from the mine are collected and treated in a septic tank which discharges to the same swampy area.

SAMPLING PROGRAMME

Grab samples were taken of the mine water discharging from Murray mine on several occasions. The latest sampling programme consisted of taking grab samples on three consecutive days and recording the pH of the samples in the field. The samples were taken while mine pumps were in operation. An unfortunate accident resulted in the breaking of the sample taken on September 4, 1963.

ANALYTICAL RESULTS

ALL RESULTS GIVEN IN PPM (PARTS PER MILLION) EXCEPT PH, UNLESS OTHERWISE SPECIFIED

SOURCE	DATE	SOLIDS			PH IN	PH AT	ACIDITY AS	NICKEL AS	COPPER AS	IRON AS	TURBIDITY IN SILICA
		TOTAL	SUSP.	DISS.	FIELD	LAB.	$CaCO_3$	NI	CU	FE	UNITS
MURRAY MINE MINE WATER DISCHARGE	6/11/63	1,754	56	1,698	--	4.2	180	52.0	0.74	39.0	65.0
	9/3/63	1,884	84	1,800	3.8	3.4	—	65.0	2.7	49.0	---
	9/4/63	B R O K E N			4.1				3.3		
	9/5/63	2,004	67	1,937	3.7	3.6	---	74	3.2	57.5	—

DISCUSSION OF RESULTS

Sample results indicate that the mine wastes contain consistently high concentrations of nickel, iron and suspended solids as well as exhibiting a low pH. The copper concentration also reaches levels which are likely to prove deleterious and inhibit the natural function of watercourses.

The high nickel concentration and low pH appear to be the most significant characteristics of the waste.

CONCLUSIONS AND RECOMMENDATIONS

The company should endeavour to raise the pH of the waste stream by neutralization to the point where it meets with OWRC objectives. Copper, nickel and suspended solids concentrations should also be reduced to an acceptable level before discharge. Both recommendations may be realized if the proper neutralizing agent is used and neutralization is followed by sedimentation.

FROOD-STOBIE MINE

The Frood-Stobie mine lies entirely within the northern limits of the City of Sudbury. Both the Frood and Stobie ore bodies were discovered in the late 1800's. The mine is served by three shafts numbered 3, 7 and 8. The mine production as well as all supplies and men employed underground, are handled through the three shafts.

PERSONNEL

Approximately 2,300 men are employed in the mine, in the production of ores for feed to the Copper Cliff mill.

DESCRIPTION OF PROCESS

The Frood-Stobie mine formerly consisted of both open pit and underground mining; however, open pit operations have recently ceased. Operations at the mine site entail mining and crushing of ore for processing at Copper Cliff. The daily capacity is 7,000 tons from the Frood section and 14,000 tons from the Stobie section. The ore receives primary crushing underground and is hoisted to surface in number 3, number 7 and number 8 shafts. The ore then receives secondary crushing on the surface and is hauled by rail to Copper Cliff for further processing.

The surface plant comprises 30 acres of buildings, railway yards and material storage areas grouped about number 3 shaft, and in addition, the plant at number 7 and number 8 shafts which covers 10 acres. The mine buildings at number 3 shaft include the headframe, sorting plant, office and changehouse, hoist and compressor building, collarhouse and warm room and heating plant, all of which service the Frood section of the mine, as well as the shops building, carpenter shop, framing shop, bit shop, warehouse, cap and fuse house and powder magazine which serve both the Frood and Stobie sections. The buildings at number 7 and number 8 shafts which serve the Stobie section are the two headframes, the collarhouses, crushing plant, office and changehouse, bin house and hoist and compressor building.

WATER SUPPLY

The water supply is obtained from Whitson Lake which is located due north of the mine. It is estimated that about 1,200,000 US gpd are pumped to the mine, about 500,000 gpd of which is delivered to the Stobie section. The surface plant consumes 150,000 gpd and the remaining 350,000 gpd are used in the mine. In the Frood section of the mine, approximately 700,000 gpd are consumed. About 300,000 gpd are used in the mine, the surface plant uses approximately 180,000 gpd and the Town of Frood consumes 20,000 gpd. Approximately 200,000 gpd overflow to waste. Mine water is recycled and pumped to the sand fill plant for pulping of tailings.

The use of cooling ponds on compressor cooling water results in a substantial reduction in water consumption.

SOURCES OF WASTE

Since the operations of the Frood-Stobie mine are confined to the production of crushed ore, the principle waste is mine water pumped from the mine. This waste includes water resulting from sand fill operations and infiltration. The water is collected and conducted to sumps located at various levels and is pumped in stages to the surface for ultimate disposal.

Pumpage from the Frood and Stobie sections to waste has been estimated at 1,030,000 US gpd and 1,340,000 US gpd respectively after some of it has been recycled for use in the tailings sand fill operations.

WASTE DISPOSAL

Mine water pumped from the Frood mine is discharged to Junction Creek, while water pumped from Stobie mine is discharged to a stream which is a tributary to Junction Creek.

SAMPLING PROGRAMME

The mine waters from the Frood-Stobie mine were sampled on several occasions. Grab samples were obtained in December 1960, June 1963, and on three consecutive days in September 1963. The pH of samples obtained in September 1963 was checked in the field as well as in the laboratory.

ANALYTICAL RESULTS

FROOD MINE:

ALL RESULTS QUOTED IN PPM (PARTS PER MILLION), EXCEPT PH, UNLESS OTHERWISE SPECIFIED

SOURCE	DATE	BOD	SOLIDS TOTAL	SOLIDS SUSP.	SOLIDS DISS.	PH IN FIELD	PH IN LAB.	ACIDITY AS $CACO_3$	NICKEL AS NI	COPPER AS CU	IRON AS FE
FROOD	12/14/60	5	3,550	182	3,368	-	4.6	446	126	18.7	94
MINE--	6/11/63	-	2,992	114	2,878	-	4.7	172	56	1.7	60
MINE	9/ 3/63	-	1,954	49	1,905	6.4	6.2	-	24	1.4	9.5
WATER	9/ 4/63	-	2,950	184	2,766	4.8	3.2	-	52	3.3	59
DISCHARGE	9/ 5/63	-	3,548	244	3,304	5.1	4.4	-	60	3.9	71

STOBIE MINE:

ALL RESULTS QUOTED IN PPM (PARTS PER MILLION), EXCEPT PH, UNLESS OTHERWISE SPECIFIED

SOURCE	DATE	BOD	SOLIDS TOTAL	SOLIDS SUSP.	SOLIDS DISS.	PH IN FIELD	PH IN LAB.	ACIDITY AS $CACO_3$	NICKEL AS NI	COPPER AS CU	IRON AS FE
STOBIE	12/14/60	17	3,220	1,588	1,632	-	4.5	276	177	8.0	440
MINE--	6/11/63*	-	138	19	119	-	4.7	16	TR.	0.43	2.9
MINE	9/ 3/63	-	2,930	546	2,387	6.3	4.6	-	56	3.0	71.0
WATER	9/ 4/63	-	2,754	320	2,434	6.3	5.7	-	53	1.9	41.0
DISCHARGE	9/ 5/63	-	2,494	230	2,264	6.3	5.8	-	38	1.9	40.0

* MINE PUMPS NOT PUMPING AT TIME OF SAMPLING.

DISCUSSION OF RESULTS

Sample results indicate that the mine water from the Frood-Stobie mine is of poor quality and should not be discharged to an open watercourse without prior treatment. The pH of the wastes does not meet the objectives of the Commission and the suspended solids concentrations are very much higher than is generally acceptable. The difference between the pH in the field and the pH at the laboratory suggests that hydrolysis of compounds present occurs after discharge and hence, the quality of the receiving water will possibly deteriorate even after initial dilution due to a depression of the pH. High concentrations of nickel and copper render the wastes toxic to biological life.

CONCLUSIONS AND RECOMMENDATIONS

Wastes from the Frood-Stobie mine should be treated to reduce the concentrations of suspended solids, nickel, copper and iron and to raise the pH before they are discharged to Junction Creek. Treatment possibilities include neutralization of acidity, accompanied by the precipitation of the metallic components, and followed by sedimentation of the precipitated material and suspended solids.

GARSON MINE

The Garson mine is situated just north of the townsite of Garson, eight miles northwest of the City of Sudbury. The ore body at Garson mine was first discovered in 1891.

PERSONNEL

Approximately 900 persons are employed in surface and underground operations at the Garson mine.

DESCRIPTION OF PROCESS

Operations at the mine are confined to mining and crushing, and the mine production capacity is 4,500 tons of raw ore per day. The mine is serviced by one shaft, number 2 shaft. Ore is crushed at the 2,000 and 3,000 foot levels and is hoisted to the surface. At the surface it is sorted into two main products - a direct smelting product and a milling product. All ore is hauled by train to Copper Cliff or Coniston for further processing.

Surface plant facilities consist of a headframe, sorting plant, hoist and compressor building, collarhouse, warehouse, office and changehouse, general shops building, carpenter shop, heating plant, fuse house and powder magazines.

WATER SUPPLY

Water, obtained from a drilled well, is chlorinated and discharged to a 100,000 gallon storage tank.

It has been estimated that about 400,000 US gpd are pumped. This is distributed to the mine (115,000 US gpd), the surface plant

(57,000 US gpd), the Company townsite (43,000 US gpd) and the remainder overflows from the storage tank into a cooling pond. Water is pumped from the cooling pond to be used as compressor cooling water and is then returned to the pond.

SOURCES OF WASTE

The major source of waste is mine water consisting of seepage and water used underground for drilling and other purposes. This waste is collected in sumps adjacent to number 2 shaft on the 1,000, 2,000, 3,000 and 4,000 foot levels. The waste is pumped from these sumps, in four stages, to the surface for final disposal. Measurement of mine water pumped from underground indicates a discharge of 400,000 US gpd.

Any overflow from the cooling pond discharges into Junction Creek.

WASTE DISPOSAL

All mine water pumpage and any excess water from the cooling pond is discharged to Junction Creek, north of the Garson Townsite.

SAMPLING PROGRAMME

The mine water discharge from Garson mine was sampled in 1960 and 1963. Grab samples were taken on December 14, 1960, June 17, 1963 and September 4, 5, and 6, 1963.

ANALYTICAL RESULTS

ALL RESULTS QUOTED IN PPM (PARTS PER MILLION), EXCEPT PH

			SOLIDS			PH	PH	ACIDITY	NICKEL	COPPER	IRON
SOURCE	DATE	BOD	TOTAL	SUSP.	DISS.	IN FIELD	IN LAB.	AS $CACO_3$	AS NI	AS CU	AS FE
GARSON	12/14/60	12	2,876	120	2,756	--	6.7	22	114	15.6	6.6
MINE--	6/17/63	1.8	2,350	--	--	--	--	--	47	4.1	0.55
MINE	9/ 4/63	--	2,634	56	2,578	6.3	6.1	--	78	7.8	6.0
WATER	9/ 5/63	--	228	52	176	--	6.9	34	58	1.3	4.7
DISCHARGE	9/ 6/63	--	2,258	40	2,218	--	6.9	38	43	0.7	4.4

DISCUSSION OF RESULTS

Sample results indicate that the mine water discharge from Garson mine contains a high level of copper and nickel. Suspended solids are also present in concentrations higher than what is usually acceptable. The pH of the mine water is higher than what has generally been found for similar mine wastes in the area and is in a range acceptable for discharge to a watercourse.

CONCLUSIONS AND RECOMMENDATIONS

The mine water pumpage from Garson mine should be treated to reduce the level of contamination due to copper and nickel before being discharged to Junction Creek. This treatment should be accompanied by sedimentation to remove suspended solids prior to discharge.

CLARABELLE OPEN PIT AND COPPER CLIFF NORTH MINE

The Clarabelle Open Pit is located in Snider Township just outside the west boundary of the City of Sudbury. The sinking of a shaft and initial stages of development at the Copper Cliff North Mine, which is located just inside the City of Sudbury, are being carried on in conjunction with operations at the Clarabelle Open Pit.

PERSONNEL

Employment is provided for approximately 350 persons at the open pit and mine.

DESCRIPTION OF PROCESS

Operations at the site presently consist of open pit mining of the Clarabelle Open Pit and the initial development of Copper Cliff North Mine. Ore from the open pit is crushed at the surface plant of the mine and is sent to Copper Cliff for further processing. The present capacity of the open pit is 7,000 tons of raw ore per day.

WATER SUPPLY

Water necessary to support operations at the Clarabelle Open Pit and at Copper Cliff North Mine is drawn from Lady Macdonald Lake. Present requirements are 720,000 US gpd.

SOURCES OF WASTE

The principle waste originating at the pit and mine is mine water consisting of water from infiltration and water used in operations such as drilling. The mine water pumpage is presently in the range of 20,000 US gpd, and it is expected that this will increase as development work progresses.

Also being discharged from the mine is a compressor cooling water flow of 288,000 US gpd.

WASTE DISPOSAL

Both mine water pumpage and compressor cooling water are discharged to a tributary of Copper Cliff Creek.

SAMPLING PROGRAMME

The mine water discharge and spent compressor cooling water from Copper Cliff North Mine were sampled. Both streams were sampled on three consecutive days in September 1963 and the mine water was also sampled on June 7, 1963. Although the two streams join together before discharging to Copper Cliff Creek it was not possible to find a suitable sampling point to sample the combined stream. The only feasible point was in a sump but at the time of sampling the contents of the sump were covered with a layer of oil.

ANALYTICAL RESULTS

ALL RESULTS QUOTED IN PPM (PARTS PER MILLION), EXCEPT PH

SOURCE	DATE	SOLIDS TOTAL	SOLIDS SUSP.	SOLIDS DISS.	PH IN FIELD	PH IN LAB.	NICKEL AS NI	COPPER AS CU	IRON AS FE
COPPER CLIFF MINE WATER DISCHARGE	6/7/63	608	67	541	-	7.5	3.7	1.0	2.98
	9/3/63	1,308	5	1,303	7.8	7.7	0	0	0.18
	9/4/63	1,206	6	1,200	7.9	7.9	0	0	0.22
	9/5/63	1,268	5	1,263	7.6	7.9	2.0	0	0.22
COMPRESSOR COOLING WATER DISCHARGE	9/3/63	354	37	317	4.5	4.7	4.2	0.80	2.60
	9/4/63	362	2	360	4.4	4.5	4.0	0.78	0.35
	9/5/63	274	2	272	4.4	4.6	3.8	0.84	0.48

DISCUSSION OF RESULTS

The analytical results of samples of the mine water discharge indicate that this waste is not objectionable. However, since the mine is only under development, these results do not indicate the conditions which will exist when the mine is under normal operation. Results obtained on compressor cooling water show a low pH and an appreciable content of copper and nickel. As it is assumed that the mine operates on one water supply, it is not possible to explain these results at this time.

CONCLUSIONS AND RECOMMENDATIONS

The pH of discharges from the mine should be controlled between 5.5 and 9.5. Present results indicate the mine water discharge is of good quality. Provisions should be made to maintain this quality when the mine is in full production. The oil in the main collection sump should be removed and steps should be taken to prevent a future build up of oil in the sump. It is conceivable that if the level of oil became great enough it would be pumped from the sump to Copper Cliff Creek.

CREIGHTON MINE & MILL

Creighton mine is situated about 11 miles west of the City of Sudbury in the townships of Snider and Creighton. Prospecting in the late 1800's indicated that the area in which this mine is located was rich in mineral wealth. The Creighton mill is located at No. 7 shaft of Creighton mine. It was placed in operation in 1951 and since that time has operated continuously.

PERSONNEL

Approximately 1,800 persons are employed at Creighton mine and mill in surface plant and underground operations.

DESCRIPTION OF PROCESS

The surface plants at Creighton mine consist of the yards and buildings, including offices, warehouse, general shops, changehouses, headframes, sorting plants, collarhouses and heating plants.

There are three shafts at the mine. Shafts No. 5 and No. 7 are the main ore hoisting shafts, while all men and supplies employed underground are handled through No. 3 and No. 5 shafts. The capacity of No. 5 shaft is 3,500 tons of raw ore per day, while that of No. 7 is 14,000 tons per day.

The mined ore is crushed at crushing stations located underground and is then hoisted to the surface for further crushing and sorting. The ore is then stored in bins, to await further processing at the Creighton Mill, or shipment by rail to Copper Cliff or Coniston.

The mill has a capacity to process 12,000 tons of raw ore per day. Four grinding units, each consisting of a rod mill, a ball mill, and a classifier, produce a final feed for the flotation cells. One flotation circuit is operated for ores from No. 5 and No. 7 shafts. This is a straight recovery circuit which yields a bulk copper-nickel-iron sulphide product.

Reagents used include potassium pentasol xanthate, copper sulphate, pine oil and sodium silicate. All reagents are added in the liquid state. Clean-up wastes from the reagent feeder floor and storage rooms are pumped to the tailings sump.

The bulk sulphides produced by flotation are laundered to a sump and pumped to the Copper Cliff mill as feed to the smelter.

Tailings from the flotation cells are laundered to a central sump and pumped to a three-way distributor ahead of classifiers. Approximately 15 per cent of the total flotation tailings are recovered in the classifier underflow as rake-sand acceptable for mine fill. The classifier overflow is returned to the final tailings sump for disposal to the central tailings disposal area.

When the sand fill plant is not operating the total tailings flow is discharged to the tailings disposal area.

WATER SUPPLY

Water is obtained from Meatbird Lake and the Vermilion River for use in the town, mine and mill. There are two systems supplying water from the Vermilion River and one from Meatbird Lake. The three systems are all interconnected and chlorination of the water supply is practised.

Pumpage from Meatbird Lake amounts to 1,150,000 US gpd. The 525,000 US gpd used at the mine is provided entirely by this supply. The Vermilion Number 1 supply is normally used to supply the mill. This supply furnishes 4,460,000 US gpd, of which 43,000 US gpd are used for domestic purposes and the remainder is used as process water. The second Vermilion River source is used to supply the town of Copper Cliff and the plants in that area.

SOURCES OF WASTE

The major waste associated with the operation of Creighton mine is mine water pumpage which includes water due to infiltration and water used underground for drilling and other purposes. These wastes are collected in four major drainage areas and are conducted to sumps from which they are pumped to the surface in a number of stages. The volume of waste thus removed from the mine has been estimated at 735,000 US gpd.

The principle waste associated with the Creighton mill is flotation tailings. Tailings from the mill are discharged to a main collection sump following partial recovery of rake-sand for mine fill. Other miscellaneous mill wastes are also collected in the tailings sump. The volume of these wastes is approximately 2,620,000 US gpd.

WASTE DISPOSAL

Wastes pumped from the mine are discharged to Mud Lake via an open channel. Mud Lake is located to the east of the mine.

The hydraulically transported tailings are pumped from the main collection sump in the mill to one of two tailings disposal areas. Approximately one-half of the waste stream is discharged to a central tailings disposal area located to the west of Copper Cliff, while the other half is discharged to a new tailings area located between the latter tailings area and Creighton. The decanted effluent from both of these areas discharge to Copper Cliff creek and thence to Kelly Lake.

SAMPLING PROGRAMME

Grab samples of the Creighton mine, mine water discharge were taken on December 15, 1960, June 11, 1963 and September 3, 4 and 5, 1963.

Both tailings basins receiving waste discharges from the Creighton concentrator were sampled on three consecutive days in September 1963.

All samples taken were grab samples and pH determinations were made in the field as well as in the laboratory on samples taken in September 1963.

ANALYTICAL RESULTS

CREIGHTON MINE:

ALL RESULTS QUOTED IN PPM (PARTS PER MILLION), EXCEPT PH, UNLESS OTHERWISE SPECIFIED

SOURCE	DATE	BOD	SOLIDS TOTAL	SOLIDS SUSP.	SOLIDS DISS.	PH IN FIELD	PH IN LAB.	ACIDITY AS $CACO_3$	NICKEL AS NI	COPPER AS CU	IRON AS FE
CREIGHTON	12/15/60	14	2,728	78	2,650	-	4.5	194	190	3.8	1,014.
MINE--	6/11/63	-	2,582	78	2,504	-	4.7	328	124	3.6	11.0
MINE	9/ 3/63	-	2,710	101	2,609	4.1	4.1	-	132	15.2	11.2
WATER	9/ 4/63	-	2,544	45	2,499	4.4	4.1	-	78	3.1	20.5
DISCHARGE	9/ 5/63	-	2,588	41	2,547	4.6	4.0	-	76	3.2	23.5

CREIGHTON MILL:

ALL RESULTS QUOTED IN PPM (PARTS PER MILLION), EXCEPT PH

SOURCE	DATE	SOLIDS TOTAL	SOLIDS SUSP.	SOLIDS DISS.	PH IN FIELD	PH IN LAB.	NICKEL AS NI	COPPER AS CU	IRON AS FE	ALKALINITY AS $CACO_3$
CENTRAL (OLD)	6/7/63	1,568	80	1,488	-	6.4	3.3	0.42	3.26	-
TAILINGS	9/4/63	44	16	28	8.0	7.6	TR.	0.41	0.80	-
DISPOSAL	9/5/63	72	13	59	7.9	7.8	TR.	0.41	0.62	-
AREA EFFLUENT	9/6/63	2,190	11	2,179	-	7.9	1.7	0.2	0.40	66
NEW TAILINGS	9/4/63	B R O	K E	N	6.7					
DISPOSAL AREA	9/5/63	836	20	816	6.8	6.9	0.0	0.18	1.00	-
EFFLUENT	9/6/63	926	20	906	-	7.2	0.0	0.0	1.30	14

DISCUSSION OF RESULTS

Analytical results indicate that the mine water discharge from Creighton mine contains a high degree of impurities and exhibits a low pH. Concentrations of suspended solids, copper, nickel, and iron are all higher than the levels acceptable for discharge to an open watercourse. The pH of the discharge is also lower than specified in the Commission objectives for discharge to an open watercourse.

As discussed under the section entitled Copper Cliff Concentrator, sample results indicate that the old tailings area appears to be operating efficiently and is producing an effluent of good quality. Results of samples from the new tailings area effluent also indicate the discharge is of good quality. The pH is in an acceptable range as is the suspended solids and metal concentrations.

CONCLUSIONS AND RECOMMENDATIONS

The mine water pumpage from Creighton mine should receive treatment to raise the pH and reduce the concentration of suspended solids, copper, nickel, and iron before it is discharged to Mud Lake. This treatment may take the form of neutralization and precipitation followed by sedimentation.

Disposal of wastes from the Creighton concentrator is carried out in a satisfactory manner. However, care should be taken to maintain disposal sites in a state of good repair. A necessary step in this direction is the establishment of routine inspections of dykes surrounding disposal areas.

The degree of influence of wind conditions on the amount of carry-over of suspended solids should also be established. If it is discovered that high winds greatly affect the efficiency of the tailings settling basins, then attempts should be made to control the effluent during unfavourable conditions.

LEVACK MINE & MILL

The Levack mine and mill is located in Levack Township 30 miles northwest of the City of Sudbury. The ore body at Levack was first discovered in 1889 and production was started in 1914.

PERSONNEL

The Levack mine and mill presently provide employment for approximately 1700 persons.

DESCRIPTION OF PROCESS

Operations at the mine include mining, crushing, hoisting and sorting of ore for further processing. The ore is sorted into two products: direct smelting ore and milling ore. The capacity of the mine is 6,500 tons of raw ore per day.

The mine is served by one shaft, No. 2 shaft, which is the main hoisting and supply shaft.

The surface plant covers 20 acres and includes buildings, railway yards and material storage areas grouped mainly around No. 2 shaft. The main buildings consist of the headframe, sorting plant, collarhouse, hoist and compressor building, office and changehouse, general shops, warehouse and heating plant.

The mill at Levack has the capacity to process 6,000 tons of crude ore per day. Operations in the mill are similar to those in the Copper Cliff and Creighton mills. The principle use of water in the plant is to hydraulically transport ground ore and tailings and to conduct wet processing of the ore.

WATER SUPPLY

Water necessary to support operations at Levack mine and mill is drawn from three drilled wells and Clear Lake in the vicinity of Levack. It is estimated that the Clear Lake supply provides about 100,000 US gpd for the town, the mine and the mine surface plant, and the remainder is supplied by Nos. 1 and 2 wells. The town consumes 206,000 US gpd, the surface plant 86,000 US gpd and the mine 160,000 US gpd.

The flow from No. 3 well is used almost exclusively in the mill. Mill consumption is presently in the range of 750,000 US gpd.

The use of cooling ponds on compressor cooling water results in a substantial decrease in water consumption.

SOURCES OF WASTE

The major waste associated with Levack mine is mine water pumpage consisting of water which has infiltrated the mine, water used in sand fill operations, and water used for underground drilling and other purposes. The volume of this waste pumped from the mine has been estimated at 575,000 US gpd.

These wastes are collected and drained to sumps at No. 2 shaft and are pumped in stages to the surface for final disposal.

The major wastes from the Levack Mill are hydraulically transported tailings. The tailings, after partial recovery of rake-sand for mine fill, are discharged in a flow of approximately 300,000 US gpd.

WASTE DISPOSAL

All mine water waste pumped from Levack mine is discharged to Moose Creek and thence to the Onaping River.

Tailings from the mill are discharged to Grassy Lake via pipeline. The decanted effluent then discharges to Grassy Creek and thence to Moose Creek and the Onaping River.

SAMPLING PROGRAMME

The mine water discharge from Levack mine and the discharge from the Levack tailings disposal area were sampled on three consecutive days in September 1963. Samples taken were grab samples and pH's of the samples were recorded in the field as well as in the laboratory.

ANALYTICAL RESULTS

LEVACK MINE:

ALL RESULTS QUOTED IN PPM (PARTS PER MILLION), EXCEPT PH

SOURCE	DATE	SOLIDS TOTAL	SOLIDS SUSP.	SOLIDS DISS.	PH IN FIELD	PH IN LAB.	ACIDITY AS $CACO_3$	NICKEL AS NI	COPPER AS CU	IRON AS FE
LEVACK MINE MINE WATER DISCHARGE	9/11/63	3,026	144	2,982	4.8	4.5	200	61	3.3	0.15
	9/12/63	3,436	219	3,217	3.8	4.0	384	110	7.1	0.15
	9/13/63	3,040	204	2,836	3.8	3.9	284	66	4.0	0.03

LEVACK MILL:

ALL RESULTS QUOTED IN PPM (PARTS PER MILLION), EXCEPT PH

SOURCE	DATE	SOLIDS TOTAL	SOLIDS SUSP.	SOLIDS DISS.	PH IN FIELD	PH AT LAB.	NICKEL AS NI	COPPER AS CU	IRON AS FE	ACIDITY AS $CACO_3$
LEVACK TAILINGS DISPOSAL AREA EFFLUENT	9/11/63	1,622	19	1,603	3.5	3.4	0	0.3	2.05	112
	9/12/63**	1,648	72	1,576	4.5	3.5	0	0.4	13.0	76
	9/13/63	1,402	9	1,393	4.3	3.8	0	0.3	2.42	72

** WINDY DAY

DISCUSSION OF RESULTS

Analytical results show that mine water from Levack mine contains high concentrations of suspended solids, nickel, and copper. As well as having the above objectionable qualities the waste is quite acidic and exhibits a low pH.

Results also indicate that the quality of the effluent from the tailings disposal area depends somewhat on weather conditions. For example, under windy conditions, the concentrations of suspended solids and iron in the effluent are much higher than is normally experienced. When the winds are calmer only moderate amounts of suspended solids and iron are discharged in the supernatant.

Regardless of weather conditions the tailings disposal area waste discharge has a pH lower than the minimum acceptable pH for discharge to an open watercourse. Other conditions of the effluent appear to be satisfactory under normal operating conditions.

CONCLUSIONS AND RECOMMENDATIONS

Waste water from Levack mine should be treated to reduce the copper, nickel, and suspended solids concentrations and increase the pH before it is discharged to Moose Creek. Treatment possibilities include neutralization of acidity, accompanied by precipitation of the metallic components, and followed by sedimentation of the precipitated material and suspended solids.

Procedures used in disposing of tailings from the Levack concentrator are generally satisfactory. However, the decanted effluent from the tailings disposal area which is discharged to Grassy Creek is acidic in nature and exhibits a low pH. This condition should be rectified by neutralizing the discharge before it is permitted to enter an open watercourse.

Sampling indicated that high winds adversely affect the operation of the tailings ponds. Further work should be done by the company to determine the degree by which efficiency of the settling basins is reduced by high winds. The possibility of controlling the effluent during periods of adverse weather conditions should also be investigated.

COPPER CLIFF MILL

The operations of the International Nickel Company of Canada, Limited in the Town of Copper Cliff form a large part of the vast operations of the company in the Sudbury District. Production facilities include the Copper Cliff mill which handles ore from all mines but Levack. The mill was first placed in operation in 1930 and operations were expanded in the years 1936, 1940 and 1942.

PERSONNEL

Approximately 4,000 persons are employed at the Copper Cliff mill and smelter which operate continuously.

DESCRIPTION OF PROCESS

The present Copper Cliff mill facilities, used for the production of feed to the smelter, have the capacity to process 28,500 tons of ore per day. The operation of the mill involves the grinding of ore to a finely divided size, treating of the ground ore in flotation cells for the recovery and separation of sulphide minerals and production of disposable waste. The copper and nickel sulphide fractions are filtered and stored for feed to the smelter.

The initial large-scale use of water in the process is to transport the ore from storage bins to the grinding mills where wet grinding is used to provide a suitable feed for subsequent flotation and magnetic separation.

The flotation section provides the first separation of metallic sulphides from rock tailings, by floating the sulphides to the surface of the cells. The sulphides adhere to finely divided air bubbles that are introduced at the bottom of the cells. Tailings from the bottom of the cells are passed through scavenger cells for final recovery of copper-nickel sulphides. Chemicals used in the flotation process include lime, to maintain the alkalinity of the pulp, potassium pentasol xanthate as the collector, and pine oil as the frother. Sodium silicate is added to maintain pulp dispersion.

WATER SUPPLY

Water is obtained from three sources. The main potable supply for Copper Cliff, as well as domestic and some process requirements for the mill, smelter and Copper Cliff Refinery is obtained from the Vermilion River No. 2 supply, mentioned in the discussion of Creighton mine. Process and cooling water requirements are met by a supply from Kelly Lake. Lady MacDonald Lake functions as a stand-by supply.

Water drawn from the Vermilion River No. 2 system is pumped to a 1,000,000 US gallon standpipe and from here is distributed to the town, mill and smelter. Approximately 115,000 US gpd of this supply are used for domestic purposes and 43,000 US gpd are used in the mill for cooling purposes.

Kelly Lake supplies approximately 6,340,000 US gpd, of which 6,120,000 US gpd are used as process water and the remaining 220,000 gallons as cooling water.

SOURCES OF WASTES

The major wastes from the mill are hydraulically transported tailings. Tailings from the mill are pumped to five circular thickeners. The overflow from these tailings thickeners is discharged to the storage reservoir located north of the mill for reuse in the plant area. The underflow constitutes the actual waste stream which is discharged to a tailings disposal area. It is estimated that approximately 22,000 tons of tailings are discharged daily in a flow of approximately 3,700,000 US gallons of water.

WASTE DISPOSAL

The waste stream consisting of hydraulically transported tailings is discharged to a central tailings disposal area located to the west of Copper Cliff. The decanted effluent from this area is discharged to Copper Cliff Creek and thence to Kelly Lake.

Present plans indicate that in about one year the tailings waste stream from the mill will be discharged to a new tailings area located between the basin they now discharge to and the site of the Creighton mine.

SAMPLING PROGRAMME

Grab samples of the decanted effluent from the central tailings disposal area were taken on several occasions. Samples were obtained on June 7, 1963 and September 4, 5 and 6, 1963. Samples taken in September had the pH checked both in the field and in the laboratory.

ANALYTICAL RESULTS

ALL RESULTS QUOTED IN PPM (PARTS PER MILLION), EXCEPT PH

SOURCE	DATE	SOLIDS TOTAL	SOLIDS SUSP.	SOLIDS DISS.	PH IN FIELD	PH IN LAB.	NICKEL AS NI	COPPER AS CU	IRON AS FE	ALKALINITY AS $CACO_3$
CENTRAL (OLD) TAILINGS DISPOSAL AREA EFFLUENT	6/7/63	1,568	80	1,488	-	6.4	3.3	0.42	3.26	-
	9/4/63	44	16	28	8.0	7.6	TR.	0.41	0.80	-
	9/5/63	72	13	59	7.9	7.8	TR.	0.41	0.62	-
	9/6/63	2,190	11	2,179	-	7.9	1.7	0.2	0.40	66

DISCUSSION OF RESULTS

The results of samples of the tailings area effluent are quite favourable. Only a minimal amount of solids are present in the effluent and the pH is in an acceptable range. The metal concentrations are low and on dilution should not present a pollution problem.

CONCLUSIONS AND RECOMMENDATIONS

The effluent from the central (old) tailings disposal area appears to be of an acceptable quality for discharge to an open watercourse. The company should endeavour to maintain this quality and establish a programme of regular dyke inspection to insure that the disposal area is maintained in a state of good repair.

In other investigations of tailings disposal sites in the area, it was discovered that wind conditions greatly affect the efficiency of operation. As it was a calm day at the time of sampling, it is suggested that the company determine what effects high winds have on the operation of this basin. If, as is suspected, high wind conditions result in a heavy carry-over of suspended solids, the company should investigate the possibilities of controlling the discharge during adverse weather conditions.

COPPER CLIFF SMELTER

The Copper Cliff smelter is located in the town of Copper Cliff on the same site as the mill. The smelter feed is supplied by all of the INCO mills in the District of Sudbury.

PERSONNEL

Employment is provided for approximately 4,000 persons in the Copper Cliff mill and smelter.

DESCRIPTION OF PROCESS

The Copper Cliff smelter consists of two main circuits, as follows:

a) A nickel circuit which receives feed containing both copper and nickel sulphides for the production of copper-nickel matte called Bessemer matte and the subsequent treatment of the Bessemer matte to produce nickel oxide sinter and blister copper.

b) A copper circuit for the treatment of a predominantly chalcopyrite feed (low in nickel), for the production of blister copper.

In the nickel circuit sand and quartzite fluxes are added to the feed which is first roasted in Nichols-Herreschoff roasters, prior to charging to reverberatory furnaces. A waste slag is taken from the latter furnaces as well as a copper nickel matte. The matte is transported to the converter building where it is further treated along with more fluxing material to produce copper-nickel Bessemer matte. This matte is then cast in moulds, slowly cooled, crushed, ground and treated in a flotation process to separate the nickel and copper sulphides.

The nickel sulphide is then treated in a fluid bed roasting process to produce nickel oxide sinter. The copper sulphide is melted in an electric furnace and transported to the Copper Cliff copper refinery in hot metal cars.

In the copper circuit, high copper sulphide from the mills is melted in an oxygen furnace along with a sand flux. A waste slag is poured off of the furnace and the copper matte is treated in Pierce-Smith type converters after more fluxing material has been added. This final step results in the production of blister copper which is electrolytically refined in the Copper Cliff copper refinery.

Water is used throughout the smelting process primarily for cooling purposes. Some water is used for the scrubbing of flue gases.

WATER SUPPLY

Water necessary to support the operation of the smelter is obtained from two sources. The second Vermilion River supply system, used to fulfill most of the water requirements of the Copper Cliff mill, furnishes 1,150,000 US gpd and a Kelly Lake supply furnishes 1,100,000 US gpd.

The Vermilion River supply is distributed in the smelter as follows: water for domestic purposes - 360,000 US gpd, cooling water - 576,000 US gpd, boiler water - 158,000 US gpd, and miscellaneous uses - 56,000 US gpd. Approximately 580,000 US gpd of the Kelly Lake supply are used for cooling water, and 520,000 US gpd for process water.

SOURCES OF WASTE

Wastes from the Copper Cliff smelter consist almost entirely of spent cooling water. Other wastes include water used in flue gas scrubbing and clean-up operations. These wastes discharge into a storm sewer. The flow in this sewer has been estimated at 2,020,000 US gpd.

WASTE DISPOSAL

The wastes from the smelter are discharged to Copper Cliff Creek which in turn discharges to Kelly Lake.

SAMPLING PROGRAMME

Grab samples of the Copper Cliff smelter effluent were obtained on September 28, 1960, June 3, 1963, and June 7, 1963. On September 4, 1963, the effluent was sampled over an eight hour period. Samples were taken at 30 minute intervals and composited to form four samples, each representing two hours of flow. The pH of each portion was determined and recorded. During the process of sampling it was noted that the waste was particularly coloured about 2:15 p.m. and a grab sample was obtained to determine the cause of the discolouration.

All samples were obtained at the outlet of the main sewer located just west of the hot car tracks near the parking lot used by shift employees.

ANALYTICAL RESULTS

ALL RESULTS QUOTED IN PPM (PARTS PER MILLION), EXCEPT PH

SOURCE	DATE	BOD	SOLIDS TOTAL	SOLIDS SUSP.	SOLIDS DISS.	PH IN LAB.	NICKEL AS NI	COPPER AS CU	IRON AS FE	NATURE OF SAMPLE
SMELTER EFFLUENT	9/28/60	8.0	4,586	1,934	2,652	9.9	23.2	2.5	32	GRAB
	6/ 3/63	6.8	1,170	114	1,056	4.0	19.5	15.5	0.8	GRAB
	6/ 7/63	-	2,988	1,178	1,810	5.1	59.0	151.0	1.2	GRAB
	9/ 4/63	-	1,690	282	1,408	6.4	14	7.8	26.5	COMPOSITE 8 A.M. —10 A.M.
	9/ 4/63	-	1,596	201	1,395	6.2	11	5.8	21.0	COMPOSITE 10 A.M. —12 NOON.
	9/ 4/63	-	1,790	284	1,542	10.0	32	13.0	25.0	COMPOSITE 12 NOON — 2 P.M.
	9/ 4/63	-	1,906	337	1,569	10.2	14	20.0	27.5	COMPOSITE 2 P.M. — 4 P.M.
	9/ 4/63	-	2,388	822	1,566	7.6	9	205.	127.5	GRAB 2:15 P.M.

FIELD PH MEASUREMENT SEPT. 4, 1963

MAX.	--	10.9
MIN.	--	9.4
AVG.	--	10.1

DISCUSSION OF RESULTS

Analytical results of samples representing the smelter effluent indicate that this waste stream is of very poor quality. The suspended solids concentration ranged from values generally associated with untreated domestic sewage to very high values approaching 1,000 ppm (parts per million) or more. Composite sampling indicated that a high suspended solids concentration is a continuous problem.

The concentrations of metallic components in the waste stream also exceed acceptable limits. The concentration of copper, in particular, is much higher than desirable and, in fact, at times reaches extremely high values as indicated by results of 151 and 205 ppm on June 7, 1963 and September 4, 1963, respectively. Nickel and iron concentrations are also often very high.

The pH of the discharge generally falls within acceptable limits. However, results of samples taken on June 3 and 7, 1963 indicate that a low pH may be a problem at times.

CONCLUSIONS AND RECOMMENDATIONS

The wastes from the Copper Cliff smelter are of poor quality and should not be discharged to an open watercourse. Provisions should be made to reduce the quantity of suspended solids, copper, nickel and iron in the waste to a level acceptable for discharge.

As most of the waste is supposedly relatively clean, spent, cooling water, this would suggest that segregation of wastes, followed by treatment, would be the most practical approach to the problem. If this approach is not feasible, the waste should be treated to reduce metal concentrations to an acceptable level and then impounded to settle suspended solids before it is discharged to a watercourse.

CONISTON SMELTER

The Coniston smelter is located eight miles east of Sudbury within the corporation limits of the Town of Coniston. The plant was initially placed in operation in 1913 and has operated almost continuously since that time.

PERSONNEL

Employment is provided for approximately 350 persons at the Coniston smelter.

DESCRIPTION OF PROCESS

The smelter consists of 4 blast furnaces and 4 Pierce-Smith converters. Coarse and fine low-silica ore from Creighton and Garson mines is used to produce Bessemer matte which is shipped to Copper Cliff for further processing.

The copper-nickel matte is converted in 4 Pierce-Smith converters with the aid of quartzite and low grade ore which is used as a fluxing material. This operation produces a waste slag and Bessemer matte. The latter is shipped to Copper Cliff.

WATER SUPPLY

Water is pumped from the Wanapitei River by INCO to fulfill the requirements of the smelter and the Town of Coniston. Approximately 2,900,000 US gpd are used by the smelter and Town of Coniston, the latter requiring about 144,000 gpd.

SOURCES OF WASTE

Since the operations of the Coniston smelter are almost entirely based on the heat reduction of ores, waste water is confined almost entirely to spent cooling water used for furnaces and compressors. Approximately 2,450,000 US gpd are used for these purposes and discharged from the smelter.

WASTE DISPOSAL

Waste waters from the smelter are discharged to Romford Creek and thence to Coniston Creek and the Wanapitei River.

SAMPLING PROGRAMME

Sampling of the Coniston smelter effluent consisted of obtaining grab samples at the main outfall on three consecutive days in September 1963. The pH of each sample was determined in the field as well as in the laboratory.

ANALYTICAL RESULTS

ALL RESULTS QUOTED IN PPM (PARTS PER MILLION), EXCEPT PH

		Solids			PH	PH	Nickel	Copper	Iron	Alkalinity
Source	Date	Total	Susp.	Diss.	in Field	at Lab.	as Ni	as Cu	as Fe	as $CaCO_3$
Coniston Smelter Effluent	9/4/63	114	3	111	6.8	6.6	0	0.53	1.20	-
	9/5/63	82	2	80	7.4	7.3	2.0	0.40	1.10	-
	9/6/63	128	3	125	-	7.3	0	0.1	1.08	10

DISCUSSION OF RESULTS

Results of samples representing the Coniston smelter effluent are very favourable. The suspended solids and metal concentrations are in range acceptable for discharge to a watercourse. The pH of the discharge is near the neutral point and should present no problems.

CONCLUSIONS AND RECOMMENDATIONS

Wastes from the Coniston smelter should not impair the quality of the receiving waters if the quality of the waste stream is maintained at the standards indicated by samples taken for the purpose of preparing this report.

COPPER REFINING DIVISION

Blister copper produced in the International Nickel Company's smelter at Copper Cliff is transported by hot metal car 1 1/4 miles to the Copper Refining Division for processing. Prior to 1935, this plant was called the Ontario Refining Company, Limited. It has operated continuously since erection in 1929-1930. Copper, nickel sulphate, silver, gold, platinum metals, selenium and tellurium are produced.

PERSONNEL

Employment is provided for up to 750 persons.

DESCRIPTION OF PROCESS

Blister copper, in molten form, is transferred a distance of one and a quarter miles from the smelter at Copper Cliff to the refinery.

The metal is subjected to thermal and oxidation-reduction treatment in gas-fired reverberatory furnaces and is then cast into anodes, each weighing 580 lbs.

Electrolytic refining is done in 1350 antimonial-lead lined concrete tanks, through which the copper sulphate-sulphuric acid electrolyte is circulated. Copper, dissolved from the anodes suspended in the tanks, is selectively deposited on pure copper "starting sheets" to form cathodes, which are withdrawn on a 14 day cycle. Anode life is 28 days.

Tank residues (slimes) and solutions from the electrolytic system are treated for the recovery of gold, silver, platinum metals, selenium, tellurium and nickel sulphate.

Copper cathodes are marketed full size or in sheared sections; or they are melted in direct-arc furnaces and cast into horizontal or vertical wire bars, cakes, billets and other forms for the fabricators' mills.

WATER SUPPLY

About 280,000 US gallons of Vermilion River water and 2,000,000 US gallons of Kelly Lake water are used per day for process work. The former is chiefly used for domestic, steam generation and electrolyte makeup purposes while Kelly Lake water is used for cooling, evaporator condensers and general work.

SOURCES OF WASTE

Waste water from the Copper Refining Division consists mainly of the overflow from the bosh cooling pond, blowdown from the steam generators and evaporator condenser water. Other discharges from the refinery include filtrate from the coke bed which is used to filter the wash water from the silver refinery changehouse and other general wastes. The volume of water discharged from the plant is substantially less than the volume supplied due to the large quantities evaporated in the tank house and lost as steam.

WASTE DISPOSAL

All waste and storm water from the Copper Refining Division enters Kelly Lake via the Copper Cliff creek.

SAMPLING PROGRAMME

Waste sampling at the Copper Cliff copper refinery was carried out on September 9, 1963.

A grab sample was obtained from the acid recovery unit cooling and settling pond near the point of discharge. Although there was no discharge at the time of sampling, the material collected would be representative of the effluent if there were an overflow. Composite samples were obtained from the Bosh cooling pond overflow, the filtrate from the coke beds, and a storm sewer located west of the Bosh cooling pond carrying general plant wastes.

Composite sampling was carried on for 2 1/2 hours during which time samples were taken at 30 minute intervals and composited.

A pH determination was made for each sample in the field as well as in the laboratory.

ANALYTICAL RESULTS

ALL RESULTS QUOTED IN PPM (PARTS PER MILLION), EXCEPT PH

SOURCE	DATE	NATURE OF SAMPLE	SOLIDS TOTAL	SOLIDS SUSP.	SOLIDS DISS.	PH IN FIELD	PH AT LAB.	NICKEL AS NI	COPPER AS CU	IRON AS FE	ALKALINITY AS $CACO_3$
COKE PIT FILTRATE AND GENERAL WASTE	9/9/63	COMPOSITE 3:30 P.M.— 6:00 P.M.	4,120	30	4,090	3.2	3.1	33	0.9	0.84	(80 ACIDITY AS $CACO_3$)
ACID RECOVERY UNIT COOLING AND SETTLING POND	9/9/63	GRAB	4,138	51	4,087	8.2	7.8	17	0.6	0.00	74
STORM SEWER CARRYING GENERAL PLANT WASTES	9/9/63	COMPOSITE 3:30 P.M. 6:00 P.M.	1,136	49	1,087	6.9	7.2	TR.*	1.2	0.15	6
BOSH COOLING POND EFFLUENT	9/9/63	COMPOSITE 3:30 P.M.— 6:00 P.M.	972	152	820	6.5	6.7	TR.*	5.8	0.15	10

TR.* — LESS THAN 1 PPM.

DISCUSSION OF RESULTS

In general, the analytical results of samples were favourable. However, there are several places where improvements should be made. The suspended solids concentration was quite high in the Bosh cooling pond effluent (152 ppm) and was higher than generally acceptable in the other discharges.

The pH of the stream carrying the coke pit filtrate was lower than is acceptable and the nickel content was high. The Bosh cooling pond effluent carried a toxic level of copper. Other features of the waste streams were, in general, satisfactory.

CONCLUSIONS AND RECOMMENDATIONS

Waste discharges from the copper refinery are, in general, of fair quality. However, the company should insure that the pH of wastes discharging from the plant premises meets with the objectives of the Commission.

The company should take steps to reduce the suspended solids and metal concentrations where necessary, either by in-plant controls and better housekeeping procedures or by establishing treatment facilities.

IRON ORE RECOVERY PLANT

Construction of the iron ore recovery plant, located in Waters Township, began in 1954 and operation on a commercial scale began in 1956. The plant produces a high grade marketable pelletized iron ore.

PERSONNEL

Employment is provided for approximately 750 persons.

DESCRIPTION OF PROCESS

The iron ore recovery plant receives pyrrhotite from the Copper Cliff mill from which is produced a high grade, pelletized iron oxide. The capacity of the plant is in the range of 2,300 long tons of pellets per day and the plant operates continuously.

Briefly, production of the iron oxide is based on recovering the iron from nickeliferous pyrrhotite recovered from ore. The pyrrhotite is pumped as a slurry from the Copper Cliff mill and roasted to drive off sulphur as sulphur dioxide. The resulting iron oxide is then charged to a kiln where the nickel and copper present are reduced to their elemental states and iron oxide is reduced to magnetite. The material, on leaving the kiln, is quenched, thickened and subjected to magnetic separation. The non-magnetics are discarded as waste while the magnetics are filtered. The filter cake is subsequently leached in aerated leaching tanks with ammoniacal ammonium carbonate solution to remove nickel.

The pregnant solution from the leaching operation is processed for recovery of metal values, ammonia and carbon dioxide. Copper is recovered as a sulphide and reverted to the Copper Cliff smelter. The nickel is recovered by distillation as basic nickel carbonate which is calcined to nickel oxide for market.

The leached magnetite is pelletized and fired on a travelling grate sinter machine for the production of iron ore pellets which is the final product.

Water is used in the process for quenching, cooling and other general plant purposes.

WATER SUPPLY

Water necessary to support operations at the iron ore recovery plant is pumped from the Vermilion River and Kelly Lake. The supply is treated in accordance with the requirements of the various industrial processes. Treatment can include clarification, filtration, softening, de-aeration and cooling.

The total pumpage to the plant is 7,500,000 US gpd. The supply is distributed in approximately the following manner:
cooling water - 1,180,000 US gpd, process water - 6,100,000 US gpd and sanitary water - 200,000 US gpd.

SOURCES OF WASTE

Wastes originating in the iron ore recovery plant consist of process waste, process water and cooling water. Pumps are provided to pump all the plant wastes to the Copper Cliff tailings disposal area.

WASTE DISPOSAL

Most of the process waste flows directly to the waste sump pumps from the various buildings. Process water overflows to the waste pumps from adjacent thickeners. Cooling water, floor drainage and storm water are collected in the plant underground drainage system and carried to a separate pumphouse.

Small pumps in this pumphouse pump the water to the plant waste pumps for relay to the tailings area during periods of low flow. Large pumps are provided to pump it directly to the tailings area during periods of high flow.

The flow to the tailings area is approximately 6,900,000 US gpd. The supernatant water from the tailings area flows to Copper Cliff creek and thence to Kelly Lake. An emergency surge capacity is provided by a large settling basin at the plant effluent pumphouse.

SAMPLING PROGRAMME

Waste sampling of process and cooling water from the iron ore recovery plant consisted of obtaining a grab sample of the plant effluent from the emergency surge capacity settling basin on September 4, 1963 and a 1 1/2-hour composite on September 5, 1963. Samples of the effluent from the Copper Cliff tailings area, which is the site of tailings disposal for the iron ore recovery plant, were also obtained on three consecutive days. The results of the latter samples and a discussion of the results were given under the section covering Copper Cliff concentrator.

ANALYTICAL RESULTS

ALL RESULTS QUOTED IN PPM (PARTS PER MILLION), EXCEPT PH

SOURCE	DATE	SOLIDS TOTAL	SOLIDS SUSP.	SOLIDS DISS.	PH IN FIELD	PH AT LAB.	NICKEL AS NI	COPPER AS CU	IRON AS FE	NATURE OF SAMPLE
IRON ORE RECOVERY PLANT DISCHARGE	9/4/63	1,888	26	1,862	9.0	9.1	2	1.1	0.8	GRAB
	9/5/63	1,936	24	1,912	8.9	9.1	3	0.8	1.0	COMPOSITE 3:30 P.M.–5:00 P.M.

DISCUSSION OF RESULTS

The results of samples of the discharge from the iron ore recovery plant are favourable in all respects.

CONCLUSIONS AND RECOMMENDATIONS

The waste discharge from the iron ore recovery is of good quality and, if present standards are maintained, should cause no problems. However, it was noted that there is a considerable build-up of solids in the emergency surge capacity settling basin located on the premises. Therefore, it is conceivable that if the present practice is pursued for an extended period of time a considerable carry-over of solids will result.

CHAPTER IV

FALCONBRIDGE NICKEL MINES LIMITED

Falconbridge Nickel Mines Limited was incorporated in 1928 with the objective of marketing the products to be derived by mining and processing ore from its property in Falconbridge Township. During the same period Falconbridge purchased a refinery in Norway, and, with the aid of metal brokers assured itself of control of its products from mine to market. In 1963 the company was operating seven mines in the District of Sudbury; namely, the Falconbridge and East mines, Hardy and Boundary mines, Onaping mine, Strathcona mine, and Fecunis Lake mine, as well as three mills, a smelter, and an iron ore recovery plant. The mills are located near the Falconbridge, Hardy and Fecunis Lake mines and the smelter and iron ore recovery plant near the Falconbridge mine.

In the remainder of this chapter each installation mentioned above, with the exception of the refinery, will be discussed as a separate entity as far as possible. Areas covered will include personnel, processes and operation, water supply, sources of waste, waste disposal, description of sampling programme, analytical results, discussion of results, and conclusions and recommendations.

FALCONBRIDGE AND EAST MINES

The Falconbridge and East mines are interrelated in that all ore from both mines is hoisted in Falconbridge mine's number 5 shaft and the method of waste disposal is common to both mines. Both mines are located in Falconbridge Township near the site of the mill and smelter twelve miles northeast of Sudbury. The Falconbridge mine has four shafts and was placed in operation in 1928. The East mine is connected underground to the Falconbridge mine and was placed in operation in the 1950's.

PERSONNEL

The total labour force at Falconbridge and East mines numbers under 1,000 men, including supervisory staff and miners.

Information on these mines and assistance in survey work necessary for the preparation of this report was provided by:

Mr. J. Asselstine	-	Chief Plant Engineer
Mr. J. B. Findlay	-	Mechanical Engineer, Falconbridge Area.
Mr. F. Jackson	-	Assistant Mechanical Superintendent, Falconbridge Area.

DESCRIPTION OF PROCESS

The combined production of the two mines is in the range of 3,000 tons of raw ore per day. Mining operations are in progress five days per week, 24 hours per day. Ore from both the Falconbridge and East mines is crushed by jaw crushers and hoisted to the surface via number 5 shaft of Falconbridge mine and stored in a 450 ton capacity bin before being processed in the ore dressing plant section of the mill.

The surface plant of the Falconbridge mine consists of a headframe and 450 ton ore bin, engineering offices,change house facilities, hoist room, compressor house, heavy repair shop, mine repair shop, carpenter shop, locomotive repair shop, oil house and core house. As all ore from the East mine is hoisted in the No. 5 shaft of Falconbridge mine, the shaft of East mine is used for development and service of the mine only. Surface facilities consist of a headframe and shaft house, hoist house, compressor house, fan house and a tailings sand fill preparation plant. Offices, change room facilities and a heating boiler are housed in one building.

WATER SUPPLY

Water is supplied to the Falconbridge and East mines as well as the Falconbridge mill, smelter and pyrrhotite plant from four drilled wells near the Falconbridge townsite. These wells are about 80 feet deep and all water supplied from them is chlorinated. An auxiliary supply of water from Lake Boucher is available for emergency purposes when necessary.

The water distribution systems of Falconbridge and East mines are interconnected at four horizons. Water is taken down No. 1 shaft and No. 5 shaft of the Falconbridge mine. Water is supplied to the mines at a rate of approximately 1,140,000 US gpd, of which 700,000 gpd is used for compressors, 140,000 gpd for fill plant and 300,000 gpd for the mines.

SOURCES OF WASTE

The major wastes associated with these two mines are mine waters. These wastes include water which has infiltrated the mine as well as water pumped into the mine as a carrier for backfill and water used in drilling operations. The combined volume of these waste waters has been estimated at 400,000 gpd for the Falconbridge and East mines. This waste water flows to settling and storage sumps located at four levels in No. 5 shaft. These sumps have a combined capacity of 1,086,000 gallons. From the sumps the water is pumped to the surface for ultimate disposal.

Compressor cooling water from Falconbridge mine is disposed of with the mine water, while compressor cooling water from the East mine and the overflow from the constant head tank used in conjunction with the sand fill operations are disposed of separately. The latter wastes amount to approximately 270,000 US gpd.

Another waste discharge from the sand fill plant is the slimes overflow from the first stage cyclones which is discharged to the mill tailings circuit.

WASTE DISPOSAL

The Falconbridge and East mine waters, along with Falconbridge mine compressor cooling water, are pumped to the old tailings area located southeast of the mill and smelter. From here these wastes discharge to Emery Creek. Compressor cooling water from East mine and constant head tank overflow from the sand fill operation discharge to Emery Creek at the point of the outfall of the old tailings basin.

The overflow of slimes from the first stage cyclones of the sand fill operation is discharged with mill tailings to Fault Lake; however, on September 10, 1963, a portion of this stream was discharging to Emery Creek along with East mine compressor cooling water.

SAMPLING PROGRAMME

Grab samples were obtained from the following discharges: mine water from the Falconbridge and East mine, Falconbridge compressor cooling water, East mine compressor cooling water, and the old tailings area effluent. The first three mentioned discharges were sampled on September 10, 11, and 12, 1963. The old tailings area discharge was sampled on September 29, 1960, when mill tailings were still discharging to the area and on June 3, 1963, and September 11, and 12, 1963, after the mill tailings discharge had been transferred to Fault Lake. Determinations of pH were made in the field as well as in the laboratory.

The old tailings area now receives pyrrhotite plant tailings as well as mine water and compressor cooling water.

ANALYTICAL RESULTS

ALL RESULTS QUOTED IN PPM (PARTS PER MILLION), EXCEPT PH

SOURCE	DATE	SOLIDS TOTAL	SOLIDS SUSP.	SOLIDS DISS.	PH IN FIELD	PH AT LAB.	NICKEL AS NI	COPPER AS CU	IRON AS FE	ACIDITY AS $CACO_3$
FALCONBRIDGE AND EAST MINE MINE WATER	9/10/63	2,706	25	2,681	7.7	7.6	5.7	0.4	0.03	—
	9/11/63	2,406	16	2,390	7.6	7.6	2.0	0.62	2.35	—
	9/12/63	2,780	21	2,759	7.3	7.3	0	0	2.40	—
EAST MINE COMPRESSOR COOLING WATER DISCHARGE	9/10/63	454	2	452	7.5	7.4	0	0	0.28	—
	9/11/63	1,542	11	1,432	5.1	4.2	0	0	150.0	—
	9/12/63	498	30	468	—	7.8	0	0	2.35	—
FALCONBRIDGE MINE COMPRESSOR COOLING WATER DISCHARGE	9/10/63	530	2	528	—	7.9	0	0	0.08	—
	9/11/63	522	2	520	—	7.7	0	0	0.05	—
	9/12/63	510	2	508	7.9	7.3	0	0	0.1	—
OLD TAILINGS DISPOSAL AREA EFFLUENT	9/29/60	3,478	46	3,432	—	4.9	26.	0.11	200.	—
	6/3/63	2,976	50	2,926	—	3.5	9.3	1.7	125.0	—
	9/11/63	2,552	25	2,527	4.0	3.9	0	0	550	1,190
	* 9/12/63	3,812	446	3,366	5.1	4.0	8.0	1.23	475	750

*VERY WINDY DAY.

DISCUSSION OF RESULTS

The analytical results of the mine water and compressor cooling water samples indicated that these wastes are generally not objectionable. The only exception to this generalization occurred on September 11, 1963 when the East mine compressor cooling water discharge had a low pH and a high iron concentration.

The results of samples representing the old tailings area effluent were not quite as favourable, and showed a low pH, a high iron concentration, and, on one day in particular, a very high suspended solids concentration. Since the unfavourable characteristics of this discharge are due to the pyrrhotite plant discharge these results will be discussed in more detail in the section dealing with this plant.

CONCLUSIONS AND RECOMMENDATIONS

Waste handling procedures followed at the Falconbridge and East mines provided satisfactory results. No problems should occur because of mine water and compressor water discharges if the present characteristics of the wastes are maintained. Provisions should be made to insure that all slimes from the sand fill plant are disposed of with mill tailings to Fault Lake.

Conclusions and recommendations with regards to the old tailings area discharge will be given in the section dealing with the pyrrhotite plant as it is apparent from the analytical results that the mine water discharge does not contribute to the poor characteristics of this waste stream.

HARDY AND BOUNDARY MINES

The Hardy and Boundary mines are located in the Onaping Improvement District south of the town of Levack, 29 miles northwest of Sudbury. The Hardy mine was collared early in 1951 and shortly after, an ore body was discovered northeast of this mine, and it was decided to work it through the Hardy mine. This new discovery became the Boundary mine. The Boundary mine is serviced by the facilities of Hardy mine and the same surface plant is used for both.

PERSONNEL

The mines are operated by a staff of under 200 men including supervisory staff and miners. Information with respect to the operation of these mines and assistance in survey work was supplied by the following:

Mr. J. B. Findlay	-	Mechanical Engineer, Falconbridge Area.
Mr. W. A. Humphreys	-	Mechanical Engineer, Onaping Area.
Mr. W. Rhude	-	Fecunis Master Mechanic.

DESCRIPTION OF PROCESS

The combined production of the Hardy and Boundary mines is in the range of 2,000 tons of raw ore per day. Operations are in progress five days per week, 24 hours per day. Ore from the two mines is crushed underground by a jaw crusher and hoisted to the surface through the Hardy shaft to await further processing. (Since the time of the initial survey the underground section of Hardy mine has been temporarily shut down and hence production has been reduced to 1,200 tons of raw ore per day.)

The surface plant servicing both the Hardy and Boundary mines consists of office and change house, hoist house, powder magazine, cap house, fuse house, headframe, shops, warehouse, garage, and compressor-boiler house.

WATER SUPPLY

Since the time of the survey changes affecting water supply practices have been made and bracketed figures indicate present operating conditions.

Water necessary to maintain operations is supplied by two drilled wells near the Onaping townsite. These wells supply the townsite, the mines and domestic water for Hardy mill. Total consumption varies from 250,000 (100,000) to 300,000 (150,000) US gpd in winter and summer, respectively. Mine and compressor cooling water consumption is approximately 200,000 US gpd. (Mine water consumption is 50,000 US gpd.) All water from the wells is chlorinated. Water is delivered to the two mines through a Hardy mine shaft.

Plans for the immediate future call for taking the mine compressors off of the well supply and supplying the cooling water from the Onaping River. When this is completed the demand on the wells will be reduced by approximately 150,000 US gpd. (Installation of new facilities now provides for supplying compressors with water from the Onaping River. Thus, present well water consumption figures are those indicated in brackets above.)

SOURCES OF WASTE

The major source of wastes for these mines is mine water. This includes water which has infiltrated the mine, as well as water used in sand fill and drilling operations. The combined volume of this water has been estimated at 75,000 gpd. The water drains from the various levels to a 100,000 US gallon sump located at the 1,000 foot level, and is pumped from here to the surface for final disposal. An auxiliary sump located at the bottom of the shaft is pumped to the main sump when necessary.

Other waste includes compressor cooling water which is discharged with the mine water.

WASTE DISPOSAL

The Hardy and Boundary mine waste waters are discharged along with compressor cooling water to the Onaping River without pretreatment.

SAMPLING PROGRAMME

Grab samples of waste discharging from the Hardy and Boundary mines were obtained in November 1962 and June and September 1963. Samples obtained in September 1963 include cooling water and general mill wastes from the Hardy mill which discharge with the mine wastes to the Onaping River. The sample obtained on September 11, 1963, contained only the general mill wastes as mine pumps were inactive at the time of sampling.

The pH of samples taken in September 1963 were determined in the field as well as in the laboratory.

ANALYTICAL RESULTS

ALL RESULTS QUOTED IN PPM (PARTS PER MILLION), EXCEPT PH

SOURCE	DATE	BOD	SOLIDS TOTAL	SOLIDS SUSP.	SOLIDS DISS.	PH IN FIELD	PH AT LAB.	NICKEL AS NI	COPPER AS CU	IRON AS FE	ACIDITY AS $CACO_3$
HARDY & BOUNDARY MINE - MINE WATER DISCHARGE	11/ 5/62	3.2	168	—	—	—	—	0.0	0.0	1.8	—
	11/14/62	3.2	1,300	68	—	—	—	3.0	0.3	10.0	—
	6/ 4/63	1.4	520	6	—	—	6.8	1.0	0.04	0.50	—
HARDY & BOUNDARY MINE - MINE WATER, MILL COOLING WATER AND GENERAL WASTE DISCHARGE TO ONAPING RIVER	9/11/63*	—	208	5	203	6.7	6.2	0.0	0.1	0.33	4
	9/12/63	—	1,338	89	1,249	6.0	3.9	TR.	0.4	42.5	64
	9/13/63	—	1,220	161	1,059	5.9	5.6	0.0	0.2	36.0	68

* MINE PUMPS INACTIVE

DISCUSSION OF RESULTS

The analytical results obtained were generally favourable; however, there were indications that the wastes intermittently contained high concentrations of suspended solids and iron and exhibited a low pH. Since pH readings determined in the field were, in every case, higher than those determined in the laboratory, it is suspected that the oxidation and hydrolysis of iron compounds present is responsible for the depressed pH conditions.

CONCLUSIONS AND RECOMMENDATIONS

Wastes from the Hardy and Boundary mines intermittently contain high concentrations of suspended solids and iron, and exhibit a low pH. It is suspected that the low pH is a direct result of the iron content.

The company should take steps to reduce the concentrations of suspended solids and iron and to elevate the pH before the waste is discharged to the Onaping River.

ONAPING MINE

The Onaping mine is located on the north rim of the Sudbury basin three-quarters of a mile east of Boundary mine in the Improvement District of Onaping. The shaft for this mine was collared in June, 1953.

PERSONNEL

Work at the Onaping mine is under the direction of the mine superintendent and staff of Hardy mine. Under 100 miners are employed at the mine. Information on the operation of the mine and assistance in Survey work was given by the following:

Mr. J. B. Findlay	-	Mechanical Engineer, Falconbridge Area.
Mr. W. A. Humphreys	-	Mechanical Engineer, Onaping Area.
Mr. K. Webb	-	Maintenance Repair Foreman, Fecunis Mine.

DESCRIPTION OF PROCESS

Mine production is in the range of 600 tons of raw ore per day and operations are maintained five days per week, 24 hours per day. Ore is crushed and hoisted to the surface to await further processing at the Hardy mill.

The surface plant is confined to two structures; a headframe and shaft house, and a combined services building. A tool room and electrical control room are included in the shaft house and an ore storage bin adjoins the headframe. The services building houses offices, change house, hoist room, compressor room and heating plant.

WATER SUPPLY

Water for domestic purposes at the surface plant and for mine use is pumped from Gill Pond, adjoining the plant, to a storage tank, from which it is delivered and distributed underground in 2-inch pipes. This water is chlorinated. Approximately 600 gallons per day are used for domestic purposes and 150,000 gpd for compressors. Water for domestic purpose underground is supplied from the Hardy deep wells.

SOURCES OF WASTE

The principal wastes associated with the operation of this mine are the mine waters. The mine water collection system consists of a permanent sump and pumping station at the 1,650 level and temporary sumps at the 2,300 level, the 3,050 level and the shaft bottom. The wastes are ultimately pumped from the 1,650 level to the surface for final disposal. It has been estimated that approximately 50,000 US gpd are handled by this system.

Other wastes include approximately 150,000 gpd of compressor cooling water.

WASTE DISPOSAL

Mine water pumped from the main collection sump is discharged beneath the surface of the ground about 200 yards from Gill Pond; and it is suspected that this pond is the ultimate receiving water.

Compressor cooling water and other surface plant wastes, with the exception of domestic sewage, are discharged directly to Gill Pond.

SAMPLING PROGRAMME

Grab samples were obtained of mine water discharging from Onaping mine in June and September 1963. As the outfall is buried, the samples were obtained from the discharge line in the mine shaft. Samples of compressor cooling water and general mine wastes discharging to Gill Pond were also obtained. Measurements of pH were made in the field and in the laboratory.

ANALYTICAL RESULTS

ALL RESULTS QUOTED IN PPM (PARTS PER MILLION) EXCEPT PH

SOURCE	DATE	BOD	SOLIDS TOTAL	SOLIDS SUSP.	SOLIDS DISS.	PH IN FIELD	PH AT LAB.	NICKEL AS NI	COPPER AS CU	IRON AS FE	ACIDITY AS $CACO_3$
ONAPING MINE MINE WATER DISCHARGE	6/ 4/63	0.4	540	9	531	—	6.5	0.0	0.08	0.60	—
	9/12/63	—	2,446	12	2,434	6.5	5.9	TR.	0.3	2.30	64
	9/13/63	—	2,156	55	2,101	6.1	5.4	4.3	0.4	4.0	14
COOLING WATER AND GENERAL MINE WASTE	9/11/63	3.2	820	6	814	6.5	6.3	0.0	TR.	0.20	4
	9/12/63	—	830	2	828	6.4	6.3	0.0	0.1	0.25	6

DISCUSSION OF RESULTS

The analytical results of samples taken of Onaping mine discharges indicate that the wastes are acceptable for discharge.

CONCLUSIONS AND RECOMMENDATIONS

Survey results indicate that waste disposal practices are satisfactory. Efforts should be made to maintain the quality of the discharge and insure that Gill Pond does not become adversely affected.

STRATHCONA MINE

The Strathcona mine which is presently under development is located in the township of Levack. Development work began in 1960 and is still in progress.

PERSONNEL

Under 100 employees are involved in the development work at Strathcona mine including Falconbridge and contractor personnel.

Information on the mine and assistance in survey work was provided by:

Mr. J. B. Findlay	-	Mechanical Engineer, Falconbridge Area.
Mr. W. A. Humphreys	-	Mechanical Engineer, Onaping Area.
Mr. K. Webb	-	Mine Maintenance Repair Foreman, Fecunis.

DESCRIPTION OF PROCESS

Present operations at the mine are confined to mine development work which is carried on three shifts per day. Surface plant facilities presently consist of a hoist room, two compressors, a dry and changehouse, stores, pumphouse, bunkhouse and heating plant.

WATER SUPPLY

Water necessary for this development work is supplied by Strathcona Lake. This supply is chlorinated and consumption has been estimated between 60,000 and 90,000 US gpd. Cooling towers used on compressor cooling water result in a substantial decrease in the water demand for the operation.

SOURCES OF WASTE

Mine water pumped from the mine is the major source of waste. The facilities for collecting and disposing of this water will be completed in the near future and will include three sumps and two pumps at the 3,200 level and three sumps and two pumps at the 1,600 level. An estimate of mine water flow is impractical at this time due to unsettled conditions.

WASTE DISPOSAL

Mine water pumped from the mine is disposed of to a swampy area tributary to Moose Creek. Other wastes are limited to domestic sewage, which is treated in a septic tank and overflows to the same swampy area.

SAMPLING PROGRAMME

Strathcona Lake, the source of the mine water supply, was sampled in October 1960. Grab samples of the mine water discharge to the swampy area were obtained on September 12 and 13, 1963. The pH determinations were made in the field and in the laboratory on the mine water samples.

ANALYTICAL RESULTS

ALL RESULTS QUOTED IN PPM (PARTS PER MILLION), EXCEPT PH

SOURCE	DATE	SOLIDS TOTAL	SUSP.	DISS.	PH IN FIELD	PH IN LAB.	NICKEL AS NI	COPPER AS CU	IRON AS FE	ALKALINITY AS $CACO_3$	ACIDITY AS $CACO_3$
STRATHCONA LAKE	10/19/60	—	—	—	—	4.5	—	—	0.36	6	—
STRATHCONA MINE - MINE WATER DISCHARGE	9/12/63	832	14	818	7.2	6.5	TR.	0.1	0.92	—	46
	9/13/63	2,958	21	2,937	7.0	6.4	0	0.3	1.40	—	16

DISCUSSION OF RESULTS

Sample results indicate that wastes are acceptable for discharge to a watercourse. However, results of a sample from Strathcona Lake show that the lake has a depressed pH.

CONCLUSIONS AND RECOMMENDATIONS

Wastes from Strathcona mine are acceptable for discharge to a watercourse. However, care should be taken to insure that the quality of the wastes is maintained as mine development progresses.

FECUNIS LAKE MINE

The Fecunis Lake mine is situated on the north rim of the Sudbury basin in the Improvement District of Onaping. Drilling to locate the ore body commenced in 1949 and the first shaft was completed by 1956. The slope of the ore body and the location of the INCO-Falconbridge property boundaries were such that independent mining by each company would have resulted in large tonnages of ore being tied up in the boundary wall pillars. Therefore, an agreement was reached between the two companies to work the mine as a joint operation with the ore from each company's part of the mining block being delivered to that company's ore passes.

PERSONNEL

The entire block is being mined by INCO, thereby making it possible to extract all the ore and to carry on mining more efficiently and under better working conditions than would be possible by independent mining. Falconbridge and contractor personnel number under 100 persons.

Information on the operations and assistance in survey work for the mine was supplied by the following personnel:

Mr. J. B. Findlay	-	Mechanical Engineer, Falconbridge Area.
Mr. W. A. Humphreys	-	Mechanical Engineer, Onaping Area.
Mr. K. Webb	-	Mine Maintenance Repair Foreman, Fecunis.

DESCRIPTION OF PROCESS

All ore mined in the Falconbridge section of the mine is hoisted via the Fecunis Lake mine shaft for processing in the Fecunis

Lake mill. Falconbridge production is in the range of 2,500 tons of raw ore per day and operations are carried out continuously five days per week.

Falconbridge is responsible for the pumping of mine water from its section of the mine, as well as for the crushing and hoisting of its ore. INCO is in charge of underground mining operations.

Operation of the tailing sand fill plant may also be considered a part of the surface activities. The plant, located in the mill, is used to prepare tailing fill, which is pumped to storage tanks at the mine.

WATER SUPPLY

Water is obtained from Moose Lake and is pumped approximately 2-1/2 miles to the mine. Estimates indicate that approximately 460,000 US gpd is consumed by the mine, of which 300,000 US gpd is used for the sand fill operation, 60,000 US gpd for compressor cooling water make up and 100,000 US gpd for drilling and other mining operations.

The use of a cooling tower greatly reduces the amount of compressor cooling water consumed than would otherwise be necessary.

SOURCES OF WASTE

The principal waste associated with this mine is mine water pumped from underground. This waste includes approximately 300,000 US gpd of water transferred underground in tailing sand fill, 100,000 US gpd from general use, as well as 75,000 US gpd from infiltration. Thus the total mine water pumpage is approximately 475,000 US gpd.

Mine waste water collection facilities consist of a deep well pump at the 3,875 level which discharges to a cone-shaped settling tank on the 3,400 level. Mine drainage is piped down the production shaft into this settler from which relatively clear water flows into a 110,000 US gallon sump. This water is then pumped to another 110,000 US gallon sump at the 1,650 level of the service shaft from which it is pumped to the surface for ultimate disposal.

Another source of waste is the overflow from the sand fill storage tanks. This is an intermittent flow which has been estimated at 110,000 US gpd.

WASTE DISPOSAL

The mine water collected underground and pumped to the surface is discharged to Fecunis Lake. Tailing slimes overflow from the sand fill plant storage tanks is also discharged to Fecunis Lake. (Plans are presently underway to return these wastes to the mill circuit.)

SAMPLING PROGRAMME

Grab samples were obtained of all industrial discharges from Fecunis Lake mine. Mine water samples were obtained in November 1962, and June and September 1963. The sand fill plant storage tank overflow was sampled in June and September 1963. The pH of samples, collected in September 1963, was determined in the field and in the laboratory.

ANALYTICAL RESULTS

ALL RESULTS QUOTED IN PPM (PARTS PER MILLION), EXCEPT PH, UNLESS OTHERWISE SPECIFIED

SOURCE	DATE	BOD	SOLIDS TOTAL	SOLIDS SUSP.	SOLIDS DISS.	PH IN FIELD	PH AT LAB.	COPPER AS CU	NICKEL AS NI	IRON AS FE	ACIDITY AS $CACO_3$	TURBIDITY IN SILICA UNITS
FECUNIS LAKE MINE - MINE WATER DISCHARGE	11/14/62	1.4	114	--	--	--	--	0.0	0.0	0.98	—	2.1
	6/4/63	6.0	2,538	50	--	--	4.0	2.5	27.4	13.5	—	—
	9/11/63	—	2,006	50	1,956	4.3	3.8	2.0	25	49.0	130	--
	9/12/63	—	1,966	36	1,930	4.7	3.9	1.8	24.0	44.5	122	—
	9/13/63	—	2,248	27	2,221	4.7	4.3	1.2	25.0	8.50	164	—
FECUNIS LAKE SAND FILL PLANT STORAGE TANK OVERFLOW	6/4/63	23.0	2,600	2,164	—	--	6.1	1.9	6.5	88.0	—	--
	9/12/63	--	25,080	24,434	646	6.1	6.8	14.0	106.0	540.0	8	—

DISCUSSION OF RESULTS

Analytical results indicate that both the mine water discharge and the sand fill plant overflow have objectionable characteristics. The mine water effluent contains high concentrations of nickel and iron and exhibits a low pH. The concentrations of suspended solids also exceed the recommended maximum and the copper content approaches a level considered as unsatisfactory for discharge.

The sand fill plant storage tank overflow contains extremely high concentrations of suspended solids, copper, nickel, and iron. The pH of this discharge appears to be in an acceptable range; however, oxidation and hydrolysis of metallic sulphides on dilution may result in a depressed pH.

CONCLUSIONS AND RECOMMENDATIONS

The mine water wastes and sand fill plant overflow from Fecunis Lake mine are not acceptable for discharge to an open watercourse.

It is recommended that the mine water be treated to reduce the concentrations of suspended solids, copper, nickel, and iron, and to raise the pH before this waste is discharged to Fecunis Lake.

The overflow from the sand fill plant storage tank should be disposed of in an alternate manner. Presumably, the most efficient method of disposal is to discharge this waste with tailings to the tailings disposal area. If this approach is not feasible then the waste should be treated to reduce the level of all contaminants and meet with Commission objectives before it is discharged to Fecunis Lake. (Since the time of the survey plans are underway to return mine waste and tailing sand fill storage tank overflow to the mill circuit.)

FECUNIS LAKE CONCENTRATOR

The Fecunis Lake mill, Falconbridge Nickel mine's most recently constructed concentrating plant, came into operation in March, 1957. The mill is located near the shaft of the Fecunis Lake mine in the Onaping Improvement District.

The mill processes ore removed from the Falconbridge section of Fecunis Lake mine. The nickel-copper concentrate produced is shipped by rail to the Falconbridge smelter for further processing.

PERSONNEL

Under 100 persons are employed at the Fecunis Lake mill, including mill employees and those employed in the various service groups. The mill operates five days per week, 24 hours per day.

Information on mill operations and assistance in survey work was provided by the following personnel:

Mr. J. B. Findlay	-	Mechanical Engineer, Falconbridge Area.
Mr. W. A. Humphreys	-	Mechanical Engineer, Onaping Area.

DESCRIPTION OF PROCESS

The mill provides for production of a partially-dried high grade copper-nickel flotation concentrate for shipment by rail to Falconbridge. The mill processes in the order of 2,500 tons per day of raw ore.

The ore entering the plant receives secondary crushing and screening. It is then subjected to tertiary crushing of the remaining ore to minus 3/8 inch. The tertiary crushed ore is stored in the mill feed bin to await concentrating.

Concentrating methods are similar to those of the Falconbridge and Hardy mills, in that the concentrator produces a high grade copper-nickel concentrate and a pyrrhotite concentrate. The crushed ore from the storage bin is subjected to grinding, classification and flotation. The copper-nickel concentrate from the flotation units is thickened and filtered. The filter cake is then dried and shipped to the smelter at Falconbridge. The scavenger concentrate from the flotation is processed in the pyrrhotite treatment circuit to produce a pyrrhotite concentrate.

Tailing is laundered to the fill preparation circuit to be prepared as tailing sand fill. When the tailing sand fill plant is not in operation, the main disposal pumps pump all mill tailings to waste.

WATER SUPPLY

In the mill approximately 1,800,000 US gpd of water is used in cooling and ore dressing operations. This water, drawn from Moose Lake, is chlorinated and has the pH adjusted by injecting ammonia. Approximately 150,000 US gpd is used in the mill for domestic and miscellaneous uses. A 120,000 gallon storage tank is provided for the distribution system.

SOURCES OF WASTE

The main wastes discharging from the mill are the water-borne tailing slimes carried in a flow estimated at 1,500,000 US gpd. Other wastes originating in the mill are crusher cooling water, water from clean-up operations and other general mill wastes.

WASTE DISPOSAL

The mill tailings discharge to a large tailings area north of Moose Lake. The effluent from this area discharges over a weir to Cranberry Lake, which acts as a secondary settling basin. The effluent from Cranberry Lake discharges over a concrete dam to a small creek feeding Moose Lake.

Crusher cooling water and other wastes from the mill discharge directly to Fecunis Lake.

Domestic wastes from the mill are treated in a septic tank and discharged to Fecunis Lake.

SAMPLING PROGRAMME

All industrial waste discharges from Fecunis Lake mill were sampled on at least one occasion since November 1957. Grab samples were obtained at the dam between Cranberry Lake and Moose Lake in November 1957, October 1960, November 1962, and September 1963. The flow over this dam represents the final effluent from the tailings disposal area. The receiving watershed for these wastes was also sampled at two points. One grab sample was obtained from Moose Lake at the Fecunis pumping station (September 1963) and another from Moose Creek immediately below Moose Lake (June 1963). Crusher cooling water and general mill wastes discharging to Fecunis Lake were sampled on three consecutive days in September 1963.

Samples obtained in September 1963 were checked for pH in the field and in the laboratory.

ANALYTICAL RESULTS

ALL RESULTS QUOTED IN PPM (PARTS PER MILLION), EXCEPT PH

SOURCE	DATE	BOD	SOLIDS TOTAL	SOLIDS SUSP.	SOLIDS DISS.	PH IN FIELD	PH AT LAB.	COPPER AS CU	NICKEL AS NI	IRON AS FE	ACIDITY AS $CACO_3$
TAILINGS AREA DISCHARGE TO MOOSE LAKE	11/6/57	--	194	184	10	--	4.1	0.045	0.0	1.9	--
	10/6/60	4.0	708	14	694	--	--	0.2	0.0	1.2	--
	11/14/62	3.9	576	112	464	--	--	0.1	--	7.5	--
	9/12/63	--	864	11	853	2.9	3.0	0.1	0	6.70	120
	9/13/63	--	704	19	685	3.0	3.0	0.1	0	5.20	120
MOOSE LAKE AT FECUNIS PUMPING STATION	9/13/63	--	172	96	76	4.0	4.0	0.1	0	0.52	22
MOOSE CREEK BELOW MOOSE LAKE	6/4/63	0.9	100	2	--	--	3.2	0.06	0.0	5.0	--
CRUSHER COOLING WATER AND GENERAL MILL WASTES	9/11/63	--	260	24	236	5.3	5.0	0.1	0	2.70	10
	9/12/63	--	254	7	247	4.9	4.8	0.2	0	1.48	10
	9/13/63	--	204	8	196	5.0	6.5	0.2	0	1.05	10

DISCUSSION OF RESULTS

Sample results indicate that the most significant characteristic of wastes discharging from Fecunis Lake mill is a low pH. The effluent from the tailings basin is the most seriously affected discharge and is having a pronounced effect on the receiving waters. Both Moose Lake and Moose Creek samples illustrate the seriousness of the problem as they show pH values much below normal. General mill wastes discharging to Fecunis Lake were also shown to have a depressed pH.

Sample results, other than those of pH, are generally favourable. It was indicated however, that the tailings disposal area effluent periodically contains a high concentration of suspended solids. This may be a direct result of weather conditions, as it was indicated by other tailings ponds in the area that this can be an influencing factor on treatment efficiency.

CONCLUSIONS AND RECOMMENDATIONS

The wastes discharging from the Fecunis Lake mill have a very low pH and hence are adversely affecting the receiving water bodies. This is particularly evident in the case of the tailings area effluent, as the receiving water body, Moose Lake, now has a pH much below normal.

Thus, it is recommended that the company treat the wastes to control the pH of discharges in a range which complies with Commission objectives. If this policy is followed, it is felt that Moose Creek and Moose Lake could be restored to conditions suitable for recreational and other purposes and further pollution of the Onaping River as a result of these discharges could be minimized.

The company should also investigate the possibility of maintaining the suspended solids concentration in the tailings disposal area effluent at a consistently low value. This may include a study of the effect of weather conditions on the treatment efficiency achieved by the tailings disposal area.

HARDY CONCENTRATOR

The Hardy mill, which went into full operation in April 1955, now processes ores from the Hardy and Boundary mines, and the Onaping mine. (Since the time of the survey Hardy mine has been temporarily shut down.) The mill is located in the Onaping Improvement District near the Hardy mine shaft.

The copper-nickel concentrate produced at the mill is partially dried and pelletized before being shipped to Falconbridge for further processing.

PERSONNEL

The mill employs under 100 persons and operates on a 24 hours per day, six days per week schedule.

Information on on mill operation and assistance in survey work was supplied by the following personnel:

Mr. J. B. Findlay	-	Mechanical Engineer, Falconbridge Area.
Mr. W. A. Humphreys	-	Mechanical Engineer, Onaping Area.

DESCRIPTION OF PROCESS

The mill is designed to produce a dried copper-nickel flotation concentrate and a pyrrhotite concentrate, and to prepare hydraulic fill for Hardy mine. The mill concentrates in the order of 1,500 tons of mill feed per day.

Ore from the mines is subjected to screening and crushing on entering the mill and the finished material is fed to a storage bin for concentrator feed.

The feed to the plant is subjected to grinding in rod and ball mills, classification and then flotation. Copper-nickel concentrate and a scavenger concentrate are the products of the flotation cells. The scavenger concentrate is reground and retreated in a pyrrhotite circuit and then the pyrrhotite concentrate is pumped to a prepared disposal area for possible future reclaimation. The copper-nickel concentrate which includes concentrate floated in the pyrrhotite circuit is pumped to a thickener, the overflow of which is directed to a disposal area for future reclaimation of solids. The underflow is filtered and partially dried and pelletized before being shipped to the smelter at Falconbridge. The overflow water from the pyrrhotite circuit thickener is returned to a constant head tank for use in the grinding circuit.

The fill used in Hardy mine is exclusively hydraulic with the exception of some development waste. Tailing sand fill is prepared from mill tailing, supplemented when necessary by deslimed natural sand. Tailing sand fill is prepared by passing mill tailings through 2 - 10" Kreb cyclones - single stage.

WATER SUPPLY

Water necessary to support the mill operations is supplied by the Onaping River at a rate of 1,100,000 US gpd. This water, used as a carrier for the crushed ore and other miscellaneous purposes, is untreated. Water used for domestic purposes in the mill is supplied by the two drilled wells near the townsite of Onaping.

SOURCES OF WASTE

For the most part, wastes originating at the mill are tailing slimes. This is the waste remaining after concentrating and desliming, which is pumped to a disposal area in a flow of approximately 750,000 US gpd. These tailings include the slimes overflow from the tailing sand fill plant storage tank.

Other waste streams include half of the overflow from a Dorr Thickener, used in thickening the concentrate, and general mill wastes which discharge to the pyrrhotite storage area. The overflow from the pyrrhotite storage area, amounting to approximately 250,000 US gpd, includes the latter plus water used to hydraulically transport the scavenger pyrrhotite concentrate to the area. Some general mill wastes are also discharged with Hardy and Boundary mines mine water.

WASTE DISPOSAL

Mill tailings are discharged to a 50 acre area northwest of the mill. This area has no visible outfall and hence dissipation of waste is confined to seepage and evaporation.

The effluent from the pyrrhotite storage basin flows over an adjustable weir to a ditch which in turn discharges to the Onaping River. The general mill wastes discharged with Hardy and Boundary mine water also go to the Onaping River.

SAMPLING PROGRAMME

All wastes discharges from the Hardy mill were sampled in 1963. The influent to the tailings disposal area was sampled on June 13, 1963. There is no apparent outfall from this area. The effluent from the pyrrhotite storage basin was sampled on June 13, 1963, and September 11, 1963. On the latter date the flow was negligible and consisted only of weir leakage. The general mill wastes discharging to the pyrrhotite storage basin were sampled on September 12, 1963. The mill wastes which discharge to the Onaping River were sampled on September 11, 1963.

The pH of samples obtained in September 1963 was determined in the field as well as in the laboratory.

ANALYTICAL RESULTS

See page 93.

DISCUSSION OF RESULTS

The results indicate that waste disposal methods followed at the Hardy mill are generally satisfactory.

However, the concentration of suspended solids and nickel appears to exceed the recommended maximum in the pyrrhotite storage basin effluent when flow conditions are normal.

CONCLUSIONS AND RECOMMENDATIONS

The company should endeavour to reduce the content of suspended solids and nickel in the effluent from the pyrrhotite storage area and maintain the quality presently being achieved for other waste streams. Present tailings disposal practice is ideal as far as the field of pollution control is concerned.

ANALYTICAL RESULTS

ALL RESULTS QUOTED IN PPM (PARTS PER MILLION), EXCEPT PH, UNLESS OTHERWISE SPECIFIED

Source	Date	BOD	Solids Total	Solids Susp.	Solids Diss.	pH in Field	pH at Lab.	Nickel as Ni	Copper as Cu	Iron as Fe	Acidity as $CaCO_3$	Alkalinity as $CaCO_3$	Turbidity in Silica Units
Mill Tailings To Tailings Disposal Area	6/13/63	--	22,762	22,292	470	--	7.6	--	--	--	--	--	--
Pyrrhotite Storage Basin Effluent	6/13/63	52	522	46	476	--	6.5	21	0.27	4.24	--	8	32.0
	9/11/63	--	722	2	720	5.9	5.4	0	0.1	2.65	4.0	--	--
General Mill Wastes To Pyrrhotite Storage Basin	9/12/63	--	874	58	816	7.0	6.4	0	0	2.60	6	--	--
General Mill Wastes To Onaping River	9/11/63	--	208	5	203	6.7	6.2	0	0.1	0.33	4	--	--

FALCONBRIDGE CONCENTRATOR

The Falconbridge mill located in Falconbridge Township consists of an ore dressing plant, a concentrator and two tailings fill preparation plants. The mill was placed in operation in April, 1933, and since that time has been expanded in stages, and modified, so that it now concentrates in the range of 3,000 tons per day of mill feed and prepares a pyrrhotite concentrate and classified tailing fill as well as an improved grade of copper-nickel concentrate.

PERSONNEL

The staff employed at the mill numbers under 200 persons including supervisory and operating personnel. Operations are carried out on a 24 hours per day, five days per week schedule.

Operating data and assistance in survey work was provided by the following persons:

Mr. J. Asselstine	-	Chief Plant Engineer
Mr. J. B. Findlay	-	Mechanical Engineer, Falconbridge Area.
Mr. F. Jackson	-	Ass't Mechanical Superintendent, Falconbridge Area.

DESCRIPTION OF PROCESS

Ore from Falconbridge and East mines is hoisted in Falconbridge mine's number 5 shaft and stored to await secondary crushing. Following secondary crushing, the ore is screened, and the coarse size subjected to magnetic separation. The magnetically separated material is stored for smelter feed. The coarse non-magnetics and the other screen sizes are subjected to a final stage of crushing and then stored as mill feed. The mill processes in the order of 3,000 tons of ore per day.

The concentrating procedure embraces the grinding, classification, flotation, wet magnetic separation, thickening and filtering required to produce a copper-nickel concentrate and a pyrrhotite concentrate. Preparation of tailings sand for mine fill and disposal of final tailings are also part of the operation.

Grinding is performed in rod and ball mills. The ground material is passed on to the flotation cells where a copper-nickel concentrate and a scavenger concentrate are produced. The copper-nickel concentrate is thickened, filtered and delivered to the smelting operation, and the scavenger concentrate is delivered to the pyrrhotite preparation circuit. Thickener overflow, filtrate water and tailings are pumped to the tailing treatment plants.

Scavenger concentrate is subjected to wet magnetic separation. The non-magnetics are thickened and floated to produce a copper-nickel concentrate and the magnetics are reground and subjected to flotation to recover pentlandite and chalcopyrite. A copper-nickel concentrate recovered from the first five flotation cells is pumped to the main circuit nickel thickener while concentrate from the last three cells is returned to the scavenger concentrate thickener for retreatment.

Tailing sand fill is prepared in the fill preparation plant by classifying mill tailing in cyclone separators.

WATER SUPPLY

Water is supplied for the operation from four drilled wells located near Falconbridge townsite. The supply from these wells is chlorinated. An auxiliary supply for emergency purposes is available from Lake Boucher. Approximately 1,500,000 US gpd is supplied for the milling operations as well as 150,000 US gpd for the sand fill plants.

SOURCES OF WASTE

The major wastes occurring in the mill are tailings, thickener overflow, and sand fill plant storage tanks overflow. These wastes amount to approximately 1,100,000 US gpd.

WASTE DISPOSAL

Mill tailings and sand fill plant storage tank overflow are discharged to Fault Lake, a deep kettle hole, located north of the mill. At the present there is no apparent outfall from this lake. Investigation on September 10, 1963 indicated that a portion of the overflow from the sand fill plant located at East mine was discharging to Emery Creek; however, it was indicated that this was a temporary measure only.

SAMPLING PROGRAMME

A grab sample of wastes discharging to Fault Lake was obtained on June 13, 1963. This is the only industrial waste discharge from the mill and the waste is completely confined in Fault Lake.

ANALYTICAL RESULTS

ALL RESULTS QUOTED IN PPM (PARTS PER MILLION), EXCEPT PH

SOURCE	DATE	SOLIDS			PH AT
		TOTAL	SUSP.	DISS.	LAB.
INFLUENT TO FAULT LAKE (TAILINGS)	6/13/63	132,804	130,576	2,228	7.3

DISCUSSION OF RESULTS

No comment.

CONCLUSIONS AND RECOMMENDATIONS

Disposal of tailings at the Falconbridge mill is satisfactory and as long as no effluent from Fault Lake is permitted, it should remain so. The company should insure that the total flow of slimes from the sand fill plant located at East mine is disposed of with the tailings.

FALCONBRIDGE SMELTER

The Falconbridge smelter was first placed in operation in 1930. The chief function of the smelter is to eliminate the iron, disposed of as a dumped slag, and most of the sulphur to produce a copper-nickel matte suitable for electrolytic refining.

PERSONNEL

The smelter presently employs under 500 persons. Most of these employees work a three-shift schedule.

Information on smelter operation and assistance in survey work was provided by the following personnel:

Mr. J. Asselstine	-	Chief Plant Engineer
Mr. J. B. Findlay	-	Mechanical Engineer, Falconbridge Area.
Mr. F. Jackson	-	Ass't Mechanical Superintendent, Falconbridge Area.

DESCRIPTION OF PROCESS

The process encompasses sintering and pelletizing as well as the operation of blast furnaces, which is the basis of the smelting operation. The matte produced by these operations is up-graded in basic-lined converters to produce a high-grade shipping matte containing about 80% copper plus nickel. This matte is processed in the company's electrolytic refinery in Norway.

WATER SUPPLY

The source of the smelter water supply is the same as that for the mill, namely four drilled wells near the Falconbridge townsite. Approximately 1,500,000 US gpd is supplied to the smelter to be used as cooling water makeup. This water is circulated through a cooling pond.

SOURCES OF WASTE

Wastes from the smelter consist of cooling water. These wastes have been estimated at 1,500,000 US gpd.

WASTE DISPOSAL

All wastes from the smelter are discharged to Boucher Lake located south of the plant. This lake originally flowed to Emery Creek; however, due to a change in water level there is presently no outfall.

SAMPLING PROGRAMME

A number of samples were obtained of the smelter waste discharge to Boucher Lake. Grab samples were obtained on October 29, 1960, June 3, 1963, and June 13, 1963 while three 2-hour composite samples were obtained on September 10, 1963. A grab sample was also obtained on September 10, 1963 for an ether soluble and phenol determination as traces of oil were continually present in the discharge.

ANALYTICAL RESULTS

See page 100.

ANALYTICAL RESULTS

ALL RESULTS QUOTED IN PPM (PARTS PER MILLION), EXCEPT PH, UNLESS OTHERWISE SPECIFIED

SOURCE	DATE	BOD	SOLIDS TOTAL	SOLIDS SUSP.	SOLIDS DISS.	COPPER AS CU	NICKEL AS NI	IRON AS FE	PH IN FIELD	PH AT LAB.	TURBIDITY IN SILICA UNITS	ALKALINITY AS $CACO_3$	PHENOLS PPB	ETHER SOLUBLES	NATURE OF SAMPLE
SMELTER	10/29/60	—	810	14	796	0.33	TR.	0.52	—	7.7	—	—	3.0	—	GRAB
EFFLUENT	6/ 3/63	2.7	1,010	—	—	0.22	0.0	0.65	—	7.9	5.0	—	3.0	—	GRAB
TO	6/13/63	1.6	1,074	51	1,023	0.47	TR.	1.70	—	8.0	29.0	—	—	—	GRAB
BOUCHER	9/10/63	—	1,152	49	1,103	0.4	0.0	2.65	7.9	7.6	—	132	—	—	9 A.M.-11 A.M.
LAKE	9/10/63	—	1,138	31	1,107	0.5	0.0	1.75	8.0	7.8	—	130	—	—	11 A.M.- 1 P.M.
	9/10/63	—	1,046	45	1,001	0.3	0.0	1.80	7.9	7.7	—	138	—	—	1 P.M.- 3 P.M.
	9/10/63	—	—	—	—	—	—	—	7.8	—	—	—	0.0	TR.*	GRAB

* LESS THAN 2 PPM.

DISCUSSION OF RESULTS

Analytical results indicate that the smelter waste is acceptable for discharge to a watercourse. The concentration of metals is low and the pH is in an acceptable range. The suspended solids concentration is often slightly higher than the recommended maximum

CONCLUSIONS AND RECOMMENDATIONS

The waste from the smelter is acceptable for discharge to a watercourse under normal conditions except for the fact that the suspended solids concentration is slightly high. However, since Boucher Lake presently has no outlet and, since it is likely this lake serves as a recharge system for the drilled wells, it is conceivable that the level of contamination which can be tolerated in a waste discharge to the lake is much less than under other conditions.

Thus, it is recommended that the company maintain close control over the smelter waste discharge, particularly with respect to the iron and phenol content as both contribute very undesirable characteristics to a water supply.

FALCONBRIDGE PYRRHOTITE PLANT

The Falconbridge Pyrrhotite Plant or iron ore recovery plant was placed in operation within the last few years and was the product of basic research started in 1951. The plant is located in Falconbridge.

PERSONNEL

The plant presently employs under 100 persons including supervisory staff.

Information on plant operation and assistance in survey work was provided by the following personnel:

Mr. J. Asselstine	-	Chief Plant Engineer,
Mr. J. B. Findlay	-	Mechanical Engineer, Falconbridge Area.
Mr. F. Jackson	-	Ass't Mechanical Superintendent, Falconbridge Area.

DESCRIPTION OF PROCESS

Operation of the pyrrhotite plant consists of thickening, filtering and repulping of the pyrrhotite concentrate, followed by the addition of sodium sulphate and roasting in fluid bed furnaces. The roasted material is quenched and the nickel salts are leached out. The pregnant solution thus formed has the ferric sulphate in it reduced to ferrous sulphate. This operation is followed by the precipitation and reclamation of nickel and copper salts from the pregnant solution. These salts are then returned to the smelter.

The material remaining following the removal of the pregnant solution, receives further processing to produce a marketable iron oxide by-product.

WATER SUPPLY

Fresh water supplied to the pyrrhotite plant from the Falconbridge drilled wells amounts to 800,000 US gpd. Also entering the plant is approximately 260,000 US gpd of water accompanying the pyrrhotite concentrate from the mill.

SOURCES OF WASTE

Wastes from the operation of the pyrrhotite plant are pyrrhotite tails and cooling water. The combined volume of these wastes has been estimated at 1,000,000 US gpd.

WASTE DISPOSAL

All industrial wastes from the pyrrhotite plant are discharged to the old tailings area located southeast of the plant. The effluent from this area discharges over an adjustable weir to Emery Creek.

SAMPLING PROGRAMME

Both the influent and effluent of the old tailings area were sampled. Grab samples of the effluent were obtained on June 3, 1963, and September 11 and 12, 1963. The combined influent was sampled on June 13, 1963, and the waste from the pyrrhotite plant alone was sampled on September 11, 1963. The pH of samples obtained in September 1963 was determined in the field and in the laboratory.

ANALYTICAL RESULTS

See page 104.

ANALYTICAL RESULTS

ALL RESULTS QUOTED IN PPM (PARTS PER MILLION), EXCEPT PH, UNLESS OTHERWISE SPECIFIED

SOURCE	DATE	BOD	SOLIDS TOTAL	SOLIDS SUSP.	SOLIDS DISS.	PH IN FIELD	PH AT LAB.	COPPER AS CU	NICKEL AS NI	IRON AS FE	ACIDITY AS $CaCO_3$	ALKALINITY AS $CaCO_3$	SULPHATE AS SO_4	PHENOL PPB	NATURE OF SAMPLE
PYRRHOTITE (OLD) TAILINGS AREA DISCHARGE	6/ 3/63	9.0	2,976	50	2,926	—	3.5	1.7	9.3	125.0	—	—	—	10	GRAB
	9/11/63	—	2,552	25	2,527	4.0	3.9	0	0	550	1,190	—	—	—	GRAB
	9/12/63*	—	3,812	446	3,366	5.1	4.0	1.23	8.0	475	750	—	—	—	GRAB
INFLUENT TO OLD TAILINGS AREA (PYRRHOTITE TAILS, MINE WATER, ETC.)	6/13/63	14	1,930	548	1,382	—	5.9	9.7	39	106.0	88	—	—	—	GRAB
PYRRHOTITE PLANT WASTES TO OLD TAILINGS AREA	9/11/63	—	2,452	948	1,504	7.2	7.1	1.0	13	127.5	—	10	895	—	9:30 A.M.—11 A.M.
	9/11/63	—	41,790	1,660	40,130	4.8	3.9	34	770.	7,500	13,320	—	23,800	—	11 A.M.—1 P.M.
	9/11/63	—	11,134	1,070	10,064	5.5	4.3	1.1	8.0	1,750	4,100	—	5,780	—	1 P.M.—3 P.M.
	9/11/63	—	3,704	1,064	2,640	6.0	4.9	29.4	14.0	390	1,100	—	168	—	3 P.M.—5 P.M.

* VERY WINDY DAY.

DISCUSSION OF RESULTS

The analytical results of samples of the old tailings area effluent indicate that this discharge may result in considerable pollution of Emery Creek, and perhaps the Wanapitei River. It appears that the pH of this discharge is continually low and the iron concentration is high. From the results, it is evident that weather conditions have a pronounced influence on the efficiency of operation of the settling basin. The suspended solids concentration, under normal weather conditions, is low; whereas under high wind conditions, the degree of carry-over of suspended solids is extremely high. Concentrations of nickel in the waste also approach levels deemed undesirable.

Analyses of samples of the influent to the old tailings area indicate that some contaminants in the waste stream from the pyrrhotite plant fluctuate over a wide range of concentrations. The iron, nickel, copper, and sulphate concentrations appear to be subject to the most variation while the concentration of suspended solids is relatively stable. The results also indicate that the pH becomes lower with time. This substantiates a theory that the depressed pH condition is caused by the oxidation and hydrolysis of components in the waste.

CONCLUSIONS AND RECOMMENDATIONS

The wastes discharging from the old tailings area are of such quality that they could cause considerable pollution of Emery Creek and the Wanapitei River. Therefore, it is recommended that the company take steps to reduce the concentration of iron contained in the waste, and raise the pH to an acceptable range. The company should also insure that copper and nickel concentrations in the discharge are controlled at a level which will not result in toxic conditions being produced in the receiving waters.

The effect of weather conditions on the operation of the tailings area should be determined and provisions should be made to overcome or reduce the influence of this phenomenon. This may include facilities to reduce the flow from the area during poor weather conditions and to increase it during periods of favourable conditions.

CHAPTER V

CANADIAN INDUSTRIES LIMITED

Canadian Industries Limited operates two plants in the District of Sudbury for the production of liquid sulphur dioxide and sulphuric acid from sulphur dioxide contained in waste flue gases from INCO. Plant No. 1 is located in Copper Cliff at the site of INCO's smelter and plant No. 2 is in Waters Township at the site of INCO's iron ore recovery plant.

PERSONNEL

Employment is provided for approximately 70 persons at plant No. 1 and 25 persons at plant No. 2.

Information on the operation of the two plants and assistance in survey work was provided by the following personnel:

Mr. A. A. Perley	-	Plant Manager,
Mr. R. Smith	-	Works Supervisor,
Mr. A. Lapalme	-	Development Engineer.

DESCRIPTION OF PROCESS

The standard contact process is used at both plants for the manufacture of sulphuric acid. The waste flue gases from INCO, which contain about 6% and 10% sulphur dioxide at plants No. 1 and No. 2 respectively, are scrubbed with 1° Be and 20° Be sulphuric acid to remove dust and entrained particles. The gas is then dried by contact with a stream of 66° Be acid. The dried gases are piped to a reactor where sulphur dioxide is converted to sulphur trioxide in the presence of a vanadium catalyst. Sulphur trioxide is then absorbed in a stream of 98% sulphuric acid to produce oleum. This process recovers about 92% of the sulphur dioxide in the feed gases.

Liquid sulphur dioxide is produced from the gases from flash smelting, which contain about 70% sulphur dioxide. The process is simply one of compression and cooling. Approximately 90% recovery of sulphur dioxide from the waste gases is achieved.

Plant No. 1 presently produces 35 tons of sulphuric acid per day and 250 tons of liquid sulphur dioxide, while plant No. 2 produces 360 tons of sulphuric acid per day.

The company is presently in the process of altering operations. Plans call for increasing production of sulphuric acid at plant No. 2 by 500 tons per day, while production of sulphuric acid at plant No. 1 will cease. Plant No. 1 will then be used exclusively for the production of liquid sulphur dioxide and production will be increased by about 6,000 tons per year. The increase in production will be accompanied by an increase in sulphur dioxide recovery from 90% to 98.5%.

It is suspected that the proposed alterations given above will result in a decrease in water demand at plant No. 1 and an increase at plant No. 2.

WATER SUPPLY

Water for all uses at plant No. 1 is obtained from INCO's Copper Cliff smelter supply. It is used for cooling, scrubbing of gas streams, absorption of sulphur trioxide and making up the product, and for sanitary purposes. The average daily requirement is presently 50,000 Imperial gpd.

Two supplies of water are utilized at plant No. 2, both of which are obtained from INCO's iron ore recovery plant. Water for domestic purposes and product dilution is obtained from INCO's deep well and scrubbing and cooling water is taken from the INCO's process water distribution system. The average plant consumption is in the range of 166,000 Imperial gpd.

The process water supply for both number 1 and 2 plants generally has a low pH and considerable impurities. The plant number 2 supply is treated by coagulation, filtration, softening, pH adjustment, and the addition of a phosphate corrosion inhibitor.

SOURCES OF WASTE

Wastes from plant number 1 eonsist of spent cooling water and weak sulphuric acid scrubbing waste water. These wastes are collected in a common sewer to which bags of lime are occasionally added, presumable to inhibit corrosion.

Wastes from number 2 plant are also confined to scrubbing and cooling water. The scrubbing waste water is treated with lime and pumped to the iron ore recovery plant for the recovery of metallic constituents. Cooling water is collected in a common sewer along with the effluent from two septic tanks used to treat plant sanitary sewage.

WASTE DISPOSAL

Wastes from plant number 1 discharge to INCO's old slag disposal area. From this area the wastes drain to Copper Cliff Creek and thence to Kelly Lake.

Wastes from plant number 2 discharge to a creek which is tributary to Kelly Lake.

SAMPLING PROGRAMME

Samples were taken of plant number 1 and plant number 2 process and cooling water in 1960 and 1963. Grab samples of these wastes were obtained on September 28, 1960 and June 14, 1963. On September 4, 1960, number 1 plant outfall was sampled for 8 hours at 30-minute intervals. The pH of each sample was obtained in the field and the samples were composited. The same procedure was repeated over a 6-hour period at 20-minute intervals for number 2 plant on September 5, 1963.

ANALYTICAL RESULTS

See page 112.

DISCUSSION OF RESULTS

The results indicate that the most objectionable characteristic of the wastes from both plants is the low pH. Composite sampling and pH recording on September 4 and 5, 1963 indicated that this is a continuous problem. Analyses also show that copper and nickel concentrations may reach objectionable levels although improvement has been indicated over the three year period that sampling has taken place. Metal concentrations in the effluent of plant number 2 do not appear to present any problems. Sulphite and sulphate concentrations also appear to reach objectionable levels although this would likely be corrected if pH adjustment was practised.

The suspended solids concentration in the plant number 2 effluent is consistently higher than the recommended maximum for discharge to a watercourse. However, this characteristic is much less objectionable than the low pH. The suspended solids concentration in the plant number 1 effluent appears to be in an acceptable range except for the result obtained on a grab sample June 14, 1963.

RECOMMENDATIONS AND CONCLUSIONS

The results of the survey show that the volume of the waste discharges from CIL is small, as compared to other industries in the area. However, these wastes exhibit an extremely low pH. This quality is very objectionable when it is realized that watercourses in the area generally have a poor buffering capacity.

Thus, it is recommended that the company take steps to bring the pH of its discharges into the range recommended by the Commission (pH 5.5 to 9.5). This may be achieved by either in-plant controls or by neutralizing the effluent. One possibility is neutralization with slaked lime. This process would result in an increase in pH and a reduction of other contaminants in the effluent if followed by adequate settling before discharge.

ANALYTICAL RESULTS

PLANT No. 1:

LOCATION	DATE	NATURE OF SAMPLE	BOD	SOLIDS TOTAL	SOLIDS SUSP.	SOLIDS DISS.	PH AT LAB.	ACIDITY AS $CACO_3$	CU	NI	FE	SO_4	SO_3	PO_4
PLANT OUTFALL	9/28/60	GRAB	-	-	-	-	1.1	18,250	79.5	25	94.8	946	1,620	-
	6/14/63	GRAB	6.0	4,226	200	4,026	1.7	2,720	8.5	8.3	3.2	2,317	0	18
	9/ 4/63	COMPOSITE 3½ HOURS *	-	816	7	809	2.6	220	0.2	8.4	14.4	-	-	-
	9/ 4/63	COMPOSITE 3½ HOURS *	-	1,122	8	1,114	2.2	564	0.66	6.2	26.4	-	-	-

* PH READINGS AT 30 MINUTE INTERVALS

MAX.	--	3.1
MIN.	--	1.8
AVG.	--	2.5

PLANT No. 2:

LOCATION	DATE	NATURE OF SAMPLE	BOD	SOLIDS TOTAL	SOLIDS SUSP.	SOLIDS DISS.	PH AT LAB.	ACIDITY AS $CACO_3$	CU	NI	FE	SO_4	SO_3	PO_4
PLANT OUTFALL	9/28/60	GRAB	-	-	-	-	7.1	12	0.8	2.4	5.4	464	0	5.0
	6/14/63	GRAB	13	2,512	165	2,347	3.9	100	0.44	TR.	20.0	1,149	0	24
	9/ 5/63	COMPOSITE 3 HOURS *	-	1,644	49	1,595	3.2	80	0.1	0	4.70	-	-	-
	9/ 5/63	COMPOSITE 3 HOURS *	-	8,412	59	8,353	2.4	412	0.32	34	16.4	-	-	-

* PH READINGS AT 20 MINUTE INTERVALS

MAX.	--	10.5
MIN.	--	2.2
AVG.	--	3.7

CHAPTER VI

LOWPHOS ORE LIMITED, MOOSE MOUNTAIN MINE

Lowphos Ore Limited, Moose Mountain Mine is located in Hutton Township about twelve miles north of Capreol. The company went into production in April of 1959 and is engaged in the production of iron ore concentrate.

PERSONNEL

Employment is provided for approximately 250 persons and operations are continuous. Information on operations and assistance in survey work was provided by the following personnel:

Mr. F. Rahne - Plant Superintendent,

Mr. B. Cameron - Mill Superintendent,

Mr. J. Durocher - Chemist.

DESCRIPTION OF PROCESS

Open pit mining operations produce 120,000 tons of crude iron ore per month under normal operating conditions and, from this ore, approximately 50,000 tons of iron ore concentrate are produced each month.

The production of the iron ore concentrate is based on the separation of waste rock from the iron. The raw ore is first crushed until 90% of it is less than 325 mesh. This is done by crushing the ore in jaw crushers, cone crushers, rod mills and ball mills, in that order. Water is first added to the process at the rod mills to provide a transportation medium for the crushed ore.

Following crushing and grinding the powdered ore is subjected to separation by magnetic and hydro separators. The iron-bearing portion of the ore is then subjected to filtration and pelletizing, while the separated waste rock is disposed of as hydraulically transported tailings.

The iron ore concentrate recovered from the hydro separator is filtered and charged to balling drums where the powdered ore is formed into small round balls. These balls are then charged to a furnace for sintering and the product from the furnace is pellets of iron ore concentrate.

Water is used in the furnace to cool the chunk breakers which break up agglomerations of the balls being fed to the furnace. This water is treated and is confined in a closed circuit. The hot water coming from the chunk breakers is cooled by general mill water in a heat exchanger.

WATER SUPPLY

The water necessary to maintain industrial operations is supplied by the Roberts River. Water necessary for domestic purposes is supplied by a dug well and is chlorinated; however, at times when the well supply will not meet the demands, industrial water is used after filtering and chlorination. Since the effluent from the final tailings pond discharges at the location of the mill pumping station, the majority of this discharge is recirculated and it has been estimated that only 1,700,000 to 3,500,000 Imperial gpd is drawn from the river, whereas, the total circulated amount is 15,000,000 to 17,000,000 Imperial gpd.

SOURCES OF WASTE

Wastes from the mill include hydraulically transported tailings, floor washings, and crusher cooling water. The tailings waste stream comprises most of the wastes from the mill. The crusher cooling water flow was estimated to be in the range of 350,000 Imperial gallons per day as was floor washing wastes.

WASTE DISPOSAL

Waste tailings from the mill are pumped to the first of four settling ponds, located in series, north of the mill. These ponds cover approximately 300 acres and are used to settle out solids before the effluent of the fourth pond discharges to the Roberts River at the site of the mill intake.

Crusher cooling water discharges directly to the Roberts River south of the mill while floor washings are collected in a sump and are pumped to the tailings disposal area. At the present time, frequent pump failures result in intermittent discharges of floor washing wastes to the Roberts River south of the mill. (Since the time of the field survey, a new sump pump has been installed to rectify this situation.)

SAMPLING PROGRAMME

A large number of samples have been taken at the Lowphos site since 1960 primarily because of a leak on a tailings pond dyke which caused considerable trouble. However, as the leak has been brought under control, only samples relative to existing conditions will be discussed in this report. All samples taken were grab samples.

ANALYTICAL RESULTS

ALL RESULTS QUOTED IN PPM (PARTS PER MILLION), EXCEPT PH, UNLESS OTHERWISE SPECIFIED

SOURCE	DATE	SOLIDS TOTAL	SOLIDS SUSP.	SOLIDS DISS.	PH AT LAB.	TURBIDITY JACKSON UNITS	IRON AS FE
ROBERTS RIVER UPSTREAM OF MILL	9/27/60	54	8	46	6.7	-	0.56
ROBERTS RIVER DOWNSTREAM OF MILL	9/27/60	66	4	62	7.0	-	0.72
FINAL SETTLING POND EFFLUENT TO ROBERTS RIVER	9/27/60	248	80	168	7.7	-	5
FINAL SETTLING POND EFFLUENT TO ROBERTS RIVER	8/14/63	134	16	118	-	23	0.96
DISCHARGE THROUGH LEAK IN NO. 1 SETTLING POND DYKE	9/10/63	240	62	178	7.5	75.0	4.10
DISCHARGE FROM MILL FLOOR SUMP TO ROBERTS RIVER	9/10/63	5,964	5,824	140	7.8	2,300	175.0
ROBERTS RIVER DOWNSTREAM OF MILL	9/10/63	436	84	352	7.7	40.0	4.5
ROBERTS RIVER UPSTREAM OF MILL	9/10/63	74	6	68	7.2	2.6	0.40

DISCUSSION OF RESULTS

Samples taken in 1960 indicate that little or no polluting material was reaching the Roberts River as a result of the operations of Lowphos Ore, Limited. The sample taken on August 14, 1963, again illustrates that the tailings settling ponds are working efficiently and under normal operations the plant should have little effect on the river.

However, results of samples taken on September 10, 1963 show that a considerable amount of polluting material is reaching the Roberts River. The suspended solids concentration, turbidity, and iron concentration in the river downstream of the mill are several times higher than that upstream. Investigations indicate that this pollution is the result of intermittent failure of the mill's floor sump pumps. These pumps ordinarily pump floor washings to the tailings disposal area, but when the pumps cease to function, these wastes are discharged directly to the river.

A sample of wastes escaping through a dyke leak on No. 1 settling pond, shows that the wastes have a higher suspended solids concentration than the recommended maximum, although they are not as serious in nature as the wastes escaping from the mill floor sump.

CONCLUSIONS AND RECOMMENDATIONS

The company plans to install a new pump which will efficiently handle wastes from the mill floor sump. This work should be carried out as soon as possible. (Has been done since the time of the field survey.)

Efforts should continue to seal all dyke leaks which result in a discharge to the Roberts River. Leaks should be sealed regardless of size, as small leaks may become enlarged if they do not receive prompt attention.

It has been illustrated in the past that the operation of this company need not affect the quality of the Roberts River and a return to these conditions should be expedited.

C H A P T E R V I I

KVP

The operations of the KVP pulp and paper company, located at Espanola, Ontario, were reviewed in conjunction with the water resources survey in the District of Sudbury in September 1961 and November 1963. Information contained in this report was drawn from both field surveys and compiled to present a picture of the position of the company in the fields of water supply and waste disposal.

PERSONNEL

The company provides employment for approximately 1,000 persons, about 200 of which are salaried.

Information on operations and assistance in survey work was provided by the following personnel:

Mr. D. P. Best - Vice-President & Resident Manager,
Mr. J. F. McCallam - Manager of Manufacturing,
Mr. H. D. Paavila - Technical Director,
Mr. R. C. Willey - Laboratory Supervisor.
Mr. X. Cormier

DESCRIPTION OF PROCESS

Operations at the KVP mill at Espanola are based on the production of both Kraft and groundwood pulps which are used in varying mixtures (with Kraft pulp predominating) in the manufacture of final paper products. Pulp production presently amounts to 9,482 tons of Kraft pulp per month and 643 tons of groundwood pulp per month. Wood consumption necessary to produce this pulp is 200,000 cords per year. The mill also processes chipped sawmill waste of which approximately

15,560 cunits are received yearly. (1 cunit =100 cubic feet of solid wood)

Wood is received at the mill through three transportation media which are railway, truck, and water. This wood is debarked and the wood to be treated by the conventional Kraft process is chipped and stored on the premises. Chips are moved to and from the storage piles by pneumatic equipment.

The chips to be processed by the Kraft process are charged to a digester with a white and black liquor mixture. The black liquor is present to maintain proper chemical and volume ratios with the pulp. The chips are cooked in the digester at elevated temperatures and pressures for about two to four hours. During the cooking period, lignins and other organic binding materials are dissolved from the wood leaving free cellulose fibre.

Following cooking, the cooked mixture is vented to a blow tank and from here pumped to a knotter for the removal of knots. The mixture is then charged to a system of washers called the brownstock washers. These washers are operated countercurrently and wash the black liquor, produced during digestion, from the pulp. The washed fibre passes through screens to remove coarse rejects and then over deckers to separate the fibre from the wash water. The washed fibre is then charged to the unbleached Kraft pulp storage chest to await bleaching. Rejects from the screening operation area are mechanically refined and sold as secondary fibre while water from the deckers is discharged to a Kraft white water storage tank. River water is added to the water storage tank as makeup when required.

The Kraft pulp is bleached in a four-stage bleaching system using Cl_2, NaOCl, a mixture of NaOH and NaOCl (essentially caustic), and ClO_2. Initially the pulp is contacted with chlorine gas, washed and then neutralized with sodium hydroxide. This is followed by bleaching and washing in the remaining three stages. The bleached pulp then proceeds either to the kamyr machine where a marketable pulp is produced or to the paper machines where a strong Kraft paper is produced.

The economics of the Kraft process are based on the recovery of chemicals used in the cooking liquor. In order to recover these chemicals, the black liquor, washed from the pulp at the brownstock washers, is charged to a series of evaporators where it is thickened to form a viscous black liquor. This liquor is then charged to a carefully controlled furnace where the organics are burned off and a smelt is formed. This smelt consists of a molten solution of sodium carbonate (Na_2CO_3) and sodium sulphide (Na_2S). In order to replenish the Na_2S lost in the system due to washings, Na_2SO_4 is added to the black liquor before it enters the recovery furnace. In the furnace it is reduced to Na_2S and appears in the smelt.

The smelt is diluted with weak wash water and becomes what is known in the industry as green liquor. This liquor is causticized with slaked lime to produce a solution of Na_2S and NaOH (white liquor) by precipitating the calcium as $CaCO_3$. The $CaCO_3$ sludge is then removed from the white liquor solution and charged to a kiln where the $CaCO_3$ is converted to CaO to be reused in the causticizing reaction following slaking. The white liquor is stored for reuse in the digesting operation.

The KVP Company also operates a groundwood mill at Espanola to produce groundwood pulp for blending with Kraft pulp. Groundwood pulp amounts to approximately 5% of the total pulp output of KVP at Espanola. The production of groundwood pulp is based on the mechanical separation of wood fibres. This is done by forcing the wood against large, rotating, grinding stones. The fibre or pulp produced is charged to a groundwood pulp storage chest from which it is blended with Kraft pulp prior to bleaching.

As an adjunct to the bleaching operation, the company also operates units to produce chlorine, sodium hydroxide, and chlorine dioxide. The chlorine and sodium hydroxide are produced by electrolysis of a brine solution while chlorine dioxide is produced by reacting a solution of $NaClO_3$ and H_2SO_4 with air and sulphur dioxide. In the latter reaction the $NaClO_3$ is reduced and chlorine dioxide and sodium sulphate is formed.

All chlorine, sodium hydroxide and chlorine dioxide produced is used in the bleach plant. The sodium sulphate, produced while making chlorine dioxide, is used as chemical makeup in the Kraft mill.

WATER SUPPLY

Water is pumped from the Spanish River to supply the mill and the Town of Espanola. All of the municipal supply and about half of the mill supply is filtered and chlorinated to a residual of 0.3 parts per million chlorine. Mill pumping capacity is about 18,000,000 Imperial gpd and the average daily consumption is in the range of 16,500,000 Imperial gallons.

SOURCES OF WASTE

Although wastes are produced throughout the process (barking, grinding, chemical pulping, chemical recovery, pulp washing, screening, thickening and paper making) the wastes from the Kraft pulp mill and from the paper mill are felt to be of major importance in assessing the effects on the Spanish River. Principal wastes resulting from the operation are given below followed by a brief statement describing present handling procedures.

1) <u>Condensed Digester Relief Gases</u>:

It is necessary to exhaust gases from the digesters, during the period that wood chips are being cooked, to permit bringing the vessel up to the desired temperature and maintain it throughout the cook. The most volatile by-products of the cook, including much of the crude sulphate turpentine that is produced, are driven off, passed through an entrainment separator and then condensed. The condensates are allowed to settle out and the turpentine layer is removed by decantation to be sold as a by-product. The aqueous layer, containing some turpentine and other emulsified or water soluble components, is drawn off the bottom of the decant vessel. This waste was previously charged directly to the black liquor recovery system; however, present practice is to use this waste plus some black liquor to transport knotter rejects back to the digester. This appears to be a most practical approach to the handling of this waste as it essentially results in a recycle system for the aqueous discharge from the decanter and results in only one point of exit for the crude sulphate turpentines, namely, the point of decant for the crude sulphate turpentine by-product.

2) <u>Blow Tank Condensates</u>:

At the end of the cook, the entire contents of the digester are blown to a central blow tank where the first separation of the pulp and the spent cooking liquor is made. The hot gases from the digester are exhausted from the blow tank through a cyclone separator (to trap fibre) to a hot water accumulator where they are condensed. The resulting hot water is passed through heat exchangers to recover heat, and, is then returned to the hot water accumulator as a condensing medium for incoming gases. The accumulator contents overflow to a surge tank and thence to the sewer. The total volume of waste from this source is approximately 150,000 gallons per day, and, although it has only moderate discolouration, it has a high BOD, is extremely malodorous, and probably contributes heavily to taste and odour problems in the river.

3) <u>Brown Stock Washing</u>:

The pulp-black liquor mixture is pumped from the blow tank to a knotter and thence to three-stage, counter-current, rotary washers, where the separation of the liquor from the fibre is made by displacement with clean water. Excessive foaming and some spillage occurs here at times, and, although these are irregular and unpredictable, they would appear to be important sources of strong wastes from time to time.

The extent of washing is largely determined by the ability of the evaporators to handle the recovered liquor, or, to some extent, by the net economy of recovered chemicals versus heat requirements to remove water. In any case, some carry-over of black liquor to the subsequent pulp screening process, and thence to the sewer in the screen room effluent is inevitable. Although the amount of carry-over is not known, it is felt to be substantial.

4) Black Liquor Evaporators:

The liquor recovered from the brown stock washers is charged to multiple effect evaporators and then to a cascade evaporator in which the solids content is raised by removal of water until a suitable recovery furnace feed is obtained. The condensates from the black liquor evaporators and water used in the barometric leg is discharged to the bleach plant wash water sewer.

5) Tall Oil Recovery:

The recovery of the soap fraction of the black liquor for the production of crude tall oil was begun in November, 1960. The residue, following removal of tall oil, is returned to the black liquor recovery system so that the process is completely closed. No spills of soaps or tall oil have been reported since this unit was installed.

6) Foam and Slime Control:

Excessive foaming in the recovery of black liquor, particularly at the brown stock washers, and to a lesser extent at other points in the process, necessitates the use of mechanical foam breakers and foam control chemicals. Furnace distillates (fuel oil) are used on the first stage of the brown stock washers, most of which is sent to the recovery plant in the recovered black liquor. A carry-over to the screen room, in a proportion similar to the carry-over of black liquor, can be expected. Non-phenolic proprietary compounds (nopco-KFA and Hartex 410 defoamer) have been used in the screen room and paper mill respectively.

Slime control is maintained in the white water system of the paper mill by the use of Dowcide Pentachlorophena. This may be a source of phenolic contamination.

7) Chemical Recovery:

The smelt from the burning of the thickened black liquor is discharged from the furnace to a dissolving tank for use in the regeneration of fresh caustic cooking solution (white liquor). The precipitated calcium carbonate resulting from causticizing this solution is removed, washed, and filtered for return to the kiln for burning to calcium oxide. The effluent from the mud washers is returned to the recausticizers as makeup. The green liquor dregs, consisting of unrecovered mud remaining in the fresh cooking liquor following calcium carbonate removal, are sewered intermittently. While this would not be a major source of river pollution, it would adversely affect the appearance of the final effluent at the time of discharge.

8) <u>Bleach Plant</u>:

Bleach plant wash water is charged directly to the main mill sewer and thence through a dyked area to the river. This sewer is inaccessible for sampling although during the 1963 survey it was possible to sample the main sewer outfall due to low flow conditions in the river. Black liquor evaporator condensate is also disposed of with this waste.

9) <u>Fibre</u>:

All wire pit water from the paper machines is put through save-alls for recovery of fibre. Number one and number two machines are equipped with Oliver rotary save-alls, while number 3 machine is equipped with a Dorr-Oliver-Long disc save-all. Reclaimed fibre is sent to the Jordan chest and then returned to the machines. The clear save-all effluents are used as shower water on the machines, and the cloudy effluents (carrying finely divided fibre) as stock diluent. Excess white water is stored for use in the hydrapulper. The only discharge to the sewers from the machines is the overflow from the white water chests below each save-all.

A sump in the machine room basement receives all machine room floor spillage and stock dumps necessitated by changes from one type of machine feed to another. These losses, formerly sewered, are now pumped to the screenings storage chest and thence to number two Kamyr (pulp) machine.

10) Parchment Area:

An acidic waste amounting to about 200,000 Imperial gpd is discharged from the parchment area by a separate sewer to the main mill sewer just preceding the lagoon at the Spanish River. This waste has not been sampled.

WASTE DISPOSAL

All Kraft and paper mill wastes are discharged to a common sewer and thence through a small lagoon to the Spanish River. Groundwood mill wastes are sewered directly to the river. A summary of flows and waste loadings in all main sewers at the mill is given under the section entitled "Analytical Results."

SAMPLING PROGRAMME

During both the 1961 and 1963 surveys, the basic sampling programme consisted of obtaining in-plant samples from automatic samplers operated by the company and grab samples of the Spanish River at various locations. When

samples could not be obtained from automatic samplers, grab samples were obtained of the flow in the sewer.

Prior to the 1963 survey, it had not been practicable to sample the main sewer discharge to the lagoon or the effluent from the lagoon due to level of the river. However, at the time of the 1963 survey, the river was experiencing extremely low flow conditions and the outfall sewers were readily accessible so composite samples of the flows were obtained.

Schematic diagrams of sewers sampled in 1961 and 1963 are presented on pages 134 and 135. A summary of sewer loadings for 1963 is also presented on page 136.

ANALYTICAL RESULTS

See pages 129, 130, 131, 132 and 133.

ANALYTICAL RESULTS

ALL RESULTS QUOTED IN PPM (PARTS PER MILLION), EXCEPT PH, UNLESS OTHERWISE SPECIFIED

SOURCE	DATE	SOLIDS TOTAL	SOLIDS SUSP.	SOLIDS DISS.		PH AT LAB.	ALKALINITY AS $CACO_3$	LIGNIN AS TANNIC ACID	RESIN ACID SOAPS	PHENOLS PPB	CALCIUM AS CA	SODIUM AS NA	SULPHATE AS SO_4	BOD	NATURE OF SAMPLE
SEWER #1—PART OF BLEACH-PLANT, HOT WATER TANK OVERFLOW, PART OF RECOVERY FURNACE AREA, BLACK LIQUOR STORAGE TANK AREA	9/27/61	1,634	384	1,250		7.1	124	30	< 2	200	-	-	-	130	COMPOSITE 8 AM- 4 PM
	11/ 6/63	1,178 1,008 170	156 142 14	1,022 866 156	DRIED ASHED LOSS	11.1	332	-	-	-	6	350	124	28	COMPOSITE 8 AM- 4 PM
	11/ 6/63	3,120 2,902 218	258 240 18	2,862 2,662 200	DRIED ASHED LOSS	11.9	1,090	-	-	-	-	1,100	-	55	COMPOSITE 4 PM-12 PM
SEWER #2—FLOOR AREA AROUND BROWN STOCK WASHERS, FOAM AND VACUUM SYSTEMS, VAT DRAINS (UNDER BROWN STOCK WASHERS)	9/27/61	194	24	170		7.3	44	22	< 2	1,000				120	COMPOSITE 8 AM- 4 PM
SEWER #2-A—FLOOR AREA AROUND BROWN STOCK WASHERS, VAT DRAINS	11/ 6/63	1,210 720 490	126 8 118	1,084 712 372	DRIED ASHED LOSS	9.7	212	-	-	-	3	170	143	220	GRAB ON 8 AM- 4 PM SHIFT
	11/ 6/63	884 622 262	30 20 10	854 602 252	DRIED ASHED LOSS	9.3	184					145		240	GRAB ON 4 PM-12 PM SHIFT
SEWER #2-B—FOAM AND VACUUM SYSTEMS	11/ 6/63	86 64 22	6 2 4	80 62 18	DRIED ASHED LOSS	7.4	32	-	-	-	6	13	18	54	COMPOSITE 8 AM- 4 PM
	11/ 6/63	94 50 44	20 8 12	74 42 32	DRIED ASHED LOSS	6.9	24	-	-	-	-	12	-	63	COMPOSITE 4 PM-11 PM
SEWER #3—EVAPORATORS AND OLD RECOVERY FURNACE CAUSTIC AREA, AND SULPHUR STORAGE AREA	9/27/61	232	16	216	-	7.6	40	28	< 2	1,500	-	-	-	100	COMPOSITE 8 AM- 4 PM
	11/ 6/63	222 156 66	6 2 4	216 154 62	DRIED ASHED LOSS	8.9	72	-	-	-	6	49	93	124	COMPOSITE 8 AM- 4 PM
	11/ 6/63	182 114 68	12 2 10	170 112 58	DRIED ASHED LOSS	7.6	40	-	-	-	-	34	-	126	COMPOSITE 4 PM-11 PM

ANALYTICAL RESULTS - CON'T.

Source	Date	Solids Total	Solids Susp.	Solids Diss.		pH at Lab.	Alkalinity as $CaCO_3$	Acidity as $CaCO_3$	Lignin as Tannic Acid	Resin Acid Soaps	Phenols PPB	Calcium as Ca	Sodium as Na	Sulphate as SO_4	BOD	Nature of Sample
Sewer #4-- Drains Evaporator Area and Caustic Evaporator Area	9/27/61	452	18	434		6.7	-	6	-	-	6	-	-	-	4.8	Composite 8 AM- 4 PM
	11/ 6/63	4,134 3,574 560	2,268 2,252 16	1,866 1,322 544	Dried Ashed Loss	11.5	570	-	-	-	-	6	390	332	400	Grab on 8 AM- 4 PM Shift
	11/ 6/63	1,486 1,112 374	78 46 32	1,408 1,066 342	Dried Ashed Loss	10.8	360	-	-	-	-	-	280	-	390	Grab on 4 PM-11 PM Shift
Sewer #5-- Drains Digester Area, Accumulator, Decanter, Digester Heaters and Black Liquor Evaporators	9/27/61	434	64	370		9.3	76	-	90	3	4,000	-	-	-	420	Grab on 8 AM-4 PM Shift
	11/ 6/63	492 292 200	86 34 52	406 258 148	Dried Ashed Loss	9.2	120	-	-	-	-	6	86	126	760	Composite 8 AM- 4 PM
	11/ 6/63	616 424 192	62 50 12	554 374 180	Dried Ashed Loss	8.9	124	-	-	-	-	-	100	-	820	Composite 8 PM-11 PM
Sewer #6-- Lime Kiln Area and Liquor Preparation Area, No. 4 and 5 Digesters	9/27/61	3,008	2,318	490	-	10.5	1,140	-	-	-	19	-	-	-	28	Grab on 8 AM- 4 PM Shift
	11/ 6/63	1,064 1,016 48	596 590 6	468 426 42	Dried Ashed Loss	11.3	210	-	-	-	-	3	125	56	32	Grab on 8 AM- 4 PM Shift
	11/ 6/63	49,590 48,950 640	43,460 43,230 230	6,130 5,720 410	Dried Ashed Loss	12.4	4,700	-	-	-	-	*15,000	1,750	-	250	Grab on 4 PM-11 PM Shift
Sewer #7-- #1 Paper Machine Area	9/27/61	282	64	218		5.8	-	28	-	-	0	-	-	-	28	Grab on 8 AM- 4 PM Shift
	11/ 6/63	142 126 16	30 16 14	112 110 2	Dried Ashed Loss	4.6	-	80	-	-	-	6	7	56	2.2	Composite 8 AM- 4 PM
	11/ 6/63	242 128 114	106 12 94	136 116 20	Dried Ashed Loss	4.7	-	44	-	-	-	-	7	-	2.0	Composite 4 PM-11 PM

* Total Calcium

ANALYTICAL RESULTS - CON'T.

Source	Date	Solids Total	Solids Susp.	Solids Diss.		pH at Lab.	Alkalinity as $CaCO_3$	Acidity as $CaCO_3$	Lignin as Tannic Acid	Resin Acid Soaps	Phenols PPB	Calcium as Ca	Sodium as Na	Sulphate as SO_4	BOD	Nature of Sample
Sewer #8— #2 Paper Machine	9/27/61	114	34	80		6.3	-	6	-	-	6	-	-	-	4.8	Grab on 8 AM- 4 PM Shift
	11/ 6/63	616	328	288	Dried	4.7	-	-	-	-	-	6	45	146	43	Composite 8 AM- 4 PM
		238	14	224	Ashed											
		378	314	64	Loss											
	11/ 6/63	890	566	324	Dried	4.7	-	68	-	-	-	-	48	-	53	Composite 4 PM-11 PM
		300	46	254	Ashed											
		590	520	70	Loss											
Sewer #9— Bleach Plant and Kamyr Room	9/27/61	300	150	150	-	4.7	90	90	-	-	50	-	-	-	54	Grab on 8 AM- 4 PM Shift
	11/ 6/63	264	164	100	Dried	6.4	-	12	-	-	-	3	15	16	41	Grab on 8 AM- 4 PM Shift
		58	32	26	Ashed											
		206	132	74	Loss											
	11/ 6/63	250	10	240	Dried	7.0	-	4	-	-	-	-	19	-	44	Grab on 4 PM-11 PM Shift
		68	6	68	Ashed											
		182	4	172	Loss											
Sewer #10— Screen Room	9/27/61	1,376	388	988	-	9.3	220	-	130	5	1,100	-	-	-	340	Grab on 8 AM- 4 PM Shift
	11/ 6/63	1,032	784	248	Dried	6.2	-	48	-	-	-	3	48	34	106	Grab on 8 AM- 4 PM Shift
		178	48	130	Ashed											
		854	736	118	Loss											
	11/ 6/63	5,338	4,976	362	Dried	6.8	-	8	-	-	-	-	68	-	185	Grab on 4 PM-12 PM Shift
		330	70	260	Ashed											
		5,008	4,906	102	Loss											
Sewer #11— Groundwood Mill	9/27/61	950	768	182	-	7.0	8	-	-	-	30				130	Grab on 8 AM- 4 PM Shift
	11/ 6/63	1,018	828	190	Dried	5.6	-	36	-	-	-	3	5.5	16	155	Composite 8 AM- 4 PM
		64	10	54	Ashed											
		954	818	136	Loss											
	11/ 6/63	464	256	208	Dried	6.4	-	44	-	-	-	-	6.5	-	142	Composite 4 PM-11 PM
		74	16	58	Ashed											
		390	240	150	Loss											

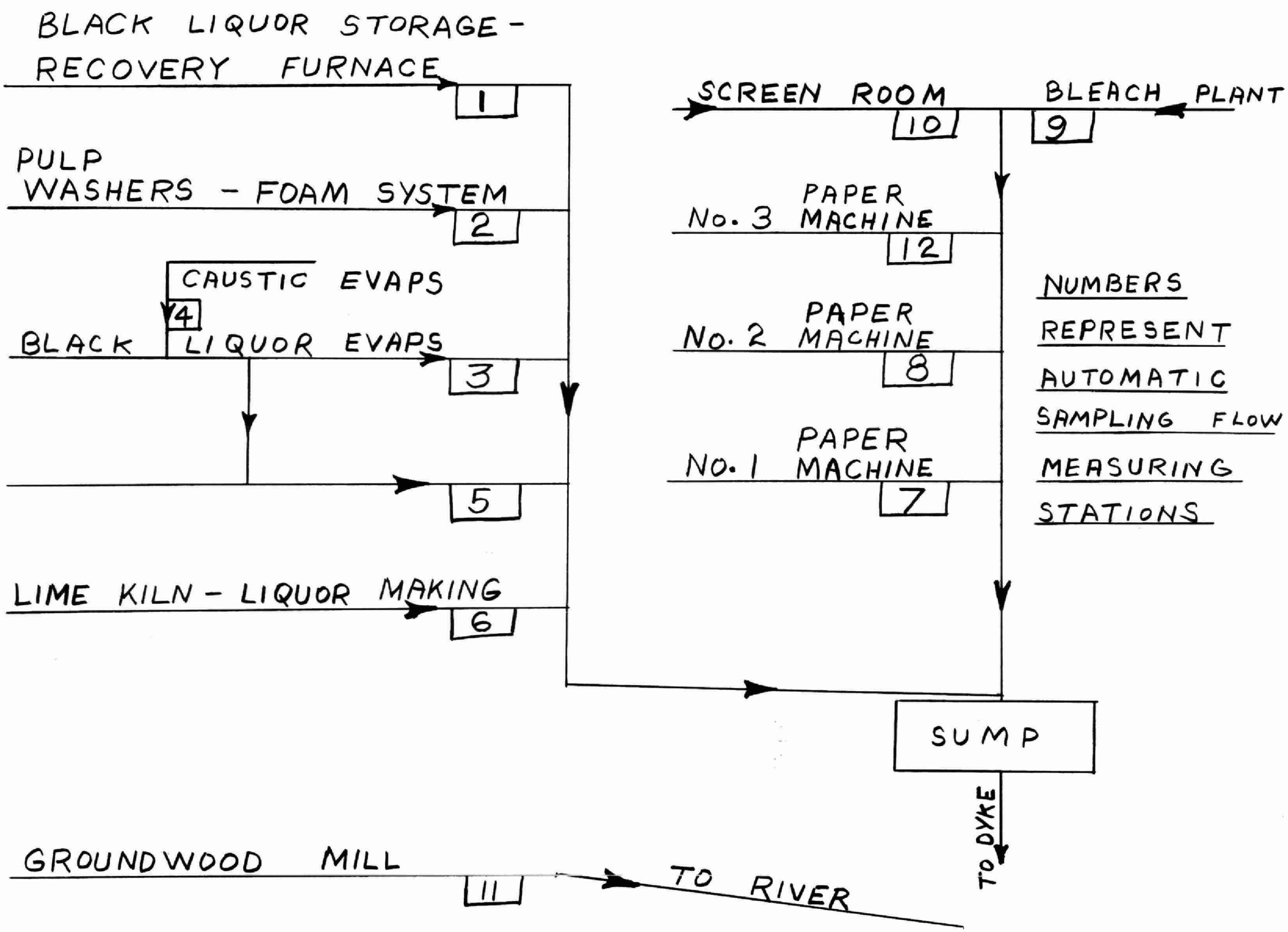
ANALYTICAL RESULTS – CON'T.

Source	Date	Solids Total	Solids Susp.	Solids Diss.		pH at Lab.	Alkalinity as $CaCO_3$	Acidity as $CaCO_3$	Lignin as Tannic Acid	Resin Acid Soaps	Phenols ppb	Calcium as Ca	Sodium as Na	Sulphate as SO_4	BOD	Nature of Sample
Sewer #12— #3 Paper Machine	11/ 6/63	316	178	138	Dried	6.3	–	20	–	–	–	6	18	34	49	Composite 8 AM– 4 PM
		82	2	80	Ashed											
		234	176	58	Loss											
	11/ 6/63	404	192	212	Dried	6.5	–	20	–	–	–	–	24	–	38	Composite 4 PM–11 PM
		230	96	134	Ashed											
		174	96	78	Loss											
Hot Water Accumulator Overflow and Decanter Underflow	11/ 6/63	458	58	400	Dried	9.2	82	–	–	–	–	6	55	53	980	Grab 2:15 PM
		268	0	268	Ashed											
		190	58	132	Loss											
Blow Steam Condensate (Hot Water Accum.) Overflow	9/27/61	596	90	506		8.1	100	–	130	5	11,000				980	
Main Sewer Outfall to the Lagoon on Spanish River	11/ 7/63	1,262	348	914	Dried	7.0	–	68	–	–	–	6	240	–	120	Composite 10 AM–12 Noon
		902	162	740	Ashed											
		360	186	174	Loss											
	11/ 7/63	1,430	472	958	Dried	7.2	128	–	–	–	–	10	240	–	110	Composite 2:15–4:15 PM
		1,022	242	780	Ashed											
		408	230	178	Loss											
Lagoon Discharge to Spanish River	11/ 7/63	1,236	308	928	Dried	7.4	–	34	–	–	–	6	240	36	105	Composite 10 AM–12 Noon
		906	178	728	Ashed											
		330	130	200	Loss											
	11/ 7/63	1,336	360	976	Dried	7.2	122	–	–	–	–	10	250	–	140	Composite 2:15–4:15 PM
		960	162	798	Ashed											
		376	198	178	Loss											

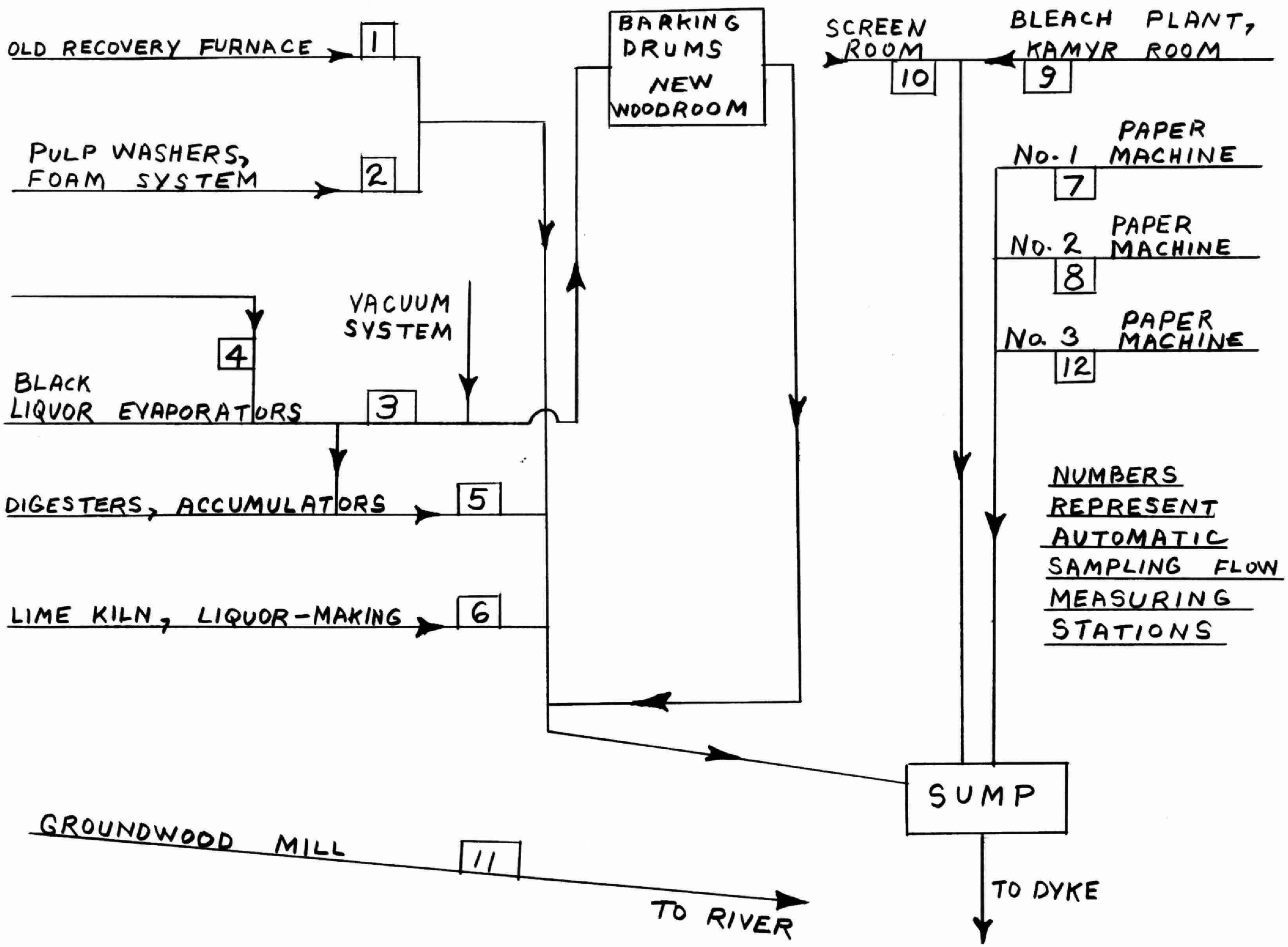
ANALYTICAL RESULTS - CON'T.

SOURCE	DATE	BOD	SOLIDS TOTAL	SOLIDS SUSP.	SOLIDS DISS.		PH AT LAB.	ALKALI-NITY AS $CACO_3$	PHENOLS PPB	TURBI-DITY UNITS	NATURE OF SAMPLE
SPANISH RIVER	9/28/61										
1. NORTH SIDE AT ESPANOLA BRIDGE	"	0.5	50	2	48		7.8	20	0	-	GRAB
2. SOUTH SIDE AT ESPANOLA BRIDGE	"	4.0	92	4	88		7.5	24	2	-	GRAB
3. 2.25 MILES DOWNSTREAM FROM KVP	"	2.0	70	2	58		7.5	12	10	-	GRAB
4. AT WEBBWOOD BRIDGE	"	2.4	60	2	58		7.4	24	16	-	GRAB
5. 0.75 MILES DOWNSTREAM FROM KVP	"	1.2	70	2	68		7.4	16	6	-	GRAB
SPANISH RIVER	11/7/63										
1. NORTH SIDE AT ESPANOLA BRIDGE	"	2.0	80	CLEAR		DRIED	7.2	-	-	2.8	GRAB
			48	"		ASHED					
			32	"		LOSS					
2. CENTRE AT ESPANOLA BRIDGE	"	12.0	216	50	166	DRIED	7.3	-	-	13.5	GRAB
			148	34	114	ASHED					
			68	16	52	LOSS					
3. SOUTH SIDE AT ESPANOLA BRIDGE	"	8.2	170	22	148	DRIED	7.4	-	-	8.0	GRAB
			112	8	104	ASHED					
			58	14	44	LOSS					
4. AT WEBBWOOD BRIDGE	"	2.2	120	CLEAR		DRIED	7.3	-	-	2.9	GRAB
			88	"		ASHED					
			32	"		LOSS					
5. AT SCHOEN'S PROPERTY	"	1.2	118	2	116	DRIED	7.2	-	-	5.5	GRAB
			92	2	90	ASHED					
			26	0	26	LOSS					
6. AT MASSEY BRIDGE	"	1.2	82	CLEAR		DRIED	7.1	-	-	6.0	GRAB
			72	"		ASHED					
			10	"		LOSS					
7. AT SPANISH	"	1.6	76	CLEAR		DRIED	7.2	-	-	2.1	GRAB
			54	"		ASHED					
			22	"		LOSS					

SCHEMATIC FLOW CHART OF MILL SEWERS - 1961



SCHEMATIC FLOW CHART OF MILL SEWERS - 1963



SUMMARY OF SEWER LOADINGS - 1963

SAMPLE POINT	AVERAGE FLOW IMP. GPD	5-DAY BOD PPM	5-DAY BOD LBS/DAY	SUSPENDED SOLIDS PPM	SUSPENDED SOLIDS LBS/DAY
SEWER #1	48,000	42	20	207	99
SEWER #2	312,000	144	450	45	140
SEWER #3	384,000	125	480	9	35
SEWER #5	510,000	790	4,030	74	378
SEWER #6	636,000	32	204	600 *	3,820
SEWER #7	943,200	2.1	20	68	642
SEWER #8	1,692,000	48	813	447	7,570
SEWER #9	682,800	42	287	87	594
SEWER #10	811,200	145	1,178	2,880 *	23,400
SEWER #12	862,800	43	371	185	1,600
TOTAL -	6,882,000		7,853		38,278
SEWER #11	66,670	148	99	542	362
MAIN SEWER DISCHARGE TO LAGOON	16,000,000	115	18,400	410	65,500
LAGOON DISCHARGE TO SPANISH RIVER	16,000,000	122	19,500	334	53,500

* VALIDITY OF FIGURE QUESTIONABLE.

DISCUSSION OF RESULTS

The results of the samples obtained during surveys were realistic and in general agreement with expected results. Deviations from expected results can be attributed to short term fluctuations in waste strength which are not uncommon in the industry. Calculated loadings for sewers number 6, 8, and 10 are suspected of being influenced by such fluctuations and hence a great deal of caution must be taken in interpreting these results.

Total loading figures based on samples obtained of flows to and from the lagoon indicate that the BOD and suspended solids loadings on the river are approximately twice as high as the in-plant samples indicate. This was not unexpected as in-plant sampling and flow metering does not account for approximately 500,000 gpd condensate from black liquor evaporators, 2,700,000 gpd barometric condenser water from the black liquor evaporators, and 6,500,000 gpd of bleach plant wash water. It appears that these flows, which are carried by an inaccessible sewer to the lagoon, contribute as much BOD and suspended solids as the combined loading of other sewers sampled in the plant.

Sample results indicate that over 25% of the BOD loading charged to the river originates in the areas drained by number 5 and number 10 sewers. As indicated above, the inaccessible sewer from the bleach plant area also contributes heavily to the BOD loading on the river, since most of the non-cellular components of the wood that remain in the pulp after the brown stock washers are removed in bleaching and are sewered.

Sample results also indicate that most of the suspended solids discharging to the river can be accounted for in a few sewers. Those making the largest contributions appear to be sewers number 6, 8, 10 and 12. As mentioned previously, the reliability of results for sewers number 6, 8, and 10 is questionable and it is suspected that the average daily loadings for sewers number 8, and 10 are lower and that for number 6 is higher than figures given in the sewer loading summary presented in this report. The inaccessible bleach plant sewer also appears to contribute heavily to the suspended solids loading on the river.

It was hoped that the contribution of sewer number 6 to the total loading on the river could be ascertained by determining the calcium content in the effluent. However, as dissolved calcium rather than total calcium determinations were made on the samples this could not be done.

Analysis made for lignins during the 1961 survey indicate that the main sources of non-cellular material in the mill are the digester, black liquor evaporator, and brown stock washing areas. These wastes likely contain the materials responsible for taste and odour problems experienced in the Spanish River.

Although it is difficult to assess the fibre loss from the mill, some effort has been made to do so. Assuming that all combustible suspended solids in the main sewer outfall and groundwood mill outfall to the river are comprised of fibre, the total fibre loss from the mill is approximately 13.2 tons. Based on a total pulp production of approximately 340 tons per day, this represents a fibre loss from the mill of about 3.9%.

CONCLUSIONS AND RECOMMENDATIONS

On the average, conditions have not changed a great deal between 1961 and 1963 surveys with respect to in-plant sewer loadings of BOD and suspended solids. It is felt that the present method of disposing of the crude sulphate turpentine decanter underflow may somewhat alleviate the taste and odour problem in the river. However, this problem is likely to persist until such time as the hot water accumulator waste from the digester area is disposed of in an alternate manner. This conclusion is substantiated by the fact that the marketing of fish caught in the North Channel at the mouth of the Spanish River continues to be a problem to commercial fishermen in the area. Past experience has also indicated that the use of fuel oil as an anti-foaming agent may also result in taste and odour problems and since the company uses a considerable amount of oil for this purpose this may be partly responsible for the problems in the river.

It was fortunate, from a survey point of view, that the river flow was minimal at the time of the 1963 survey as this permitted the main sewer outfall from the mill to be sampled for the first time. Results of the samples substantiated what had been expected and indicated a BOD loading in the order of nine tons per day and a suspended solids loading in the order of 25 to 30 tons per day. This indicates that approximately 50% of the BOD and suspended solids are not accounted for by in-plant samplers. For this reason, it is recommended that the company provide for automatic sampling and continuous flow recording of the flow in the main mill effluent sewer just prior to the lagoon. Provision of such facilities will permit closer surveillance of wastes discharging to the river via the lagoon.

As can be noted by the samples of the influent and effluent of the lagoon on the Spanish River, this lagoon does not perform effectively in reducing suspended solids and BOD in the mill discharge.

Thus the lagoon could not be considered to be an efficient form of primary treatment. However, the lagoon does operate effectively as a foam trap. The fact that the liquid level, and hence the retention time, of the lagoon is ultimately controlled by the flow level of the river results in poor performance of the lagoon as a waste treatment facility when the river level is low.

It would appear that the company has reached the level where further in-plant controls to reduce pollution would result in only a minimal reduction in waste loadings on the river. However, the waste discharges continue to carry contaminants to the river in amounts considered unfavourable if the river is to be used for all reasonable purposes in the future. Therefore, it is recommended that the company initiate studies into the provision of treatment for the wastes. It is suggested that a programme be followed whereby primary treatment for the total discharge or for specific segregated wastes is considered first, to be followed by secondary treatment at a later date.

At the time of the survey the flow in the river was much below normal (November 5, 1,395 cfs and November 6, 2,115 cfs) and it is felt for this reason the solids were settling to the bottom within a short distance from the plant. In order to detect the effect of the resulting deposits over the years an extensive biological survey of the river would be necessary. Past biological surveys have indicated that the bottom fauna in the river are limited in both production and diversity of species, and this is considered to be due to the deposition of pulp fibre on the river bottom.

The general appearance of the river was, as a whole, quite good, and floating fibre mats, visible in previous surveys, were absent on the day of the survey. However, a good deal of suspended fibre was visible in the upper reaches of the river near the mill as well as what appeared to be a slick of oily substance which extended for a short distance downstream of the mill. The source of this oily material should be determined and suitable control effected.