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Yellowknife, N.W.T.

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*cc - R. Morton - I. Price*

April 18, 1979

Your file    Votre référence

Our file    Notre référence

4123-7

Mr. W. Moore  
Manager  
Giant Yellowknife Mines Ltd.  
Yellowknife, N.W.T.  
XOE IHO

Dear Mr. Moore:

Re: EPS Stack Sampling Report

Attached is a copy of the draft report entitled "Measurement of Arsenic Emissions from Gold Roasting Operations - Giant Yellowknife Mines Ltd., Yellowknife, N.W.T."

The report contains the sampling results from the survey carried out in August 1978. It is being forwarded to you for your information and comment.

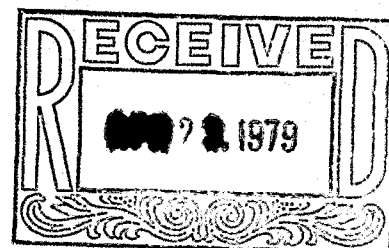
I wish to thank you for the stack emission data recently forwarded by you staff. It is presently being reviewed.

Yours truly,

Tom Dafoe  
Manager, Environmental Engineer  
Environmental Protection Service

TD/jmc.

cc: H. Veldhuizen



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TABLE OF CONTENTS

|  | PAGE |
|--|------|
| APPENDIX I            Sampling Data - Sulphur Oxides                   | 28   |
| APPENDIX II          Sampling Data - Arsenic and Total<br>Particulates | 30   |
| APPENDIX III         Analytical Results                                | 40   |

MEASUREMENT OF ARSENIC EMISSIONS  
FROM GOLD ROASTING OPERATIONS  
GIANT YELLOWKNIFE MINES LTD.  
YELLOWKNIFE, N.W.T.

by

RAY CAPOWSKI

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Air Pollution Control Section  
Environmental Protection Service  
Northwest Region  
Edmonton, Alberta  
December, 1978

DRAFT

TABLE OF CONTENTS

|   | PAGE |
|---|------|
| LIST OF TABLES  | iii  |
| LIST OF FIGURES                                       | iii  |
| 1 INTRODUCTION  | 1    |
| 2 PROCESS DESCRIPTION                                 | 3    |
| 3 SAMPLE SITE AND TRAVERSE POINTS                     | 9    |
| 4 SAMPLING PROCEDURES                                 | 10   |
| 4.1 Dry Gas Composition                               | 10   |
| 4.2 Sulphur Dioxide and Sulphuric Acid Mist           | 10   |
| 4.3 Total Particulates and Moisture                   | 10   |
| 4.4 Arsenic   | 10   |
| 4.5 Other Heavy Metals                                | 11   |
| 5 ANALYTICAL METHODS                                  | 12   |
| 6 RESULTS   | 14   |
| 6.1 Sulphur Dioxide and Sulphuric Acid Mist Emissions | 14   |
| 6.2 Total Particulate Emissions                       | 14   |
| 6.3 Arsenic Emissions                                 | 14   |
| 6.3.1 Arsenic Sample Recovery                         | 14   |
| 6.4 Other Heavy Metal Emissions                       | 19   |
| 6.5 Analytical Methods                                | 19   |
| 7 DISCUSSION OF RESULTS                               | 22   |
| 8 CONCLUSIONS AND RECOMMENDATIONS                     | 24   |
| REFERENCES  | 26   |
| ACKNOWLEDGEMENTS                                      | 27   |

DRAFT

### LIST OF TABLES

| NUMBER |  | PAGE |
|--------|--|------|
| 1      | SURVEY SCHEDULE                                    | 5    |
| 2      | PLANT OPERATING DATA                               | 6    |
| 3      | EMISSION CONTROL DATA - ELECTROSTATIC PRECIPITATOR | 7    |
| 4      | EMISSION CONTROL DATA - BAGHOUSE                   | 8    |
| 5      | SUMMARY OF SULPHUR DIOXIDE EMISSIONS               | 15   |
| 6      | SUMMARY OF ARSENIC AND TOTAL PARTICULATE EMISSIONS | 16   |
| 7      | ARSENIC COLLECTED IN SAMPLE TRAIN COMPONENTS       | 17   |
| 8      | ARSENIC SAMPLE RECOVERY RESULTS                    | 18   |
| 9      | SUMMARY OF OTHER HEAVY METAL EMISSIONS             | 20   |
| 10     | ANALYTICAL METHODS, QUALITY CONTROL - ARSENIC %    | 21   |

### LIST OF FIGURES

| NUMBER |  | PAGE |
|--------|--|------|
| 1      | PROCESS FLOW DIAGRAM, GIANT YELLOWKNIFE MINES LTD. | 4    |

DRAFT

## 1 INTRODUCTION

In August of 1978, the Air Pollution Control Section of the Environmental Control Branch of EPS, Northwest Region, performed a stack emission survey at Giant Yellowknife Mines Ltd. in Yellowknife, N.W.T. Personnel included Mr. Roy Prokopuk, Mr. R. Clough and Mr. S. Shewchuk with EPS in Edmonton and Mr. P.K. Leung with the Source Monitoring Section, Surveillance Division, APCD, Ottawa.

Earlier work performed for the purpose of the development of a particulate emission test method for arsenic from gold roasting operations was carried out by the Surveillance Division of EPS during July, 1976 at Campbell Red Lake Mines in Balmertown, Ontario. Initial testwork had also taken place at Giant Yellowknife Mines in August, 1975, utilizing the methods as described in report EPS-1-AP-74-1, "Standard Reference Methods of Source Testing: Measurement of Emissions of Particulate from Stationary Sources", as published by Environment Canada. As a result of these surveys and other development work performed by Chemistry Division, APCD, Ottawa, a reference method for source testing was drafted: Measurement of Arsenic Emissions from Gold Roasting Operations was written in May, 1978 by Surveillance Division, APCD, Ottawa.

There were, however, a number of recommendations resulting from these programs and before finalizing the method, additional evaluation of certain procedures described in the method was in order. These recommendations formed the basis of much of the 1978 Giant Yellowknife Mines Ltd. testwork. The primary objective was to validate the draft Reference Method: "Measurement of Arsenic Emissions from Gold Roasting Operations" along with a modified sample recovery program. In the proposed arsenic method, the sample recovery procedures specify a caustic wash although the earlier development work on the method was carried out using water as the primary recovery agent. Therefore, the following sample recovery program was carried out:

Container 1 - Front half water/acetone wash including any material brushed from the probe and nozzle interior surfaces.

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Container 2 - Caustic (5% NaOH) wash of front half. Completely fill the probe and let stand for 5 minutes or half-fill and agitate for five minutes.

Container 3 - Repeat caustic wash.

Container 4 - Rinse front half with acid (5% HNO<sub>3</sub>) followed by a water rinse.

Preliminary indications from a similar multi-wash project carried out on a different survey had indicated that present procedures may not be sufficiently rigorous. It was hoped that the results from the enclosed tests would provide the required information to allow one to recommend a procedure that would quantitatively recover arsenic which adheres to the interior surfaces of the sampling train.

These series of tests were also performed to obtain values for the arsenic emission rates from Giant Yellowknife Mines Ltd. roasting operations utilizing the present state of the art, namely, the draft standard reference method and to quantify the total particulate emissions associated with these arsenic emissions. A further series of tests were conducted to quantify the sulphur dioxide emissions according to methods described in report EPS-1-AP-74-3, Standard Reference Methods for Source Testing: "Measurement of Sulphur Dioxide from Stationary Sources".

This report describes briefly the methods used and some of the limitations and difficulties encountered during their application. Based on the results of this program, comments on method suitability and recommendations to improve their performance are made.

It must be emphasized that due to the exploratory nature of method development, the calculated emission rates reported herein may not be entirely representative of this source.

DRAFT

2 PROCESS DESCRIPTION

A complete description of the process is contained in report EPS-4-NW-78-1, "Development of an Arsenic Measurement Method on a Gold Roasting Operation", published by EPS, Northwest Region in February, 1976. The process is shown schematically in Figure 1. Tables 2, 3 and 4 represent the operating conditions which were present during this study. The roaster was operating at a reduced feed rate because of mill concentrate shortages and therefore, the throughput was atypical. The percentages of arsenic and sulphur contained within the roaster feed are typical of normal values.

The baghouse, which normally operates with all eight compartments for a total of 2,400 orlon bags, was currently undergoing some modifications in bag type and was operating with seven compartments and only 2,100 bags. The bags were a mixture of Universal and Porter-Spencer type. As a result of these changes the bags were vibrated on a predetermined pressure setting instead of the normal timed sequences of eight cycles per day. Under this arrangement the bags were being cleaned approximately four times daily. This change in operating mode may affect the emissions somewhat with a tendency to decrease the amount of particulate matter which would become re-entrained into the gas stream with each shaking cycle.



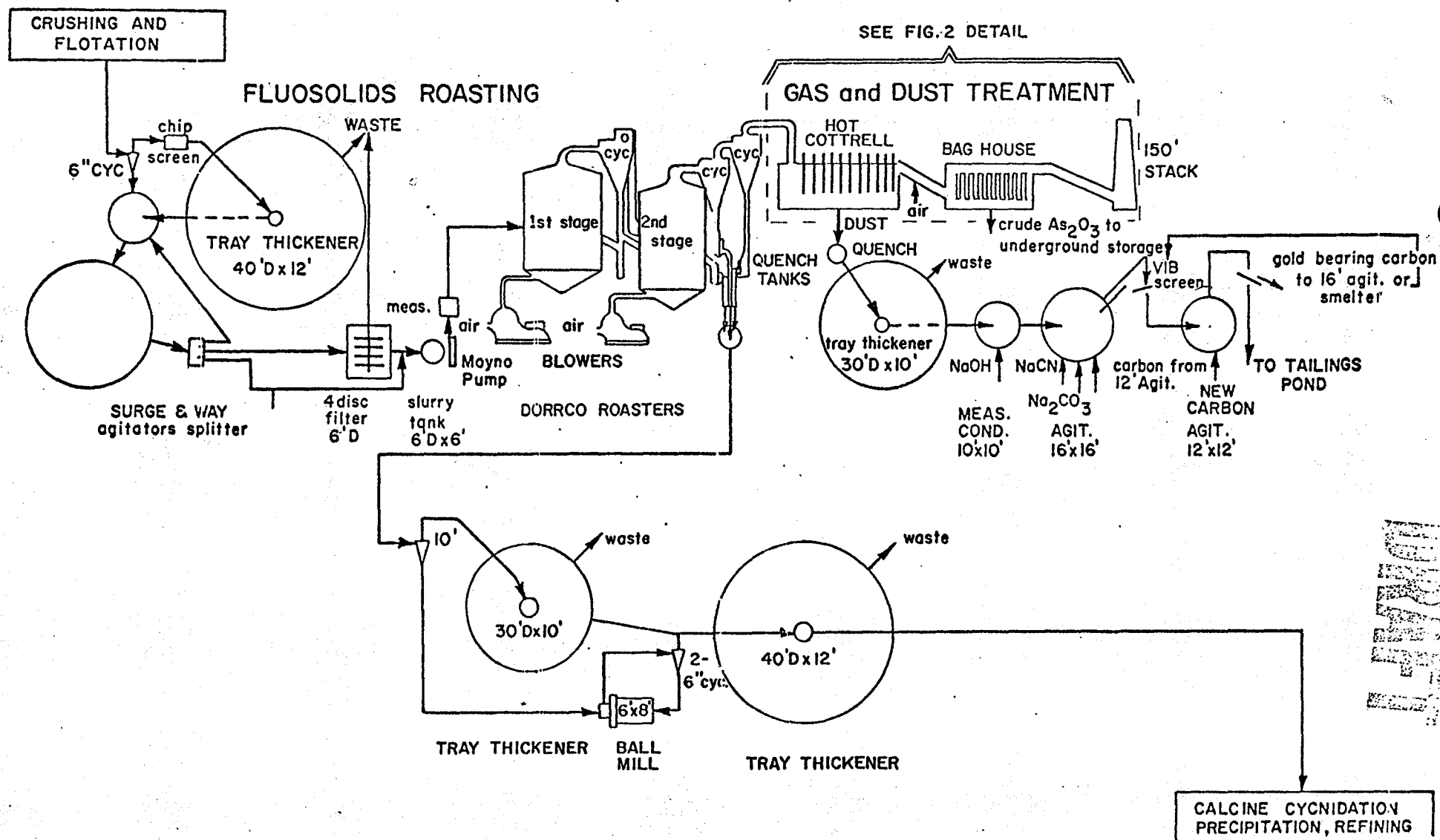


FIGURE 1 PROCESS FLOW DIAGRAM GIANT YELLOWKNIFE MINES LTD.

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TABLE 1 SURVEY SCHEDULE - GIANT YELLOWKNIFE MINES, YELLOWKNIFE, N.W.T.

| Parameter       | Run No.     | Date      | Time         |
|-----------------|-------------|-----------|--------------|
| Arsenic         | 1           | Aug 17/78 | 9:05 - 12:40 |
| Arsenic         | 2           | Aug 18/78 | 9:00 - 12:50 |
| Arsenic         | 3           | Aug 19/78 | 9:05 - 13:15 |
| SO <sub>2</sub> | Preliminary | Aug 16/78 |              |
| SO <sub>2</sub> | 1S          | Aug 17/78 |              |
| SO <sub>2</sub> | 2S          | Aug 18/78 |              |
| SO <sub>2</sub> | 3S          | Aug 19/78 |              |

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TABLE 2 PLANT OPERATING DATA - GIANT YELLOWKNIFE MINES, YELLOWKNIFE, N.W.T.

| Date      | Roaster Feed<br>Rate Tons/hr | Operating hrs | Arsenic %<br>By Weight | Sulphur %<br>By Weight |
|-----------|------------------------------|---------------|------------------------|------------------------|
| Aug 16/78 | 5.80                         | 16.0          | 8.08                   | 19.07                  |
| Aug 17/78 | 5.82                         | 23.8          | 8.73                   | 18.84                  |
| Aug 18/78 | 5.51                         | 24.0          | 8.70                   | 18.96                  |
| Aug 19/78 | 5.52                         | 24.0          | 8.70                   | 18.96                  |

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TABLE 3

EMISSION CONTROL DATA - ELECTROSTATIC PRECIPITATOR  
GIANT YELLOWKNIFE MINES, YELLOWKNIFE, N.W.T.

| Date   | <u>Precipitator Temperatures °F</u> |        | Dust Collected - TPD |
|--------|-------------------------------------|--------|----------------------|
|        | Inlet                               | Outlet |                      |
| Aug 16 | 696                                 | 560    | 13.3                 |
| Aug 17 | 698                                 | 550    | 13.3                 |
| Aug 18 | 698                                 | 533    | 13.3                 |
| Aug 19 | 692                                 | 548    | 13.3                 |

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TABLE 4

EMISSION CONTROL DATA - BAGHOUSE  
GIANT YELLOWKNIFE MINES, YELLOWKNIFE, N.W.T.

| Date   | Baghouse<br>Temp - °F | Pressure<br>Drop-in H <sub>2</sub> O | Dust Collected - TPD |
|--------|-----------------------|--------------------------------------|----------------------|
| Aug 16 | 220                   | 2.1                                  | 9.2                  |
| Aug 17 | 220                   | 2.1                                  | 9.6                  |
| Aug 18 | 220                   | 2.2                                  | 9.6                  |
| Aug 19 | 220                   | 2.2                                  | 9.6                  |

### 3 SAMPLE SITE AND TRAVERSE POINTS

Sampling for arsenic and other gaseous emissions were carried out downstream of the baghouse and induced draft fan at the 60 foot level of the 150 foot stack.

The 9 foot diameter stack was divided into 32 equal areas and traversed through two ports located at 90 degrees to each other, with 16 points being sampled from each port. Each point was sampled for 5 minutes for a total sample time of 160 minutes. Points closest to the stack walls were extremely difficult to sample because of flow irregularities, so the sample times on points 2, 15, 18, and 31 were doubled to 10 minutes and points 1, 16, 17, and 32 were not sampled. All sample recovery, dry gas analysis, sulphur oxides and moisture determinations were conducted in Giant Yellowknife Mines Ltd. mill laboratory.

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#### 4 SAMPLING PROCEDURES

##### 4.1 Dry Gas Composition

Gas samples from the stack were removed daily for molecular weight determinations in accordance with Method C of report EPS-1-AP-74-1. The  $O_2$  and  $CO_2$  concentrations in the flue gas were determined using Fyrite kits. Sulphur oxide concentrations were determined in accordance with Standard Reference Methods for Source Testing: "Measurement of Emissions of Sulphur Dioxide from Stationary Sources" (EPS-1-AP-74-3). Nitrogen was calculated by difference.

##### 4.2 Sulphur Dioxide and Sulphuric Acid Mist

Measurements for sulphur dioxide were conducted according to methods published in report EPS-1-AP-74-3. The gas sample was taken from a single point and passed through a heated probe to the impinger train where the gas was first scrubbed for  $SO_3$  in an isopropanol impinger before entering the  $H_2O_2$  impingers for  $SO_2$  removal.

##### 4.3 Total Particulates and Moisture

Stack gas samples for particulate determination were removed from the stack according to Method E of the federal standard reference method for source testing. An acetone/water wash was used as the first rinse on the front half of the sampling train to collect total particulates. The particulate loading was then determined gravimetrically after removal of uncombined water from the previously mentioned sample and adding this dry weight to the dry weight of particulate matter collected on the filter. There was no inclusion of weight from the back half of the sampling train in the determination of total particulate loading.

Moisture content of the gas stream was determined in accordance with Method D of the federal standard reference methods for source testing by relating this to the total volume sampled.

##### 4.4 Arsenic

The development of this method is the major concern of this report. A draft reference method for the measurement of arsenic emis-

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sions from gold roasting operations was published in May, 1978. The method describes a procedure to measure the particulate and gaseous arsenic emissions where the material is primarily arsenious oxides. A few modifications to this sampling procedure were evaluated including; sequential washing of the entire front half and back half of the sampling train with acetone/water, 5% w/v sodium hydroxide, 5% w/v nitric acid and distilled water to effectively remove all traces of particulate arsenic adhering to the interior surfaces of the sampling train. Also, an evaluation of a more vigorous digestion technique on the collected arsenic was conducted in order to overcome the cohesive effects of various arsenic matrices in the collected dusts. The total arsenic weight and subsequent emission rate were determined from the addition of all washings utilizing the modified laboratory procedure - fusion of all particulate matter with sulphate followed by analysis using a Perkin Elmer 360 with graphite furnace.

#### 4.5 Other Heavy Metals

Other parameters such as antimony, iron and copper were determined in both the dry particulate and scrubbed gases for information purposes only.



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5 ANALYTICAL METHODS

Analyses were carried out for:

- a) A quantitative analyses for arsenic on samples obtained from the roaster feed and baghouse, utilizing two different methods of digestion; and
- b) Arsenic, antimony, iron and copper on the probe and nozzle wash, filters, impinger solutions and impinger wash solutions utilizing the fusion technique with sulphate only.

In previous studies<sup>1</sup> the particulate samples were digested in hot 2% sodium hydroxide and the determination for arsenic was performed using a colorimetric technique developed by Vasak and Sedivec.<sup>2</sup> These methods neglected to consider the cohesion effects of the arsenic matrices in possible flue dust sources - ore concentrates, roaster feed, cottrell dust and baghouse dust. In discussion with personnel from Giant Yellowknife Mines Ltd. it was suggested that a more vigorous digestion of the stack sampling particulate was necessary to extract the arsenic into solution prior to analysis via spectrophotometry. Therefore, samples of roaster and baghouse dust were analyzed using two different procedures prior to analyzing the samples obtained from the emission tests.

In method A, 0.2 grams of sample was digested in hot 2% w/v sodium hydroxide. The unfiltered sample was then diluted in a 100 millilitre volumetric flask. An aliquot of this sample was further rediluted with nickel nitrate and nitric acid. Analysis was completed on a graphite furnace Perkin Elmer 360 atomic absorption spectrophotometer.

In method B, 0.2 grams of sample was digested with 15 millilitres of concentrated nitric acid and 10 millilitres of concentrated sulphuric acid. The sample was further evaporated to sulphuric acid fumes. The residue was fused with 6 grams of sodium sulphate salt over a bunsen burner. This sample was diluted to volume in a 100 millilitre volumetric flask and an aliquot rediluted with nickel nitrate. Analysis was completed on a graphite furnace Perkin Elmer 360 atomic absorption spectrophotometer.

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The analyses were performed on all emission test samples utilizing method B for arsenic, antimony, iron and copper.

The total particulate results were determined after desiccating the filter and the front half acetone/water wash for 24 hours and weighing all material collected.

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## 6 RESULTS

### 6.1 Sulphur Dioxide and Sulphuric Acid Mist Emissions

Sulphur dioxide emissions were measured in conjunction with the arsenic tests. The average concentration of sulphur dioxide was found to be 25.1 g/scm with a standard deviation of 6.1 g/scm. The average sulphur dioxide mass emission rate was found to be 37,845 kg/day. Table 5 presents the individual sulphur dioxide test results. The flow rates applied to these tests were determined from the arsenic tests. Sampling data and analytical results are contained in Appendix 1.

### 6.2 Total Particulates Emissions

Particulate emissions were calculated from the gravimetrically determined weights of particulate caught on the filter and nozzle probe assembly. The average particulate concentration was found to be 39.9 mg/scm. The average mass emission was calculated to be 57.0 kg/day. Table 6 contains the individual test results.

### 6.3 Arsenic Emissions

Arsenic emissions were calculated from the weights collected in the front half, filter, and back half portion of the sampling assembly. The average arsenic concentration was found to be 26.0 mg/scm. The average mass emission was calculated to be 35.7 kg/day. Table 6 contains the individual test results. Sampling data and a summary of percent isokineticity achieved is contained in Appendix 2.

#### 6.3.1 Arsenic Sample Recovery

The arsenic content of the various sample train components is given in Tables 7 and 8. Approximately 25 percent of the arsenic collected was contained within the impinger portion of the sampling train. The concentration of arsenic in the impingers averaged 7.1 mg/scm with a standard deviation of 2.2 mg/scm. The percent total arsenic to total particulates was approximately 60%. The total particulate portion, however, does not contain any weights from the back half of the sampling train.

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TABLE 5

SUMMARY OF SULPHUR DIOXIDE EMISSIONS  
GIANT YELLOWKNIFE MINES, YELLOWKNIFE, N.W.T.

| Run No. | Date   | Stack Flow Rate <sup>1</sup><br>SCM/MINUTE | SO <sub>2</sub> Concentration<br>G/SCM | SO <sub>2</sub> Emission Rate<br>KG/DAY |
|---------|--------|--|--|---|
| 1S      | Aug 16 | N/A  | 31.2                                   | N/A                                     |
| 2S      | Aug 17 | 832  | 22.6                                   | 37,380                                  |
| 3S      | Aug 18 | 1074                                       | 21.3                                   | 34,950                                  |
| 4S      | Aug 19 | 1131                                       | 25.3                                   | 41,205                                  |
| AVERAGE |        |  | 25.1                                   | 37,845                                  |

Note:

- 1 Accuracies limited due to problems associated with measurement of low stack velocities (scm = Standard cubic metre @ 21°C, 1 atm)

TABLE 6

SUMMARY OF ARSENIC AND TOTAL PARTICULATE EMISSIONS  
GIANT YELLOWKNIFE MINES, YELLOWKNIFE, N.W.T.

| Run No. | Date      | Stack Flow <sup>1</sup><br>SCM/MINUTE | Arsenic <sup>2</sup><br>Concentration<br>MG/SCM | Particulate <sup>3</sup><br>Concentration<br>MG/SCM | Mass Emissions <sup>4</sup> |                       |
|---------|-----------|---------------------------------------|---|---|-----------------------------|-----------------------|
|         |           |                                       |   |   | Arsenic<br>KG/DAY           | Particulate<br>KG/DAY |
| 1       | Aug 17/78 | 832                                   | 26.0  | 48.8  | 31.2                        | 58.5                  |
| 2       | Aug 18/78 | 1074                                  | 26.0  | 39.0  | 40.2                        | 60.3                  |
| 3       | Aug 19/78 | 1131                                  | N/A   | 32.0  | N/A                         | 52.1                  |
| AVERAGE |           |                                       | 26.0  | 39.9  | 35.7                        | 57.0                  |

Note:

1. Accuracies limited due to problems associated with measurement of low stack velocities (SCM = Standard cubic metre @ 21°C, 1 atm).
2. Values reported include impinger portion (back half) and complete sample recovery - acetone/water, sodium hydroxide, nitric acid, water.
3. Sample recovery includes front half with acetone/water wash only.
4. All values reported are of limited accuracy because of (1) above.

TABLE 7

## ARSENIC COLLECTED IN SAMPLE TRAIN COMPONENTS - MG

| Run No. | Nozzle/Probe<br>Front Half | Filter | Impinger<br>Back Half | Total | Percentage<br>of Impinger<br>Catch As | MG/SCM As<br>in Impingers | Percentage As<br>to Total<br>Particulates |
|---------|----------------------------|--------|-----------------------|-------|---------------------------------------|---------------------------|---|
| 1       | 22.4                       | 14.9   | 8.5                   | 45.8  | 18.6                                  | 4.9                       | 53.9                                      |
| 2       | 39.2                       | 10.2   | 23.8                  | 73.2  | 32.5                                  | 8.4                       | 65.9                                      |
| 3       | 33.4                       | N/A    | 23.3                  | N/A   | N/A                                   | 7.9                       | N/A                                       |
| AVERAGE |                            |        |                       |       | 25.6                                  | 7.1                       | 59.9                                      |

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TABLE 8 ARSENIC SAMPLE RECOVERY RESULTS -  $\mu\text{g}$

NOZZLE/PROBE, FRONT HALF

| RUN NO. | DATE      | ACETONE WASH | HYDROXIDE WASH | ACID WASH | WATER WASH |
|---------|-----------|--------------|----------------|-----------|------------|
| 1       | Aug 17/78 | 17,400       | 4,900          | 75        | 35         |
| 2       | Aug 18/78 | 28,400       | 10,600         | 91        | 58         |
| 3       | Aug 19/78 | 22,200       | 10,950         | 170       | 88         |

IMPINGER, BACK HALF

|   |           |        |       |     |    |
|---|-----------|--------|-------|-----|----|
| 1 | Aug 17/78 | 6,062  | 2,350 | 68  | 19 |
| 2 | Aug 18/78 | 15,425 | 8,275 | 106 | 80 |
| 3 | Aug 19/78 | 16,802 | 5,400 | 118 | 29 |

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The recovery of arsenic from the nozzle-probe assembly and impinger portion utilizing the various washing procedures is detailed in Table 8. The wash procedure, using an organic solvent followed by two successive rinses with a caustic reagent, was sufficient to remove in excess of 99% of the measured arsenic. The acid wash removed only 0.5% of the total arsenic collected and measured.

#### 6.4 Other Heavy Metal Emissions

The summary of other heavy metal emissions are detailed in Table 9. The concentration of antimony and iron were 0.92 mg/scm and 9.92 mg/scm respectively, while the mass emissions of the same two elements were 1.31 kg/day and 14.27 kg/day. These values include the entire front half and back half portion of the sampling train with complete sample recovery - acetone/water, sodium hydroxide, nitric acid, and water wash.

#### 6.5 Analytical Methods

All analytical results are contained in Appendix 3. The method of analysis was that which is described in section 5 as Method B. A summary of the results obtained from a comparison of two different digestion techniques is detailed in Table 10. The major differences in techniques is recognized in the results of the analysis performed on the roaster feed. EPS Method A averaged 2.1% arsenic while EPS Method B averaged 10.0% arsenic. The roaster feed normally averaged 8 to 10 percent arsenic as confirmed by Giant Yellowknife Mines Ltd. personnel. EPS Method B would appear to be the preferred method of analysis for this particular product and for any form of particulate matter which may contain portions of this product. Some roaster feed may be escaping collection in the control system and reporting in the stack emission. It was therefore decided to utilize EPS Method B in all subsequent analyses. The analysis performed on samples of baghouse dust utilizing the two different methods of digestion gave comparable results as depicted in Table 10. The primary form of arsenic contained in that product would be the trivalent form as arsenious oxide ( $\text{As}_2\text{O}_3$ ). Both methods of digestion would be suitable for the analysis of arsenic in that form.



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TABLE 9

SUMMARY OF OTHER HEAVY METAL EMISSIONS  
GIANT YELLOWKNIFE MINES, YELLOWKNIFE, N.W.T.

| Run No. | Date   | Stack Flow<br>scm/minute | Antimony <sup>1</sup>   | Iron <sup>1</sup>       | Mass Emission      |                |
|---------|--------|--------------------------|-------------------------|-------------------------|--------------------|----------------|
|         |        |                          | Concentration<br>mg/scm | Concentration<br>mg/scm | Antimony<br>kg/day | Iron<br>kg/day |
| 1       | Aug 17 | 832                      | 1.15                    | 11.45                   | 1.38               | 13.72          |
| 2       | Aug 18 | 1074                     | 0.92                    | 9.16                    | 1.42               | 14.17          |
| 3       | Aug 19 | 1131                     | 0.69                    | 9.16                    | 1.12               | 14.92          |
| AVERAGE |        |                          | 0.92                    | 9.92                    | 1.31               | 14.27          |

Note:

1. Values reported include impinger portion (back half) and complete sample recovery - acetone/water, sodium hydroxide, nitric acid, and water washes.

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TABLE 10

ANALYTICAL METHODS, QUALITY CONTROL - ARSENIC %  
GIANT YELLOWKNIFE MINES LTD., YELLOWKNIFE, N.W.T.

| Date    | Roaster Feed - % As |              | Baghouse Dust - % As |              |
|---------|---------------------|--------------|----------------------|--------------|
|         | EPS-Method A        | EPS-Method B | EPS-Method A         | EPS-Method B |
| Aug 16  | 2.28                | 10.9         | 58.3                 | 58.1         |
| Aug 17  | 2.33                | 8.7          | 62.3                 | 64.1         |
| Aug 18  | 1.75                | 10.4         | 61.6                 | 61.9         |
| Aug 19  | ----                | ----         | 59.6                 | 61.0         |
| Aug 20  | ----                | ----         | 60.5                 | 70.1         |
| AVERAGE | 2.10                | 10.0         | 60.5                 | 63.0         |

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7

## DISCUSSION OF RESULTS

The test program was designed primarily to evaluate the draft standard reference method for the measurement of arsenic emissions from gold roasting operations and specifically the sample recovery procedures and methods. Tables 7 and 8 detail the distribution of arsenic within the sampling train and the amounts removed using the various wash solutions. The amounts of arsenic collected in the impingers indicate that the methods described for sample collection are adequate to collect all forms of arsenic at the concentrations encountered. However, the analytical procedures described in the report may require further evaluation. The results in Table 10 indicate that a sodium hydroxide digestion may not be sufficiently rigorous to effectively account for total arsenic.

The small quantities of arsenic removed during the acid wash and water rinse would indicate that this step will more than likely not be required in the sample recovery step. The acetone wash followed by two successive sodium hydroxide rinses is sufficient to remove in excess of 99% of the collected arsenic.

The results depicting the total mass emissions of arsenic, particulate, sulphur dioxide and other heavy metals have been presented but the degree of confidence is limited. The difficulties experienced in measuring the low stack velocities on this particular source resulted in a high degree of error associated with the total flue gas flow calculations. Definite bias may have been introduced and as a result, the data should be interpreted with caution. The stack flows, as depicted in Table 5, 6 and 9, are in all likelihood higher than that which is normally experienced. The average flow rate from six tests performed in 1975 was  $690 \text{ sm}^3/\text{min}$ . At that time the process was at or near full production. Tests completed during this study were performed at relatively lower production levels and therefore the flue gas flow rates should be proportionately lower. Because of the possible errors associated with the stack flow rates, the mass emissions would also contain equivalent errors.

The concentrations of arsenic and particulate matter, which are independent of the calculated stack flow rates are probably the more

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accurate parameters to use when assessing the magnitude of the emissions from Giant Yellowknife Mines Ltd. operation. However, a note should be made in regards to the modifications which were taking place in the bag-house section and the changes in the shaking cycle. A complete description of these changes was given in Section 2 under Process Description.

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8

## CONCLUSIONS AND RECOMMENDATIONS

The concentrations of arsenic particulate matter emitted from this source have decreased significantly since 1975 when the initial tests were performed. The concentration of arsenic for six tests in 1975 averaged 76.6 mg/scm. The average of the two valid tests performed during this study was 26.0 mg/scm, a decrease of 50 mg/scm or 66%. A significant change occurred in the distribution of arsenic within the sampling train. In 1975 the filter was maintained at or near a temperature of 195°F and approximately 1% of the arsenic was collected in the back half, impinger portion of the sampling train. The test results from the 1978 program, where the filter was maintained at or near 230°F for all the tests, revealed that approximately 27% of the arsenic became entrapped in the impingers. This indicates that arsenious oxide is extremely unstable over a very short temperature range and care should be taken in the efficient collection of this material after the particulate filter.

The total particulate concentrations averaged 39.9 mg/scm for the three tests performed during this study. No comparison can be made with the 1975 results, as no total particulates were obtainable in that initial study. This concentration includes only the sample recovery from the front half portion of the sampling train. The arsenic concentration in the equivalent front half was 18.9 mg/scm. Therefore, 47% of the particulate matter collected in the front half was particulate arsenic. This represents a significant portion of the overall emissions and points out the rather difficult problem of controlling this particular hazardous pollutant.

The sulphur dioxide emissions were in the typical range expected from this source. The concentration in the flue gases for the four tests performed was 25.1 g/scm. The single test performed in 1975 was 38.5 g/scm, but the process was at significantly higher production rates in 1975.

Recommendations for further testing of this particular source and in the application of the standard reference method for the measurement of arsenic emissions from gold processing facilities include:

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- a) Use of a caustic wash in the recovery of arsenic from the interior surfaces of the entire sampling train;
- b) Review of the analytical procedures described in the draft reference method because of the different arsenic matrices which may be present in the particulate matter emitted from these source types; and
- c) Development and use of a more accurate method of determining flue gas velocities in the range of 5 to 10 feet per second.

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REFERENCES

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#### ACKNOWLEDGEMENTS

The author wishes to thank Mr. R. Prokopuk, Mr. R. Clough, Mr. S. Shewchuk and Mr. P.K. Leung of the Department of Fisheries and Environment Canada for their efforts in conducting all field work associated with this survey. The processing of all resulting data was performed by Mr. R. Prokopuk.

The analytical expertise was provided by the Chemistry Laboratory of EPS in Edmonton, Alberta under the direction of Mr. R. Clough and Mr. R. Prokopuk.



APPENDIX I

SAMPLING DATA  
SULPHUR OXIDES

SULPHUR OXIDES

|                               |                      |           |           |           |
|-------------------------------|----------------------|-----------|-----------|-----------|
| DATE - AUGUST (1978)          | <u>16</u>            | <u>17</u> | <u>18</u> | <u>19</u> |
| Test Run                      | 1S                   | 2S        | 3S        | 4S        |
| Sample Time (min)             | 20                   | 30        | 30        | 30        |
| Stack Gas Temperature (°F)    | 180                  | 180       | 180       | 180       |
| Gas Meter Volume (scf)        |                      |           |           |           |
| - Initial                     | 17.86                | 20.00     | 23.38     | 26.36     |
| - Final                       | 19.70                | 22.86     | 26.36     | 29.22     |
| Gas Meter Rate (scf/min)      | 0.092                | 0.095     | 0.099     | 0.095     |
| Gas Meter Temperature (°F)    | 56                   | 50        | 62        | 55        |
| Gas Meter Vacuum (in Hg)      | 3                    | 3         | 3         | 3         |
| Barometric Pressure (in Hg)   | 28.51                | 28.67     | 28.69     | 28.54     |
| Volumetric Flow Rate (scf/hr) | 1.765E6<br>(assumed) | 1.765E6   | 2.278E6   | 2.397E6   |
| Normality of Titrant          | 0.0102               | 0.0102    | 0.0102    | 0.0102    |
| Dilution Factor               |                      |           |           |           |
| - SO <sub>2</sub>             | 1000                 | 1000      | 1000      | 1000      |
| - SO <sub>3</sub>             | 50                   | 50        | 50        | 50        |
| Titration Volume (mls)        |                      |           |           |           |
| - SO <sub>2</sub>             | 4.2                  | 4.8       | 4.6       | 3.8       |
| - SO <sub>3</sub>             | 3.2                  | 11.9      | 3.6       | 2.3       |
| Meter Calibration Factor      | 0.97                 |           |           |           |
| Stack Moisture (%)            | 8                    |           |           |           |

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APPENDIX II

SAMPLING DATA

ARSENIC AND TOTAL PARTICULATES

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APPENDIX II  
TRAVERSE DATA

| Traverse Point | Sample Time (min.) | Stack Gas Temp (°R) | Velocity Press. (in H <sub>2</sub> O) | Orifice Press. (in H <sub>2</sub> O) | Gas Meter Volume (acf) | Gas Meter Temp (°R) |
|----------------|--------------------|---------------------|---------------------------------------|--------------------------------------|------------------------|---------------------|
| 32             | --                 | ---                 | -----                                 | ----                                 | -----                  | ---                 |
| 31             | 10                 | 650                 | 0.035                                 | 0.28                                 | 99.75                  | 555                 |
| 30             | 5                  | 650                 | 0.035                                 | 0.28                                 | 95.78                  | 550                 |
| 29             | 5                  | 650                 | 0.04                                  | 0.33                                 | 93.66                  | 550                 |
| 28             | 5                  | 650                 | 0.04                                  | 0.32                                 | 91.55                  | 550                 |
| 27             | 5                  | 650                 | 0.035                                 | 0.29                                 | 89.45                  | 550                 |
| 26             | 5                  | 640                 | 0.04                                  | 0.32                                 | 87.42                  | 550                 |
| 25             | 5                  | 640                 | 0.04                                  | 0.32                                 | 85.15                  | 550                 |
| 24             | 5                  | 640                 | 0.035                                 | 0.32                                 | 83.02                  | 545                 |
| 23             | 5                  | 640                 | 0.04                                  | 0.33                                 | 80.85                  | 540                 |
| 22             | 5                  | 640                 | 0.035                                 | 0.31                                 | 78.65                  | 540                 |
| 21             | 5                  | 640                 | 0.035                                 | 0.28                                 | 76.62                  | 540                 |
| 20             | 5                  | 640                 | 0.025                                 | 0.20                                 | 74.60                  | 535                 |
| 19             | 5                  | 640                 | 0.025                                 | 0.19                                 | 72.85                  | 535                 |
| 18             | 10                 | 640                 | 0.015                                 | 0.12                                 | 71.10                  | 535                 |
| 17             | --                 | ---                 | negative                              | ----                                 | -----                  | ---                 |
| 16             | --                 | ---                 | -----                                 | ----                                 | -----                  | ---                 |
| 15             | 5                  | 650                 | 0.05                                  | 0.38                                 | 68.24                  | 530                 |
| 14             | 5                  | 650                 | 0.04                                  | 0.31                                 | 65.92                  | 530                 |
| 13             | 5                  | 650                 | 0.04                                  | 0.31                                 | 63.79                  | 530                 |
| 12             | 5                  | 640                 | 0.04                                  | 0.30                                 | 61.67                  | 530                 |
| 11             | 5                  | 640                 | 0.025                                 | 0.23                                 | 59.68                  | 530                 |
| 10             | 5                  | 640                 | 0.025                                 | 0.23                                 | 57.78                  | 525                 |
| 9              | 5                  | 640                 | 0.025                                 | 0.23                                 | 55.88                  | 525                 |
| 8              | 5                  | 640                 | 0.025                                 | 0.19                                 | 54.03                  | 520                 |
| 7              | 5                  | 640                 | 0.025                                 | 0.22                                 | 52.21                  | 520                 |
| 6              | 5                  | 640                 | 0.025                                 | 0.23                                 | 50.32                  | 520                 |
| 5              | 5                  | 640                 | 0.02                                  | 0.18                                 | 48.44                  | 515                 |
| 4              | 5                  | 640                 | 0.02                                  | 0.18                                 | 46.69                  | 510                 |
| 3              | 5                  | 640                 | 0.01                                  | 0.08                                 | 45.06                  | 510                 |
| 2              | 5                  | 640                 | 0.01                                  | 0.08                                 | 43.83                  | 510                 |
| 1              | 10                 | 640                 | 0.01                                  | 0.08                                 | 42.64/40.21            | 510                 |
| TOTAL          |                    | AVERAGE             |                                       | AVERAGE                              |                        | AVERAGE             |
| 160            |                    | 640                 |                                       | 0.29                                 |                        | 531                 |

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APPENDIX II  
ANALYSIS OF ISOKINETICITY

| Traverse Point | Flue Gas Velocity (ft/sec) | Sampling Rate (scf/min) | Percent Isokineticity Achieved |
|----------------|----------------------------|-------------------------|--------------------------------|
| 31             | 11.62                      | 0.410                   | 94.0                           |
| 30             | 11.62                      | 0.437                   | 100.2                          |
| 29             | 12.43                      | 0.439                   | 94.1                           |
| 28             | 12.42                      | 0.428                   | 91.8                           |
| 27             | 11.62                      | 0.418                   | 95.9                           |
| 26             | 12.43                      | 0.468                   | 100.3                          |
| 25             | 12.33                      | 0.439                   | 91.9                           |
| 24             | 11.54                      | 0.447                   | 101.6                          |
| 23             | 12.33                      | 0.453                   | 96.4                           |
| 22             | 11.54                      | 0.418                   | 95.0                           |
| 21             | 11.54                      | 0.416                   | 94.6                           |
| 20             | 9.75                       | 0.361                   | 97.2                           |
| 19             | 9.75                       | 0.361                   | 97.2                           |
| 18             | 7.55                       | 0.295                   | 102.4                          |
| 15             | 13.90                      | 0.478                   | 91.6                           |
| 14             | 12.43                      | 0.439                   | 94.1                           |
| 13             | 12.43                      | 0.437                   | 93.7                           |
| 12             | 12.33                      | 0.439                   | 93.4                           |
| 11             | 9.75                       | 0.391                   | 105.2                          |
| 10             | 9.75                       | 0.391                   | 105.2                          |
| 9              | 9.75                       | 0.381                   | 102.5                          |
| 8              | 9.75                       | 0.374                   | 100.6                          |
| 7              | 9.75                       | 0.389                   | 104.7                          |
| 6              | 9.75                       | 0.387                   | 104.2                          |
| 5              | 8.72                       | 0.361                   | 108.6                          |
| 4              | 8.72                       | 0.336                   | 101.1                          |
| 3              | 6.17                       | 0.253                   | 107.6                          |
| 2              | 6.17                       | 0.245                   | 104.2                          |
| 1              | 6.17                       | 0.250                   | 106.3                          |
| AVERAGE        | 10.48                      |                         | AVERAGE 99.2                   |

Run No.1 August 17, 1978 905-1240 hrs Giant Yellowknife Roaster Stack

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APPENDIX II  
STACK CONDITIONS DURING TEST

|   |         |
|---|---------|
| Stack Diameter (in)                       | 108     |
| Stack Area (ft <sup>2</sup> )             | 63.62   |
| Barometric Pressure (in Hg)               | 28.67   |
| Abs. Stack Press. (in Hg)                 | 28.65   |
| Assumed Moisture (percent)                | 7       |
| Actual Moisture (percent)                 | 8       |
| Molecular Weight (dry basis) (lb/lb mole) | 29.70   |
| Molecular Weight (wet basis) (lb/lb mole) | 28.76   |
| Volumetric Gas Flow Rate (acf/hr)         | 2.401E6 |
| Volumetric Gas Flow Rate (scf/hr)         | 1.765E6 |

SAMPLING DATA DURING TEST

|                                    |       |
|------------------------------------|-------|
| Total Sampling Time (min)          | 160   |
| Sampling Nozzle Diameter (in)      | 0.375 |
| Pitot Tube Correction Factor       | 0.82  |
| Dry Gas Meter Calibration Factor   | 1.03  |
| Orifice Calibration Factor         | 0.98  |
| Average Gas Meter Pressure (in Hg) | 28.69 |
| Volume of Water Collected (scf)    | 5.71  |
| Total Sample Volume (acf)          | 59.54 |

Run No. 1

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# APPENDIX II TRAVERSE DATA

| Traverse Point | Sample Time (min.) | Stack Gas Temp (°R) | Velocity Press. (in H <sub>2</sub> O) | Orifice Press. (in H <sub>2</sub> O) | Gas Meter Volume (acf) | Gas Meter Temp (°R) |
|----------------|--------------------|---------------------|---------------------------------------|--------------------------------------|------------------------|---------------------|
| 31             | 10                 | 650                 | 0.045                                 | 0.63                                 | 658.58/664.55          | 550                 |
| 30             | 5                  | 650                 | 0.04                                  | 0.57                                 | 667.44                 | 545                 |
| 29             | 5                  | 650                 | 0.04                                  | 0.57                                 | 670.30                 | 545                 |
| 28             | 5                  | 650                 | 0.045                                 | 0.65                                 | 673.37                 | 550                 |
| 27             | 5                  | 650                 | 0.045                                 | 0.65                                 | 676.30                 | 545                 |
| 26             | 5                  | 640                 | 0.05                                  | 0.72                                 | 679.28                 | 555                 |
| 25             | 5                  | 640                 | 0.055                                 | 0.80                                 | 682.61                 | 555                 |
| 24             | 5                  | 640                 | 0.055                                 | 0.82                                 | 685.97                 | 555                 |
| 23             | 5                  | 640                 | 0.05                                  | 0.75                                 | 689.15                 | 555                 |
| 22             | 5                  | 640                 | 0.05                                  | 0.75                                 | 692.34                 | 560                 |
| 21             | 5                  | 640                 | 0.045                                 | 0.67                                 | 695.35                 | 560                 |
| 20             | 5                  | 640                 | 0.04                                  | 0.60                                 | 698.28                 | 560                 |
| 19             | 5                  | 640                 | 0.035                                 | 0.52                                 | 700.97                 | 560                 |
| 18             | 10                 | 640                 | 0.025                                 | 0.37                                 | 705.61                 | 560                 |
| 15             | 10                 | 650                 | 0.055                                 | 0.74                                 | 602.84/609.41          | 505                 |
| 14             | 7                  | 650                 | 0.05                                  | 0.67                                 | 613.78                 | 515                 |
| 13             | 5                  | 650                 | 0.06                                  | 0.83                                 | 617.34                 | 515                 |
| 12             | 5                  | 650                 | 0.06                                  | 0.89                                 | 620.90                 | 520                 |
| 11             | 5                  | 650                 | 0.06                                  | 0.89                                 | 624.91                 | 520                 |
| 10             | 5                  | 640                 | 0.06                                  | 0.90                                 | 628.21                 | 525                 |
| 9              | 5                  | 640                 | 0.06                                  | 0.92                                 | 631.73                 | 530                 |
| 8              | 6                  | 640                 | 0.055                                 | 0.78                                 | 635.64                 | 535                 |
| 7              | 5                  | 640                 | 0.055                                 | 0.79                                 | 638.88                 | 540                 |
| 6              | 5                  | 640                 | 0.055                                 | 0.80                                 | 642.15                 | 540                 |
| 5              | 5                  | 640                 | 0.06                                  | 0.87                                 | 645.54                 | 540                 |
| 4              | 5                  | 640                 | 0.06                                  | 0.88                                 | 648.91                 | 550                 |
| 3              | 5                  | 640                 | 0.06                                  | 0.88                                 | 652.31                 | 550                 |
| 2              | 10                 | 640                 | 0.05                                  | 0.74                                 | 658.58                 | 555                 |
| TOTAL<br>160   |                    | AVERAGE<br>643      |                                       | AVERAGE<br>0.74                      |                        | AVERAGE<br>543      |

Run No. 2      August 18, 1978      900-1250 hrs      Giant Yellowknife Roaster Stack

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APPENDIX II  
ANALYSIS OF ISOKINETICITY

| Traverse Point | Flue Gas Velocity (ft/sec) | Actual Sampling Rate (scf/min) | Percent Isokineticity Achieved |
|----------------|----------------------------|--------------------------------|--------------------------------|
| 31             | 13.15                      | 0.615                          | 89.6                           |
| 30             | 12.40                      | 0.595                          | 92.0                           |
| 29             | 12.40                      | 0.589                          | 91.1                           |
| 28             | 13.15                      | 0.632                          | 92.2                           |
| 27             | 13.15                      | 0.603                          | 87.9                           |
| 26             | 13.76                      | 0.613                          | 84.2                           |
| 25             | 14.43                      | 0.686                          | 89.7                           |
| 24             | 14.43                      | 0.692                          | 90.5                           |
| 23             | 13.76                      | 0.655                          | 89.9                           |
| 22             | 13.76                      | 0.657                          | 90.1                           |
| 21             | 13.05                      | 0.620                          | 89.7                           |
| 20             | 12.30                      | 0.604                          | 92.6                           |
| 19             | 11.51                      | 0.554                          | 90.9                           |
| 18             | 9.73                       | 0.478                          | 92.7                           |
| 15             | 14.54                      | 0.677                          | 89.2                           |
| 14             | 13.86                      | 0.643                          | 88.9                           |
| 13             | 15.19                      | 0.737                          | 93.1                           |
| 12             | 15.19                      | 0.733                          | 92.5                           |
| 11             | 15.19                      | 0.826                          | 104.2                          |
| 10             | 15.07                      | 0.680                          | 85.1                           |
| 9              | 15.07                      | 0.725                          | 90.8                           |
| 8              | 14.43                      | 0.671                          | 87.8                           |
| 7              | 14.43                      | 0.667                          | 87.3                           |
| 6              | 14.43                      | 0.686                          | 89.7                           |
| 5              | 15.07                      | 0.698                          | 87.5                           |
| 4              | 15.07                      | 0.694                          | 86.9                           |
| 3              | 15.07                      | 0.700                          | 87.7                           |
| 2              | 13.76                      | 0.616                          | 88.6                           |
| AVERAGE        | 13.37                      |                                | AVERAGE 90.1                   |

Run No. 2



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APPENDIX II  
STACK CONDITIONS DURING TEST

|   |         |
|---|---------|
| Stack Diameter (in)                       | 108     |
| Stack Area (ft <sup>2</sup> )             | 63.62   |
| Barometric Pressure (in Hg)               | 28.69   |
| Abs. Stack Press. (in Hg)                 | 28.67   |
| Assumed Moisture (percent)                | 9       |
| Actual Moisture (percent)                 | 7       |
| Molecular Weight (dry basis) (lb/lb mole) | 29.70   |
| Molecular Weight (wet basis) (lb/lb mole) | 28.88   |
| Volumetric Gas Flow Rate (acf/hr)         | 3.062E6 |
| Volumetric Gas Flow Rate (scf/hr)         | 2.278E6 |

SAMPLING DATA DURING TEST

|                                    |        |
|------------------------------------|--------|
| Total Sampling Time (min)          | 160    |
| Sampling Nozzle Diameter (in)      | 0.4375 |
| Pitot Tube Correction Factor       | 0.82   |
| Dry Gas Meter Calibration Factor   | 1.03   |
| Orifice Calibration Factor         | 0.98   |
| Average Gas Meter Pressure (in Hg) | 28.75  |
| Volume of Water Collected (scf)    | 7.536  |
| Total Sample Volume (acf)          | 102.77 |

Run No. 2

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APPENDIX II  
TRAVERSE DATA

| Traverse Point | Sample Time (min.) | Stack Gas Temp (°R) | Velocity Press. (in H <sub>2</sub> O) | Orifice Press. (in H <sub>2</sub> O) | Gas Meter Volume (acf) | Gas Meter Temp (°R) |
|----------------|--------------------|---------------------|---------------------------------------|--------------------------------------|------------------------|---------------------|
| 31             | 10                 | 640                 | 0.04                                  | 0.61                                 | 763.91/769.64          | 535                 |
| 30             | 5                  | 650                 | 0.05                                  | 0.76                                 | 773.18                 | 535                 |
| 29             | 5                  | 650                 | 0.05                                  | 0.76                                 | 776.41                 | 540                 |
| 28             | 5                  | 650                 | 0.055                                 | 0.83                                 | 779.81                 | 540                 |
| 27             | 5                  | 640                 | 0.055                                 | 0.84                                 | 783.18                 | 540                 |
| 26             | 5                  | 640                 | 0.05                                  | 0.77                                 | 786.43                 | 540                 |
| 25             | 5                  | 640                 | 0.055                                 | 0.84                                 | 789.85                 | 540                 |
| 24             | 5                  | 640                 | 0.055                                 | 0.84                                 | 793.25                 | 540                 |
| 23             | 5                  | 640                 | 0.055                                 | 0.84                                 | 796.64                 | 540                 |
| 22             | 5                  | 640                 | 0.055                                 | 0.82                                 | 799.98                 | 550                 |
| 21             | 5                  | 640                 | 0.05                                  | 0.78                                 | 803.21                 | 550                 |
| 20             | 5                  | 640                 | 0.05                                  | 0.78                                 | 806.48                 | 550                 |
| 19             | 5                  | 640                 | 0.045                                 | 0.70                                 | 809.59                 | 550                 |
| 18             | 10                 | 640                 | 0.04                                  | 0.63                                 | 815.64                 | 555                 |
| 15             | 10                 | 645                 | 0.05                                  | 0.72                                 | 709.95/716.60          | 505                 |
| 14             | 5                  | 650                 | 0.05                                  | 0.72                                 | 719.93                 | 510                 |
| 13             | 5                  | 650                 | 0.055                                 | 0.79                                 | 723.41                 | 515                 |
| 12             | 5                  | 650                 | 0.055                                 | 0.87                                 | 726.81                 | 515                 |
| 11             | 5                  | 650                 | 0.06                                  | 0.87                                 | 730.38                 | 520                 |
| 10             | 5                  | 650                 | 0.06                                  | 0.88                                 | 733.83                 | 525                 |
| 9              | 5                  | 640                 | 0.06                                  | 0.90                                 | 737.35                 | 530                 |
| 8              | 5                  | 640                 | 0.055                                 | 0.82                                 | 740.83                 | 530                 |
| 7              | 5                  | 640                 | 0.055                                 | 0.83                                 | 744.22                 | 535                 |
| 6              | 5                  | 640                 | 0.055                                 | 0.84                                 | 747.53                 | 535                 |
| 5              | 5                  | 640                 | 0.055                                 | 0.84                                 | 750.88                 | 535                 |
| 4              | 5                  | 640                 | 0.055                                 | 0.85                                 | 754.27                 | 540                 |
| 3              | 5                  | 640                 | 0.05                                  | 0.76                                 | 757.49                 | 540                 |
| 2              | 10                 | 640                 | 0.05                                  | 0.76                                 | 763.91                 | 540                 |
| TOTAL<br>160   |                    | AVERAGE<br>643      |                                       | AVERAGE<br>0.79                      | TOTAL<br>105.69        | AVERAGE<br>535      |

Run No. 3      August 19, 1978      905-1315 hrs      Giant Yellowknife Roaster Stack

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APPENDIX II  
ANALYSIS OF ISOKINETICITY

| Traverse Point | Flue Gas Velocity (ft/sec) | Actual Sampling Rate (scf/min) | Percent Isokineticity Achieved |
|----------------|----------------------------|--------------------------------|--------------------------------|
| 31             | 12.33                      | 0.588                          | 91.4                           |
| 30             | 13.89                      | 0.729                          | 102.1                          |
| 29             | 13.89                      | 0.665                          | 93.2                           |
| 28             | 14.57                      | 0.700                          | 93.5                           |
| 27             | 14.45                      | 0.694                          | 92.0                           |
| 26             | 13.78                      | 0.670                          | 93.1                           |
| 25             | 14.45                      | 0.704                          | 93.4                           |
| 24             | 14.45                      | 0.700                          | 92.8                           |
| 23             | 14.45                      | 0.698                          | 92.6                           |
| 22             | 14.45                      | 0.688                          | 91.2                           |
| 21             | 13.78                      | 0.676                          | 93.6                           |
| 20             | 13.78                      | 0.674                          | 93.6                           |
| 19             | 13.07                      | 0.641                          | 93.9                           |
| 18             | 12.33                      | 0.624                          | 97.0                           |
| 15             | 13.83                      | 0.685                          | 95.6                           |
| 14             | 13.89                      | 0.686                          | 96.1                           |
| 13             | 14.57                      | 0.717                          | 95.7                           |
| 12             | 14.57                      | 0.700                          | 93.5                           |
| 11             | 15.21                      | 0.735                          | 94.1                           |
| 10             | 15.21                      | 0.711                          | 90.9                           |
| 9              | 15.10                      | 0.725                          | 92.0                           |
| 8              | 14.45                      | 0.725                          | 96.1                           |
| 7              | 14.45                      | 0.698                          | 92.6                           |
| 6              | 14.45                      | 0.690                          | 91.5                           |
| 5              | 14.45                      | 0.690                          | 91.5                           |
| 4              | 14.45                      | 0.698                          | 92.6                           |
| 3              | 13.78                      | 0.661                          | 91.9                           |
| 2              | 13.78                      | 0.661                          | 91.9                           |
| AVERAGE        | 14.14                      |                                | AVERAGE 93.6                   |

Run No. 3

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APPENDIX II  
STACK CONDITIONS DURING TEST

|   |         |
|---|---------|
| Stack Diameter (in)                       | 108     |
| Stack Area (ft <sup>2</sup> )             | 63.62   |
| Barometric Pressure (in Hg)               | 28.54   |
| Abs. Stack Press. (in Hg)                 | 28.52   |
| Assumed Moisture (percent)                | 6       |
| Actual Moisture (percent)                 | 7       |
| Molecular Weight (dry basis) (lb/lb mole) | 29.70   |
| Molecular Weight (wet basis) (lb/lb mole) | 28.94   |
| Volumetric Gas Flow Rate (acf/hr)         | 3.238E6 |
| Volumetric Gas Flow Rate (scf/hr)         | 2.397E6 |

SAMPLING DATA DURING TEST

|                                    |        |
|------------------------------------|--------|
| Total Sampling Time (min)          | 160    |
| Sampling Nozzle Diameter (in)      | 0.4375 |
| Pitot Tube Correction Factor       | 0.82   |
| Dry Gas Meter Calibration Factor   | 1.03   |
| Orifice Calibration Factor         | 0.98   |
| Average Gas Meter Pressure (in Hg) | 28.60  |
| Volume of Water Collected (scf)    | 8.256  |
| Total Sample Volume (acf)          | 108.86 |

Run No. 3

DRAFT  
10/10/88

### APPENDIX III

#### ANALYTICAL RESULTS

APPENDIX III  
YELLOWKNIFE STACK SURVEY

| Sample Number | Sample   | Date      | As <sup>t</sup><br>(ug) | Sb <sup>t</sup><br>(ug) | Fe <sup>t</sup><br>(ug) | Cu <sup>t</sup><br>(ug) | Particulates<br>(g) |
|---------------|--|-----------|-------------------------|-------------------------|-------------------------|-------------------------|---------------------|
| 100           | Front half, probe & nozzle contents - acetone wash - TR #1 | Aug 17/78 | 17,400                  | 121                     | 3559                    | 26.5                    | 0.0618              |
| 101*          | Impinger Contents - acetone wash - TR #1                   | "         | 4,488                   | 25.3                    | 6610                    | 9.3                     | **23.3974           |
| 102           | Impinger and U tubes - acetone wash - TR #1                | "         | 1,539                   | 97                      | 28.8                    | 17.8                    | 0.3884              |
| 103           | Back half acetone wash - TR #1                             | "         | 75                      | <1                      | <5                      | 8.2                     | -                   |
| 104           | Front half - NaOH wash - TR #1                             | "         | 4,900                   | 293                     | 282                     | 63.2                    | -                   |
| 105           | Impinger and U tubes - NaOH wash - TR #1                   | "         | 1,125                   | 188                     | 71                      | 24.7                    | -                   |
| 106           | Back half NaOH wash - TR #1                                | "         | 1,225                   | <1                      | 25                      | 8.2                     | -                   |
| 107           | Front half acid wash - TR #1                               | "         | 75                      | 27.5                    | 3076                    | 132                     | -                   |
| 108           | Impinger and U tube acid wash - TR #1                      | "         | 50.3                    | 3.3                     | 178                     | 8.2                     | -                   |
| 109           | Back half acid wash - TR #1                                | "         | 17.5                    | <1                      | 12                      | 2.7                     | -                   |
| 110           | Front half water wash - TR #1                              | "         | 35                      | 5.7                     | 5141                    | 33.0                    | -                   |
| 111           | Impinger and U tubes water wash - TR #1                    | "         | 18.0                    | 104                     | <5                      | 13.3                    | 0.0532              |

## YELLOWKNIFE STACK SURVEY (Cont'd)

| Sample Number | Sample  | Date      | As <sup>t</sup><br>(ug) | Sb <sup>t</sup><br>(ug) | Fe <sup>t</sup><br>(ug) | Cu <sup>t</sup><br>(ug) | Particulates<br>(g) |
|---------------|---|-----------|-------------------------|-------------------------|-------------------------|-------------------------|---------------------|
| 112           | Back half water wash - TR #1                              | "         | 1                       | 3.3                     | 12                      | 2.7                     | -                   |
| 113*          | Filter (preserved in 5% NaOH) - TR #1                     | "         | 14,876                  | 1177                    | 1525                    | 36                      | -                   |
| 114           | Distilled water blank                                     | "         | -                       | -                       | -                       | -                       | -                   |
| 116           | Distilled water blank                                     | Aug 18/78 | -                       | -                       | -                       | -                       | -                   |
| 117           | Front half probe & nozzle contents - acetone wash - TR #2 | "         | 28,400                  | 250                     | -                       | 20.0                    | 0.0778              |
| 118           | Impinger contents acetone wash - TR #2                    | "         | 14,200                  | 282                     | <5                      | <1.0                    | 0.3425              |
| 119           | Impinger and U tube acetone wash - TR #2                  | "         | 1190                    | 225                     | <5                      | <1.0                    | 0.0333              |
| 120           | Back half acetone wash - TR #2                            | "         | 34.8                    | 1.6                     | 386                     | 74.2                    | -                   |
| 121           | Front half NaOH wash - TR #2                              | "         | 10,600                  | 530                     | 382                     | 76.9                    | -                   |
| 122           | Impinger and U tubes - NaOH wash - TR #2                  | "         | 4,050                   | 80                      | 46                      | 19.2                    | -                   |
| 123           | Back half NaOH wash - TR #2                               | "         | 4,225                   | 318                     | 79                      | 33.0                    | -                   |
| 124           | Front half acid wash - TR #2                              | "         | 91                      | 22.7                    | 14,925                  | 198                     | -                   |
| 125           | Impinger and U tubes acid wash - TR #2                    | "         | 7.15                    | 9.0                     | 33                      | 5.5                     | -                   |

DRIFT

## YELLOWKNIFE STACK SURVEY (Cont'd)

| Sample Number | Sample                                    | Date      | As <sup>t</sup><br>(ug) | Sb <sup>t</sup><br>(ug) | Fe <sup>t</sup><br>(ug) | Cu <sup>t</sup><br>(ug) | Particulates<br>(g) |
|---------------|---|-----------|-------------------------|-------------------------|-------------------------|-------------------------|---------------------|
| 126           | Back half acid wash - TR #2               | "         | 34.1                    | 9.8                     | 108                     | 11.0                    | -                   |
| 127           | Front half water wash - TR #2             | "         | 58                      | 1.4                     | 4768                    | 38.5                    | -                   |
| 128           | Impinger and U tubes water wash -         | "         | 47                      | 3.1                     | 25                      | 5.5                     | -                   |
| 129           | Back half water wash - TR #2              | Aug 18/78 | 32.9                    | 2.3                     | 199                     | 8.2                     | -                   |
| 130*          | Filter preserved in 5% NaOH - TR #2       | "         | 10,182                  | 1089                    | 4067                    | 34.9                    | 0.4679              |
| 131           | Impinger contents - TR #3                 | Aug 19/78 | 15,500                  | <1                      | 12                      | <1.0                    | -                   |
| 132           | Impinger and U tubes acetone wash - TR #3 | "         | 1240                    | 177                     | <5                      | <1.0                    | 0.0097              |
| 133           | Impinger and U tubes NaOH wash - TR #3    | "         | 2,225                   | <1                      | 42                      | 13.7                    | -                   |
| 134           | Impinger and U tubes acid wash - TR #3    | "         | 80.3                    | 11.7                    | 25                      | 2.7                     | -                   |
| 135           | Impinger and U tubes water wash - TR #3   | "         | 22.8                    | 1.2                     | 17                      | 2.7                     | -                   |
| 136*          | Filter preserved in 5% NaOH - TR #3       | "         | sample lost             | 1080                    | 153                     | 16.7                    | -                   |
| 137           | Front half acetone wash - TR #3           | "         | 22,200                  | 350                     | 4067                    | 17.8                    | 0.0600              |
| 138           | Front half NaOH wash - TR #3              | "         | 10,950                  | 585                     | 935                     | 104                     | -                   |



## YELLOWKNIFE STACK SURVEY (Cont'd)

| Sample Number | Sample                         | Date      | As <sup>t</sup><br>(ug) | Sb <sup>t</sup><br>(ug) | Fe <sup>t</sup><br>(ug) | Cu <sup>t</sup><br>(ug) | Particulates<br>(g) |
|---------------|--------------------------------|-----------|-------------------------|-------------------------|-------------------------|-------------------------|---------------------|
| 139           | Front half acid wash - TR #3   | "         | 170                     | 34.4                    | 12,230                  | <1.0                    | -                   |
| 140           | Front half water wash - TR #3  | "         | 88                      | 5.5                     | 7048                    | 33.0                    | -                   |
| 141           | Back half acetone wash - TR #3 | "         | 62.5                    | 2.7                     | 260                     | 57.7                    | -                   |
| 142           | Back half NaOH wash - TR #3    | "         | 3175                    | 213                     | 54                      | 19.2                    | -                   |
| 143           | Back half acid wash - TR #3    | "         | 37.5                    | 3.5                     | 149                     | 5.5                     | -                   |
| 144           | Back half water wash - TR #3   | "         | 600                     | 3.5                     | 129                     | 8.2                     | -                   |
|               | BLK 17                         | Aug 17/78 | -                       | -                       | -                       | -                       | 0.0046              |
|               | BLK 18                         | Aug 18/78 | -                       | -                       | -                       | -                       | 0.0042              |
|               | BLK 19                         | Aug 19/78 | -                       | -                       | -                       | -                       | 0.0056              |

\* Strong effervescence occurred when  $\text{HNO}_3/\text{H}_2\text{SO}_4$  added for digestions.

\*\* Brown oily viscous liquid remained.