SARA GROUP

Sudbury Area Risk Assessment
Volume II

Appendix F:

City of Greater Sudbury
Air Monitoring Network

Sudbury Soils Study | Étude des sols sudburois
metals • health • environment
métaux • santé • environnement

SUDBURY AIR MONITORING STUDY

DATA REPORT: OCTOBER 2003 TO SEPTEMBER 2004

Draft

Prepared by:

SARA GROUP

HHRA Document
Air Monitoring Results for October 2003 to September 2004
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SUDBURY AREA RISK ASSESSMENT
AIR MONITORING SURVEY
RESULTS OCTOBER 2003-SEPTEMBER 2004

Table Of Contents

Tables

Figures

Appendices

1.0 INTRODUCTION

The Sudbury Basin is an area rich in mineral deposits, particularly the nickel and copper ores that have drawn people to the region for the past 125 years. Recent studies have identified areas in Sudbury with elevated metal levels in the soil. These areas are generally close to the historic smelting sites of Coniston, Falconbridge and Copper Cliff. Although these metals do occur naturally in all soils, the studies generally indicate higher levels in surface soil (the top 5 cm) as a result of local mining, smelting and refining operations.

In 2001, the Ontario Ministry of the Environment (MOE) released a report that identified that concentrations of nickel, cobalt, copper and arsenic in the area exceeded the generic MOE soil quality guidelines. Under Ontario legislation, this triggers the need for more detailed study. Therefore, the MOE made two recommendations:

1. That a more detailed soil study be undertaken to fill data gaps; and,
2. That a human health and ecological risk assessment be undertaken.

Both Inco Ltd. and Falconbridge Ltd. voluntarily accepted the recommendations and began working together to establish what is commonly referred to as “The Sudbury Soils Study”. The mining companies partnered with four other major stakeholders in Sudbury to oversee this rigorous study. The community partners are Inco Ltd., Falconbridge Ltd., the MOE, the Sudbury & District Health Unit, the City of Greater Sudbury, and the First Nations and Inuit Health Branch of Health Canada. These partners formed a Technical Committee (TC) to oversee the study. A Public Advisory Committee was also established to help address questions and concerns about the potential impact of elevated metal levels on the local environment and human health.

Later in 2001, a comprehensive soil sampling and analysis program was undertaken by the MOE and the mining companies. Approximately 9,000 soil samples were collected from urban and remote areas and analyzed for 20 elements. These data form the basis for the Sudbury Soils Study. Early in 2003, a consortium of consulting firms working together as the SARA (Sudbury Area Risk Assessment) Group was retained to undertake the risk assessment portion of the study.

The human health implications of metal levels in soils and the environment will be examined under the Human Health Risk Assessment (HHRA) of the Sudbury Soils Study. To conduct the HHRA exposure pathway analysis, detailed information is being gathered on metal levels in air, soil, water, vegetation and other environmental matrices. The purpose of the air monitoring study was to collect samples of the air breathed by residents of the Greater Sudbury area as part of the overall HHRA.

Based on detailed screening and evaluation of the 2001 soils data, the following Chemicals of Concern (CoCs) were designated for the Sudbury Soils Study: arsenic, cobalt, copper, lead, nickel, and selenium. Although various studies have measured air quality in the Sudbury area, many of these have focused on gaseous substances (*e.g.*, sulphur dioxide) or select metals. There has been no consistent monitoring network providing complete spatial coverage of the City of Greater Sudbury, or one that measured all of the CoCs considered in the Sudbury Soils Study. This resulted in a significant data gap for the HHRA, which was best addressed by designing and implementing the Sudbury-specific air monitoring program. It was decided that ambient air quality data would not constitute an integral part of the Ecological Risk Assessment (ERA) analysis under the Sudbury Soils Study. Therefore, no monitoring stations were located to specifically address ERA requirements.

Members of the Sudbury Soils Study Technical Committee (TC), the SARA Group, and technical experts from the MOE, Inco Ltd. and Falconbridge Ltd. were involved in the final development of a workplan and operations manual for the air monitoring program (SARA Group, 2004). This workplan linked the air quality study to the HHRA portion of the Sudbury Soils Study. Ultimately, air specialists at RWDI, part of the SARA Group, were responsible for conducting the air monitoring program for the Sudbury Soils Study.

The air monitoring program was in operation for a one year period (52 weeks) to enable the collection of data from all seasons under different wind and climate conditions. After this period, it is anticipated that long term monitoring at some of the sites may be continued. This report provides the results obtained during the air monitoring study for the period of October 2003 to September 2004.

2.0 MEASURED PARAMETERS

Three size fractions of particulate matter were collected on quartz fibre filters using high volume (hi-vol - samples a volume of air that is approximately 1630 m^3 per day) and low volume (lo-vol – samples approximately 24 m^3 volume of air per day) samplers. These size fractions include:

1. Respirable particulate matter less than 2.5 microns in diameter ($PM_{2.5}$);
2. Respirable particulate matter less than 10 microns in diameter (PM_{10}); and,
3. Total suspended particulate matter less than 44 microns in diameter (TSP).

These size fractions are relevant to the HHRA because they represent particulate matter that could be retained in the nose (TSP), upper lung (PM_{10}) and lower lung ($PM_{2.5}$). The particulate size considered to be of primary toxicological significance in the HHRA is PM_{10}, and this fraction will be used as the main inhalation component for the exposure assessment modelling.

Total mass of the particulate matter collected was determined by weighing the filters before and after sampling. The samples were then analysed for a suite of metals based on analysis conducted on soil samples collected in 2001. These metals include the six CoCs for the Sudbury Soils Study: arsenic, cobalt, copper, lead, nickel, and selenium, as well as antimony, arsenic, beryllium, boron, cadmium, chromium, iron, molybdenum, sulphur, thallium, uranium, vanadium, and zinc.

TSP, PM_{10} and $PM_{2.5}$ ratios were also determined at the end of the year of monitoring, to allow differentiation of samples influenced by smelting and non-smelting operations in the Greater Sudbury Area.

Some metals analyzed in the 2001 soil samples were omitted from the air filter analysis, including: aluminum, barium, calcium, magnesium, manganese and strontium. These were not part of the common filtered analytes at the laboratory, and it is commonly accepted that these elements would have to be present in exceptional quantities to have an appreciable toxicological impact, and therefore have little relevance to the HHRA. The soil samples collected in 2001 were not analyzed for boron, sulphur, thallium, and uranium. These have been included in this analysis due to their known presence in the air in the Sudbury area, and their potential relevance to the toxicological profile for the HHRA.

3.0 MONITORING SITES

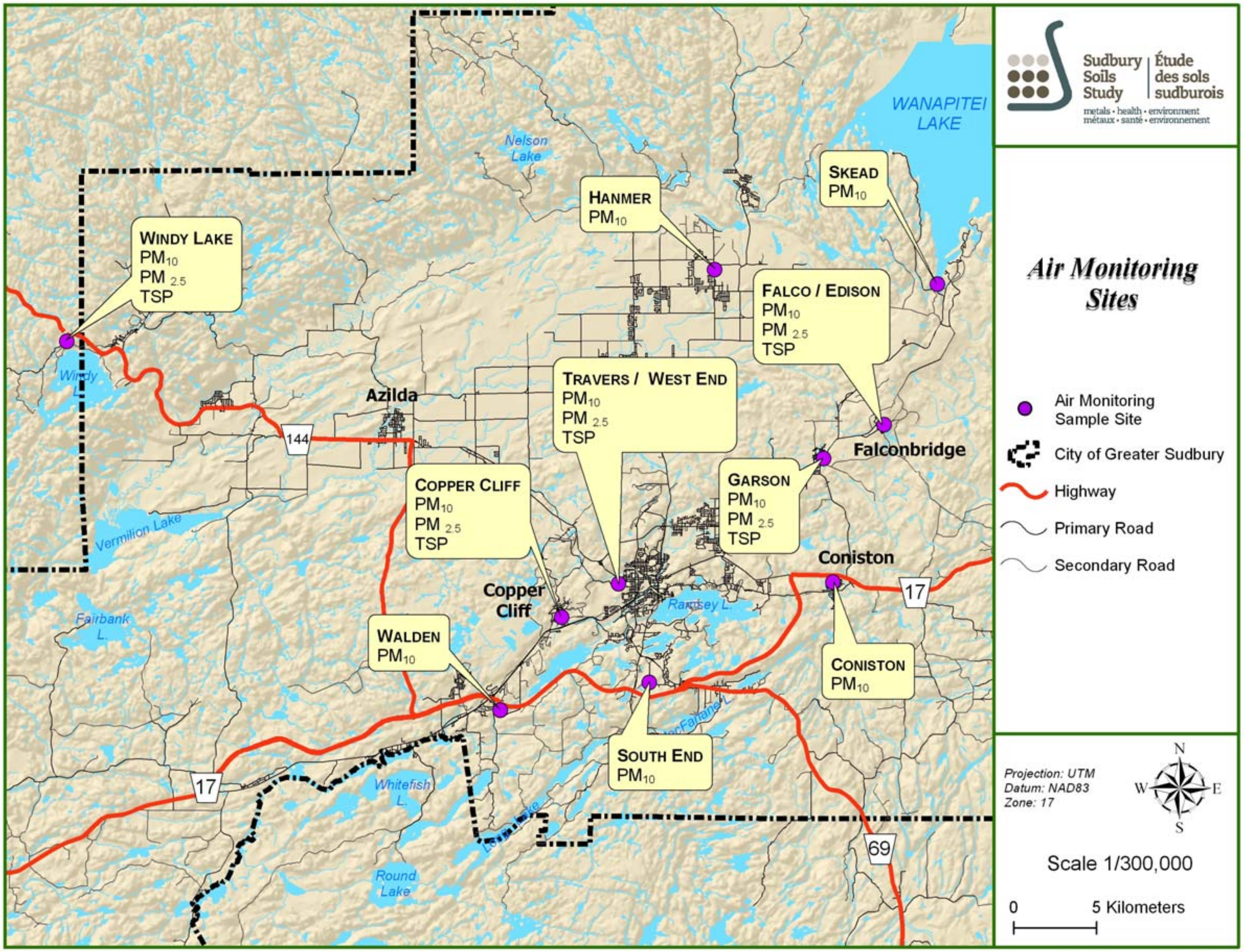
Ten monitoring sites were chosen for the Sudbury Soils Study air quality monitoring survey (Table 3.1 and Figure 3.1; photos of each site are provided in Appendix A). These included two existing MOE sites (Copper Cliff and Falconbridge/Edison), seven new sites at locations within the Greater Sudbury area, and one background site at Windy Lake Provincial Park. An extensive site selection process was followed by the SARA Group, as described in the Workplan and Operations Manual (SARA Group, 2004). The sites were chosen based on proximity to current and past smelter and mining operations and/or as a result of predicted impacts from these operations derived through dispersion modelling. All selected sites were located in different communities throughout the Greater Sudbury area. Power, security, access, and unobstructed air flow to the site were some of the additional conditions that were considered when choosing site locations.

In order to establish representative ratios between different size fractions, samples of all three size fractions were collected as part of this study, though it was not considered necessary to install three monitors at each sampling location. If determined to be statistically appropriate, the ratios can be applied to sites where only PM_{10} was measured. The current design was sufficient to give an indication of the ratios, should they exist.

Table 3.1 Site Locations and Parameters for SARA Air Quality Monitoring Network

Site Location	Parameters Measured at Each Site *
Copper Cliff (Pumphouse on Nickel Street)– MOE 77570 (existing) UTM 495006E 5146535N elev.272 m ASL	TSP, $PM_{10,}$ $PM_{2.5}$ and $PM_{2.5}$ Partisol lo-vol
Falconbridge (Edison Building) – Falco/Edison-MOE (existing) UTM 514506E 5158211N elev.300m ASL	TSP, PM_{10}, $PM_{2.5}$ and $PM_{2.5}$ Partisol lo-vol
West End (Travers Street, Catholic School Board yard) UTM 498447E 5148565N elev.276 m ASL	TSP, PM_{10} and $PM_{2.5}$
Garson (Public Works Building yard) UTM 510847E 5156155N elev.306 m ASL	TSP, PM_{10} AND $PM_{2.5}$
Walden (Jesse Hamilton School, adjacent to SO_2 monitor) UTM 491299E 5140894N elev.264m ASL	PM_{10}
Coniston (on hill adjacent to Communication Tower) UTM 511410E 5148657N elev.267m ASL	PM_{10}
Hanmer (Pumphouse on Notre Dame Road) UTM 514261E 5167616N elev.314m ASL	PM_{10}
South End (Algonquin Public School) UTM 500311E 5142571N elev.287m ASL	PM_{10}
Skead (Bowland Bay Road, adjacent to SO_2 monitor) UTM 517738E 5166733N elev.335 m ASL	PM_{10}
Windy Lake Provincial Park, Onaping (near works yard) UTM 465072E 5163256N elev.297 m ASL	TSP, PM_{10} and $PM_{2.5}$

* All monitors are hi-vol unless indicated.


Sudbury Soils Study
Étude des sols sudburois
metals · health · environment
métaux · santé · environnement
Air Monitoring Sites
Air Monitoring Sample Site
City of Greater Sudbury
Highway
Primary Road
Secondary Road
Projection: UTM
Datum: NAD83
Zone: 17
N
S
E
W
Scale 1/300,000
0
5 Kilometers
WANAPITEI LAKE
Nelson Lake
SKEAD PM10
HANMER PM10
WINDY LAKE PM10 PM 2.5 TSP
FALCO / EDISON PM10 PM 2.5 TSP
Windy L.
Azilda
144
TRAVERS / WEST END PM10 PM 2.5 TSP
Falconbridge
GARSON PM10 PM 2.5 TSP
COPPER CLIFF PM10 PM 2.5 TSP
Vermilion Lake
Coniston
17
Copper Cliff
Ramsey L.
Fairbank L.
WALDEN PM10
CONISTON PM10
McFarlane L.
SOUTH END PM10
17
Whitefish L.
69
Round Lake
Long Lake

4.0 FACILITIES DESCRIPTION

Samplers were placed on wooden platforms to allow the air inlets to be at the minimum MOE required height of 2m above ground level. Both existing MOE sites (Copper Cliff and Falconbridge Edison) were located on the roofs of buildings - Copper Cliff approximately 4m above ground level (+1.5m for sampler inlets) and Falconbridge Edison approximately 12m above ground level (+1.5m for sampler inlets). The South End PM_{10} monitor was located on the roof of Algonquin Public School, approximately 6m above ground level (+2m for sampler inlet). There were no furnace or incineration flues located near these monitors.

There was a 2m minimum required separation from walls or other structures located on the roofs, with each monitor located well away from the edge of the roof. These heights conformed to the MOE requirements in Section 2.2.3 of their Operations Manual, which states "…for middle or larger spatial scales … the required air intake is 2 to 15 metres above ground" (MOE, 2003). In the past, hi-vols have been sited on rooftops to avoid collection of larger dust particles from traffic, which is an annoyance and not of great interest for health. Particles originating from industrial sources are finer and are just as likely to be collected by a sampler located on a roof as one located at ground level given the distance they have traveled from their source. The samplers were enclosed on all sides by a fence for security reasons; as an additional measure, the tops of the enclosures were also fenced to prevent vandalism.

All ground level monitors were situated at a distance from adjacent buildings or structures that was at least twice the height of those structures. Each monitor was located at an acceptable distance from roadways (conforming to distance requirements of 20 to 25m specified in the MOE Operations Manual for PM_{10} and $PM_{2.5}$ samplers), with the possible exception of Windy Lake Provincial Park. Each of the monitors was at least 20m from any significant trees.

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5.0 SAMPLING SYSTEM AND MEDIA

The existing Falco/Edison and Copper Cliff sites have General Metals TSP, PM_{10} and $PM_{2.5}$ hi-vols and Anderson Sierra “heads” for these units. The TSP and PM_{10} samplers are U.S. EPA designated. The Model TE-6070-2.5HV hi-vol “heads” used to collect $PM_{2.5}$ samples are not U.S. EPA designated, but have been used extensively for research and assessment studies throughout Canada and the U.S. As this is not a compliance study, it was deemed appropriate to use these units.

Two Rupprecht & Patascnick Partisol (U.S.) Federal Reference Method RFPS-0498-117 (lo-vol) $PM_{2.5}$ samplers were used in this study. Two TSP and two PM_{10} Wedding brand samplers were also used at the start of this study (U.S. EPA Method IO–2.3) and later switched to hi-vols manufactured by Tisch Environmental in Ohio, after problems developed with the Wedding motors. The remaining samplers (one TSP, six PM_{10} and three $PM_{2.5}$ units) were manufactured by Tisch Environmental and rented from a distributor in Hamilton, Ontario:

- **TSP -** Model TE-5170, U.S. federal designation;
- **PM_{10} -** Model TE-6070, U.S. federal reference number #RFPS-0202-141, and;
- **$PM_{2.5}$ -** Model TE-6070-2.5HVS.

The units contain a timer that automatically starts and stops the monitor, allowing it to run for one 24-hour period every 6 days. Each hi-vol unit sampled approximately 1630 m^3 of air over each 24-hour period, while each Partisol lo-vol unit sampled approximately 24 m^3 over the same time period. To ensure that enough material would be collected on the filters for analysis, hi-vol $PM_{2.5}$ units were installed at the five stations designated to sample $PM_{2.5}$, and two lo-vol $PM_{2.5}$ units were installed to run alongside existing samplers at the Falco/Edison and Copper Cliff MOE stations.

Quartz filters were used on all units to sample TSP, PM_{10}, and $PM_{2.5.}$ These are considered to be the standard filter for the collection of PM_{10} metal samples in Canada. Glass fibre filters have been reported to have higher background levels of some metals, and were not advocated for use in this study, although these are still used extensively for collection of TSP samples in many jurisdictions. There was no apparent advantage to using the more costly Teflon filters for this study, as determined through extensive discussions with MOE scientists.

6.0 SITE AND SAMPLER OPERATION

The air monitoring network was set up to run on the National Air Pollution Surveillance Network (NAPS) 6-day schedule (Appendix B). The sampling program began in October 2003 and continued to run until September 2004, to ensure that one complete year of samples was collected. The sites were maintained and kept free of obstructions to airflow, including snow removal during the winter.

Quartz filters used in this study were sent to an analytical laboratory (PSC Analytical Services, Burlington, Ontario) to be stamped with a serial number and weighed prior to sampling. The serial number and weight of each filter was entered in the SARA record log, along with the monitor location, date of sample, and date installed and removed from each site.

Filters were installed in filter cassettes with the rough side facing up, and imperfect filters with perforations, missing pieces, large cracks, *etc.* were discarded. Gloves were used to prevent contamination of the filter surface during handling, and all contact with the clean filter was made along the edge of the filter only. Observations about each filter were recorded to assist in the data validation process, such as:

- An exposed filter should always be darker than a new filter. If the sample filter being removed is as white as an unexposed filter, it would suggest that the sampler motor did not run or ran for a very brief period; and,
- If a filter was observed to have a very low loading (very light in colour) after a sample had been collected in the field, but the laboratory result indicated a very high loading, it would suggest a laboratory error.

Observations of filter colouring were noted on each envelope that was submitted to the laboratory, recorded in the electronic field notes, and compared to the final results.

The exposed filter was removed from the sampler and a new filter installed as soon as possible during the 5-day period between NAPS sampling days. All conditions during this exchange were recorded, including elapsed time (number recorded on hi-vol timer before and after sample taken), date, motor pressure, and atmospheric pressure. Appendix C provides tables showing the sampling parameters and observed conditions of the filters for each sample at each monitoring site, together with tables showing sampler flow calibrations. After removal from the sampler, the filters were folded in half, encased in a cardboard file folder and placed in individual envelopes. These envelopes were then delivered to the analytical laboratory at the end of each month of sampling.

At the lab, filters were cut into strips for analysis. Extra filter strips were cut from the MOE Copper Cliff and Falco/Edison samples and were provided to the MOE and Falconbridge Ltd. laboratories for independent analysis. This served as a partial quality assurance procedure (*i.e*. the comparison of results obtained from different laboratories for the same filter). However, differences in analytical methodologies must be taken into consideration, as well as the possibility of uneven distribution of particulate matter over the surface of the filters caused by additional handling.

Filter cassettes and other parts of the samplers were inspected to check for integrity and cleanliness of the screen, a tight seal of the gasket on the filter, and normal operation of the flow controller and timer.

All hi-vol and lo-vol units were subject to a full calibration by RWDI employees once every three months, or more often if required (*e.g.*, if equipment was replaced). The first RWDI calibration was performed in September 2003, immediately after the units were installed at the sites, followed by the second in December 2003, a third in March 2004, the fourth in July 2004 and the final at the end of the study in September 2004.

The MOE performed audits on all hi-vols at the onset of the study, before any samples were collected. A second audit was performed in March 2004 (after 6 months of operation), and the last audit was performed at the conclusion of the study, in September 2004. The MOE reported a pass or fail designation for each instrument (*i.e.*, that the units are within +/- 10% of the required air flow rates for each of the motors, airflow to the units is unobstructed, and all other parts of the hi-vols appear to be in working order). The MOE has issued letters after each of the audits verifying that all of the instruments passed (Appendix D).

For the MOE hi-vol programs operating in cities throughout Ontario, the validity of a sample depends on meeting the following conditions:

1. 75% of the total number of samples collected from each monitor for the sampling period must be considered to be valid in order to allow for an annual arithmetic/geometric mean to be calculated and considered statistically valid (45 valid samples for the entire year on a 6-day schedule). This requirement for valid samples applies to quarterly/seasonal means as well (approximately 11 samples for a season);

2. The volume of air sampled during the 24-hour period by a hi-vol unit must be within +/- 10% of the required total air volume of 1631m^3 (*i.e.*, 1468m^3 to 1794m^3);

3. The sampling period must be +/- 10% of the required 24 hours (*i.e.*, 21.5 hours to 26.5 hours); and,

4. Daily parameters measured must be within +/- 10% of the air flow calibration standard.

The last three conditions were met before a sample was considered to be valid for use in this study. As this study was being undertaken for purposes other than just regulatory compliance, all results were presented, even if the sample number for the year was less than required for a “valid” annual mean.

The program ran for a full year, during which time both Inco Ltd. and Falconbridge Ltd. facilities operated under “normal” conditions. These conditions included regularly scheduled maintenance and other shut-down times, but no extended outages such as might occur during a labour dispute.

Safety procedures were developed for field personnel involved with this project. The field person had a cell phone at all times. The field technician would inform the Project Manager (voice mail message) whenever leaving to do field work, and also called upon returning at the end of the day. Two of the sites were located on rooftops and required the use of a ladder to access the samplers. The field technician used an assistant to spot the ladder and to ensure that no one else climbed the ladder while the hi-vol unit was being serviced. Ladders were tied off and/or made secure at these two locations before the field person used the ladder to access the monitors.

7.0 ANALYSIS

PSC Analytical Services in Burlington, Ontario was selected by the SARA Group for the analysis of the filters for this study, based on the following criteria: appropriate accreditation for the procedure, accuracy and turn-around time (based on RWDI past experience), many years of experience analyzing hi-vol filters, and ability to provide independent, unbiased results.

Filters were personally delivered by RWDI representatives to the PSC Analytical Services, MOE, and Falconbridge Ltd. laboratories (for the last two, these consisted of a strip of the filter for co-analysis), at which time a chain of custody form was completed for each sample, describing the sample, sample ID, and appropriate analysis to be performed on each filter. Results provided by PSC Analytical Services were entered into a database that linked to the electronic field log containing information such as the volume of air sampled on the same day for derivation of air concentrations.

Samples collected on the quartz filters were analysed for total particulate matter for the TSP, PM_{10} and $PM_{2.5}$ samples and a multi-metal scan was performed. Some of the samples collected were also submitted for further metal speciation for CoCs identified during the screening phase of the HHRA process. This requirement for speciation is based upon the relative differences in respiratory toxicology of the various chemical species (*e.g.*, soluble *versus* insoluble forms). The results of the speciation analysis for air filters are provided in a separate report under the HHRA.

One blank filter was submitted for analysis with every 10 sample filters, as a quality assurance measure. Each batch of 10 filters, plus the blank filters, was taken from the same lot to eliminate the effects of inter-lot variability in background levels on the filters. As discussed below, metal levels measured on the sample filters were very low in most cases. For these situations, it was found that slight variability in the results of the analysis on the blank filters could cause a significant variability in metal levels calculated for exposed filters after subtracting background levels.

The decision was made to calculate the geometric mean value of all blank filters having the same lot number and use this as the background value to be subtracted from each of the individual exposed samples. For this study, the filter manufacturer provided 8” x 10” filters from only 2 lot numbers, with the first lot used for samples collected from October 2003 to May 2004, and filters from the second lot number used for the June to September 2004 samples. The 47 mm filters used for the Partisol units were from the same lot number for the entire year of measurements. Lab analysis of sample filters from each lot number showed zero concentrations of the CoCs on the unused filters.

Care was taken when delivering the samples to the laboratory. Envelopes containing the samples were sealed, and put into sturdy waterproof containers. The envelopes containing the filters were maintained in a flat position, to prevent the dislocation of particulate matter from the filter, which could cause uneven distribution and inconsistent lab results.

The gravimetric weight of each filter was determined in a special climate (temperature and humidity) controlled, static-free weighing room at the PSC Analytical Services facility. Filters were weighed prior to exposure and after submission of the sample to the lab, with the "clean" weight subtracted from the "exposed" weight of each filter to determine the amount of particulate matter collected during sampling. The final gravimetric weight provided by the lab was entered into a database and combined with the total volume of air sampled during the sample collection day, to derive an ambient air concentration. Despite all of these measures, it was found that the weights of the "clean" filters were higher than expected during the summer months of 2004, due most likely to higher than acceptable humidity levels in the storage chambers at the PSC facility. As a result, the decision was made not to subtract the blank values from any of the total particulate results. This did not influence the results of the metals analyses, as the filters were "digested" into a liquid solution for analysis, and blanks were subtracted for the metals.

PSC Analytical Services recommended that the analysis for metals be done using the ICP AES Axial method, which was approved by the MOE and other members of the Sudbury Soils Study Technical Committee (TC). Filter and concentration method detection limits (MDL) associated with this method are provided in Table 7.1 below. As a general rule, to be conservative, it is advised that the detection limit of the sample be at least 10 times less than the Ontario Ambient Air Quality Criteria (AAQC) (MOE, 2003) and this appears to be the case for all of the CoCs below.

Table 7.1 24-hour AAQC and Detection Limits for metals using ICP AES Axial Method

Element	Lab MDL Hi-vol/Lo-vol (µg)	Sample Detection Limit Hi-vol (TSP and PM$_{10}$ monitors)* (µg/m^3)	Sample Detection Limit Lo-vol (PM$_{2.5}$ monitors)** (µg/m^3)	24-hour AAQC (µg/m^3)***	AAQC Rationale
Antimony	10.0 / 1.0	0.0061	0.0417	25	Health
Arsenic	6.0 / 0.5	0.0037	0.0208	0.3	Health
Beryllium	1.0 / 0.1	0.00061	0.0042	0.01	Health
Boron	2.0 / 0.3	0.0012	0.0125	120	Particulate
Cadmium	2.0 / 0.2	0.0012	0.0083	2	Health
Chromium	2.0 / 0.2	0.0012	0.0083	1.5	Health
Cobalt	2.0 / 0.2	0.0012	0.0083	0.1	Health
Copper	2.0 / 0.2	0.0012	0.0083	50	Health
Iron	5.0 / 0.5	0.0031	0.0208	4	Soiling
Lead	3.0 / 0.3	0.0018	0.0125	2	Health
Molybdenum	3.0 / 0.3	0.0018	0.0125	120	Particulate
Nickel	3.0 / 0.3	0.0018	0.0125	2.0	Vegetation
Selenium	10.0 / 1.0	0.0061	0.04167	10	Health
Sulphur	25.0 / 2.5	0.015	0.1042	N/A	none
Thallium	10.0 / 1.0	0.0061	0.04167	N/A	none
Uranium	30.0 / 3.0	0.0184	0.1250	N/A	none
Vanadium	2.0 / 0.2	0.0012	0.0083	2	Health
Zinc	5.0 / 0.5	0.0030	0.0208	120	Particulate

*assumed volume of air sampled by hi-vol over 24 hours to be 1630 m^3
**assumed volume of air sampled by lo-vol over 24 hours to be 24 m^3
***N/A - no AAQC

8.0 QA PROCEDURES, DATA SCREENING AND MANAGEMENT

Quality Assurance/Quality Control (QA/QC) measures have been presented as part of the standard operating procedures in the sections above. Appendix C contains copies of the calibration curves as well as volumes and comments for each sample day.

Weights of total particulate matter on the filters before and after sampling were taken at PSC Analytical Services. Gravimetric weights were provided to the MOE and Falconbridge Ltd. for the stations at Copper Cliff (MOE: all parameters; Falconbridge Ltd.: TSP only) and Falco/Edison (MOE: PM_{10} and $PM_{2.5}$; Falconbridge Ltd.: TSP only) via e-mail before the end of the following month of sampling. The filters containing the TSP, PM_{10} and $PM_{2.5}$ samples from the Copper Cliff and Falco/Edison sites were cut in half at PSC Analytical Services, with one-half of the filter provided to the MOE and Falconbridge laboratories for their own analysis before the end of the following month of sampling.

Concentrations of particulate matter as TSP, PM_{10} and $PM_{2.5}$, as well as concentrations of each of the metals, were recorded for each sample. The following summary information was also recorded for each site and constituent measured:

- Annual geometric mean;
- Annual arithmetic mean;
- Maximum 24-hour concentration;
- Minimum 24-hour concentration;
- Number of times that 24-hour AAQC, Interim AAQC (PM_{10} only) and Canada Wide Standards ($PM_{2.5}$ only) were exceeded over the one year period;
- Number of valid samples;
- Detection limit for each contaminant; and
- Percent of samples less than the individual detection limits.

All of the data collected during this study, with the exception of the analyses performed by the MOE and Falconbridge Ltd. on their filters, is stored in a data acquisition system at RWDI, and has been backed up on CD monthly. Once the data were determined to be final (January, 2005), they were provided to Cantox Environmental for input to the HHRA analysis. All of the results are included in this report.

The data were reviewed to determine validity. Outliers were identified and discarded if determined to be extremely low (<0 is a good example), or too high (higher than possible) after other factors were considered (production schedules, other activities in the area on the day of sample collection, meteorological conditions), or not theoretically possible (*e.g.* PM_{10} results that are significantly greater than TSP results for co-located samplers). Site and sampler operation records were also closely considered, to ensure that a sample was valid (refer to screening criteria outlined in Section 6.0). Data collected during periods when the volume of air sampled was outside of the acceptable range, or if filters were damaged, or if incorrect sampling conditions and periods were observed, were also discarded and/or noted. These records have been included in Appendix C.

It was agreed at the onset of this study that any air quality measurements that could pose an immediate human health risk would be reported by the SARA Group in a timely fashion to the TC. When data were received from the analytical laboratory and calculations were performed to determine ambient concentrations, they were:

- Checked to meet standard field and lab QA/QC; and
- Compared with the associated MOE 24-hour AAQC, as listed in Table 7.1 - any values greater than the AAQC were reported from the Director of the SARA Group to the TC as soon as the value was verified.

All levels measured that were greater than the air regulation limits (discussed in Chapter 11) were reported to the members of the TC.

9.0 RESULTS

The results from the monitoring study are presented in Tables 9.1 to 9.22, inclusive, as 24-hour concentrations of TSP, PM_{10}, $PM_{2.5}$ and metals/metalloids for the 22 monitors at 10 sites. These tables also provide the annual geometric and arithmetic means, maximum and minimum values for the year, lab detection limits, and the number of times that levels were reported to be greater than ambient air quality criteria and standards. The original lab results from PSC Analytical Services are provided in Appendix E. The results are also presented in Figures 9.1 to 9.24, to illustrate various trends and comparisons. These findings are discussed in more detail below.

9.1 Valid Samples

Overall, very few samples were missed or invalidated over the course of the year at the majority of the 22 air monitors (Tables 9.1 to 9.22). No samples were missed and all were considered valid at the Coniston, Falco/Edison PM_{10}, Skead, Walden and Windy Lake TSP monitors for the one-year period. Between one and four sample days were missed at the remaining stations as a result of power outages or equipment (timer, flow controller) malfunction, except for the Windy Lake PM_{10} and the Copper Cliff Partisol $PM_{2.5}$ units. Seven samples were missed at the Windy Lake PM_{10} monitor, which malfunctioned despite efforts to replace individual parts. Finally the entire unit was replaced, and valid samples were collected for the remainder of the year. The Copper Cliff Partisol $PM_{2.5}$ unit appeared to have manufacturer's defects (it was a new unit at the start of the study), which resulted in long delays associated with different replacement parts. An unusual power surge and other outages caused additional problems when the new parts were installed, resulting in collection of only 30 samples over the year-long program. These results have been provided in Table 9.21 despite the lack of a full year of monitoring, for non-regulatory purposes.

9.2 Particulate Matter

TSP and $PM_{2.5}$ samples were collected at five of the ten monitoring sites (Garson, Copper Cliff, Falco/Edison, Travers/West End and Windy Lake). PM_{10} samples were collected at all 10 sites. Particulate matter concentrations are provided in the first column of each of Tables 9.1 to 9.22 for each sample taken over the monitoring period. Figure 9.1 provides a comparison of the particulate matter collected at the ten PM_{10} sites, Figures 9.2 and 9.3 provide a comparison of the three sizes of particulate matter (TSP, PM_{10} and $PM_{2.5}$) at the five sites where all size fractions were measured. Figures 9.4 and 9.5 compare $PM_{2.5}$ lo-vol and hi-vol results at the Copper Cliff and Falconbridge sites, respectively.

Twenty-four hour PM_{10} concentrations during the study ranged from zero to a single maximum value of 85 µg/m^3, measured at the Travers/West End monitor (Figure 9.6). The next single highest PM_{10} concentration was measured at Windy Lake (58 µg/m^3). For the remaining 8 stations, the maximum 24-hour PM_{10} concentrations ranged from 41 to 47 µg/m^3. Annual geometric means measured at the PM_{10} stations ranged from 7 µg/m^3 (Falco/Edison) to 14 µg/m^3 (Travers/West End). Annual geometric mean values measured at the other stations fell into the range of these extremes - 8 µg/m^3 (Skead), 9 µg/m^3 (Algonquin/South End, Coniston, Hanmer and Windy Lake) and 10 µg/m^3 (Copper Cliff, Garson and Walden).

TSP concentrations ranged from 2 to 154 µg/m^3 at the five stations over the monitoring period. The highest values were recorded at the Travers/West End and the Windy Lake stations (154 and 147 µg/m^3 respectively), whereas the remaining stations recorded maximum concentrations of 90 µg/m^3 (Falco/Edison) and 82 µg/m^3 (Copper Cliff and Garson). Annual geometric means in the range of 11 to 32 µg/m^3 were measured, with Windy Lake and Falco/Edison at 11 and 13 µg/m^3, respectively, Copper Cliff and Garson both at 21 µg/m^3 and Travers/West End at 32 µg/m^3.

$PM_{2.5}$ concentrations in the range of zero to 66 µg/m^3 were measured at the five stations: 66 µg/m^3 at Windy Lake, 41 µg/m^3 at Travers/West End, 31 µg/m^3 at Copper Cliff, 35 µg/m^3 at Falco/Edison and 36 µg/m^3 at Garson. Annual geometric means in the range of 5 to 10 µg/m^3 were recorded.

To exclude the outliers in the datasets that may have been caused by isolated incidents at a site, the 5th, 25th, 50th, 75th, 95th percentiles of PM_{10} at the 10 sites were calculated (Figure 9.1). These plots indicate that the highest concentrations were consistently measured at the Travers/West End site, and that once the outliers are removed, stations like Windy Lake (which had a relatively high single maximum concentration for the year) were shown to experience much lower levels for the majority of the year. The plots in Figure 9.1 show interesting trends as a group. Travers/West End and, to a lesser extent, Garson show a higher range between the 25th and 75th percentile value than other sites. The remaining stations have a smaller range between the 25th and the 75th percentile, and somewhat variable median values (sometimes closer to the 25th percentile, sometimes closer to the 75th). The median concentrations for all sites varied from a low of 7 µg/m^3 at Falco/Edison to 13 µg/m^3 at Travers/West End (Figure 9.1), which is almost identical to the annual geometric means listed above for the PM_{10} monitors (ranging from 7 µg/m^3 to 14 µg/m^3 for these stations).

All three size fractions of particulate matter (TSP, PM_{10} and $PM_{2.5}$) were measured at five sites. Figure 9.2 presents box plots with distributions for TSP, PM_{10} and $PM_{2.5}$ data measured at these stations. These plots indicate that the highest concentrations of TSP were measured at the Travers/West End station, similar to the PM_{10} results. The highest degree of variability was seen in the TSP sample results, and in most cases the lowest variability seen in the results for $PM_{2.5}$. This is likely due to the relatively low concentrations, i.e., the $PM_{2.5}$ sampler rarely measured concentrations greater than 20 $\mu g/m^3$, thus allowing for less variability compared to the much higher concentrations of TSP at sites like Travers/West End. Factors such as the precision of analytical techniques (weighing) for filters with low loadings and the handling of the filters in the process of the sample collection may also affect the results.

The annual geometric means for those sites with three monitors are shown in Figure 9.3. TSP:PM_{10} ratios were calculated at Copper Cliff (2.1:1), Falco/Edison (1.9:1), Garson (2.1:1), Travers/West End (2.2:1), and Windy Lake (1.2:1). The average ratio for these 4 stations is 2.07:1, and it generally appears that a measured PM_{10} value can be multiplied by an approximate factor of 2 to derive a reasonable estimate of equivalent annual mean TSP concentration at the sites where only PM_{10} was measured. This allows us to extrapolate annual mean TSP at sites without these monitors. It would appear that the Windy Lake station results (1.2:1) are sufficiently different from those for the other four sites, and thus are not recommended for use in developing a ratio for sites in the Sudbury area.

The ratio of $PM_{2.5}$:PM_{10} was more consistent among the five sites, with a value of 0.71:1 at both Travers/West End and Windy Lake, 0.76:1 at Falco/Edison, 0.82:1 at Garson and 0.86:1 at Copper Cliff. Averaging these five values gives a mean ratio of 0.78:1. Thus, a PM_{10} value measured in the Sudbury area could be multiplied by 0.78 to derive an equivalent annual mean $PM_{2.5}$ concentration.

Two lo-vol $PM_{2.5}$ monitors were installed alongside the $PM_{2.5}$ hi-vols at the Falco/Edison and Copper Cliff stations, for experimental purposes. The Copper Cliff monitor experienced technical problems for the first half of the year, so the results presented in Table 9.21 are incomplete, and are provided for comparative purposes only. The results for the Falco/Edison lo-vol are provided in Table 9.22. A comparison of the lo-vol and hi-vol results for these sites is provided in Figures 9.4 and 9.5. These figures suggest the two methods demonstrate similar trends, but the values are not directly comparable. Also, neither method appears to read consistently high or low compared to the other instrument. For example, approximately 60% of the concentrations measured using the hi-vol sampler at Falco/Edison were higher than the concentrations measured using the lo-vol sampler, while only 33% were greater at the Copper Cliff site. As noted above, factors such as the precision of weighing of filters with low loadings and the handling of filters during sample collection may also results in some of this variability. The smaller filters and lower flows of the Partisol samplers could lead to greater variability and precision issues than in the case of the hi-vols.

There was a single instance (August 25, 2004) when the Partisol sampler result at Copper Cliff was greater than the 30 ug/m3 Canada Wide Standard for $PM_{2.5}$ (24-hour concentration value of 45.8 ug/m^3; the only sample shown to be above the limit). Near the end of the study, there were periodic emissions from a diesel generator located inside the Copper Cliff pumphouse on which the Partisol unit was housed, with the exhaust pipe located within 5 metres of the Partisol monitor. The other monitors were further away from this source. We were not able to obtain the records of when the generator was run, but feel that this value is an outlier influenced by the generator, especially given the fact that on August 25th the PM_{10} monitor only measured a concentration of 25.4 ug/m^3, and the hivol $PM_{2.5}$ monitor a value of 16.9 ug/m^3. Thus the Partisol value was not reported as an exceedance.

The 24-hour PM_{10} data was measured over the entire monitoring program at each of the 10 sites (Figure 9.6). A number of observations can be made. The Travers/West End site exhibited a very marked seasonal pattern, with significantly higher concentrations measured during the summer months and lowest during the winter. The other stations exhibited this pattern on occasion, but to a lesser degree. It is interesting to note that all 10 stations recorded high concentrations on June 8th, despite their different locations. It was a warm summer day, with moderate winds from the southwest and dry conditions. Contrary to this was the high value recorded only at Travers/West End on July 26th, as all other stations recorded relatively low concentrations on this day. An interesting observation is the significant number of times that all 10 stations recorded similar values, despite their different locations and settings (proximity to sources and alignment with local winds). This gives further confidence in the results and the design of the monitoring program.

9.3 Chemicals of Concern

Concentrations of each of the six COCs for the Sudbury Soils Study (arsenic, cobalt, copper, lead, nickel and selenium) measured at each of the 10 sites are provided in Tables 9.1 to 9.22. Concentrations of the COCs in PM_{10} are shown graphically in Figures 9.7 to 9.12. The geometric mean values for each of the CoCs in the TSP, PM_{10} and $PM_{2.5}$ filters is compared in Figures 9.13 to 9.18.

The method detection limits were no more than one-tenth of the air quality criteria, to ensure that exceedances can be adequately detected. Copper was detected in 100% of all samples collected at all of the sites. For cobalt, non-detectable levels were found in 8% of the samples at Travers/West End and 100% of the samples at Windy Lake, with the other sites falling between those two extremes (Tables 9.1

to 9.20). Lead and nickel were detected more often than cobalt, with the non-detectable levels in 0 to 53% (lead) and 0 to 57% (nickel) of the samples, depending on the site. Selenium was found to be very close to or at non-detectable levels 100% of the time at all 20 monitors. Cobalt and selenium were not detected in any of the lo-vol samples.

Figure 9.7 presents a comparison of the distributions of arsenic at the ten PM_{10} sites. In general very low levels of arsenic were measured at all sites, in most cases at or below detection even at the 75th percentile level. The exception to this is Travers/West End, where there were a significant number of concentrations measured in the range of 0.002 to 0.008 $\mu g/m^3$. This is well above the detection limit but still at least two orders of magnitude lower than the AAQC level of 0.3 $\mu g/m^3$. The median value was at the detection limit, indicating that there were "non-detectable" levels measured during the majority of the sampling days at all stations. The highest 95th percentile level was measured at the Travers/West End site, at a level that was three times greater than the levels at any of the other stations.

Very low levels of cobalt were also measured at the ten PM_{10} sites (Figure 9.8). The highest concentrations were measured at the Travers/West End station, followed by significantly lower but still measurable levels at Copper Cliff and Falco/Edison. Most cobalt concentrations measured in the PM_{10} samples were several orders of magnitude less than the 24-hour AAQC of 0.1 $\mu g/m^3$, with the exception of the maximum concentration of 0.06 $\mu g/m^3$ measured at the PM_{10} monitor at Travers/West End, which approached but still remained below the AAQC.

Copper levels were fairly low, but still measurable, at all ten PM_{10} stations (Figure 9.9). The highest levels were found at Travers/West End, followed by Copper Cliff and Hanmer. The other sites reported concentration distributions with 95th percentiles less than 0.05 $\mu g/m^3$. The highest 24-hour value for the year at the PM_{10} sites was 1.05 $\mu g/m^3$ at Travers/West End, which is still well below the AAQC of 50 $\mu g/m^3$.

Except for occasionally higher values, all of the ten PM_{10} stations recorded consistently low levels of lead (Figure 9.10), with the exception of Copper Cliff, where the highest 95th percentile value was measured, and Travers/West End which recorded the highest 75th percentile level. This would indicate that Copper Cliff experienced some relatively high values of lead, but not as often as the moderately high levels experienced at Travers/West End. The 25th, 75th percentiles and median values were all below 0.025 $\mu g/m^3$. The highest single concentration of 0.13 $\mu g/m^3$ was measured at the Travers/West End monitoring station. All stations recorded concentrations well below the provincial AAQC level of 2.0 $\mu g/m^3$.

Fairly low levels of nickel were experienced at most stations, with the exception of Travers/West End, which reported considerably higher distributions than the other stations, and Copper Cliff which was moderately higher (Figure 9.11). The maximum single nickel concentration measured was 0.87 µg/m^3 at Travers/West End. All levels were below the 24-hour AAQC of 2.0 µg/m^3.

Selenium was essentially non-detectable, and was measured only very occasionally at levels above the detection limit (Figure 9.12). The Travers/West End site recorded the highest single concentration during the year (0.08 µg/m^3), whereas the other sites did not record much higher than the detection limit. All were well below the 24-hour AAQC level of 10.0 µg/m^3.

The monitoring data discussed above refers to the levels of the COCs in the PM_{10} filters. The geometric mean values for each of the CoCs, as calculated from the TSP, PM_{10} and $PM_{2.5}$ results, are compared in Figures 9.13 to 9.18. The pattern of decreasing concentration with size of particulate matter collected is evident for all other COCs, but certainly not consistently at the same ratio as the particulate matter (2:1 for TSP:PM_{10} and 0.78:1 for $PM_{2.5}$:PM_{10}) before it was analyzed for metals.

Figure 9.13 shows a slight decrease in annual geometric mean with decreasing particle size for arsenic. The small differences may be due to the low levels measured, but also may indicate that the majority of this metal is found in the $PM_{2.5}$ size range. The difference is much more obvious for cobalt (Figure 9.14), especially at the Travers/West End station, where the annual geometric mean concentration of cobalt in TSP is approximately four times greater than the concentration in PM_{10}. At Windy Lake all levels were below detection, likely because of the remote location (removed from sources). This trend was also evident with selenium (Figure 9.18), i.e., virtually no difference with particulate size, and extremely low concentrations at Windy Lake.

Figure 9.17 also shows high TSP:PM_{10} ratios for nickel at the Travers/West End site and the Copper Cliff site, at 5:1 and $PM_{2.5}$:PM_{10} ratios at approximately 0.5:1. Lead concentration ratios presented for the three size fractions in Figure 9.16 are less extreme than the nickel ratios discussed above, with the highest concentrations measured in TSP and the other sizes at the Travers/West End and Copper Cliff sites. Similar patterns were evident for Garson and Falco/Edison. It is likely that low levels of lead at Windy Lake were the cause of a lack of size differentiation, or the fact that all of the lead was in the $PM_{2.5}$ fraction. Copper concentrations presented in Figure 9.15 show that this metals occurs predominantly in the larger size fractions, with concentrations in the TSP fraction at least seven times greater than those in the PM_{10} at all of the stations, even at Windy Lake.

Seasonal trends for the six CoCs are presented in Figures 9.19 to 9.24, which display the 24-hour metal concentrations measured in PM_{10} over the entire study period at the 10 stations. Arsenic was present at somewhat higher concentrations during the summer months, indicating the possibility of fugitive sources such as windblown dust. Most of the COCs were higher at the Travers/West End site during the summer months, but fairly constant at the other stations. This trend was also evident for copper, with the exception of higher than normal levels measured at Hanmer early in the study period that may have been related to the hivol unit used for measurement. A Wedding unit was originally used at this site. Some air quality scientists feel that copper may be released from wiring in the motor of some hivols – this unit was replaced and the levels of copper measured decreased after January at this site.

Nickel levels increased during the summer months at the Travers/West End site (Figure 9.23) emphasizing the contribution from the waste rock piles located near to this site. The highest concentrations at Copper Cliff were measured during the spring, but remained at lower levels during the rest of the year. The other sites recorded relatively low nickel levels without significant variation throughout the study period. Selenium was measured on occasion at the Travers/West End, Copper Cliff and a few others, with no pattern evident (Figure 9.24). Lead concentrations presented in Figure 9.22 were fairly constant over the year (i.e., no seasonal fluctuations, just source/wind related fluctuations), with several high levels recorded at Travers/West End and Copper Cliff.

9.4 Other Metals/Metalloids

Concentrations of the non-Chemical of Concern metals/metalloids are presented in Tables 9.1 to 9.22. All results were found to be considerably less than their respective AAQC’s during the sampling period.

10.0 METEOROLOGICAL DATA

The CoC concentrations measured in each of the PM_{10} samples were overlain onto a map of Sudbury along with the wind rose for each day that shows the wind directions and speeds experienced over the 24 hours of sampling. These maps (n=60, for each sample day) are provided electronically as Appendix F. A single example figure is provided at the end of the Figures section of this report. A brief description of the sky conditions and temperature for each day is also provided with the wind rose. These maps allow for a more detailed interpretation of the results obtained for each sampling day at each of the stations (Appendix F). They are preceded (in this Appendix) by a single map showing the location of past and present smelters in the Sudbury area, and the approximate location of fugitive sources of dust such as tailing and waste rock piles.

Meteorological data for each sampling day were obtained and archived from the following sources:

- Sudbury Airport, an Environment Canada Class A meteorological station (used to develop the wind roses presented in Appendix F);
- MOE stations at Frood (MOE #77025) located in downtown Sudbury and Hanmer (MOE #77013) located adjacent to the Hanmer air monitoring station in Hanmer; and
- Falconbridge Smelter on-site tower (Falconbridge Ltd.).

The primary objective of this study was the collection and presentation of air monitoring data for the one-year period at 10 stations in the Sudbury area, for use in the HHRA exposure analysis. The study scope did not include detailed interpretation of the results (such as source apportionment) using meteorological information for each day. The meteorological data were collected and archived but are not presented in this report. At the onset of this study, attempts were made to obtain Ontario Ministry of Transportation (MTO) data from their Cartier site located approximately 15 km north of Windy Lake on Highway 144 and from their South Sudbury site located at the intersection of Highway 69 and Highway 17, but these data were not made available to this study.

11.0 COMPLIANCE WITH AIR QUALITY REGULATIONS

As previously discussed, relatively low levels of all COCs were measured during the monitoring program. The very few exceedences of provincial and federal air quality regulations are summarized in Table 11.1.

Table 11.1 Exceedances of 24-hour Air Quality Regulations

Date	Location	Contaminant	Ambient Air Quality Criteria (µg/m^3)	Concentration (µg/m^3)
July 26, 2004	Travers/West End	TSP	120	154
Sept 30, 2004	Travers/West End	TSP	120	131
June 8, 2004	Windy Lake	TSP	120	147 *
July 26, 2004	Travers/West End	Cobalt in TSP	0.1	0.132
Sept 30, 2004	Travers/West End	Cobalt in TSP	0.1	0.158
Date	**Location**	**Contaminant**	**Interim Ambient Air Quality Criteria (µg/m^3)**	**Concentration (µg/m^3)**
June 8, 2004	Travers/West End	PM_{10}	50	69.7
July 26, 2004	Travers/West End	PM_{10}	50	84.9
June 8, 2004	Windy Lake	PM_{10}	50	58.4 *
Date	**Location**	**Contaminant**	**Canada Wide Standard (µg/m^3)**	**Concentration (µg/m^3)**
June 8, 2004	Copper Cliff	$PM_{2.5}$	30	30.9
June 8, 2004	Falco/Edison	$PM_{2.5}$	30	34.8
June 8, 2004	Garson	$PM_{2.5}$	30	35.9
March 22,2004	Travers/West End	$PM_{2.5}$	30	41.1
June 8, 2004	Travers/West End	$PM_{2.5}$	30	37
June 8, 2004	Windy Lake	$PM_{2.5}$	30	66.3 *

* filter was visually observed to have pollen loading on this day (yellow material in addition to grey or brown which indicates dust loading). As well, nearby temporary construction/road traffic may have contributed to this level.

All of the exceedances were measured on four dates - March 22, June 8, July 26 and September 30, 2004 (Table 11.1). The meteorological conditions recorded at the Sudbury Airport for those days is provided in Table 11.2.

Table 11.2 Meteorological Conditions on Days with Air Quality Regulation Exceedances

Date	Meteorological Conditions
Mar 22, 2004	Mainly clear, temperatures varied from – 6 to –20 deg.C, wind speeds varied from 7 to 30 km/hr, and were from NW and SW.
June 8, 2004	Partly cloudy, temperatures varied from 16 to 29 deg.C, wind speeds varied from 4 to 26 km/hr, winds predominantly from the SW.
July 26, 2004	Partly cloudy, temperatures varied from 12 to 25 deg.C, wind speeds varied from 4 to 13 km/hr, winds from S to W directions.
Sept 30, 2004	Mainly clear with some clouds, temperatures varied from 5 to 21 deg.C, wind speeds varied from 0 to 11 km/hr, winds from SW and NW directions.

The exceedances occurred on days with variable meteorological conditions. All days were clear and somewhat windy, with winds from south-westerly directions, in addition to north-west winds on two of the days (displayed in Appendix F). The following observations can be made:

- The March 22, 2004 exceedance at Travers/West End was localized and resulted in relatively high concentrations of all CoCs at this site only. This is likely attributable to higher than normal wind speeds from the direction of the slag piles located near this site.

- Eight of the 14 exceedances were recorded on June 8, 2004, for dust levels experienced at Windy Lake, Travers/West End, Copper Cliff, Falco/Edison and Garson. It was a hot summer day with clouds and moderate winds from the southwest. It is likely that the Windy Lake samples were high because of high pollen loadings, as yellow material was observed on the filters. Dust from localized construction and road dust sweeping may also have contributed to these exceedances, because other than at the Travers/West End site (influenced by the dry conditions and the south-westerly winds blowing from the nearby slag pile), the levels of CoCs were relatively low at the other sites.

- Three exceedances were recorded on July 26, 2004 at the Travers/West End site, attributed to the southwesterly winds (light to moderate) blowing from the direction of the adjacent slag piles. One of the two cobalt exceedances was measured on this day at this site, with the concentration just barely above the 0.1 criteria value.

- Fairly light south-southwesterly winds in combination with dry conditions experienced on September 30, 2004 resulted in exceedances of the cobalt and the TSP standard at the Travers/West End site. Levels of the other CoCs were relatively low on this day at the other sites.

There were 20 different samples collected at the Travers/West End site that had total iron levels greater than the 24-hour AAQC for metallic iron (4.0 µg/m^3), 16 from the TSP monitor and 4 from the PM$_{10}$ monitor at this site. These have not been reported as exceeding the criteria because there is no evidence to indicate that the samples contained metallic iron. As a general rule, metallic iron emissions are associated with the steel production industry, not mining and smelting of copper and nickel.

12.0 DISCUSSION AND CONCLUSIONS

The Travers/West End site consistently recorded higher concentrations of particulate matter and metals/metalloids than the other monitoring sites. This site is situated close to a waste rock/slag pile, and these results emphasize the importance of fugitive emissions, i.e., the concentrations recorded at this station were greater than those measured at stations that were situated close to industrial process sources.

Windy Lake was established as a background station. Moderate levels of arsenic, copper and particulate matter were measured on occasion at this site, but of interest was the fact that much of the particulate matter measured on these days was observed to be pollen (filters were yellow rather than grey or brown), and seemed to be present on all of the particulate size fractions.

Higher than expected copper levels were recorded at the Hanmer site at the onset of this study, but these were reduced when the Wedding hi-vol was replaced with a newer (Tisch) model.

In some instances, the Falco/Edison station recorded concentrations that were lower than those in less industrialized settings. This may be due to the local meteorology (this station is not consistently downwind of the Falconbridge smelter) or the influence of site location (on a roof) on the measurement capacity of the hi-vols.

Overall, very few samples were missed. The study collected a wealth of data that can be further analyzed and used to define the ambient air quality in many neighbourhoods where these monitors were located.

A comparison of $PM_{2.5}$ levels measured with a hi-vol vs. a lo-vol monitor was made at two of the stations (Copper Cliff and Falco/Edison), but little correlation was found. It was felt that the lo-vol units did not collect enough sample material to allow detection in many cases, which was evidenced by the number of "non-detectable" results compared to the $PM_{2.5}$ results collected with the hi-vol units.

In conclusion, it would seem that relatively low levels of all metals/metalloids and particulate matter were found in the 1220 hi-vol samples collected from October 2003 to September 2004, inclusive. The air quality limits were exceeded only 14 times (5 times for the AAQC, 3 times for the Interim AAQC and 6 times for the Canada-Wide Standard), with some of these exceedances attributed to natural sources. All of this information has been provided to the HHRA, for further analysis.

13.0 REFERENCES

Sara Group, 2004, “Sudbury Air Monitoring Study – Work Plan and Operations Manual|”, January 13, 2004.

Ontario Ministry of the Environment (MOE), 2003. Operations Manual for Point Source Air Quality Monitoring, Operations Division – Technical Support Section.

APPENDIX A

PHOTOGRAPHS OF SARA AIR MONITORING SITES

APPENDIX B

NAPS SAMPLING DAYS

NATIONAL Air Pollution Surveillance Network
2003/2004 High Volume, PM_{10}, $PM_{2.5}$ and Partisol Sampling Schedule

October 2003:
- Monday 6th
- Sunday 12th
- Saturday 18th
- Friday 24th
- Thursday 30th

November 2003:
- Wednesday 5th
- Tuesday 11th
- Monday 17th
- Sunday 23rd
- Saturday 29th

December 2003:
- Friday 5th
- Thursday 11th
- Wednesday 17th
- Tuesday 23rd
- Monday 29th

January 2004:
- Sunday 4th
- Saturday 10th
- Friday 16th
- Thursday 22nd
- Wednesday 28th

February 2004:
- Tuesday 3rd
- Monday 9th
- Sunday 15th
- Saturday 21st
- Friday 27th

March 2004:
- Thursday 4th
- Wednesday 10th
- Tuesday 16th
- Monday 22nd
- Sunday 28th

April 2004:
- Saturday 3rd
- Friday 9th
- Thursday 15th
- Wednesday 21st
- Tuesday 27th

May 2004:
- Monday 3rd
- Sunday 9th
- Saturday 15th
- Friday 21st
- Thursday 27th

June 2004:
- Wednesday 2nd
- Tuesday 8th
- Monday 14th
- Sunday 20th
- Saturday 26th

July 2004:
- Friday 2nd
- Thursday 8th
- Wednesday 14th
- Tuesday 20th
- Monday 26th

August 2004:
- Sunday 1st
- Saturday 7th
- Friday 13th
- Thursday 19th
- Wednesday 25th
- Tuesday 31st

September 2004:
- Monday 6th
- Sunday 12th
- Saturday 18th
- Friday 24th
- Thursday 30th

APPENDIX C

CALIBRATION INFORMATION AND FIELD NOTES

APPENDIX D

LETTERS FROM THE MOE RE AUDITS

APPENDIX E

LAB RESULTS

APPENDIX F

SPATIAL PRESENTATION OF COC CONCENTRATIONS AND METEOROLOGICAL CONDITIONS FOR EACH SAMPLING DAY