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DETERMINATION OF CONCENTRATIONS OF SELECTED FINE PARTICULATE AIR CONTAMINANTS IN SEVEN CANADIAN CITIES

APPENDIX II

A COMPARATIVE STUDY OF ANALYTICAL METHODS TO DETERMINE ELEMENTAL CONCENTRATIONS OF AIRBORNE PARTICLES ON TEFLON FILTERS

ACKNOWLEDGEMENTS

Concord Scientific Corporation is pleased to acknowledge the participation, advice and assistance of several key individuals and organizations whose contributions to the comparative study were in large part responsible for its success.

The Ontario Ministry of the Environment, Laboratory Services Branch contributed generously in terms of analyses and materials. Dr. Richard Judge is to be thanked particularly. Dr. Denis Corr and Mr. Jim Smith (MOE, Air Resources Branch) are to be thanked for expert advice and assistance throughout the course of this study and the companion field study.

Mr. Robert K. Stevens, U.S. Environmental Protection Agency, provided valuable expert advice and generously made available to the study the facilities of the X-ray fluorescence laboratory at Northrup Services Inc. Dr. William Courtney of Northrup also contributed helpful comments.

Input from Dr. John Cooper and Mr. Clifton Frazier, NEA Laboratories was invaluable.

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1.0 INTRODUCTION/BACKGROUND

1.1 Introduction

Concord Scientific Corporation was contracted to undertake a comparative study of analytical methods used to determine elemental concentrations of airborne particulate matter collected on teflon filters. The study was to consider about fifteen elements frequently detected in airborne particles. As part of a study entitled "Determination of Concentrations of Selected Fine Particulate Air Contaminants in Seven Canadian Cities", conducted for Environmental Protection Service, Environment Canada, an interlaboratory analytical methods comparative study was to be carried out for the elements arsenic, cadmium, chromium and lead, and sulphate ion. This contract was supplemented by a contract with the Air Resources Branch, Ontario Ministry of the Environment to add ten elements to the interlaboratory comparison: aluminum, silicon, sulphur, chlorine, calcium, titanium, manganese, iron, zinc and bromine.

The substrate collection media to be investigated were small-format (37 mm diameter) teflon filters as similar as practicable to those used in commercial dichotomous samplers, the samplers to be used in the federal "Seven Cities" study (see section 1.2). The concentrations of elements and ions to be determined on these filters were to be typical ambient loadings on dichotomous sampler filters.

This report, then, is a report to both sponsoring agencies on the complete comparative study. It constitutes the final report on the Ministry of the Environment contract and forms part of the final report on the Department of the Environment contract. This format has been chosen to give both sponsors the benefit of the entire study in a consistent treatment.

1.2 Background

Studies of airborne particles in a number of areas have shown that most of the particle mass lies in two size fractions: those with aerodynamic diameters (d) < 2 μm and those for which d lies between 2 and 30 μm. It is also becoming more generally accepted that, from the viewpoint of human health, airborne particles with d < 15 μm are of greater importance than large particles. Furthermore, it is known that, generally, many of the potentially harmful substances such as Pb, As, SO_4^{-2}, and others, are heavily concentrated in the d < 2 μm fraction. However, up until the present, by far the most commonly used method in North America of determining the airborne particle loading has been high volume ("HI VOL") air sampling. This method does not, however, provide any information on the particle size distribution. Size information is extremely important, in addition to human health considerations, for assessment of such areas as: visibility reduction, pollutant dry deposition rates and precipitation scavenging.

Recently, single stage virtual impactors ("Dichotomous Samplers"), using teflon filter membranes as the collection medium, have become commercially available and are being considered as possible replacements/supplements to the HI VOL sampler as they divide the collected airborne particles into two size fractions d < 2.5 μm and 2.5< d < 15 μm. These two fractions are of primary interest from the standpoint of air pollution control and for many purposes constitute an acceptable trade off between the size/mass information desired and important practical considerations such as cost.

1.3 Previous Studies

Two major comparative studies of the determination of trace element composition of airborne particulate matter samples collected on small format filters have been carried out in the United States (1, 2, 3). Several collection media and several analytical methods were compared, and in the latter study, eleven different designs of aerosol samplers were also compared. Included in that study were several versions of the dichotomous sampler.

Since the two comparative studies referred to above, the dichotomous sampler has been adopted by the U.S. Environmental Protection Agency, along with the size-selective-inlet-equipped Hi Vol, to supplement the U. S. particulate matter HiVol sampling network. Environment Canada has decided to evaluate the dichotomous sampler as a candidate for use in its National Air Pollution Surveillance network. The Ontario Ministry of the Environment is evaluating, likewise, the dichotomous sampler for possible inclusion in the Ontario Air Quality Monitoring Network.

In addition to the new information on physical characteristics of airborne particles afforded by the size-selective and size-fractionating instrumentation, more detailed chemical characterization data are also being sought. The current emphasis in both Canada and the U.S. is on multi-element and ionic analysis, although in the future, specific chemical compound analysis will become more important. More frequent sampling than is customary will likely be carried out to generate the desired data.

Because of the large number of samples that would be collected by the extensive sampling program that is anticipated and the number of parameters to be determined per sample, it is essential to have analytical methods that will produce the required number of tests in a timely and cost effective manner, with no sacrifice in accuracy or precision.

The selected analytical methods were to be evaluated for a specific substrate - airborne particles collected on a teflon filter medium. Teflon film membranes are currently favored as the sampling medium to be used with the various commercial models of the dichotomous sampler. One of the principal reasons for preferring a teflon filter is the absence of the formation of spurious particulate sulphates and nitrates by oxidation of gaseous SO_2 and NO_2 and reaction with HNO_3 on the filter surface. These artifacts can be avoided by using teflon or teflon-coated media other than in the thin film format, but the latter is preferred because of the essentially planar configuration of the deposited particle load which is highly desirable for subsequent analysis by X-ray fluorescence spectrometry (XRF). XRF is the U.S. EPA's method of choice to analyze these filters.

The comparative study of analytical methods, then, addressed only particles collected on the thin-film teflon filter medium, recognizing that other media might eventually prove to be more desirable, considering the analytical finish(es) that might be chosen for use in Canada. XRF (especially the energy dispersive version) is not widely used in Canada for trace analysis. In fact, simultaneous multi-element analysis of environmental samples by XRF is at the developmental stage in government laboratories and is not available commercially in Canada for the desired range of elements.

2.0 STUDY PROTOCOL

2.1 General

One of the major drawbacks in previous comparative studies of methods for analysing air filters has been the lack of appropriate standards in a format that was suitable for various analytical methods. For example, the homogeneous, thin film materials that are most suitable for testing and calibrating X-ray fluorescence spectrometers are not suitable for techniques such as plasma emission spectrometry that require the analyte to be dissolved during sample preparation. That is, it is difficult to compare methods quantitatively, especially non-destructive methods with destructive methods, when the sample format requirements for optimum performance of the techniques may be very different.

A related problem has been the difficulty of preparing standard samples on a teflon medium. Teflon, of course, is hydrophobic, so that aqueous solutions or aerosols are difficult to deposit with the uniform loading required for a technique like XRF, without a fixative agent, if the deposit can be made to adhere to the substrate at all.

The use of fixative agents or embedding the analyte (permanently) in teflon or another polymeric film usually precludes quantitative dissolution or extraction of the analyte for a type of analysis requiring the sample to be prepared in this manner.

A compromise was necessary in this situation. As described in sections 2.3 and 2.4 below, the standard filters that were submitted to the various participating laboratories/techniques were not optimized for some laboratories' requirements, nor could the standard samples and field test samples be matched to the filter medium used in the dichotomous samplers.

The analytical methods to be evaluated in this study and the number of laboratories representing each method had to be restricted, both because of the limitation of funds and because of the limited availability of time in candidate laboratories.

The analytical methods that were chosen for study represented one well-established technique and two of the promising techniques for quantitative, simultaneous multi-element analysis - one non-destructive (energy dispersive X-ray fluorescence spectrometry, XRF) and two destructive (directly-coupled plasma emission spectrometry, DCP, and atomic absorption spectrometry, AAS).

Special techniques were evaluated for a few of the analytical parameters, namely sulphate ion, chloride ion, and arsenic. Ion exchange chromatography (IC) is currently generally accepted as a valid technique for the analysis of anions in airborne particulate matter. It was used for sulphate and chloride in this study. Similarly, flameless atomic absorption spectrometry (FAA) is a generally accepted method for arsenic (via arsine generation) and was compared with XRF for this parameter.

The ion chromatography method was compared with XRF for chloride in this study.

2.2 Participating Laboratories

The following list summarizes the laboratories that participated in the comparative study and the techniques that were used for the elements sought in this study.

1. NEA Laboratories Inc. (NEA)
   8310 S.W. Nimbus St.,
   Beaverton, Oregon 97005
   Telephone (503) 643-4661

   Contacts: Dr. John Cooper, President
   Mr. Clifton Frazier, Analytical Chemist

   Method: Energy - dispersive X-ray fluorescence spectrometry

   Role: Analysis of standard and field test filters.

2. X-ray Assay Laboratories Ltd. (XRAL)
   1885 Leslie Street
   Don Mills, Ontario M3B 3J4
   Telephone (416) 445-5755

   Contacts: Mr. J. H. Opdebeeck, Manager
   Dr. T. Eagles, Director of Research

   Methods: Directly-coupled plasma emission spectrometry, flameless atomic absorption spectrometry.

   Role: Analysis of standard and field test filters.

3. Environment Canada (DOE)
   Air Pollution Control Directorate
   Chemistry Division
   Air Pollution Technology Centre
   River Road
   Ottawa, Ontario
   Telephone: (613) 998-3671

   Contact: Dr. Chris Pupp

   Methods: Unable to report results because of scheduling and instrumental difficulties.

4. Northrup Services Inc. (EPA)
   Environmental Sciences Center
   P. O. Box 12313
   Research Triangle Park
   North Carolina 27709
   Telephone (919) 549-0611

   Contact: Dr. W. J. Courtney, Senior Project Scientist (arranged by Mr. R. K. Stevens, U.S. EPA, Environmental Sciences Research Laboratory (919) 541-3156).

   Method: Energy-Dispersive X-ray fluorescence spectrometry.

   Role: Analysis of standard and field test filters

5. Ministry of the Environment (MOE)
   Laboratory Services Branch, Inorganic Trace Contaminants
   P. O. Box 213
   Resources Road
   Rexdale, Ontario M9W 5L1
   Telephone (416) 248-7101

   Contact: Dr. Richard Judge, Project Scientist

   Methods: Atomic absorption spectrometry (flame and flameless graphite furnace), ion chromatography.

   Role: Analysis of standard and field test filters; provision of synthetic standard filters.

6. Concord Scientific Corporation (CSC)
2 Tippett Road
Downsview, Ontario M3H 2V2
Telephone (416) 630-6331

Contact: Dr. S. Stevens, Vice-President

Methods: Ion chromatography

Role: Analysis of field test filters for sulphate only.

The other participating laboratory did not perform analyses but was responsible for preparing most of the synthetic standard filters:

7. Columbia Scientific Industries (CSI)
11950 Jollyville Road
P. O. Box 9908
Austin, Texas 78766
Telephone (512) 258-5191

Contact: Mr. John Schindler

Role: Provision of standard dried solution of specified elements on Whatman 541 cellulose filters.

2.3 Synthetic Standard Filters

Whatman 541 cellulose was chosen as the primary medium for loading known amounts of the target elements. This filter has a low background of all of the elements sought and is compatible with XRF and the methods requiring extraction. Columbia Scientific Industries employed their established technique (2) of uniformly loading 37 mm diameter W-541 filters by dropwise addition of aliquots of a standard solution of salts or oxides of the specified elements. Cr, As, Cd and Pb were loaded on one set of filters; Al, Si, S, Cl, Ti, Ca, Mn, Fe, Zn and Br were loaded on another set of filters. The loadings have been shown to be homogeneous to 3% or better for areas $\geq 5\ mm^2$ (2).

Another set of standards was prepared on Millipore cellulose ester membrane filters (HAWP) by the Ministry of the Environment. Deposits of standard solutions of salts or oxides of As, Cd, Cr, and Pb were placed by dropwise addition on 37 mm diameter filters and dried.

All participating laboratories were given CSI filters to analyze; whereas, only MOE and XRAL analyzed the MOE Millipore standards.

2.4 Field-Exposed Test Filters ("Real" Filters)

In order to provide uniform samples of airborne particulate matter as similar to the dichotomous sampler filters as possible, 200 x 250 mm sheets of Ghia Corporation "Zefluor" polycarbonate-mesh-supported teflon (2 micrometer pore size) were exposed by sampling with a high volume sampler for a sufficient period of time to collect a loading of about 400 $\mu g/cm^2$. 37 mm diameter aliquots were cut by a die from the large sheets in sufficient numbers to supply all of the analysts and to provide up to quadruplicate samples to some labs to test loading homogeneity and analytical reproducibility.

2.5 Distribution of Samples

Depending upon which parameters were to be analyzed and by which techniques, and depending upon the role that each laboratory had agreed to play in the exercise, the appropriate type and number of filters (or aliquots) were distributed to the six analysts.

Samples destined for local Toronto laboratories (3 of 6) were distributed by hand delivery from Concord Scientific, packed in plastic petri dishes. Samples for remote destinations (3 of 6: Ottawa, Research Triangle Park, and Beaverton) were shipped in plastic petri dishes housed in a specially constructed shipping box, designed to encourage maintenance of the upright position during transport, thus avoiding particle loss from the filters. "Tip-n-tell" gauges were attached to indicate whether a box had been kept upright during its journey. These devices record rather sensitively any deviation from the vertical that the shipping box has undergone.

2.6 Analytical Methods

The filter samples, whether synthetic standard, "real" filter, or blank, were processed in a manner appropriate to the analytical finish to be applied in each laboratory.

Each of the laboratories using XRF (NEA and EPA) analyzed the filters "as received" with no special preparations, except to cut aliquots required to fit the sample holders in their XRF spectrometers.

Filter samples to be subjected to either AAS or DCP were prepared either by aqua regia leaching (for metals analysis) or by deionized water leaching (for the water-soluble ions sulphate and chloride).

MOE and XRAL used the same acid digestion procedure, as specified by MOE. MOE and CSC used the same procedure for water leaching - 30 minutes of agitation in 20 ml of deionized water by means of a mechanical shaker.

Standard filters, "real" filters and blanks were treated identically.

It is assumed, for the purposes of this report, that the details of the analytical methodology need not be stated explicitly. The methods evaluated in this study are either well-established or reasonably well-established, and details in any case can best be obtained from the practitioners themselves.

3.0 STUDY RESULTS

All of the raw data reported to Concord Scientific by the participating laboratories are listed in the Appendix, Table A1. Table A2, Appendix, summarizes the data in the form of mean values obtained by a given laboratory for one or more aliquots of a given filter. These mean values are used subsequently to compute the results of the reporting laboratories relative to one another. Various filter blank values are separately listed in Table A3. The format of these appended tables is explained on page 63 of the Appendix. All results are reported as micrograms of the element found per whole filter (10.75 cm^2).

The results for blind duplicate and quadruplicate aliquots of the field-exposed ("real") Zefluor filters indicate that these filters were uniformly loaded, as judged by the relatively small standard deviations of intra-laboratory means for these multiple aliquots.

Table 3-1 lists and compares the results of four laboratories for the synthetic standard Whatman 541 filters prepared by Columbia Scientific Industries. The accepted CSI value is listed in the column labelled "ACCEPT". The "REL-DEV" column is the relative deviation in

TABLE 3-1

(SYNTHETIC STD. - MEDIA: WHATMAN 541)

ELEMENT	FILTER	LAB	RESULT	ACCEPT	REL DEV
ALUMINUM	01810	2	20.00	21.00	-4.76
	00510	4	1.20	0.00	
	02010	4	14.00	21.00	-33.33
SILICON	00110	0	18.28	10.50	74.10
	00610	0	22.58	4.20	437.62
	01110	0	124.70	0.00	
	01610	0	328.95	0.00	
	00510	4	5.00	10.50	-52.38
	01010	4	10.50	4.20	150.00
	01510	4	208.00	0.00	
	02010	4	404.00	0.00	
POTASSIUM	00110	0	29.02	0.00	
	00610	0	(64.50)	0.00	
CALCIUM	01110	0	(6.24)	5.00	24.80
	01610	0	(56.97)	50.40	13.04
	01510	4	0.50	5.00	-90.00
	02010	4	20.00	50.40	-60.32
TITANIUM	01110	0	(6.02)	4.30	40.00
	01510	4	3.00	4.30	-30.23
CHROMIUM	001H0	0	0.00	0.00	
	005H0	0	0.00	0.00	
	009H0	0	14.30	15.25	-6.23
	013H0	0	38.38	38.13	0.66
	003H0	2	0.06	0.00	
	007H0	2	0.00	0.00	
	011H0	2	13.00	15.25	-14.75
	015H0	2	34.00	38.13	-10.83
MANGANESE	01110	0	4.52	4.20	7.62
	01610	0	40.85	41.50	-1.57
	01310	2	4.20	4.20	0.00
	01810	2	39.00	41.50	-6.02
	01510	4	2.30	4.20	-45.24
	02010	4	33.00	41.50	-20.48
IRON	01110	0	5.91	5.20	13.65
	01610	0	53.75	51.80	3.76
	01210	1	7.80	5.20	49.98
	01710	1	43.73	51.80	-15.57
	01510	4	4.10	5.20	-21.15
	02010	4	14.00	51.80	-72.97

LAB 0 = NEA
LAB 1 = EPA
LAB 2 = XRAL
LAB 4 = MOE
LAB 5 = CSC

TABLE 3-1 (cont)

(SYNTHETIC STD. - MEDIA: WHATMAN 541)

ELEMENT	FILTER	LAB	RESULT	ACCEPT	REL DEV
ZINC	01110	0	6.77	6.00	12.83
	01610	0	59.12	60.20	-1.79
	01210	1	5.69	6.00	-5.20
	01710	1	54.36	60.20	-9.70
	01310	2	5.20	6.00	-13.33
	01810	2	50.00	60.20	-16.94
	01510	4	6.40	6.00	6.67
	02010	4	57.00	60.20	-5.32
ARSENIC	001H0	0	8.92	4.40	102.73
	005H0	0	13.97	8.80	58.75
	009H0	0	3.87	4.40	-12.05
	013H0	0	10.21	11.00	-7.18
	003H0	2	3.90	4.40	-11.36
	007H0	2	4.00	8.80	-54.55
	011H0	2	3.90	4.40	-11.36
	015H0	2	10.00	11.00	-9.09
BROMINE	00110	0	3.44	10.10	-65.94
	00610	0	9.03	4.10	120.24
	00210	1	3.37	10.10	-66.60
	00710	1	9.51	4.10	131.90
CADMIUM	001H0	0	2.26	4.43	-48.98
	005H0	0	7.31	8.86	-17.49
	009H0	0	2.04	4.38	-53.42
	013H0	0	8.17	10.96	-25.46
	003H0	2	3.60	4.43	-18.74
	007H0	2	8.40	8.86	-5.19
	011H0	2	3.60	4.38	-17.81
	015H0	2	9.20	10.96	-16.06
LEAD	001H0	0	212.85	220.25	-3.36
	005H0	0	438.60	440.49	-0.43
	009H0	0	0.00	0.00	
	013H0	0	0.00	0.00	
	002H0	1	196.58	220.25	-10.75
	014H0	1	0.25	0.00	
	003H0	2	220.00	220.25	-0.11
	007H0	2	440.00	440.49	-0.11
	011H0	2	0.00	0.00	
	015H0	2	0.00	0.00	

LAB 0 = NEA
LAB 1 = EPA
LAB 2 = XRAL
LAB 4 = MOE
LAB 5 = CSC

TABLE 3-1 (cont)

(SYNTHETIC STD. - MEDIA: WHATMAN 541)

ELEMENT	FILTER	LAB	RESULT	ACCEPT	REL DEV
ZINC	01110	0	6.77	6.00	12.83
	01610	0	59.12	60.20	-1.79
	01210	1	5.69	6.00	-5.20
	01710	1	54.36	60.20	-9.70
	01310	2	5.20	6.00	-13.33
	01810	2	50.00	60.20	-16.94
	01510	4	6.40	6.00	6.67
	02010	4	57.00	60.20	-5.32
ARSENIC	001H0	0	8.92	4.40	102.73
	005H0	0	13.97	8.80	58.75
	009H0	0	3.87	4.40	-12.05
	013H0	0	10.21	11.00	-7.18
	003H0	2	3.90	4.40	-11.36
	007H0	2	4.00	8.80	-54.55
	011H0	2	3.90	4.40	-11.36
	015H0	2	10.00	11.00	-9.09
BROMINE	00110	0	3.44	10.10	-65.94
	00610	0	9.03	4.10	120.24
	00210	1	3.37	10.10	-66.60
	00710	1	9.51	4.10	131.90
CADMIUM	001H0	0	2.26	4.43	-48.98
	005H0	0	7.31	8.86	-17.49
	009H0	0	2.04	4.38	-53.42
	013H0	0	8.17	10.96	-25.46
	003H0	2	3.60	4.43	-18.74
	007H0	2	8.40	8.86	-5.19
	011H0	2	3.60	4.38	-17.81
	015H0	2	9.20	10.96	-16.06
LEAD	001H0	0	212.85	220.25	-3.36
	005H0	0	438.60	440.49	-0.43
	009H0	0	0.00	0.00	
	013H0	0	0.00	0.00	
	002H0	1	196.58	220.25	-10.75
	014H0	1	0.25	0.00	
	003H0	2	220.00	220.25	-0.11
	007H0	2	440.00	440.49	-0.11
	011H0	2	0.00	0.00	
	015H0	2	0.00	0.00	

LAB 0 = NEA
LAB 1 = EPA
LAB 2 = XRAL
LAB 4 = MOE
LAB 5 = CSC

TABLE 3-2

(MILLIPORE STD. - MEDIA: MILLIPORE)

ELEMENT	FILTER	LAB	RESULT	ACCEPT	REL DEV
CHROMIUM	S1-2	2	1.00	0.40	150.00
	S1-3	2	0.80	0.40	100.00
	S2-1	2	2.40	2.00	20.00
	S2-2	2	2.40	2.00	20.00
	S1-10	4	0.58	0.40	45.00
	S1-6	4	0.59	0.40	47.50
	S2-10	4	1.49	2.00	-25.50
ARSENIC	S1-2	2	0.06	0.40	-85.00
	S1-3	2	0.06	0.40	-85.00
	S2-1	2	0.16	2.00	-92.00
	S2-2	2	0.16	2.00	-92.00
	S1-10	4	0.22	0.40	-45.00
	S1-6	4	0.13	0.40	-67.50
	S2-10	4	0.28	2.00	-86.00
CADMIUM	S1-2	2	1.50	2.00	-25.00
	S1-3	2	1.50	2.00	-25.00
	S2-1	2	0.20	0.40	-50.00
	S2-2	2	0.30	0.40	-25.00
	S1-10	4	0.82	2.00	-59.00
	S1-6	4	0.54	2.00	-73.00
	S2-10	4	0.30	0.40	-25.00
LEAD	S1-2	2	3.90	4.00	-2.50
	S1-3	2	3.70	4.00	-7.50
	S2-1	2	0.60	0.80	-25.00
	S2-2	2	0.70	0.80	-12.50
	S1-10	4	2.77	4.00	-30.75
	S1-6	4	2.37	4.00	-40.75
	S2-10	4	0.62	0.80	-22.50

LAB 0 = NEA
LAB 1 = EPA
LAB 2 = XRAL
LAB 4 = MOE
LAB 5 = CSC

TABLE 3-3

LAB 0 = NEA
LAB 1 = EPA
LAB 2 = XRAL
LAB 4 = MOE
LAB 5 = CSC

REAL FILTERS (TYPE 6 MEDIUM 542: TEFLON)

MEAN VALUES

ELEMENT	LAB	F-001	F-003	F-006
Aluminum	LAB-0	107.50	96.75	101.33
	LAB-2	.	.	60.00
	LAB-4	57.45	50.30	41.00
	1 MEAN	82.47	73.52	67.44
	2 STD	35.39	32.84	30.85
	3 C.V.	42.91	44.67	45.74
Silicon	LAB-0	359.59	285.95	310.13
	LAB-2	.	.	200.00
	1 MEAN	359.59	285.95	255.07
	2 STD	.	.	77.88
	3 C.V.	.	.	30.53
Sulphur	LAB-0	191.35	317.12	166.62
	1 MEAN	191.35	317.12	166.62
	2 STD	.	.	.
	3 C.V.	.	.	.
Chlorine	LAB-0	17.73	33.32	59.66
	LAB-4	32.00	49.00	80.00
	1 MEAN	24.87	41.16	69.83
	2 STD	10.09	11.09	14.38
	3 C.V.	40.56	26.93	20.60
Potassium	LAB-0	43.80	32.52	72.56
	1 MEAN	43.80	32.52	72.56
	2 STD	.	.	.
	3 C.V.	.	.	.
Calcium	LAB-0	344.80	406.35	396.96
	LAB-1	316.21	362.03	349.25
	LAB-4	367.50	417.50	275.00
	1 MEAN	342.83	395.29	340.40
	2 STD	25.70	29.34	61.46
	3 C.V.	7.50	7.42	18.06
Titanium	LAB-0	10.53	12.33	10.44
	LAB-1	9.02	8.75	6.55
	LAB-4	1.07	2.50	0.85
	1 MEAN	6.87	7.86	5.94
	2 STD	5.08	4.98	4.82
	3 C.V.	73.98	63.31	81.20
Vanadium	LAB-0	1.21	2.25	2.04
	1 MEAN	1.21	2.25	2.04
	2 STD	.	.	.
	3 C.V.	.		

LAB 0 = NEA
LAB 1 = EPA
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LAB 4 = MOE
LAB 5 = CSC

TABLE 3-3 (CONTINUED)

REAL FILTERS (TYPE 6 MEDIUM 542: TEFLON)

MEAN VALUES

ELEMENT	LAB	F-001	F-003	F-006
Chromium	LAB-0	2.20	3.90	5.04
	LAB-1	1.45	1.91	3.00
	LAB-2	0.60	1.35	1.40
	LAB-4	0.55	2.45	0.47
	1 MEAN	1.20	2.40	2.48
	2 STD	0.79	1.09	2.00
	3 C.V.	65.41	45.57	80.71
Manganese	LAB-0	13.60	26.07	42.99
	LAB-1	12.83	23.16	37.73
	LAB-2	14.00	27.00	42.00
	LAB-4	13.20	24.00	27.50
	1 MEAN	13.41	25.06	37.56
	2 STD	0.50	1.78	7.08
	3 C.V.	3.76	7.11	18.86
Iron	LAB-0	247.78	546.90	630.20
	LAB-1	223.89	449.19	517.85
	LAB-4	125.30	435.50	129.50
	1 MEAN	198.99	477.20	425.85
	2 STD	64.92	60.76	262.72
	3 C.V.	32.63	12.73	61.69
Nickel	LAB-0	0.82	1.20	0.85
	1 MEAN	0.82	1.20	0.85
	2 STD	.	.	.
	3 C.V.	.	.	.
Copper	LAB-0	67.99	40.3	27.42
	1 MEAN	67.99	40.3	27.42
	2 STD	.	.	.
	3 C.V.	.	.	.
Zinc	LAB-0	24.72	23.65	25.26
	LAB-1	18.64	17.75	19.40
	LAB-2	20.50	21.00	21.00
	LAB-4	20.60	19.65	15.50
	1 MEAN	21.12	20.51	20.29
	2 STD	2.57	2.48	4.04
	3 C.V.	12.16	12.09	19.91
Arsenic	LAB-0	0.00	0.00	0.00
	LAB-1	0.00	0.00	0.00
	LAB-2	0.10	0.40	0.56
	LAB-4	0.06	0.23	.
	1 Mean	0.04	0.16	0.19
	2 STD	0.05	0.19	0.32
	3 C.V.	120.55	123.59	173.21

LAB 0 = NEA
LAB 1 = EPA
LAB 2 = XRAL
LAB 4 = MOE
LAB 5 = CSC

TABLE 3-3 (CONTINUED)

REAL FILTERS (TYPE 6 MEDIUM 542: TEFLON)

MEAN VALUES

ELEMENT	LAB	F-001	F-003	F-006
Selenium	LAB-0	0.00	0.00	0.00
	1 MEAN	0.00	0.00	0.00
	2 STD	.	.	.
	3 C.V.	.	.	.
Bromine	LAB-0	14.08	3.36	12.37
	LAB-1	12.90	2.53	10.60
	1 MEAN	13.49	2.94	11.49
	2 STD	0.83	0.58	1.25
	3 C.V.	6.17	19.86	10.89
Cadmium	LAB 0	0.00	0.00	3.28
	LAB-1	0.00	0.12	0.37
	LAB-2	0.00	0.10	0.10
	LAB-4	0.13	0.21	0.13
	1 MEAN	0.03	0.11	0.97
	2 STD	0.07	0.09	1.54
	3 C.V.	200.00	80.75	158.79
Barium	LAB-0	0.00	0.00	0.00
	1 MEAN	0.00	0.00	0.00
	2 STD	.	.	.
	3 C.V.	.	.	.
Lead	LAB-0	66.65	23.38	52.41
	LAB-1	64.33	23.46	50.64
	LAB-2	53.00	24.00	50.00
	LAB-4	49.00	16.35	18.50
	1 MEAN	58.24	21.80	42.89
	2 STD	8.57	3.64	16.29
	3 C.V.	14.72	16.71	37.98
Sulphate	LAB-4	680.00	1380.0	516.50
	LAB-5	678.50	1276.8	572.63
	1 MEAN	679.25	1328.4	544.56
	2 STD	1.06	73.01	39.69
	3 C.V.	0.16	5.50	7.29

LAB 0 = NEA
LAB 1 = EPA
LAB 2 = XRAL
LAB 4 = MOE
LAB 5 = CSC

TABLE 3-4

REAL FILTERS (TYPE 6 MEDIUM 542: TEFLON)

RATIOS

ELEMENT	LAB	F-001	F-003	F-006	AVERAGE	STD	CV
Aluminum	LAB-0	1.303	1.316	1.502	1.374	0.112	8.116
	LAB-2	.	.	0.890	0.890	.	.
	LAB-4	0.697	0.684	0.608	0.663	0.048	7.242
	1 MEAN	1.000	1.000	1.000	1.000	.	.
	2 STD	0.429	0.447	0.457	0.444	.	.
Silicon	LAB-0	1.000	1.000	1.216	1.072	0.125	11.628
	LAB-2	.	.	0.784	0.784	.	.
	1 MEAN	1.000	1.000	1.000	1.000	.	.
	2 STD	.	.	0.305	0.305	.	.
Sulphur	LAB-0	1.000	1.000	1.000	1.000	0.000	0.000
	1 MEAN	1.000	1.000	1.000	1.000	.	.
	2 STD	.	.	.	.	.	.
Chlorine	LAB-0	0.713	0.810	0.854	0.792	0.072	9.104
	LAB-4	1.287	1.190	1.146	1.208	0.072	5.973
	1 MEAN	1.000	1.000	1.000	1.000	.	.
	2 STD	0.406	0.269	0.206	0.294	.	.
Potassium	LAB-0	1.000	1.000	0.337	0.779	0.383	49.137
	LAB-1	.	.	1.663	1.663	.	.
	1 MEAN	1.000	1.000	1.000	1.000	.	.
	2 STD	.	.	0.938	0.938	.	.
Calcium	LAB-0	1.142	1.028	1.408	1.193	0.195	16.373
	LAB-1	1.047	0.916	0.616	0.860	0.221	25.693
	LAB-4	0.812	1.056	0.976	0.948	0.125	13.147
	1 MEAN	1.000	1.000	1.000	1.000	.	.
	2 STD	0.170	0.074	0.397	0.214	.	.
Titanium	LAB-0	1.512	1.569	1.781	1.621	0.142	8.747
	LAB-1	1.295	1.113	1.074	1.161	0.118	10.141
	LAB-4	0.194	0.318	0.145	0.219	0.089	40.758
	1 MEAN	1.000	1.000	1.000	1.000	.	.
	2 STD	0.707	0.633	0.820	0.720	.	.
Vanadium	LAB-0	1.000	1.000	1.000	1.000	0.000	0.000
	1 MEAN	1.000	1.000	1.000	1.000	0.000	0.000
	2 STD	.	.	.	.	.	.

LAB 0 = NEA
LAB 1 = EPA
LAB 2 = XRAL
LAB 4 = MOE
LAB 5 = CSC

TABLE 3-4 (CONTINUED)

REAL FILTERS (TYPE 6 MEDIUM 542: TEFLON)

RATIOS

ELEMENT	LAB	F-001	F-003	F-006	AVERAGE	STD	CV
Chromium	LAB-0	1.835	1.623	2.033	1.830	0.205	11.191
	LAB-1	1.207	0.794	1.211	1.071	0.240	22.383
	LAB-2	0.500	0.562	0.565	0.542	0.037	6.781
	LAB-4	0.458	1.020	0.192	0.557	0.423	76.000
	1 MEAN	1.000	1.000	1.000	1.000	.	.
	2 STD	0.654	0.456	0.807	0.639	.	.
Manganese	LAB-0	1.014	1.040	1.145	1.066	0.069	6.479
	LAB-1	0.957	0.924	1.005	0.962	0.040	4.208
	LAB-2	1.044	1.078	1.118	1.080	0.037	3.435
	LAB-4	0.985	0.958	0.732	0.892	0.139	15.548
	1 MEAN	1.000	1.000	1.000	1.000	.	.
	2 STD	0.038	0.071	0.189	0.099	.	.
Iron	LAB-0	1.245	1.146	1.480	1.290	0.171	13.285
	LAB-1	1.125	0.941	1.216	1.094	0.140	12.792
	LAB-4	0.630	0.913	0.304	0.615	0.305	49.476
	1 MEAN	1.000	1.000	1.000	1.000	.	.
	2 STD	0.326	0.127	0.617	0.357	.	.
Nickel	LAB-0	1.000	1.000	1.000	1.000	0.000	0.000
	1 MEAN	1.000	1.000	1.000	1.000	.	.
	2 STD	.	.	.	.	.	.
Copper	LAB-0	1.000	1.000	1.000	1.000	0.000	0.000
	1 MEAN	1.000	1.000	1.000	1.000	.	.
	2 STD	.	.	.	.	.	.
Zinc	LAB-0	1.171	1.153	1.245	1.190	0.049	4.101
	LAB-1	0.883	0.865	0.956	0.901	0.048	5.345
	LAB-2	0.971	1.024	1.035	1.010	0.034	3.394
	LAB-4	0.976	0.958	0.764	0.899	0.117	13.061
	1 MEAN	1.000	1.000	1.000	1.000	.	.
	2 STD	0.122	0.121	0.199	0.147	.	.
Arsenic	LAB-0	0.000	0.000	0.000	0.000	0.000	.
	LAB-1	0.000	0.000	0.000	0.000	0.000	.
	LAB-2	2.424	2.540	3.000	2.655	0.305	11.475
	LAB-4	1.576	1.460	.	1.518	0.082	5.377
	1 MEAN	1.000	1.000	1.000	1.000	.	.
	2 STD	1.206	1.236	1.732	1.391	.	.

LAB 0 = NEA
LAB 1 = EPA
LAB 2 = XRAL
LAB 4 = MOE
LAB 5 = CSC

TABLE 3-4 (CONTINUED)

REAL FILTERS (TYPE 6 MEDIUM 542: TEFLON)

RATIOS

ELEMENTS	LAB	F-001	F-003	F-006	AVERAGE	STD	CV
Selenium	LAB-0	.	.	.	.	.	.
	1 MEAN	.	.	.	.	.	.
	2 STD	.	.	.	.	.	.
	3 C.V.	.	.	.	.	.	.
Bromine	LAB-0	1.044	1.140	1.077	1.087	0.049	4.526
	LAB-1	0.956	0.860	0.923	0.913	0.049	5.389
	1 MEAN	1.000	1.000	1.000	1.000	.	.
	2 STD	0.062	0.199	0.109	0.123	.	.
Cadmium	LAB-0	0.000	0.000	3.374	1.125	1.948	173.21
	LAB-1	0.000	1.089	0.384	0.491	0.552	112.52
	LAB-2	0.000	0.939	0.103	0.347	0.515	148.29
	LAB-4	4.000	1.972	0.139	2.037	1.931	94.819
	1 MEAN	1.000	1.000	1.000	1.000	.	.
	2 STD	2.000	0.807	1.588	1.465	.	.
Barium	LAB-0	.	.	.	.	.	.
	1 MEAN	.	.	.	.	.	.
	2 STD	.	.	.	.	.	.
Lead	LAB-0	1.144	1.073	1.222	1.146	0.075	6.518
	LAB-1	1.104	1.076	1.181	1.121	0.054	4.826
	LAB-2	0.910	1.101	1.166	1.059	0.133	12.561
	LAB-4	0.841	0.750	0.431	0.674	0.215	31.922
	1 MEAN	1.000	1.000	1.000	1.000	.	.
	2 STD	0.147	0.167	0.380	0.231	.	.
Sulphate	LAB-4	1.001	1.039	0.948	0.996	0.045	4.558
	LAB-5	0.999	0.961	1.052	1.004	0.045	4.523
	1 MEAN	1.000	1.000	1.000	1.000	.	.
	2 STD	0.002	0.055	0.073	0.043	.	.

labelled "LAB" are the ratios of that laboratory's mean result for the element and filter to the mean result for all laboratories reporting that element for the given filter. In Table 3-4, the rows labelled "1 MEAN" are the means of the ratios to the overall mean, and thus, the entries must be 1.0, as indicated. Entries in the row labelled "2 STD" are the standard deviations of the mean ratios. The entries in the columns labelled "AVERAGE" are the mean of the ratios for the given laboratory for all three "real" filters. The column labelled "STD" is the standard deviation of the "lab average" ratio for the three "real" filters. The column labelled "C.V." is the coefficient of variation (in percent) defined as 100 times the ratio of "STD" to "AVERAGE" in the previous columns. These ratios serve to normalize sample-to-sample loading variations so that results are compared consistently.

The standard deviations appearing in the rows "2 STD" in Tables 3-3 and 3-4 are measures of the lab-to-lab variation of determinations for the given element on the given filter.

The "STD" and "C.V." entries in the columns so labelled in Table 3-4 are measures of the sample-to-sample reproducibility for a given laboratory for that element, since ratios of results to overall mean results are compared.

The summary of results for each element which follows is based on Tables 3-1, 3-2, 3-3 and 3-4.

3.1 Results for Individual Elements

3.1.1 ALUMINUM

3.1.1.1 Standard Filters

Aluminum was analyzed only by XRAL and MOE in CSI standards. XRF is not a very sensitive method for Al; therefore, laboratories using this technique did not report this element for standard filters, which were relatively lightly loaded.

3.1.1.2 Real Filters

There was enough Al on the three field-exposed filters for three labs - NEA, XRAL and MOE - to report results. The XRF result was generally higher than either the DCP or AAS result.

3.1.1.3 Blank Filters*

XRAL appeared to have an Al contamination problem, as evidenced by the high blank W-541 value.

3.1.2 SILICON

3.1.2.1 Standard Filters

There was only one result (XRAL) for Si on the CSI standard filters (see Table A1). This result is suspect because of a high blank value (see below).

*NOTE: All NEA 'blank' results have been corrected for typical blank values for that filter material.

3.1.2.2 Real Filters

NEA reported twelve individual results for Si and XRAL only one value, so that a valid comparison is not possible.

3.1.2.3 Blank Filters

XRAL reported a high blank value for Si on W-541, indicating contamination. NEA's Zefluor blank was low.

3.1.3 SULPHUR

3.1.3.1 Standard Filters

No S results were reported for standard filters.

3.1.3.2 Real Filters

Only NEA reported S results on Zefluor filters (12 values), so that no comparison is possible.

3.1.3.3 Blank Filters

NEA reported the only S blank value (1 result from Zefluor).

3.1.4 CHLORINE (Chloride)

3.1.4.1 Standard Filters

Two laboratories reported results for Cl: NEA and MOE. The results were variable. The high lab results corresponding to the accepted values of "zero" in Table 3-1 are real, since CSI required "excess chloride" to prepare these particular standards. Cl was not intended to be analyzed as a standard on the filters containing "excess chloride". There may be a loss of Cl by volatilization from the W-541 filters (CSI so fore-warned).

3.1.4.2 Real Filters

The same two labs - NEA and MOE - reported Cl on Zefluor filters. Results were consistent and comparable.

3.1.4.3 Blank Filters

NEA's results indicate a significantly higher Cl blank on W-541 than on Zefluor, as expected. NEA's and MOE's Zefluor blanks were essentially the same (less than a similar detection limit). See footnote on Page 27, however.

3.1.5 POTASSIUM

3.1.5.1 Standard Filters

Only NEA reported potassium for standard filters. K was present in excess as a counter ion in the CSI samples and was not intended for analysis as a standard.

3.1.5.2 Real Filters

Only NEA reported K for Zefluor filters.

3.1.5.3 Blank Filters

NEA found very low K blanks for both W-541 and Zefluor filters.

3.1.6 CALCIUM

3.1.6.1 Standard Filters

NEA and MOE reported Ca on CSI standard filters. MOE's two results were lower than the accepted values.

3.1.6.2 Real Filters

NEA, EPA and MOE reported Ca loadings on Zefluor filters that were essentially identical.

3.1.6.3 Blank Filters

NEA and EPA found low Ca blanks on W-541 and Zefluor filters, and EPA reported an appreciable but not significant Ca blank on a Millipore filter.

3.1.7 TITANIUM

3.1.7.1 Standard Filters

NEA and MOE reported Ti in CSI standard filters. Both results were reasonably close to the accepted values.

3.1.7.2 Real Filters

NEA, EPA and MOE reported Ti on Zefluor filters. The two XRF results tended to agree and were somewhat higher than the MOE results.

3.1.7.3 Blank Filters

NEA, EPA, and MOE reported low Ti blanks on all media.

3.1.8 VANADIUM

Only NEA reported V on any medium. Blanks were low relative to loadings on real filters. V was present on one set of CSI standard filters, but the only lab that received one of these filters and reported a result did not find any above the detection limit (see Table A1: filter number 059).

3.1.9 CHROMIUM

An extensive set of results was reported for Cr, one of the elements sought in the Environment Canada national survey.

3.1.9.1 Standard Filters

NEA, XRAL and MOE reported results for Cr on standard filters: NEA for CSI filters only, XRAL for both CSI and MOE standards, and MOE only for their own standards. Results for the CSI filters were quite close. There was greater variation in results for the MOE standards.

3.1.9.2 Real Filters

NEA, EPA, XRAL and MOE all reported results for Cr on Zefluor filters. The XRF results were consistently higher than either of the destructive methods, DCP (XRAL) or AAS (MOE), which required acid digestion of the particulate matter. See Section 4.2.3. for a discussion of this point.

3.1.9.3 Blank Filters

All labs found negligible blanks for Cr on W-541 and Zefluor, but both EPA and MOE reported a significant Cr blank on Millipore.

3.1.10 MANGANESE

Reported Mn results were also quite extensive.

3.1.10.1 Standard Filters

NEA, XRAL and MOE all reported Mn values in CSI standards that agreed very well with the accepted values.

3.1.10.2 Real Filters

NEA, EPA, XRAL and MOE results for Zefluor filters all agreed closely.

3.1.10.3 Blank Filters

All four reporting labs found very low blank Mn on W-541, Zefluor and Millipore filters.

3.1.11 IRON

3.1.11.1 Standard Filters

NEA, EPA and MOE reported values for Fe on CSI standard filters. XRAL did not report iron because of a lab contamination problem. Reported results tended to agree well with accepted values, except for MOE's, which were relatively low.

3.1.11.2 Real Filters

The results reported for Zefluor filters paralleled those for the standard filters described above. MOE's results (destructive method) were somewhat lower than NEA's and EPA's (non-destructive method).

3.1.11.3 Blank Filters

The only appreciable blank for Fe was found by EPA on Zefluor. The amount was not significant in comparison with typical ambient loadings, such as the "real" Zefluor filters in this study.

3.1.12 NICKEL

Nickel was not included in the elements deposited on standard filters. NEA reported Ni in trace quantities on the "real" filters (Zefluor) and found Ni to be non-detectable on CSI standard filters and on both W-541 and Zefluor blanks.

3.1.13 COPPER

Copper was not among the elements deposited on the standard filters. NEA reported Cu in appreciable amounts on all three "real" Zefluor filters and on one of the CSI standard filters. NEA's result for a W-541 blank was very low.

3.1.14 ZINC

3.1.14.1 Standard Filters

NEA, EPA, XRAL and MOE all reported Zn on CSI standard filters. All four laboratories were very close to the accepted values.

3.1.14.2 Real Filters

Again, all four reporting laboratories (as above) found very similar amounts of Zn on the "real" filters.

3.1.14.3 Blank Filters

Blank results were uniformly low relative to typical ambient filter loadings.

3.1.15 ARSENIC

Arsenic is the second of the four elements sought in the Environment Canada national survey.

3.1.15.1 Standard Filters

Arsenic was reported by NEA and XRAL for CSI standard filters and by XRAL and MOE for MOE standard filters. The results for the CSI filters were somewhat variable. XRAL was very close to the accepted values for three out of four samples. NEA was very close to the accepted values for two out of four CSI filters. The two samples for which NEA's results were significantly high for As both contained large loadings of lead (see below and Table 3-1). This suggests an interference in the XRF result for As when Pb is present. Both XRAL and MOE reported As results for MOE standards well below the nominal values, suggesting significant loss during processing.

3.1.15.2 Real Filters

NEA, EPA, XRAL and MOE all reported As results for the "real" Zefluor filters below or near the detection limit.

3.1.15.3 Blank Filters

All four of the above laboratories reported blank values for As on W-541, Zefluor and Millipore below or at the detection limit.

3.1.16 SELENIUM

Selenium was not deposited on CSI standard filters. NEA reported Se as below the detection limit on CSI standard filters, blanks and "real" filters.

3.1.17 BROMINE (Bromide)

3.1.17.1 Standard Filters

NEA and EPA both reported variable results (2 values from each laboratory) for Br on CSI standard filters. High Br loadings were underdetermined and low Br loadings were overdetermined. CSI had warned that the filters containing Br (and Cl) might be expected to lose Br (and Cl) unless "protected from an oxidizing atmosphere". This phenomenon may explain some of the variability mentioned with reference to the chlorine results above, but in that case, most of the significant deviations were positive.

3.1.17.2 Real Filters

NEA and EPA reported appreciable and consistent results for Br on Zefluor filters.

3.1.17.3 Blank Filters

All reported Br blank values (all three filter media) were below detection limits and significantly below ambient loadings.

3.1.18 CADMIUM

Cadmium is the third of four metals sought in the Environment Canada national survey that was included in this comparative study.

3.1.18.1 Standard Filters

NEA and XRAL reported results for Cd on CSI standard filters. XRAL and MOE reported Cd on MOE standard filters. NEA's XRF results were consistently and significantly below the accepted values. XRAL's results were also less than the accepted values, but with a much smaller deviation.

Both XRAL and MOE reported Cd results that were systematically and significantly lower than the nominal MOE standard values.

3.1.18.2 Real Filters

Cd loadings were below or near the detection limit for two of the three Zefluor filters. NEA, EPA, XRAL and MOE reported only trace values for these filters. NEA reported an appreciable Cd loading on the third filter but the other three laboratories found only a trace.

3.1.18.3 Blank Filters

All reporting laboratories found Cd blanks below their detection limits for all three filter media (W-541, Zefluor, Millipore).

3.1.19 BARIUM

Only NEA reported Ba. None was found above the detection limits for CSI standard filters, real filters or blanks. Barium was not deposited on the standard filters.

3.1.20 LEAD

Lead is the fourth parameter sought in the Environment Canada national survey and included in this study.

3.1.20.1 Standard Filters

NEA, EPA and XRAL all reported results for CSI standard filters that were extremely close to the accepted values. For the MOE standard filters, XRAL's and MOE's results were generally less than the nominal values, although XRAL's deviation was typically less than MOE's.

3.1.20.2 Real Filters

NEA, EPA, XRAL and MOE all reported results for Pb on Zefluor filters. NEA, EPA and XRAL agreed very closely; whereas, MOE's results were somewhat lower than the other three laboratories on two of the three "real" filters.

3.1.20.3 Blank Filters

All reporting laboratories found blank values for Pb to be less than their detection limits for all three filter media. The blanks are significantly less than typical ambient filter loadings.

3.1.21 SULPHATE

Sulphate is one of the parameters sought in the Environment Canada survey. No standard filters were prepared for sulphate ion and no blank determinations were reported during the comparative study. Prior to the comparative study, however, the Air Pollution Control Directorate, Chemistry Division, evaluated the prospective contractors for this study by requiring reports of analytical results for a small number of test filters. MOE and DOE laboratories acted as control laboratories in this check. The results are shown in Table 3-5.

Results reported by CSC (ion chromatography) and MOE (ion chromatography) for "real"filters agreed extremely closely.

MOE reported several results for "sulphate" on CSI W-541 standard filters. Although the CSI filters for which MOE reported $SO_4^=$ values had been loaded with "sulphur", it is not known in what form, nor accurately what quantity of S would have been present as $SO_4^=$. In this situation, MOE's results for the W-541 filters cannot be evaluated.

TABLE 3-5

SULPHATE AND NITRATE ANALYSIS

(μg/filter)

	DOE	MOE	CONCORD	SPIKED VALUE (CSI)
Blank, SO_4^{--}	<1	<12.5	8.3	<1
SO_4^{--}	320	312.5	304	327
Blank, NO_3^-	<1	<2.5	1.2	
NO_3^-	293	287.5	271	289

4.0 DISCUSSION

4.1 Statistical Analysis of Results

The relatively simple statistics generated for Tables 3 - 1 to 3 - 4 are believed to be adequate for assessing inter-laboratory, intra-laboratory and inter-sample variations.

One might have computed linear regression equations between laboratory results and accepted values for CSI standard filters, but in only two cases (As and Cd) were there three or more accepted values upon which to carry out the regression analysis. For the same reason, it was judged inappropriate to display Student's t statistics on the mean absolute deviations between paired laboratory results and accepted values. That is, these statistics for two, three or four pairs of results and accepted values would not be meaningful.

t-Statistics on the above data pairs were calculated and a complete analysis of variance (ANOVA) was attempted for inter-lab, intra-lab and inter-sample variations. Because of the very small data set, as expected, based on the argument above, these statistics did not illuminate significant differences any better than the simple means and relative deviations given in Tables 3 - 1 to 3 - 4.

4.2 Observations on the Set of Elements: As, Cr, Cd, Pb.

4.2.1 ARSENIC

Arsenic results for both types of synthetic standards and for real filters were quite variable. This result may be explained by the potential volatility of As on the prepared standards and by the trace quantities that are and were encountered in ambient airborne particulate matter. XRAL's method of aqua regia leaching followed by arsine (AsH_3) generation and flameless atomic absorption sepctrometric detection appeared to perform about as reliably as the non-destructive XRF method used by NEA. The FAA method did not appear to be affected by interferences; whereas, the XRF result appeared to be somewhat elevated by the presence of large amounts of lead. Typical airborne particulate matter would contain far more lead than arsenic. FAA seemed to be somewhat more sensitive than XRF for these samples in this study.

The results by XRAL and MOE for MOE standard filters indicate a significant loss of As from all samples. After the comparative study was carried out, MOE changed the method of preparing filter standards and now uses freeze-drying rather than heat-drying to fix the standard solutions onto the filters. Apparently, improved sample stability and reproducibility have resulted (5).

4.2.2 CADMIUM

NEA's XRF results and XRAL's DCP results were systematically low for Cd in the CSI standard filters. The same is true of XRAL and

MOE results on MOE standards, although the Cd loadings on these filters were much less than those on the CSI filters and might be expected to lead to more variable results.

It is difficult to compare the performance of one method with others on the basis of the results for the real filters because of the extremely small loadings of cadmium. NEA detected appreciable cadmium only on filter F-006, and the results of four different aliquots had good precision (relatively small standard deviation). All other results, including other laboratories' results for F-006, were near detection limits. This sample was high in K and the K/Cd interferance may not have been eliminated totally.

Since the XRF and DCP results were comparable for the CSI standard filters (in fact, DCP > XRF), the real filter results, although fragmentary, indicate that the destructive methods may produce somewhat lower results than XRF. The evidence for this conclusion is not strong, since EPA's XRF results were comparable in each case with XRAL's and MOE's.

4.2.3 CHROMIUM

For chromium, there is a clear contrast betweeen the results of all laboratories for standard filters (both types) and their results for the real filters.

Both NEA and XRAL achieved essentially quantitative agreement with the CSI accepted values. XRAL and MOE did not come as close to the nominal values of the MOE standards, but the loadings on these filters were quite low and would be expected to lead to results of greater uncertainty.

Table 3 - 4 clearly displays the laboratory-to-laboratory variation in the determination of Cr on real airborne particles. The ratios of laboratory results to overall mean results indicate that the two sets of XRF results (NEA and EPA) had a significantly higher average ratio than XRAL or MOE. EPA's results were at the mean value, NEA's somewhat above the mean value (1.8 times as great) and both XRAL's and MOE's results were about one-half of the mean value. Both XRAL and NEA showed good precision (coefficients of variation of 7% and 11%, respectively, for three filters. See last column, Table 3-4).

It is likely that the above disparity arises from inefficiency of the aqua regia leaching process in extracting chromium from the airborne particle matrix (as compared with particle surface).

4.2.4 <u>LEAD</u>

NEA, EPA and XRAL all achieved essentially quantitative agreement with CSI standards and produced essentially identical results for the three real filters. MOE was slightly low relative to the other three laboratories for the three real filters (0.67 times the mean value).

These results suggest that the acid leaching procedure is reasonably efficient in extracting lead from airborne particles. Lead would be expected to be found on the surface of particles rather than embedded in the particle matrix.

4.3 Observations on Sulphate Determination

The only criterion that can be used to judge the validity of the results for sulphate ion in this study is the level of intra- and inter-laboratory reproducibility for real samples, since standard samples were not distributed. The results from MOE and CSC, using the same extraction procedure and analytical method, were essentially indistinguishable. The overall coefficients of variation for both intra- and inter-laboratory reproducibility were about 5 percent for the three real filters (2 aliquots each). See Table 3-4.

4.4 Observations on Results for Other Elements

Of the remaining elements in the study, the only ones that had sufficient data reported to justify either an inter-method or inter-laboratory comparison were aluminum, chlorine, calcium, titanium, manganese, iron and zinc.

Although the aluminum results were variable, and although one of the participating laboratories had a contamination problem, the results indicate that XRF, DCP and AAS may all be reliable methods to determine Al in airborne particles.

Chlorine (chloride) results were also variable and may have suffered from volatility losses from standard filters. XRF and IC produced consistent results for real filters, suggesting that either the non-destructive or destructive sample work-up and the respective analytical methodologies are suitable for airborne particulate matter.

Calcium results on real airborne particles were consistent between XRF and AAS methods. This indicates that the combined sample preparation and analytical methods may be considered adequate for airborne particulate matter.

Manganese and zinc were both determined with high accuracy and precision by all reporting laboratories. The coefficients of variation for both inter-laboratory and intra-laboratory comparisons were all less than 15 percent. See Table 3-4.

Titanium results exhibit a discrepancy between destructive and non-destructive methods similar to that for chromium. This suggests that titanium is another component of the particle matrix that may be difficult to extract by acid digestion.

Results for iron exhibit behaviour similar to Cr and Ti; that is, the destructive method (digestion followed by AAS) produced lower results than XRF. Iron is a ubiquitous component of airborne particulate matter because of its crustal abundance and would be expected to appear in the particle matrix and probably in the larger particles. Thus, iron might also be inefficiently extracted by acid digestion.

4.5 Comparison with Results of Similar Studies

Data from two previous studies (2, 3) parallel the results of the study reported here. During the earlier study (2) analytical results for three types of analyte configurations were investigated:

a) dried solution deposits,

b) artificial particulate deposits (finely ground rock),

c) air particulate (power plant post-precipitator fly ash collected in-stack on HiVol filters).

The filter medium in all cases was Millipore cellulose ester membrane. Twenty-two laboratories participated in the intercomparison, representing six analytical techniques.

The later study (4) comprised eleven different designs of samples operated by eight different groups. Many different collection substrates and analytical protocols were used.

Generally, methods requiring sample extraction prior to analysis performed about as well as non-destructive methods for most elements on dried-solution standard filters (2). In both studies, however, destructive methods tended to give low results for some elements in particulate samples (ground rock, fly ash or airborne particulate matter). Elements for which AAS and emission spectroscopy (cf. DCP) produced low results in the former studies were Ca, Mn, Fe and Al and in the latter study, Si, Ca, Ti, and Fe. All of these are elements that would occur in larger particles in the matrix rather than on the surface, because of their crustal origin. In the second study, as in the current study, Mn, Zn and Pb were all determined relatively precisely by all methods, representing both destructive and non-destructive sample processing.

Non-destructive methods tended to produce results closer to the overall mean than destructive methods, but this tendency may have been influenced by the large number of sampler configurations and sampling media used and by the predominance of non-destructive analysis, primarily XRF.

A number of detailed comparisons could be made between the current study and its predecessors, but it is more appropriate to consult the reports on these studies for this purpose.

General tendencies found in the current study are usually confirmed by the results of previous, similar studies.

4.6 Relevance of Results of this Study to Analysis of Dichotomous Sampler Filters

As was pointed out at the outset, the current study did not assess the performance of analytical methods for particles collected on the specific substrate that was to be used as the dichotomous sampler collection medium. There appears to be no reason to believe that the results obtained for samples on Ghia Zefluor mesh-supported teflon filters would be substantially different from the Ghia edge-supported teflon film filters used by both MOE and DOE for their dichotomous samplers. Both filters are hydrophobic and should affect extraction efficiency by aqueous acidic leaching agents similarly. XRF results would likely have been more reproducible and possibly more accurate had the thin film teflon filter been used in this study. Real filter loadings were also somewhat heavy for optimum XRF results.

One must also be careful to distinguish between evaluating performance of an analytical method and evaluating a combined sampling and analytical method aimed at a specific substrate. The spiked cellulose filters used in part of the comparative study are supplied as "X-ray fluorescence standards" by CSI. They have three disadvantages for XRF analysis.

1. The analyte is not a surficial deposit, but penetrates the body of the filter.

2. The surface of the filter is textured because of the fibrous matte structure, so that even a surficial loading is not planar.

3. The dried solution deposit does not produce particles that are similar in structure,size or composition to real airborne particles.

XRF spectrometers can be optimized to allow for these factors, hopefully sacrificing little in precision and accuracy. For the purposes of this study, NEA was able to make the necessary adjustments to handle the CSI standard filters. The EPA/Northrup system is highly optimized for processing teflon film filters from the U.S. dichotomous sampler network. Sophisticated computer software performs functions such as peak deconvolution, background correction, blank correction and particle size correction for each element in a typically loaded dichotomous filter sample. Because of the large in-house sample demand, the EPA system could not be re-optimized for the purposes of the present study. Consequently, only those elements for which estimated accuracy met certain standards were reported by EPA. The XRF results that were reported, then, could be compared with confidence. NEA and EPA results did agree very closely, in most cases.

Two additional factors influenced the results of the real particle analyses on Zefluor filters:

1. Ghia Zefluor is a "thick" textured medium, therefore, non-planar surficial loadings resulted and

2. Particle loadings (mass/unit area) on the Hi Vol-exposed Zefluor filters were heavier than typical dichotomous filter loadings, therefore, heavier than desirable or optimal.

The performance of the participating laboratories on the CSI standard filters indicated the relative reliability of the analytical methodology or combined analytical/sample work-up methodology, as appropriate, irrespective of the performance to be expected for real, airborne particles. This benchmarking was especially important for the prospective sub-contracting laboratory for the national survey (XRAL).

It would have been advantageous to use the thin film filter, but there is still no reliable way to generate reproducible copies of standard filters or field-exposed filters on this medium for inter-laboratory comparison purposes.

The Zefluor "real" filters were exposed on a HiVol sampler. It is difficult to assess the effect on analytical results of the larger-sized particles collected by HiVol as compared to a dichotomous sampler.

4.7 Selection of Analytical Method for the Environment Canada National Survey

The analytical parameters for this survey were to be arsenic, cadmium, chromium, lead, nitrate and sulphate. Only nitrate was not addressed by the comparative study. It had been generally accepted before the study that NO_3^- and $SO_4^=$ would be done by IC. The acceptable performance of IC for $SO_4^=$ was confirmed by the study.

For the elements, XRF produced superior results for chromium, and perhaps cadmium on "real" filters. AAS produced superior results for arsenic. The methods produced essentially the same results for lead.

For this specific set of elements, based on the results of this study and on experience elsewhere, there appeared to be no strong reason for eliminating either XRF or DCP/FAA from consideration as the method of choice.

It is apparent that for chromium and cadmium, the digestion method was inefficient at extracting the metals from the real airborne particles. This is clearly an area for more critical evaluation in the future.

4.7.1 The Selected Sub-Contractor

XRAL was chosen as the sub-contractor for analysis of As, Cd, Cr and Pb on exposed filters from the national survey to complement NO_3^- and $SO_4^=$ analyses by IC (CSC). This was a compromise because of the apparent difficulty with the extraction method. XRF demonstrated a potential problem with As in the presence of Pb, and DCP demonstrated a problem with Cd and Cr because of its reliance on sample digestion. In addition, As was below the XRF detection limit on fairly heavily loaded real filters. There was no apparent problem with water-extraction of sulphate or nitrate.

4.7.2 Accuracy, Precision and Detection Limit of the Selected Methods

4.7.2.1 Arsenic

XRAL's mean relative deviation from the accepted values on four CSI standard filters was -22%. Accuracy cannot be determined for the real particulate matter samples, but XRAL's FAA results agreed to within a factor of two with MOE's FAA results. Considering the low levels of As that are found in ambient particles, a factor of two (±) is a reasonable estimate of the overall accuracy of XRAL's method.

XRAL's precision on three pairs of real filter aliquots is indicated by standard deviations of 0.0, 0.0 and 0.14 corresponding to CV's of 0%, 0% and 25% (mean 8%). Taking the worst case, rather than the mean, a precision of ±25% is a reasonable estimate of operational performance.

XRAL's detection limit was about 0.02 μg/filter, but the mean blank value for Zeflour was about 0.08 μg/filter. Assuming the about 20 m^3 of air would be sampled by the dichotomous sampler, an amount corresponding to twice the blank value translates into a detection limit of about 8 ng/m^3 for As.

4.7.2.2 Cadmium

XRAL's mean relative deviation from accepted values on four standard filters was -14%. As noted in section 4.2.2, the results for Cd on real filters was not consistent, and no conclusions about accuracy or precision on those filters are possible.

The detection limit for Cd on Zeflour was 0.2 μg/filter and the mean blank value less than this amount, corresponding to a concentration of about 10 ng/m³, or 20 ng/m³ if a reasonable estimate of operational analytical limit at twice the stated detection limit is used.

4.7.2.3 Chromium

The mean relative deviation from accepted values achieved by XRAL on two standard filters for Cr was -13%. Accuracy on filter loaded with real airborne particles can be estimated only by comparison with the XRF results. XRAL's results were consistently a factor of two to three lower than NEA's or EPA's XRF results. A reasonable estimate of XRAL's accuracy, then, is 1/3 to 1/2 of the actual value for real particles.

XRAL's precision on real filter samples is indicated by coefficients of variation on three pairs of filter aliquots: 0%, 5% and 10% (mean 5%).

Reasonable estimates of the actual concentrations of Cr in dichotomous filter samples could be made by multiplying XRAL's results by a factor of three, arbitrarily.

XRAL's detection limit for Cr was about 0.02 μg/filter. Assuming a blank value for Zeflour of about twice this level (see results) and a quantitation limit of twice the blank value, the operational analytical limit would be about 4 ng/m^3 for dichotomous filters.

4.7.2.4 Lead

XRAL's results for two standard filters had a mean relative deviation from accepted values of -0.1%. The only other measure of accuracy possible in this study, comparison with XRF results for real filters indicated that XRAL's results, typically, would be within about 7 to 9% of the actual value (assuming XRF to be the benchmark).

The precision of XRAL's results on three pairs of real filter aliquots is indicated by CV's of 8%, 0% and 0% (mean 3%).

XRAL's detection limit for lead was about 0.2 μg/filter and the Zefluor blank value appeared to be less than that amount (see results). Assuming quantitation at twice the detection limit, the operational analysis limit would be about 20 ng/m^3.

4.7.2.5 Sulphate

CSC's accuracy on a single pre-contract standard filter is represented by a relative deviation from the accepted value of -7%. Since the target analyte for real particles is water-soluble sulphate, accuracy on real filters should reflect performance on dried aqueous solution standard filters. CSC and MOE agreed to within about 4% on the real Zefluor filters (two different analytical methods).

CSC's precision on three pairs of real filter aliquots is given by CV's of 6%, 0.9%, and 7% (mean 5%).

The operational analytical limit for $SO_4^=$ in CSC's hands was about 6 μg/filter or 0.3 μg/m³.

5.0 CONCLUSIONS/RECOMMENDATIONS

5.1 Conclusions

1. The comparative study successfully achieved its objectives of a) providing a quantitative assessment of and basis for selecting among some promising analytical techniques for airborne particulate matter and (b) identifying weaknesses and needs for future research in this area.

2. The study supports the selection of XRAL's DCP/FAA analytical protocol for analysis of dichotomous sampler filter samples for As, Cd, Cr and Pb and of Concord Scientific's IC protocol for $SO_4^=$ analysis (and for NO_3^- by inference).

   It must be recognized, however, that the destructive analytical methodology is weak for chromium and cadmium because of its reliance on digestion of the particulate matter. Aqua regia leaching has been used for extraction of Hi Vol glass fibre filters prior to analysis. Its application to dichotomous sampler teflon filters may suffer because of the small amount of sample (leading to loss of appreciable portions of the total loading) and the hydrophobicity of the filter medium.

The standard MOE digestion mixture for suspended particulate matter on glass fibre (GF) Hi Vol filters is a 1:1:1 mixture of $HF:HNO_3:H_2O$ (MOE Method AMP-105, December 1979). The HF is present to dissolve the GF filter matrix, but it may also be necessary to dissolve the glassy silicate matrix of some airborne particles (e.g. crustal minerals and fly ash).

3. The study could have been more quantitative, hence, more conclusive, if the following had been available:
   a) reliable standards on a teflon film medium that would be compatible with both destructive and non-destructive analytical protocols; and
   b) a means of collecting ambient airborne particulate matter on a teflon film medium such that enough exact duplicate samples or aliquots could be collected to supply a reasonably extensive study.

4. The performance of (energy-dispersive) XRF in this study recommends it as a method whose development should be encouraged in Canada.

5. There does not appear to be a single ideally-suited analytical protocol for the target parameters. Only lead and sulphate of those covered by the national survey and only manganese, zinc and perhaps calcium of the supplementary group could be considered to be quantitatively analysed by the means investigated.

XRF appears to have insufficient sensitivity for arsenic and cadmium at ambient levels, compared with the destructive methods.

5.2 Recommendations

1. Additional research and development should be devoted to small format standard filter samples on a teflon medium (and other media).

2. Depending upon the analytical method that is anticipated for future work on dichotomous sampler filters, filter media other than naked teflon film should be evaluated.

3. More extensive research should be carried out on elements other than As, Cd, Cr and Pb, for which this study was not as complete as it might have been.

4. Future studies of this type should allocate sufficient resources to support a larger number of samples per laboratory, so that more sophisticated statistics could be employed to illuminate sources of variance.

5. The U.S. National Bureau of Standards (NBS) Standard Reference Material (SRM) number 1648, Urban Particulate, could be used in future studies of extraction efficiency or comparisons of destructive and non-destructive methods. The digestion of a deposit on a teflon film is an important part of the comparison, however, and it would be difficult to resuspend SRM1648 on teflon filters and maintain its uniformity (and certified analysis).

SRM 1648 is certified for As, Cd, Cr, Cu, Fe, Pb, Ni, U and Zn.

6. Acid digestion mixtures and procedures other than aqua regia should be investigated if destructive analytical methods are to be pursued. As indicated in Conclusion (2), a mixture containing hydrofluoric acid should be compared with aqua regia, and/or a wetting agent such as ethanol should be tried.

6.0 REFERENCES

1. D. C. Camp, J. A. Cooper, and J. R. Rhodes, "X-Ray Fluorescence Analysis - Results of a First Round Intercomparison Study," X-Ray Spectrometry 3, 47-50 (1974).

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3. D. C. Camp, A. L. VanLehn and B. W. Loo, "Intercomparison of Samplers Used in the Determination of Aerosol Composition," U. S. Environmental Protection Agency Report, EPA-600/7-78-118, July 1978.

4. P. A. Pella, "The Development of Potential Thin Standards for Calibration of X-Ray Fluorescence Spectrometry," U. S. Environmental Protection Agency Report, EPA-600/7-80-123, June 1980.

5. Dr. Richard Judge, private communication, March 1981.

Appendices - Explanatory Notes

A1 - Raw Data Listing

Results are sorted according to element, filter type/medium, laboratory and filter identification numbers.

Key

TYPE-MED ≡ Type and medium

Prefixes:
- 6 - = Zefluor "real" filter aliquot
- 7 - = CSI synthetic standard
- 8 - = MOE synthetic standard
- 9 - = Blank filter

Suffixes:
- \- 541 = Whatman 541, 37 mm
- \- 542 = Ghia Zefluor, 37 mm aliquot
- \- 543 = Millipore HAWP, 37 mm

LAB ≡ Laboratory

- 0 = NEA
- 1 = EPA (Northrup Services)
- 2 = XRAL
- 3 = DOE
- 4 = MOE
- 5 = CSI (except = CSC for sulphate)

Results are expressed in micrograms of the element found per whole filter (37 mm diameter or 10.75 cm^2).

A minus sign in the RESULT column indicates "less than" the stated quantative (detection or quantitation limit, depending on the reporting lab).

LABERROR is the laboratory's estimate of the uncertainty (±) of the stated result.

A2 - Mean Values for Each Element

TYPE-MED, LAB and FILTER ID column headings have the same meaning as in appendix 1.

N is the number of duplicate samples (aliquots) of a given filter for which results were reported (N is 1, 2 or 4).

RESULT is the mean of all determinations reported by a lab for a given filter.

STD-RES is the standard deviation of the mean RESULT.

MIN-RES is the minimum result reported for a given filter.

MAX-RES is the maximum result reported for a given filter.

LABERROR is the mean of the estimated uncertainties of results used to compute the mean RESULT.

A3 - Analytical Determinations for Blanks

These results are a subset of the raw data listing separately displayed for clarity. Column headings have the same meaning as in Appendix 1.

Appendix 1: Raw Data Listing

Appendix 2: Mean Values for Each Element (Real Filters)

Appendix 3: Analytical Determinations for Blanks

RAW DATA LISTING
SORTED BY ELEMENT TYPE_MED AND FILTERID

ELEMENT= ALUMINUM

TYPE_MED	LAB	FILTERID	RESULT	LABERROR	FILTERNO
6-542	0	001	106.42	5.370	001
6-542	0	001	115.02	6.450	006
6-542	0	001	109.65	5.370	052
6-542	0	001	98.90	5.370	054
6-542	0	003	101.05	5.370	037
6-542	0	003	94.60	5.370	038
6-542	0	003	93.52	5.370	048
6-542	0	003	97.82	5.370	050
6-542	0	006	103.20	5.400	012
6-542	0	006	96.80	5.400	034
6-542	0	006	105.35	5.400	045
6-542	0	006	99.98	5.400	049
6-542	2	006	60.00	0.300	005
6-542	2	006	60.00	3.000	009
6-542	4	001	47.60	2.500	094
6-542	4	001	67.30	2.500	095
6-542	4	003	51.80	2.500	098
6-542	4	003	48.80	2.500	099
6-542	4	006	40.00	2.500	096
6-542	4	006	42.00	2.500	097
7-541	2	003	20.00	1.200	057
7-541	2	008	20.00	1.200	084
7-541	2	013	20.00	1.200	068
7-541	2	018	20.00	1.200	066
7-541	4	005	1.20	0.125	106
7-541	4	010	-0.25	0.000	107
7-541	4	015	1.60	0.125	108
7-541	4	020	14.00	2.500	109
7-541	5	001	0.00	0.000	
7-541	5	002	0.00	0.000	
7-541	5	004	0.00	0.000	
7-541	5	005	0.00	0.000	
7-541	5	016	21.00	1.000	
7-541	5	017	21.00	1.000	
7-541	5	018	21.00	1.000	
7-541	5	019	21.00	1.000	
7-541	5	020	21.00	1.000	
8-543	4	S1	-0.25	0.000	090
8-543	4	S1	0.32	0.125	104
8-543	4	S2	-0.25	0.000	105
9-541	2	BLA	20.00	1.200	061
9-542	0	BLA	-1.07	.	083

LAB 0 = NEA
LAB 1 = EPA
LAB 2 = XRAL
LAB 4 = MOE
LAB 5 = CSI

APPENDIX 1 - 2

RAW DATA LISTING
SORTED BY ELEMENT TYPE_MED AND FILTERID

ELEMENT= SILICON

TYPE_MED	LAB	FILTERID	RESULT	LABERROR	FILTERNO
6-542	0	001	348.30	17.20	001
6-542	0	001	387.00	19.30	006
6-542	0	001	369.80	18.30	052
6-542	0	001	333.25	17.20	054
6-542	0	003	299.92	17.20	037
6-542	0	003	281.65	17.20	038
6-542	0	003	276.27	17.20	048
6-542	0	003	285.95	17.20	050
6-542	0	006	313.90	16.12	012
6-542	0	006	299.90	15.05	034
6-542	0	006	319.28	16.12	045
6-542	0	006	307.45	15.05	049
6-542	2	006	200.00	10.00	005
6-542	2	006	200.00	10.00	009
7-541	2	003	140.00	7.00	057
7-541	5	001	40.40	2.00	
7-541	5	002	40.40	2.00	
7-541	5	004	40.40	2.00	
7-541	5	005	40.40	2.00	
7-541	5	006	20.20	1.00	
7-541	5	007	20.20	1.00	
7-541	5	008	20.20	1.00	
7-541	5	009	20.20	2.10	
7-541	5	010	20.20	2.10	
9-541	2	BLA	120.00	6.00	061
9-542	0	BLA	-0.54	0.00	083

ELEMENT= SULPHUR

TYPE_MED	LAB	FILTERID	RESULT	LABERROR	FILTERNO
6-542	0	001	187.05	10.75	001
6-542	0	001	196.72	10.75	006
6-542	0	001	193.50	10.70	052
6-542	0	001	188.12	10.75	054
6-542	0	003	340.77	16.12	037
6-542	0	003	314.97	16.12	038
6-542	0	003	297.77	16.12	048
6-542	0	003	314.97	16.12	050
6-542	0	006	163.40	8.60	012
6-542	0	006	170.90	8.60	034
6-542	0	006	168.78	8.60	045
6-542	0	006	163.40	8.60	049
7-541	5	001	40.00	2.00	
7-541	5	002	40.00	2.00	
7-541	5	004	40.00	2.00	
7-541	5	005	40.00	2.00	
7-541	5	006	20.00	1.00	
7-541	5	007	20.00	1.00	
7-541	5	008	20.00	1.00	
7-541	5	009	20.00	1.00	
7-541	5	010	20.00	1.0	
7-541	5	011	37.50	1.9	
7-541	5	012	37.50	1.9	
7-541	5	013	37.50	1.9	
7-541	5	014	37.50	1.9	
7-541	5	015	37.50	1.9	
7-541	5	016	150.00	7.5	
7-541	5	017	150.00	7.5	
7-541	5	018	150.00	7.5	
7-541	5	019	150.00	7.5	
7-541	5	020	150.00	7.5	
9-542	0	BLA	-2.15	0.0	083

LAB 0 = NEA
LAB 1 = EPA
LAB 2 = XRAL
LAB 4 = MOE
LAB 5 = CSI

Concord Scientific Corporation

ELEMENT= CHLORINE

TYPE_MED	LAB	FILTERID	RESULT	LABERROR	FILTERNO
6-542	0	001	16.12	1.07	001
6-542	0	001	18.27	1.07	006
6-542	0	001	19.35	1.07	052
6-542	0	001	17.20	1.07	054
6-542	0	003	37.62	1.61	037
6-542	0	003	27.95	1.61	038
6-542	0	003	31.17	1.61	048
6-542	0	003	36.55	1.61	050
6-542	0	006	59.10	3.20	012
6-542	0	006	60.20	3.20	034
6-542	0	006	61.28	3.20	045
6-542	0	006	58.05	3.20	049
6-542	4	001	33.00	0.60	094
6-542	4	001	31.00	0.60	095
6-542	4	003	53.00	0.60	098
6-542	4	003	45.00	0.60	099
6-542	4	006	80.00	0.60	096
6-542	4	006	80.00	0.60	097
7-541	0	001	(18.28)	(3.22)	082
7-541	0	006	(22.58)	(3.22)	063
7-541	0	011	(124.70)	(18.27)	059
7-541	0	016	(328.95)	(48.37)	070
7-541	4	005	5.00	0.60	106
7-541	4	010	10.50	0.60	107
7-541	4	015	208.00	0.60	108
7-541	4	020	404.00	0.60	109
7-541	5	001	10.50	0.50	
7-541	5	002	10.50	0.50	
7-541	5	004	10.50	0.50	
7-541	5	005	10.50	0.50	
7-541	5	006	4.20	0.20	
7-541	5	007	4.20	0.20	
7-541	5	008	4.20	0.20	
7-541	5	009	4.20	0.20	
7-541	5	010	4.20	0.20	
7-541	5	011	.	.	
7-541	5	012	.	.	
7-541	5	013	.	.	
7-541	5	014	.	.	
7-541	5	015	.	.	
7-541	5	016	.	.	
7-541	5	017	.	.	
7-541	5	018	.	.	
7-541	5	019	.	.	
7-541	5	020	.	.	
9-541	0	BLA	(8.60)	(2.15)	064
9-542	0	BLA	-1.18	0.00	083
9-542	4	BLA	-1.00	0.00	103

LAB 0 = NEA
LAB 1 = EPA
LAB 2 = XRAL
LAB 4 = MOE
LAB 5 = CSI

ELEMENT= POTASSIUM

TYPE_MED	LAB	FILTERID	RESULT	LABERROR	FILTERNO
6-542	0	001	40.85	2.15	001
6-542	0	001	46.22	2.15	006
6-542	0	001	45.15	2.15	052
6-542	0	001	43.00	2.15	054
6-542	0	003	32.25	2.15	037
6-542	0	003	32.25	2.15	038
6-542	0	003	32.25	2.15	048
6-542	0	003	33.32	2.15	050
6-542	0	006	72.00	4.30	012
6-542	0	006	73.10	4.30	034
6-542	0	006	74.18	4.30	045
6-542	0	006	70.95	.	049
7-541	0	001	29.02	4.3	082
7-541	0	006	64.50	10.70	063
7-541	0	011	-0.40	0.00	059
7-541	0	016	1.07	0.22	070
7-541	5	001	.	.	
7-541	5	002	.	.	
7-541	5	004	.	.	
7-541	5	005	.	.	
7-541	5	006	.	.	
7-541	5	007	.	.	
7-541	5	008	.	.	
7-541	5	009	.	.	
7-541	5	010	.	.	
9-541	0	BLA	(-0.40)	(0.00)	064
9-542	0	BLA	-0.21	0.00	083

LAB 0 = NEA
LAB 1 = EPA
LAB 2 = XRAL
LAB 4 = MOE
LAB 5 = CSI

APPENDIX 1 - 5

RAW DATA LISTING
SORTED BY ELEMENT TYPE_MED AND FILTERID

ELEMENT= CALCIUM

TYPE_MED	LAB	FILTERID	RESULT	LABERROR	FILTERNO
6-542	0	001	314.970	16.120	001
6-542	0	001	360.120	18.270	006
6-542	0	001	364.420	18.270	052
6-542	0	001	339.700	16.120	054
6-542	0	003	451.500	18.120	037
6-542	0	003	379.470	18.250	038
6-542	0	003	376.250	18.250	048
6-542	0	003	418.170	18.250	050
6-542	0	006	397.800	20.400	012
6-542	0	006	387.000	19.300	034
6-542	0	006	407.430	20.400	045
6-542	0	006	395.600	19.300	049
6-542	1	001	310.516	15.906	041
6-542	1	001	321.902	16.487	053
6-542	1	003	397.488	20.340	020
6-542	1	003	326.576	16.725	023
6-542	1	006	340.463	17.434	025
6-542	1	006	358.046	18.330	047
6-542	4	001	370.000	0.300	094
6-542	4	001	365.000	0.300	095
6-542	4	003	390.000	0.300	098
6-542	4	003	445.000	0.300	099
6-542	4	006	275.000	0.300	096
6-542	4	006	275.000	0.300	097
7-541	0	001	(1.720)	(2.000)	082
7-541	0	006	(2.900)	(0.430)	063
7-541	0	011	(6.240)	(0.750)	059
7-541	0	016	(56.970)	(6.000)	070
7-541	4	005	3.000	0.300	106
7-541	4	010	-0.500	0.000	107
7-541	4	015	0.500	0.300	108
7-541	4	020	20.000	0.300	109
7-541	5	011	5.000	0.200	
7-541	5	012	5.000	0.200	
7-541	5	013	5.000	0.200	
7-541	5	014	5.000	0.200	
7-541	5	015	5.000	0.200	
7-541	5	016	50.400	2.500	
7-541	5	017	50.400	2.500	
7-541	5	018	50.400	2.500	
7-541	5	019	50.400	2.500	
7-541	5	020	50.400	2.500	
8-543	4	S1	-0.500	0.300	090
8-543	4	S1	-0.500	0.000	104
8-543	4	S2	-0.500	0.000	105
9-541	0	BLA	(-0.040)	(0.000)	064
9-542	0	BLA	0.640	0.110	083
9-542	1	BLA	-0.284	0.000	075
9-543	1	BLA	3.100	0.299	104

LAB 0 = NEA
LAB 1 = EPA
LAB 2 = XR
LAB 4 = MOE
LAB 5 = CSI

Concord Scientific Corporation

RAW DATA LISTING
SORTED BY ELEMENT TYPE_MED AND FILTERID

ELEMENT= TITANIUM

TYPE_MED	LAB	FILTERID	RESULT	LABERROR	FILTERNO
6-542	0	001	9.890	0.540	001
6-542	0	001	10.860	0.540	006
6-542	0	001	10.860	0.540	052
6-542	0	001	10.530	0.540	054
6-542	0	003	13.760	0.540	037
6-542	0	003	11.930	0.540	038
6-542	0	003	11.180	0.540	048
6-542	0	003	12.470	0.540	050
6-542	0	006	10.500	0.500	012
6-542	0	006	10.300	0.500	034
6-542	0	006	10.640	0.540	045
6-542	0	006	10.320	0.540	049
6-542	1	001	9.181	0.565	041
6-542	1	001	8.862	0.549	053
6-542	1	003	9.035	0.570	020
6-542	1	003	8.461	0.538	023
6-542	1	006	6.297	0.452	025
6-542	1	006	6.812	0.473	047
6-542	4	001	0.500	0.050	094
6-542	4	001	0.500	0.050	094
6-542	4	001	2.200	0.050	095
6-542	4	003	2.800	0.050	098
6-542	4	003	2.200	0.050	099
6-542	4	006	0.700	0.050	096
6-542	4	006	1.000	0.050	097
7-541	0	001	(-0.100)	(0.000)	082
7-541	0	006	(-0.100)	(0.000)	063
7-541	0	011	(6.020)	(0.540)	059
7-541	0	016	(0.500)	(0.070)	070
7-541	4	005	0.100	0.050	106
7-541	4	010	0.100	0.050	107
7-541	4	015	3.000	0.050	108
7-541	4	020	0.450	0.050	109
7-541	5	011	4.300	0.200	
7-541	5	012	4.300	0.200	
7-541	5	013	4.300	0.200	
7-541	5	014	4.300	0.200	
7-541	5	015	4.300	0.200	
8-543	4	S1	-0.100	0.000	090
8-543	4	S1	-0.100	0.000	104
8-543	4	S2	-0.100	0.000	105
9-541	0	BLA	(-0.100)	(0.000)	064
9-542	0	BLA	-0.110	0.000	083
9-542	1	BLA	-0.168	0.000	075
9-542	4	BLA	-0.100	0.000	103
9-543	1	BLA	0.158	0.126	104

LAB 0 = NEA
LAB 1 = EPA
LAB 2 = XRAL
LAB 4 = MOE
LAB 5 = CSI

RAW DATA LISTING
SORTED BY ELEMENT TYPE_MED AND FILTERID

ELEMENT= VANADIUM

TYPE_MED	LAB	FILTERID	RESULT	LABERROR	FILTERNO
6-542	0	001	1.29	0.11	001
6-542	0	001	1.18	0.11	006
6-542	0	001	1.18	0.11	052
6-542	0	001	1.18	0.11	054
6-542	0	003	2.58	0.16	037
6-542	0	003	1.93	0.16	038
6-542	0	003	2.15	0.16	048
6-542	0	003	2.36	0.16	050
6-542	0	006	2.15	0.11	012
6-542	0	006	1.94	0.11	034
6-542	0	006	2.04	0.11	045
6-542	0	006	2.04	0.11	049
7-541	0	001	-0.08	0.00	082
7-541	C	006	-0.08	0.00	063
7-541	0	011	-0.08	0.00	059
7-541	0	016	0.17	0.05	070
9-541	C	BLA	-0.08	0.00	064
9-542	0	BLA	-0.09	0.00	083

ELEMENT= CHROMIUM

TYPE_MED	LAB	FILTERID	RESULT	LABERROR	FILTERNO
6-542	0	001	2.040	0.1100	001
6-542	0	001	2.360	0.1100	006
6-542	0	001	2.150	0.1100	052
6-542	0	001	2.260	0.1100	054
6-542	0	003	4.410	0.1600	037
6-542	0	003	3.980	0.1600	038
6-542	0	003	3.440	0.1600	048
6-542	C	003	3.760	0.1600	050
6-542	0	006	5.100	0.2100	012
6-542	0	006	4.840	0.2100	034
6-542	C	006	4.950	0.2100	045
6-542	0	006	5.270	0.3200	049
6-542	1	001	1.306	0.1480	041
6-542	1	001	1.592	0.1580	053
6-542	1	003	2.148	0.1960	020
6-542	1	003	1.664	0.1720	023
6-542	1	006	2.882	0.2220	025
6-542	1	006	3.121	0.2360	047
6-542	2	001	0.600	0.0200	002
6-542	2	001	0.600	0.0200	051
6-542	2	003	1.400	0.0300	018
6-542	2	003	1.300	0.0300	029
6-542	2	006	1.300	0.0300	005
6-542	2	006	1.500	0.0300	009
6-542	4	001	0.300	0.0130	094
6-542	4	001	0.800	0.0130	095
6-542	4	003	2.100	0.0130	098
6-542	4	003	2.800	0.0130	099

LAB 0 = NEA
LAB 1 = EPA
LAB 2 = XRAL
LAB 4 = MOE
5 =

Concord Scientific Corporation

RAW DATA LISTING
SORTED BY ELEMENT TYPE_MED AND FILTERID

ELEMENT= CHROMIUM CONTINUED

TYPE_MED	LAB	FILTERID	RESULT	LABERROR	FILTERNO
6-542	4	006	0.440	0.0130	096
6-542	4	006	0.510	0.0133	097
7-541	0	001	-0.060	0.0000	004
7-541	0	001	-0.080	0.0000	082
7-541	0	005	-0.060	0.0000	032
7-541	0	006	-0.080	0.0000	063
7-541	0	009	14.300	1.2900	039
7-541	0	011	-0.080	0.0000	059
7-541	0	013	38.380	3.3300	030
7-541	0	016	0.360	0.0500	070
7-541	2	003	0.060	0.0020	017
7-541	2	003	-0.020	0.0000	057
7-541	2	007	-0.020	0.0000	010
7-541	2	008	-0.020	0.0000	084
7-541	2	011	13.000	0.1900	027
7-541	2	013	0.600	0.0200	068
7-541	2	015	34.000	3.3300	016
7-541	2	018	0.180	0.0050	066
7-541	4	005	2.000	0.0130	106
7-541	4	010	-0.025	0.0000	107
7-541	4	015	0.075	0.0130	108
7-541	4	020	-0.025	0.0000	109
7-541	5	001	0.000	0.0000	
7-541	5	002	0.000	0.0000	
7-541	5	003	0.000	0.0000	
7-541	5	004	0.000	0.0000	
7-541	5	005	0.000	0.0000	
7-541	5	006	0.000	0.0000	
7-541	5	007	0.000	0.0000	
7-541	5	008	0.000	0.0000	
7-541	5	009	15.250	0.7600	
7-541	5	010	15.250	0.7600	
7-541	5	011	15.250	0.7600	
7-541	5	012	15.250	0.7600	
7-541	5	013	38.130	1.9100	
7-541	5	014	38.130	1.9100	
7-541	5	015	38.130	1.9100	
7-541	5	016	38.130	1.9100	
8-543	2	S1	1.000	0.0500	077
8-543	2	S1	0.800	0.0500	086
8-543	2	S2	2.400	0.0500	058
8-543	2	S2	2.400	0.0500	078
8-543	4	S1	0.590	0.0130	090
8-543	4	S1	0.580	0.0130	104
8-543	4	S1	0.400	.	
8-543	4	S2	1.490	0.0130	105
8-543	4	S2	2.000	.	
9-541	0	BLA	-0.080	0.0000	064
9-541	0	017	-0.060	0.0000	031
9-541	2	BLA	-0.020	0.0000	061
9-541	2	019	-0.020	0.0000	007
9-542	0	BLA	-0.060	0.0000	083
9-542	1	BLA	-0.080	0.000	075
9-542	2	BLA	0.160	.	071
9-542	4	BLA	-0.100	0.000	103
9-543	1	BLA	0.115	0.062	104
9-543	2	BLA	0.400	0.050	088
9-543	4	BLA	-0.100	0.000	091

LAB 0 = NEA
LAB 1 = EPA
LAB 2 = XRAL
LAB 4 = MOE
LAB 5 = CSI

ELEMENT= MANGANESE

TYPE_MED	LAB	FILTERID	RESULT	LABERROR	FILTERNO
6-542	0	001	11.820	0.640	001
6-542	0	001	14.190	0.750	006
6-542	0	001	14.080	0.750	052
6-542	0	001	14.300	0.750	054
6-542	0	003	30.100	1.000	037
6-542	0	003	24.720	1.000	038
6-542	0	003	23.650	1.000	048
6-542	0	003	25.800	1.000	050
6-542	0	006	43.000	2.150	012
6-542	0	006	41.900	2.150	034
6-542	0	006	45.150	2.150	045
6-542	0	006	41.930	2.150	049
6-542	1	001	13.199	0.703	041
6-542	1	001	12.465	0.666	053
6-542	1	003	25.651	1.337	020
6-542	1	003	20.664	1.083	023
6-542	1	006	36.425	1.884	025
6-542	1	006	39.045	2.018	047
6-542	2	001	15.000	0.050	002
6-542	2	001	13.000	0.050	051
6-542	2	003	27.000	0.270	018
6-542	2	003	27.000	0.270	029
6-542	2	006	41.000	0.410	005
6-542	2	006	43.000	0.430	009
6-542	4	001	13.200	0.500	094
6-542	4	001	13.200	0.500	095
6-542	4	003	26.500	0.500	098
6-542	4	003	21.500	0.500	099
6-542	4	006	29.000	0.500	096
6-542	4	006	26.000	0.500	097
7-541	0	001	0.140	0.060	082
7-541	0	006	-0.09	0.000	063
7-541	0	011	4.520	0.040	059
7-541	0	016	40.850	3.220	070
7-541	2	003	0.060	0.005	017
7-541	2	003	0.180	0.010	057
7-541	2	007	0.100	0.010	010
7-541	2	008	-0.040	0.000	084
7-541	2	011	0.200	0.020	027
7-541	2	013	4.200	0.300	068
7-541	2	015	0.100	0.010	016
7-541	2	018	39.000	0.390	066
7-541	4	005	0.120	0.025	106
7-541	4	010	-0.050	0.000	107
7-541	4	015	2.300	0.025	108
7-541	4	020	33.000	0.500	109
7-541	5	011	4.200	0.200	
7-541	5	012	4.200	0.200	
7-541	5	013	4.200	0.200	
7-541	5	014	4.200	0.200	
7-541	5	015	4.200	0.200	
7-541	5	016	41.500	2.000	
7-541	5	017	41.500	2.000	
7-541	5	018	41.500	2.000	
7-541	5	019	41.500	2.000	
7-541	5	020	41.500	2.000	
8-543	2	S1	0.040	0.003	077
8-543	2	S1	0.080	0.006	086
8-543	2	S2	0.100	0.008	058
8-543	2	S2	0.100	0.008	078
8-543	4	S1	-0.050	0.000	090
8-543	4	S1	-0.050	0.000	104
8-543	4	S2	-0.050	0.000	105
9-541	0	BLA	-0.090	0.000	064
9-541	2	BLA	-0.040	0.000	061
9-541	2	019	0.100	0.008	007
9-542	0	BLA	0.090	0.050	083
9-542	1	BLA	-0.070	0.000	075
9-542	2	BLA	-0.040	0.000	071
9-542	4	BLA	-0.100	0.000	103
9-543	1	BLA	-0.048	0.000	104
9-543	2	BLA	0.080	0.006	088

LAB 0 = NEA
_A_ . = E.A
LAB 2 = XRAL
LAB 4 = MOE
LAB 5 = CSI

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ELEMENT= IRON

TYPE_MED	LAB	FILTERID	RESULT	LABERROR	FILTERNO
6-542	0	001	219.300	10.750	001
6-542	0	001	256.900	12.900	006
6-542	0	001	267.670	13.970	052
6-542	0	001	247.250	12.900	054
6-542	0	003	610.600	31.000	037
6-542	0	003	518.150	25.800	038
6-542	0	003	505.250	25.800	048
6-542	0	003	553.620	27.950	050
6-542	0	006	632.100	32.250	012
6-542	0	006	615.900	31.170	034
6-542	0	006	652.530	33.320	045
6-542	0	006	620.280	31.170	049
6-542	1	001	214.742	10.966	041
6-542	1	001	233.030	11.388	053
6-542	1	003	488.945	24.947	020
6-542	1	003	409.426	20.892	023
6-542	1	006	504.506	25.740	025
6-542	1	006	531.190	27.101	047
6-542	4	001	62.600	1.500	094
6-542	4	001	188.000	1.500	095
6-542	4	003	481.000	1.500	098
6-542	4	003	390.000	1.500	099
6-542	4	006	105.000	1.500	096
6-542	4	006	154.000	1.500	097
7-541	0	001	-0.090	0.000	082
7-541	0	006	-0.090	0.000	063
7-541	0	011	5.910	0.430	059
7-541	0	016	53.750	4.300	070
7-541	1	002	0.224	0.068	036
7-541	1	002	0.232	0.060	081
7-541	1	006	0.209	0.074	035
7-541	1	007	0.251	0.046	060
7-541	1	012	7.799	0.418	073
7-541	1	014	-0.065	0.000	022
7-541	1	017	43.733	2.248	069
7-541	4	005	4.200	0.025	106
7-541	4	010	0.600	0.025	107
7-541	4	015	4.100	0.025	108
7-541	4	020	14.000	1.500	109
7-541	5	011	5.200	0.200	
7-541	5	012	5.200	0.200	
7-541	5	013	5.200	0.200	
7-541	5	014	5.200	0.200	
7-541	5	015	5.200	0.200	
7-541	5	016	51.800	2.000	
7-541	5	017	51.800	2.000	
7-541	5	018	51.800	2.000	
7-541	5	019	51.800	2.000	
7-541	5	020	51.800	2.000	
8-543	4	S1	0.080	0.025	090
8-543	4	S1	0.140	0.025	104
8-543	4	S2	0.080	0.025	105
9-542	0	BLA	0.250	0.090	083
9-542	1	BLA	2.982	0.185	075
9-542	4	BLA	-0.100	0.000	103
9-543	1	BLA	-0.055	0.000	104

LAB 0 = NEA
LAB 1 = EPA
LAB 2 = XRAL
B 4 = MOE
LAB 5 = CSI

RAW DATA LISTING
SORTED BY ELEMENT TYPE_MED AND FILTERID

ELEMENT= NICKEL

TYPE_MED	LAB	FILTERID	RESULT	LABERROR	FILTERNO
6-542	0	001	0.77	0.07	001
6-542	0	001	0.76	0.07	006
6-542	0	001	0.92	0.07	052
6-542	0	003	1.34	1.00	037
6-542	0	003	1.14	0.09	038
6-542	0	0C3	1.01	0.09	048
6-542	0	003	1.33	1.00	050
6-542	0	006	0.85	0.07	012
6-542	0	006	0.80	0.07	034
6-542	0	006	1.05	0.08	045
6-542	0	006	0.72	0.06	049
7-541	0	001	-0.05	0.00	082
7-541	0	006	-0.05	0.00	063
7-541	0	011	-0.05	0.0C	059
7-541	0	016	-0.05	0.00	070
9-541	0	BLA	-0.05	0.00	064
9-542	0	BLA	-0.05	0.00	083

ELEMENT= COPPER

TYPE_MED	LAB	FILTERID	RESULT	LABERROR	FILTERNO
6-542	0	001	66.65	3.22	001
6-542	0	001	56.97	3.22	006
6-542	0	001	60.20	3.22	052
6-542	0	001	88.15	4.30	054
6-542	0	003	45.2	2.15	037
6-542	0	003	55.9	3.22	038
6-542	C	0C3	26.9	1.07	048
6-542	0	003	33.3	2.2	050
6-542	0	006	23.70	1.1C	012
6-542	0	006	35.47	2.15	034
6-542	0	006	26.88	1.10	045
6-542	C	006	23.65	1.07	049
7-541	0	001	-0.05	0.00	082
7-541	0	006	-0.05	0.00	063
7-541	0	011	-0.05	0.00	059
7-541	0	016	10.93	0.04	070
9-541	0	BLA	-0.05	0.00	064

LAB 0 = NEA
LAB 1 = EPA
LAB 2 = XRAL
4 = MOE
LAB 5 = CSI

RAW DATA LISTING
SORTED BY ELEMENT TYPE_MED AND FILTERID

---------------------------------- ELEMENT= ZINC ----------------------------------

TYPE_MED	LAB	FILTERID	RESULT	LABERROR	FILTERNO
6-542	0	001	24.720	1.070	001
6-542	0	001	24.720	1.070	006
6-542	0	001	25.800	1.070	052
6-542	0	001	23.650	1.070	054
6-542	0	003	25.800	1.100	037
6-542	0	003	23.650	1.100	038
6-542	0	003	21.500	1.100	048
6-542	0	003	23.650	1.100	050
6-542	0	006	24.700	1.100	012
6-542	0	006	24.730	1.070	034
6-542	0	006	26.880	1.070	045
6-542	0	006	24.730	1.070	049
6-542	1	001	17.879	0.923	041
6-542	1	001	19.406	1.000	053
6-542	1	003	19.878	1.024	020
6-542	1	003	15.620	0.808	023
6-542	1	006	19.379	0.999	025
6-542	1	006	19.420	1.001	047
6-542	2	001	22.000	3.000	002
6-542	2	001	19.000	3.000	051
6-542	2	003	21.000	0.310	018
6-542	2	003	21.000	0.310	029
6-542	2	006	20.000	0.300	005
6-542	2	006	22.000	0.300	009
6-542	4	001	21.000	0.050	094
6-542	4	001	20.200	0.050	095
6-542	4	003	20.800	0.050	098
6-542	4	003	18.500	0.050	099
6-542	4	006	17.000	0.050	096
6-542	4	006	14.000	0.050	097
7-541	0	001	0.075	0.032	082
7-541	0	006	-0.030	0.000	063
7-541	0	011	6.770	0.320	059
7-541	0	016	59.120	3.220	070
7-541	1	002	-0.044	0.000	036
7-541	1	002	0.336	0.178	081
7-541	1	006	-0.052	0.000	035
7-541	1	007	0.276	0.042	060
7-541	1	012	5.688	0.301	073
7-541	1	017	54.360	2.780	069
7-541	2	003	0.300	0.050	017
7-541	2	003	0.500	0.080	057
7-541	2	007	0.600	0.100	010
7-541	2	008	0.300	0.050	084
7-541	2	011	0.500	0.080	027
7-541	2	013	5.200	0.070	068
7-541	2	015	0.300	0.050	016
7-541	2	018	50.000	0.750	066
7-541	4	005	0.300	0.050	106
7-541	4	010	0.150	0.050	107
7-541	4	015	6.400	0.070	108
7-541	4	020	57.000	0.750	109

LAB 0 = NEA
LAB 1 = EPA
LAB 2 = XRAL
LAB 4 = MOE
LAB 5 = CSI

RAW DATA LISTING
SORTED BY ELEMENT TYPE_MED AND FILTERID

ELEMENT= ZINC CONTINUED

TYPE_MED	LAB	FILTERID	RESULT	LABERROR	FILTERNO
7-541	5	011	6.00	0.3000	
7-541	5	012	6.00	0.3000	
7-541	5	013	6.00	0.3000	
7-541	5	014	6.00	0.3000	
7-541	5	015	6.00	0.3000	
7-541	5	016	60.20	2.0000	
7-541	5	017	60.20	2.0000	
7-541	5	018	60.20	2.0000	
7-541	5	019	60.20	2.0000	
7-541	5	020	60.20	2.0000	
8-543	2	S1	0.30	0.0500	077
8-543	2	S1	0.30	0.0500	086
8-543	2	S2	0.20	0.0300	058
8-543	2	S2	0.30	0.0500	078
8-543	4	S1	-0.10	0.0000	090
8-543	4	S1	-0.10	0.0000	104
8-543	4	S2	-0.10	0.0000	105
9-541	0	BLA	0.20	0.0300	064
9-541	2	BLA	0.20	0.0800	061
9-541	2	019	0.40	0.0600	007
9-542	0	BLA	-0.03	0.0000	083
9-542	1	BLA	-0.05	0.0000	075
9-542	2	BLA	0.30	.	071
9-542	4	BLA	-0.10	0.0000	103
9-543	1	BLA	0.19	0.0347	104
9-543	2	BLA	0.60	0.1000	088

ELEMENT= ARSENIC

TYPE_MED	LAB	FILTERID	RESULT	LABERROR	FILTERNO
6-542	0	001	-0.400	0.00	001
6-542	0	001	-0.400	0.00	006
6-542	0	001	-0.400	0.00	052
6-542	0	001	-0.400	0.00	054
6-542	0	003	-0.400	0.00	037
6-542	0	003	-0.400	0.00	038
6-542	0	003	-0.400	0.00	048
6-542	0	003	-0.400	0.00	050
6-542	0	006	-0.430	0.00	012
6-542	0	006	-0.430	0.00	034
6-542	0	006	-0.430	0.00	045
6-542	0	006	-0.430	0.00	049
6-542	1	001	-0.187	0.00	041
6-542	1	001	-0.190	0.00	053
6-542	1	003	-0.132	0.00	020
6-542	1	003	-0.116	0.00	023
6-542	1	006	-0.177	0.00	025
6-542	1	006	-0.177	0.00	047
6-542	2	001	0.100	0.02	002
6-542	2	001	0.100	0.02	051

LAB 0 = NEA
LAB 1 = EPA
2 = XR
LAB 4 = MOE
LAB 5 = CSI

RAW DATA LISTING
SORTED BY ELEMENT TYPE_MED AND FILTERID

------------------------------- ELEMENT= ARSENIC CONTINUED -------------------

TYPE_MED	LAB	FILTERID	RESULT	LABERROR	FILTERNO
6-542	2	003	0.40	0.01	018
6-542	2	003	0.40	0.01	029
6-542	2	006	0.66	0.10	005
6-542	2	006	0.46	0.10	009
6-542	4	001	0.05	0.03	094
6-542	4	001	0.08	0.03	095
6-542	4	003	0.25	0.03	098
6-542	4	003	0.21	0.03	099
7-541	0	001	8.92	1.40	004
7-541	0	001	-0.10	0.00	082
7-541	0	005	13.97	2.15	032
7-541	0	006	-0.10	0.00	063
7-541	0	009	3.87	0.21	039
7-541	0	011	-0.10	0.00	059
7-541	0	013	10.21	0.54	030
7-541	0	016	-0.10	0.00	070
7-541	2	003	3.90	0.06	017
7-541	2	003	0.06	0.00	057
7-541	2	007	4.00	0.06	010
7-541	2	008	0.10	0.00	084
7-541	2	011	3.90	0.06	027
7-541	2	013	0.10	0.00	068
7-541	2	015	10.00	0.06	016
7-541	2	018	0.06	0.00	066
7-541	4	005	-0.03	0.00	106
7-541	4	010	-0.03	0.00	107
7-541	4	015	0.05	0.03	108
7-541	4	020	0.05	0.03	109
7-541	5	001	4.40	0.22	
7-541	5	002	4.40	0.22	
7-541	5	003	4.40	0.22	
7-541	5	004	4.40	0.22	
7-541	5	005	8.80	0.44	
7-541	5	006	8.80	0.44	
7-541	5	007	8.80	0.44	
7-541	5	008	8.80	0.44	
7-541	5	009	4.40	0.22	
7-541	5	010	4.40	0.22	
7-541	5	011	4.40	0.22	
7-541	5	012	4.40	0.22	
7-541	5	013	11.00	0.55	
7-541	5	014	11.00	0.55	
7-541	5	015	11.00	0.55	
7-541	5	016	11.00	0.55	
8-543	2	S1	0.06	0.11	077
8-543	2	S1	0.06	0.11	086
8-543	2	S2	0.16	0.11	058
8-543	2	S2	0.16	0.11	078
8-543	4	S1	0.13	0.03	090
8-543	4	S1	0.22	0.03	104
8-543	4	S1	0.40	.	
8-543	4	S2	0.280	0.03	105
8-543	4	S2	2.000	.	
9-541	0	BLA	-0.100	0.00	064
9-541	0	017	-0.400	0.00	031
9-541	2	BLA	0.060	0.00	061
9-541	2	019	-0.100	0.00	007
9-542	0	BLA	-0.100	0.00	083
9-542	1	BLA	-0.029	0.00	075
9-542	2	BLA	0.100	.	071
9-543	1	BLA	-0.020	0.00	104
9-543	2	BLA	-0.020	0.00	088
9-543	4	BLA	-0.100	0.00	091

LAB 0 = NEA
LAB 1 = EPA
LAB 2 = XRAL
LAB 4 = MOE

ELEMENT= SELENIUM

TYPE_MED	LAB	FILTERID	RESULT	LABERROR	FILTERNO
6-542	0	001	-0.30	0	001
6-542	0	001	-0.30	0	006
6-542	0	001	-0.30	0	052
6-542	0	001	-0.30	0	054
6-542	0	003	-0.30	0	037
6-542	0	003	-0.30	0	038
6-542	0	003	-0.30	0	048
6-542	0	003	-0.30	0	050
6-542	0	006	-0.32	0	012
6-542	0	006	-0.32	0	034
6-542	0	006	-0.32	0	045
6-542	0	006	-0.32	0	049
7-541	0	001	-0.10	0	082
7-541	0	006	-0.10	0	063
7-541	0	011	-0.10	0	059
7-541	0	016	-0.10	0	070
9-541	0	BLA	-0.10	0	064
9-542	0	BLA	-0.10	0	083

ELEMENT= BROMINE

TYPE_MED	LAB	FILTERID	RESULT	LABERROR	FILTERNO
6-542	0	001	13.330	0.640	001
6-542	0	001	14.940	0.750	006
6-542	0	001	14.510	0.750	052
6-542	0	001	13.540	0.060	054
6-542	0	003	3.650	0.210	037
6-542	0	003	3.220	0.210	038
6-542	0	003	3.120	0.210	048
6-542	0	003	3.440	0.210	050
6-542	0	006	12.400	0.600	012
6-542	0	006	12.360	0.640	034
6-542	0	006	12.580	0.640	045
6-542	0	006	12.150	0.640	049
6-542	1	001	12.512	0.644	041
6-542	1	001	13.295	0.684	053
6-542	1	003	2.739	0.150	020
6-542	1	003	2.322	0.129	023
6-542	1	006	10.602	0.547	025
6-542	1	006	10.604	0.548	047
7-541	0	001	3.440	0.210	082
7-541	0	006	9.030	0.430	063
7-541	0	011	-0.110	0.000	059
7-541	0	016	-0.110	0.000	070
7-541	1	002	0.067	0.040	036
7-541	1	002	3.373	0.178	081
7-541	1	006	0.215	0.055	035
7-541	1	007	9.508	0.490	060
7-541	1	012	-0.019	0.000	073
7-541	1	014	-0.024	0.000	022
7-541	1	017	0.025	0.019	069
7-541	5	001	10.100	0.500	
7-541	5	002	10.100	0.500	
7-541	5	004	10.100	0.500	
7-541	5	005	10.100	0.500	
7-541	5	006	4.100	0.200	
7-541	5	007	4.100	0.200	
7-541	5	008	4.100	0.200	
7-541	5	009	4.100	0.200	
7-541	5	010	4.100	0.200	
9-541	0	BLA	-0.110	0.000	064
9-542	0	BLA	-0.100	0.000	083
9-542	1	BLA	-0.020	0.000	075
9-543	1	BLA	-0.015	0.000	104

LAB 0 = NEA
LAB 1 = EPA
LAB 2 = XRAL
LAB 4 = MOE
LAB 5 = CSI

ELEMENT= CADMIUM

TYPE_MED	LAB	FILTERID	RESULT	LABERROR	FILTERNO
6-542	0	001	-0.400	0.000	001
6-542	0	001	-0.400	0.000	006
6-542	0	001	-0.400	0.000	052
6-542	0	001	-0.400	0.000	054
6-542	0	003	-0.400	0.000	037
6-542	0	003	-0.400	0.000	038
6-542	0	003	-0.400	0.000	048
6-542	0	003	-0.400	0.000	050
6-542	0	006	3.550	0.640	012
6-542	0	006	3.550	0.640	034
6-542	0	006	2.690	0.640	045
6-542	0	006	3.330	0.640	049
6-542	1	001	-0.092	0.000	041
6-542	1	001	-0.093	0.000	053
6-542	1	003	0.134	0.101	020
6-542	1	003	0.098	0.098	023
6-542	1	006	0.378	0.107	025
6-542	1	006	0.368	0.112	047
6-542	2	001	-0.200	0.000	002
6-542	2	001	-0.200	0.000	051
6-542	2	003	-0.200	0.000	018
6-542	2	003	0.200	0.000	029
6-542	2	006	-0.200	0.000	005
6-542	2	006	0.200	.	009
6-542	4	001	0.130	0.003	094
6-542	4	001	0.140	0.003	095
6-542	4	003	0.120	0.003	098
6-542	4	003	0.300	0.003	099
6-542	4	006	0.160	0.003	096
6-542	4	006	0.110	0.003	097
7-541	0	001	2.260	0.650	004
7-541	0	001	-0.400	0.000	082
7-541	0	005	7.310	0.750	032
7-541	0	006	-0.400	0.000	063
7-541	0	009	2.040	0.650	039
7-541	0	011	-0.400	0.000	059
7-541	0	013	8.170	0.750	030
7-541	0	016	-0.400	0.000	070
7-541	2	003	3.600	0.250	017
7-541	2	003	-0.200	0.000	057
7-541	2	007	8.400	0.250	010
7-541	2	008	-0.200	0.000	084
7-541	2	011	3.600	0.250	027
7-541	2	013	-0.200	0.000	068
7-541	2	015	9.200	0.250	016
7-541	2	018	-0.200	0.000	066
7-541	4	005	0.015	0.003	106
7-541	4	010	0.015	0.003	107
7-541	4	015	0.082	0.003	108
7-541	4	020	0.028	0.003	109
7-541	5	001	4.430	0.220	
7-541	5	002	4.430	0.220	
7-541	5	003	4.430	0.220	
7-541	5	004	4.430	0.220	
7-541	5	005	8.860	0.440	
7-541	5	006	8.860	0.440	
7-541	5	007	8.860	0.440	
7-541	5	008	8.860	0.440	
7-541	5	009	4.380	0.220	
7-541	5	010	4.380	0.220	
7-541	5	011	4.380	0.220	
7-541	5	012	4.380	0.220	
7-541	5	013	10.960	0.550	
7-541	5	014	10.960	0.550	
7-541	5	015	10.960	0.550	
7-541	5	016	10.960	0.550	

L..B 0 = ...A
LAB 1 = EPA
LAB 2 = XRAL
LAB 4 = MOE
LAB 5 = [illegible]

RAW DATA LISTING
SORTED BY ELEMENT TYPE_MED AND FILTERID

ELEMENT= CADMIUM CONTINUED

TYPE_MED	LAB	FILTERID	RESULT	LABERROR	FILTERNO
8-543	2	S1	1.500	0.100	077
8-543	2	S1	1.500	0.100	086
8-543	2	S2	0.300	0.090	058
8-543	2	S2	0.200	0.090	078
8-543	4	S1	0.540	0.003	090
8-543	4	S1	0.820	0.002	104
8-543	4	S1	2.000	.	
8-543	4	S2	0.300	0.003	105
8-543	4	S2	0.400	.	
9-541	0	BLA	-0.400	0.000	064
9-541	0	017	-0.400	0.000	031
9-541	2	BLA	-0.200	0.000	061
9-541	2	019	-0.200	0.000	007
9-542	0	BLA	-0.400	0.000	083
9-542	1	BLA	-0.090	0.000	075
9-542	2	BLA	-0.200	0.000	071
9-542	4	BLA	-0.100	0.000	103
9-543	1	BLA	-0.062	0.000	104
9-543	2	BLA	-0.200	0.000	088
9-543	4	BLA	-0.200	0.000	091

ELEMENT= BARIUM

TYPE_MED	LAB	FILTERID	RESULT	LABERROR	FILTERNO
6-542	0	001	-0.40	0	001
6-542	0	001	-0.40	0	006
6-542	0	001	-0.40	0	052
6-542	0	001	-0.40	0	054
6-542	0	003	-0.40	0	037
6-542	0	003	-0.40	0	038
6-542	0	003	-0.40	0	048
6-542	0	003	-0.40	0	050
6-542	0	006	-0.43	0	012
6-542	0	006	-0.43	0	034
6-542	0	006	-0.43	0	045
6-542	0	006	-0.43	0	049
7-541	0	001	-4.00	0	082
7-541	0	006	-4.00	0	063
7-541	0	011	-4.00	0	059
7-541	0	016	-4.00	0	070
9-541	0	BLA	-4.00	0	064
9-542	0	BLA	-0.40	0	083

LAB 0 = NEA
LAB 1 = EPA
LAB 2 - XR^'
LAB 4 = MOE
LAB 5 - CSI

RAW DATA LISTING
SORTED BY ELEMENT TYPE_MED AND FILTERID

ELEMENT= LEAD

TYPE_MED	LAB	FILTERID	RESULT	LABERROR	FILTERNO
6-542	0	001	65.570	3.220	001
6-542	0	001	68.800	3.220	006
6-542	0	001	66.650	3.220	052
6-542	0	001	65.570	3.220	054
6-542	0	003	25.800	1.100	037
6-542	0	003	22.570	1.100	038
6-542	0	003	21.500	1.100	048
6-542	0	003	23.650	1.100	050
6-542	0	006	51.600	2.150	012
6-542	0	006	53.750	7.500	034
6-542	0	006	52.680	2.150	045
6-542	0	006	51.600	2.150	049
6-542	1	001	62.908	3.219	041
6-542	1	001	65.744	3.363	053
6-542	1	003	25.872	1.330	020
6-542	1	003	21.053	1.086	023
6-542	1	006	50.560	2.590	025
6-542	1	006	50.729	2.598	047
6-542	2	001	56.000	1.120	002
6-542	2	001	50.000	0.600	051
6-542	2	003	24.000	0.500	018
6-542	2	003	24.000	0.500	029
6-542	2	006	50.000	1.000	005
6-542	2	006	50.000	1.000	009
6-542	4	001	47.500	1.500	094
6-542	4	001	50.500	1.500	095
6-542	4	003	18.700	1.500	098
6-542	4	003	14.000	1.500	099
6-542	4	006	19.000	1.500	096
6-542	4	006	18.000	1.500	097
7-541	0	001	212.850	10.750	004
7-541	0	001	-0.300	0.000	082
7-541	0	005	438.600	21.500	032
7-541	0	006	-0.300	0.000	063
7-541	0	009	-0.300	0.000	039
7-541	0	011	-0.300	0.000	059
7-541	0	013	-0.300	0.000	030
7-541	0	016	-0.300	0.000	070
7-541	1	002	196.580	10.031	036
7-541	1	002	-0.035	0.000	081
7-541	1	006	414.180	21.126	035
7-541	1	007	-0.039	0.000	060
7-541	1	012	0.106	0.038	073
7-541	1	014	0.247	0.046	022
7-541	1	017	-0.037	0.000	069
7-541	2	003	220.000	8.800	017
7-541	2	003	-0.200	0.000	057
7-541	2	007	440.000	8.800	010
7-541	2	008	0.200	0.030	084
7-541	2	011	-0.200	0.000	027
7-541	2	013	0.200	0.003	068
7-541	2	015	-0.200	0.000	016

LAB 0 = NEA
LAB 1 = EPA
LAB 2 = XRAL
LAB 4 = MOE
LAB 5 = CSI

RAW DATA LISTING
SORTED BY ELEMENT TYPE_MED AND FILTERID

ELEMENT= LEAD · CONTINUED

TYPE_MED	LAB	FILTERID	RESULT	LABERROR	FILTERNO
7-541	2	018	0.400	0.060	066
7-541	4	005	2.200	0.025	106
7-541	4	010	0.250	0.025	107
7-541	4	015	0.320	0.025	108
7-541	4	020	-0.050	0.000	109
7-541	5	001	220.250	11.000	
7-541	5	002	220.250	11.000	
7-541	5	003	220.250	11.000	
7-541	5	004	220.250	11.000	
7-541	5	005	440.490	22.000	
7-541	5	007	440.490	22.000	
7-541	5	008	440.490	22.000	
7-541	5	009	0.000	0.000	
7-541	5	010	0.000	0.000	
7-541	5	011	0.000	0.000	
7-541	5	012	0.000	0.000	
7-541	5	013	0.000	0.000	
7-541	5	014	0.000	.	
7-541	5	015	0.000	0.000	
7-541	5	016	0.000	0.000	
8-543	2	S1	3.900	0.060	077
8-543	2	S1	3.700	0.060	086
8-543	2	S2	0.700	0.110	058
8-543	2	S2	0.600	0.110	078
8-543	4	S1	2.370	0.025	090
8-543	4	S1	2.770	0.025	104
8-543	4	S1	4.000	.	
8-543	4	S2	0.620	0.025	105
8-543	4	S2	0.800	.	
9-541	0	BLA	-0.300	0.000	064
9-541	0	017	-0.300	0.000	031
9-541	2	BLA	-0.200	0.000	061
9-541	2	019	-0.200	0.000	007
9-542	0	BLA	-0.300	0.000	083
9-542	1	BLA	-0.044	0.000	075
9-542	2	BLA	-0.200	0.000	071
9-542	4	BLA	-0.100	0.000	103
9-543	1	BLA	-0.031	0.000	104
9-543	2	BLA	-0.200	0.000	088
9-543	4	BLA	-0.200	0.000	091

LAB 0 = NEA
LAB 1 = EP^
LAB 2 = XRAL
LAB 4 = MOE
LAB 5 = CSI

RAW DATA LISTING
SORTED BY ELEMENT TYPE_MED AND FILTERID

ELEMENT= SULPHATE

TYPE_MED	LAB	FILTERID	RESULT	LABERROR	FILTERNO
6-542	4	001	705.00	2	094
6-542	4	001	655.00	2	095
6-542	4	003	1500.00	2	098
6-542	4	003	1260.00	2	099
6-542	4	006	519.00	2	096
6-542	4	006	514.00	2	097
6-542	5	001	647.50	.	
6-542	5	001	709.50	.	
6-542	5	003	1268.50	.	
6-542	5	003	1285.00	.	
6-542	5	006	542.50	.	
6-542	5	006	602.75	.	
7-541	4	005	50.00	2	106
7-541	4	010	112.00	2	107
7-541	4	015	38.00	2	108
7-541	4	020	405.00	2	109

LAB 0 = NEA
LAB 1 = EPA
LAB 2 = XRAL
LA_ 4 = MO_
LAB 5 = CSC

MEAN VALUES FOR EACH ELEMENT

ELEMENT= ALUMINUM

TYPE_MED	LAB	FILTERID	N	RESULT	STD_RES	MIN_RES	MAX_RES	LABERROR
6-542	0	001	4	107.50	6.74	98.90	115.02	5.64
6-542	0	003	4	96.75	3.40	93.52	101.05	5.37
6-542	0	006	4	101.33	3.74	96.80	105.35	5.40
6-542	2	006	2	60.00	0.00	60.00	60.00	1.65
6-542	4	001	2	57.45	13.93	47.60	67.30	2.50
6-542	4	003	2	50.30	2.12	48.80	51.80	2.50
6-542	4	006	2	41.00	1.41	40.00	42.00	2.50
8-543	4	SI-	2	0.16	0.23	0.00	0.32	0.06

ELEMENT= SILICON

TYPE_MED	LAB	FILTERID	N	RESULT	STD_RES	MIN_RES	MAX_RES	LABERROR
6-542	0	001	4	359.59	23.64	333.25	387.00	18.00
6-542	0	003	4	285.95	10.12	276.27	299.92	17.20
6-542	0	006	4	310.13	8.36	299.90	319.28	15.58
6-542	2	006	2	200.00	0.00	200.00	200.00	10.00

ELEMENT= SULPHUR

TYPE_MED	LAB	FILTERID	N	RESULT	STD_RES	MIN_RES	MAX_RES	LABERROR
6-542	0	001	4	191.35	4.56	187.05	196.72	10.74
6-542	0	003	4	317.12	17.73	297.77	340.77	16.12
6-542	0	006	4	166.62	3.82	163.40	170.90	8.60

ELEMENT= CHLORINE

TYPE_MED	LAB	FILTERID	N	RESULT	STD_RES	MIN_RES	MAX_RES	LABERROR
6-542	0	001	4	17.73	1.39	16.12	19.35	1.07
6-542	0	003	4	33.32	4.56	27.95	37.62	1.61
6-542	0	006	4	59.66	1.39	58.05	61.28	3.20
6-542	4	001	2	32.00	1.41	31.00	33.00	0.60
6-542	4	003	2	49.00	5.66	45.00	53.00	0.60
6-542	4	006	2	80.00	0.00	80.00	80.00	0.60

ELEMENT= POTASSIUM

TYPE_MED	LAB	FILTERID	N	RESULT	STD_RES	MIN_RES	MAX_RES	LABERROR
6-542	0	001	4	43.60	2.38	40.85	46.22	2.15
6-542	0	003	4	32.52	0.54	32.25	33.32	2.15
6-542	0	006	4	72.56	1.39	70.95	74.18	4.30

LAB 0 = NEA
LAB 1 = EPA
LAB 2 = XRAL
LAB 4 = MOE

MEAN VALUES FOR EACH ELEMENT

ELEMENT= CALCIUM

TYPE_MED	LAB	FILTERID	N	RESULT	STD_RES	MIN_RES	MAX_RES	LABERROR
6-542	0	001	4	344.80	22.62	314.97	364.42	17.19
6-542	0	003	4	406.35	35.62	376.25	451.50	18.22
6-542	0	006	4	396.96	8.39	387.00	407.43	19.85
6-542	1	001	2	316.21	8.05	310.52	321.90	16.20
6-542	1	003	2	362.03	50.14	326.58	397.49	18.53
6-542	1	006	2	349.25	12.43	340.46	358.05	17.88
6-542	4	001	2	367.50	3.54	365.00	370.00	0.30
6-542	4	003	2	417.50	38.89	390.00	445.00	0.30
6-542	4	006	2	275.00	0.00	275.00	275.00	0.30
8-543	4	S1-	2	0.00	0.00	0.00	0.00	0.15

ELEMENT= TITANIUM

TYPE_MED	LAB	FILTERID	N	RESULT	STD_RES	MIN_RES	MAX_RES	LABERROR
6-542	0	001	4	10.53	0.46	9.89	10.86	0.54
6-542	0	003	4	12.33	1.09	11.18	13.76	0.54
6-542	0	006	4	10.44	0.16	10.30	10.64	0.52
6-542	1	001	2	9.02	0.23	8.86	9.18	0.56
6-542	1	003	2	8.75	0.41	8.46	9.03	0.55
6-542	1	006	2	6.55	0.36	6.30	6.81	0.46
6-542	4	001	3	1.07	0.98	0.50	2.20	0.05
6-542	4	003	2	2.50	0.42	2.20	2.80	0.05
6-542	4	006	2	0.85	0.21	0.70	1.00	0.05
8-543	4	S1-	2	0.00	0.00	0.00	0.00	0.00

ELEMENT= VANADIUM

TYPE_MED	LAB	FILTERID	N	RESULT	STD_RES	MIN_RES	MAX_RES	LABERROR
6-542	0	001	4	1.21	0.05	1.18	1.29	0.11
6-542	0	003	4	2.25	0.28	1.93	2.58	0.16
6-542	0	006	4	2.04	0.09	1.94	2.15	0.11

LAB 0 = NEA
LAB 1 = EPA
LAB 2 = XRAL
LAB 4 = MOE

ELEMENT= CHROMIUM

TYPE_MED	LAB	FILTERID	N	RESULT	STD_RES	MIN_RES	MAX_RES	LABERROR
6-542	0	001	4	2.20	0.14	2.04	2.36	0.11
6-542	0	003	4	3.90	0.41	3.44	4.41	0.16
6-542	0	006	4	5.04	0.19	4.84	5.27	0.24
6-542	1	001	2	1.45	0.20	1.31	1.59	0.15
6-542	1	003	2	1.91	0.34	1.66	2.15	0.18
6-542	1	006	2	3.00	0.17	2.88	3.12	0.23
6-542	2	001	2	0.60	0.00	0.60	0.60	0.02
6-542	2	003	2	1.35	0.07	1.30	1.40	0.03
6-542	2	006	2	1.40	0.14	1.30	1.50	0.03
6-542	4	001	2	0.55	0.35	0.30	0.80	0.01
6-542	4	003	2	2.45	0.49	2.10	2.80	0.01
6-542	4	006	2	0.47	0.05	0.44	0.51	0.01
7-541	0	001	2	0.00	0.00	0.00	0.00	0.00
7-541	2	003	2	0.03	0.04	0.00	0.06	0.00
8-543	2	S1-	2	0.90	0.14	0.80	1.00	0.05
8-543	2	S2-	2	2.40	0.00	2.40	2.40	0.05
8-543	4	S1-	2	0.58	0.01	0.58	0.59	0.01

ELEMENT= MANGANESE

TYPE_MED	LAB	FILTERID	N	RESULT	STD_RES	MIN_RES	MAX_RES	LABERROR
6-542	0	001	4	13.60	1.19	11.82	14.30	0.72
6-542	0	003	4	26.07	2.83	23.65	30.10	1.00
6-542	0	006	4	42.99	1.53	41.90	45.15	2.15
6-542	1	001	2	12.83	0.52	12.46	13.20	0.68
6-542	1	003	2	23.16	3.53	20.66	25.65	1.21
6-542	1	006	2	37.73	1.85	36.42	39.04	1.95
6-542	2	001	2	14.00	1.41	13.00	15.00	0.05
6-542	2	003	2	27.00	0.00	27.00	27.00	0.27
6-542	2	006	2	42.00	1.41	41.00	43.00	0.42
6-542	4	001	2	13.20	0.00	13.20	13.20	0.50
6-542	4	003	2	24.00	3.54	21.50	26.50	0.50
6-542	4	006	2	27.50	2.12	26.00	29.00	0.50
7-541	2	003	2	0.12	0.08	0.06	0.18	0.01
8-543	2	S1-	2	0.06	0.03	0.04	0.08	0.00
8-543	2	S2-	2	0.10	0.00	0.10	0.10	0.01
8-543	4	S1-	2	0.00	0.00	0.00	0.00	0.00

ELEMENT= IRON

TYPE_MED	LAB	FILTERID	N	RESULT	STD_RES	MIN_RES	MAX_RES	LABERROR
6-542	0	001	4	247.78	20.74	219.30	267.67	12.63
6-542	0	003	4	546.90	47.13	505.25	610.60	27.64
6-542	0	006	4	630.20	16.38	615.90	652.53	31.98
6-542	1	001	2	223.89	12.93	214.74	233.03	11.18
6-542	1	003	2	449.19	56.23	409.43	488.94	22.92
6-542	1	006	2	517.85	18.87	504.51	531.19	26.42
6-542	4	001	2	125.30	88.67	62.60	188.00	1.50
6-542	4	003	2	435.50	64.35	390.00	481.00	1.50
6-542	4	006	2	129.50	34.65	105.00	154.00	1.50
7-541	1	002	2	0.23	0.01	0.22	0.23	0.06
8-543	4	S1-	2	0.11	0.04	0.08	0.14	0.02

ELEMENT= NICKEL

TYPE_MED	LAB	FILTERID	N	RESULT	STD_RES	MIN_RES	MAX_RES	LABERROR
6-542	0	001	3	0.82	0.09	0.76	0.92	0.07
6-542	0	003	4	1.20	0.16	1.01	1.34	0.54
6-542	0	006	4	0.85	0.14	0.72	1.05	0.07

LAB 0 = NEA
LA_ 1 = EP..
LAB 2 = XRAL
LAB 4 = MOE

MEAN VALUES FOR EACH ELEMENT

ELEMENT= COPPER

TYPE_MED	LAB	FILTERID	N	RESULT	STD_RES	MIN_RES	MAX_RES	LABERROR
6-542	0	001	4	67.99	14.03	56.97	88.15	3.49
6-542	0	003	4	40.3	12.8	26.7	55.9	2.16
6-542	0	006	4	27.42	5.57	23.65	35.47	1.35

ELEMENT= ZINC

TYPE_MED	LAB	FILTERID	N	RESULT	STD_RES	MIN_RES	MAX_RES	LABERROR
6-542	0	001	4	24.72	0.88	23.65	25.80	1.07
6-542	0	003	4	23.65	1.76	21.50	25.80	1.10
6-542	0	006	4	25.26	1.08	24.70	26.88	1.08
6-542	1	001	2	18.64	1.08	17.88	19.41	0.96
6-542	1	003	2	17.75	3.01	15.62	19.88	0.92
6-542	1	006	2	19.40	0.03	19.38	19.42	1.00
6-542	2	001	2	20.50	2.12	19.00	22.00	3.00
6-542	2	003	2	21.00	0.00	21.00	21.00	0.31
6-542	2	006	2	21.00	1.41	20.00	22.00	0.30
6-542	4	001	2	20.60	0.57	20.20	21.00	0.05
6-542	4	003	2	19.65	1.63	18.50	20.80	0.05
6-542	4	006	2	15.50	2.12	14.00	17.00	0.05
7-541	1	002	2	0.17	0.24	0.00	0.34	0.09
7-541	2	003	2	0.40	0.14	0.30	0.50	0.06
8-543	2	S1-	2	0.30	0.00	0.30	0.30	0.05
8-543	2	S2-	2	0.25	0.07	0.20	0.30	0.04
8-543	4	S1-	2	0.00	0.00	0.00	0.00	0.00

ELEMENT= ARSENIC

TYPE_MED	LAB	FILTERID	N	RESULT	STD_RES	MIN_RES	MAX_RES	LABERROR
6-542	0	001	4	0.00	0.00	0.00	0.00	0.00
6-542	0	003	4	0.00	0.00	0.00	0.00	0.00
6-542	0	006	4	0.00	0.00	0.00	0.00	0.00
6-542	1	001	2	0.00	0.00	0.00	0.00	0.00
6-542	1	003	2	0.00	0.00	0.00	0.00	0.00
6-542	1	006	2	0.00	0.00	0.00	0.00	0.00
6-542	2	001	2	0.10	0.00	0.10	0.10	0.02
6-542	2	003	2	0.40	0.00	0.40	0.40	0.01
6-542	2	006	2	0.56	0.14	0.46	0.66	0.10
6-542	4	001	2	0.06	0.02	0.05	0.08	0.03
6-542	4	003	2	0.23	0.03	0.21	0.25	0.03
7-541	0	001	2	4.46	6.31	0.00	8.92	0.70
7-541	2	003	2	1.98	2.72	0.06	3.90	0.03
8-543	2	S1-	2	0.06	0.00	0.06	0.06	0.11
8-543	2	S2-	2	0.16	0.00	0.16	0.16	0.11
8-543	4	S1-	2	0.17	0.06	0.13	0.22	0.03

LAB 0 = NEA
LAB 1 = EPA
LAB 2 = XRAL
LAB 4 = MOE

MEAN VALUES FOR EACH ELEMENT

ELEMENT= SELENIUM

TYPE_MED	LAB	FILTERID	N	RESULT	STD_RES	MIN_RES	MAX_RES	LABERROR
6-542	0	001	4	0.00	0.00	0.00	0.00	0.00
6-542	0	003	4	0.00	0.00	0.00	0.00	0.00
6-542	0	006	4	0.00	0.00	0.00	0.00	0.00

ELEMENT= BROMINE

TYPE_MED	LAB	FILTERID	N	RESULT	STD_RES	MIN_RES	MAX_RES	LABERROR
6-542	0	001	4	14.08	0.77	13.33	14.94	0.55
6-542	0	003	4	3.36	0.24	3.12	3.65	0.21
6-542	0	006	4	12.37	0.18	12.15	12.58	0.63
6-542	1	001	2	12.90	0.55	12.51	13.29	0.66
6-542	1	003	2	2.53	0.29	2.32	2.74	0.14
6-542	1	006	2	10.60	0.00	10.60	10.60	0.55
7-541	1	002	2	1.72	2.34	0.07	3.37	0.11

ELEMENT= CADMIUM

TYPE_MED	LAB	FILTERID	N	RESULT	STD_RES	MIN_RES	MAX_RES	LABERROR
6-542	0	001	4	0.00	0.00	0.00	0.00	0.00
6-542	0	003	4	0.00	0.00	0.00	0.00	0.00
6-542	0	006	4	3.28	0.41	2.69	3.55	0.64
6-542	1	001	2	0.00	0.00	0.00	0.00	0.00
6-542	1	003	2	0.12	0.03	0.10	0.13	0.10
6-542	1	006	2	0.37	0.01	0.37	0.38	0.11
6-542	2	001	2	0.00	0.00	0.00	0.00	0.00
6-542	2	003	2	0.10	0.14	0.00	0.20	0.00
6-542	2	006	2	0.10	0.14	0.00	0.20	0.00
6-542	4	001	2	0.13	0.01	0.13	0.14	0.00
6-542	4	003	2	0.21	0.13	0.12	0.30	0.00
6-542	4	006	2	0.13	0.04	0.11	0.16	0.00
7-541	0	001	2	1.13	1.60	0.00	2.26	0.32
7-541	2	003	2	1.80	2.55	0.00	3.60	0.13
8-543	2	S1-	2	1.50	0.00	1.50	1.50	0.10
8-543	2	S2-	2	0.25	0.07	0.20	0.30	0.09
8-543	4	S1-	2	0.68	0.20	0.54	0.82	0.00

ELEMENT= BARIUM

TYPE_MED	LAB	FILTERID	N	RESULT	STD_RES	MIN_RES	MAX_RES	LABERROR
6-542	0	001	4	0.00	0.00	0.00	0.00	0.00
6-542	0	003	4	0.00	0.00	0.00	0.00	0.00
6-542	0	006	4	0.00	0.00	0.00	0.00	0.00

LAB 0 = NEA
LAB 1 = EPA
LAB 2 = XRAL
LAB 4 = MOE

MEAN VALUES FOR EACH ELEMENT

ELEMENT= LEAD

TYPE_MED	LAB	FILTERID	N	RESULT	STD_RES	MIN_RES	MAX_RES	LABERROR
6-542	0	001	4	66.65	1.52	65.57	68.80	3.22
6-542	0	003	4	23.38	1.84	21.50	25.80	1.10
6-542	0	006	4	52.41	1.03	51.60	53.75	3.49
6-542	1	001	2	64.33	2.01	62.91	65.74	3.29
6-542	1	003	2	23.46	3.41	21.05	25.87	1.21
6-542	1	006	2	50.64	0.12	50.56	50.73	2.59
6-542	2	001	2	53.00	4.24	50.00	56.00	0.86
6-542	2	003	2	24.00	0.00	24.00	24.00	0.50
6-542	2	006	2	50.00	0.00	50.00	50.00	1.00
6-542	4	001	2	49.00	2.12	47.50	50.50	1.50
6-542	4	003	2	16.35	3.32	14.00	18.70	1.50
6-542	4	006	2	18.50	0.71	18.00	19.00	1.50
7-541	0	001	2	106.42	150.51	0.00	212.85	5.38
7-541	1	002	2	98.29	139.00	0.00	196.58	5.02
7-541	2	003	2	110.00	155.56	0.00	220.00	4.40
8-543	2	S1-	2	3.80	0.14	3.70	3.90	0.06
8-543	2	S2-	2	0.65	0.07	0.60	0.70	0.11
8-543	4	S1-	2	2.57	0.28	2.37	2.77	0.02

LAB 0 = NEA
LAB 1 = EPA
LAB 2 = XRAL
LAB 4 = MOE

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ELEMENT= SULPHATE

TYPE_MED	LAB	FILTERID	N	RESULT	STD_RES	MIN_RES	MAX_RES	LABERROR
6-542	4	001	2	680.00	35.36	655.00	705.00	2.00
6-542	4	003	2	1380	169.71	1260	1500	2.00
6-542	4	006	2	516.50	3.54	514.00	519.00	2.00
6-542	5	001	2	678.50	43.84	647.50	709.50	.
6-542	5	003	2	1276.8	11.67	1268.5	1285	.
6-542	5	006	2	572.63	42.60	542.50	602.75	.

LAB 0 = NEA
LAB 1 = EPA
LAB 2 = XRAL
LAB 4 = MOE
LAB 5 = CSC

ANALYTICAL DETERMINATIONS FOR BLANKS

ELEMENT	TYPE_MED	LAB	FILTERNO	RESULT	LABERROR
ALUMINUM	9-541	2	061	20.0000	1.20000
	9-542	0	083	-1.0700	.
SILICON	9-541	2	061	120.000	6
	9-542	0	083	-0.540	0
SULPHUR	9-542	0	083	-2.15000	0
CHLORINE	9-541	0	064	(8.60000)	(2.15000)
	9-542	0	083	-1.18000	0.00000
	9-542	4	103	-1.00000	0.00000
POTASSIUM	9-541	0	064	(-0.400000)	0
	9-542	0	083	(-0.210000)	0
CALCIUM	9-541	0	064	(-0.04000)	0.000000
	9-542	0	083	0.64000	0.110000
	9-542	1	075	-0.28400	0.000000
	9-543	1	104	3.10000	0.299000
TITANIUM	9-541	0	064	-0.100000	0.000000
	9-542	0	083	-0.110000	0.000000
	9-542	1	075	-0.168000	0.000000
	9-542	4	103	-0.100000	0.000000
	9-543	1	104	0.158000	0.126000
VANADIUM	9-541	0	064	-0.0800000	0
	9-542	0	083	-0.0900000	0
CHROMIUM	9-541	0	064	-0.080000	0.0000000
	9-541	2	061	-0.020000	0.0000000
	9-542	0	083	-0.060000	0.0000000
	9-542	1	075	-0.080000	0.0000000
	9-542	2	071	0.160000	.
	9-542	4	103	-0.100000	0.0000000
	9-543	1	104	0.115000	0.0620000
	9-543	2	088	0.400000	0.0500000
	9-543	4	091	-0.100000	0.0000000
MANGANESE	9-541	0	064	-0.090000	0.0000000
	9-541	2	061	-0.040000	0.0000000
	9-542	0	083	0.090000	0.0500000
	9-542	1	075	-0.070000	0.0000000
	9-542	2	071	-0.040000	0.0000000
	9-542	4	103	-0.100000	0.0000000
	9-543	1	104	-0.048000	0.0000000
	9-543	2	088	0.080000	0.0060000
IRON	9-542	0	083	0.25000	0.090000
	9-542	1	075	2.98200	0.185000
	9-542	4	103	-0.10000	0.000000
	9-543	1	104	-0.05500	0.000000

LAB 0 = NEA
LAB 1 = EPA
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LAB 5 = CSC

Note: All NEA 'blanks' are corrected for typical values of background for that filter material.

ANALYTICAL DETERMINATIONS FOR BLANKS

ELEMENT	TYPE_MED	LAB	FILTERNO	RESULT	LABERROR
NICKEL	9-541	0	064	-0.0500000	0
	9-542	0	083	-0.0500000	0
COPPER	9-541	0	064	-0.0500000	0
ZINC	9-541	0	064	0.200000	0.030000
	9-541	2	061	0.200000	0.080000
	9-542	0	083	-0.030000	0.000000
	9-542	1	075	-0.050000	0.000000
	9-542	2	071	0.300000	•
	9-542	4	103	-0.100000	0.000000
	9-543	1	104	0.190000	0.034700
	9-543	2	088	0.600000	0.100000
ARSENIC	9-541	0	064	-0.100000	0
	9-541	2	061	0.060000	0
	9-542	0	083	-0.100000	0
	9-542	1	075	-0.029000	0
	9-542	2	071	0.100000	•
	9-543	1	104	-0.020000	0
	9-543	2	088	-0.020000	0
	9-543	4	091	-0.100000	0
SELENIUM	9-541	0	064	-0.100000	0
	9-542	0	083	-0.100000	0
BROMINE	9-541	0	064	-0.110000	0
	9-542	0	083	-0.100000	0
	9-542	1	075	-0.020000	0
	9-543	1	104	-0.015000	0
CADMIUM	9-541	0	064	-0.400000	0
	9-541	2	061	-0.200000	0
	9-542	0	083	-0.400000	0
	9-542	1	075	-0.090000	0
	9-542	2	071	-0.200000	0
	9-542	4	103	-0.100000	0
	9-543	1	104	-0.062000	0
	9-543	2	088	-0.200000	0
	9-543	4	091	-0.200000	0
BARIUM	9-541	0	064	-4.00000	0
	9-542	0	083	-0.40000	0
LEAD	9-541	0	064	-0.300000	0
	9-541	2	061	-0.200000	0
	9-542	0	083	-0.300000	0
	9-542	1	075	-0.044000	0
	9-542	2	071	-0.200000	0
	9-542	4	103	-0.100000	0
	9-543	1	104	-0.031000	0
	9-543	2	088	-0.200000	0
	9-543	4	091	-0.200000	0

LAB 0 = NEA
LAB 1 = EPA
LAB 2 = XRAL
LAB 4 = MOE
LAB 5 = CSC