QUALITY ASSURANCE PROJECT PLAN (QAPjP)
and QA Report for Pacific 2001

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1. Principal Investigator

Dr. Michael Mozurkewich
Centre for Atmospheric Chemistry
York University
[**Name, affiliation and address of the Principal Investigator responsible for the measurements and data described herein**]

2. Team Members

[**Names and affiliations of other scientific and technical staff involved with the Principal Investigator (if desired)**]

Yayne-abeba Aklilu

3. Measurement Program

[**List the measurement instruments and species categories involved in this part of the project.** For example:

a) Hivol measurements of trace metals,
b) Moudi sampling of size selective particle composition
c) Low volume filter measurements of inorganic ions
d) Denuder measurements of precursor gases
e) Tropospheric ozone measurements]

Measurement of Hygroscopic properties of aerosol using a Tandem Differential Mobility Analyzer (TDMA)

4. Measurement Species and Units

Hygroscopic growth of particulate matter. Reported data are the ratio of wet diameter to dry diameter, the fraction of particles in the hygroscopic and non-hygroscopic modes and ratio of the measured to expected mobility distribution width (see section 11.6).

5. Representative Size Range (if PM)

Particle dry diameter of 80 and 114nm

6. Measurement Platform (surface, airborne)

      Surface - sample line inlet was 3m above ground on trailer

7. Measurement Sites (surface only)

August 7th -11th

8. Measurement Objective(s)

To investigate the hygroscopic properties of aerosol impacted by anthropogenic and biogenic compounds

9. Measurement Details

               The sample aerosol was dried to a relative humidity of about 15% and a

monodispersed fraction was selected using a differential mobility analyzer (DMA 1). This was then humidified to various relative humidities (50-85%) and the resulting size distribution was scanned with a second DMA (DMA 2).
Percent relative humidity and temperature at DMA 1 and DMA 2 are measured using Vaisala Humitter 50Y sensor
Aerosol fraction reaching DMA 2 was determined from concentration of particles in each peak divided by the concentration exiting DMA 1.

9.1. Field Measurements

9.1.1. Measurement Principle

[**List the main measurement components and briefly describe the measurement principles,** e.g., Ozone: U-V absorption]
Change in particle diameter due to an increase in relative humidity

9.1.2. Instrumentation (Manufacturer/Model)

[**Briefly describe the instrumentation, including the types of instruments, media/ coatings, Manufacturer's names and model numbers. Provide a photo or diagram if possible**.   For example:
Denuder System: This is a double denuder system with a PM2.5 URG Model AAA cyclone at the inlet.   The cyclone is followed by a sodium carbonate annular denuder (diameter = YYY and length = ZZZ) for HNO_3 and SO_2, and a citric acid annular denuder for NH_3. The denuders are followed by a 2-stage filter pack containing a Gelman Zeflour Teflon filter for collecting particles and a Gelman Nylasorb nylon filter for collecting volatilized HNO_3. The denuder/filter pack system is located inside a box mounted vertically on the top of a trailer.]

- Electrostatic Classifier DMA (TSI 3071 as DMA1 & TSI 3079 as DMA 2)
  This instrument classifies particles according to electrical mobility.
- Condensation nucleus counter CNC (TSI 7610)
  The CNC is used to count particles
- Viasala Humitter 50Y relative humidity and temperature sensor
  This instrument was used to measure percent relative humidity and temperature at the excess air outlet of DMA 1 and DMA 2.
- Mass flow controllers (MKS 1259C) and read out (MKS 247C)
  Mass flow controllers are part of closed loop sheath air circulation, and is used to control the sheath air flow in the two DMAs.
- Pressure transducer (MKS 223B) and meter (MKS PDR-D-1)
  Used to measure the pressure drop across a laminar flow element to monitor aerosol outlet flow of the DMA 2 (sample 2)
- Pressure transducer (Omega XP277) and meter (Omega DP25-E-A)
  Used to measure the pressure drop across a laminar flow element to monitor the part of DMA 1 flow that is directed to CNC (sample 1)
- Multi tube Nafion Dryer (Perma pure inc. model PD -625-24SS series)
  Used to dry sample before entering DMA 1
- Nafion Dryer (Perma pure inc. model MD 110 24 F)
  Used as equilibration chamber, to equilibrate the relative humidity of DMA 2 sheath flow and monodispersed sample flow
- Nafion humidifier (Perma pure inc. model HM 070 24P)
  Used to humidify DMA 2 sheath flow
- Diaphram Pumps (Gast model DOA-P10A-AA and DAA-V174-EB)

9.1.3. Flow System

[**Briefly describe the flow system associated with each measurement component. Include information on the inlet height, inlet type, model and cut-point, configuration of instruments, flow measurement/control method, pump, material and length of flow lines). Provide a photo or diagram if**

possible. For example:
Denuder System: The flow inlet is a URG PM2.5 cyclone followed by the double denuder/filter pack system described above. 1 meter of Teflon tubing connects the downstream end of the filter pack to a Hastings Model AAA flow controller at a set point of 16 lpm (at 0 degrees C and 1 atmosphere). The flow controller is connected to a diaphragm pump that exhausts to the atmosphere.]
Air is sampled using ¾" stainless steel tubing mounted on the side of the trailer (3m above ground), then directed to the instrument though ¾" stainless steal tubing. The flow through the inlet was set at 1.2 lpm (liters per min)
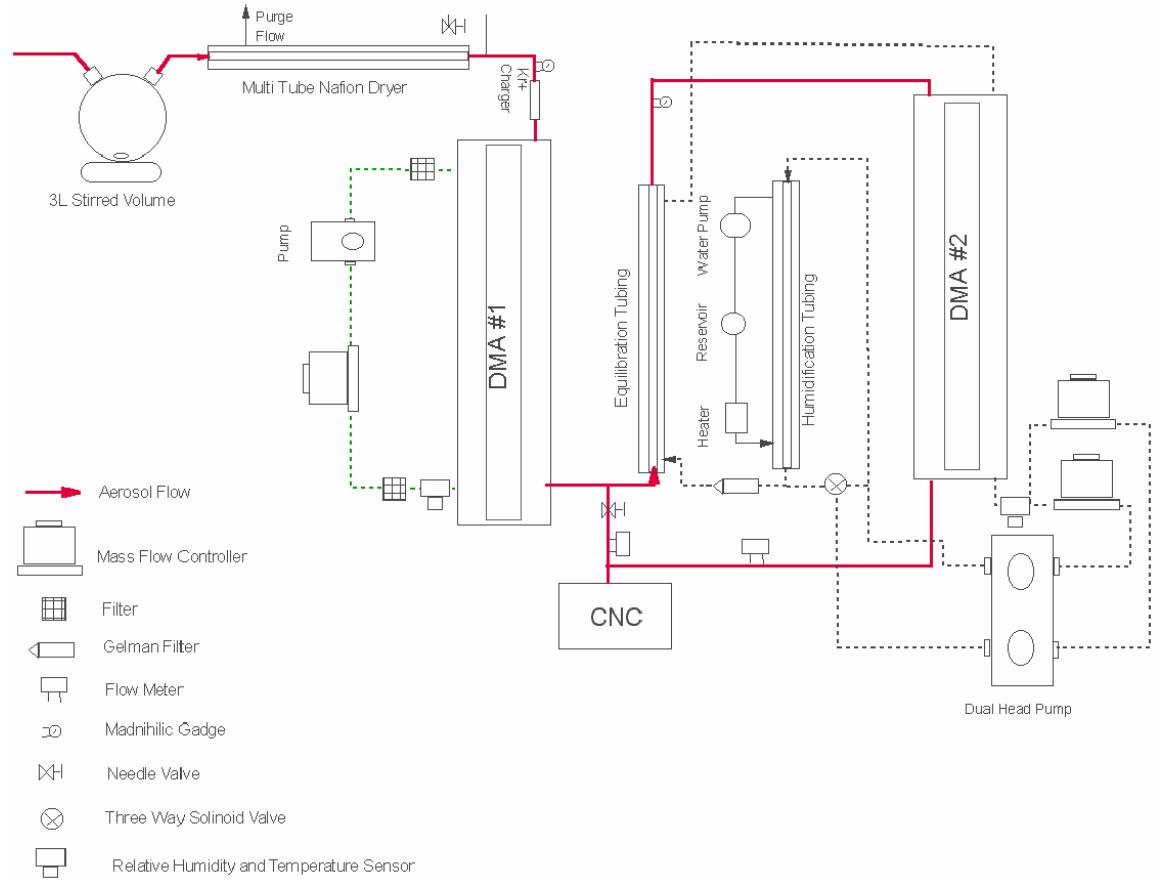
Figure 1: Tandem Mobility Analyzer used in measuring hygroscopic growth of particle

9.1.4. Inlet Height Above Ground (if surface)
[**Indicate the anticipated height of all sampling inlets above ground level**.
For example:
Hivol: 2 m above ground level on top of trailer
Moudi sampler: 1 m above ground level on wooden stand
Denuder System: 2 m above ground level on top of trailer]
3m above ground level mounted on the side of a trailer

9.1.5. Nominal Flow Rate
[**Indicate the nominal flow rate for each measurement component**]
Sheath flow (in both DMA1 and DMA 2):10.57 alpm (actual liters per minute)
Excess flow (in both DMA1 and DMA 2): 10.50 alpm
Aerosol flow in to DMA 1: 1.2 alpm
Aerosol flow through equilibration chamber and into DMA 2: 0.98 alpm
Sample 1 flow (from DMA 1 to CNC): 0.30 alpm

Sample 2 flow (from DMA 2 to CNC): 1.07 alpm
Total aerosol flow (into CNC): 1.34 alpm

9.1.6. Flow Measurement/Control

[**Indicate how the flow is measured and/or controlled**, e.g., mass flow controller, mass flow meter, critical orifice, etc.]

Aerosol flows: manual control with valves and measured pressure drop across a laminar flow elements using pressure transducers or magnehilic gages.
Sheath flow: controlled using mass flow controller and monitored with mass flow meter.

9.1.7. Flow Temperature and Pressure

[**Specify the temperature and pressure conditions associated with the flow measurements**, e.g., 0 or 25 degrees C and 1 atmosphere or ambient temperature and pressure]

Ambient Temperature
DMA running in under-pressure mode, pressure slightly below ambient.

9.1.8. Sampling Times/Period/Frequency

[**State the anticipated sampling times/periods and frequency. For integrated measurements such as filters, denuders, flasks, etc., include the planned nominal start and end times, elapsed sampling periods and number of samples to be collected**. For example:

Denuder system: 4 samples to be collected per day, each for 6 hours from 0000-0600, 0600-1200, 1200-1800 and 1800-2400 LST. For continuous monitoring methods, indicate the data logging frequency and the reported integration times, e.g., 1 second values averaged to 5 minute values.]

Data was recorded every 2 sec
Each scan was about 3.3 min long (about 100 data points for each scan)

9.1.9. Sampling Methods

[**Describe the standard operating procedures for collecting samples including sample preparation, sample storage, sample collection and handling, sample preservation, sample identification and sample custody**]

Documentation of flows entered in to log book
Data stored on computer hard drive and zip disc

9.1.10.   Filter Type/Coating Type/Reagent Type

[**Indicate the types of filters, impregnation compounds, coatings, and/or reagents of relevance to the measurement methods**]

NA

9.1.11.   Planned Changes to Instruments or Methods During Study

[**Briefly describe any expected major changes to the site (e.g., construction in the vicinity), the instrumentation or the measurement methods during the study which may affect the quality of the data or the interpretation of the results**]

NA

9.2. Laboratory Measurements (If Applicable)

NA

9.2.1. Laboratory Name and Address

[**State the name and address of the laboratory**]

9.2.2. Analytical Method(s)

[**For each measurement component that involves chemical analysis,**

describe the analytical measurement technique to be used. Use a table for multiple species. For example:

Low volume filter pack $SO_4^=$ ion chromatography
          NO_3^- ion chromatography
          Ca: AAS

Hivol filters: PAH: GC/FID
          Alkanes: GC/MS]

9.2.3. Sample Extraction or Work-up
[**Describe extraction or work-up methods that will be used on the samples (where applicable). Indicate the location/laboratory where the extraction or work up will take place, e.g., field laboratory**
For example:
Low volume filter pack $SO_4^=$ extraction in deionized water
          NO_3^- extraction in deionized water
          Ca: acid digestion

Hivol filters: PAH: solvent extraction
          Alkanes: thermal desorption]

9.2.4. Analytical Detection Limits
[**State the anticipated analytical detection limits and the methods used to quantify the detection limits -- for all species being analyzed. Use a table for multiple species. References to published materials are acceptable but still give a summary**]

10. Quality Assurance/Quality Control
[**Note: the purpose of this section is to summarize the main quality assurance/quality control procedures that will be used to ensure high quality measurements in the field and laboratory**]

10.1. Field Quality Assurance/Quality Control
10.1.1. Traceability
[**State the sources and methods that will be used to ensure traceability of the measurement methods (where applicable)**. For example, give the name/number of standard reference materials, primary gas standards, primary reference instruments, etc., e.g., flow rates are referenced to an MSC MKS primary flow standard and ozone measurement is referenced to the OME/NIST primary photometer.]
NA
10.1.2. Calibration
[**Describe the planned calibration methods (e.g., comparison against standard gases, serial dilutions, etc.) and the frequency -- for all measurement components**. Indicate the source of calibration standards and how the calibration data will be applied to the data set.]
All calibrations of flow meters were done in the laboratory shortly before the field study. In addition the TDMA was calibrated using atomizer generated particles and the growth factors were compared to theoretical values. Percent differences between experimental and theoretical values were about 3 %.

10.1.3. Zeros and spans
[**Describe the planned frequency and method of carrying out zero/span determinations for continuous measurements**]
Zeros of flow meters and gauges were checked daily. Offsets if any were recorded and zeros reset.

10.1.4. Blanks
[**Specify the number, frequency and type (e.g., dynamic/static/shipping) of field blanks to be collected**]
NA

10.1.5. Field Quality Control procedures
[**Briefly describe the field QC procedures that will be used in the measurement program to ensure high quality sampling**. For example, For filter pack sampling: disposable gloves will be worn when loading/unloading filters; filters will be loaded/unloaded in a clean room; filters will be inspected for holes when loaded and unloaded in the lab and field; the filter pack assembly will be checked for tightness to avoid leaks; the individual filter packs will be given colour-coded fittings to ensure they are loaded in the correct locations on the sampling head; all filter packs will be double bagged before and after exposure; etc.]
NA

10.1.6. Precision determination
[**Indicate whether/how precision will be determined for the field measurements**, e.g., duplicate instruments will be run simultaneously for 2 days to determine precision. **References to published materials are acceptable but still give a summary**]

10.1.7. Comparison with other measurements
[**Indicate whether/how comparability with other methods will be established**, e.g., The PM2.5 Hivol will be collocated within 2 meters of the PM2.5 low volume filter pack system; the data from the two types of instruments will be cross-checked for comparability of $SO_4^=$ concentrations. **References to published materials are acceptable but still give a summary**]
Growth factor measured at Golden Ears Park was compared with another TDMA (Colorado State University) located at the same site. Preliminary comparison in the field indicates that agreement was excellent (see section 14.1.3).

10.1.8. Inspections and Audits
[**Describe how/when inspections and independent audits will be done.**]
NA

10.2. Laboratory Quality Assurance/Quality Control
10.2.1. Traceability
[**Specify the standard reference materials (SRMs) to which the laboratory measurements are traceable. Include the frequency of SRM analysis.** **References to published materials are acceptable but still give a summary**]
NA

10.2.2. Calibration procedures
[**Provide details of the analytical calibration procedures,** e.g., number of calibration standards (internal or external) per batch, frequency of calibrations, range of calibration standards, source of calibration reagents, salts or materials. **References to published materials are acceptable but still give a summary**]
NA

10.2.3. Blanks

[**Indicate the type and frequency of laboratory blanks,** e.g., reagent blanks, DI water blanks, glassware blanks, unused filter blanks]

NA

10.2.4. Other lab QC

[**Describe laboratory QC methods used to ensure high quality analyses,** e.g., the use of calibration check solutions, matrix spike recoveries, blinds, quality control charts]

NA

10.2.5. Precision determination

[**Indicate the level of analytical precision and describe the procedures to be used to calculate applicable statistics**, e.g., Analytical precision = ± 5%. Calculated as the standard deviation of between-run duplicate sample analyses (run on every 10th sample) divided by the mean concentration of the duplicate samples. **References to published materials are acceptable but still give a summary**]

10.2.6. Comparison with other methods

[**Indicate whether the laboratory analyses will be tested for comparability to other analytical techniques**, e.g., 10 filters will be split and analyzed by AAS and INAA to determine the comparability of the analytical measurements]

NA

10.2.7. Audits

[**Specify whether the laboratory will undergo an independent audit. Name the auditor**]

NA

11. Data Management and Quality Control

11.1. Raw Data Recording

[**Describe the data recording methods and frequency,** e.g., flow recorded by manually logging the pressure differential at the beginning and end of the sampling periods; ozone recorded every second on Campbell Scientific CR23X Data Logger and a tape recorder and chart recorder used for backup.]

Data is recorded using 16 Bit National Instruments Data Acquisition Board (model PCI-6052E) and a PC. IGOR pro was used to manage the data acquisition. Data is recorded every 2 sec. Particle count and DMA 2 voltage is recorded and stored as 2 sec average. Relative humidity, temperature, flow rates and DMA 1 voltage is stored as 3.3 min average.

11.2. Final Data Reporting

[**Specify the planned data reporting interval for the final data**, e.g., 1 second raw data will be recorded and reported; 1 second data will be collected but reported as 5, 15 and 30 minute averages]

Final data will be reported as 3.3 min average (period of one DMA 2 scan).

11.3. Data Quality Control and Validation

[**Briefly describe the data quality control and validation procedures that will be used to finalize the measurement data.** E.g., All reported data values will be flagged as either Valid (V) or Invalid (I). Raw data will inspected and all instrument and power failures, zero, span and calibration periods will be flagged as invalid. Data will be zero-corrected and calibration factors will be applied every 24 hours. If spans exceed the expected results by ±25%, the data for the span period will be invalidated. Percentage changes exceeding ±75% from one recorded value to the next will be investigated.]

All reported data will be flagged as either Valid or Invalid (see section 11.4).

11.4. Validity Flags

[**Specify the flags that will be used to identify valid and invalid data. The flags should be detailed enough to identify the reasons that you validated or invalidated the data. Less than Detection Limit Values should be clearly identified with the flag V1.** . The following NARSTO flags can be used if you prefer not to produce your own:

V0   Valid value
V1   Valid value but comprised wholly or partially of below-MDL data
V2   Valid estimated value
V3   Valid interpolated value
V4   Valid value despite failing to meet some QC or statistical criteria
V5   Valid value but qualified because of possible contamination (e.g., pollution source, laboratory contamination source)
V6   Valid value but qualified due to non-standard sampling conditions (e.g., instrument malfunction, sample handling)
M1   Missing value because no value is available
M2   Missing value because invalidated by data originator
H1   Historical data that have not been assessed or validated]

V0=Valid Value
V4= Relative humidity variability during DMA2 scan is greater than 3% but less than 5%
V6= Relative humidity variability during DMA2 scan greater than 5%
M1= Missing value because no data collected
M2= Invalid Data, Data too noisy to process

11.5. Below Method Detection Limit Values

[**Where applicable, state the anticipated Method Detection Limit for each measured species and describe the statistical method used for its determination. Indicate how you plan to identify the stated below-MDL values and flags in your data set. The use of zero or negative values is discouraged; the use of the below-MDL value with a V1 flag is encouraged**]
NA

11.6. Derived Parameters

[**List any derived parameters that will be calculated from the measurement data and explain the method of calculation,** e.g., non-sea-salt sulphate from measured sulphate and sodium measurements, black carbon from light extinction measurements]. **Specify any factors that may impact on the interpretation of the final data,** e.g., the TEOM PM2.5 mass concentration data include a factory-set +3 μg m^{-3} offset. **References to published materials are acceptable but still give a summary**]

Particle diameter growth factor (GD)
The ratio of particle diameter at relative humidity equal to that in DMA 2 (humid diameter) to particle diameter at relative humidity equal to that of DMA1 (dry diameter)

More or less hygroscopic fraction
At higher relative humidity (>70%), the distribution measured using TDMA revealed bimodal or unimodal distributions. In the case of unimodal distribution particle have similar composition and therefore grow to the same size at a given relative humidity. Bimodal distribution indicates that some particles

are more hygroscopic than others. The more hygroscopic group of particles have the ability to take up more water and grow to larger sizes than the less hygroscopic group. The fraction of more and less hygroscopic particle reaching DMA 2 is determined by a fitting procedure. Due to uncertainties in flows and fitting procedure, fractional amount reaching DMA 2 may be greater than 1.

Organic fraction

The organic fraction of dry particle may be calculated using the equation below,

$$\varepsilon_{org} = \frac{\left(GF_{mixed}^{\ 3} - GF_{ing}^{\ 3}\right)}{\left(GF_{org}^{\ 3} - GF_{ing}^{\ 3}\right)} \tag{1}$$

where ε_{org} is the Organic fraction, GF_{mixed} is growth factor observed and GF_{org} and GF_{inorg} are the growth factors for pure organic and pure inorganic particles

GF_{inorg} can be calculated using the following equation

$$GF_{ing} = \left[\left(\frac{\rho_s}{\rho_{aq}}\right) \times \left(\frac{100}{w\%}\right)\right]^{\frac{1}{3}} \tag{2}$$

where

ρ_S = density of crystalline salt

ρ_{aq} = density of aqueous salt solution

$w\%$ = Solute weight percent ((weight of salt/weight of water)X 100)

The relationship between $w\%$, ρ_{aq} and relative humidity is determined using polynomial expressions found in Tang and Munkelwitz (1994)

GF_{org} is determined by fitting the less hygroscopic particles.

$$GF_{org} = \left(1 - \frac{b}{RH/100}\right)^{\frac{1}{3}} \tag{3}$$

Where b=0.07

Spread factor

Ratio of the measured to expected mobility distribution width (Stolzenburg and McMurry, 1988). Using 95% confidence interval, upper and lower limits were defined around the mean spread factor when the relative humidity in DMA 1 and 2 were within 1% of each other.
95% confidence Interval = 1.42 +/- 0.05

A spread factor greater than 1.47 indicates that the particles probably have a range of compositions and growth factors.

11.7. Explanation of Zero or Negative Data

[If zero or negative values will appear in the data set, explain why they are used and what they mean. The use of zero values is discouraged; the use of Less Than Detection Limit values, with the flag V1, is encouraged.]

NA

12. Data Quality Objectives (Pre-Study)

[Note: The purpose of this section is to document the expected data quality objectives (DQOs) based on a fore-knowledge of the measurement methods]

12.1. Accuracy

[***Definition: Accuracy is defined as the degree of agreement of a measurement with an accepted reference or true value.*** **State the *Accuracy* objective for each measurement type. Indicate how the accuracy will be quantitatively determined**. For example:
Ozone: Accuracy Objective = $\pm$ 3% at 80 ppb. To be calculated as the median difference between NIST primary photometer readings and calibrated values from the field ozone monitors at/near 80 ppb. The calibrations against the NIST photometer will be done immediately before and after the field program.]

12.2. Precision

[***Definition: Precision is a measure of mutual agreement among individual measurements of a property, usually under prescribed similar conditions.*** **State the *Precision* objective for each measurement type. Indicate how the precision will be determined**. For example, Ozone: Precision Objective = $\pm$ 5% at 80 ppb. To be determined by: (1) giving each ozone monitor a known concentration at/near 80 ppb (from a calibrated TECO 49PS Calibrator) on 10 separate days; (b) determining for each monitor, the standard deviation of the 10 measurement values (3) dividing the standard deviation by the mean concentration from the 10 different days.]

12.3. Comparability

[***Definition: Comparability is the confidence with which one data set may be compared to another.*** **State the *Comparability* objective for each measurement type**. For example, Low volume open face filter pack measurements of $SO_4^=$ will be comparable to Hivol PM2.5 measurements to within $\pm$ 15% based on previous measurements cited in Atmos. Envir. 26:4, 1993.]

NA

12.4. Representativeness

[***Definition: Representativeness is the degree to which data accurately and precisely represent a characteristic of a population or variations at a sampling point.*** **Provide a statement of the anticipated *Representativeness* of the measurements in terms of the land use, meteorological and temporal conditions which they represent.** Each of the measurement sites will have specific goals and the measurements will be a representation of the site and its meteorological and temporal conditions. For example:

- The measurements at the Cassiar Tunnel will be representative of the emission from light duty traffic.
- The measurements at the Golden Ears Park will be representative of the conditions under which biogenic emissions are dominant and the biogenic

particles are generated with limited anthropogenic pollutants.

- The measurements at the Slocan Park site will be representative of the typical urban/suburban pollution mix that is not processed photochemically.
- The measurements at the Langley site will be representative of processed air pollution in which secondary pollutants, such as ozone and secondary particulate matter, will have formed.
- The measurements at the Sumas Mountain site will be representative of processed air pollution with significant influence from biogenic and ammonia sources. They will also be representative of the free boundary layer air and thus representative of the processes affecting the evolution of pollutants throughout the diurnal cycle. They will also capture the visibility reduction at the eastern end of the Lower Fraser Valley.

Particles sampled at the Golden Ears Park will be representative of biogenic particles and or aerosol transported to the site and influenced by biogenic emission. Very little anthropogenic influence is expected.

12.5.   Completeness

[*Definition: Completeness is a measure of the amount of valid data obtained from a measurement system compared to the amount one would expect to obtain under correct normal conditions.*

Indicate the *Completeness* objective and the method used to calculate *Completeness.*   For example: Ozone completeness objective = 95%. Calculated as the number of 15 minute averaging periods with valid data (excluding periods of instrument failure, power failure, zero and span readings, calibrations, and on-site motor vehicle interference) divided the total number of 15 minute periods in the field campaign.]

Completeness Objective 90% (excluding period of instrument or power failure)

12.6.   Other Quality Information

[**State any other information that may influence the quality of the final measurement data and someone's interpretation of the data**. Examples include:

1. the ground-level ozone measurements may be affected by infrequent impingements of a local coal-fired electrical generating plant plume. These data will be detected and flagged appropriately.

2. Denuder-filter pack measurements of p-NO_3^- will be calculated as the sum of the NO_3^- collected on the front particle filter plus the volatilized NO_3^- collected as HNO_3 on the back-up nylon filter.]

End of Pre-Study QAPjP
Start of Post-Study QA Report **[This Section to be completed after the Study]**

13. Significant Changes to Site, Instruments or Methods During Study

[**Briefly describe any major changes to the site (e.g., construction in the vicinity), the instrumentation or the measurement methods during the study which may affect the quality of the data or the interpretation of the results**]

14. Post-study Data Quality Indicators (DQIs)

14.1.1.   Accuracy

14.1.2. Precision

Error estimates for the results were obtained from the propagation of standard errors computed from the counting statistics of the raw data.

14.1.3. Comparability

Growth factor measurements for Golden Ears Park were compared with a second TDMA. The initial size selection for the two DMAs is slightly different (100nm and 115 nm for example) and compared data points had relative humidity that were within 2%. The average percent difference was calculated to be 0.5% when comparing 100nm and 115nm, and 1.25% when comparing (50 and 80nm).

14.1.4. Representativeness

14.1.5. Completeness

94%

14.2. Blank correction (describe whether done and method used):

14.3. Other Quality Information

15. References:

Pitchford, M.L., and P.H. McMurry, Relationship between measured water vapor growth and chemistry of the atmospheric aerosol for grand canyon, Arizona, in Winter 1990., *Atmospheric Environment*, *28* (5), 827-839, 1994.

Stolzenburg, M.R., and P.H. McMurry, TDMAFIT user's manual, Particle Technology Laboratory, Department of Mechanical Engineering University of Minnesota, Minneapolis, MN, 1988.

Tang, I.N., and H.R. Munkelwitz, Water activities, densities and refractive indices of aqueous sulfates and sodium nitrate droplets of atmospheric importance, Journal of Geophysical Research, 99 (D9), 18801-18808, 1994.