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Atmospheric Nitrogen Concentrations in the Lower Fraser Valley 1996

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I. Abstract

Nitrogen compounds in the atmosphere can exist in various forms, including ammonia and nitrate. These compounds can contribute to particle formation which can result in atmospheric haze, acid rain and groundwater contamination by nitrate to local aquifers. The extent of their concentrations in the atmosphere in the agricultural area of the lower Fraser Valley in British Columbia has not been previously assessed. Concerns about the high levels of nitrate concentrations in groundwater and aquifers in this area prompted an assessment of the atmospheric concentrations and their potential deposition contributions to the aquifers. This report examines the data from a sampling program with respect to temporal and spatial concentrations and depositions. Actual measurements taken during a portion of the growing season at the Abbotsford site showed a maximum deposition of 42.5 kg/ha/year as nitrogen and an average of 8.6 kg/ha/year as nitrogen.

Résumé

Les composés d'azote sont présents dans l'atmosphère sous différentes formes, dont l'ammoniac et le nitrate. Les composés d'azote peuvent contribuer à la formation de particules pouvant produire une brume sèche et des pluies acides et entraîner la contamination par des nitrates des formations aquifères locales. C'est la première fois que l'on évalue la concentration atmosphérique de ces composés dans la région agricole de la vallée inférieure du fleuve Fraser, en Colombie-Britannique. C'est en raison de l'inquiétude suscitée par les concentrations élevées de nitrate dans les eaux souterraines et les formations aquifères de cette région qu'a été entreprise une évaluation des concentrations de ces composés dans l'atmosphère et de la mesure dans laquelle leur dépôt risque de contribuer à la contamination des formations aquifères. Dans ce rapport, on examine les données obtenues dans le cadre d'un programme d'échantillonnage portant sur les concentrations et les quantités déposées à différents moments et à différents endroits. Des mesures obtenues pendant une partie de la saison de croissance au site d'Abbotsford révèlent un taux de dépôt maximum de 42,5 kg/ha/an (en azote) et un taux moyen de 8,6 kg/ha/an (en azote).

II. Introduction

The presence of excesses of nitrogenous compounds in the atmosphere (such as ammonia) primarily from agricultural sources has been a concern for several reasons: the potential impact on the groundwater and aquifers; the formation of atmospheric aerosols; visibility impairment; and the possible transport of particles to other areas. Ammonia can be transported distances from the original sources because it has a significant vapour pressure, and it can react with nitrate and nitrite to form fine particles that are also readily transportable.

Atmospheric ammonia readily reacts with airborne acids to form ammonium ions (NH_4^+) which are an important constituent in aerosol formation and precipitation (Erisman *et al.*, 1988). Ammonia is also readily soluble in water and can be dissolved in rain and deposited on the ground from where it can be transported downward into the aquifers. Of the different forms of nitrogen, ammonia in surface water is a primary concern because elevated ammonia levels can quickly reach toxic levels for fish (van Vliet *et al.*, 1997).

Deposition of ammonia and ammonium ions contribute to the eutrofication and acidification of nitrogen-limited ecosystems (Schulze *et al.*, 1989). Emissions from uncovered animal slurry depend on solar radiation, temperature and to a small extent, wind speed (Sommer, 1997); levels varied from zero (in the winter) to 30 (in the summer) grams nitrogen per square meter per day (g/m^2/day). Although this work was done on anaerobically slurried animal wastes, the end result of exposed slurry is not significantly different from the result of field spraying applications onto soils in the lower Fraser Valley.

Atmospheric ammonia plays an important role in the formation of particles in the atmosphere through weak dative bonding with sulfur dioxide/ sulfate ion, nitrogen dioxide/ nitrate ion and nitric oxide/ nitrite ion. Ammonium nitrate has been found to be the major secondary component of suspended particulates in urban areas of the western U.S. (Watson *et al.*, 1992). These salts are fine particulates in dry air, but are also very hygroscopic and accumulate water vapour to form aerosols that are quite effective in the reduction of visibility. Therefore the presence of ammonia in the atmosphere can also be associated with presence of locally reduced visibility. Visibility has been reduced in this area in recent years and other research (Pryor *et al.*, 1995) has indicated that the presence of these ammonium-based particulates may be responsible for much of this problem. Researchers (Pryor *et al*, 1995, Pryor *et al*, 1996, Pryor *et al*, 1997) have used IMPROVE samplers in the Fraser valley and have noted the presence of fine particulate and ammonia has been attributed as the main fraction of these particulates. Ammonia can also react with other airborne compounds such as nitrogen and sulfur oxides to form ammonium sulfate and ammonium nitrate salts (Russell *et al.*, 1983; Harrison and Msibi, 1984). These salts are extremely small in size but are hygroscopic and can attract water vapour and thereby become larger particles.

The impact of fine particulates in the atmosphere (ammonium nitrates and sulfates) is important because they are inhalable and can pass the human respiratory defense system and may cause lung damage (Paul, 1997). An epidemiological study in Toulouse, France (Giroux *et al.*, 1997) reported a relationship between acute respiratory pathology and the presence of ammonia based particulates.

The lower Fraser Valley area (Canadian and U.S.) occupies about 281,000 hectares (ha); about two thirds of this is in agricultural use. The Canadian side has a total of 85,825 ha in farm use, and of that area 73,587 ha is used for pasture or crop production. The agricultural area is used for both crops and animal husbandry; about 43,000 ha is in livestock use and 15,000 ha in non-livestock use. About 9,000 ha are used in vegetable production. The number of dairy farms and cattle has decreased between 1991 and 1994, but milk production has increased or remained constant; consequently dairy manure production may not have decreased (Brisbin, 1994). Approximately 67% of the dairy cattle, 74% of the swine and 79% of the poultry in B.C. is located

in the lower Fraser Valley (Statistics Canada, 1992). There has been a significant increase in 'hobby farms' and the total unit number of hog and chicken farms in the last decade. The use of fertilizers and wastes from animal production in this area has been proposed as a source of the increased levels of observed nitrate levels in the aquifers in the area (Brisbin & Runka, 1995a; Liebscher *et al.*, 1992; Carmichael *et al.*, 1995; Zebarth and Paul, 1996).

Virtually all of the manure applied in the eastern area is in a liquid form, whereas a solid pellet-type manure is applied in the western portion of the valley, near Abbotsford. In order to try to understand the distribution of nitrogen in the various chemical compounds and physical states, a computer program was developed for B.C. Ministry of Environment (Brisbin & Runka, 1995b) employing a nutrient balance approach to assess nitrogen production and usage within this area. That program identified a knowledge gap in the area of atmospheric concentrations and resultant deposition to agricultural lands. Livestock manure is one of the most important sources of atmospheric ammonia (Buijsman *et al.*, 1987). Ammonia is lost by volatilization from barns, manure and from applied manure (Kruse *et al.*, 1989; Ryden *et al.*, 1987).

In order to assess the levels ammonia and other forms of atmospheric nitrogen, two sites were selected in the valley to establish sampling for gaseous, particulate and dissolved forms of these nitrogen containing compounds. The sites selected were at Agriculture Canada research stations at Agassiz and Abbotsford (Figure q: Lower Fraser Valley sampling area).

III. Sites

The Agriculture Canada sites at Agassiz and Abbotsford were selected because they were already established secure facilities with power and nearby meteorological stations. The Agassiz site was at the eastern-most end of the Fraser Valley. This area is dominated by crop production and little animal husbandry. The Abbotsford site was in the middle of the Fraser Valley in an area with intensive pig and chicken production. These two sites were expected to provide a picture of nearby source contributions to the atmosphere as well as the background concentrations of atmospheric nitrogen over the course of the year-long sampling program.

IV. Meteorology and Geography

The lower Fraser Valley has the Pacific Range mountains to the north, running west -east for about 100 km to Hope, where they meet the Cascade Mountains, running south-west to the coast (Figure 1: Lower Fraser Valley sampling area). This forms a river delta/ triangle area where half the population of British Columbia live and work. The mountains in this unique geographical area support a reversing flow of air up and down the river valley, especially during diurnal flow patterns. Air quality can become poor in the valley area when periods of stagnation occur and air masses are stationary allowing collection and atmospheric reaction of pollutants.

Meteorological data for the Agassiz site was obtained from an Environment Canada climate station and complimented with rainfall measurements from a standard rainfall gauge at the site. Data for the Abbotsford site were obtained from instrumentation installed at the site; this was augmented with data from a nearby meteorological station at the Abbotsford airport. Wind data were obtained with an R. M. Young anemometer (model 05103), temperature and relative humidity from a Campbell Scientific probe (model 207) and atmospheric pressure from a Setra (Model SBP270) device. Data was collected from a datalogger system and stored in an Environment Canada computer archive.

Meteorological equipment was sited and operated in accordance with accepted standards (Environment Canada, 1994; EPA, 1989).

V. Sampling Equipment and Methods

Sampling for dry gases and particulates was accomplished by using a filter-pack denuder (FP/D) sampling device developed by the Harvard School of Medicine (Koutrakis, P. *et al*, 1993). The FP/D (Figure 2: Filter pack/denuder sample head schematic) operated at a flow rate of 10 liters per minute and has an impaction plate that removes particles greater than 2.3 microns (μm) in size. This is followed by a sodium carbonate coated section of co-axial glass tubes (NCD), a section of citric acid coated co-axial glass tubes (CAD), a Teflon filter (TF), a sodium carbonate coated filter (NCF), and a citric acid coated filter (CAF).

The first denuder (NCD) removed acidic gases such as sulfur dioxide and nitric acid. The second denuder (CAD) removed the basic gases such as ammonia. There was the potential for some reaction of these gases to form fine particulates in the form of ammonium sulfate ($(NH_4)_2SO_4$) and ammonium nitrate (NH_4NO_3). These particulate matter may already have been created in the atmosphere before sampling. The purpose of the TF was to capture these fine particulates. Because these ammonium compounds were formed by weak bonds, they may break down and reform the ammonia (NH_3) and nitrite (NO_2) or nitrate (NO_3) that created them. Therefore, back-up filters were used to re-capture these break-down products. The NCF collected the acidic gases - sulfur dioxide (SO_2), nitrogen dioxide (NO_2) and nitrogen trioxide (NO_3). and the CAF collected the basic gas - NH_3.

Rainfall was collected in an MIC sampler similar to those used in the Canadian Air and Precipitation Monitoring Network (CAPMoN, 1985). The sampler collected precipitation in a chemically clean polyethylene bag inside a collector bucket. The collector bucket remained covered by a sealing lid that was activated by a moisture sensor; the collector was only open to the atmosphere when precipitation occurred. The sampler opening had an area of 0.212 m^2.

Samples were collected on a weekly basis, from Tuesday to Tuesday at approximately 9:00 am local time. At the end of the sampling period samples were immediately taken to the laboratory for analyses to minimize any sample degradation. Unfortunately, no field refrigeration was possible during sampling to minimize sample degradation.

VI. Laboratory Analyses Methods

The contract laboratory, Analytical Services Laboratory (ASL), was responsible for sample media preparation and sample analyses. As well, they prepared lab and field blanks and spiked samples to assess field, laboratory and analytical procedures.

The preparation and extraction of the sampling media for ammonia, nitrate, nitrite and sulfate were carried out according to procedures obtained from the Harvard School of Medicine. The ammonia was analyzed according to procedures in “Standard Methods for the Examination of Water and Wastewater”, 18th Edition, published by the American Public Health Association (APHA); generally, ammonia was determined colourimetrically by a reaction with phenol, hypochlorite and an indicating salt (APHA Method 4500-NH_3).

Nitrate, nitrite and sulfate were measured using a procedure described in “The Determination of Inorganic Anions in Water by Ion Chromatography”, Revision 2.1, 1993, published by the EPA Environmental Monitoring Systems Laboratory.; generally, the procedure involves analyses of the extract by Dionex Ion Chromatograph with a chemically suppressed conductivity detector, using an Ion Pac ASA12A Anion Separator column with an Ion Pac AG12A Guard (EPA Method 300.0).

Rainwater samples were carried out in accordance with procedures described in: “Standard Methods for the Examination of Water and Wastewater”, 19th Edition, 1995 published by the American Public Health Association; and in procedures adapted from “Test Methods for Evaluating Solid Waste”, EPA procedure SW-846. The procedure involved preliminary filtration (EPA Method 3005) and optical emission spectroscopy (EPA Method 6010).

VII. Quality Assurance

A. Field Data

Meteorological data was subject to standard Environment Canada procedures for quality assurance (Environment Canada, 1994; EPA, 1989).

B. Lab Data

An extensive quality assurance program was routinely incorporated with the sample analyses. This included procedures to assess precision, accuracy and contamination control. Procedures included method blanks, sample replicates, certified and standard reference materials and analyte or matrix spikes. Lab data included: method blanks that were always less than the detection limits (<0.3, <0.1, <0.2 and <0.1 μg for sulfate, NH_3 (as N), NO_3 (as N) and NO_2 (as N) respectively) ; matrix spikes that consistently had recoveries at 100% ± 5%. Field blanks were very similar to lab blanks and had absolute levels at 15, 4.5, 0.2 and 0.3 μg for sulfate, NH_3 (as N), NO_3 (as N) and NO_2 (as N) respectively. Sulfate and ammonia levels were higher than blanks but nitrate and nitrite were at blank levels. The potential for ammonia contamination in sampler preparation was observed by the Harvard sampler preparation protocols. Levels encountered in this study were consistent and were used for blank corrections.

VIII. Data Analyses and Discussion

A. Field Data

Data for the meteorological parameters were evaluated with respect to the week long sampling periods. Rainfall was measured upon sample collection. Wind, temperature and pressure data were averaged over the sampling period. The temperature and pressure data were used to calculate the corrected air volumes sampled at standard temperature (25 °C) and pressures (1013 mb). Sampling periods were typically from 9:00 am Tuesday to 9:00 am on the following Tuesday, and calculations were made according to sample logs. This data is shown in Appendix 1: Abbotsford field data and Appendix 2: Agassiz field data and Table 1: Rainfall field data for Abbotsford.

B. Dry Air

This Abbotsford site (Appendix 1) had the most extensive sampling program and operated for about thirteen months from February 1996 through to March 1997. For the last few months a second FP/D was operated in tandem to assess sampling efficiency. Most of the data was collected from measuring devices at the sampling site, however, some data gaps did occur and were replaced with data from a nearby (5 km) Environment Canada climate station. The only data gap was in May-June 1996 when the sampling program was stopped for a four week period due to program difficulties. The meteorological data was used to calculate corrected sample volumes and concentrations at standard temperature and pressure (STP).

Flow rates were to be set at 10.0 liters per minute (l/min) to allow an impaction plate at the entrance of the FP/D to remove large particles (greater than 2.3 microns). Concurrent particulate sampling as well as previous work has shown that fine particulate concentrations dominate large particulate in the Pacific northwest (Trijonis, 1990), so flow rates less than the optimum were not expected to be a problem. In fact, high concentrations of ammonium were expected to be the main problem, requiring reduced flow rates to avoid over saturating the denuders. The FP/D system was developed by the Harvard School of medicine and they determined a saturation point of approximately one milligram of ammonia as nitrogen in the denuder portion (Koutrakis, 1993). At the start of the sampling program the flow rates were measured by two methods, in-line rotometer and an external flow calibration device. The rotometer was used to assess the

instantaneous operation of the sample pumps. The flow rates were quite variable at the start of sampling and this was attributed to the preparation of the filter pack denuders. The denuders and the back-up filters were coated with either citric acid or sodium bicarbonate to enable them to capture the appropriate gas or salt particle. This coating process was performed in a 'clean laboratory' area away from sources of contamination. This coating process was determined to cause periodic flow restrictions due to excessive salt deposits in the denuder tubes. In order to eliminate these problems, field staff observed the instantaneous flow rates when the FP/D was installed, and then waited fifteen minutes to determine whether flow rates improved when/ if the blockage was removed; this proved to be somewhat effective. However, the most effective procedure was to insert a second/ spare FP/D that in almost all cases had a better flow rate. In some cases the FP/D was removed and returned to the laboratory for complete replacement.

The sampling data for the Agassiz site is in Appendix 2: Agassiz field data. This site had a shorter sampling program and operated for about twelve months from January 1996 through to December 1996. This sampler was moved to the Abbotsford site in January 1997 and was operated in tandem with that sites FP/D to assess sampling efficiency. Most of the data was collected from a co-located Environment Canada climate station. The only data gap was in May-June 1996 when the sampling program was stopped for a four week period due to program difficulties. The meteorological data was used to calculate corrected sample volumes and concentrations at standard temperature and pressure (STP).

C. Rainfall

The rainfall for the Abbotsford site is shown in Table 1: Rainfall field data for Abbotsford. This sampler was started in July of 1997 and was operated for a period of about seven months. This sampler was used to assess the relative contribution of wet deposition to the ground in the vicinity of this sampling site. The rainfall data was used to determine concentration and deposition of nitrogen compounds in the precipitation for this site. Sampling was performed at ambient air temperatures for periods of about seven days. It would have been desirable to have a refrigerated sampling device to minimize the possible vaporization or biological degradation of samples over the extended sampling period; consequently, there exists the possibility of some sample loss, or change of state due to oxidation/ reduction processes.

IX. Lab Data

A. Dry Air

For the Abbotsford site, the air volume corrected data for the ammonia FP/D system are shown in Appendix 3: Abbotsford sample data and Figure 3: FP/D concentrations at Abbotsford. This data has been blank corrected and adjusted to STP. The flow rates varied between 2 and 16 l/min, but for most of the sampling program the flow was at 8 to 10 l/min. The data for Agassiz is in Appendix 4: Agassiz field data and Figure 4: FP/D concentration data at Agassiz.

The Abbotsford data showed ammonia concentrations that were typically higher than those at the Agassiz site. Ammonia concentrations ranged from about 8 to 30 micrograms per cubic meter ($\mu g/m^3$). At Agassiz the ammonia concentrations ranged from 2 to 10 $\mu g/m^3$ with spikes at 2 and 60 $\mu g/m^3$. The yearlong sampling program showed a couple of peak periods for ammonia concentrations in February and September when it was observed that fields were sprayed with manure to fertilize the land for crops. This was most pronounced in the Abbotsford area and to a smaller extent, in the Agassiz area.

Nitrate concentrations were observed to be higher than the nitrite concentrations in almost all cases. The low concentrations of these oxidized nitrogen compounds indicated that the atmospheric oxidation process was minimal, even in the summer months when ultra-violet radiation levels are higher and might be expected to influence oxidation rates.

Sulfate concentrations appear to have increased concentrations in the summer periods at both sites, but higher at the Abbotsford site. Sources of sulfate are few in the immediate area, but there are petroleum refineries about 50-60 km to the southwest in the United States and two cement plants about 30 km to the west, as well as biogenic sources from the ocean.

Deposition from dry air depends upon winds, surface roughness and the type of source - gas or particulate. Deposition velocities for ammonia have been reported in the literature with varying rates (Sehmel, 1973, Slinn & Slinn, 1980, Lin *et al*, 1994). This reference data indicates that a deposition velocity of 0.1 cm/sec be used as that is the velocity noted for the 2.3 µm size removed by an impaction plate in the FP/D. This may result in a higher deposition rate than may be true as particles with smaller diameter have lower deposition velocities. Deposition rates were calculated for each sampling period using this deposition velocity and the ambient concentrations.

Dry deposition for the Abbotsford site is shown in Table 3: Dry Deposition at Abbotsford and Figure 6: Dry deposition at Abbotsford. Deposition rates varied between 0.2 and 2.7 mg/m^2/day for ammonia, with an average dry deposition rate of about 1.4 mg/m^2/day (averages were simple arithmetic mean based on the available data set). Nitrate varied between 0.01 to 0.10 with an average of 0.04 mg/m^2/day. Nitrite varied between 0.0 to 0.06 with an average of 0.01 mg/m^2/day. Dry deposition sulfate varied between 0.05 to 1.27 (or 0.18 - 4.63 kg/ha/yr) with an average of 0.24 mg/m^2/day (or 0.88 kg/ha/yr).

The Agassiz data is presented in Table 4: Agassiz dry deposition and Figure 7. Deposition rates varied between 0.003 and 5.4 mg/m^2/day for ammonia, with an average dry deposition rate of about 0.6 mg/m^2/day. Nitrate varied between 0.0 to 0.55 with an average of 0.04 mg/m^2/day. Nitrite varied between 0.0 to 0.1 with an average of 0.01 mg/m^2/day. Dry deposition sulfate varied between 0.00 to 1.97 27 (or 0.00 - 7.19 kg/ha/yr) with an average of 0.18 mg/m^2/day (or 0.66 kg/ha/yr).

B. Rainfall

The concentration data for the nitrogen in rainfall are shown in Table 2: Rainfall concentration data for Abbotsford and Figure 5: Rainfall concentrations at Abbotsford. In this table, field and lab data combine to show the concentrations are linked to rainfall amounts. For ammonia, nitrate and nitrite, concentrations appear higher when rainfall is low, as they are not diluted with the higher rainfall amounts. In related rainfall studies it has been shown that rainfall removes most of the airborne pollutants in the first few minutes of a rainfall event, and any rainfall after the initial purge of contaminants from the air only dilutes the concentration.

Rainfall measured in this study at the Abbotsford site showed maximum and average values for ammonia/ nitrate/ nitrite at 1.87, 0.74/ 0.71, 0.16/ 0.039, 0.011 mg/L as N.

During July and September, two rainfall events contributed a significantly higher concentration of sulfate ion to the rainfall, at about 2.0 and 1.6 mg/L. At other times, concentrations appeared to be less than 0.01 mg/L.

Rainfall acidity had a maximum pH of 7.1, a minimum of 4.78 and an average 6.4. The pH of normal rainfall (due to dissolved carbon dioxide) is pH 5.65. On average there is a more neutral rainfall pH but there are acidic episodes which appear to occur when ammonia levels decrease and nitrate levels increase.

Rainfall deposition at Abbotsford is shown in Table 5: Rainfall deposition rates at Abbotsford and Figure 8: Wet deposition rates at Abbotsford. The wet deposition rate for ammonia varied between 0.39 and 11.0 mg/m^2/day with an average of about 4.04 mg/m^2/day. Deposition was only measured over the summer and winter months at this one site and had 23 wet weeks in the 32 week sampling period.

X. Summary Discussion

The total deposition for the year was calculated to be the sum of all ammonia (gaseous and particulate) over the year divided by the sampling area and the sampling time. In order to calculate an average deposition from both wet and dry sources, there was a need to normalize the data to a yearly average rate for the dry and wet forms.

The yearlong sampling program showed a couple of peak periods for ammonia concentrations in February and September when it was observed that fields were sprayed with manure to fertilize the land for crops. This was most pronounced in the Abbotsford area and to a smaller extent, in the Agassiz area. This was expected as manure from the dairy sources, used in the eastern area near Agassiz, was applied over a wider time frame than that in the Abbotsford area where poultry fertilizer is applied to raspberry crops during a much narrower time frame.

The Abbotsford rainfall values measured showed maximum and average values for ammonia/ nitrate/ nitrite at 1.87, 0.74/ 0.71, 0.16/ 0.039, 0.011 mg/L as N. The B.C. Ministry of Environment lands and Parks has a maximum concentration of 0.06 mg N /L for chloride concentrations less than 2 mg/L; the toxicity of nitrite in an aquatic environment is dependent on the chloride concentration, increasing as the chloride concentration decreases (B.C. Environment, 1994). Rainfall values are two-thirds this value and may have some impact on aquatic life. The maximum concentration for nitrate is 200 mg/L as N; rainfall concentrations are much below this value.

The dry samples were taken over a 58 week period. There were 23 wet week-long samples taken over a 32 week period. Assuming a consistent rainfall pattern for the whole year, and using data from Environment Canada archives, over a thirty year period for any one year, there were 166 days with measurable rainfall, and 199 days that were dry. Table 6 shows the results of calculating a daily deposition rate from weekly samples and then calculating a yearly value based on average archived meteorological data. The average, maximum and minimum deposition rates over a year were calculated and their totals for Abbotsford are in Table 6: Atmospheric deposition at Abbotsford and Figure 9: Total atmospheric deposition at Abbotsford. The maximum and minimum values were calculated because of the variability in weekly values within a single one year sampling period, and the possible yearly variability of measurements when a final yearly value is required to assess deposition impacts.

The total atmospheric deposition measured at Abbotsford showed wet deposition to be the greatest contributor to the total amount deposited at this site by factors of three to ten times. Dry deposition was approximately 1-3 mg/m^2/day and was relatively consistent through the sampling period, with a slight decrease during winter months. Wet deposition was approximately 1-12 mg/m^2/day and appeared to be higher in the winter months, as expected.

Atmospheric concentrations of ammonia are in a state of flux in emission and deposition phases depending on the humidity, temperature and the acidity of soils. In Great Britain, Sutton (Sutton, 1993) estimated an annual emission/ deposition for hay crop land at 0.4 kg N per hectare per year, or 40. mg/m^2/year. This is well below the average measured value of 721 mg/m^2/year at Abbotsford. This was not surprising as this measurement was made in the centre of agricultural activity in the Fraser Valley and the value for Britain was averaged for hay crop lands over the whole country.

The area of the lower Fraser Valley is approximately 281,000 hectares. The deposition rate for nitrogen at Abbotsford is 0.3 to 42.5 kg/ha/yr. Assuming the Abbotsford value is representative of the whole valley, a big assumption, then a calculation of the total amount of nitrogen from atmospheric sources to this area over a year is the simple product of the deposition rate, time and the area. This would result in a yearly overall total loading to the lower Fraser valley for nitrogen as: (281,000 ha) • (0.3 to 42.5 kg/ha/yr) • (1 year) ➔ 84 to 11,942 kilograms nitrogen.

The impact of ammonia deposition on soils is not necessarily a neutralizing effect because the action of *Nitrosomas* and *Nitrobacter* bacteria in the soil can oxidize the ammonia to nitrate and increase soil acidity (Van Breemen *et al.*, 1982; Van Dijk *et al.*, 1989). This acidity can result in leaching of base cations (Ca^{+2}, Mg^{+2} and K^{+1}) from soils and result in root damage. This can also result in weakened plants that are subject to root infections and disease.

Known sources of atmospheric nitrogen compounds are limited but include automotive exhaust (Harkins *et al*, 1967; Sutton *et al*, 1995), oceanic sources and agricultural fertilizing processes (Lee & Dollard, 1994). The data from Harkins *et al* indicate a value of 1-6 ppm ammonia in exhaust condensate, and they attributed a maximum of 10% of the atmospheric ammonia to automotive sources. Ammonia and dimethyl sulfate are generated during biological activities in the oceans (Liss and Galloway, 1993). Liss and Galloway reported ammonia levels at Baring Head, New Zealand at an average of about 105. ng/m^3 with a range of 16-766 nanograms per cubic meter (ng/m^3) ammonia as nitrogen. Concentrations of ammonia at Abbotsford ranged from 1.9 to 31.1 µg/m^3 and averaged about 16.4 µg/m^3; Agassiz ammonia concentrations were from <0.1 to 62.5 µg/m^3 with an average of 7.0 µg/m^3. If the data from Liss and Galloway are representative, oceanic sources, are orders of magnitude lower than those encountered in this study. Consequently, oceanic sources are not expected to be of importance in this area. Ammonia concentrations in a study in Phoenix, Arizona (Watson *et al*, 1992) had atmospheric concentrations from 2 to 20 µg/m^3 with an average near 10 µg/m^3; Phoenix does not have a large agricultural base, and lower ammonia concentrations were expected. In eastern Canada, an Environment Canada study (Sirois and Fricke, 1992) reported average ammonia concentrations between 0.2 and 2.1 µg/m^3.

XI. Conclusions

Nitrogen compounds in the form of ammonia and nitrate are present in the atmosphere of the lower Fraser Valley area in significant amounts. The concentrations vary from <0.1 to 62 µg/m^3 ammonia as nitrogen, the primary nitrogen compound in the atmosphere. This gas is readily soluble in water and can easily be deposited to land and surface waters. The potential contribution to ground water and the possible seepage into aquifers is a serious concern. Deposition rates are higher for wet deposition than for dry deposition mechanisms. The average atmospheric concentrations of ammonia are higher at Abbotsford than at Agassiz (16.4 µg/m^3 and 7.0 µg/m^3), but Agassiz has a higher maximum value (62.5 µg/m^3). This that may be due to different types of sources in these areas. The source of these nitrogen compounds is expected to be from the agricultural sector as contributions from the ocean and automotive exhausts are at some distance from the sampling locations. The Abbotsford area has a larger abundance of poultry and swine production facilities than does the Agassiz area where agricultural land use is primarily crops. It would appear that use of animal husbandry waste products in fertilizing procedures contributes large amounts to the atmospheric loading of nitrogen compounds in the agricultural area of the Fraser valley.

Total deposition calculations for Abbotsford show ammonia deposition variations of 32 to 2370 mg/m^2/year with an average of 721 mg/m^2/year. This is a significant amount compared to other sites. The Brisbane report (Brisbane, 1995a) expected atmospheric contributions in the order of 40 to 80 kg/ha/year and actual measurements at the Abbotsford site showed a maximum 42.5 kg/ha/year and an average of 8.6 kg/ha/year. These values appear to be consistent with those in other areas and can therefore be used in nitrogen mass balance evaluations of the ecosystem in this agricultural area.

XII. Acknowledgments

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XIV. Tables

Table 1: Rainfall field data for Abbotsford

Abbotsford Rain Data								
Rain Gauge measured in millimeters rainfall.								
Date on	23-7-96 11:15	30-7-96 8:20	6-8-96 10:15	13-8-96 8:00	20-8-96 9:47	27-8-96 9:40	3-9-96 9:55	10-9-96 11:25
Date off	30-7-96 8:20	6-8-96 10:15	13-8-96 8:00	20-8-96 9:25	27-8-96 9:40	3-9-96 9:55	10-9-96 10:40	17-9-96 9:50
mm RG	<0.2	22.1	<0.2	0.6	0.0	19.4	21.6	60.4
Date on	17-9-96 10:40	24-9-96 10:10	1-10-96 10:50	8-10-96 10:15	15-10-96 10:20	22-10-96 10:35	29-10-96 10:20	5-11-96 11:20
Date off	24-9-96 10:00	1-10-96 10:50	8-10-96 10:10	15-10-96 10:20	22-10-96 9:55	29-10-96 10:20	5-11-96 10:40	12-11-96 10:15
mm RG	11.2	<0.2	21.6	33.0	50.0	104.0	23.2	25.8
Date on	12-11-96 11:05	19-11-96 11:30	25-11-96 12:00	3-12-96 12:00	10-12-96 11:20	16-12-96 11:00	23-12-96 9:30	31-12-96 9:30
Date off	19-11-96 11:30	25-11-96 12:00	3-12-96 12:00	10-12-96 11:20	16-12-96 11:00	23-12-96 9:30	31-12-96 9:30	7-1-97 9:00
mm RG	na	na	73.0	79.0	35.2	na	na	129.0
Date on	7-1-97 9:00	14-1-97 9:00	21-1-97 9:00	28-1-97 9:00	4-2-97 9:00	11-2-97 10:40	18-2-97 8:30	25-2-97 8:40
Date off	14-1-97 9:00	21-1-97 9:00	28-1-97 9:00	4-2-97 9:00	11-2-97 10:40	18-2-97 8:30	25-2-97 8:40	4-3-97 9:00
mm RG	na	113.0	na	92.0	3.2	63.0	33.0	36.6

Table 2: Rainfall concentration data for Abbotsford

Final Report ASL WO#	Symbol	Detection Limit mg/L	G3542 Rain-water #1	G3826 Rain-water		G4289 Rain-water	
Sample Date (start)	Symbol		7-23-96 11:00 AM	7-30-96 8:30 AM	8-6-96 11:00 AM	8-13-96 8:00 AM	8-20-96 10:05 AM
Sample Date (stop)	stop		7-30-96 8:20 AM	8-6-96 10:30 AM	8-13-96 8:00 AM	8-20-96 10:05 AM	8-27-96 10:40 AM
	# of Days		6.89	7.08	6.88	7.09	7.02
Sample Comment						20 mm rain limited anal.	
Rainfall (mm)			<0.2	22.1	<0.2	0.6	
Concentration (mg/L)							
Sulphate:SO4	SO4	<1.0	<1.0	**2.000**	na	N/A	na
Ammonia Nitrogen:N	NH3-N	<0.02	**1.370**	NA	na	NA	na
Nitrate Nitrogen:N	NO3-N	<0.005	**0.167**	**0.201**	na	N/A	na
Nitrite Nitrogen:N	NO2-N	<0.001	**0.008**	**0.007**	na	N/A	na
Total Phosphate:P	PO4-P	<0.001	**0.007**	**0.011**	na	N/A	na

Final Report ASL WO#	Symbol	Detection Limit mg/L	G4888 Rain-water	G4941 Rain-water	G5138 Rain-water	G5345 Rain-water	Rain-water
Sample Date (start)	Symbol		8-27-96 10:40 AM	9-3-96 10:15 AM	9-10-96 11:15 AM	9-17-96 10:15 AM	9-24-96 10:30 AM
Sample Date (stop)	stop		9-3-96 10:00 AM	9-10-96 11:10 AM	9-17-96 10:00 AM	9-24-96 10:30 AM	10-1-96 10:50 AM
	# of Days		6.97	7.04	6.95	7.01	7.01
Sample Comment							
Rainfall (mm)			19.4	21.6	60.4	11.2	<0.2
Concentration (mg/L)							
Sulphate:SO4	SO4	<1.0	<1.0	<1.0	<1.0	**1.6**	na
Ammonia Nitrogen:N	NH3-N	<0.02	**0.690**	**0.940**	**0.510**	**1.870**	na
Nitrate Nitrogen:N	NO3-N	<0.005	**0.123**	**0.157**	**0.006**	**0.619**	na
Nitrite Nitrogen:N	NO2-N	<0.001	**0.008**	**0.012**	**0.004**	**0.025**	na
Total Phosphate:P	PO4-P	<0.001	**0.009**	**0.011**	**0.004**	**0.017**	na

Final Report ASL WO#	Symbol	Detection Limit mg/L	G6002 Rain-water	G6083 Rain-water	G6319 Rain-water	G6575	G6826
Sample Date (start)	Symbol		10-1-96 10:50 AM	10-8-96 10:40 AM	10-15-96 10:10 AM	10-22-96 10:48 AM	10-29-96 11:15 AM
Sample Date (stop)	stop		10-8-96 10:30 AM	10-15-96 11:00 AM	10-22-96 10:45 AM	10-29-96 11:10 AM	11-5-96 11:20 AM
	# of Days		6.99	7.01	7.02	7.02	7.00
Sample Comment							
Rainfall (mm)			21.6	33.0	50.0	104.0	23.2
Concentration (mg/L)							
Sulphate:SO4	SO4	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Ammonia Nitrogen:N	NH3-N	<0.02	**0.720**	**1.030**	**0.350**	**0.490**	**0.700**
Nitrate Nitrogen:N	NO3-N	<0.005	**0.082**	**0.103**	**0.053**	**0.103**	**0.22**
Nitrite Nitrogen:N	NO2-N	<0.001	**0.016**	**0.008**	**0.005**	**0.008**	**0.011**
Total Phosphate:P	PO4-P	<0.001	**0.007**	**0.01**	**0.002**	**0.002**	**0.005**

		mg/					
Sample Date (start)	**Symbol**		11-5-96 11:40 AM	11-12-96 11:15 AM	11/19/96	11-25-96 12:17 PM	12-3-96 12:00 PM
Sample Date (stop)	**stop**		11-12-96 11:05 PM	11-25-96 12:10 PM		12-3-96 12:00 PM	12-10-96 11:30 PM
	# of Days		7.48	13.04		7.99	7.48
Sample Comment						*** Spiked w ith Sr: 74-85% recovery** 7-8L spl!	
Rainfall (mm)			25.8	54.4		123.8	79.0
Concentration (mg/L)							
Sulphate:SO4	**SO4**	<1.0	<1.0	<1.0	N/A	<1.0	
Ammonia Nitrogen:N	**NH3-N**	<0.02	**0.850**	**0.550**	N/A	**0.490**	
Nitrate Nitrogen:N	**NO3-N**	<0.005	**0.123**	**0.215**	N/A	**0.713**	
Nitrite Nitrogen:N	**NO2-N**	<0.001	**0.012**	**0.011**	N/A	**0.006**	
Total Phosphate:P	**PO4-P**	<0.001	**0.005**	**0.003**	N/A	**0.002**	

Final Report ASL WO#	**Symbol**	**Detection Limit mg/**	G7979	G8171		G8594	G8570
Sample Date (start)	**Symbol**		12-10-96 11:30 PM	12-16-96 11:15 AM	12-23-96 9:30 AM	12-31-96 9:00 AM	1-7-97 9:00 AM
Sample Date (stop)	**stop**		12-16-96 11:15 AM	12-23-96 9:30 AM	12-31-96 9:00 AM	1-7-97 9:00 AM	1-14-97 9:00 AM
	# of Days		5.49	6.93	7.98	7.00	7.00
Sample Comment					Sampler knocked over & lost		
Rainfall (mm)			35.2	14.1	NA	129.0	12.8
Concentration (mg/L)							
Sulphate:SO4	**SO4**	<1.0	<1.0	<1.0	NA	<1.0	<1.0
Ammonia Nitrogen:N	**NH3-N**	<0.02	**0.460**	**0.370**	NA	**0.600**	**1.440**
Nitrate Nitrogen:N	**NO3-N**	<0.005	**0.123**	**0.138**	NA	**0.061**	**0.051**
Nitrite Nitrogen:N	**NO2-N**	<0.001	**0.01**	**0.016**	NA	**0.005**	**0.039**
Total Phosphate:P	**PO4-P**	<0.001	**0.004**	**0.002**	NA		**0.009**

Final Report ASL WO#	**Symbol**	**Detection Limit mg/L**	G8724	G8946		G9216	G9437
Sample Date (start)	**Symbol**		1-14-97 9:15 AM	1-21-97 9:00 AM	1/28/97	2-4-97 9:00 AM	2-11-97 10:40 AM
Sample Date (stop)	**stop**		1-21-97 9:00 AM	2-4-97 9:00 AM		2-11-97 10:40 AM	2-18-97 8:30 AM
	# of Days		6.99	14.00		7.07	6.91
Sample Comment			Bag slipped & precip found in bucket	Frozen spl to Lab		Frozen spl to Lab	
Rainfall (mm)			113	92		3.2	63
Concentration (mg/L)							
Sulphate:SO4	**SO4**	<1.0	<1.0	<1.0	N/A	<1.0	<1.0
Ammonia Nitrogen:N	**NH3-N**	<0.02	**0.490**	**0.730**	N/A	**0.860**	**0.710**
Nitrate Nitrogen:N	**NO3-N**	<0.005	**0.08**	**0.129**	N/A	**0.104**	**0.121**
Nitrite Nitrogen:N	**NO2-N**	<0.001	**0.004**	**0.008**	N/A	**0.021**	**0.007**
Total Phosphate:P	**PO4-P**	<0.001		**0.007**	N/A	**0.005**	**0.003**

Final Report ASL WO#	**Symbol**	**Detection Limit mg/L**		G9756
Sample Date (start)	**Symbol**		2-18-97 8:30 AM	2-25-97 8:40 AM
Sample Date (stop)	**stop**		2-25-97 8:40 AM	3-4-97 9:00 AM
	# of Days		7.01	7.01
Sample Comment			No bags available	
Rainfall (mm)			33	36.6
Concentration (mg/L)				
Sulphate:SO4	**SO4**	<1.0	NA	<1.0
Ammonia Nitrogen:N	**NH3-N**	<0.02	NA	**0.700**
Nitrate Nitrogen:N	**NO3-N**	<0.005	NA	**0.138**
Nitrite Nitrogen:N	**NO2-N**	<0.001	NA	**0.008**
Total Phosphate:P	**PO4-P**	<0.001	NA	**0.004**

Table 3: Dry deposition at Abbotsford

Abbotsford Data Ammonia Deposition Rate in mg/m2/day

File #	F7324	F7435	F7642	F7846	F8027	F8219	F8458	F8657	F8846	F8987	F9222
Sample Start	17-1-96	7-2-96	13-2-96	20-2-96	27-2-96	5-3-96	12-3-96	19-3-96	26-3-96	2-4-96	9-4-96
Sample Stop	5-2-96	13-2-96	20-2-96	27-2-96	5-3-96	12-3-96	19-3-96	26-3-96	2-4-96	9-4-96	16-4-96
SO4		1.270	0.127	0.087	0.226	0.296	0.210	0.229	0.214	0.242	0.165
NH3 as N		1.491	0.866	0.683	2.376	2.329	2.029	1.219	1.177	2.540	1.631
NO3 as N		0.037	0.077	0.021	0.054	0.078	0.047	0.043	0.024	0.058	0.042
NO2 as N		0.024	0.010	0.005	0.014	0.010	0.012	0.010	0.002	0.015	0.004

File #	F9432	F9584	F9785	G1030					G2167	G2415	G2618
Sample Start	16-4-96	23-4-96	30-4-96	7-5-96	14-5-96	21-5-96	28-5-96	4-6-96	11-6-96	18-6-96	25-6-96
Sample Stop	23-4-96	30-4-96	7-5-96	14-5-96	21-5-96	28-5-96	4-6-96	11-6-96	18-6-96	25-6-96	2-7-96
SO4	0.179	0.220	0.290	0.199					0.342	0.347	0.288
NH3 as N	0.755	1.959	1.648	1.473					1.638	1.395	1.831
NO3 as N	0.033	0.021	0.035	0.037					0.056	0.068	0.051
NO2 as N	0.002	0.004	0.004	0.003					0.008	0.014	0.009

File #	G2851	G3096	G3319	G3577	G3782	G4045	G4301	G4511	G4680	G4925	G5139
Sample Start	2-7-96	9-7-96	16-7-96	23-7-96	30-7-96	6-8-96	13-8-96	20-8-96	27-8-96	3-9-96	10-9-96
Sample Stop	9-7-96	16-7-96	23-7-96	30-7-96	6-8-96	13-8-96	20-8-96	27-8-96	3-9-96	10-9-96	17-9-96
SO4	0.324	0.474	0.303	0.477	0.384	0.420	0.420	0.479	0.381	0.168	0.283
NH3 as N	1.400	1.559	1.667	0.831	1.622	2.089	1.577	1.947	1.774	1.582	1.544
NO3 as N	0.050	0.066	0.065	0.090	0.032	0.095	0.032	0.076	0.059	0.030	0.056
NO2 as N	0.009	0.008	0.021	0.013	0.008	0.019	0.008	0.015	0.010	0.009	0.009

File #	G5339	G5587	G5864	G6073	G6331	G6542	G6766	G6981	G7368	N/A	G7559
Sample Start	17-9-96	24-9-96	1-10-96	8-10-96	15-10-96	22-10-96	29-10-96	5-11-96	12-11-96	19-11-96	25-11-96
Sample Stop	24-9-96	1-10-96	8-10-96	15-10-96	22-10-96	29-10-96	5-11-96	12-11-96	25-11-96		3-12-96
SO4	0.269	0.344	0.114	0.048	0.101	0.095	0.106	0.082	0.113		0.101
NH3 as N	2.467	1.860	1.726	1.774	0.978	1.273	2.687	0.948	0.632		0.978
NO3 as N	0.055	0.086	0.038	0.020	0.020	0.026	0.014	0.018	0.023		0.013
NO2 as N	0.011	0.016	0.025	0.003	0.005	0.008	0.019	0.009	0.003		0.024

File #	G7787	G7955	G8169	G8238	G8331	G8498	G8667	G8837	G9021	G9182	G9378
Sample Start	3-12-96	10-12-96	16-12-96	23-12-96	31-12-96	7-1-97	14-1-97	21-1-97	28-1-97	4-2-97	11-2-97
Sample Stop	10-12-96	16-12-96	23-12-96	31-12-96	7-1-97	14-1-97	21-1-97	28-1-97	4-2-97	11-2-97	18-2-97
SO4	0.071	0.081	0.066	0.059	0.092	0.125	0.084	0.121	0.106	0.201	0.095
NH3 as N	0.832	1.272	0.614	0.163	0.882	1.329	0.841	0.695	0.834	1.400	1.051
NO3 as N	0.023	0.020	0.027	0.008	0.028	0.021	0.022	0.021	0.025	0.081	0.014
NO2 as N	0.002	0.009	0.004	0.000	0.005	0.026	0.005	0.001	0.006	0.058	0.002

File #	G9594	G9753	Maximum	Minimum	Average
Sample Start	18-2-97	25-2-97			
Sample Stop	25-2-97	4-3-97			
SO4	0.319	0.259	1.270	0.048	0.237
NH3 as N	1.094	1.065	2.687	0.163	1.412
NO3 as N	0.030	0.042	0.095	0.008	0.041
NO2 as N	0.016	0.007	0.058	0.000	0.011

Table 4: Agassiz dry deposition

Agassiz Data Ammonia Dry Deposition Rate in mg/m^2/day

File #	F7324	F7435	F7642	F7846	F8027	F8219	F8458	F8657	F8846	F8987	F9222
Sample Start	17-1-96	6-2-96	13-2-96	20-2-96	27-2-96	5-3-96	12-3-96	19-3-96	26-3-96	2-4-96	9-4-96
Sample Stop	6-2-96	13-2-96	20-2-96	27-2-96	5-3-96	12-3-96	19-3-96	26-3-96	2-4-96	9-4-96	16-4-96
SO4	0.250	0.090	0.055	0.108	0.100	0.085	0.208	0.145	0.160	0.100	0.112
NH3 as N	0.133	0.146	0.333	0.211	0.661	0.617	1.670	0.404	0.331	0.364	0.468
NO3 as N	0.060	0.023	0.027	0.014	0.033	0.015	0.053	0.019	0.024	0.014	0.027
NO2 as N	0.0069	0.0064	0.0041	0.0025	0.0089	0.0064	0.0084	0.0066	0.0017	0.0039	0.0021

File #	F9432	F9584	F9785	G1030					G2167	G2415	G2618
Sample Start	16-4-96	23-4-96	30-4-96	7-5-96	21-5-96	28-5-96	4-6-96	11-6-96	11-6-96	18-6-96	25-6-96
Sample Stop	23-4-96	30-4-96	7-5-96	14-5-96	28-5-96	4-6-96	11-6-96	18-6-96	18-6-96	25-6-96	2-7-96
SO4	0.118	0.185	0.131	0.045	--	--	--	--	0.186	0.196	0.181
NH3 as N	0.583	0.528	0.309	0.138	--	--	--	--	0.745	0.664	0.587
NO3 as N	0.026	0.024	0.021	0.006	--	--	--	--	0.041	0.044	0.038
NO2 as N	0.0018	0.0034	0.0014	0.0014	--	--	--	--	0.0042	0.0095	0.0052

File #	G2851	G3096	G3319	G3577	G3782	G4045	G4301	G4511	G4680	G4925	G5139
Sample Start	2-7-96	9-7-96	16-7-96	23-7-96	30-7-96	6-8-96	13-8-96	20-8-96	27-8-96	3-9-96	10-9-96
Sample Stop	9-7-96	16-7-96	23-7-96	30-7-96	6-8-96	13-8-96	20-8-96	27-8-96	3-9-96	10-9-96	17-9-96
SO4	0.361	0.150	0.167	0.349	0.256	0.175	0.194	0.193	0.326	0.104	0.041
NH3 as N	0.775	0.514	0.451	1.001	0.439	0.801	0.824	0.869	0.949	0.486	0.104
NO3 as N	0.069	0.044	0.037	0.048	0.032	0.050	0.037	0.049	0.072	0.018	0.014

NO2 as N	0.0100	0.0082	0.0063	0.0006	0.0037	0.0080	0.0088	0.0130	0.0099	0.0036	0.0015

File #	**G5339**	**G5587**	**G5864**	**G6073**	**G6331**	**G6542**	**G6766**	**G6981**	**G7368**	**G7559**	**G7787**
Sample Start	**17-9-96**	**24-9-96**	**1-10-96**	**8-10-96**	**15-10-96**	**22-10-96**	**29-10-96**	**5-11-96**	**12-11-96**	**25-11-96**	**3-12-96**
Sample Stop	**24-9-96**	**1-10-96**	**8-10-96**	**15-10-96**	**22-10-96**	**29-10-96**	**5-11-96**	**12-11-96**	**25-11-96**	**3-12-96**	**10-12-96**
SO4		N/A			0.011	0.055	0.068	0.062	0.096	0.038	0.035
NH3 as N	0.003	N/A	0.016	0.010	0.085	0.327	0.668	0.433	0.122	0.277	0.566
NO3 as N		N/A			0.003	0.017	0.015	0.017	0.013	0.008	0.021
NO2 as N	0.0006	N/A	0.0002	0.0004	0.0008	0.0032	0.0070	0.0057	0.0019	0.0116	0.0039

File # **Sample Start** **Sample Stop**	**Maximum**	**Minimum**	**Average**
SO4	0.361	0.00008	0.132
NH3 as N	1.670	0.00342	0.477
NO3 as N	0.072	0.00008	0.028
NO2 as N	0.013	0.00015	0.005

Table 5: Rainfall deposition rates at Abbotsford
(Sampler area = 0.212 m^2)

Final Report			G3542	G3826		G4289		G4888	G4941	G5138	G5345
		Sample Date (start)	23-7-96	30-7-96	6-8-96	13-8-96	20-8-96	27-8-96	3-9-96	10-9-96	17-9-96
		Sample Date (stop)	30-7-96	6-8-96	13-8-96	20-8-96	27-8-96	3-9-96	10-9-96	17-9-96	24-9-96
		No. Days	6.89	7.08	6.88	7.09	7.02	6.97	7.04	6.95	7.01
Concentration mg/L	Detection Limit	Sample Comment				20 mm rain limited anal.					
Rainfall (mm)		Rain (mm)	<0.2	22.1	<0.2	0.6		19.4	21.6	60.4	11.2
pH		pH						**6.52**	**6.57**	**6.38**	**6.81**
Sulphate:SO4	<1.0	SO4		**6.240**				<1.0	<1.0	<1.0	**2.556**
Ammonia Nitrogen:N	<0.02	NH3-N						**1.920**	**2.885**	**4.434**	**2.988**
Nitrate Nitrogen:N	<0.005	NO3-N		**0.627**				**0.342**	**0.482**	**0.052**	**0.989**
Nitrite Nitrogen:N	<0.001	NO2-N		**0.022**				**0.022**	**0.037**	**0.035**	**0.040**
Total Phosphate:P	<0.001	PO4-P		**0.034**				**0.025**	**0.034**	**0.035**	**0.027**

Final Report				G6002	G6083	G6319	G6575	G6826	G7105	G7375	
		Sample Date (start)	24-9-96	1-10-96	8-10-96	15-10-96	22-10-96	29-10-96	5-11-96	12-11-96	11/19/96
		Sample Date (stop)	1-10-96	8-10-96	15-10-96	22-10-96	29-10-96	5-11-96	12-11-96	25-11-96	
		No. Days	7.01	6.99	7.01	7.02	7.02	7.00	7.48	13.04	
Concentration mg/L	Detection Limit	Sample Comment									
Rainfall (mm)		Rain (mm)	<0.2	21.6	33.0	50.0	104.0	23.2	25.8	54.4	
pH		pH		**6.8**	**7.03**	**6.1**	**6.36**	**6.42**	**6.69**	**6.03**	
Sulphate:SO4	<1.0	SO4		<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	
Ammonia Nitrogen:N	<0.02	NH3-N		**2.226**	**4.846**	**2.491**	**7.264**	**2.319**	**2.934**	**2.295**	
Nitrate Nitrogen:N	<0.005	NO3-N		**0.254**	**0.485**	**0.377**	**1.527**	**0.729**	**0.424**	**0.897**	
Nitrite Nitrogen:N	<0.001	NO2-N		**0.049**	**0.038**	**0.036**	**0.119**	**0.036**	**0.041**	**0.046**	
Total Phosphate:P	<0.001	PO4-P		**0.022**	**0.047**	**0.014**	**0.030**	**0.017**	**0.017**	**0.013**	

Final Report			G7591		G7979	G8171		G8594	G8570	G8724	G8946
		Sample Date (start)	25-11-96	3-12-96	10-12-96	16-12-96	23-12-96	31-12-96	7-1-97	14-1-97	21-1-97
		Sample Date (stop)	3-12-96	10-12-96	16-12-96	23-12-96	31-12-96	7-1-97	14-1-97	21-1-97	4-2-97
		No. Days	7.99	7.48	5.49	6.93	7.98	7.00	7.00	6.99	14.00
Concentration mg/L	Detection Limit	Sample Comment	* Spiked with Sr: 74-85% recovery 7-8L spl!				Sampler knocked over & lost			Bag slipped & precip found in bucket	Frozen spl to Lab
Rainfall (mm)		Rain (mm)	123.8	79.0	35.2	14.1		129.0	12.8	113	92
pH		pH	**4.78**		**6.18**	**6.07**		**6.31**	**6.81**	**6.72**	**6.55**
Sulphate:SO4	<1.0	SO4	<1.0		<1.0	<1.0		<1.0	<1.0	<1.0	<1.0
Ammonia Nitrogen:N	<0.02	NH3-N	**7.594**		**2.950**	**0.753**		**11.057**	**2.633**	**7.922**	**4.797**
Nitrate Nitrogen:N	<0.005	NO3-N	**11.050**		**0.789**	**0.281**		**1.124**	**0.093**	**1.293**	**0.848**
Nitrite Nitrogen:N	<0.001	NO2-N	**0.093**		**0.064**	**0.033**		**0.092**	**0.071**	**0.065**	**0.053**
Total Phosphate:P	<0.001	PO4-P	**0.031**		**0.026**	**0.004**			**0.016**		**0.046**

Final Report				G9216	G9437		G9756
		Sample Date (start)	1/28/97	4-2-97	11-2-97	18-2-97	25-2-97
		Sample Date (stop)		11-2-97	18-2-97	25-2-97	4-3-97
		No. Days		7.07	6.91	7.01	7.01
Concentration mg/L	Detection Limit	Sample Comment		Frozen spl to Lab		No bags available	
Rainfall (mm)		Rain (mm)		3.2	63	33	36.6
pH		pH		**6.67**	**6.63**		**6.26**
Sulphate:SO4	<1.0	SO4		<1.0	<1.0		<1.0
Ammonia Nitrogen:N	<0.02	NH3-N		**0.389**	**6.473**		**3.653**
Nitrate Nitrogen:N	<0.005	NO3-N		**0.047**	**1.103**		**0.720**
Nitrite Nitrogen:N	<0.001	NO2-N		**0.010**	**0.064**		**0.042**
Total Phosphate:P	<0.001	PO4-P		**0.002**	**0.027**		**0.021**

Table 6: Atmospheric deposition at Abbotsford
(kg/ha/yr = mg/m^2/d * 3.65)

Total Yearly Atmospheric Deposition At Abbotsford				
Daily	**Dry Deposition (mg/m2/d)**	**Maximum**	**Minimum**	**Average**
	SO4	1.270	0.048	0.237
	NH3 as N	2.687	0.163	1.412
	NO3 as N	0.095	0.008	0.041
	NO2 as N	0.058	0.000	0.011
	Average number of dry days:		199	
Daily	**Wet Deposition (mg/m2/d)**	**Maximum**	**Minimum**	**Average**
	SO4	6.240		0.733
	NH3 as N	11.057		2.651
	NO3 as N	11.050		0.767
	NO2 as N	0.119		0.035
	Average number of wet days:		166	
Yearly	**Dry Deposition (mg/m2/yr)**	**Maximum**	**Minimum**	**Average**
	SO4	252.73	9.56	47.19
	NH3 as N	534.71	32.50	281.06
	NO3 as N	18.93	1.50	8.21
	NO2 as N	11.56	0.10	2.12
Yearly	**Wet Deposition (mg/m2/yr)**	**Maximum**	**Minimum**	**Average**
	SO4	1035.84		121.68
	NH3 as N	1835.49		440.01
	NO3 as N	1834.30		127.27
	NO2 as N	19.69		5.74
Yearly	**Total Deposition (mg/m2/yr)**			
		Maximum	**Minimum**	**Average**
	SO4	1288.57	9.56	168.87
	NH3 as N	2370.20	32.50	721.07
	NO3 as N	1853.23	1.50	135.48
	NO2 as N	31.25	0.10	7.86
Yearly	**Total Deposition (kg/ha/yr)**			
		Maximum	**Minimum**	**Average**
	SO4	12.9	0.1	1.7
	NH3 as N	23.7	0.3	7.2
	NO3 as N	18.5	0.0	1.4
	NO2 as N	0.3	0.0	0.1
	Total N	42.5	0.3	8.6

XV. Figures

Figure 1: Lower Fraser Valley sampling area

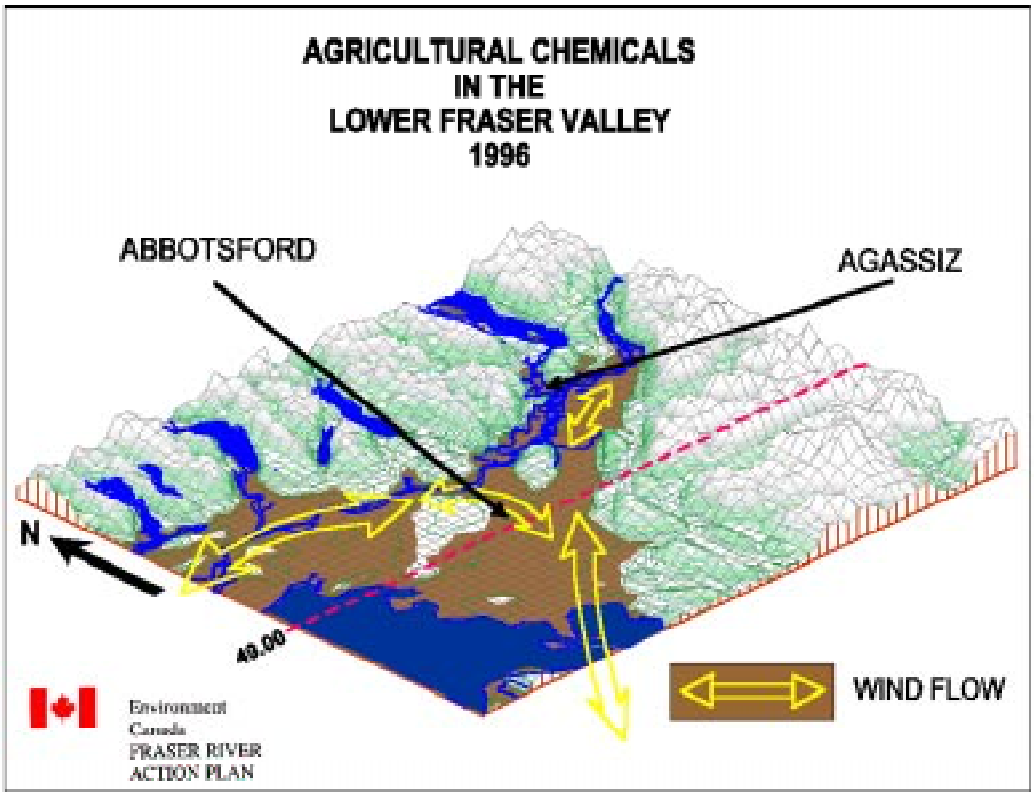


Figure 2: Filter Pack/ Denuder sample head schematic

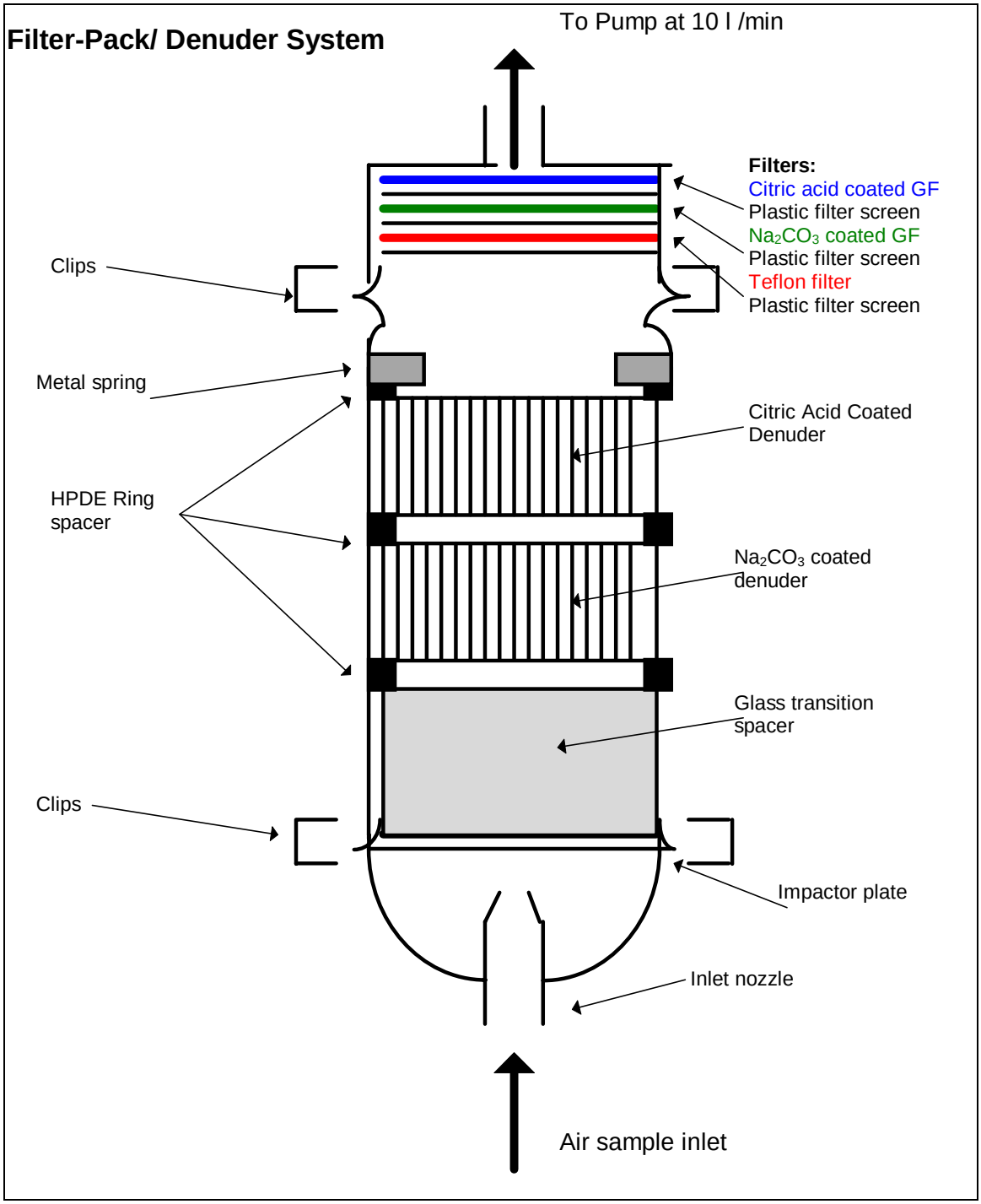


Figure 3: FP/D concentrations at Abbotsford

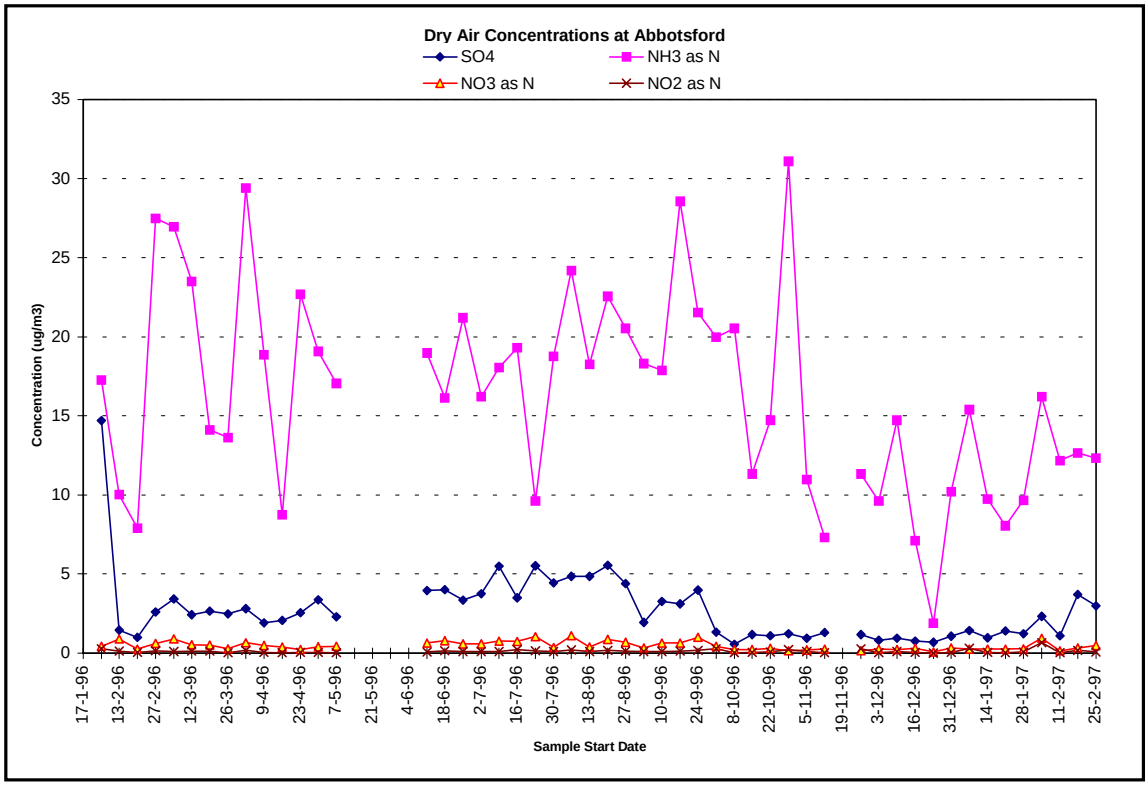


Figure 4: FP/D concentration data at Agassiz

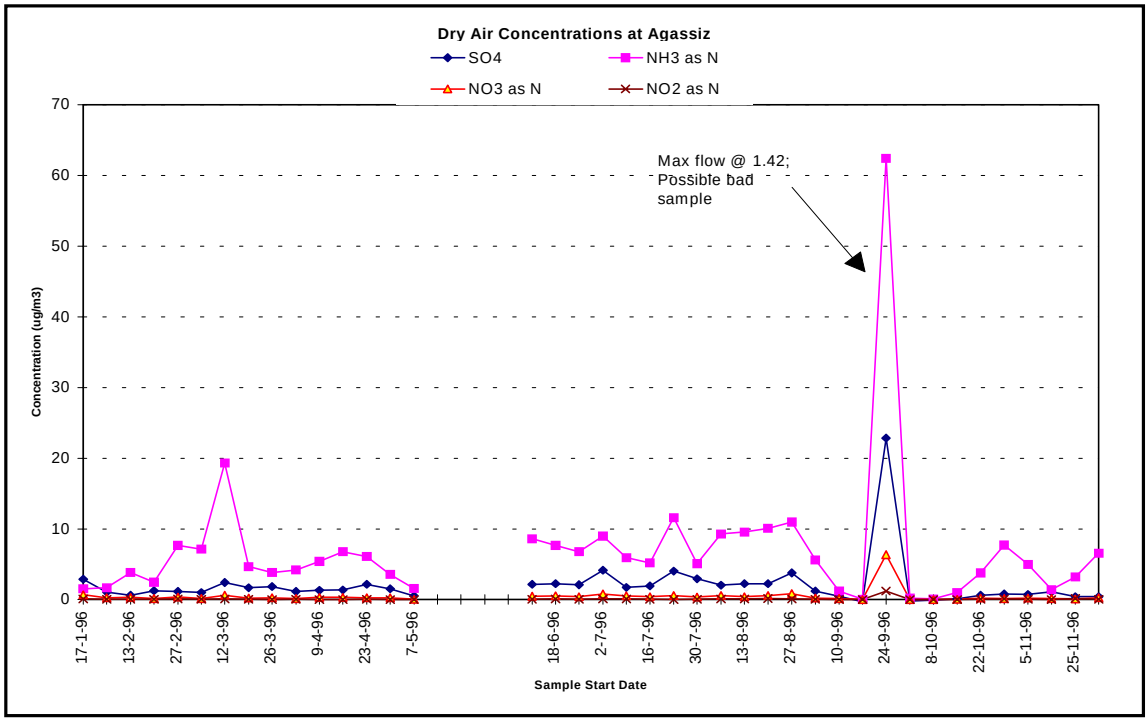


Figure 5: Rainfall concentrations at Abbotsford

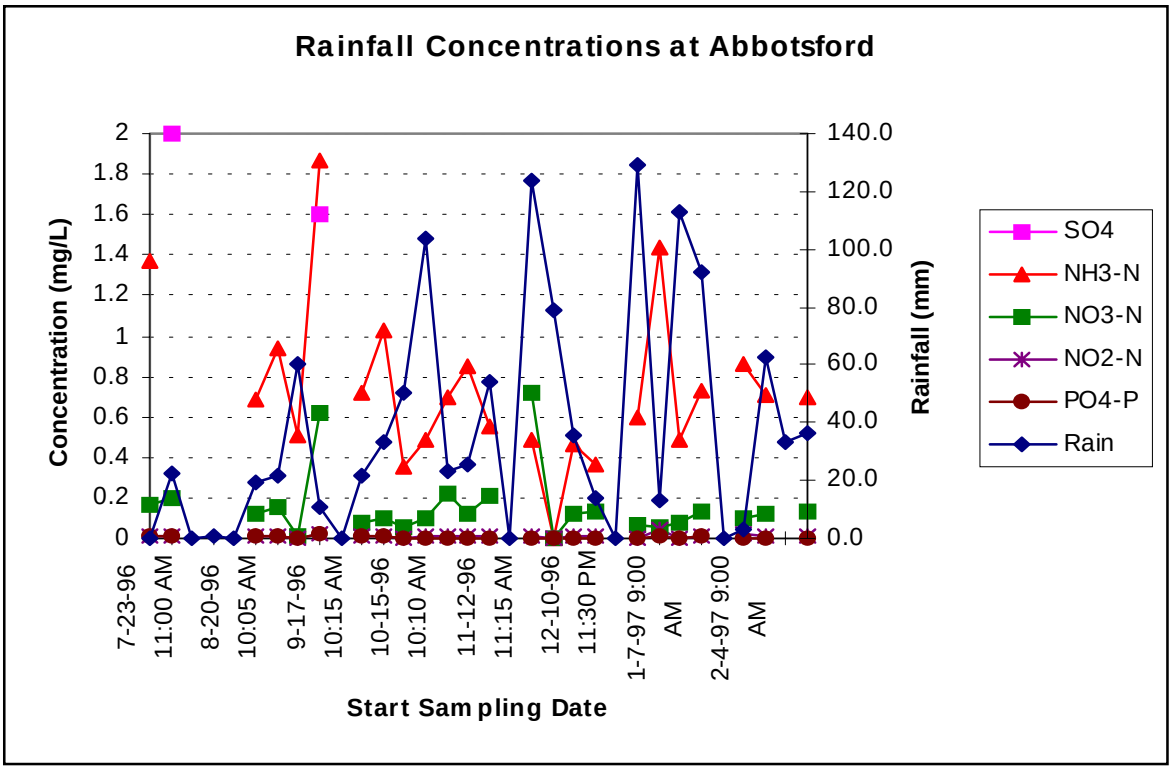


Figure 6: Dry Deposition at Abbotsford

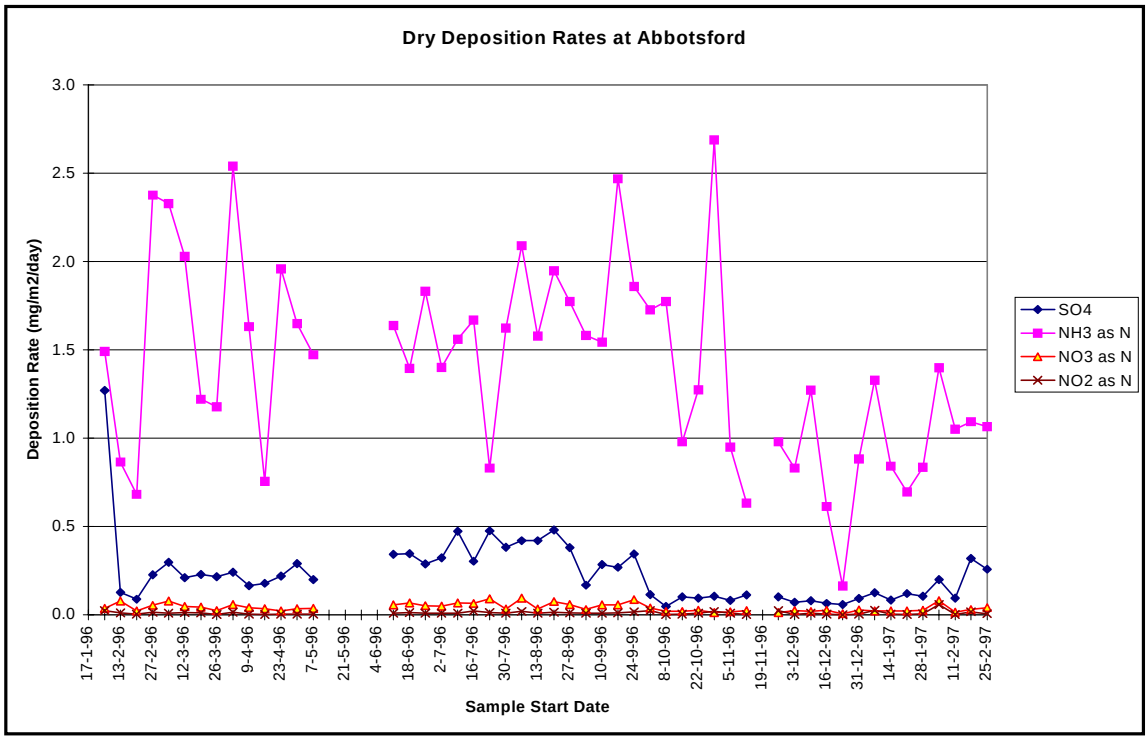


Figure 7: Dry deposition at Agassiz

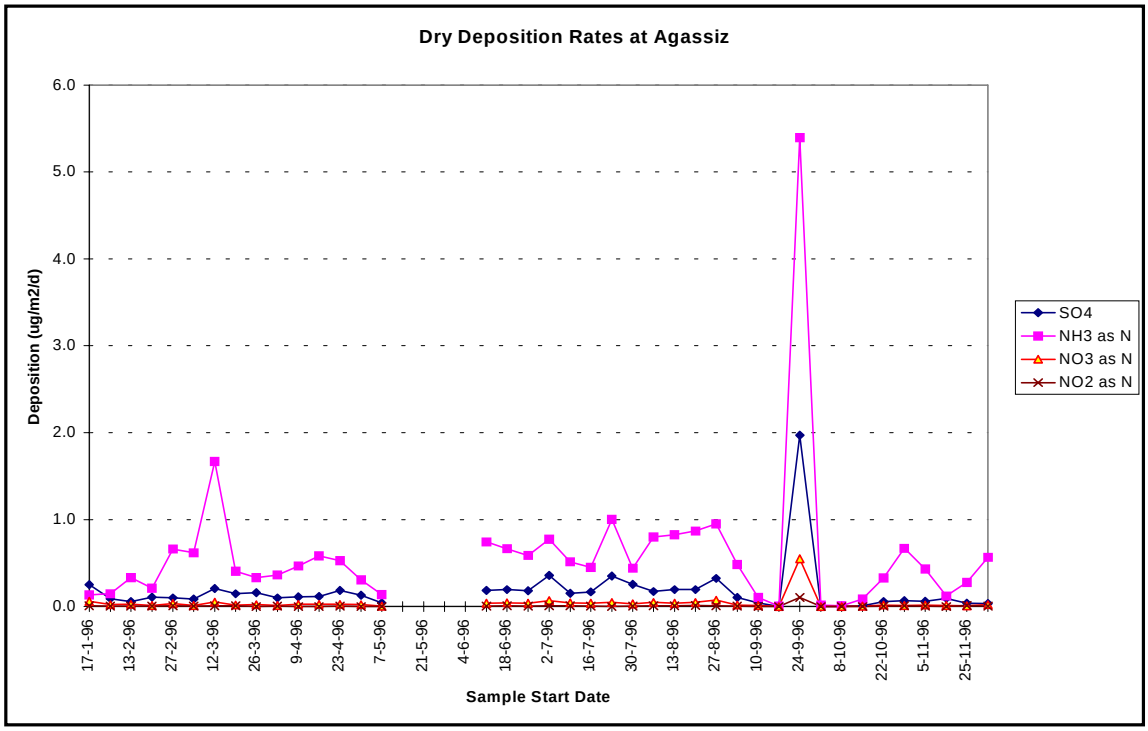


Figure 8: Wet deposition rates at Abbotsford

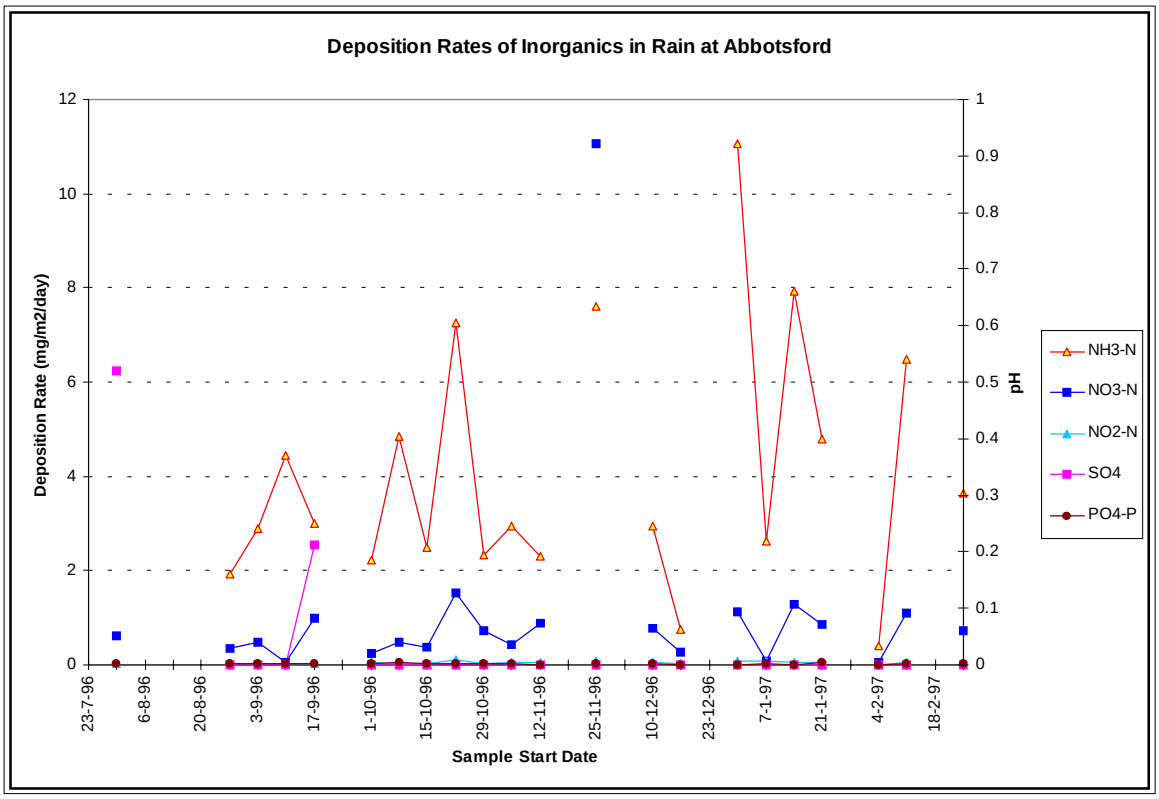
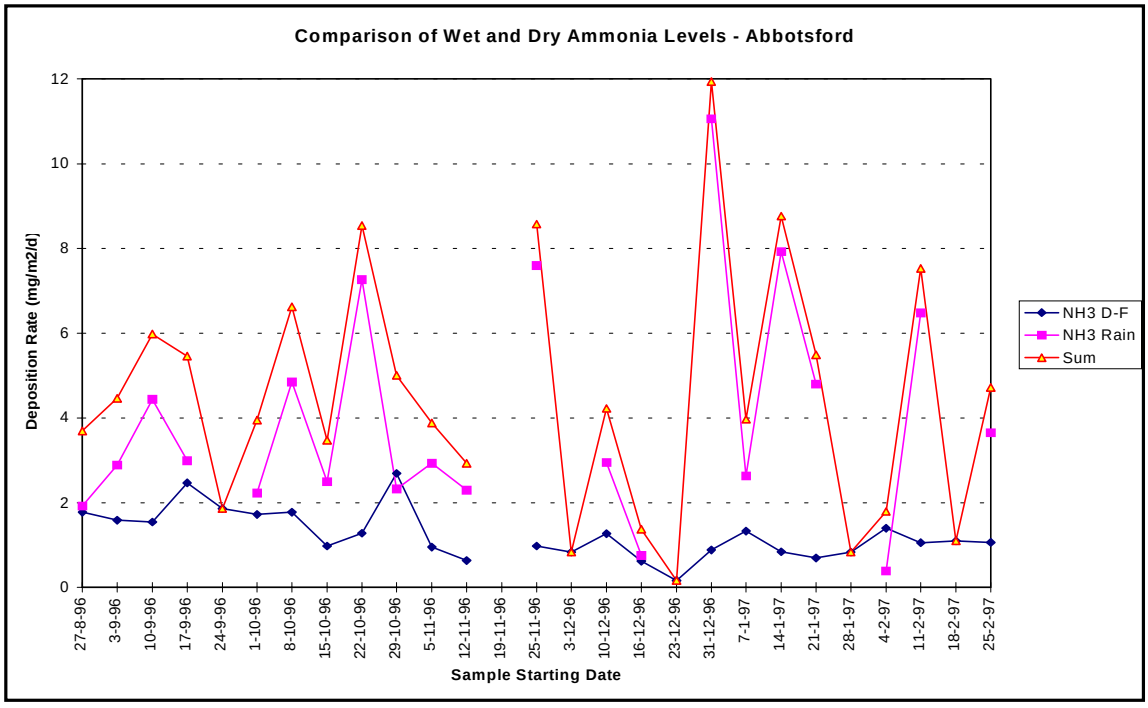


Figure 9: Total Atmospheric Deposition at Abbotsford



XVI. Appendices

Appendix 1: Abbotsford field data

Abbotsford - Ammonia Sample Periods 96-97						
The met data averages and maximums are calculated over a 24-hr period from 9 am to 9am LST and are assumed to be representative of the sampling period.						
The values in this file are from files found in the folders "Met Data from Abbotsford A", "Met Data from Abbotsford Site" and "For Rain Sampling Periods from Abbotsford Site						
Data for rainfall marked by an asterisk (*) was obtained from Abbotsford Airport						
The Pressure is "MSL" pressure (not Station Pressure, which would be lower).						
Sample Start	**2-7-96 9:30 AM**	**2-13-96 11:35 AM**	**2-20-96 10:50 AM**	**2-27-96 11:20 AM**	**3-5-96 11:20 AM**	**3-12-96 11:10 AM**
Sample Stop	**2-13-96 11:30 AM**	**2-20-96 10:45 AM**	**2-27-96 11:10 AM**	**3-5-96 11:15 AM**	**3-9-96 11:00 AM**	**3-19-96 10:40 AM**
Temp max (C)	14.87	18.87	11.3	12.3	11.74	18.47
T Avg (C)	5.84	8.78	3.11	2.86	5.97	8.03
T Avg (K)	279.0	281.9	276.3	276.0	279.1	281.2
P avg (mb) MSL	1019.7	1010.2	1008.8	1017.6	1021.8	1024.6
mm RG	29.6*	> 49.5*	10*	5.8	27.0	10.2
Sample Start	**3-19-96 10:45 AM**	**3-26-96 11:25 AM**	**4-2-96 11:50 AM**	**4-9-96 10:35 AM**	**4-16-96 11:08 AM**	**4-23-96 10:40 AM**
Sample Stop	**3-26-96 11:20 AM**	**4-2-96 11:48 AM**	**4-9-96 10:30 AM**	**4-16-96 11:05 AM**	**4-23-96 10:37 AM**	**4-30-96 10:30 AM**
Temp max (C)	15.1	13.21	21.46	18.78	20.05	16.83
T Avg (C)	6.28	6.57	11.61	10.75	9.88	9.16
T Avg (K)	279.4	279.7	284.8	283.9	283.0	282.3
P avg (mb) MSL	1020.0	1010.7	1019.2	1013.1	1012.4	1022.0
mm RG	20.8	28.4	26.6	32.4	77.8	34.0
Sample Start	**4-30-96 10:35 AM**	**5-7-96 10:04 AM**	**5-14-96 9:33 AM**	**5-21-96 9:02 AM**	**5-28-96 8:31 AM**	**6-4-96 8:00 AM**
Sample Stop	**5-7-96 10:00 AM**	**5-14-96 9:30 PM**	**5-21-96 9:00 AM**	**5-28-96 8:30 PM**	**4-6-96 8:00 AM**	**6-11-96 7:30 PM**
Temp max (C)	17.27	19.4				
T Avg (C)	8.96	10.65	Sampling	Sampling	Sampling	Sampling
T Avg (K)	282.1	283.8	Stopped	Stopped	Stopped	Stopped
P avg (mb) MSL	1020.8	1019.6				
mm RG	24.8	59.0				
Sample Start	**6-11-96 10:05 AM**	**6-18-96 9:53 AM**	**6-25-96 9:20 AM**	**7-2-96 10:20 AM**	**7-9-96 10:15 AM**	**7-16-96 9:55 AM**
Sample Stop	**6-18-96 9:50 AM**	**6-25-96 9:45 AM**	**7-2-96 10:08 AM**	**7-9-96 10:10 AM**	**7-16-96 9:48 AM**	**7-23-96 11:15 AM**
Temp max (C)	22.73	24.33	25.42	28.74	32.48	28.11
T Avg (C)	13.41	14.55	16.50	17.07	20.35	15.68
T Avg (K)	286.6	287.7	289.7	290.2	293.5	288.8
P avg (mb) MSL	1019.9	1015.5	1017.2	1017.5	1016.7	1019.9
mm RG	1.0	4.4	7.9	5.8	<0.2	22.8
Sample Start	**7-23-96 11:25 AM**	**7-30-96 8:20 AM**	**8-6-96 12:00 PM**	**8-13-96 8:30 AM**	**8-20-96 9:32 AM**	**8-27-96 9:50 AM**
Sample Stop	**7-30-96 8:00 AM**	**8-6-96 10:30 AM**	**8-13-96 8:30 AM**	**8-20-96 9:30 AM**	**8-27-96 9:50 AM**	**9-3-96 10:00 AM**
Temp max (C)	33.16	25.1	31.2	30.2	32.97	34.72
T Avg (C)	22.72	15.95	19.77	17.43	19.22	17.79
T Avg (K)	295.9	289.1	292.9	290.6	292.4	291.0
P avg (mb) MSL	1015.7	1015.9	1018.3	1019.1	1016.0	1016.1
mm RG	<0.2	22.1	<0.2	0.6	0.0	19.4
Sample Start	**9-2-96 10:15 AM**	**9-10-96 11:00 AM**	**9-17-96 10:45 AM**	**9-24-96 10:20 AM**	**10-1-96 11:00 AM**	**10-8-96 10:20 AM**
Sample Stop	**9-10-96 10:45 AM**	**9-17-96 10:00 AM**	**9-24-96 10:15 AM**	**10-1-96 10:55 AM**	**10-8-96 9:55 AM**	**10-15-96 9:30 AM**
Temp max (C)	21.08	27.41	20.1	22.37	20.4	25
T Avg (C)	13.74	15.11	11.28	12.66	13.41	13.17
T Avg (K)	286.9	288.3	284.4	285.8	286.6	286.3
P avg (mb) MSL	1015.2	1009.0	1021.3	1019.6	1018.3	1014.1
mm RG	21.6	60.4	11.2	<0.2	21.6	33.0
Sample Start	**10-15-96 9:30 AM**	**10-22-96 10:15 AM**	**10-29-96 10:30 AM**	**11-5-96 11:25 AM**	**11-12-96 10:50 PM**	**11-25-96 1:20 PM**
Sample Stop	**10-22-96 10:00 AM**	**10-29-96 10:23 AM**	**11-5-96 10:45 AM**	**11-12-96 10:20 AM**	**11-25-96 1:10 PM**	**12-3-96 11:45 AM**
Temp max (C)	11.83	13.59	15.51	15.66	-0.06	9.32
T Avg (C)	6.44	7.66	6.59	9.31	12.47	3.94
T Avg (K)	279.6	280.8	279.8	282.5	285.6	277.1
P avg (mb) MSL	1016.3	1015.1	1020.6	1019.9	1012.8	1017.0
mm RG	50.0	104.0	23.2	25.8	na	na
Sample Start	**12-3-96 12:00 PM**	**12-10-96 11:45 AM**	**12-16-96 11:00 AM**	**12-23-96 9:40 AM**	**12-31-96 9:30 AM**	**1-7-97 9:00 AM**
Sample Stop	**12-10-96 11:35 AM**	**12-16-96 11:00 AM**	**12-23-96 9:30 AM**	**12-31-96 9:30 AM**	**1-7-97 9:00 AM**	**1-14-97 8:45 AM**
Temp max (C)	6.7	9.44	4.336	8.09	12.92	8.04
T Avg (C)	3.26	3.57	-0.94	-8.06	4.59	2.68
T Avg (K)	276.4	276.7	272.2	265.1	277.8	275.8
P avg (mb) MSL	1003.7	1019.4	1017.0	1009.2	1012.0	1023.3
mm RG	73.0	79.0	35.2	na	na	129.0
Sample Start	**1-14-97 8:45 AM**	**1-21-97 8:45 AM**	**1-28-97 8:45 AM**	**2-4-97 8:45 AM**	**2-11-97 10:00 AM**	**2-18-97 9:00 AM**
Sample Stop	**1-21-97 8:45 AM**	**1-28-97 8:45 AM**	**2-4-97 8:40 AM**	**2-11-97 9:55 AM**	**2-18-97 9:00 AM**	**2-25-97 9:00 AM**

Appendix 2: Agassiz field data

Agassiz - Ammonia Sample Periods 96-97							
The values for rain can be found in the folder "For Rain Sampling Periods from Agassiz Site							
Sample Start	**1-17-96 12:40 PM**	**2-6-96 1:17 PM**	**2-13-96 9:25 AM**	**2-20-96 9:10 AM**	**2-27-96 8:50 AM**	**3-5-96 9:15 AM**	**3-12-96 9:05 AM**
Sample Stop	**2-6-96 12:35 PM**	**2-13-96 9:15 AM**	**2-20-96 9:00 AM**	**2-27-96 8:40 AM**	**3-5-96 9:10 AM**	**3-12-96 9:00 AM**	**3-19-96 8:55 AM**
T max (C)	9.7	13.9	17.5	9.4	12.6	15.5	18.9
T avg (C)	-2.7	7.0	10.3	3.7	3.5	8.1	9.1
T avg (K)	270.5	280.2	283.5	276.9	276.7	281.3	282.3
P avg (MSL mb)	1016.4	1019.8	1010.7	1009.8	1019.7	1020.4	1025.2
mm RG	17.2	64.4	34.4	15.4	10.6	26.8	16.4
Sample Start	**3-19-96 9:00 AM**	**3-26-96 9:50 AM**	**4-2-96 9:30 AM**	**4-9-96 8:55 AM**	**4-16-96 8:58 AM**	**4-23-96 8:50 AM**	**4-30-96 8:02 AM**
Sample Stop	**3-26-96 8:40 AM**	**4-2-96 9:00 AM**	**4-9-96 8:50 AM**	**4-16-96 8:53 AM**	**4-23-96 8:45 AM**	**4-30-96 8:58 AM**	**5-7-96 8:13 AM**
T max (C)	14.5	14.0	21.8	19.5	20.0	15.6	17.1
T avg (C)	7.1	7.0	12.1	11.2	10.4	9.2	9.1
T avg (K)	280.3	280.2	285.3	284.4	283.6	282.4	282.3
P avg (MSL mb)	1020.9	1011.8	1020	1013.8	1013.1	1022.8	1021.5
mm RG	9.0	40.0	22.6	26.0	49.4	40.8	20.6
Sample Start	**5-7-96 8:15 AM**	**5-14-96 8:00 AM**	**5-21-96 12:00 AM**	**5-28-96 12:00 AM**	**6-4-96 12:00 AM**	**6-11-96 7:50 AM**	**6-18-96 7:55 AM**
Sample Stop	**5-14-96 8:00 AM**	**5-21-96 12:00 AM**	**5-28-96 12:00 AM**	**6-4-96 12:00 AM**	**6-11-96 12:00 AM**	**6-18-96 7:55 AM**	**6-25-96 8:00 AM**
T max (C)	18.7					23.1	24.6
T avg (C)	10.9					14.7	15.6
T avg (K)	284.1					287.9	288.8
P avg (MSL mb)	1020.4	no sampling	no sampling	no sampling	no sampling	1020.5	1016
mm RG	48.4					3.6	3.8
Sample Start	**6-25-96 8:02 AM**	**7-2-96 8:07 AM**	**7-9-96 8:15 AM**	**7-16-96 8:07 AM**	**7-23-96 8:40 AM**	**7-30-96 11:30 AM**	**8-6-96 9:00 AM**
Sample Stop	**7-2-96 8:00 AM**	**7-9-96 8:10 AM**	**7-16-96 8:04 AM**	**7-23-96 8:35 AM**	**7-30-96 11:10 AM**	**8-6-96 8:50 AM**	**8-13-96 11:50 AM**
T max (C)	25.9	29.7	33.2	29.5	32.9	25.5	32.0
T avg (C)	17.3	18.3	21.8	16.4	23.9	15.7	20.0
T avg (K)	290.5	291.5	295.0	289.6	297.1	288.9	293.2
P avg (MSL mb)	1017.3	1017.9	1017.1	1020.6	1015.9	1016.5	1018.9
mm RG	9.1	12.4	<0.2	29.8	<0.2	58.4	<0.2
Sample Start	**8-13-96 12:00 AM**	**8-20-96 8:00 AM**	**8-27-96 8:00 AM**	**9-3-96 8:20 AM**	**9-10-96 8:00 AM**	**9-17-96 8:05 AM**	**9-24-96 8:35 AM**
Sample Stop	**8-20-96 7:52 AM**	**8-27-96 8:00 AM**	**9-3-96 8:20 AM**	**9-10-96 7:55 AM**	**9-17-96 8:00 AM**	**9-24-96 8:35 AM**	**10-1-96 8:25 AM**
T max (C)	29.9	32.5	34.0	21.4	26.2	20.2	22.9
T avg (C)	17.2	19.0	17.4	13.3	15.5	11.6	13.2
T avg (K)	290.4	292.2	290.6	286.5	288.7	284.8	286.4
P avg (MSL mb)	1019.7	1016.8	1016.9	1016.2	1009.8	1022	1020.1
mm RG	2.0	1.0	28.2	50.0	50.4	26.6	0.2
Sample Start	**10-1-96 9:55 AM**	**10-8-96 8:35 AM**	**10-15-96 9:15 AM**	**10-22-96 8:35 AM**	**10-29-96 8:43 AM**	**11-5-96 9:35 AM**	**11-12-96 9:15 AM**
Sample Stop	**10-8-96 8:00 AM**	**10-15-96 8:08 AM**	**10-22-96 7:45 AM**	**10-29-96 8:40 AM**	**11-5-96 8:55 AM**	**11-12-96 8:55 AM**	**11-25-96 9:20 AM**
T max (C)	19.7	24.7	12.4	12.0	13.8	15.0	12.7
T avg (C)	13.1	12.6	6.3	7.7	7.0	9.3	2.2
T avg (K)	286.3	285.8	279.5	280.9	280.2	282.5	275.4
P avg (MSL mb)	1019.2	1014.8	1017.3	1016.9	1021.8	1020.7	1014.5
mm RG	42.6	54.6	78.4	80.0	17.8	53.2	na
Sample Start	**11-25-96 9:45 AM**	**12-3-96 10:10 AM**					
Sample Stop	**12-3-96 10:00 AM**	**12-10-96 9:25 AM**					
T max (C)	8.8	5.3					
T avg (C)	3.1	2.3					
T avg (K)	276.3	275.5					
P avg (MSL mb)	1018	1004.8					
mm RG	138.0	82.0					

Appendix 3: Abbotsford sample data

Abbotsford Data
Dry Ammonia

File # **Version** **Sample Start** **Sample Stop**	**F7324** **final** **17-1-96** **5-2-96**	**F7435** **final** **7-2-96** **13-2-96**	**F7642** **final** **13-2-96** **20-2-96**	**F7846** **final** **20-2-96** **27-2-96**	**F8027** **final** **27-2-96** **5-3-96**	**F8219** **final** **5-3-96** **12-3-96**
Head ID		4	6	5		
Lab File #						
Version						
Sample Start		**2-7-96 9:30 AM**	**2-13-96 11:35 AM**	**2-20-96 10:50 AM**	**2-27-96 11:20 AM**	**3-5-96 11:20 AM**
Sample Stop		**2-13-96 11:30 AM**	**2-20-96 10:45 AM**	**2-27-96 11:10 AM**	**3-5-96 11:15 AM**	**3-9-96 11:00 AM**
Flow (l/m) start		1.650	6.000	3.768	6.545	1.739
Flow (l/m) stop		6.592	>10	>10	6.518	6.563
Rotometer start		1.65	9	9	6	5
Rotometer stop		1.9	16	18	9	9
Comments	Sample test		Flow >10 l/min	flow -> 9 or 7.922	lock valve nut	
	data not used	Flow at end used	Avg Rotameter used	Avg Rotameter used	Mar 1 @ 6.545	Flow at end used
Flow (l/m) avg.		6.592	12.5	13.5	6.5315	6.563
Temp max (C)		14.9	18.9	11.3	12.3	11.7
Time spl (hh:mm)		146:00:00	167:10:00	168:20:00	167:55:00	95:40:00
Time in min.		8760.00	10030.00	10100.00	10075.00	5740.00
T Avg (K)		279.0	281.9	276.3	276.0	279.1
P avg (mb) MSL		1019.7	1010.2	1008.8	1017.6	1021.8
Volume spld (m3)		57.75	125.38	136.35	65.80	37.67
V corr (m^3)		62.09	132.15	146.46	71.37	40.57

ug/m3 corrected						
SO_4		14.70	1.47	1.01	2.62	3.43

		0.00	0.00	0.00	0.00	0.00
NH_3 as N		17.26	10.02	7.91	27.49	26.96
NO_3 as N		0.43	0.89	0.25	0.63	0.90
NO_2 as N		0.28	0.12	0.06	0.16	0.11

Abbotsford Data
Dry Ammonia

File # **Version** **Sample Start** **Sample Stop**	**F8458** **final** **12-3-96** **19-3-96**	**F8657** **final** **19-3-96** **26-3-96**	**F8846** **final** **26-3-96** **2-4-96**	**F8987** **final** **2-4-96** **9-4-96**	**F9222** **final** **9-4-96** **16-4-96**	**F9432** **final** **16-4-96** **23-4-96**
Head ID	2			5		
Lab File #						
Version						
Sample Start	**3-12-96 11:10 AM**	**3-19-96 10:45 AM**	**3-26-96 11:25 AM**	**4-2-96 11:50 AM**	**4-9-96 10:35 AM**	**4-16-96 11:08 AM**
Sample Stop	**3-19-96 10:40 AM**	**3-26-96 11:20 AM**	**4-2-96 11:48 AM**	**4-9-96 10:30 AM**	**4-16-96 11:05 AM**	**4-23-96 10:37 AM**
Flow (l/m) start	2.920	2.029	5.836	6.104	6.345	6.366
Flow (l/m) stop	6.565	6.569	6.636	6.577	6.483	6.335
Rotometer start	6	5	8	8	8	8
Rotometer stop	8	8	8	8	8	8
Comments						
	Flow at end used	Flow at end used				
Flow (l/m) avg.	6.565	6.569	6.236	6.3405	6.414	6.3505
Temp max (C)	18.5	15.1	13.2	21.5	18.8	20.1
Time spl (hh:mm)	167:30:00	168:35:00	168:23:00	166:40:00	168:30:00	167:29:00
Time in min.	10050.00	10115.00	10103.00	10000.00	10110.00	10049.00
T Avg (K)	281.2	279.4	279.7	284.8	283.9	283.0
P avg (mb) MSL	1024.6	1020.0	1010.7	1019.2	1013.1	1012.4
Volume spld (m3)	65.98	66.45	63.00	63.41	64.85	63.82
V corr (m^3)	70.72	71.36	66.96	66.76	68.07	67.15

ug/m3 corrected						
SO_4	2.43	2.65	2.48	2.80	1.91	2.07
	0.00	0.00	0.00	0.00	0.00	0.00
NH_3 as N	23.49	14.11	13.63	29.39	18.88	8.74
NO_3 as N	0.55	0.50	0.28	0.67	0.48	0.39
NO_2 as N	0.14	0.12	0.02	0.17	0.04	0.02

Abbotsford Data
Dry Ammonia

File #	**F9584**	**F9785**	**G1030**			
Version	**final**	**final**	**final**			
Sample Start	**23-4-96**	**30-4-96**	**7-5-96**	**14-5-96**	**21-5-96**	**28-5-96**
Sample Stop	**30-4-96**	**7-5-96**	**14-5-96**	**21-5-96**	**28-5-96**	**4-6-96**
Head ID						
Lab File #						
Version						
Sample Start	**4-23-96 10:40 AM**	**4-30-96 10:35 AM**	**5-7-96 10:04 AM**	**5-14-96 9:33 AM**	**5-21-96 9:02 AM**	**5-28-96 8:31 AM**
Sample Stop	**4-30-96 10:30 AM**	**5-7-96 10:00 AM**	**5-14-96 9:30 PM**	**5-21-96 9:00 AM**	**5-28-96 8:30 PM**	**4-6-96 8:00 AM**
Flow (l/m) start	5.555	5.791	??			
Flow (l/m) stop	6.234	??	6.348			
Rotometer start	8	7	7			
Rotometer stop	8	8	8			
Comments		Flow meter dead	Flow meter dead	No sampling	No sampling	No sampling
Flow (l/m) avg.	5.8945	5.791	6.348			
Temp max (C)	16.8	17.3	19.4			
Time spl (hh:mm)	167:50:00	167:25:00	179:26:00			
Time in min.	10070.00	10045.00	10766.00			

T Avg (K)	282.3	282.1	283.8			
P avg (mb) MSL	1022.0	1020.8	1019.6			
Volume spld (m3)	59.36	58.17	68.34			
V corr (m^3)	63.21	61.92	72.23			

ug/m3 corrected						
SO_4	2.55	3.36	2.31			
	0.00	0.00	0.00			
NH_3 as N	22.67	19.07	17.04			
NO_3 as N	0.24	0.40	0.43			
NO_2 as N	0.04	0.05	0.04			

Abbotsford Data
Dry Ammonia

File # **Version** **Sample Start** **Sample Stop**	**4-6-96** **11-6-96**	**G2167** **final** **11-6-96** **18-6-96**	**G2415** **final** **18-6-96** **25-6-96**	**G2618** **final** **25-6-96** **2-7-96**	**G2851** **final** **2-7-96** **9-7-96**	**G3096** **final** **9-7-96** **16-7-96**
Head ID		6				
Lab File #						
Version						
Sample Start	**6-4-96 8:00 AM**	**6-11-96 10:05 AM**	**6-18-96 9:53 AM**	**6-25-96 9:20 AM**	**7-2-96 10:20 AM**	**7-9-96 10:15 AM**
Sample Stop	**6-11-96 7:30 PM**	**6-18-96 9:50 AM**	**6-25-96 9:45 AM**	**7-2-96 10:08 AM**	**7-9-96 10:10 AM**	**7-16-96 9:48 AM**
Flow (l/m) start		4.356	4.060	6.360	6.300	5.990
Flow (l/m) stop		6.388	6.420	6.350	6.240	6.030
Rotometer start		7	7	8	6	6
Rotometer stop		8	8	6	6	7
Comments	No sampling					
Flow (l/m) avg.		5.372	5.24	6.355	6.27	6.01

Temp max (C)		22.7	24.3	25.4	28.7	32.5
Time spl (hh:mm)		167:45:00	167:52:00	168:48:00	167:50:00	167:33:00
Time in min.		10065.00	10072.00	10128.00	10070.00	10053.00
T Avg (K)		286.6	287.7	289.7	290.2	293.5
P avg (mb) MSL		1019.9	1015.5	1017.2	1017.5	1016.7
Volume spld (m3)		54.07	52.78	64.36	63.14	60.42
V corr (m^3)		56.61	54.80	66.49	65.12	61.57

ug/m3 corrected						
SO_4		3.96	4.01	3.34	3.75	5.49
		0.00	0.00	0.00	0.00	0.00
NH_3 as N		18.96	16.14	21.19	16.21	18.05
NO_3 as N		0.65	0.78	0.60	0.58	0.76
NO_2 as N		0.09	0.16	0.10	0.10	0.10

Abbotsford Data
Dry Ammonia

File # **Version** **Sample Start** **Sample Stop**	**G3319** **final** **16-7-96** **23-7-96**	**G3577** **final** **23-7-96** **30-7-96**	**G3782** **final** **30-7-96** **6-8-96**	**G4045** **final** **6-8-96** **13-8-96**	**G4301** **final** **13-8-96** **20-8-96**	**G4511** **final** **20-8-96** **27-8-96**
Head ID						
Lab File #						
Version						
Sample Start	**7-16-96 9:55 AM**	**7-23-96 11:25 AM**	**7-30-96 8:20 AM**	**8-6-96 12:00 PM**	**8-13-96 8:30 AM**	**8-20-96 9:32 AM**
Sample Stop	**7-23-96 11:15 AM**	**7-30-96 8:00 AM**	**8-6-96 10:30 AM**	**8-13-96 8:30 AM**	**8-20-96 9:30 AM**	**8-27-96 9:50 AM**
Flow (l/m) start	5.200	5.760	5.900	5.400	6.130	6.065
Flow (l/m) stop	6.210	6.930	5.960	5.980	5.976	5.920
Rotometer start	7.1					

Rotometer stop	7.5		7.5			
Comments		power bar had tripped				
		reset on Jul 26 @~1400				
Flow (l/m) avg.	5.705	6.345	5.93	5.69	6.053	5.9925
Temp max (C)	28.1	33.2	25.1	31.2	30.2	33.0
Time spl (hh:mm)	169:20:00	164:35:00	170:10:00	164:30:00	169:00:00	168:18:00
Time in min.	10160.00	9875.00	10210.00	9870.00	10140.00	10098.00
T Avg (K)	288.8	295.9	289.1	292.9	290.6	292.4
P avg (mb) MSL	1019.9	1015.7	1015.9	1018.3	1019.1	1016.0
Volume spld (m3)	57.96	62.66	60.55	56.16	61.38	60.51
V corr (m^3)	60.21	63.27	62.59	57.43	63.32	61.86

ug/m3 corrected						
SO_4	3.50	5.52	4.44	4.86	4.86	5.54
	0.00	0.00	0.00	0.00	0.00	0.00
NH_3 as N	19.30	9.62	18.77	24.18	18.25	22.54
NO_3 as N	0.75	1.04	0.37	1.10	0.37	0.87
NO_2 as N	0.24	0.15	0.09	0.21	0.09	0.17

Abbotsford Data
Dry Ammonia

File #	**G4680**	**G4925**	**G5139**	**G5339**	**G5587**	**G5864**
Version	**final**	**final**	**final**	**final**	**final**	**final**
Sample Start	**27-8-96**	**3-9-96**	**10-9-96**	**17-9-96**	**24-9-96**	**1-10-96**
Sample Stop	**3-9-96**	**10-9-96**	**17-9-96**	**24-9-96**	**1-10-96**	**8-10-96**
Head ID						
Lab File #						
Version						
Sample Start	**8-27-96 9:50 AM**	**9-3-96 10:15 AM**	**9-10-96 11:00 AM**	**9-17-96 10:45 AM**	**9-24-96 10:20 AM**	**10-1-96 11:00 AM**

Sample Stop	9-3-96 10:00 AM	9-10-96 10:45 AM	9-17-96 10:00 AM	9-24-96 10:15 AM	10-1-96 10:55 AM	10-8-96 9:55 AM
Flow (l/m) start	5.936	5.920	6.170	5.830	5.060	4.662
Flow (l/m) stop	5.920	6.027	6.018	1.800	5.012	4.876
Rotometer start						
Rotometer stop						
Comments				Flow dropped		reset ->8.350
				Problem w pump?		
Flow (l/m) avg.	5.928	5.9735	6.094	3.815	5.036	4.769
Temp max (C)	34.7	21.1	27.4	20.1	22.4	20.4
Time spl (hh:mm)	168:10:00	168:30:00	167:00:00	167:30:00	168:35:00	166:55:00
Time in min.	10090.00	10110.00	10020.00	10050.00	10115.00	10015.00
T Avg (K)	291.0	286.9	288.3	284.4	285.8	286.6
P avg (mb) MSL	1016.1	1015.2	1009.0	1021.3	1019.6	1018.3
Volume spld (m3)	59.81	60.39	61.06	38.34	50.94	47.76
V corr (m^3)	61.45	62.86	62.87	40.50	53.46	49.93

ug/m3 corrected						
SO_4	4.41	1.94	3.28	3.12	3.98	1.32
	0.00	0.00	0.00	0.00	0.00	0.00
NH_3 as N	20.53	18.31	17.87	28.56	21.52	19.97
NO_3 as N	0.68	0.34	0.64	0.64	0.99	0.44
NO_2 as N	0.12	0.10	0.10	0.13	0.19	0.28

Abbotsford Data
Dry Ammonia

File #	G6073	G6331	G6542	G6766	G6981	G7368
Version	final		final	final	final	final
Sample Start	8-10-96	15-10-96	22-10-96	29-10-96	5-11-96	12-11-96
Sample Stop	15-10-96	22-10-96	29-10-96	5-11-96	12-11-96	25-11-96

Head ID						
Lab File #						
Version						
Sample Start	**10-8-96 10:20 AM**	**10-15-96 9:30 AM**	**10-22-96 10:15 AM**	**10-29-96 10:30 AM**	**11-5-96 11:25 AM**	**11-12-96 10:50 AM**
Sample Stop	**10-15-96 9:30 AM**	**10-22-96 10:00 AM**	**10-29-96 10:23 AM**	**11-5-96 10:45 AM**	**11-12-96 10:20 AM**	**11-25-96 1:10 PM**
Flow (l/m) start	7.984	9.868	11.160	4.179	13.050	9.592
Flow (l/m) stop	3.819	12.970	10.620	3.042	13.540	**
Rotometer start						
Rotometer stop						
Comments	Flow dropped	reset to 10.91 l/m		3.18 max! pump dead		Flowmeter dead
	Problem w pump?					2 wk spl
Flow (l/m) avg.	5.9015	11.419	10.89	3.6105	13.295	9.592
Temp max (C)	25.0	11.8	13.6	15.5	15.7	-0.1
Time spl (hh:mm)	167:10:00	168:30:00	168:08:00	168:15:00	166:55:00	314:20:00
Time in min.	10030.00	10110.00	10088.00	10095.00	10015.00	18860.00
T Avg (K)	286.3	279.6	280.8	279.8	282.5	285.6
P avg (mb) MSL	1014.1	1016.3	1015.1	1020.6	1019.9	1012.8
Volume spld (m3)	59.19	115.45	109.86	36.45	133.15	180.91
V corr (m^3)	61.67	123.44	116.82	39.12	141.43	188.70

ug/m3 corrected						
SO_4	0.56	1.17	1.10	1.23	0.95	1.30
	0.00	0.00	0.00	0.00	0.00	0.00
NH_3 as N	20.53	11.32	14.74	31.10	10.98	7.31
NO_3 as N	0.23	0.23	0.31	0.16	0.20	0.27
NO_2 as N	0.03	0.06	0.09	0.22	0.10	0.03

Abbotsford Data
Dry Ammonia

File # Version Sample Start Sample Stop	N/A 19-11-96 25-11-96	G7559 final 25-11-96 3-12-96	G7787 final 3-12-96 10-12-96	G7955 final 10-12-96 16-12-96	G8169 final 16-12-96 23-12-96	G8238 final 23-12-96 31-12-96
Head ID						
Lab File #						
Version						
Sample Start		**11-25-96 1:20 PM**	**12-3-96 12:00 PM**	**12-10-96 11:45 AM**	**12-16-96 11:00 AM**	**12-23-96 9:40 AM**
Sample Stop		**12-3-96 11:45 AM**	**12-10-96 11:35 AM**	**12-16-96 11:00 AM**	**12-23-96 9:30 AM**	**12-31-96 9:30 AM**
Flow (l/m) start		**	9.200	10.500	10.060	9.100
Flow (l/m) stop		2.670	10.600	10.800	9.830	10.170
Rotometer start						
Rotometer stop						
Comments		Sample head knocked				
		off; Spl bad ??				
Flow (l/m) avg.		2.67	9.9	10.65	9.945	9.635
Temp max (C)		9.3	6.7	9.4	4.3	8.1
Time spl (hh:mm)		190:25:00	167:35:00	143:15:00	166:30:00	191:50:00
Time in min.		11425.00	10055.00	8595.00	9990.00	11510.00
T Avg (K)		277.1	276.4	276.7	272.2	265.1
P avg (mb) MSL		1017.0	1003.7	1019.4	1017.0	1009.2
Volume spld (m3)		30.50	99.54	91.54	99.35	110.90
V corr (m^3)		32.94	106.33	99.20	109.19	124.19

ug/m3 corrected						
SO_4		1.17	0.82	0.93	0.76	0.68
		0.00	0.00	0.00	0.00	0.00
NH_3 as N		11.32	9.62	14.72	7.11	1.89
NO_3 as N		0.15	0.27	0.23	0.31	0.09
NO_2 as N		0.28	0.03	0.11	0.05	0.01

Abbotsford Data
Dry Ammonia

File # Version Sample Start Sample Stop	G8331 final 31-12-96 7-1-97	G8498 final 7-1-97 14-1-97	G8667 final 14-1-97 21-1-97	G8837 final 21-1-97 28-1-97	G9021 final 28-1-97 4-2-97	G9182 final 4-2-97 11-2-97
Head ID						
Lab File #						
Version						
Sample Start	**12-31-96 9:30 AM**	**1-7-97 9:00 AM**	**1-14-97 8:45 AM**	**1-21-97 8:45 AM**	**1-28-97 8:45 AM**	**2-4-97 8:45 AM**
Sample Stop	**1-7-97 9:00 AM**	**1-14-97 8:45 AM**	**1-21-97 8:45 AM**	**1-28-97 8:45 AM**	**2-4-97 8:40 AM**	**2-11-97 9:55 AM**
Flow (l/m) start	10.150	9.290	9.830	9.830	9.500	9.970
Flow (l/m) stop	10.350	9.730	10.150	9.900	10.040	3.200
Rotometer start						
Rotometer stop						
Comments						Flow drop!!
Flow (l/m) avg.	10.25	9.51	9.99	9.865	9.77	6.585
Temp max (C)	12.9	8.0	8.3	8.6	11.9	10.2
Time spl (hh:mm)	167:30:00	167:45:00	168:00:00	168:00:00	167:55:00	169:10:00
Time in min.	10050.00	10065.00	10080.00	10080.00	10075.00	10150.00
T Avg (K)	277.8	275.8	276.5	272.0	278.2	275.5
P avg (mb) MSL	1012.0	1023.3	1016.0	1014.7	1020.1	1025.2
Volume spld (m3)	103.01	95.72	100.70	99.44	98.43	66.84
V corr (m^3)	110.41	104.46	108.86	109.14	106.19	73.16

ug/m3 corrected						
SO_4	1.07	1.44	0.97	1.40	1.22	2.32

NH_3 as N	10.21	15.38	9.74	8.05	9.66	16.20
NO_3 as N	0.33	0.25	0.26	0.25	0.29	0.93
NO_2 as N	0.06	0.30	0.05	0.02	0.07	0.67

Abbotsford Data
Dry Ammonia

File # **Version** **Sample Start** **Sample Stop**	**G9378** **final** **11-2-97** **18-2-97**	**G9594** **final** **18-2-97** **25-2-97**	**G9753** **final** **25-2-97** **4-3-97**
Head ID			20
Lab File #			0
Version			0
Sample Start	**2-11-97 10:00 AM**	**2-18-97 8:30 AM**	**2-25-97 8:45 AM**
Sample Stop	**2-18-97 8:30 AM**	**2-25-97 8:40 AM**	**3-4-97 8:40 AM**
Flow (l/m) start	9.610	9.970	10.340
Flow (l/m) stop	10.200	10.250	10.230
Rotometer start			0
Rotometer stop			0
Comments			0
			0
Flow (l/m) avg.	9.905	10.11	10.285
Temp max (C)	12.3	13.7	11.7
			0
Time spl (hh:mm)	166:30:00	168:10:00	167:55:00
Time in min.	9990.00	10090.00	10075.00
T Avg (K)	279.9	278.8	277.9
P avg (mb) MSL	1018.3	1027.9	1011.9
Volume spld (m3)	98.95	102.01	103.62
V corr (m^3)	105.90	110.66	111.01

ug/m3 corrected			
SO_4	1.10	3.70	3.00
NH_3 as N	12.17	12.67	12.33
NO_3 as N	0.16	0.34	0.48
NO_2 as N	0.03	0.19	0.09

Appendix 4: Agassiz data

Agassiz Data Ammonia **File #** **Version** **Sample Start** **Sample Stop**	**F7324** **final** **17-1-96** **6-2-96**	**F7435** **final** **6-2-96** **13-2-96**	**F7642** **final** **13-2-96** **20-2-96**	**F7846** **final** **20-2-96** **27-2-96**	**F8027** **final** **27-2-96** **5-3-96**
Head ID	2	3	?	2	4
Lab File #					
Version					
Sample Start	**1-17-96 12:40 PM**	**2-6-96 1:17 PM**	**2-13-96 9:25 AM**	**2-20-96 9:10 AM**	**2-27-96 8:50 AM**
Sample Stop	**2-6-96 12:35 PM**	**2-13-96 9:15 AM**	**2-20-96 9:00 AM**	**2-27-96 8:40 AM**	**3-5-96 9:10 AM**
Flow (l/m) start	3.900	6.800	5.420	1.351	3.973
Flow (l/m) stop	2.660	7.830	>10	>10	>10
Rotometer start	n/a	n/a	6	6	8
Rotometer stop	n/a	n/a	17	18	18
Comments	Flow too low	6.8 on gauge	Flow too variable	flow >10 l/min	turn flow down
		7.83 on flow cell	Use rotameter values	Use rotameter values	Use rotameter values
Flow (l/m) avg.	3.28	7.315	11.5	12	13
Temp max (C)	9.70	13.90	17.50	9.40	12.60
Time spl (hh:mm)	479:55:00	163:58:00	167:35:00	167:30:00	168:20:00
Time in min.	28795.00	9838.00	10055.00	10050.00	10100.00
T Avg (K)	270.46	280.16	283.46	276.86	276.66
P avg (mb) MSL	1016.4	1019.8	1010.7	1009.8	1019.7
Volume spld (m3)	94.45	71.96	115.63	120.60	131.30
V corr (m^3)	104.41	77.06	121.29	129.40	142.36

ug/m3 corrected					
SO_4	2.89	1.04	0.63	1.25	1.16

	0.00	0.00	0.00	0.00	0.00
NH_3 as N	1.54	1.69	3.86	2.44	7.65
NO_3 as N	0.70	0.27	0.31	0.17	0.38
NO_2 as N	0.08	0.07	0.05	0.03	0.10

Agassiz Data Ammonia					
File #	**F8219**	**F8458**	**F8657**	**F8846**	**F8987**
Version	**final**	**final**	**final**	**final**	**final**
Sample Start	**5-3-96**	**12-3-96**	**19-3-96**	**26-3-96**	**2-4-96**
Sample Stop	**12-3-96**	**19-3-96**	**26-3-96**	**2-4-96**	**9-4-96**
Head ID	6	5	?	6	?
Lab File #					
Version					
Sample Start	**3-5-96 9:15 AM**	**3-12-96 9:05 AM**	**3-19-96 9:00 AM**	**3-26-96 9:50 AM**	**4-2-96 9:30 AM**
Sample Stop	**3-12-96 9:00 AM**	**3-19-96 8:55 AM**	**3-26-96 8:40 AM**	**4-2-96 9:00 AM**	**4-9-96 8:50 AM**
Flow (l/m) start	5.675	2.323	1.870	7.000	1.527
Flow (l/m) stop	8.833	8.335	7.661	7.857	8.626
Rotometer start	8	7	6	7	7
Rotometer stop	12	12	12	12	12
Comments					
			Use rotameter values		Use rotameter values
Flow (l/m) avg.	7.254	5.329	9	7.4285	9.5
Temp max (C)	15.50	18.90	14.50	14.00	21.80
Time spl (hh:mm)	167:45:00	167:50:00	167:40:00	167:10:00	167:20:00
Time in min.	10065.00	10070.00	10060.00	10030.00	10040.00
T Avg (K)	281.26	282.26	280.26	280.16	285.26
P avg (mb) MSL	1020.4	1025.2	1020.9	1011.8	1020
Volume spld (m3)	73.01	53.66	90.54	74.51	95.38
V corr (m^3)	77.92	57.34	97.02	79.16	100.33

ug/m3 corrected					
SO_4	0.99	2.41	1.68	1.86	1.16
	0.00	0.00	0.00	0.00	0.00
NH_3 as N	7.14	19.33	4.68	3.84	4.21
NO_3 as N	0.17	0.61	0.22	0.27	0.16
NO_2 as N	0.07	0.10	0.08	0.02	0.04

Agassiz Data **Ammonia** **File #** **Version** **Sample Start** **Sample Stop**	**F9222** **final** **9-4-96** **16-4-96**	**F9432** **final** **16-4-96** **23-4-96**	**F9584** **final** **23-4-96** **30-4-96**	**F9785** **final** **30-4-96** **7-5-96**	**G1030** **final** **7-5-96** **14-5-96**
Head ID					
Lab File #					
Version					
Sample Start	**4-9-96 8:55 AM**	**4-16-96 8:58 AM**	**4-23-96 8:50 AM**	**4-30-96 8:02 AM**	**5-7-96 8:15 AM**
Sample Stop	**4-16-96 8:53 AM**	**4-23-96 8:45 AM**	**4-30-96 8:58 AM**	**5-7-96 8:13 AM**	**5-14-96 8:00 AM**
Flow (l/m) start	8.804	7.147	5.403	6.074	??
Flow (l/m) stop	8.138	8.351	7.920	??	6.277
Rotometer start	12	12	11	9	11
Rotometer stop	12	12	12	12	12
Comments				Flow meter died	No flow @ start
				Use rotameter values	Use rotameter values
Flow (l/m) avg.	8.471	7.749	6.6615	10.5	11.5
Temp max (C)	19.50	20.00	15.60	17.10	18.70
Time spl (hh:mm)	167:58:00	167:47:00	168:08:00	168:11:00	167:45:00
Time in min.	10078.00	10067.00	10088.00	10091.00	10065.00

T Avg (K)	284.36	283.56	282.36	282.26	284.06
P avg (mb) MSL	1013.8	1013.1	1022.8	1021.5	1020.4
Volume spld (m3)	85.37	78.01	67.20	105.96	115.75
V corr (m^3)	89.54	81.99	71.61	112.80	122.31

ug/m3 corrected					
SO_4	1.30	1.37	2.14	1.51	0.52
	0.00	0.00	0.00	0.00	0.00
NH_3 as N	5.42	6.75	6.12	3.57	1.60
NO_3 as N	0.32	0.30	0.28	0.25	0.07
NO_2 as N	0.02	0.02	0.04	0.02	0.02

Agassiz Data					
Ammonia					
File #					**G2167**
Version					**final**
Sample Start					**11-6-96**
Sample Stop					**18-6-96**
Head ID					
Lab File #					
Version					
Sample Start	**5-14-96 8:00 AM**	**5-21-96 12:00 AM**	**5-28-96 12:00 AM**	**6-4-96 12:00 AM**	**6-11-96 7:50 AM**
Sample Stop	**5-21-96 12:00 AM**	**5-28-96 12:00 AM**	**6-4-96 12:00 AM**	**6-11-96 12:00 AM**	**6-18-96 7:55 AM**
Flow (l/m) start					6.692
Flow (l/m) stop					5.045
Rotometer start					12
Rotometer stop					10
Comments	Splg stopped	Splg stopped	Splg stopped	Splg stopped	Flow too low

Flow (l/m) avg.					5.8685
Temp max (C)					23.1
Time spl (hh:mm)					168:05:00
Time in min.					10085.00
T Avg (K)					287.86
P avg (mb) MSL					1020.5
Volume spld (m3)					59.18
V corr (m^3)					61.72

ug/m3 corrected					
SO_4					2.15
					0.00
NH_3 as N					8.62
NO_3 as N					0.47
NO_2 as N					0.05

Agassiz Data **Ammonia** **File #** **Version** **Sample Start** **Sample Stop**	**G2415** **final** **18-6-96** **25-6-96**	**G2618** **final** **25-6-96** **2-7-96**	**G2851** **final** **2-7-96** **9-7-96**	**G3096** **final** **9-7-96** **16-7-96**	**G3319** **final** **16-7-96** **23-7-96**
Head ID					
Lab File #					
Version					
Sample Start	**6-18-96 7:55 AM**	**6-25-96 8:02 AM**	**7-2-96 8:07 AM**	**7-9-96 8:15 AM**	**7-16-96 8:07 AM**
Sample Stop	**6-25-96 8:00 AM**	**7-2-96 8:00 AM**	**7-9-96 8:10 AM**	**7-16-96 8:04 AM**	**7-23-96 8:35 AM**
Flow (l/m) start	8.878	1.817	4.800	7.495	5.233

Flow (l/m) stop	7.784	9.875	7.498	5.715	5.700
Rotometer start	13	7	8	11	8
Rotometer stop	14	14	10	7	7
Comments	ok	ok	?ok	flow low	flow low
		Use rotameter values			
Flow (l/m) avg.	8.331	10.5	6.149	6.605	5.4665
Temp max (C)	24.6	25.9	29.7	33.2	29.5
Time spl (hh:mm)	168:05:00	167:58:00	168:03:00	167:49:00	168:28:00
Time in min.	10085.00	10078.00	10083.00	10069.00	10108.00
T Avg (K)	288.76	290.46	291.46	294.96	289.56
P avg (mb) MSL	1016	1017.3	1017.9	1017.1	1020.6
Volume spld (m3)	84.02	105.82	62.00	66.51	55.26
V corr (m^3)	86.96	109.03	63.70	67.46	57.29

ug/m3 corrected					
SO_4	2.27	2.09	4.17	1.73	1.94
	0.00	0.00	0.00	0.00	0.00
NH_3 as N	7.68	6.80	8.97	5.95	5.22
NO_3 as N	0.51	0.44	0.80	0.51	0.43
NO_2 as N	0.11	0.06	0.12	0.09	0.07

Agassiz Data **Ammonia**					
File #	**G3577**	**G3782**	**G4045**	**G4301**	**G4511**
Version	**final**	**final**	**final**	**final**	**final**
Sample Start	**23-7-96**	**30-7-96**	**6-8-96**	**13-8-96**	**20-8-96**
Sample Stop	**30-7-96**	**6-8-96**	**13-8-96**	**20-8-96**	**27-8-96**
Head ID					

Lab File #					
Version					
Sample Start	**7-23-96 8:40 AM**	**7-30-96 11:30 AM**	**8-6-96 9:00 AM**	**8-13-96 12:00 AM**	**8-20-96 8:00 AM**
Sample Stop	**7-30-96 11:10 AM**	**8-6-96 8:50 AM**	**8-13-96 11:50 AM**	**8-20-96 7:52 AM**	**8-27-96 8:00 AM**
Flow (l/m) start	5.776	6.090	5.700	6.020	5.126
Flow (l/m) stop	5.930	5.820	6.080	5.692	6.295
Rotometer start	7	6			
Rotometer stop	7	7.5	7		
Comments	flow low	flow low	flow low	flow low	flow low
Flow (l/m) avg.	5.853	5.955	5.89	5.856	5.7105
Temp max (C)	32.9	25.5	32	29.9	32.5
Time spl (hh:mm)	170:30:00	165:20:00	170:50:00	175:52:00	168:00:00
Time in min.	10230.00	9920.00	10250.00	10552.00	10080.00
T Avg (K)	297.06	288.86	293.16	290.36	292.16
P avg (mb) MSL	1015.9	1016.5	1018.9	1019.7	1016.8
Volume spld (m3)	59.88	59.07	60.37	61.79	57.56
V corr (m^3)	60.24	61.15	61.73	63.84	58.93

ug/m3 corrected					
SO_4	4.03	2.96	2.02	2.24	2.24
	0.00	0.00	0.00	0.00	0.00
NH_3 as N	11.59	5.08	9.27	9.54	10.06
NO_3 as N	0.56	0.37	0.57	0.43	0.57
NO_2 as N	0.01	0.04	0.09	0.10	0.15

Agassiz Data					
Ammonia					

File #	**G4680**	**G4925**	**G5139**	**G5339**	**G5587**
Version	**final**	**final**	**final**	**final**	**final**
Sample Start	**27-8-96**	**3-9-96**	**10-9-96**	**17-9-96**	**24-9-96**
Sample Stop	**3-9-96**	**10-9-96**	**17-9-96**	**24-9-96**	**1-10-96**
Head ID					
Lab File #					
Version					
Sample Start	**8-27-96 8:00 AM**	**9-3-96 8:20 AM**	**9-10-96 8:00 AM**	**9-17-96 8:05 AM**	**9-24-96 8:35 AM**
Sample Stop	**9-3-96 8:20 AM**	**9-10-96 7:55 AM**	**9-17-96 8:00 AM**	**9-24-96 8:35 AM**	**10-1-96 8:25 AM**
Flow (l/m) start	5.597	6.420	6.675	4.027	1.420
Flow (l/m) stop	7.620	7.803	1.815	4.390	>10
Rotometer start					
Rotometer stop					
Comments			Adjusted flow to 6.97		Max flow @1.42!
			Lab -no part on teflon	Pump dead!	Flow too low?
Flow (l/m) avg.	6.6085	7.1115	4.245	4.2085	1.42
Temp max (C)	34	21.4	26.2	20.2	22.9
Time spl (hh:mm)	168:20:00	167:35:00	168:00:00	168:30:00	167:50:00
Time in min.	10100.00	10055.00	10080.00	10110.00	10070.00
T Avg (K)	290.56	286.46	288.66	284.76	286.36
P avg (mb) MSL	1016.9	1016.2	1009.8	1022	1020.1
Volume spld (m3)	66.75	71.51	42.79	42.55	14.30
V corr (m^3)	68.72	74.62	44.03	44.92	14.98

ug/m3 corrected					
SO_4	3.77	1.21	0.48	0.00	22.83
	0.00	0.00	0.00	0.00	0.00
NH_3 as N	10.99	5.63	1.21	0.04	62.46
NO_3 as N	0.83	0.21	0.17	0.00	6.35

NO_2 as N	0.11	0.04	0.02	0.01	1.20

Agassiz Data Ammonia					
File #	**G5864**	**G6073**	**G6331**	**G6542**	**G6766**
Version	**final**	**final**	**final**	**final**	**final**
Sample Start	**1-10-96**	**8-10-96**	**15-10-96**	**22-10-96**	**29-10-96**
Sample Stop	**8-10-96**	**15-10-96**	**22-10-96**	**29-10-96**	**5-11-96**
Head ID					
Lab File #					
Version					
Sample Start	**10-1-96 9:55 AM**	**10-8-96 8:35 AM**	**10-15-96 9:15 AM**	**10-22-96 8:35 AM**	**10-29-96 8:43 AM**
Sample Stop	**10-8-96 8:00 AM**	**10-15-96 8:08 AM**	**10-22-96 7:45 AM**	**10-29-96 8:40 AM**	**11-5-96 8:55 AM**
Flow (l/m) start	4.626	7.201	>10	9.240	8.923
Flow (l/m) stop	5.090	7.618	15.880	8.747	6.133
Rotometer start					
Rotometer stop					
Comments	New pump installed		New pump		Adjust to 10.41
	Flow increase->8.354		set to 9.974		
Flow (l/m) avg.	4.858	7.4095	15.88	8.9935	7.528
Temp max (C)	19.7	24.7	12.4	12	13.8
Time spl (hh:mm)	166:05:00	167:33:00	166:30:00	168:05:00	168:12:00
Time in min.	9965.00	10053.00	9990.00	10085.00	10092.00
T Avg (K)	286.26	285.76	279.46	280.86	280.16
P avg (mb) MSL	1019.2	1014.8	1017.3	1016.9	1021.8
Volume spld (m3)	48.41	74.49	158.64	90.70	75.97
V corr (m^3)	50.70	77.82	169.88	96.61	81.51

ug/m3 corrected					

SO_4	0.00	0.00	0.12	0.64	0.79
	0.00	0.00	0.00	0.00	0.00
NH_3 as N	0.19	0.12	0.98	3.79	7.73
NO_3 as N	0.00	0.00	0.03	0.20	0.17
NO_2 as N	0.00	0.00	0.01	0.04	0.08

Agassiz Data **Ammonia** **File #** **Version** **Sample Start** **Sample Stop**	**G6981** **final** **5-11-96** **12-11-96**	**G7368** **final** **12-11-96** **25-11-96**	**G7559** **final** **25-11-96** **3-12-96**	**G7787** **final** **3-12-96** **10-12-96**
Head ID				
Lab File #				
Version				
Sample Start	**11-5-96 9:35 AM**	**11-12-96 9:15 AM**	**11-25-96 9:45 AM**	**12-3-96 10:10 AM**
Sample Stop	**11-12-96 8:55 AM**	**11-25-96 9:20 AM**	**12-3-96 10:00 AM**	**12-10-96 9:25 AM**
Flow (l/m) start	9.887	10.250	na	na
Flow (l/m) stop	10.540	na	na	9.700
Rotometer start				
Rotometer stop				
Comments		Flow meter not working	Flow meter not working	Flow meter not working
		2 wk spl	assume avg value	Splr moved to Clearbrook
Flow (l/m) avg.	10.2135	10.25	9.975	9.7
Temp max (C)	15	12.7	8.8	5.3
Time spl (hh:mm)	167:20:00	312:05:00	192:15:00	167:15:00
Time in min.	10040.00	18725.00	11535.00	10035.00
T Avg (K)	282.46	275.36	276.26	275.46
P avg (mb) MSL	1020.7	1014.5	1018	1004.80
Volume spld (m3)	102.54	191.93	115.06	97.34

V corr (m^3)	109.01	208.02	124.73	104.45

ug/m3 corrected				
SO_4	0.72	1.11	0.44	0.40
	0.00	0.00	0.00	0.00
NH_3 as N	5.01	1.41	3.21	6.55
NO_3 as N	0.19	0.15	0.10	0.24
NO_2 as N	0.07	0.02	0.13	0.04