The Statistical Derivation of Environmental Quality Guidelines

by

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Author's Declaration

I hereby declare that I am the sole author of this thesis. This is a true copy of the thesis, including any required final revisions, as accepted by my examiners.

I understand that my thesis may be made electronically available to the public.

Abstract

The thesis investigated statistical tools to improve the derivation of direct and indirect environmental quality guidelines (EQGs). Direct EQGs use measurements taken directly from the environmental matrix or phase of interest to estimate an EQG. An example is the set of Ontario Typical Ranges (OTR) that are used as criteria for lakefill, storm water pond sediment, brownfields remediation, application of non-agricultural source materials to farmland and as general soil benchmarks for use in risk assessments. An OTR for a specific analyte is estimated as a quantile of a dataset comprised of jurisdiction-specific direct measurements. OTRs are estimated in a variety of matrices; currently the most sampled matrix is surficial soil. OTRs estimated using rural park data include background concentrations and non-point source and/or long range transport contributions. As such, these are estimates of ambient levels (ALs) used by many jurisdictions including Canada, as source terms in human health and ecological risk assessments.

A limitation of soil OTRs is that OTRs are estimated within administrative regions without consideration of soil taxonomy or pedogenic processes. Further limitations are the logic underpinning how administrative regions are combined and the choice of sub-optimal statistical tools. Weaknesses of the current OTR derivation method were addressed in this thesis by geostatistical models that do not consider administrative regions thereby obviating the logic paradigm for combining administrative regions and choice of sub-optimal statistical tools. Geostatistically derived site-specific ALs reduce the bias implicit in more broadly based ALs such as those generated using the current OTR paradigm. Given the myriad uses of OTRs in Ontario and ALs globally, reduced bias will result in improved environmental decision making.

Indirect EQGs use measurements taken from a surrogate environmental matrix or phase to estimate an EQG in the environmental matrix or phase of interest. An example is the set of Canadian Council of Ministers of the Environment (CCME) water quality guidelines (WQGs). In this EQG derivation paradigm, analyte concentrations are measured in water (the surrogate

environmental matrix) and calibrated to responses in aquatic species (the environmental phase of interest). Those responses are used to estimate a concentration in water to achieve the desired level of protection (a calibration experiment in statistical terminology). CCME WQGs are used to derive effluent quality criteria and as general water quality benchmarks for use in risk assessments.

A limitation of the indirect EQGs (CCME WQGs) is in the application of the CCME-preferred species sensitivity distribution (SSD) approach to datasets that represent mixtures of sensitivities due to the presence of two or more modes of toxic action. In this thesis, the presence of multimodal SSDs for a pesticide with a known mode of toxic action is demonstrated. Multimodal SSDs are also demonstrated in non-pesticide contaminant SSDs (nonylphenol in water and zinc in soil). The implication of ignoring multimodality is an inadvertent and unknown degree of over or under-protection at the ecosystem level.

One alternative to ignoring multimodality is to restrict attention to only those species with the most sensitive mode of toxic action. This approach is not preferred because: 1) it is wasteful of toxicity test data leading to unnecessarily wide confidence intervals (the lower of which comprises the EQG) and; 2) the species comprising sub-distributions may not be known for a required element such as soil zinc due to the inclusion of multiple phyla. Another alternative is to statistically identify sub-distributions and estimate EQGs from the most relevant sub-distribution as appropriate. This is done by estimating the parameters of the mixture distribution, identifying the relevant distribution and using the jointly estimated parameters to estimate the EQGs. The advantage of this approach is that the lower confidence interval (which is the EQG) is less biased than it would be otherwise. Thus because the bias is reduced, the level of environmental protection afforded is more consistent with the nominal level of protection.

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Table 1: List of Abbreviations

Abbreviation	Definition
AIC	an information criterion
AL(s)	ambient level(s)
ANZECC	Australian and New Zealand Environment and Conservation Council
AOPC	analyte of potential concern
CCME	Canadian Council of Ministers of the Environment
ECL	effect concentration low
ECx	effect concentration corresponding to an x% response relative to controls
EQG(s)	environmental quality guideline(s)
FOREGS	Forum of European Geological Surveys
HCx	hazard concentration corresponding to an effect on x% of the population
ICx	Inhibition concentration corresponding to an x% response relative to controls
IQR	interquartile range
LCx	lethal concentration corresponding to an x% response relative to controls
MLE	maximum likelihood estimation
NHMRC	National Health and Medical Research Council
NPER	no potential effects range
OECD	Organisation for Economic Cooperation and Development
OLS	ordinary least squares
OMAFRA	Ontario Ministry of Agriculture, Food and Rural Affairs
OMOE	Ontario Ministry of Environment
OTR	Ontario Typical Range
REML	restricted maximum likelihood estimation
SMAV(s)	species mean acute value(s)
SSD	species sensitivity distribution
WLS	weighted least squares
WQG(s)	water quality guideline(s)

1 Introduction

Environmental quality guidelines (EQGs) are used to inform environmental management decisions in a variety of ways. For example, an EQG may be used to designate an area as "contaminated" (CCME, 2006; ICMM, 2007a), as a criterion for placing quarried rock within lakes (OMOE, 2003a), as a criterion for application of storm water pond sediment to soils (OMOE, 2003b), as "background standards" during the cleanup of brownfield sites either directly as site condition standards or as bases of reference for risk assessments (OMOE, 2004, 2009) and based on long experience with environmental monitoring, as a criterion for investigating potential risks or environmental impacts associated with developments.

EQGs fall into two classes; direct and indirect. Direct EQGs use measurements taken from the phase of interest or environmental matrix to estimate an EQG. An example is the set of Ontario Typical Ranges (OTRs: OMOE, 1993) that provide a benchmark that is variously used in environmental decision making. An OTR for a specific analyte is estimated as a quantile of a dataset comprised of jurisdiction-specific measurements. OTRs are estimated in a variety of matrices; currently the most sampled matrix is surficial soils. Indirect EQGs use measurements taken from an environmental matrix or phase that is not of direct interest to estimate an EQG in the environmental matrix or phase of interest. An example is the set of Canadian Council of Ministers of the Environment (CCME) water quality guidelines (WQGs: CCME, 2007). Analyte concentrations are measured in water (the surrogate environmental matrix) and calibrated to responses in aquatic species (the environmental phase of interest). Those responses are used to estimate a concentration in water to achieve the desired level of protection.

Methods for deriving EQGs have evolved over time in response to sociologic pressures, better understanding of contaminant environmental transport and fate and a deeper understanding of the links between toxicity to individual organisms and effects at the community and ecosystem levels. Stephan, (2002) discusses the evolution of water quality guideline development from an *ad hoc* approach based on use of toxicity tests on individual organisms to the use of statistical distributions of sensitivities of organisms to protect ecosystem functionality. While these methods are a distinct improvement over earlier methods, they apply only to single statistical distributions. However modern pesticides with highly specific modes of toxic action generate statistical distributions that are a mixture of very sensitive targeted organisms and typically, less sensitive non-target organisms. The current species sensitivity distribution methodologies (which are an example of indirect EQGs) are extended to deal with mixtures of statistical distributions in Chapter 3 of this thesis. A brief summary precedes the body of the chapter.

Just as the derivation of indirect EQGs has evolved over time so has the derivation of direct EQGs. The 1989 version of OTRs (an example of direct EQGs) represents improvements over the intial 1971 estimates that were "less than satisfactory because they varied among contaminants, were too subjective, and could not be supported by any consistent procedure or mathematical model" (OMOE, 1993). These concerns led to revisions culminating in a 1989 update that consistently used the "upper limit of normal" as a soil quality guideline. Although the 1989 version was an improvement over the earlier version, further issues were identified including the defined "land use categories, the sample categories and the model used in developing the ULN guidelines". These issues led to a revision in 1993 that is still currently being used. A variety of issues were identified in the 1993 version by Zajdlik (2006a). A detailed discussion is provided in section 2.2 but briefly, the issues include the logic paradigm, the choice of statistical methods and the use of administrative regions. The use of geostatistical models to address these issues is discussed in Chapter 2 of this thesis. A brief summary precedes the body of the chapter.

2 Improving the Derivation of Ontario Typical Ranges

2.1 Summary

Soil analyte concentrations directly measured from samples thought to represent natural background are used as soil quality guidelines in Ontario. As these EQGs can include inputs from diffuse and long range transport they are more accurately described as ambient levels (ALs). In Ontario the estimated 97.5th percentile of measurements collected within a specific land use is referred to as the OTR for that land use. If the land use is rural parks then the OTR is thought to represent the AL. The current methodology to estimate OTRs is logically flawed as it relies on the absence of a statistically detectable difference in the statistical distribution of an analyte among the 6 Ontario Ministry of Environment administrative regions to combine data among regions. As the regions represent administrative regions there is no reason to expect that the within region statistical distribution is anything but an artitical construct that ignores pedogenic processes. Moreover, relying on the absence of detectable differences among regions for combining regions leads to groupings of regions that are logically impossible. The likelihood of logically impossibile groupings is exacerbated by the use of statistical tools lacking in power. Finally, the outcome of the OTR derivation process is typically a single AL for the entire province. Given that Ontario comprises a vast region (more than $1x10^6$ km^2) with a variety of soil taxonomic units that have been influenced by the underlying regolith and primary pedogenic processes and massive secondary pedogenic processes such as glaciation, the relevance of a single provincially based number to a specific site is doubtful. The implication is that ALs are substantively biased at local scales. As ALs are used as 1) criteria for the deposition of quarried rock placed within lakes; 2) criteria for defining storm water pond sediment as “inert fill” prior to applying dredged sediment to soils; 3) “background standards” during the cleanup of brownfield sites either directly as site condition standards or as bases of reference for risk assessments; 4) as source terms in human health-based soil guidelines; and, 5) formally define a site as being “contaminated”, biased ALs will adversely affect environmental decision making. For example a provincially based AL applied to a minearlized area such as the Sudbury Basin may result in unnecessary cleanup of a brownfield site because the AL is biased downwards on the local scale. Conversely, an AL that is biased upwards may result in a failure to remediate a site to the local AL.

Local scale bias may be reduced by using AL predictions on a local scale and also to circumvent the other issues identified regarding the current method to estimate ALs. Random field models or kriging were used to predict location specific ALs. The use of ancillary information to improve geostatistical predictions of ALs was explored. A literature review showed that Al and Fe are often correlated with metals of interest (Co, Cr, Mn, and Ni). Strong correlations between Al, Co, Cr and other analytes were also detected in soil quality data from Ontario. Consequently, Al was selected as a test analyte, although on the basis of the literature review, Fe could also have been selected. The ability to predict Pb on a local basis was also investigated because the Ministry of Environment stated that the current Pb AL was controversial and because a single Pb AL is unrealistic for an analyte known to be associated with anthropogenic activities. Formal testing of unimodality of Al concentrations led to rejection of the null hypothesis that a single statistical distribution best describes the Al concentrations and by extension rejection of the current Al OTR.

Geostatistical models were fit to Al data using three different datasets. Over the geographic range common to the three datasets, predicted Al concentrations are generally similar although some small scale differences due to the effects of changes in sample support by dataset were apparent. Location specific 97.5th percentiles were predicted using a grid on 0.1 degree increments and compared to the current AL OTR. The first quartile of the 97.5% percentiles is 16,670 mg/kg Al or approximately 55% of the rural park OTR. The third quartile of the 97.5% percentiles is 30,190 mg/kg Al or approximately equal to the rural park OTR. The results demonstrate the large extent of the location specific bias On this basis the Al OTR is almost twice as large as it should be for 25% of the province and too low for another 25% of the province. The Pb kriging results show that the probability of exceeding the Pb OTR is consistently greater than the expected 2.5% in historic urbanized areas which can lead to unnecessary remediation or overestimates of risk. Together, the analyses of Al and Pb show that OTRs estimated using a geostatistical approach will reduce location specific biases. Given the myriad uses of OTRs and the geographic nature of biases, environmental decision making will also be systematically biased on a geographic basis. Adoption of the geostatistical approach will reduce the bias in estimated ALs resulting in improved environmental decision making.

2.2 Introduction

Directly measured, natural background concentrations are often used as EQGs. Natural background soil concentrations have been used as guidelines by ANZECC/NHMRC (1992), Fields et al., (1993), OMOE (1993), San Juan (1994), Watkins et al., (1994), US EPA (2002, 2007), CCME (2006), Wyoming (2006) and ICMM(2007a).

Background concentrations are concentrations of substances not subject to anthropogenic influence (US EPA, 2002). It may be difficult if not impossible to estimate true background element concentrations due to anthropogenic influence on a global scale (Reimann and Garrett, 2005). Ambient levels (ALs) are distinguished from background levels reflecting both background and low-level non point-source inputs such as those due to long range transport (US EPA, 2002; CCME, 2006; Ander et al., 2013). ALs reflect the same intent as do the OTRs measured in the rural parks land use category defined by the OMOE (1993). ISO (2005) and Appleton et al., (2008) define ambient levels using the terms “background content” and “ambient background concentration”, respectively, in the same manner. In this thesis the term “ambient level” (AL) was used to emphasize the difference between natural background and natural background with the addition of low-level non point-source inputs such as those due to long range transport.

Methods for estimating ALs include site-specific ALs estimated using soils from reference areas (US EPA, 2002; Wyoming, 2006; National Environment Protection Council, 2011), predicted using geochemical indices (Hamon et al., 2004 as recommended by National Environment Protection Council, 2011) or inferred using results from similar locations (*loc. cit.* Olszowy et al., 1995 as recommended by National Environment Protection Council, 2011). Estimation of broad geographic scale ALs use homogenous soil types (MDEQ, 2005) or within land-use estimates (Fields et al., 1993; OMOE, 1993; ISO, 2005). Once data are collected for a given area, statistical methods are used to estimate ALs. Sinclair (1974), Reimann et al., (2005) and Díez et al., (2009) use cumulative distribution functions to visually identify multimodal distributions such that distributions of non-background elements may be identified. Once the background distribution is identified, subjective but consistent decisions regarding anomalous or background thresholds can be made. The subjective element is the choice of quantile or standard deviation from a measure of central tendency to define the threshold or anomalous level. Once this method is selected consistent application is possible. This graphical method is used by Davies (1983) to estimate background concentrations of lead in British soils. Zhao et al., (2007) point out that the probability graph methods of Sinclair (1974) and Davies (1983) may be biased if the frequency distribution is comprised of non-representative proportions of soils with inherent characteristics that can affect metal concentrations. Note that this is not a short-coming of the probabilistic technique but rather a misapplication.

The choice of a quantile, measure of central tendency or deviation from the measure of central tendency that represents the AL is arbitrary. Hamon et al., (2004) notes that regional metal background values have been variously estimated using geometric means, medians or the 95th percentile. The Ontario Ministry of the Environment (1993) uses the 98th percentile of data collected in rural parks as ALs. Ander el al. (2013) use the 95th percentile, California EPA (1997) recommends 95th or 99th quantiles or 99th empirical percentiles and does not recommend upper percentiles or confidence limits thereon, estimated from "small" samples or the use of a mean plus a fixed standard deviation. Reimann et al., (2005) strongly decry using a deviation from a measure of central tendency and instead recommend statistical graphics (cumulative distribution functions and box and whisker plots) and geographical displays to identify ALs. Some authors reasonably place the onus for choosing a quantile, measure of central tendency or deviation from a measure of central tendency to represent an AL on the investigator. For example Auckland Regional Council (2001) states only that a mean is inappropriate; ISO (2005) discusses percentiles in general without recommending a specific percentile and US EPA (2007) states that ranges or specific numbers for background values depend upon the degree of conservatism desired by the risk assessor.

Geostatistical models have long been used to estimate ore reserves; the seminal work is Matheron (1962). Geostatistical models have also been used to delineate contaminated sites using bioassays (Thomas et al., 1986) and investigate spatial relationships between metals and regolith (McBratney et al., 1982; Goovaerts and Webster, 1994; Rawlins et al., 2003). More recently, Ander et al., (2013) describe the estimation of ALs for As, Cd, Cu, Hg, Ni, Pb and benzo[a]pyrene for use in England. The country is divided into discrete “domains” or polygons defined using the results of k-means clustering and geospatial maps generated using inverse distance weighting (i.e. not using geostatistical models) and, in consideration of non-ferrous metalliferous mineralisation, mining activities, underlying parent material and presence of urban areas (Ander et al., 2012). ALs are estimated using the 95th percentile of the within-domain data. This approach uses geospatial methods but not geostatistical models. Geostatistical models (block regression-kriging) are used by Lado et al., (2008) with the Forum of European Geological Surveys (FOREGS) database to predict As, Cd, Cr, Cu, Hg, Ni, Pb and Zn, in topsoils over Europe that may be used as a baseline to assess temporal changes. However, these baseline concentrations do not represent ALs. The geospatial maps presented in the FOREGS Geochemical Atlas of Europe (FOREGS, 2014) use inverse distance weighting (i.e. a mathematical rather than geostatistical approach). To the best of my knowledge, the research presented in this thesis is the first instance of geostatistical models being used to estimate ALs, quantify uncertainty and estimate the probability of exceeding a specific concentration.

ALs are not only used as EQGs but as benchmarks for designating an area as contaminated. CCME (2006) and ICMM (2007a) define a contaminant with respect to natural background; CCME (2006) states that a contaminant is “Any substance present in an environmental medium at concentrations in excess of natural background.” (However the CCME (2006) definition is circular because natural background concentration is defined as a “concentration that is typical of most unimpacted soils in Canada”.) ALs are also used in risk assessments. In Canada, the background soil concentration is an exposure term in the equation for the direct human health-based soil guideline and derivative equations such as dermal or inhalation exposure, for both threshold and non-threshold contaminants (CCME, 2006). In Australia, a soil EQG is defined as the sum of an AL and a risk based toxicity estimate. For example, National Environment Protection Council (2013) uses a species sensitivity distribution approach (following ANZECC, 2000) in consideration of physical and chemical properties of a soil on a site-specific basis to estimate the “added contaminant limit”. The “ecological investigation limit” is the sum of the AL and the site specific “added contaminant limit”.

Biased estimates of ALs can lead to biased EQGs, incorrectly defining a site as contaminated and biased risk-based human health guidelines. OTRs, (OMOE, 1993) based on measurements in rural parks represent ALs in Ontario. This thesis investigates improved estimation of Ontario Typical Ranges.

2.2.1 Ontario Typical Ranges – Derivation

In this thesis, improvements to the estimation of a direct soil guideline, OTRs or ambient levels, were explored. OMOE (1993) uses the following general paradigm (subject to data quality criteria) to estimate an OTR:

1. Test equality of distributions for a given parameter within a matrix across administrative regions using the Kolmogorov-Smirnov test (Kolmogorov, 1933).

2. Combine administrative regions where possible, while at the same time following the sample frequency requirements (OMOE, 1993, pg. 3).

3. Using the combined datasets, test equality of distributions across land uses and receptors (OMOE, 1993, Instruction set B, pg. A6) and combine where possible.

4. Estimate the OTR using a nonparametric quantile estimator following OMOE (1993).

Under this paradigm, for a given analyte, there may be as few as 1 OTR or as many as the number of administrative regions in Ontario. Section 2.2.3 discusses the limitations of the estimated OTRs.

2.2.2 Ontario Typical Ranges – Usage

The estimated OTRs are variously used by the Ministry of Environment. OTRs are used as criteria for quarried rock placed within lakes as described in the Receiving Water Simulation test (OMOE, 2003a). OTRs are also used to define storm water pond sediment as “inert fill” prior to applying dredged sediment to soils (OMOE, 2003b). Finally, OTRs are used as “background standards” during the cleanup of brownfield sites either directly as site condition standards or as bases of reference for risk assessments (OMOE, 2004, 2009). More general uses of OTRs as estimates of ALs are presented in section 2.2.

2.2.3 Ontario Typical Ranges – Weaknesses

Weaknesses in the current OTR paradigm were identified by Zajdlik (2006a). These are described in the following subsections.

2.2.4 Use of Administrative Regions

OTRs are generated using pre - August 1, 1993 Ontario Ministry of the Environment administrative regions. The regions are defined below following OMOE (1993, Table G1)

Table 2: OMOE Administrative Regions

Region	Counties
1- Southwest Region	Bruce, Elgin, Essex, Grey, Huron, Lambton, Kent, Middlesex, Oxford, Perth
2 - West Central Region	Brant, Dufferin, Haldimand-Norfolk, Hamilton-Wentworth, Niagara, Waterloo-Cambridge, Wellington
3-Central Region	Durham, Haliburton, Halton, Muskoka, Northumberland, Peel, Peterborough, Simcoe, Toronto, Victoria, York
4 -Southeast Region	Dundas-Stormont-Glengarry, Frontenac, Leeds-Grenville, Hastings, Lanark, Lennox-Addington, Ottawa-Carleton, Prescott-Russell, Prince Edward, Renfrew
5-Northeast Region	Algoma, Cochrane, Nipissing, Parry Sound, Sudbury

Region	Counties
6-Northwest Region	Kenora, Rainy River, Thunder Bay

Ontario covers a very large area and the surficial soils include a large variety of soil taxonomic units (Soil Classification Working Group, 1998). These units have been influenced not only by the underlying regolith but also by primary pedogenic processes and massive secondary pedogenic processes such as glaciation. Kabata-Pendias et al., (1992) and Zhao et al., (2007) showed that soil textural classes and to a lesser extent soil taxonomic units, can affect means and ranges of trace metals. This leads to the idea that a single background concentration for a "large" area is unrealistic (Reimann and Garrett, 2005). This idea was assessed by Hamon et al., (2004) who compared predicted background concentrations to the small scale single values used across Australia. They found that the predicted values (if correct) demonstrated substantive bias. The factors described, suggest that partitioning Ontario by administrative regions and using those partitions to test for statistically distinct chemical distributions can obscure real differences. The failure to detect differences can lead to biases in OTR estimates at a local scale.

2.2.5 Combination of Administrative Regions

The OTR generating paradigm summarized above combines datasets from administrative regions that are not significantly different from one another on the basis of failing to reject a statistical hypothesis test. The use of a hypothesis test is desirable in that natural variability is acknowledged in a transparent, objective manner and a limit can be set on Type I and II errors. Some of the implications of using a statistical hypothesis test, however are not considered within the current OTR paradigm.

Using statistical tools we cannot prove that anything is true. We can only state that the evidence (data) is sufficiently compelling to reject the null hypothesis. This idea is reflected in the conclusions following two hypothesis tests:

Test A: There is insufficient evidence to reject the null hypothesis.

Test B: There is sufficient evidence to reject the null hypothesis.

Of the two statements the second is much stronger. In fact, following "Test A" the 1993 OTR estimation paradigm incorrectly states that the distributions are the same. The correct conclusion is that no difference between the two distributions was detected. The conclusion that the distributions are the same should only be made following a power analysis showing that some minimally acceptable statistical power was achieved.

Now consider the comparison of the hypothetical regions a, b and c using the Kolmogorov-Smirnov test. In Table 3 the first row represents a comparison of the statistical distribution of an analyte between regions "a" and "b" and "a" and "c". An inability to detect a difference in the distributions is presented with the symbol "=" which is consistent with the paradigm for combining administrative regions in OMOE (1993). The detection of a difference in the distributions between two regions is denoted by the symbol "≠".

Table 3: Comparison of Empirical Cumulative Distribution Functions for an Analyte among Hypothetical Administrative Regions a, b and c.

	a	b	c
a		≠	=
b	≠		=
c	=	=	

In Table 3 we have the following equalities: a=c and b=c and inequalities a ≠ b. We should not produce an OTR for combined regions a-c and b-c since two OTRs will exist for region c. If the regions are combined following the proviso in step 6, pg. A5, OMOE (1993) we contradict the strongest statement in the matrix of comparisons: the statement of inequality between regions a and b. Following the strongest conclusion (even with power calculations) that a ≠ b we should produce separate OTRs for each region.

The consequence of not considering the strongest statement- the distributions from two regions are demonstrably different is that regions may be combined inappropriately in some cases.

An example using silver in soil from old urban parks, presented in Figure 1 concretizes this concept. The Kolmogorov-Smirnov test results are shown in Table 4. Shaded cells indicate differences at the 5% level of significance in the distribution of Ag among the regions.

Table 4: Results of Kolmogorov-Smirnov Test on Ag for Old Urban Parks

Region	1	2	3	4	5	6
1	NA	0.143431	0.833102	0.941181	0.415365	0.06614
2	NA	NA	0.003252	0.299111	0.007589	0.03251
3	NA	NA	NA	0.266813	0.724981	0.011938
4	NA	NA	NA	NA	0.415365	0.011193
5	NA	NA	NA	NA	NA	0.01019

Following the current OTR paradigm, all the regions are combined. Figure 1 illustrates the distribution of data in regions 6, 2 and combined across 1, 3, 4 and 5. It is visually evident that the distributions of Ag among the three regions are different from one another and that the data should not be combined. The implication is that combining data across regions after ignoring results of the Kolmogorov-Smirnov test can lead to under estimation or over estimation of the OTR.

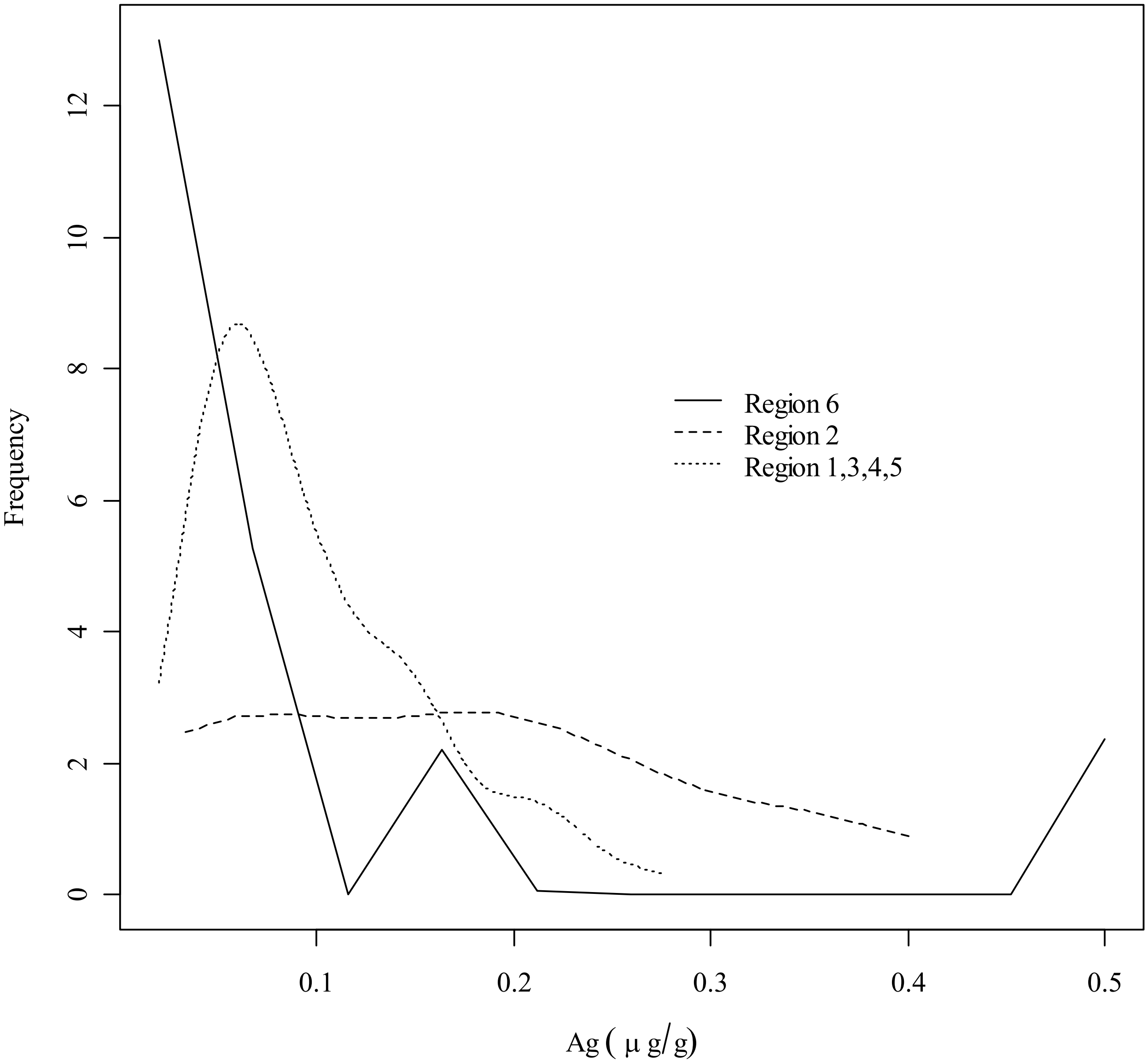

Figure 1: Example of Distribution Comparison for Ag in Old Urban Parks

2.2.6 Statistical Issues

2.2.6.1 Choice of Test

The Kolmogorov-Smirnov test for equality of two distributions is not generally recommended as it has poor discriminatory power, particularly when only the tails of two distributions vary. Consider Figure 2 where the Kolmogorov-Smirnov test does not detect a difference between three distributions with similar ranges. The OTRs (97.5th percentiles) for each distribution are: 25.1, 24 and 19.9, for regions "A", "B" and "C", respectively. The OTRs vary by approximately 20% in this case. The Kolmogorov-Smirnov test can fail to detect differences in shapes of this nature. It is also possible to generate a similar example where the discrepancy in OTRs would be much higher. To summarize, the choice of distribution comparison method could lead to a failure to correctly distinguish between regions relative to other distribution comparison methods. This can lead to under or over estimation of the OTR.

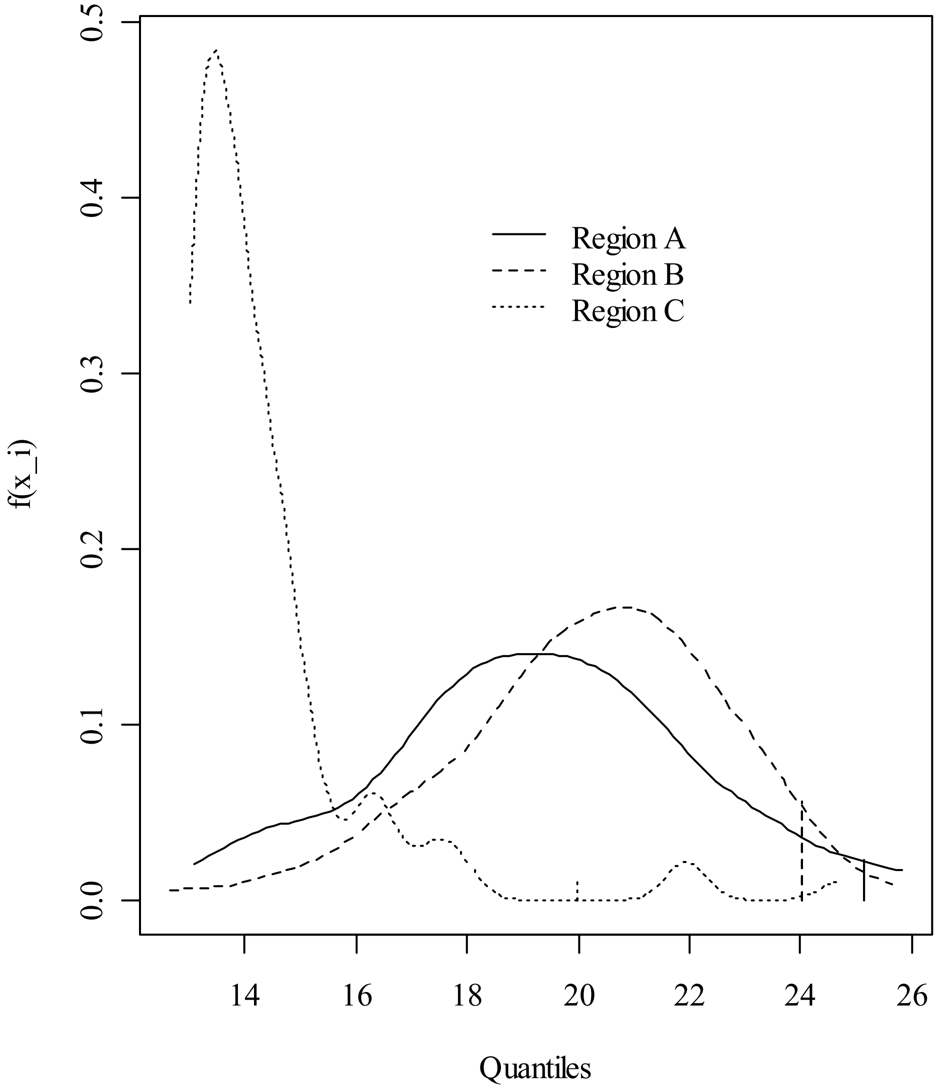

Figure 2: Comparing Three Hypothetical Distributions with Similar Ranges

2.2.6.2 Quantile Estimate

The OTR is estimated using a simple interpolation between ranked values (OMOE, 1993). The advantage of this approach is that no assumption regarding a statistical distribution is necessary. The disadvantage is that the OTR can be unduly influenced by one value. This was demonstrated during quality assurance screening of the generated OTRs. When OTRs were re-estimated in 2006 (Zajdlik, 2006a), one OTR was very much larger than the previous (1993) value simply because <u>one</u> observation was incorrectly entered. The use of nonparametric estimation method that is heavily dependent upon a few values can lead to overestimation of the OTR.

2.2.7 Direct Guidelines Research Objectives

Sections 2.2.1 through 2.2.6 describe the derivation and weaknesses of one specific direct guideline; the Ontario Typical Range. Given the importance of OTR uses, mproved defensibility of the estimation process and the attendant reductions in bias will be widely useful. Two areas selected for investigation in this thesis are assessment of the statistical distribution within an OTR dataset and, the use of geostatistical models to estimate OTRs. The specific null hypotheses tested herein are:

H_o1: The Al OTR dataset is comprised of indistinguishable statistical distributions.

A mixture distribution approach is used to determine whether distinct (statistical) populations of analyte measurements are detectable. The implications of acceptance or rejection of this null hypothesis on an analyte-specific basis will be assessed relative to the comparison of statistical distributions among administrative regions using the current OTR paradigm. An alternative to distinguishing statistical distributions for portions of the province is to predict typical concentrations as a continuum across the province. In this case the following methodological hypotheses are tested:

H_o2a: Geostatistical models cannot be used with available OTR data to estimate OTRs.

H_o2b: Geostatistical models cannot be used with the OMAFRA (Ontario Ministry of Agriculture, Food and Rural Affairs) field metal data to corroborate location specific OTRs.

Refuting these null hypotheses is a pragmatic decision based on "utility" of the model. Utilitiy is assessed using internal cross-validation methods, congruence in predicted values using different datasets and magnitude of confidence intervals around predicted concentrations. Rejection of either null hypothesis leads to alternative methods for derivation of OTRs that are independent of administrative regions. The use of geostatistical models will allow for the prediction of location-specific ambient levels.

As a general contaminant class, metal dynamics and conservation within soil are better understood than other contaminant classes. Thus metals were selected to assess direct EQGs. Initially, Cu was selected as an analyte for detailed evaluation due to the wealth of toxicity-related information and regulatory interest (A. Takar, pers. comm.). However, the Cu dataset included a small percentage of seeming outliers, particularly in rural parks. Given that the small number of aberrant concentrations precluded explicitly modelling the mixture of distributions (investigations not presented) and robust spatial methods were not of interest at the time, Cu was not investigated. In addition to predicting location specific analyte concentration using kriging, an overarching goal was to use ancillary information such as soil texture, taxonomic class, or co-variables to improve predictions. For this reason, a literature review of correlations among soil analytes was conducted.

Zhao et al., (2007) used principal components analysis to find an association among Al, Fe, K, Mn, Cr, Co and Ni. They stated that Co and Ni which are siderophilic (iron-loving), and trivalent forms of Cr, Fe and Al tend to associate with each other (Goldschmidt, *loc. cit.*1937). Following the principal component analysis, Zhao et al., (2007) regressed Al and Fe (separately) on Co, Cr and Ni and found that the simple linear regressions explained between 53 and 72% of the variation in the trace metal concentrations. Sterckeman et al., (2006) also found significant (Type I error rate = 5%) linear correlations between both Al and Fe with Co, Cr, Mn, Ni as well as Tl, V and Zn in the surficial horizons of loess deposits in France. All metals were extracted using an *aqua regia* digestion. Other elements were associated with either Al or Fe, but not both. Hamon et al., (2004) found strong correlations (correlations in parentheses) between *aqua regia* soluble Fe and a similar suite of metals: As (0.69), Cr (0.82), Cu (0.60), Ni (0.48), Pb (0.66), and Zn (0.61) for the reference dataset. No correlations between Fe oxides (as opposed to *aqua regia* soluble Fe) and trace metals were found. The authors suggest that the *aqua regia* digestion for Fe better represents soil metal binding capacity than a standard oxalate/citrate dithionite extraction. Hamon et al., (2004) also suggest that *aqua regia* soluble Fe/Mn ratio can be considered a semi-conservative property of soils; their concentrations are related more to the chemical composition of the soil-forming parent materials and the degree of weathering than to the anthropogenic influence. Thus the ratio may be used to define background concentrations of As, Co, Cr, Cu, Ni, Pb, and Zn. Finally, Rawlins et al., (2003) conducted a spatially extensive study (4,609 sites over 10,000 km^2 in eastern England) and found that background concentrations of As, Cr, Ni and U were spatially correlated with Fe over short distances. Both Al and Fe are correlated with metals that are often of interest in ecological risk assessments. Al was selected to test H_o 1, 2a, and 2b although Fe could also have been selected. Pb was also used to test Ho2a, because the Ontario Ministry of Environment stated that the current Pb AL was controversial and because a single Pb AL is unrealistic for an analyte known to be associated with anthropogenic activities.

2.3 Methods

2.3.1 Sources of Data

The direct EQG data used are from two distinctly different datasets: 1) Ontario Typical Range Rural Parks and Old Urban Parks; and 2) OMAFRA field datasets. These datasets are described below.

2.3.1.1 Ontario Typical Range (OTR) Dataset: Rural Park and Old Urban Parks

The Ontario Typical Range data (OMOE, 1993) were collected to estimate typical ranges of metals, polycyclic aromatic hydrocarbons, chlorinated organic compounds and pesticides in soil, vegetation, moss bags and snow across Ontario. Note that not all analyte classes were measured in all environmental matrices. Only the soil data were used within this thesis. The soil data were collected beginning in 1991 and ending in 2002. Data available as of 1993 were used to estimate the OTRs presented in OMOE (1993). Subsequent data for metals and some nutrients in soil and maple foliage in old urban parks and rural parks were used to update OTRs (Zajdlik, 2006a). Again, only the soil data are used in this thesis.

Micro-scale variability is a characteristic of soil physical properties and analyte concentrations. Patterson and Wall (1982) studied the within pedon variability of particle size distribution, organic matter content, calcium carbonate equivalent and pH. They found that as many as 5 within pedon samples were required to "satisfactorily" estimate some of these soil properties. Walls and Marsh (1988) studied within pedon variability of trace metals and found that as many as 23 samples were required to estimate mean elemental concentrations within ± 10 %. MacDonald and Hendershot (1983) linked variability in soil characteristics with variability of Cd, Cu, Mn, Ni, Pb and Zn in podzols which underlay much of central Ontario (Baldwin et al., 2000). This micro-scale variability is addressed to some extent by the OMOE (1992) sampling methodology. At each OTR site, three soil subsamples were collected in 1991 in order to develop the 1993 version of the OTRs. The original OTRs were augmented by additional sampling in 1992 and subsequent years using only two soil subsamples at each

OTR site. All subsamples were submitted separately for chemical analysis. Soils were collected from the top 5 cm of soil except for gardens and fields where samples were collected from the top 15 cm. Specific details on sampling methods are found in OMOE (1992). All OTR soil locations are classified within the land use categories defined in Table 5. Of those land use categories, and because of the interest in estimating ambient levels, only data collected in old urban or rural parks were used.

Table 5: OTR Terminology Definitions (OMOE, 1993)

Term	Definition
agricultural	"all land actively used as tilled or managed cropland or untilled pasture"
commercial	"all properties used for industrial or commercial businesses, and all designated transportation rights-of-way"
industrial	see commercial
new urban	after world war II
old urban	prior to world war II
parkland	"everything that is not residential, commercial/industrial, transportation rights-of-way, or active agricultural land. This would include parks, cemeteries, schools, forests or woodlots and most large undeveloped areas." Golf courses are NOT included within parkland.
residential	"includes a dwelling and associated gardens and lawns up to the dwelling side of the sidewalk or to 3 m from the road where a sidewalk does not exist"
rural	"all areas not considered urban"
transportation	see commercial
urban	"any property that is fully serviced by both municipal water and sewage systems"

Following data quality assurance 321 Al and 107 Pb observations were available from rural park OTR sites and 253 Al observations from old urban park OTR sites. The quality assured OTR data used herein are presented in Appendix 1. Slightly more than 94% of the rural park sites are found south of the 50th parallel. This number increases to more than 96% for old urban park OTR sites. The distribution of OTR sites for these two land use categories is shown in Figure 3.

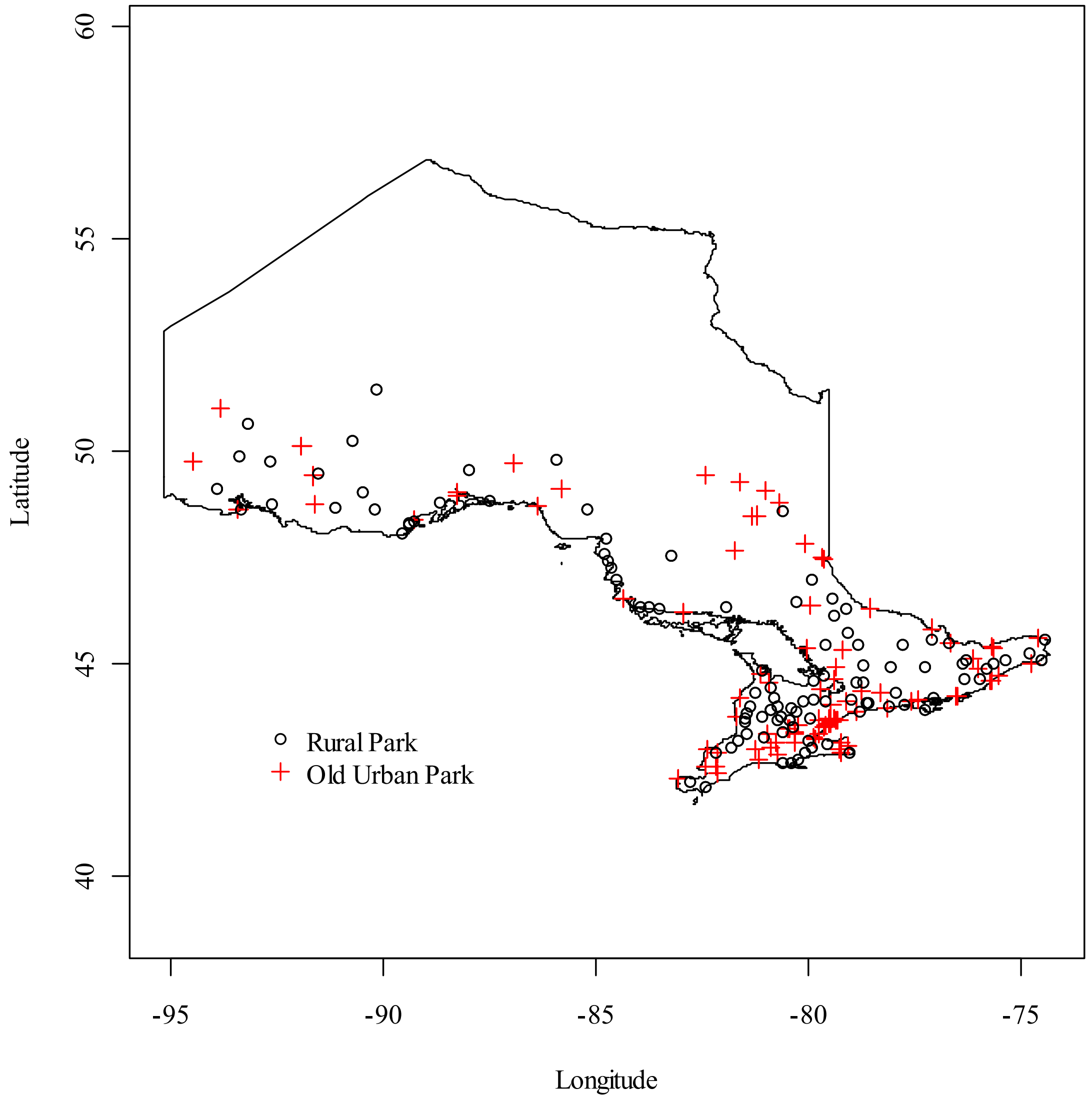

Figure 3: OTR Rural and Old Urban Park Sampling Locations

2.3.1.2 OMAFRA Field Soil Metals Data

The OMAFRA field data were collected by OMFAFRA while conducting a nitrogen study at the request of OMOE in 2002 and 2003 (A. Takar, pers. comm.). The purpose of the OMOE request was to establish background levels for metals in agricultural fields. Replicate samples (0-15 cm) were collected from agricultural fields across Southern Ontario using procedures describe in OMOE (1992) and were analysed by OMOE lab. There are a total of 75 unique sampling locations comprised of 148 surficial soil samples. The median of all replicate data is used in subsequent geospatial analyses. The dataset is referred to herein as the "OMAFRA dataset".

A confidentiality agreement regarding non-disclosure of field metal sampling locations was signed at the request of the Ontario Ministry of Environment. Therefore exact coordinates are not presented and the raw data are not provided. Any graphics that present OMAFRA sampling locations are **randomly moved within a 20 km radius (jittered) so that individual fields cannot be identified**. Twenty km applies to latitude; the jittering in the longitude axis is slightly less due to convergence of meridians. Thus some jittered locations may appear within a waterbody. Note that all analyses use actual sample locations.

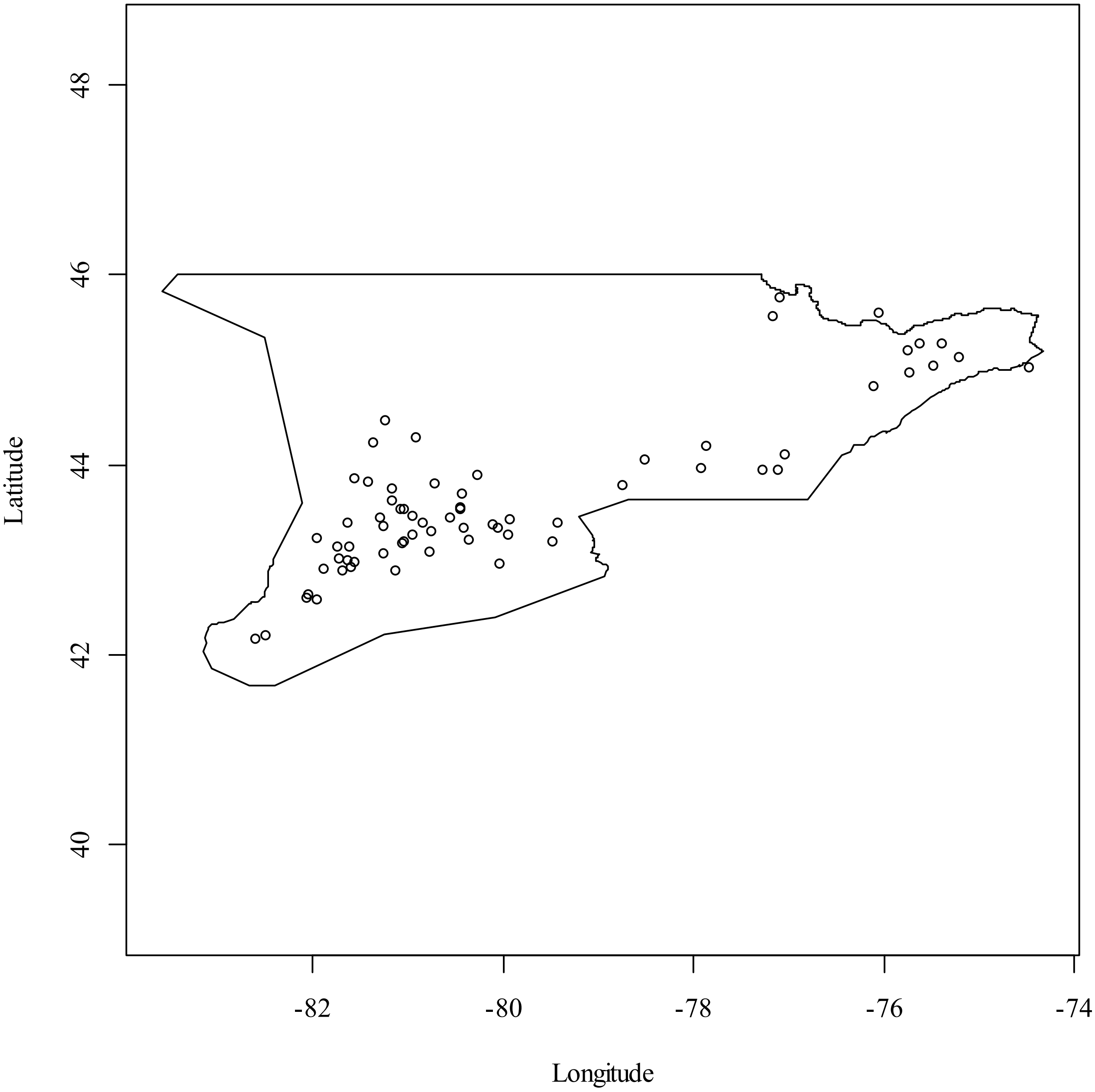

Figure 4: OMAFRA Dataset Jittered Sampling Locations

2.3.2 Statistical Methods for Assessing Relationships among Co-Analytes

The relationship among co-analytes was explored for possible use in cokriging (kriging using co-located variables) and external drift kriging (kriging using covariates at unsampled locations) as discussed in section 2.3.3.2. The linear correlation structure among OTR analytes was explored using Spearman rank correlations. As there are some instances where samples are unavailable for all locations, data are retained for all pairwise cases. Spearman rank correlations were estimated using package "stats" (R Development Core Team, 2010).

The Spearman rank correlations are presented using colours to present ranges of correlations. The ordering of rows (= order of columns) is driven by the output from hierarchical clustering using complete linkage. The value of the graphic particularly given the groupings constructed by the hierarchical clustering relative to a tabulation of correlation coefficients is a visualization of how groups of analytes behave similarly. Graphics were constructed using code developed by Neuwirth (2011) and Warnes (2012).

2.3.3 Statistical Methods for Estimating Ambient Levels

The methods described below were selected to understand and eventually describe the statistical and spatial distributions of ALs of selected metals. The methods applied follow a hierarchical pattern. In the current OTR paradigm the only spatial information used to stratify the dataset is administrative boundaries. Ignoring this level of organization the data can be examined as a cohesive "set" ignoring spatial attributes entirely. Thus the first set of "methods" or tools applied to a dataset explores the data ignoring the spatial context (summary statistics, frequency histograms and empirical density estimates) or merely presenting data spatially (bubble plots). These methods are described in section 2.3.3.1. Section 2.3.3.2 describes modelling statistical distributions without consideration of spatial context using mixture models. The spatial context of the data set is invoked in section 2.3.3.3 and subsequent subsections that discuss fitting, refining and choosing among, geostatistical models.

2.3.3.1 Data Exploration

Summary statistics and empirical density estimates are used to explore the location, scale and shape of the OTR Al datasets. Due to the almost certain asymmetric nature of the sets, robust measures of location (quantiles (0.05, 0.15, 0.25, 0.5, 0.75, 0.85 and 0.95) and Huber's M-estimator for location and scale (Huber, 1981) and the inter-quartile range were estimated in addition to the more familiar measures of location (mean) and scale (variance).

2.3.3.2 Modelling Statistical Distributions

Statistical distributions are visualized using frequency histograms, empirical density estimates and cumulative distribution functions. For many distributions, closed forms exist for model parameters and these are used for estimating parameters when available.

When a mixture model is suggested by a graphic, multimodality is first tested using Hartigan's dip test (Hartigan and Hartigan, 1985) and possibly corroborated with the appropriate lack of fit test for the corresponding univariate distribution(s).

Parameters of the mixture models are estimated using maximum likelihood via the function "optim" in R (R Development Core Team, R version 2.12.0). Likelihood functions, first derivatives and quantile-quantile plot programs were custom-written but use elements of the "fitdistr" function of Venables and Ripley (2002). Constrained optimizations are used for poorly behaved likelihoods following Byrd et al., (1995).

The number of components to be retained in the final model is primarily assessed using quantile-quantile plots, Monte Carlo simulated p-values for the Kolmogorov-Smirnov goodness of fit test and the likelihood ratio tests. Likelihood ratio tests are used cautiously following Everitt (1981), McLachlan (1987) and Garel (2007) who discuss the degeneracy of the asymptotic $\chi 2$ distribution used to test hypotheses regarding number of mixture components.

2.3.3.3 Spatially Explicit Methods

The spatial correlation structure is explored using empirical variograms with simulation envelopes (Diggle and Ribeiro, 2007) and directional variograms. The need for a trend model is assessed using empirical variograms and comparison of simulation envelopes for variograms fitted with and without a trend, plots of the responses (Al) versus longitude and latitude and three dimensional graphics. Trend models entertained are simple mean and first and second order polynomials as shown below.

Second Order Trend Model

μ(latitude, longitude) = β0 + β1 *longitude + β2*latitude + β3*longitude2 + β4 *latitude2 + β5* longitude * latitude.

Finally because the geostatistical models fitted assume a Gaussian random field, the requirement for a transformation was assessed using the frequency histograms and density estimates mentioned above and a Box-Cox transformation using the mean as a descriptor of the spatial variable in the R library "MASS" (Venables and Ripley, 2002).

Geostatistical models assume that the correlation between observations separated by a distance "d" attenuates to the same extent in all directions. This assumption is known as "isotropy". Isotropy in geostatistical data can be visually assessed by a three-dimensional graphic where trends indicate potential anisotropy and through use of directional variograms.

Three-dimensional graphics (used to visually assess data) generally require a regular grid of points. Since the OTR data are not collected on a grid the data are interpolated using a bilinear interpolation method by Akima (1978). The interpolated data are plotted in R version 2.12.0.

2.3.3.3.1 Fitting Geostatistical Surfaces

Prior to fitting geostatistical surfaces: 1) data are explored using methods described in section 2.3.3.1; 2) possible statistical distributions are assessed using the methods described in section 2.3.3.2; and, 3) trends in data are explored using methods described in section 2.3.3.1. Replicate grabs at a given sample location (variable = Station ID) were aggregated using the median because the median is more robust estimator of central tendency than the mean.

Geostatistical covariance models are estimated using the R libraries “gstat” (Pebesma, 2004) and “geoR” (Ribeiro and Diggle, 2001). Initial variogram estimates for the sill (variance of the random process generating the observations), nugget (micro-scale variability) and range (spatial distance over which sill is approached) are obtained visually from the empirical variograms. Non-anisotropic models are fit using ordinary and weighted least squares (weight = number of pairs used to estimate a covariance) (OLS and WLS, respectively), maximum likelihood (MLE) and restricted maximum likelihood (REML). Models that include anisotropy were only fit using likelihood methods due to software limitations. Issues with MLE estimates presented in section 2.4.4.1 led to examination of the properties of MLE spatial process estimates and a comparison of MLE with other estimation properties.

The estimated covariance model is used to predict values at the nodes of a grid of locations using kriging (Cressie, 1993; Diggle and Ribeiro, 2007). Kriging predictions and standard errors are obtained using the kriging function in the R library “geoR” (Ribeiro and Diggle, 2001). Both ordinary kriging (assuming an overall mean) and universal kriging (trend in locations) were considered.

2.3.3.3.2 Choosing Among Contending Models

Each fitted variogram was assessed subjectively using Monte Carlo simulation envelopes under the assumption of a Gaussian random field model (Ribeiro and Diggle, 2001). The fitted variograms were assessed objectively using cross-validation predictions. Cross-validation predictions used the model fitted using all the data to predict the value for a removed observation with each observation being removed one at a time. The cross-validation predictions were used to estimate the mean prediction error, mean absolute prediction error, mean square prediction error and mean squared standardized prediction error. The best-fitting model was chosen using these three criteria. Likelihood based models are compared using Akaike’s Information Criterion. The cross-validation residuals were plotted spatially to assess patterns in magnitude and sign indicating lack of fit and the empirical cumulative distribution function was examined to see if the assumption of a Gaussian random field was viable.

2.3.3.3.3 Assumptions

Distance Metrics

Geodetic or great circle distances are the shortest distances between two points on the globe. They are defined as:

$$\text{geodetic distance} = r\cos^{-1}\{\sin\phi_1 \sin\phi_2 + \cos\phi_1 \cos\phi_2 \cos(\theta_1 - \theta_2)\},$$

where r = earth's radius, θ = degrees of longitude and φ = degrees of latitude.

Geodetic distances better reflect the true distance between points separated by large distances (such as across Ontario) than planar distances based on Mercator projections. However planar (Euclidean) distances are used herein rather than geodetic distances when fitting geostatistical models because: 1) they are easily understood; 2) are readily available within geostatistical software; and 3) have well known theoretical properties. Problems associated with using planar distances over large areas are: 1) possible induction of anisotropy at high latitudes due to differences in spatial distances covered by latitude and longitude (Bannerjee, 2005); 2) concerns with the largely unknown effects on correlation. Correlation matrices must be positive definite and the use on non-Euclidean metrics such as geodetic distances do not guarantee that correlation matrices will in fact be positive definite; and 3) possible effects on parameter estimates. For example, Bannerjee (2005) showed that the effect of Euclidean distances relative to geodetic, chordal, (etc.) distances when assessing exponential and Matérn correlation structures was an overestimate of the range by a factor of approximately 1.5. Chordal distances are measured as follows:

$$\text{chordal distance} = \|u_2 - u_1\|,$$

where $u_1 = (x_1, y_{1.} z_1)$ represents a point in 3 dimensional Cartesian space centered at the centre of the earth. u_2 is similarly defined.

One metric that largely reflects geodetic distances and preserves euclideanarity is the chordal metric. Curriero (2007) warns against the indiscriminate use of non-Euclidean distance metrics due to the negative effect on the requisite positive definitiveness of correlation matrices which play an integral role in geostatistical modelling.

2.4 Results and Discussion

2.4.1 Assessing Relationships among Co-Analytes

The relationship among co-analytes is assessed to see if ancillary information might be used to improve site–specific predictions. Spearman rank correlations among co-analytes in the OTR dataset using the methods described section 2.3.2 are presented in Figure 5 below.

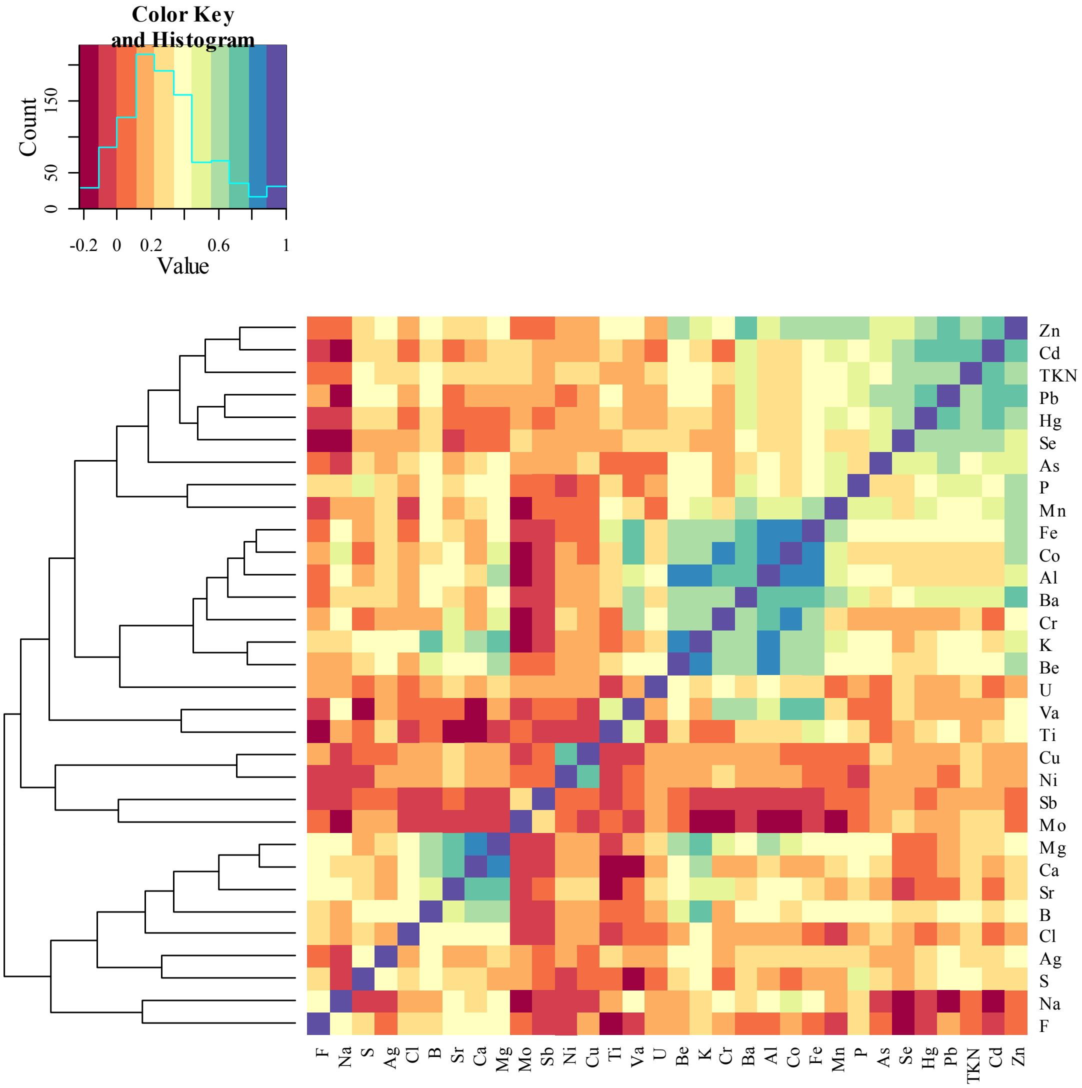

Figure 5: Spearman Rank Correlations between Soil Analytes in Ontario Old Urban and Rural Parks

Experientially, environmental correlations of approximately 0.7 or greater have been corroborated by applicable theory. Using this arbitrary but experientially validated correlation magnitude, and, the structure revealed through a hierarchical complete linkage clustering algorithm, Figure 5 shows four groups of analytes that are internally highly correlated. Group 1 consists of Zn, Cd, TKN, Pb, Hg and Se. Group 2 consists of Fe, Co, Al, Ba, Cr, K and Be. Group 3 consists of Mg, Ca and Sr and Group 4 consists of Cu and Ni. The same data are re-plotted separately by land use category.

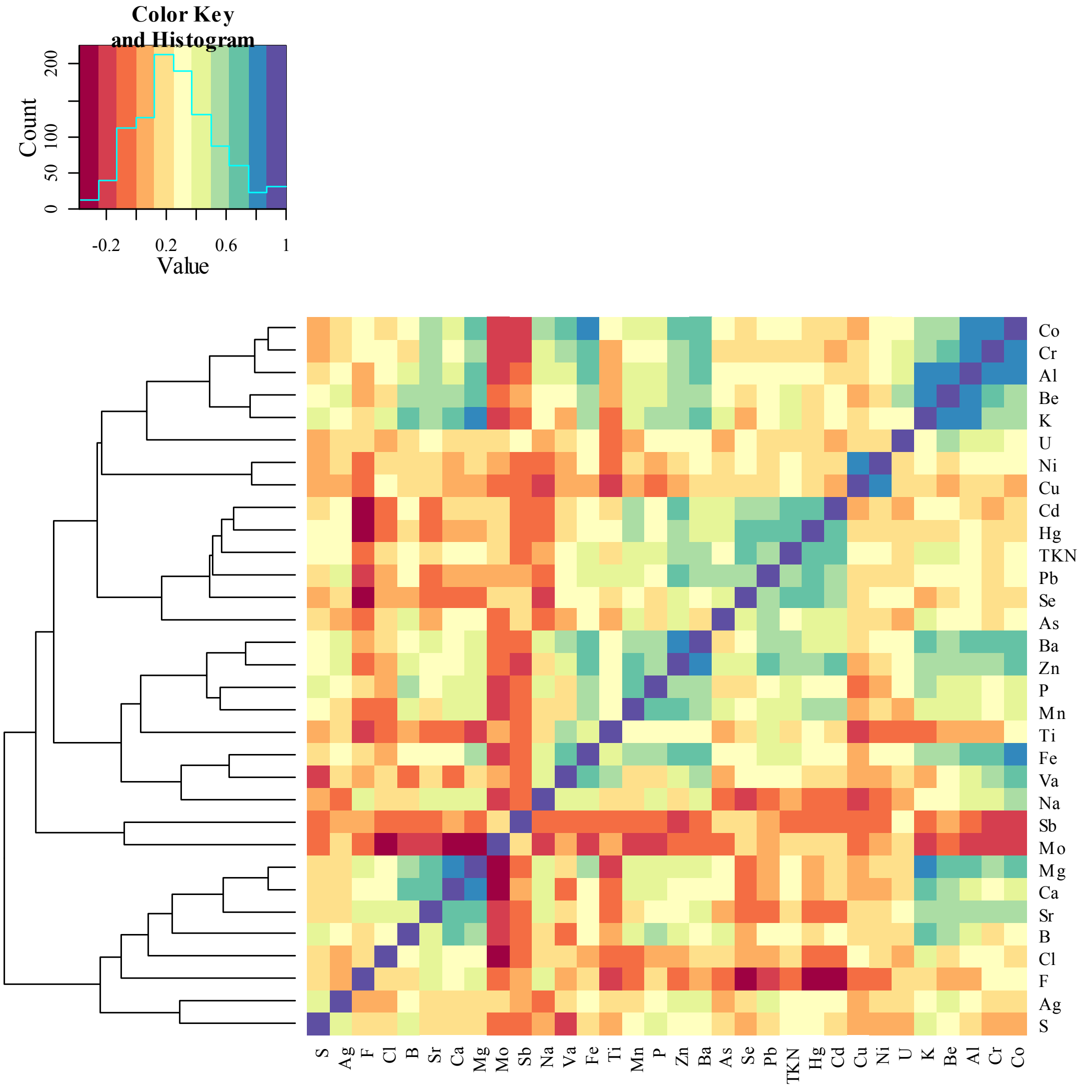

Figure 6: Spearman Rank Correlation between Soil Analytes in Ontario Rural Parks (OTR Dataset)

Figure 6 which describes the correlation among surficial soil analytes in Ontario rural parks shows four groups of analytes. Group 1 is comprised of Co, Cr, Al, Be and K. Group 2 is comprised of Ba and Zn, possibly including P and Mn and Group 3 is comprised of Mg, Ca and Sr. Group 4 consists of Cu and Ni.

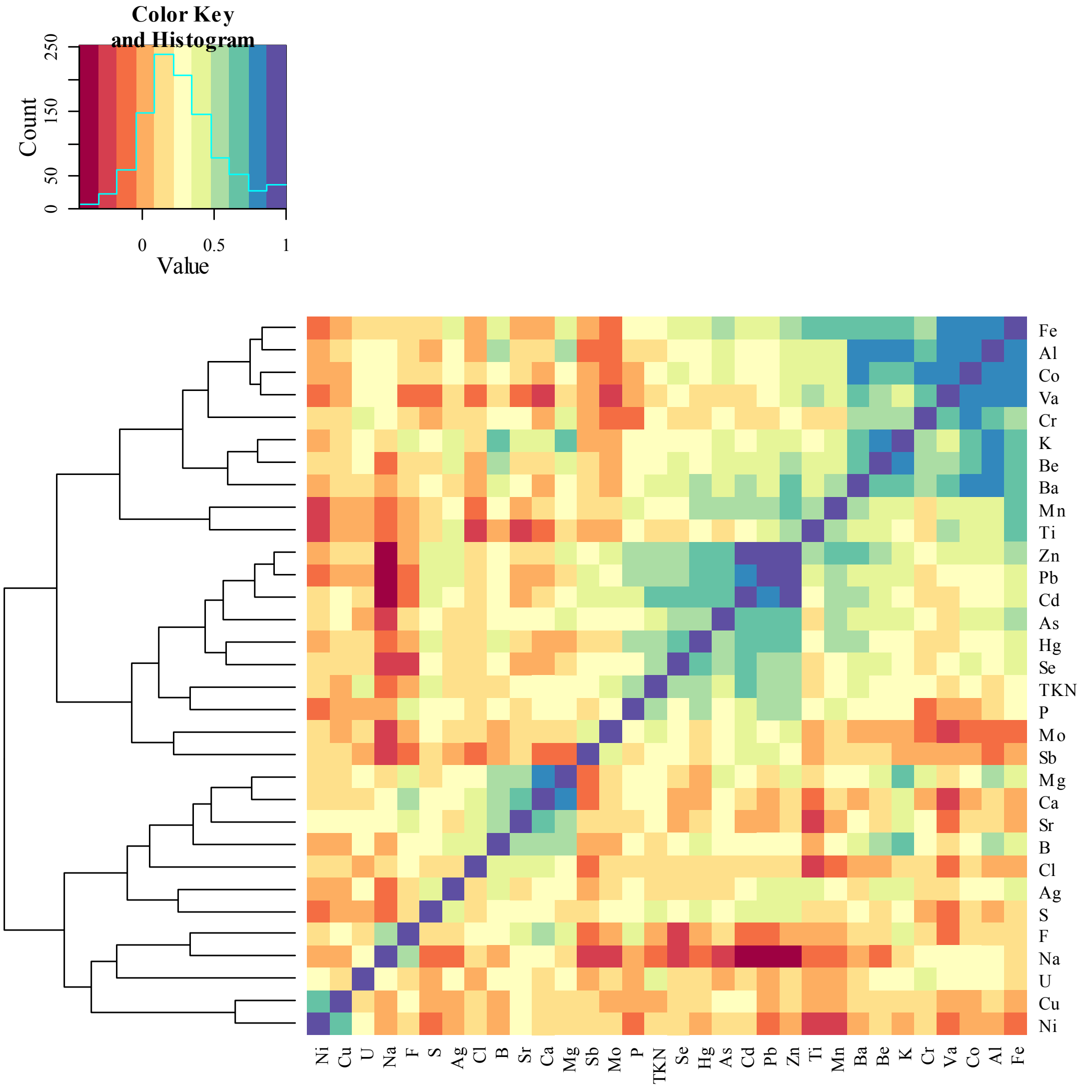

Figure 7: Spearman Rank Correlation between Soil Analytes in Ontario Old Urban Parks (OTR Dataset)

Figure 7 which describes the correlation among surficial soil analytes in Ontario old urban parks shows four groups of analytes. Group 1 is comprised of Fe, Al, Co, Va, Cr, K, Be and Ba. Group 2 is comprised of Zn, Pb, Cd, As, Hg, Se and possibly TKN. Group 3 is comprised of Sr, Ca and Mg and possibly B. The fourth group is comprised of Cu and Ni.

Groups of analytes by land use are summarized in Table 6. It is important to note that the “groups” identified are somewhat subjective. Groupings are based upon the magnitude of linear rank correlation between analytes that experientially has often been validated on theoretical grounds and, the structure revealed through a hierarchical complete linkage clustering algorithm. Other choices of distance metric or agglomeration method would produce slightly different groupings.

Table 6 shows that there are three sets of analytes (in bold font) that are correlated with one another regardless of the land use type examined and are of particular interest when estimating background concentrations. These three sets of analytes are 1) Sr, Ca and Mg; 2) Co, Cr, Al, Be and K and 3) Cu and Ni.

Table 6: Summary of Groups of Surficial Soil Analytes Identified Using Correlation Analysis, by Land Use (OTR Dataset)

Land Use	Group 1	Group 2	Group 3	Group 4
Rural Parks	**Co**, **Cr**, **Al**, **Be** and **K**	Ba and Zn, possibly including P and Mn	**Sr**, **Ca** and **Mg**	**Cu** and **Ni**
Old Urban Parks	**Co**, **Cr**, **Al**, **Be**, **K**, Va and Ba.	Zn, Pb, Cd, As, Hg, Se and possibly TKN	**Sr**, **Ca** and **Mg** and possibly B.	**Cu** and **Ni**

These results suggest that Al could be used as a co-variable to improve prediction of Co, Cr, Be and K. Zhao et al., (2007) found that Al was correlated with Co, Cr and K after assessing 5691 soil samples from England and Wales, while Sterckeman et al., (2006) found that Al was correlated with Co and Cr in the surficial horizons of loess deposits in France.

2.4.2 Statistical Distribution of Selected OTR Analytes

2.4.2.1 Aluminum

2.4.2.1.1 Data Exploration

Bubble plots showing location and Al concentrations in old urban parks (Figure 8), rural parks (Figure 9) and fields (Figure 10) across Ontario are presented below. As described in section 2.3.1.2, t**he locations for the bubble plot using the OMAFRA dataset are randomly moved within a 20 km radius (jittered) so that individual fields cannot be identified**.

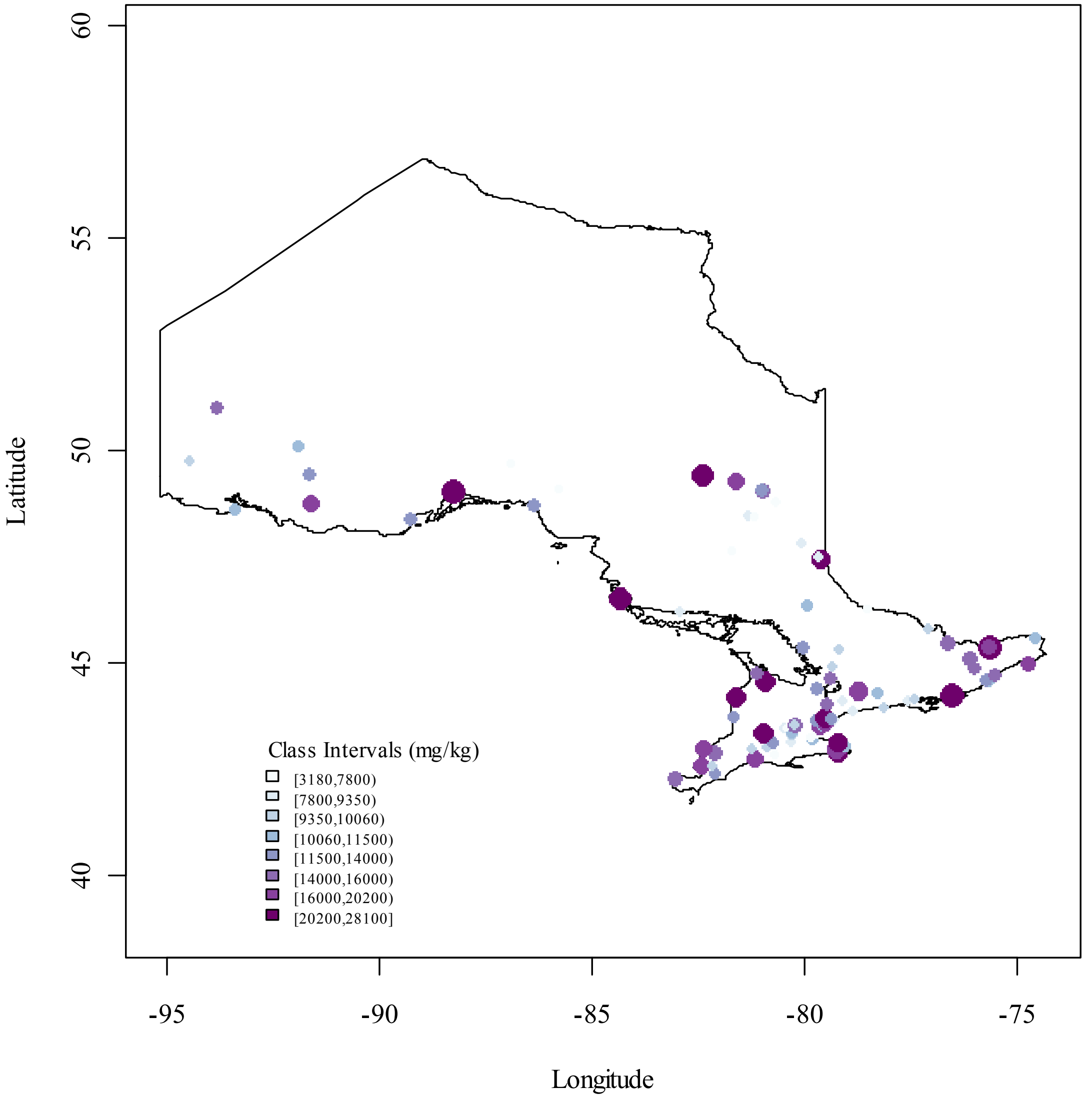

Figure 8: Al in Old Urban Parks (OTR Dataset)

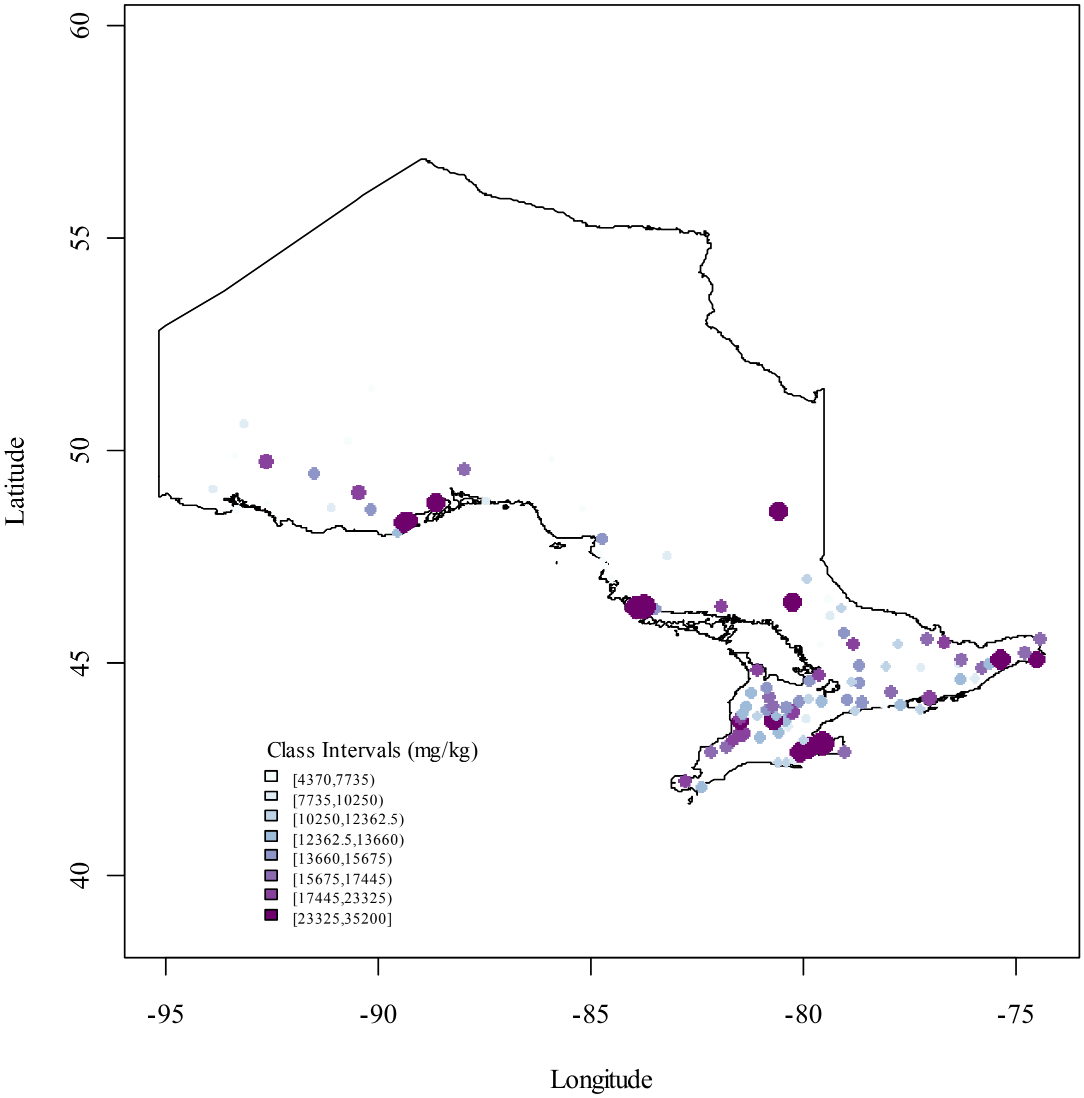

Figure 9: Al in Rural Parks (OTR Dataset)

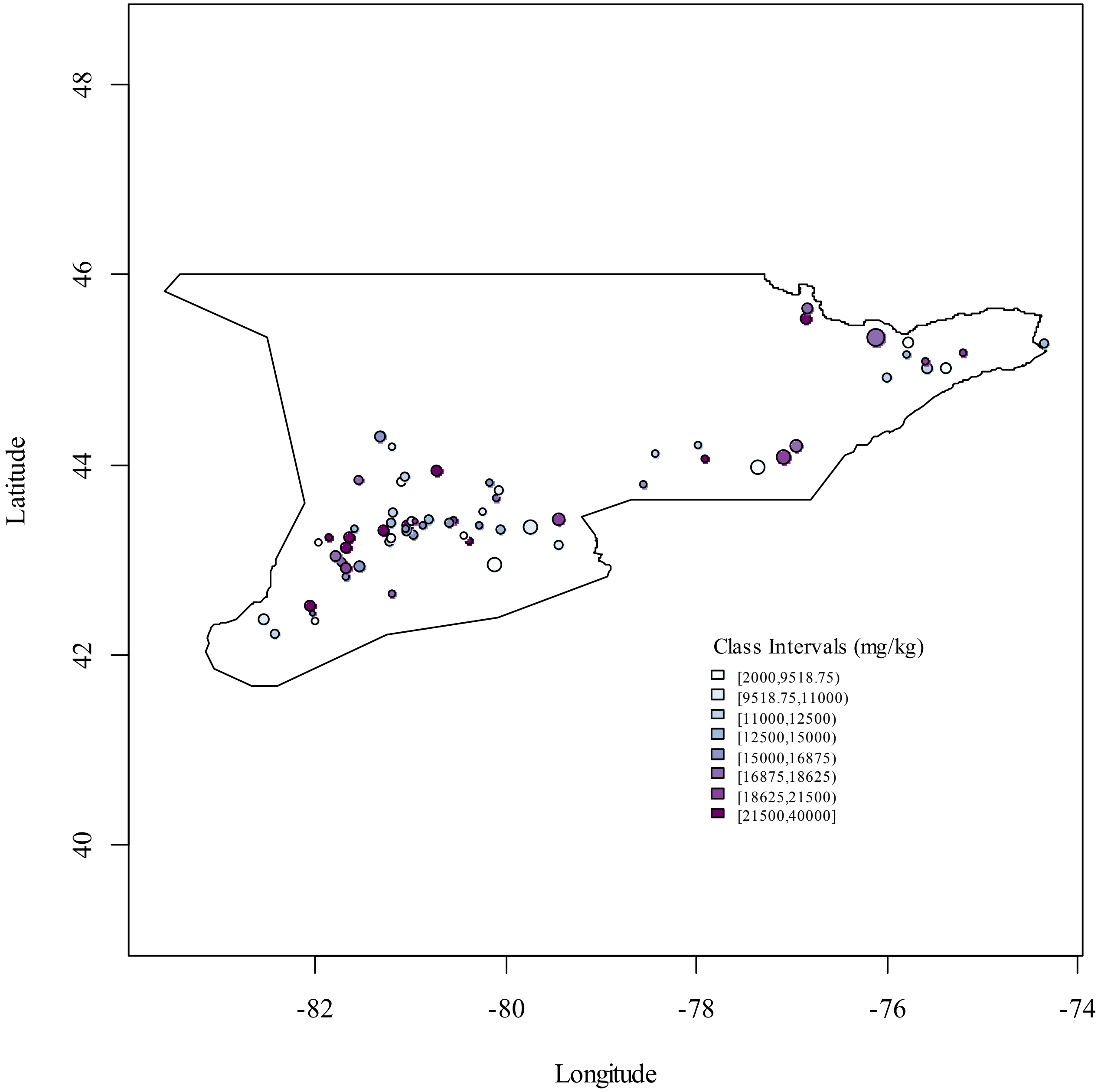

Figure 10: Al in Fields, OMAFRA Dataset (Jittered Locations)

Both figures presenting Al in parks suggest regional heterogeneity.

Figure 8 through Figure 10 show sampling locations and concentrations. The next graphic compares the sampling coverage for the three datasets in order to directly compare kriged surfaces (Figure 11). The graphic is zoomed to the limited coverage provided by the

OMAFRA dataset. **The locations in the OMAFRA dataset are randomly moved within 20 km (jittered) so that individual fields cannot be identified**. Note that some of the approximate OMAFRA field data may appear in a waterbody due to the deliberate jittering.

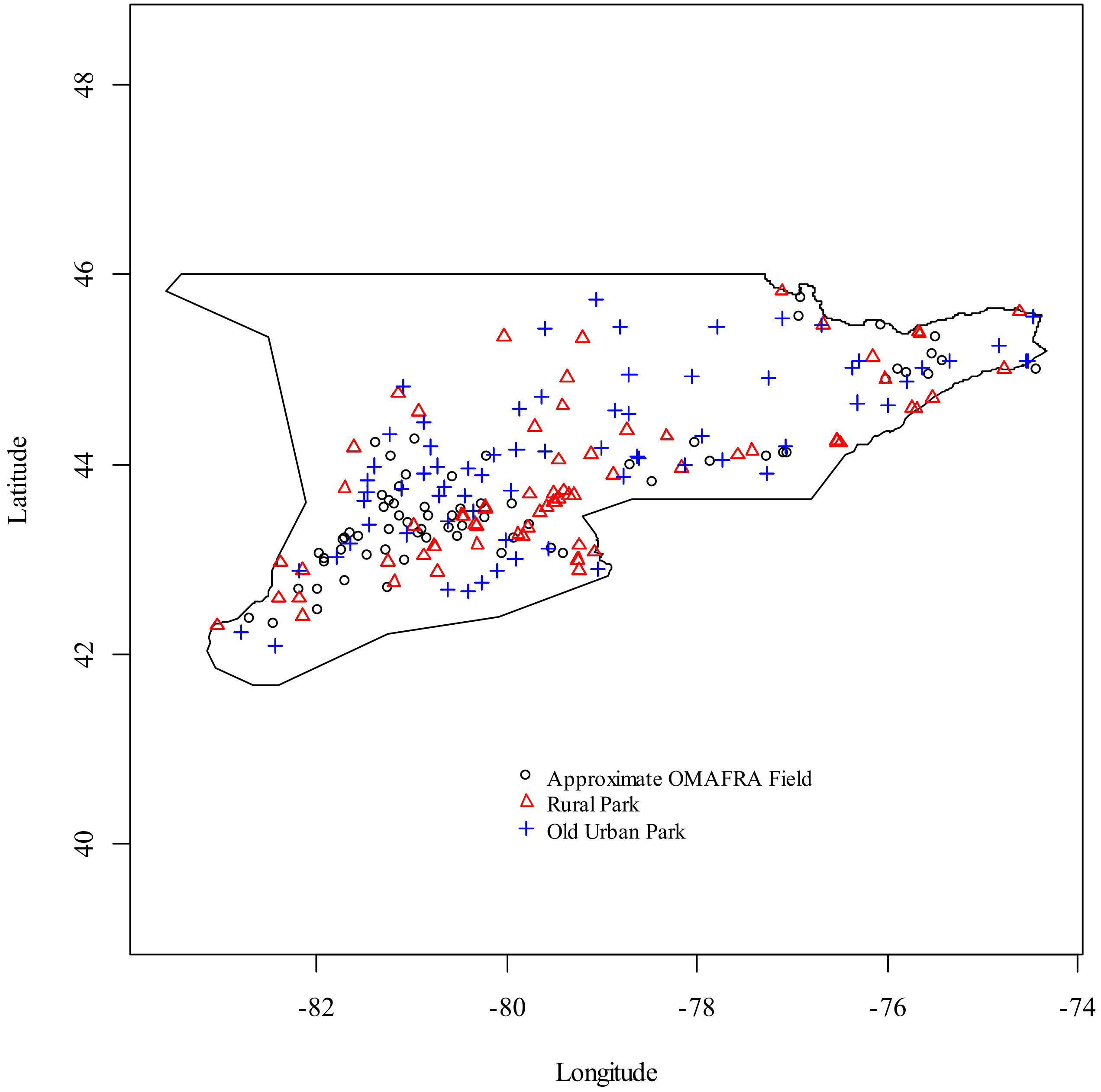

Figure 11: Al Sampling Locations for Combined Datasets (Jittered Locations for OMAFRA Dataset)

Summary statistics for Al in rural, old urban parks and the OMAFRA dataset are presented in Table 7. Robust measures of location such as the quantiles (0.05, 0.15, 0.25, 0.5, 0.75, 0.85 and 0.95) and Huber's M-estimator for location (robust centre; Huber, 1981) suggest that Al concentrations may on average be higher in rural parks. Robust estimators of dispersion such as Huber's M-estimator for scale (robust scale; Huber, 1981) and the inter-quartile range (difference between 3rd and 4th quartiles) suggest that the dispersion among the two OTR datasets is not unduly different. These two observations are confirmed using empirical distributions (Figure 13).

Table 7: Summary Statistics for Al in Rural and Old Urban Parks and OMAFRA Data

	Rural Parks	**Old Urban Parks**	**OMAFRA**
n	321	253	68
mean (µg/g)	14859.0	13276.0	15482.0
median	13890.0	12000.0	15000.0
Robust centre	14173.0	12909.0	14947.0
Variance	47634000.0	30724000.0	42110000.0
SD	6901.8	5542.9	6489.2
Robust Scale	5767.2	5326.2	5588.3
Minimum	3600.0	2960.0	2000.0
Maximum	51800.0	29200.0	40000.0
Range	48200.0	26240.0	38000.0
1st Quartile (q.0.25)	10400.0	9200.0	11000.0
3rd Quartile (q.075)	17390.0	16770.0	18625.0
IQR	6990.0	7570.0	7625.0
Skewness	1.2892	0.7964	1.0613
Kurtosis	3.0318	0.0799	1.9896
q.05	5380.0	6000.0	7152.5
q.15	8390.0	8080.0	9760.0
q.85	20400.0	19088.0	20950.0
q.95	28900.0	24000.0	28325.0

2.4.2.2 Lead

Pb in rural parks is investigated to identify how kriged surfaces can be used to assess the utility and defensibility of EQGs based on direct measurements.

2.4.2.2.1 Data Exploration

The available Pb concentration by location data are presented in Figure 12.

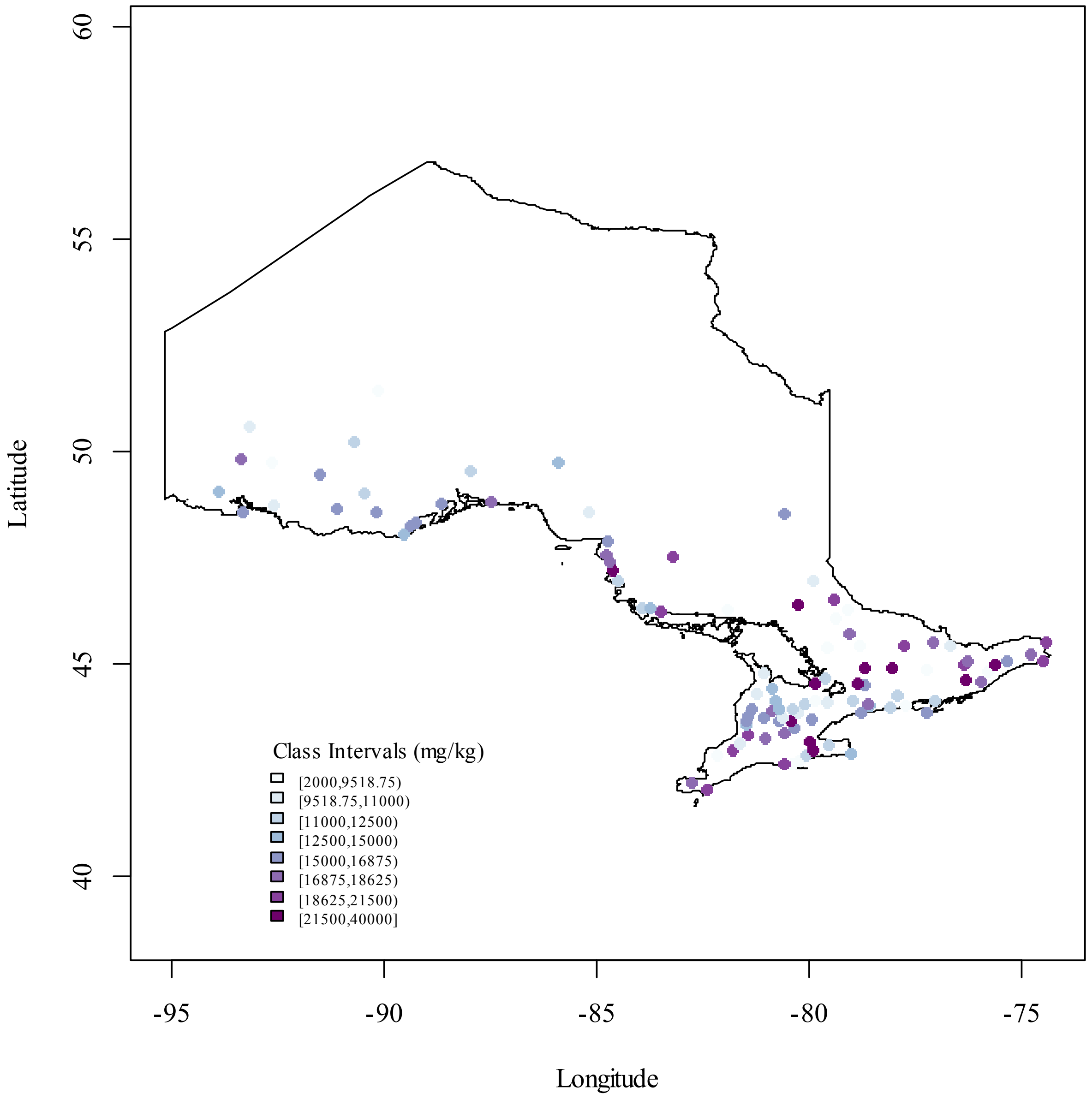

Figure 12: Pb in Rural Parks (OTR Dataset)

Figure 12 suggests regional heterogeneity although a single Pb OTR was estimated by Zajdlik (2006a), following OMOE (1993). Summary statistics are presented in Table 8.

Table 8: Summary Statistics for Pb in Rural Parks Data

Summary Statistic	Estimate
n	107
mean (μg/g)	21.5
median	19.4
Robust centre	20.5
Variance	107.7
SD	10.4
Robust Scale	8.2
Minimum	5.9
Maximum	75.7
Range	69.8
1st Quartile (q.0.25)	16.1
3rd Quartile (q.075)	25.5
IQR	9.4
Skewness	2.0125
Kurtosis	7.3151
q.05	8.7
q.15	12.5
q.85	29.9
q.95	35.9

The empirical cumulative distribution was assessed visually. This plot and a Box-Cox plot suggest log transformation to achieve normality prior to geostatistical modelling (plots not shown).

2.4.3 Assessing Statistical Distributions

Empirical distribution functions for Al in rural and old urban parks are presented in Figure 13 in order to compare OTRs estimated by OMOE (1993) and Zajdlik (2006a) with alternative methods developed herein. As the sole intent of assessing the OMAFRA dataset is to test Ho2b: “Geostatistical models cannot be used with the OMAFRA field metal data to make geostatistical predictions” the statistical distribution of Al in this dataset is not assessed. Also as discussed in section 2.2.7, Pb in rural parks was only assessed to identify how kriged surfaces may be used to assess the utility and defensibility of EQGs based on direct measurements. Thus the possibility of mixture distributions is not explored.

Figure 13 shows two right-skewed distributions typical of data generated as a series of multiplicative effects. Note the larger measure of central tendency of Al in rural parks relative to old urban parks.

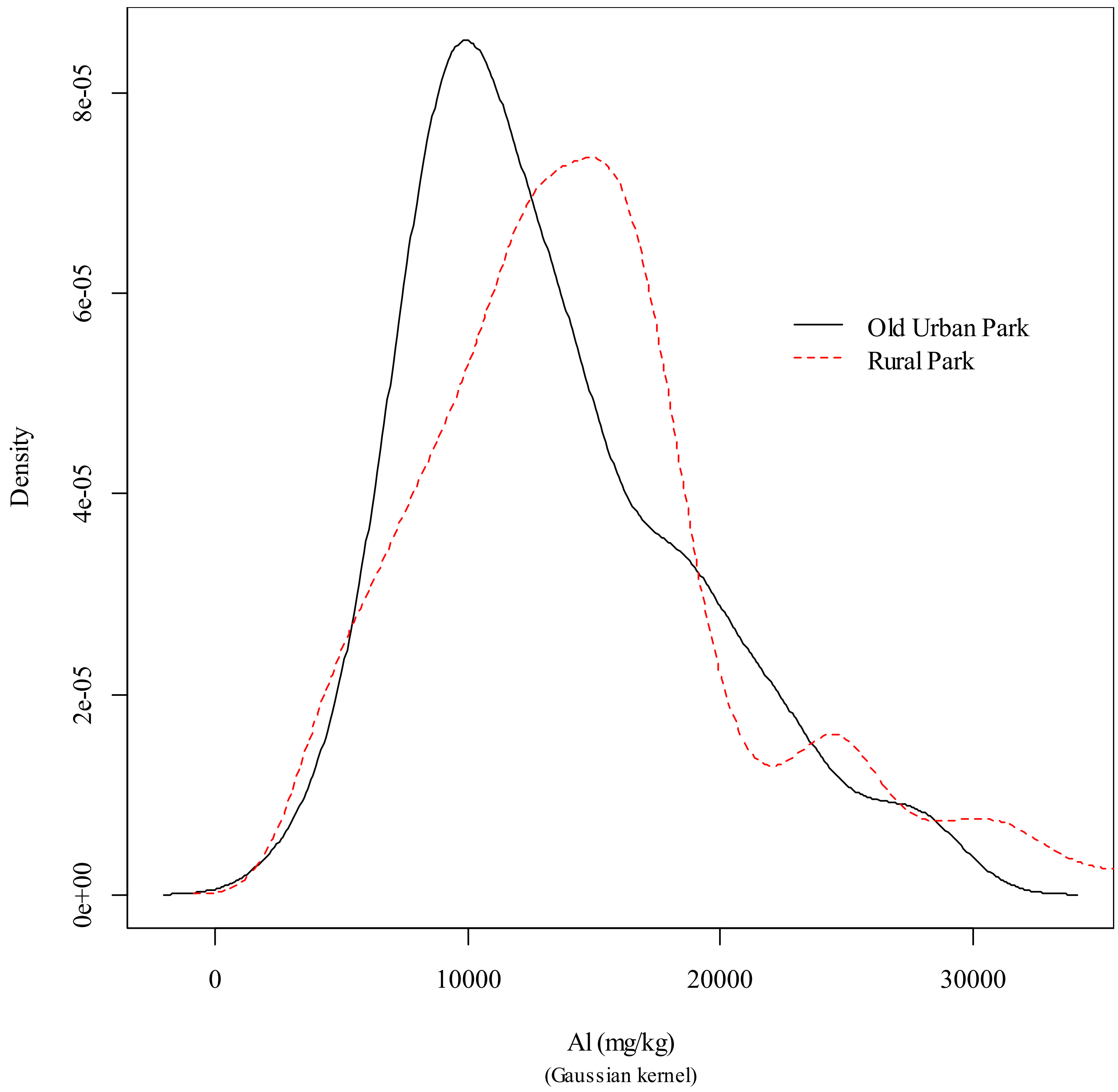

Figure 13: Empirical Distribution Functions for Al in Rural and Urban Parks (OTR Dataset)

Since many geostatistical inferential techniques require (or are improved by) approximately normally distributed data, a log-transformation was attempted. This induced a moderately symmetric density as shown in Figure 14 but there is a suggestion of multimodality and leptokurtosis (data are more "peaked" than expected for a normal distribution).

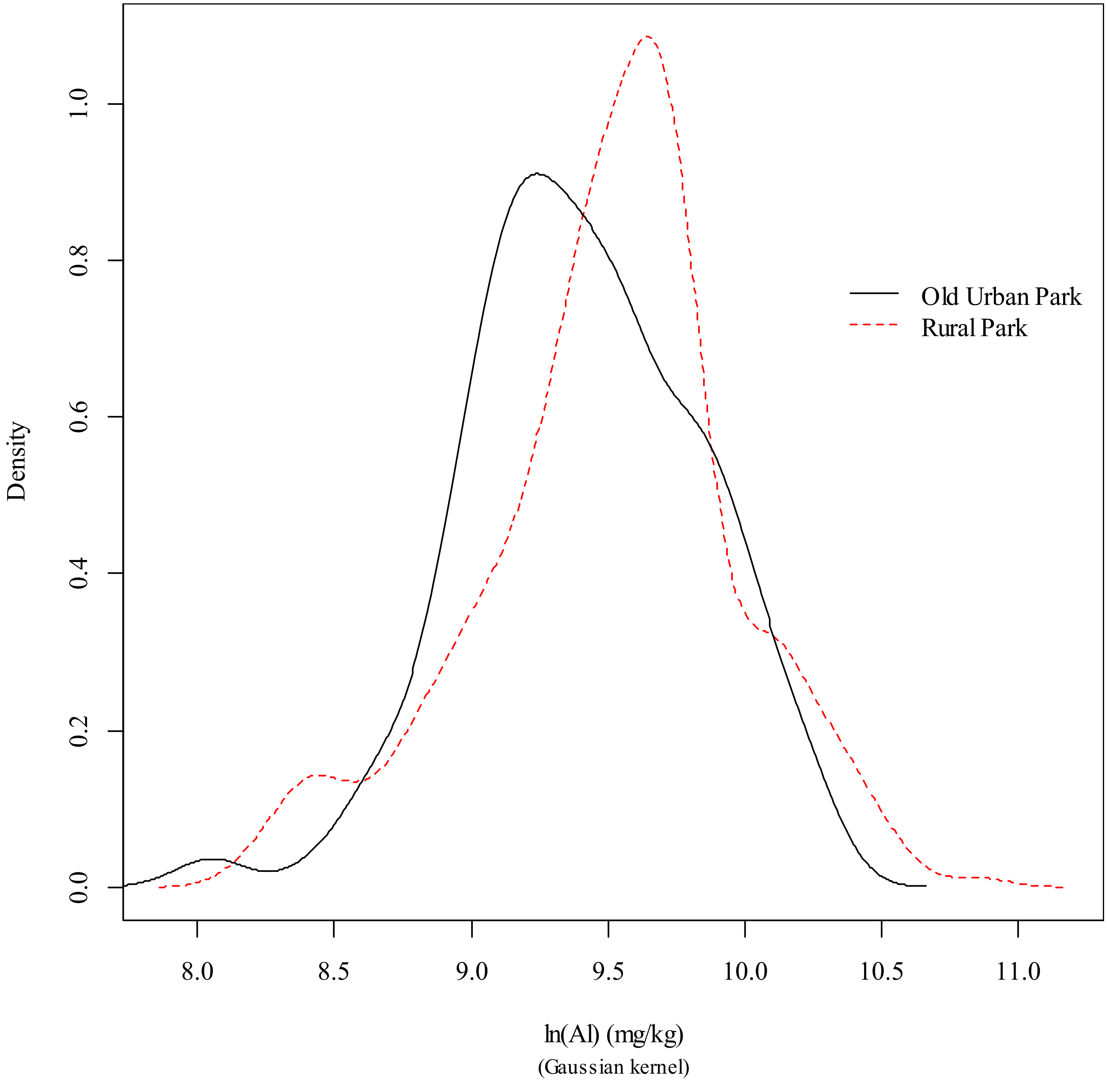

Figure 14: Empirical Distribution Functions for ln(Al) (OTR Dataset)

The multimodality of the ln(Al) rural park dataset is confirmed using Hartigan's dip test (Hartigan and Hartigan, 1985) with a p-value of 0.01392. Also, a Shapiro-Wilks test for normality on the log scale with a p-value of 0.0002156 indicates a significant departure from normality.

After log-transformation, the data were fitted following the methods described in section 2.3.3.2. Bivariate and tetravariate normal mixture distributions were fit to the data and a kernel density is superimposed (Figure 15). Attempts were made to fit a trivariate normal mixture without success. This was due to the inability of a single normal distribution to describe the empirical distribution between approximately 8.7 and 10 mg/kg ln(Al).

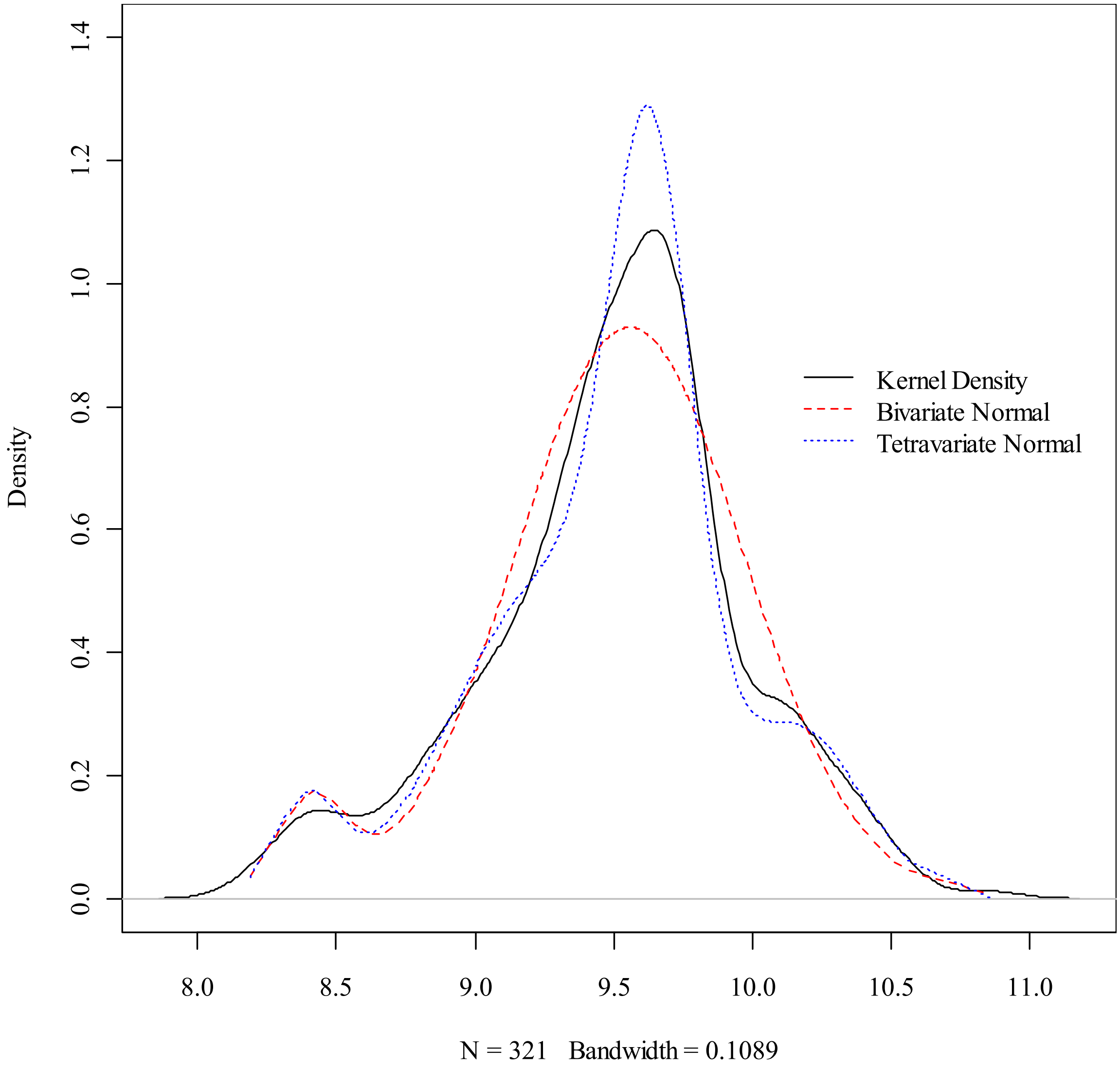

Figure 15: Fitted Bivariate and Tetravariate Density Functions and Superimposed Kernel Density - Al in Rural Parks (OTR Dataset)

The utility of the bivariate normal model relative to the univariate normal is a given following the confirmation of multimodality based on the results of Hartigan's dip test confirmation by the Shapiro-Wilk test for normality. Visually, the tetravariate normal differs significantly from the bivariate model in the right tail. The difference in likelihoods (likelihood ratio tests described in section 2.3.3.2) between the bi and tetravariate normal distributions is 45.6853 on 6 degrees of freedom with a p-value = 3.4198e-08 indicating that the tetravariate model provides a substantive improvement in fit despite the addition of 6 parameters. The model parameters (p = mixing proportions 1:3 with 4th mixing proportion fixed as the difference between 1 and the sum of the first three mixing proportions; u = 4 location parameters; and s= 4 scale parameters) and standard errors for the fitted tetravariate normal mixture model are summarized in Table 9. A large number of significant digits are presented in order to preserve accuracy if used for calculations; the implied level of precision should not be assumed for predictions.

Table 9: Estimated Tetravariate Normal Mixture Model Parameters – Al in Rural Parks (OTR Dataset)

	Estimate	Standard Deviation
p1	0.04459	0.01836
p2	0.44378	0.2310
p3	0.3609	0.1954
u1	8.3953	0.05247
u2	9.2747	0.1945
u3	9.6371	0.03908
u4	10.172	0.08480
s1	0.1151	0.03821
s2	0.3430	0.09075
s3	0.1484	0.04103
s4	0.2281	0.04867

Table 9 shows that slightly more than 15% of the data correspond to a distribution with a peak at approximately 26,169 μg Al/g (≈ exp(u4)).

If the Al rural park data are treated as a cohesive “set” without reference to spatial information, the data based on modelling of the distribution, suggests four groups are present in rural parks with <u>means</u> of 4,426 10,665, 15,323 and 26, 169 mg Al/kg. It may be useful to identify which observations fall within each group, particularly if the geostatistical models are not used to estimate OTRs. Using the mixture distribution results, the null hypothesis:

H_o1: An analyte-specific OTR dataset is comprised of indistinguishable statistical distributions,

is rejected as different statistical distributions are clearly identifiable. This result contrasts with that reached using the current OTR paradigm applied to the rural park data where all administrative regions across Ontario were combined to generate a single Al OTR of 30,050 µg Al/g (Zajdlik, 2006a).

2.4.4 Geostatistical Modelling

In this section the spatial relationship among variables is considered by fitting geostatistical models to the Al data following the methods described in section 2.3.3.3.

2.4.4.1 Al in Rural Parks

The empirical variogram presented in Figure 16 is used to provide initial estimates of the sill, nugget and range.

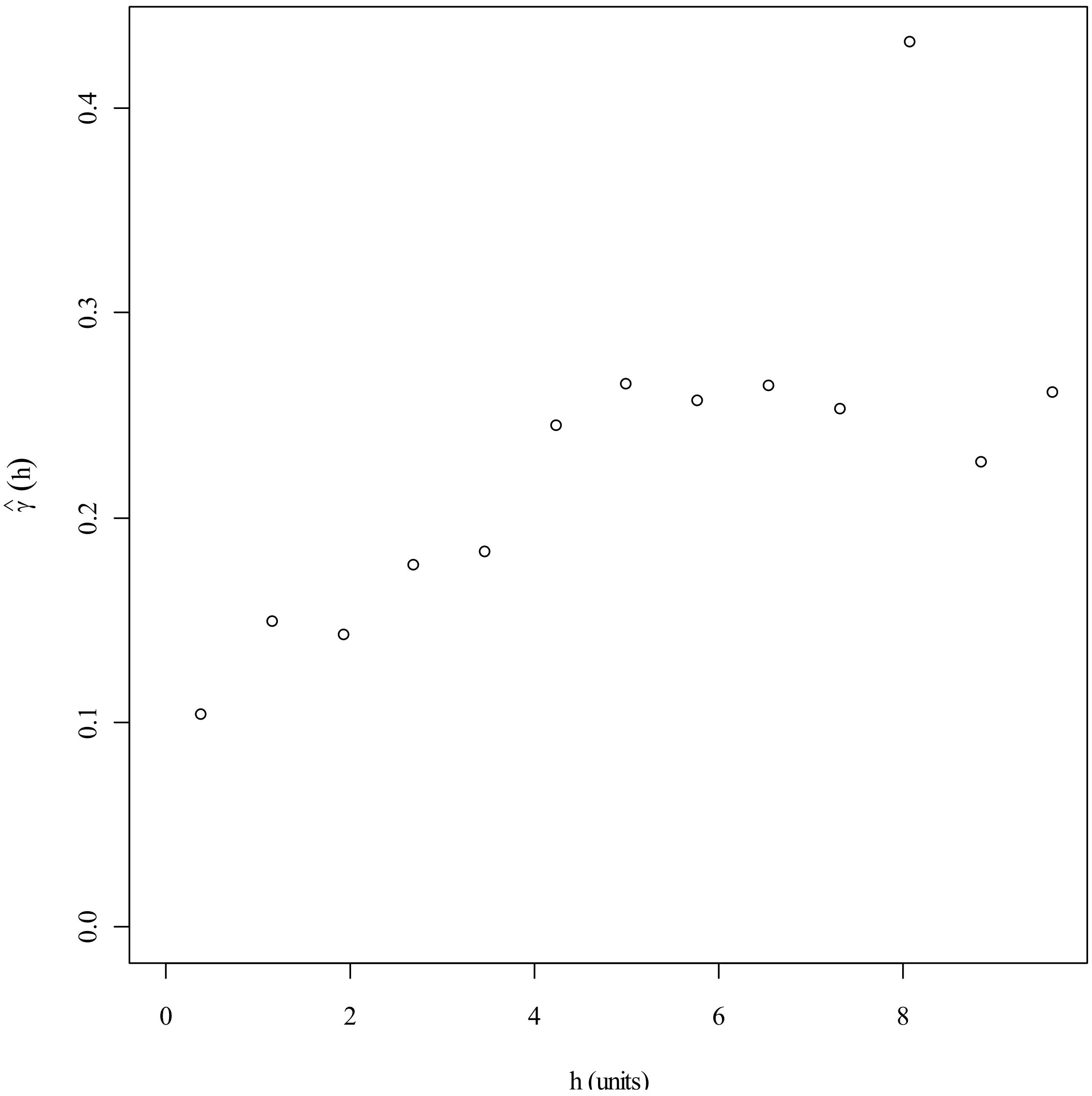

Figure 16: Empirical Variogram for Al in Rural Parks (OTR Dataset)

Figure 16 suggests that the nugget, sill and range are respectively; 0.1, 0.3, and 6. Because structural forms of the directional variograms presented in Figure 17 vary somewhat with direction, anisotropy may be present.

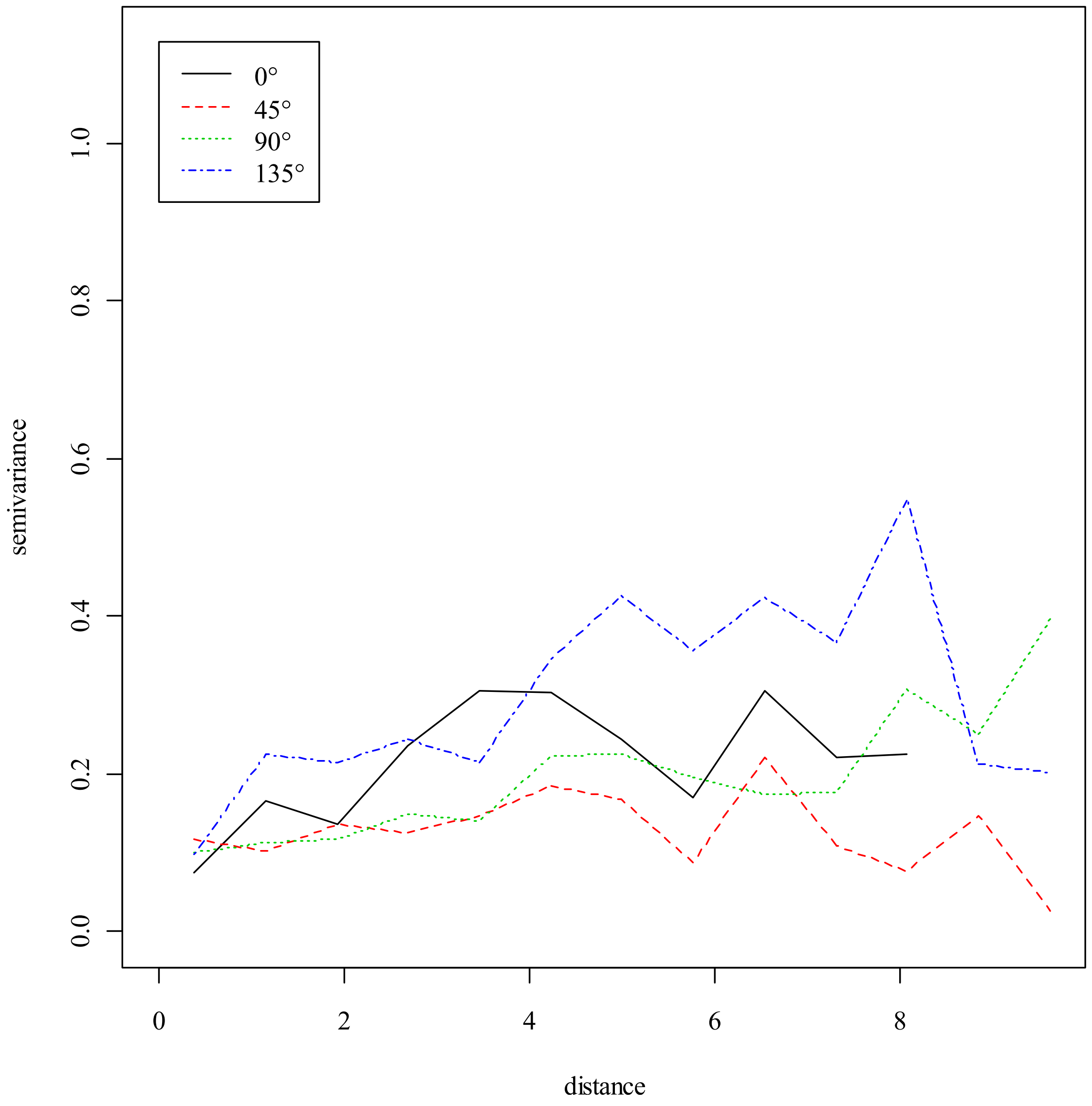

Figure 17: Directional Variograms; Al in Rural Parks (OTR Dataset)

Models fitted to the raw and aggregated data considered four theoretical variograms; spherical, exponential, Gaussian and Cauchy variograms and, whether linear trends or isotropic behaviour was present or not. The non-anisotropic models were fit using ordinary least squares, weighted least squares, maximum likelihood and restricted maximum likelihood. Models that include anisotropy were only fit using likelihood methods due to software limitations. The best fitting models on the bases of likelihood estimation and use of raw versus aggregated data are presented in Figure 18.

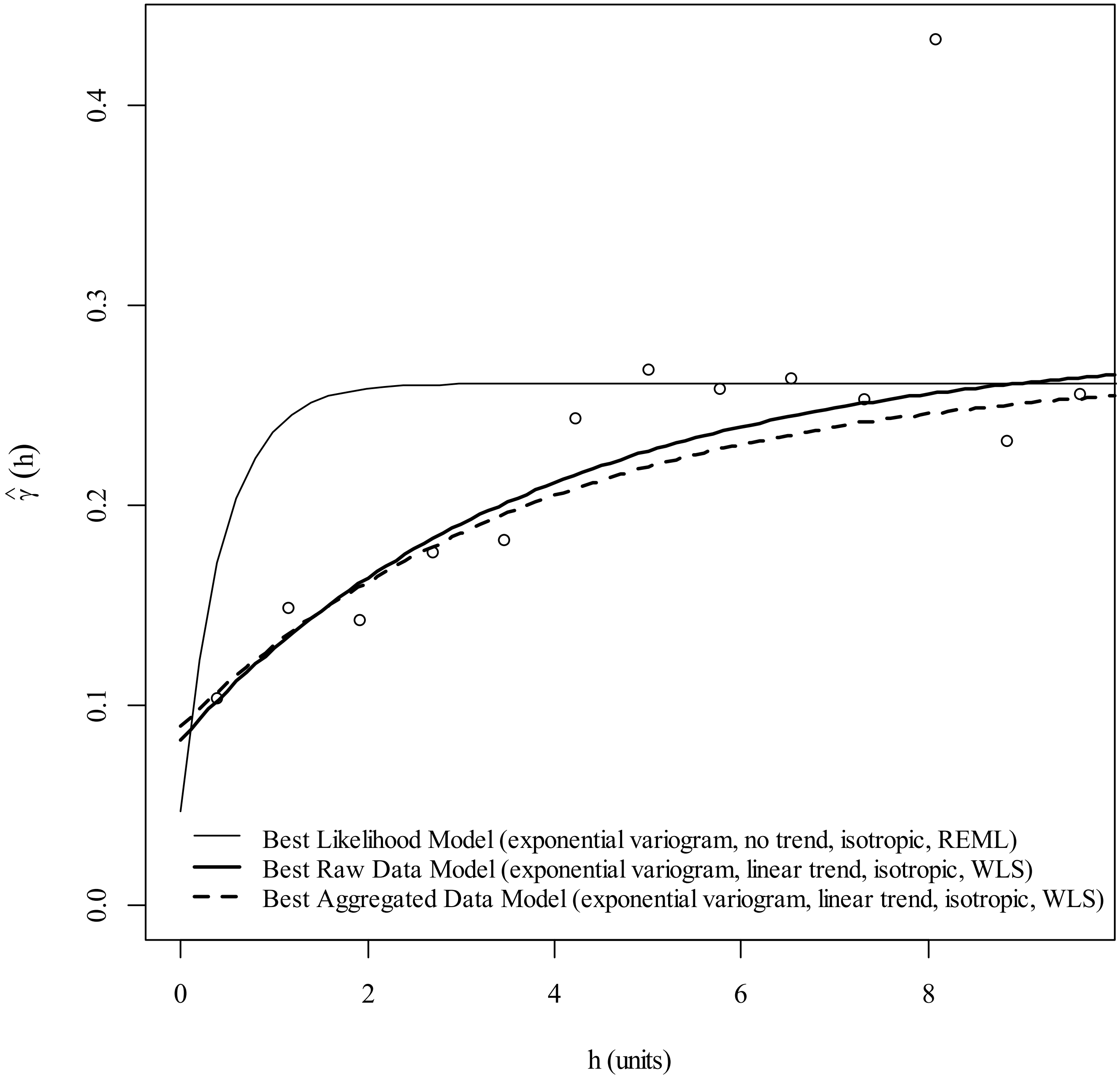

Figure 18: Candidates for Best Fitting Theoretical Variograms for Al in Rural Parks (OTR Dataset)

Figure 18 shows that the best fitting likelihood model did not fit as well subjectively (as shown above) or objectively (using the criteria presented in section 2.3.3.3.2) as weighted least squares models. The poor fit of likelihood-based models was consistent for this and the urban park data despite considerable effort with model tuning parameters, choice of initial estimates, etc. Possible reasons are discussed in section 2.5.2. The “best” fitting model using the criteria presented in section 2.1.6 is an isotropic exponential variogram with a linear trend with parameters estimated using WLS based on either the raw or aggregated data. The model fit to the raw data is presented in Figure 19 with a Monte Carlo simulation envelope and is used in subsequent presentations.

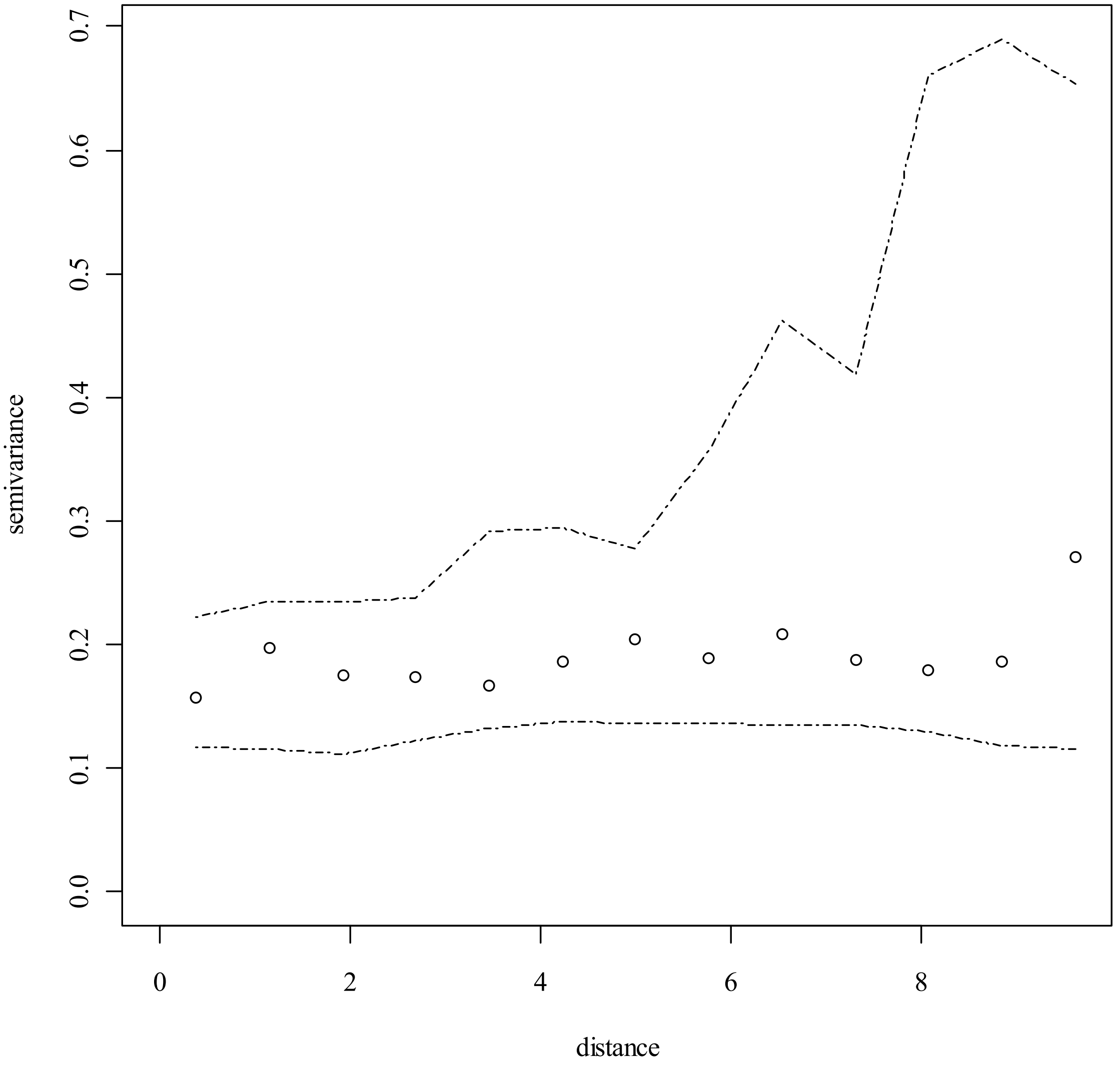

Figure 19: Fitted Variogram and Monte Carlo Simulation Envelope for Al in Rural Parks (OTR Dataset, raw data)

The fitted variogram is used to predict Al concentrations across the sampled portion of Ontario (Figure 20).

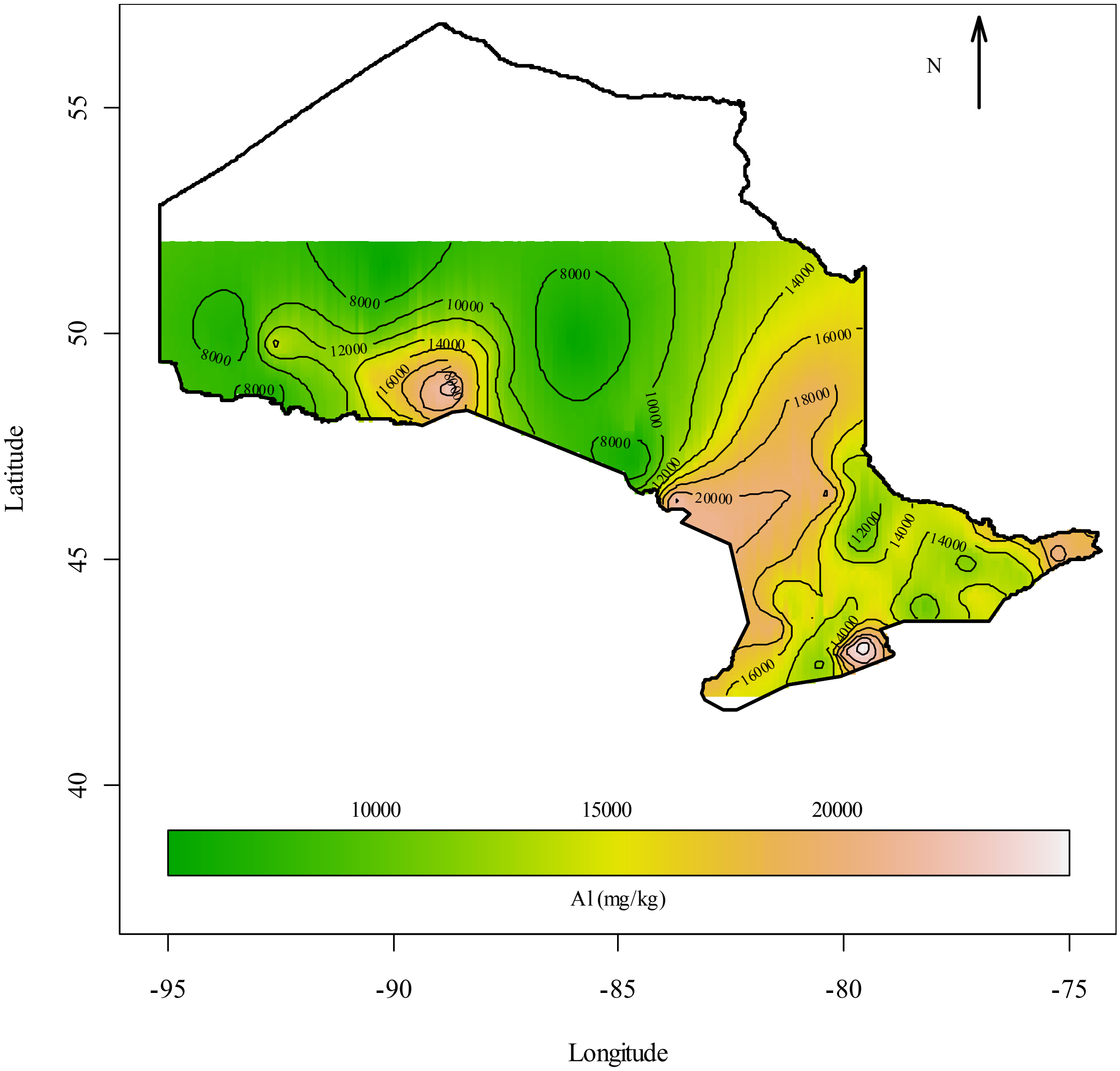

Figure 20: Predicted Al in Ontario Based on Rural Park Data (OTR Dataset)

The prediction standard errors are presented in Figure 21.

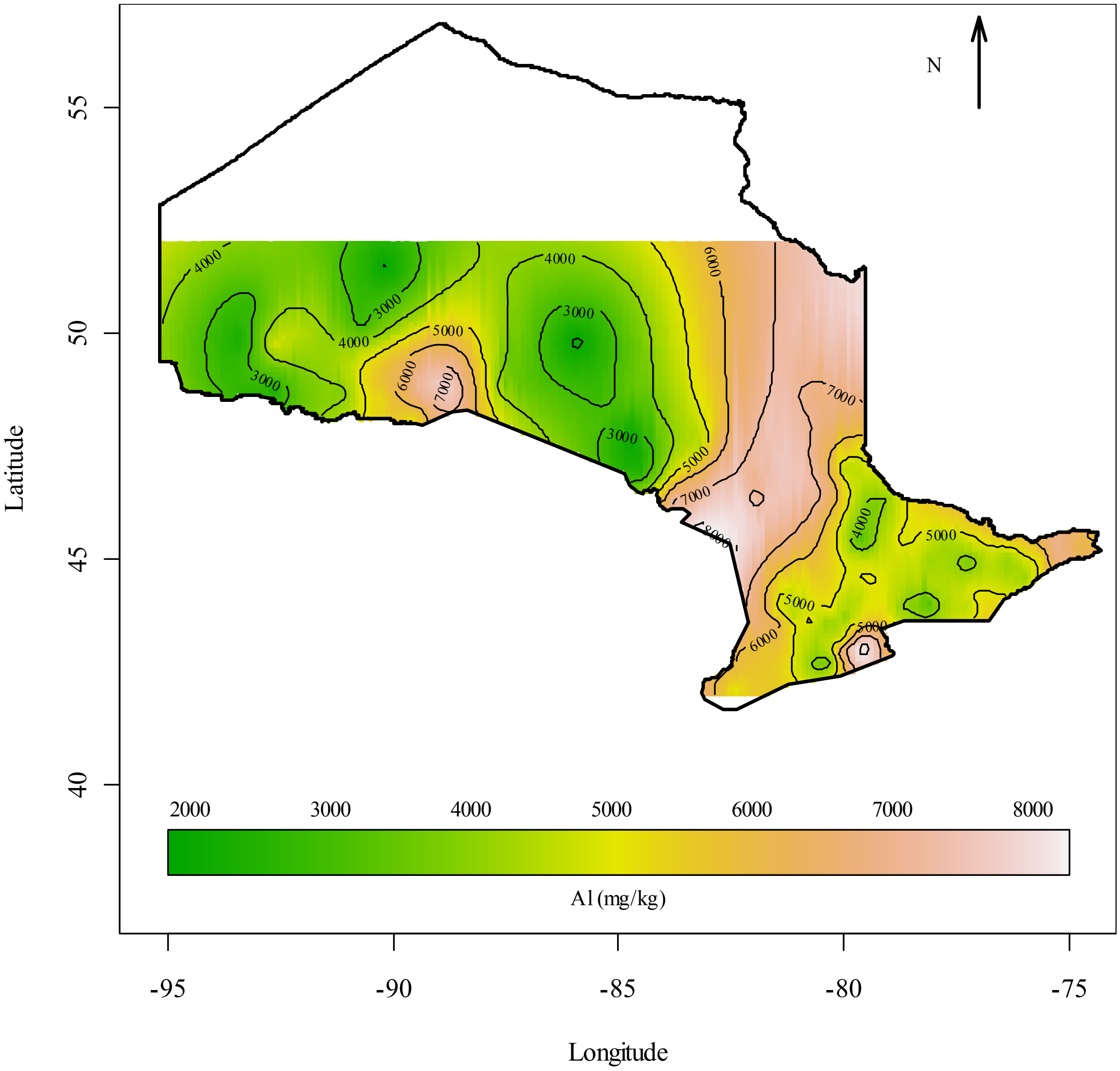

Figure 21: Prediction Standard Errors for Al in Ontario Based on Rural Park Data (OTR Dataset)

Figure 21 shows that the smallest standard errors are approximately 2,000 mg/kg and correspond to predictions of approximately 8,000 mg/kg (Figure 20). Under the assumption that kriging predictions are normally distributed, 95% confidence intervals for Al concentrations corresponding to the smallest and largest standard errors are presented in Table 10.

Table 10: Summary of Confidence Intervals for Predicted Al Concentrations in Ontario on the Basis of Al in Rural Parks (OTR Dataset)

	Predicted Al Concentration (mg/kg)	**Lower 95% Confidence Interval (mg/kg)**	**Upper 95% Confidence Interval (mg/kg)**
Smallest Standard Error	5,572	1,905	9,238
Largest Standard Error	20,760	4,635	36,884

An alternative method of investigating variability at a specific location is to simulate the Gaussian random field and plot a specific pointwise percentile. The 97.5th percentile is chosen as it represents the upper limit of normal chosen by the Ontario Ministry of Environment in the OTR paradigm. An image map of point-wise 97.5th percentiles on a grid on 0.1 degree increments with a bounding box delimited by sampling locations is presented in Figure 22. The grid increment is an arbitrary selection but one that minimizes the effects of sparse data and extrapolation. Using the current OTR methodologies for Al in rural parks, all administrative regions across Ontario were combined to generate a single Al OTR of 30,050 (Zajdlik, 2006a). This OTR is superimposed as a contour on the image map.

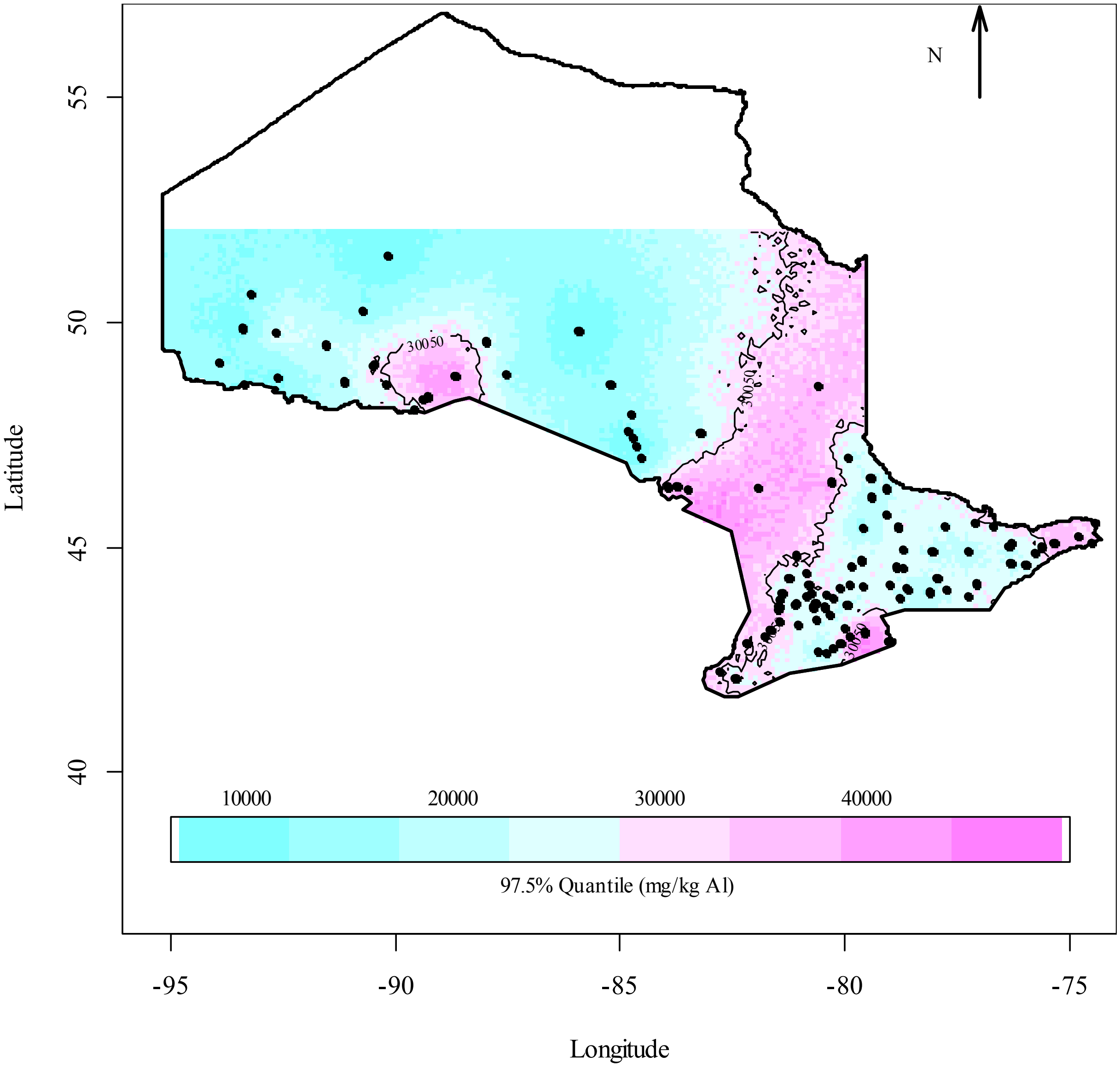

Figure 22: Pointwise 97.5% Percentiles for Al in Ontario Based on Rural Park Data (OTR Dataset)

Figure 22 shows that the location-specific 97.5th percentiles vary around the Al OTR guideline of 30,050 mg/kg for rural parks. Depending upon how the OTR is used, the current rural parks-based Al OTR may provide a significantly lower or higher degree of environmental protection than intended.

For example, consider a scenario where the current Al OTR is used as a "background standard" following OMOE (2004, 2009) at a location with a 97.5th percentile that is much lower than the current OTR of 30,050 mg/kg. At this location, "under protection" necessarily occurs because the location-specific 97.5th or estimated location-specific upper range of normal, is lower than the OTR representing the upper range of normal on a provincial scale. Over the locations at which site-specific 97.5th percentiles were estimated, the first quartile of the 97.5% percentiles is 16,670 mg/kg Al or approximately 55% of the rural park OTR. On this basis, 25% of the province is under protected by a factor of almost 2. The third quartile of the 97.5% percentiles is 30,190 mg/kg Al or approximately equal to the rural park OTR. On this basis, 25% of the province is over protected.

2.4.4.2 Al in Urban Parks

The empirical variogram presented in Figure 23 is used to provide initial estimates of the sill, nugget and range.

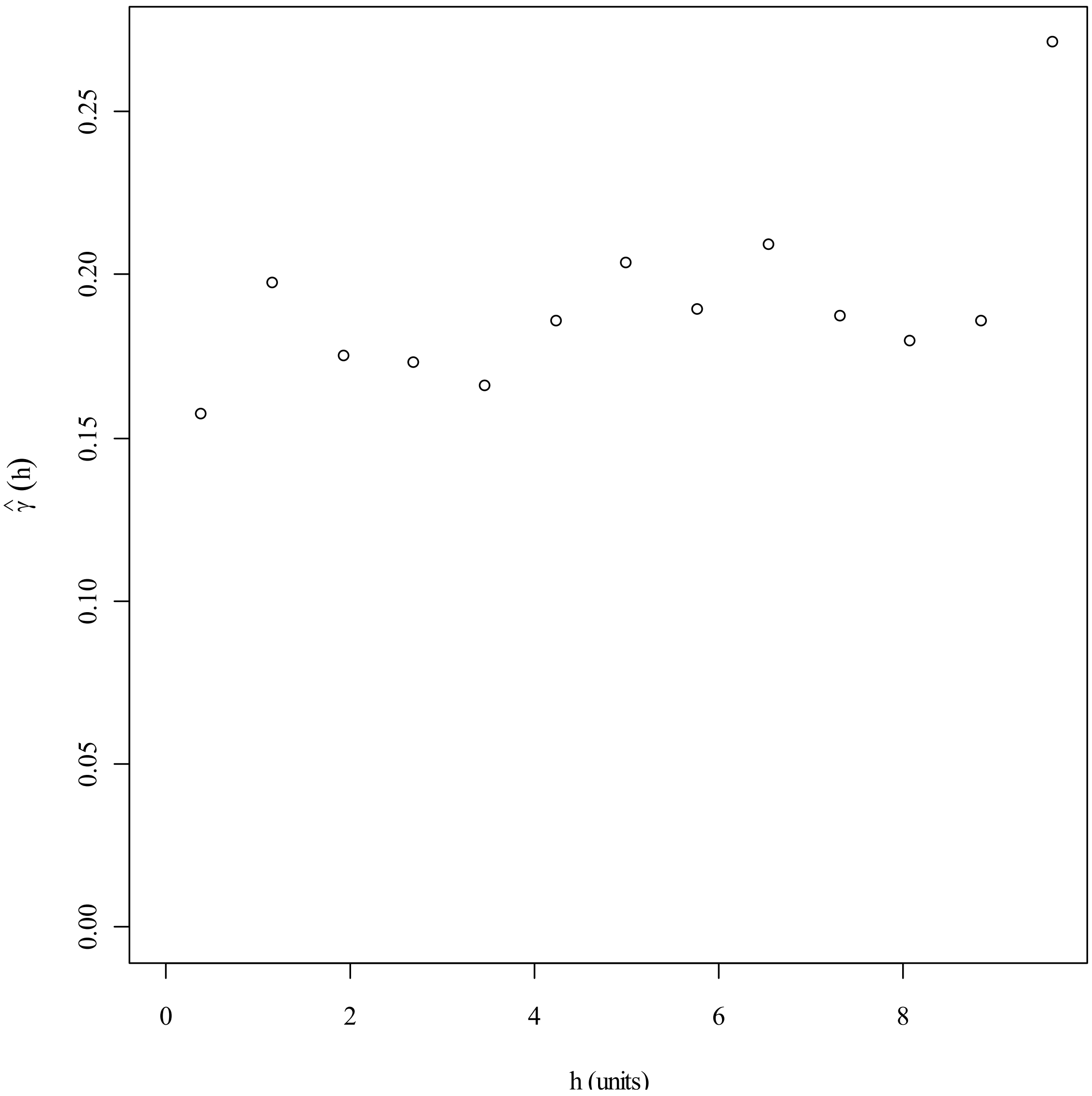

Figure 23: Empirical Variogram for Al in Urban Parks (OTR Dataset)

Figure 23 suggests that the nugget, sill and range are respectively; 0.15, 0.20, and 5. Note how little the covariance changes with distance relative to Al in rural parks (Figure 16). The directional variograms presented in Figure 24 may suggest anisotropy.

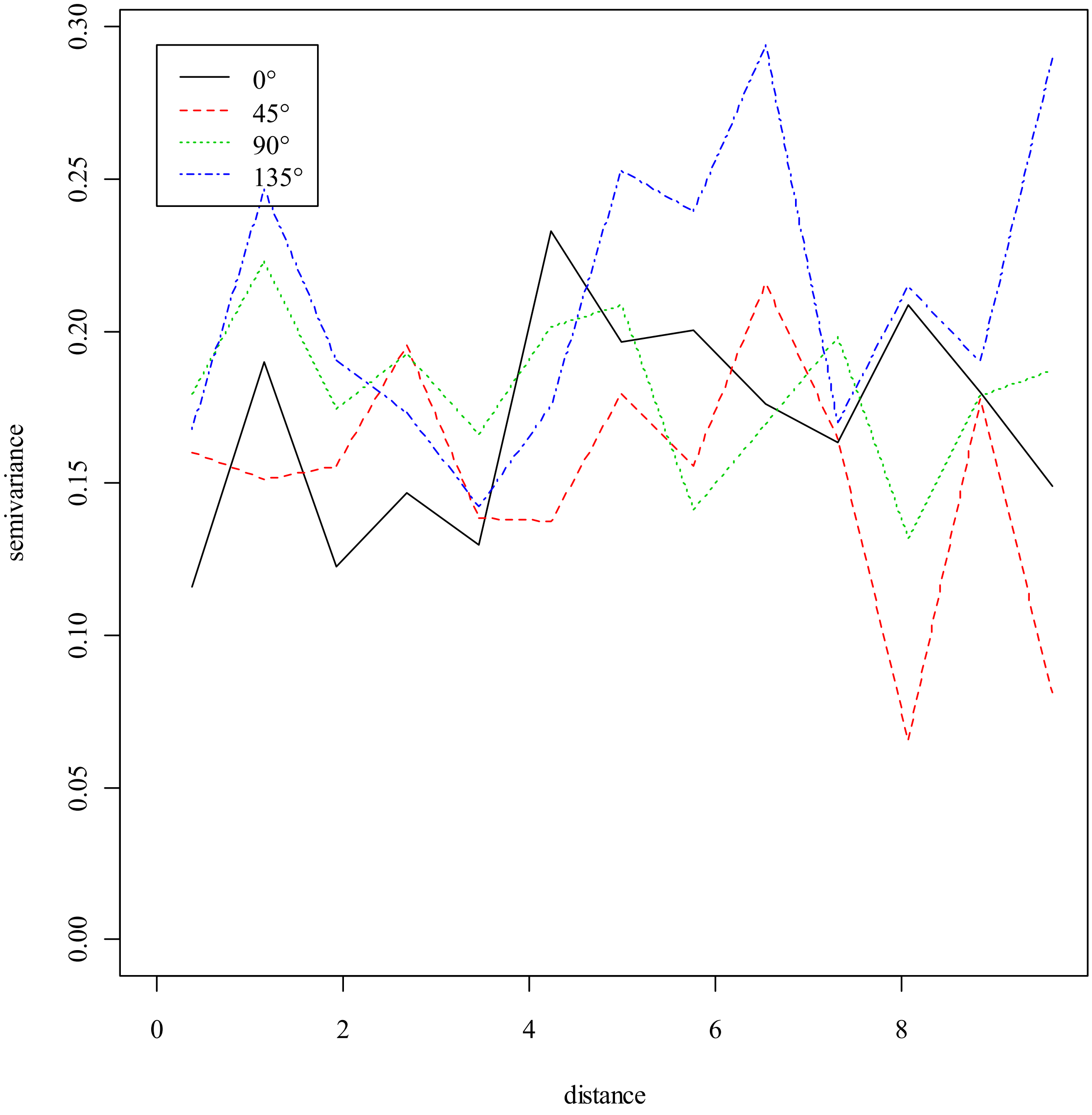

Figure 24: Directional Variograms; Al in Urban Parks (OTR Dataset)

The same set of 32 variogram models used to fit Al in rural parks data was used for the Al urban park OTR data. A wide variety of models were fitted to these data. The non-anisotropic models were fit using ordinary least squares, weighted least squares, maximum likelihood and restricted maximum likelihood. Models that include anisotropy were only fit using likelihood methods due to software limitations. The best fitting models on the bases of likelihood estimation and use of raw versus aggregated data are presented in Figure 25.

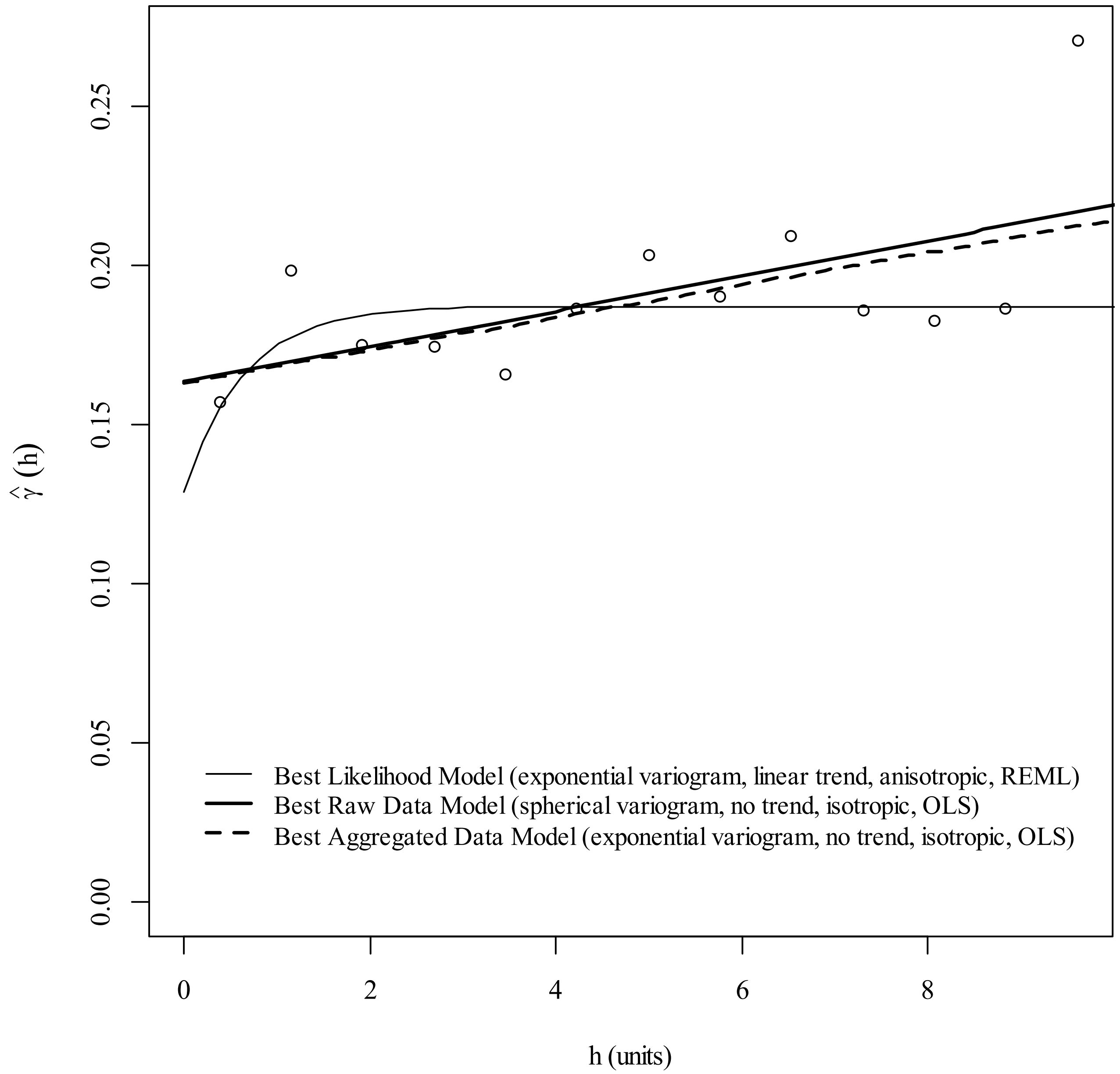

Figure 25: Candidates for Best Fitting Theoretical Variograms for Al in Urban Parks (OTR Dataset)

Figure 25 shows that the best fitting likelihood model did not fit as well subjectively (as shown above) or objectively (using the criteria presented in section 2.3.3.3.2) as models fit using ordinary least squares. The poor fit of likelihood-based models was consistent for this and the rural park data. The two "best" fitting models using the criteria presented in section 2.1.6 are isotropic with parameters estimated using OLS. The models differ by covariance model with aggregated data being best described by an exponential variogram and the raw data best described by the spherical variogram. The model fit to the raw data is used for consistency with the rural park data usage in subsequent presentations and predictions. This model is presented in Figure 26 with a Monte Carlo simulation envelope.

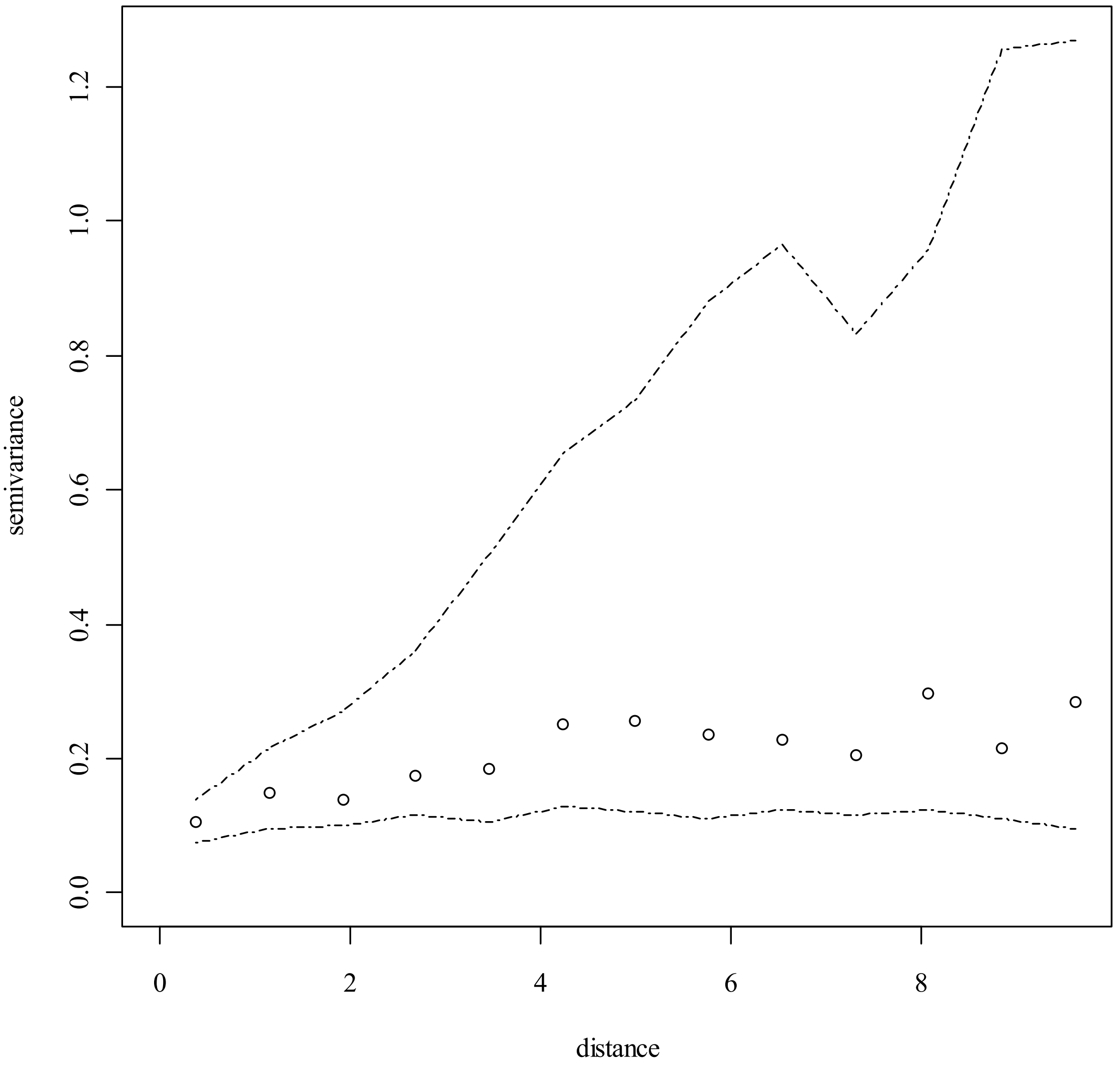

Figure 26: Fitted Variogram and Monte Carlo Simulation Envelope for Al in Urban Parks (OTR Dataset, raw data)

The fitted variogram is used to predict concentrations across the sampled portion of Ontario (Figure 27).

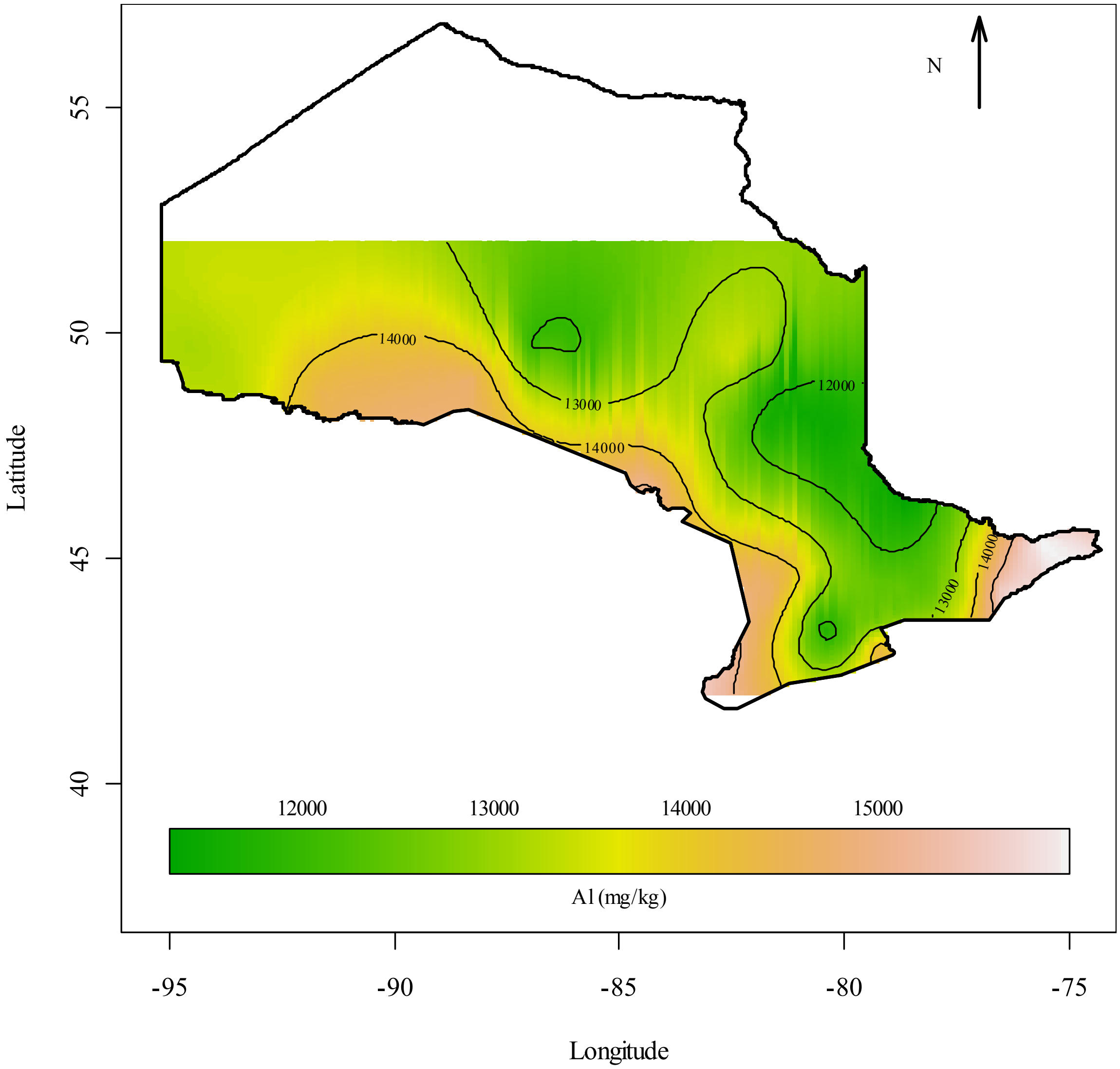

Figure 27: Predicted Al in Ontario Based on Urban Park Data (OTR Dataset)

Note the marked association of Al with the Georgian Bay / Lake Huron coastline in Figure 27. At this point in time the association is not investigated but may be realted to the Niagara Escarpment. Also note the lower predicted Al concentrations relative to those predicted using rural park data. The prediction standard errors are presented in Figure 28.

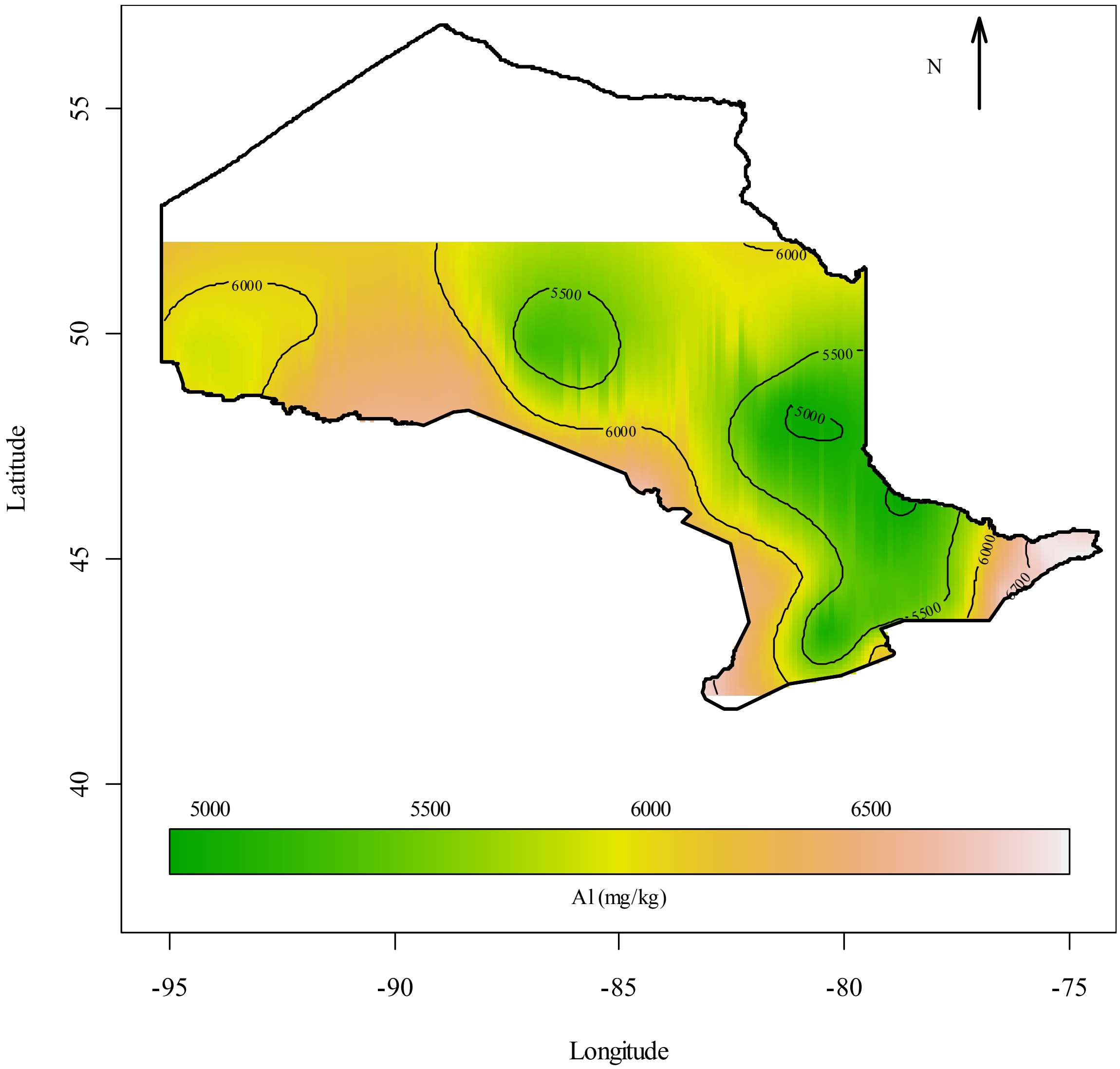

Figure 28: Prediction Standard Errors for Al in Ontario Based on Urban Park Data (OTR Dataset)

Figure 28 shows that the smallest standard errors are approximately 5,000 mg/kg and correspond to predictions of approximately 12,000 mg/kg (Figure 27). Under the assumption that kriging predictions are normally distributed, 95% confidence intervals for Al concentrations corresponding to the smallest and largest standard errors are presented in Table 11.

Table 11: Summary of Confidence Intervals for Predicted Al Concentrations in Ontario on the Basis of Al in Urban Parks (OTR Dataset)

	Predicted Al Concentration (mg/kg)	**Lower 95% Confidence Interval (mg/kg)**	**Upper 95% Confidence Interval (mg/kg)**
Smallest Standard Error	11,339	1,696	20,981
Largest Standard Error	15,827	2,219	29,434

As described in section 2.4.4.1, pointwise 97.5th percentiles may be estimated to represent the upper limit of normal chosen by the Ontario Ministry of Environment in the OTR paradigm. These 97.5th percentiles are plotted as an image map with the single Al OTR of 25,886 mg/kg for urban parks (Zajdlik, 2006a) superimposed in Figure 29.

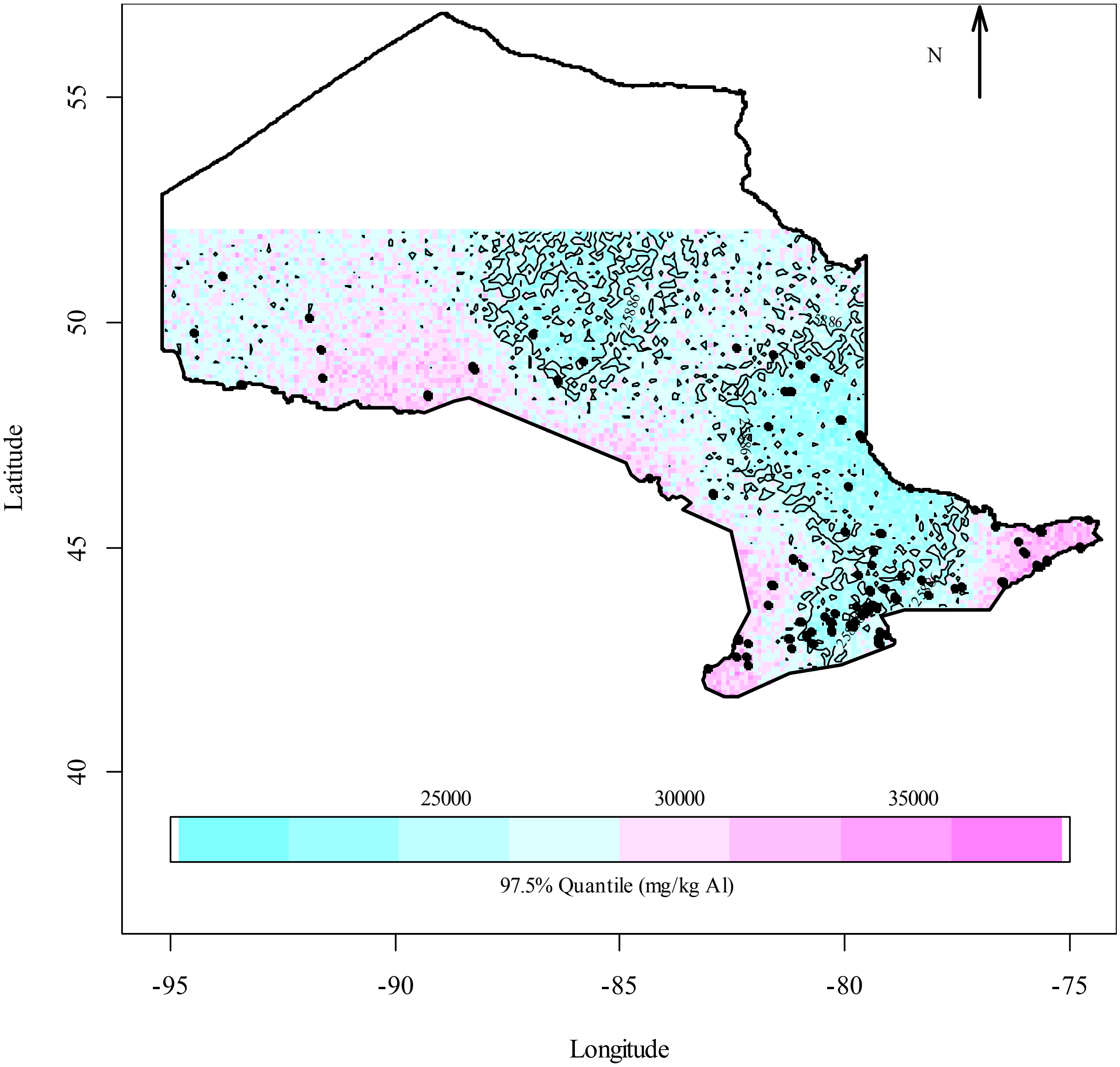

Figure 29: Pointwise 97.5% Percentiles for Al in Ontario Based on Urban Park Data (OTR Dataset)

Figure 29 shows that the location-specific 97.5th percentiles vary around the Al OTR guideline of 25,886 mg/kg for urban parks. Depending upon how the OTR is used, the current urban parks-based Al OTR may provide a significantly lower or higher degree of environmental protection than intended.

For example, consider that the current Al OTR is used as a "background standard" following OMOE (2004, 2009) at a location with a 97.5th percentile that is much higher than the OTR. If the current OTR of 25,886 mg/kg is applied at that location, "over protection" necessarily occurs because the location-specific 97.5th or estimated location-specific upper range of normal, is higher than the OTR representing the upper range of normal on a provincial scale. Over the locations at which site-specific 97.5th percentiles were estimated, the first quartile of the 97.5% percentiles is 25,690 mg/kg Al or approximately equal to the urban park OTR. On this basis, approximately 75% of the province is overprotected. Similar statements can be made regarding under protection.

2.4.4.3 Al using OMAFRA Field Metal Data

A Box-Cox transformation (using the mean as a descriptor of soil Al) suggests a square root transformation. Aside from the obvious change in scale little difference was noted in the empirical variograms. Thus the raw data are used in the empirical variogram presented in Figure 30. This variogram is used to provide initial estimates of the sill, nugget and range.

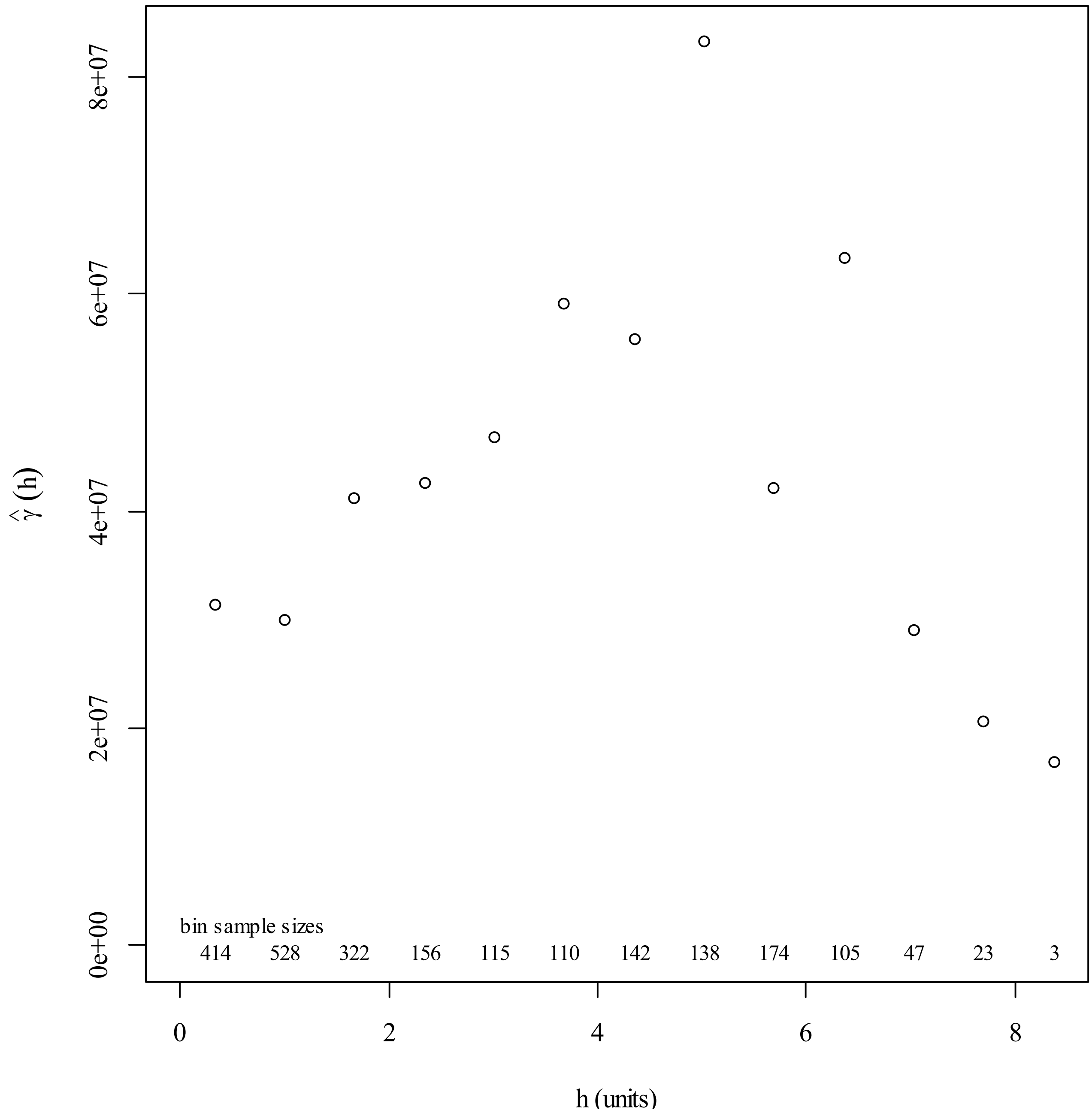

Figure 30: Empirical Variogram for Al in Fields (OTR Dataset)

The empirical variogram shows that the covariance among observations decreases with increasing separation as it should. However beyond a certain distance (about 500 km) the covariance begins decreasing. Because the OMAFRA dataset coverage is limited from North to South, the 500 km distance is by and large an east-west comparison and by virtue of the coverage 500 km comparisons are only achievable by selecting stations at the extremes of southwestern and southeastern Ontario. If concentrations are similar in these two areas the variogram will at distances that represent this separation begin to decrease. The similarity of concentrations at the extremes of southern lake-delimited Ontario is corroborated by the Al distributions in rural parks (Figure 20) and old urban parks (Figure 27) where Al concentrations are highest in the extremes in the counties of Ontario (Essex, Chatham-Kent versus Prescott and Russel and Stormont-Dundas-Glengarry). Assuming that the decreased semi-variances beyond 500 km are explained, Figure 30 suggests that the nugget, sill and range are respectively; 3e+07, 4e+07 and 5. Empirical variograms with 0th, 1st and 2nd order polynomial mean trends were similar. The similarity of variograms is likely due to the structure imparted in the data due to the orientation of variogram distance bins that are restricted by the northern shore of Lake Erie that tends ENE (approximately 70°) - WSW (250°). The directional variograms corresponding to a global mean (i.e. no trend model) presented in Figure 31 may suggest anisotropy.

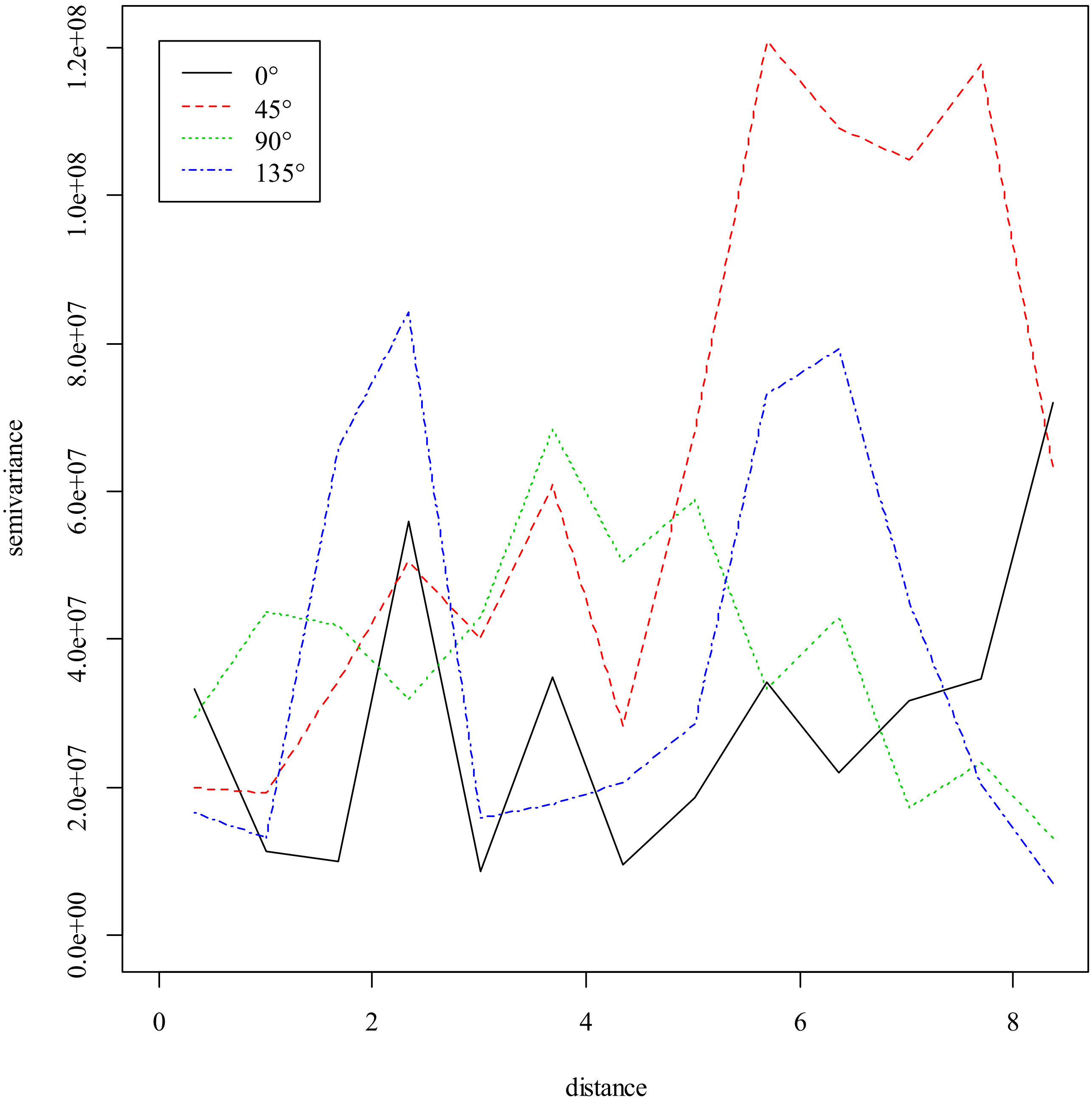

Figure 31: Directional Variograms; Al in Fields (OMAFRA Aggregated Dataset)

There may be evidence of anisotropy as the 45° variogram differs somewhat from the other variograms. The presence of (detectable) anisotropy is assessed objectively using the methods described in section 2.3.3.3.2.

A wide variety of models were fitted to these data. The models fitted considered four theoretical variograms (spherical, exponential, Gaussian and Cauchy variograms), the presence or absence of a linear trend and the presence or absence of anisotropy for aggregated data for a total of 4x2x2 = 16 models. The non-anisotropic models were fit using ordinary least squares, weighted least squares, maximum likelihood and restricted maximum likelihood. Models that include anisotropy were only fit using likelihood methods due to software limitations. The best fitting models on the bases of likelihood estimation anduse of aggregated data are presented in Figure 32.

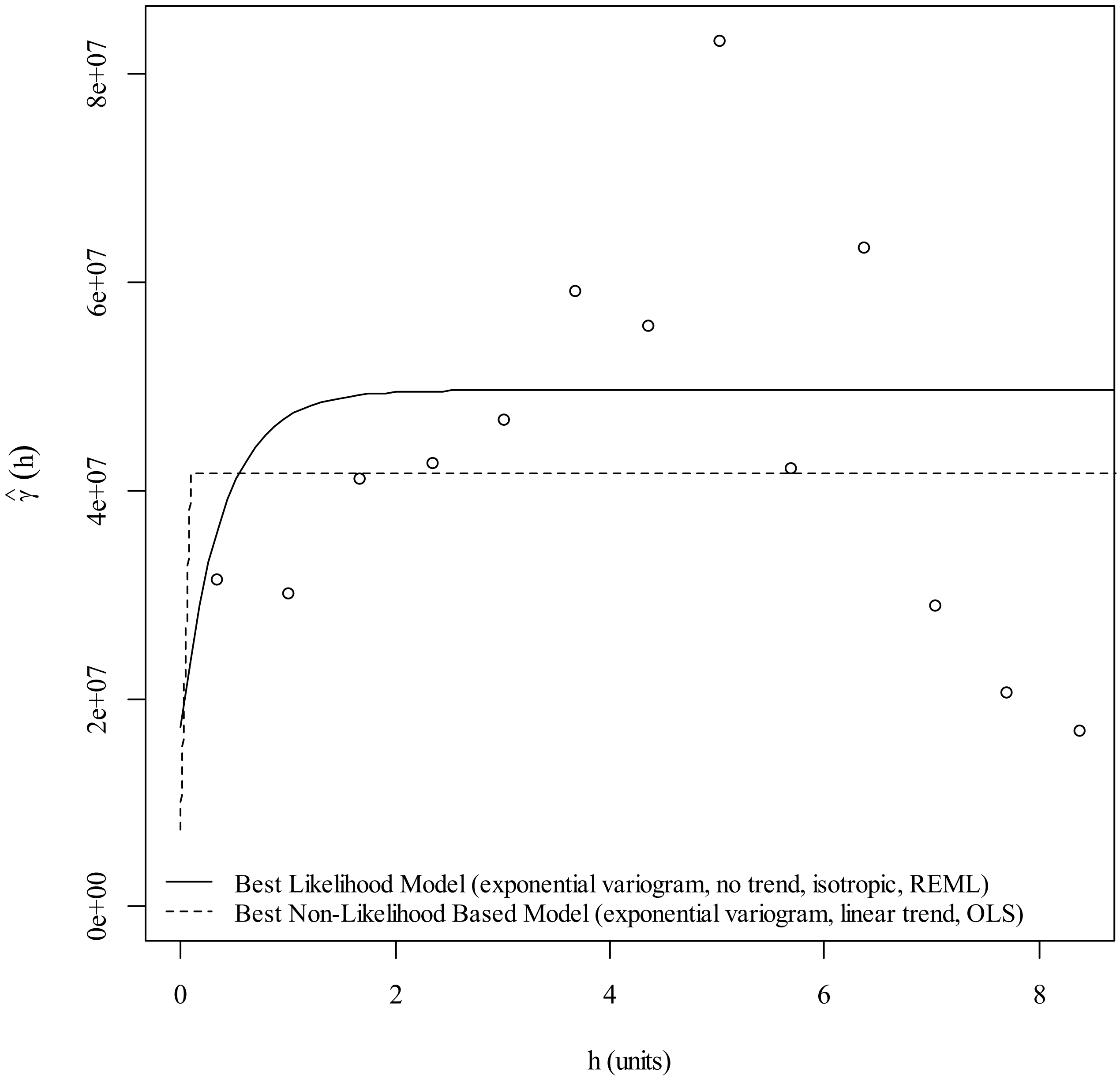

Figure 32: Candidates for Best Fitting Theoretical Variograms for Al in Fields (OMAFRA Aggregated Dataset)

Neither model fits the data well at large distances due to the peculiar behaviour exhibited in the semi-variogram. The abrupt change in OLS model reflects a range = 0. The best fitting models use an exponential variogram. A mean only model fits "best" using the REML estimates but a linear trend is the “best” model fitted using ordinary or weighted least squares. The model fit using likelihood methods is used in subsequent presentations and predictions as it is the “best” fitting likelihood-based model and the range is non-zero reflecting better behaviour at small distances. This model is presented in Figure 33 with a Monte Carlo simulation envelope.

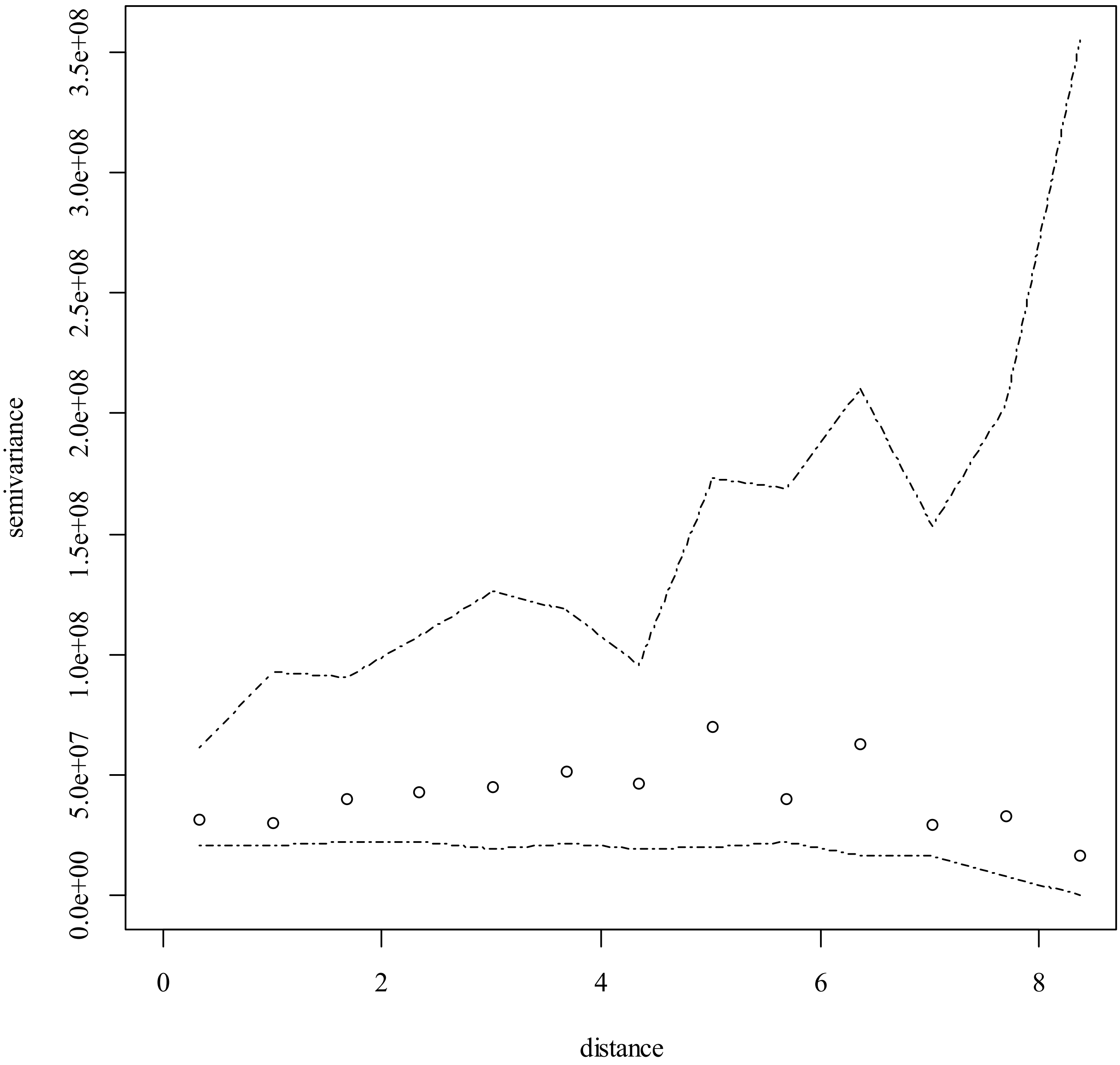

Figure 33: Fitted Variogram and Monte Carlo Simulation Envelopes for Al in Fields (OMAFRA Aggregated Dataset)

The fitted variogram is used to predict concentrations across the sampled portion of Ontario (Figure 34).

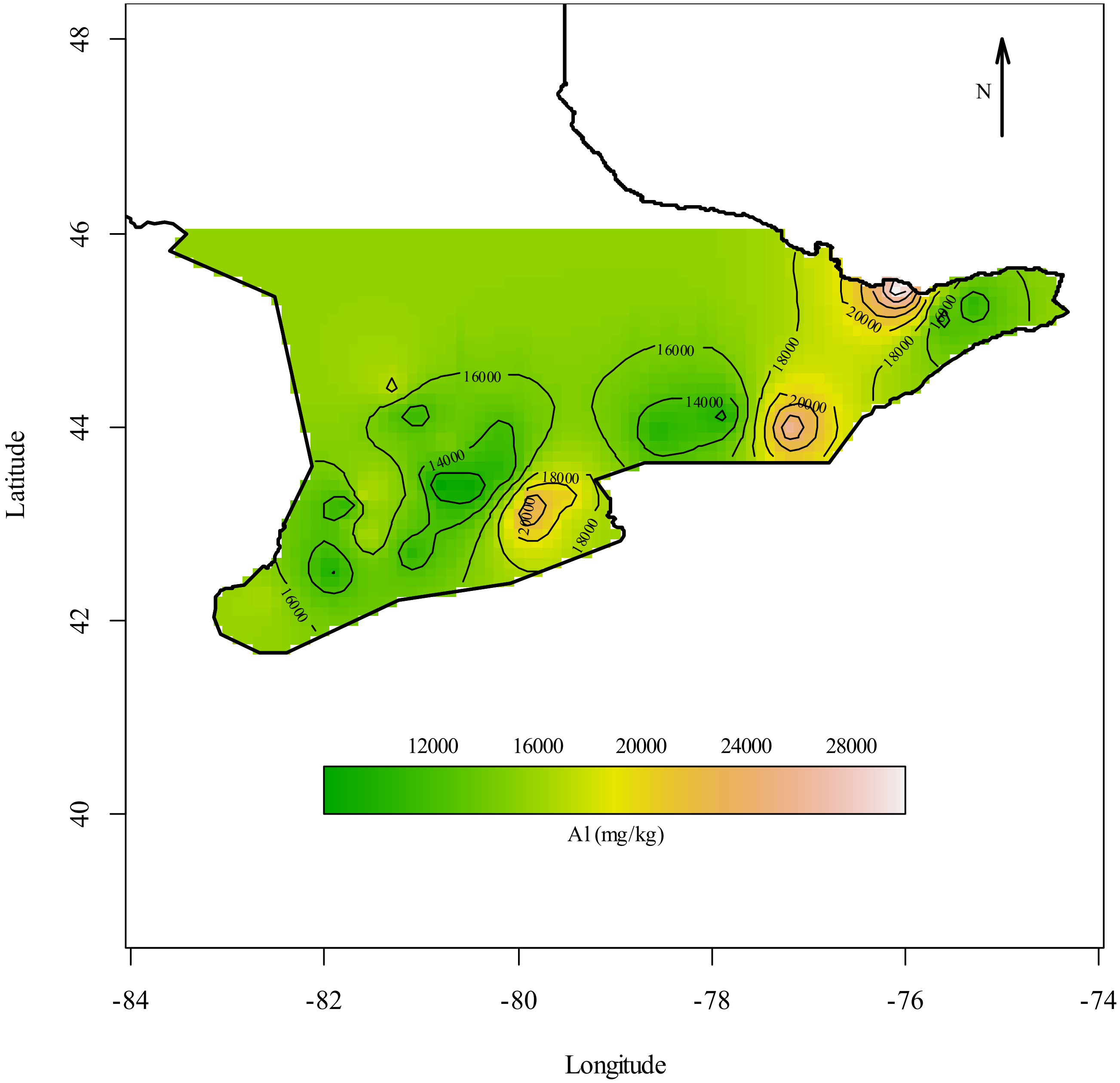

Figure 34: Predicted Al in Ontario Based on Field Data (OMAFRA Aggregated Dataset)

There are three areas of relatively elevated Al. Al predictions based on agricultural field data, urban and rural park data are compared in a subsequent section. The standard errors for Al predictions based on field data are presented in Figure 35.

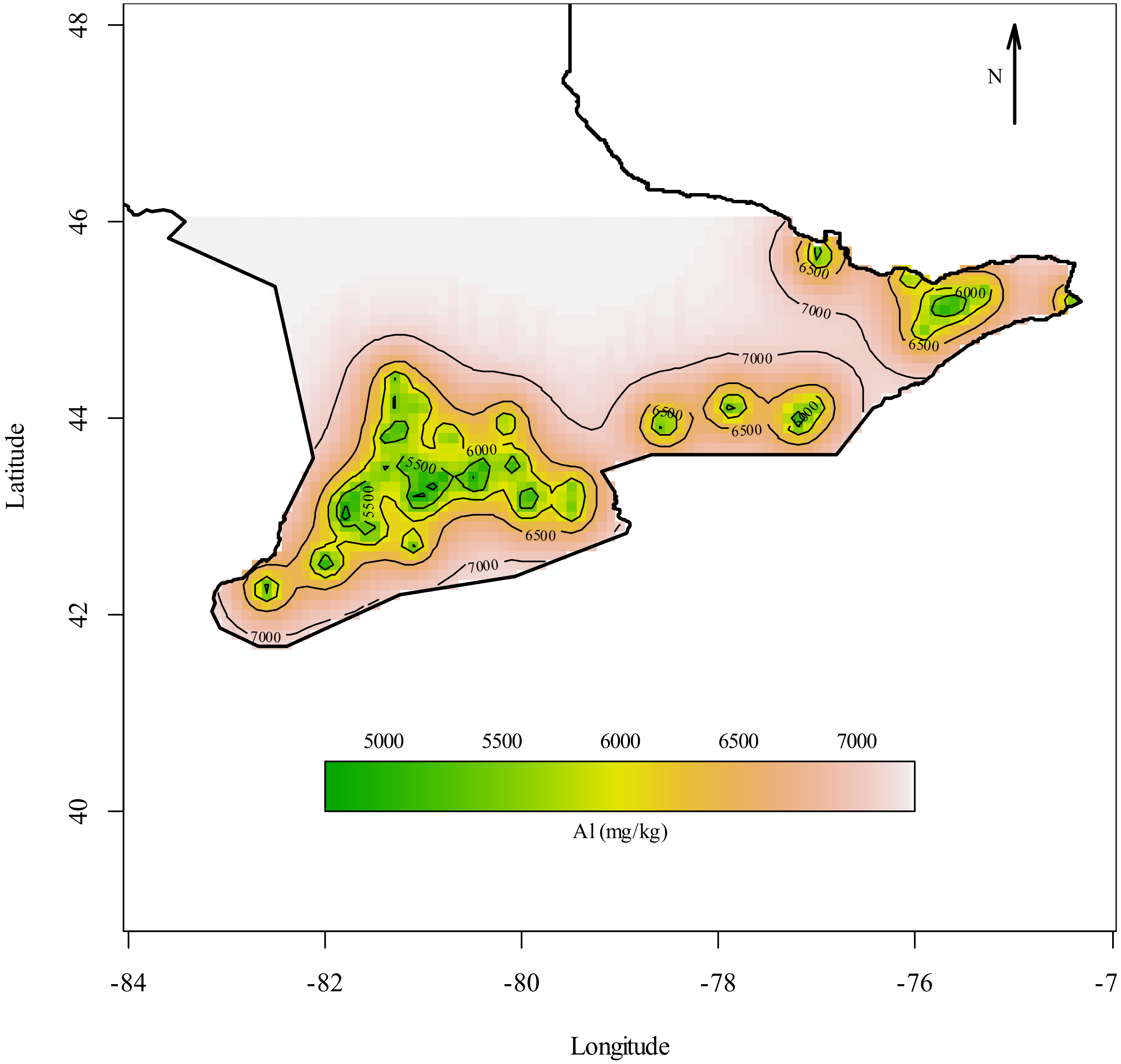

Figure 35: Prediction Standard Errors for Al in Ontario Based on Field Data (OMAFRA Aggregated Dataset)

Figure 35 shows that the smallest standard errors are approximately 5,250 mg/kg and correspond to predictions of approximately 14,000 mg/kg (Figure 34). (Note the similarity to prediction standard errors using urban park data). Under the assumption that kriging predictions are normally distributed, 95% confidence intervals for Al

concentrations corresponding to the smallest and largest standard errors are presented in

Table 12.

Table 12: Summary of Confidence Intervals for Predicted Al Concentrations in Ontario on the Basis of Al in Fields (OMAFRA Aggregated Dataset)

	Predicted Al Concentration (mg/kg)	**Lower 95% Confidence Interval (mg/kg)**	**Upper 95% Confidence Interval (mg/kg)**
Smallest Standard Error	15,461	6,114	24,807
Largest Standard Error	16,780	2,600	30,961

In the current OTR paradigm, the only spatial information used to stratify the dataset is in the context of administrative boundaries. Provincial OTRs for Al were separately estimated using rural and urban park data (Zajdlik, 2006a). The lower OTR corresponding to Al in urban parks of 25,886 mg/kg is used as a conservative basis for comparing the frequency distribution of predicted mean Al concentrations (not the 97.5th percentile) using the loci described in section 2.4.4.1 but with a bounding box corresponding to the OMAFRA dataset (Figure 36). As noted previously, this is an arbitrary selection but one that minimizes the effects of sparse data and extrapolation.

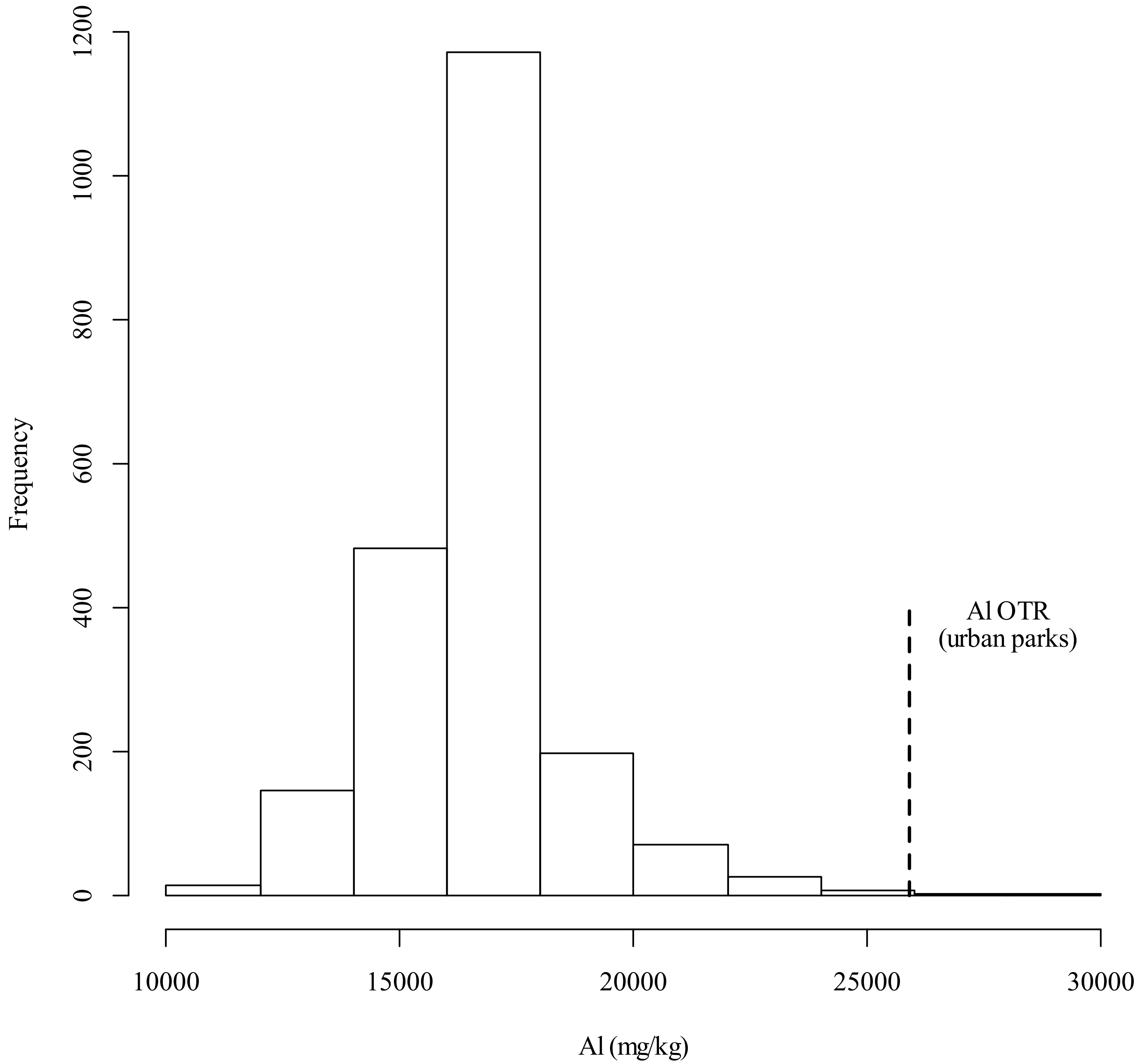

Figure 36: Frequency Histogram of Predicted Al Concentrations at OTR Sampling Locations Based on OMAFRA Field Data

Figure 36 shows that the OTR guideline for urban parks falls within the range of values predicted at objective loci for fields (maximum predicted value is 29,410 mg/kg). The Al OTR value is equivalent to the 99.7th percentile of the predicted Al values based on field data and is thus somewhat conservative. However note that the Al field data were not used in the derivation of the Al urban park-based OTR.

2.4.4.3.1 Comparison of Predictions using Three Datasets

Three datasets were used to predict Al concentration in soils in Ontario. Two of the datasets (rural parks and urban parks) were used in the derivation of soil OTRs for Ontario (Zajdlik, 2006a). Colours used to represent concentrations are held constant through the next set of graphics so direct comparisons are possible Figure 37.

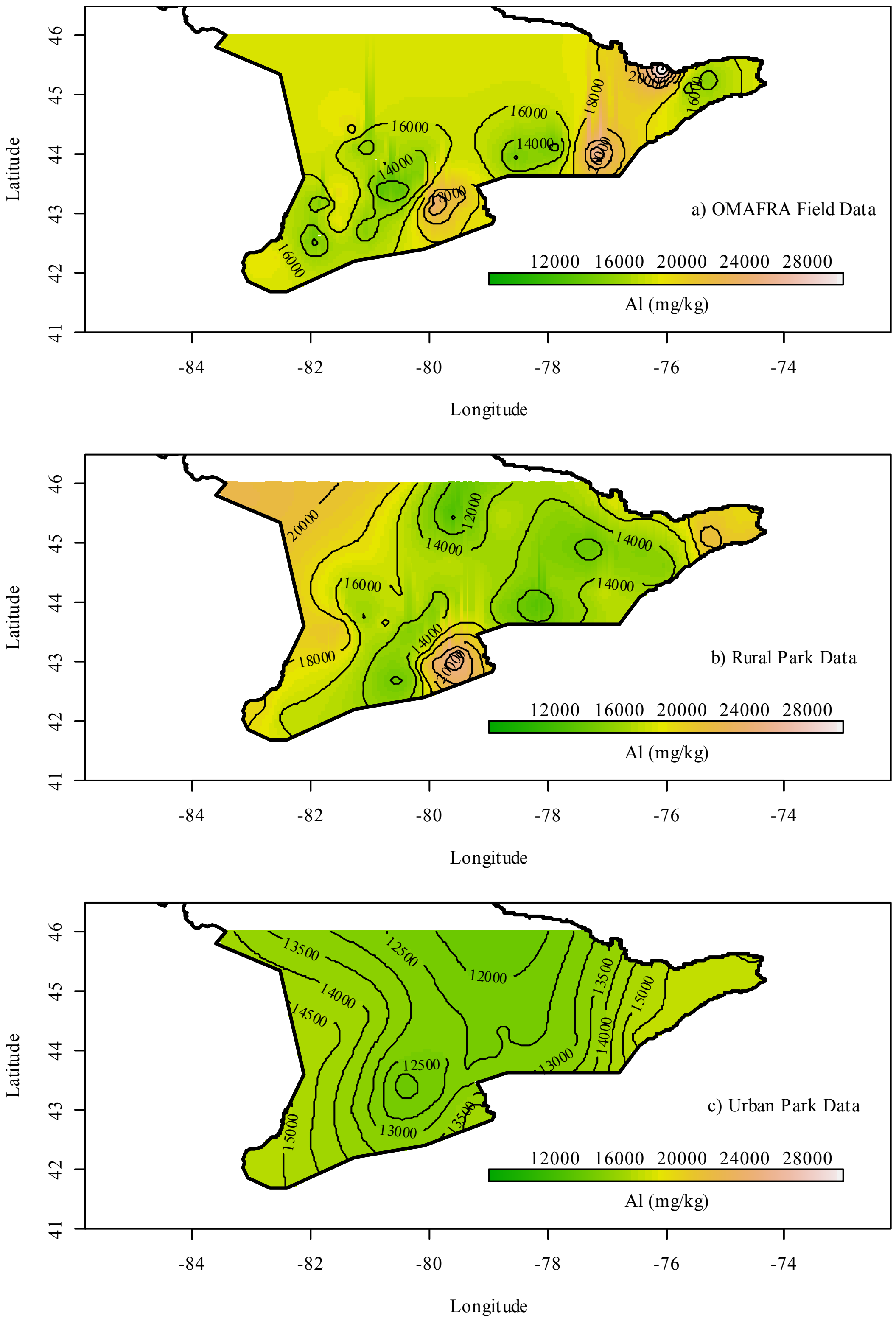

Figure 37: Comparison of Predicted Al Concentrations by Dataset, a) OMAFRA Field Data, b) Rural Park Data; c) Urban Park Data

Figure 37 shows that predicted Al concentrations are, on a provincial basis, generally similar in pattern although the level varies somewhat with data source. Although the OTR and OMAFRA studies both followed OMOE (1992) sampling methods, OTR urban and rural park soil samples were collected from the top 5 cm of soil and OMAFRA field samples were collected from the top 15 cm. Both studies used the Ontario Ministry of Environment analytical laboratory and followed the same analytical protocols. Therefore one systematic difference between the OTR and OMAFRA datasets is depth of sample collection. Given that the soil sampling protocol requires the removal of organic material down to mineral soil and that agricultural soils are well mixed within the top 15 cm, the difference in depth sampling among the OTR and OMAFRA datasets is unlikely to bias AL concentrations (A. Takar, Ontario Ministry of Environment pers. com.)

In general concentrations tend to be higher for OMAFRA field data, followed by rural park data and then urban park data. The means of predicted concentrations at loci restricted to coverage of OMAFRA dataset for OMAFRA field data, rural parks and urban parks are, respectively: 16,576, 15,757 and 13,461 mg/kg . The predicted Al concentrations using rural park and OMAFRA field data are quite similar particularly when the absence of OMAFRA field sampling locations in the mid-north to northwestern portion of the province is kept in mind (note the absence of contours in this region).

There are some exceptions to the general pattern of Al across the mapped area of Ontario. One exception is the area west of Kingston where an area of elevated Al is detected with the OMAFRA field data, is suggested by the rural park data but missed entirely by the urban park data. This is attributable to a combination of the locations sampled (Figure 11) and the concentrations at proximal sampling locations (Figure 5 and Figure 10). Other exceptions are the elevated Al concentrations in the vicinity of Brantford (OMAFRA field data) and south-southwest of Brantford (Rural Park Data) but not detected using the urban park data. Note that no urban park data are collected in this area (Figure 3). The third exception occurs in the vicinity of Almonte where an elevated Al concentration is detected with OMAFRA data but not by the park data.

It is interesting to speculate on reasons why Al is distributed as it is, over Ontario. Surficial background concentrations of many elements are related to the parent material. ISO (2005) states in general that: "The natural pedo-geochemical content and the usual content of substances in soil vary according to soil parent material." Sterckeman et al., (2006) found significant relationships between various elements in the surficial horizons with those in deep horizons and the surficial continental crust for the loess soils of north-western France. The authors suggest that element concentrations in aeolian deposits as well as from fine-grained clastic sediments may be predicted from surficial continental crust concentrations. They explain observed differences between surficial element concentrations and others on the basis of enrichment factors. However, Reimann and de Caritat (2005) and Reimann and Garrett (2005) criticize the use of enrichment factors. Focusing on metals in topsoil, Rawlins et al., (2003) investigated variation in ambient background concentrations in topsoil over 10,000 km^2 of eastern England and concluded that background concentrations were related to distribution of parent materials due to; 1) presence of a long-range correlation structure (which they attribute to parent material); and, 2) short range anisotropy for several elements with axes corresponding to bed orientation particularly for Mg. Baize and Sterckeman (2001) with very limited sampling (15 samples) and use of ancillary information also concluded that spatial variability in background concentrations of at least Cd and possibly Cu and Zn was attributable to variation in composition of regolith. Stückrad et al., (2010) found that the contributions of parent materials to recently developed soils in the Rhenish Slate Mountains were quantifiable using trace metal concentrations and Pb isotope ratios.

The idea that correlations between surficial element concentrations and parent materials varies with age of soils was explicitly addressed by Palumbo et al., (2000) who found that heavy metal concentrations could be differentiated on the basis of parent material (sedimentary versus volcanic) for "most" pedons (Italy) studied. However, exceptions include the highly weathered alfisols and mollisols (members of the solonetzic order; Soil Classification Working Group, 1998). Hamon et al., (2004, *loc cit* Rose et al., 1979 and Palumbo et al., 2000) concluded that elements in surficial soil "often bear little resemblance" to parent material in highly weathered soils due to pedogenic processes. As a whole, and based on the limited review it appears that the correlation between some analytes and parent material is demonstrable with the likely exception of highly weathered soils.

Given this, the bedrock geology of Ontario was examined visually to speculate on possible reasons for the distribution of surficial Al. Regolith in Ontario is divided into three provinces, Superior, Southern and Grenville. The Grenville province includes all of southern Ontario and its upper limit roughly demarcates the axis of higher Al concentration isopleths shown in Figure 20 (MNDM, 1991a). At this demarcation, regolith changes abruptly and is dominated by felsic igneous rocks and migmatitic (partially melted metamorphic rock) rock and gneisses of indeterminate protolith. Because the protolith is indeterminate, generalizations about the elemental composition cannot be made. Felsic igneous rocks however, are enriched with lighter elements such as silicon and oxygen, potassium, and of note, aluminium.

Soil is formed through the concurrent processes of transformation, translocation, addition and loss. Transformative processes include chemical and physical transformations of the bedrock or parent material. The physical processes are obvious; the chemical processes include the decomposition of minerals but also the synthesis of new minerals. Translocation processes include the movement of materials by gravity, water, wind and glaciation. Addition processes include aeolian deposition to create the huge loess deposits in some great plains of the world. Loss processes include illuviation (loss or movement from one horizon to another), eluviation (movement of suspended materials) and leaching (movement of dissolved materials). The sum total of these pedogenic processes results in the chemical signature of the superficial horizons sampled in the OTR program with the addition of long range transport of analytes due to human activities. The superficial horizons in the vicinity of the axis of higher Al concentration isopleths shown in Figure 20 are humo-ferric podzols (Baldwin et al., 2000). Soil orders are defined on the bases of physical and chemical criteria. The chemical criteria of interest with respect to podzols are that the B horizon has a pyrophosphate extractable combined Fe and Al content that is: 1) > 0.4 -0.6% depending upon soil textural class and, 2) a pyrophosphate extractable combined Fe and Al to clay ratio that is > 0.05. Humo-ferric podzols are distinguished from podzols on the bases of thickness of the B horizon, percent organic carbon and a minimum pyrophosphate extractable combined Fe and Al content of at least 0.4% for sands (Soil Classification Working Group, 1998). The other major soil classes in southern Ontario are melanic brunisols, gray-brown luvisols and mesisols (Baldwin et al., 2000) and have no criterion for minimal Al and Fe content (Soil Classification Working Group, 1998). This observation regarding soil taxonomic class, like the regolith composition is consistent with, or more safely, not inconsistent with the major feature in the observed Al pattern in Figure 20. Given all the pedogenic process described, the limited geospatial coverage of the OTR rural park dataset and the lack of any objective data analyses, it would be imprudent to make a stronger assertion.

2.4.4.4 Pb in Rural Parks

Visual assessment of the empirical cumulative distribution function and Box-Cox plot (not presented) suggest a log transformation. Based on experience with raw and aggregated data for other analytes aggregated data (median of sub-samples) were used when modelling Pb. The empirical variogram presented in Figure 38 is used to provide initial estimates of the sill, nugget and range.

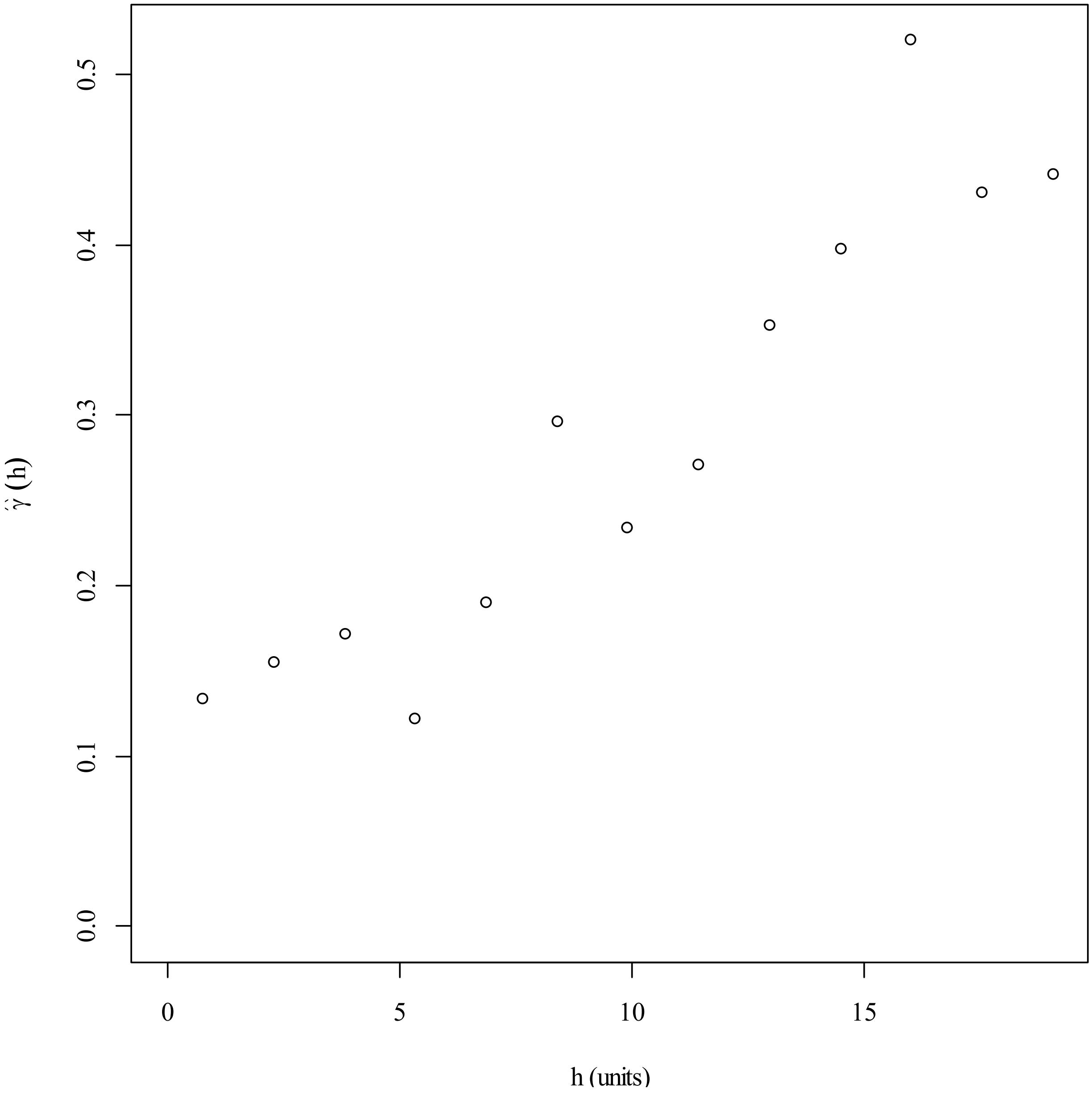

Figure 38: Empirical Variogram Pb Rural Park Aggregated Data Log Transform

A plot of Pb versus latitude and longitude (not presented) suggests a trend with longitude. This is confirmed with the Monte Carlo simulated envelope around the empirical variogram after removing first order polynomial trend.

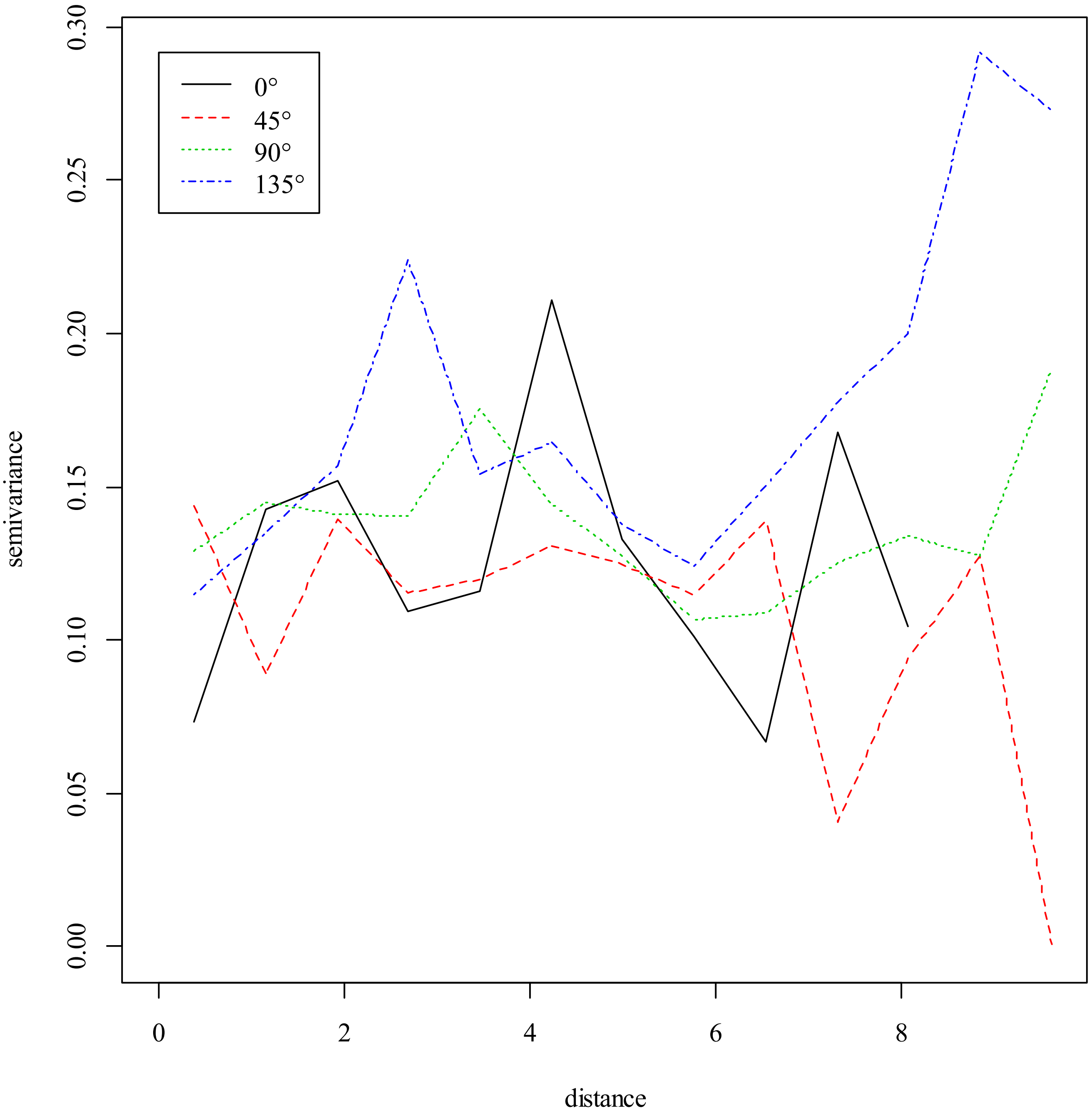

Figure 39: Directional Variograms for Pb Rural Park Data

There is no clear interpretation of the directional variogram. Note that sample sizes are small. Models fitted to the aggregated data considered 5 variogram types (exponential, spherical, Gaussian, Cauchy and linear) with no trend and first order polynomial trend using ordinary and weighted least squares for a total of 20 fitted models. Maximum likelihood and restricted maximum likelihood considered 2 variogram types (exponential and spherical as these were the best least squares models) with no trend and first order polynomial trend as well as isotropic and anisotropic variograms for a total of 16 models.

Using the criteria described (and note that the AIC cannot be applied to non-likelihood-based models) a single model was identified as “best”. This is an anisotropic exponential variogram with a first order polynomial trend fit using maximum likelihood. However the major axis of anisotropy was nonsensically large and thus the closely contending model, an isotropic spherical variogram with a first order polynomial trend fit using restricted maximum likelihood is presented in Figure 40 and used as the *de facto* “best” model.

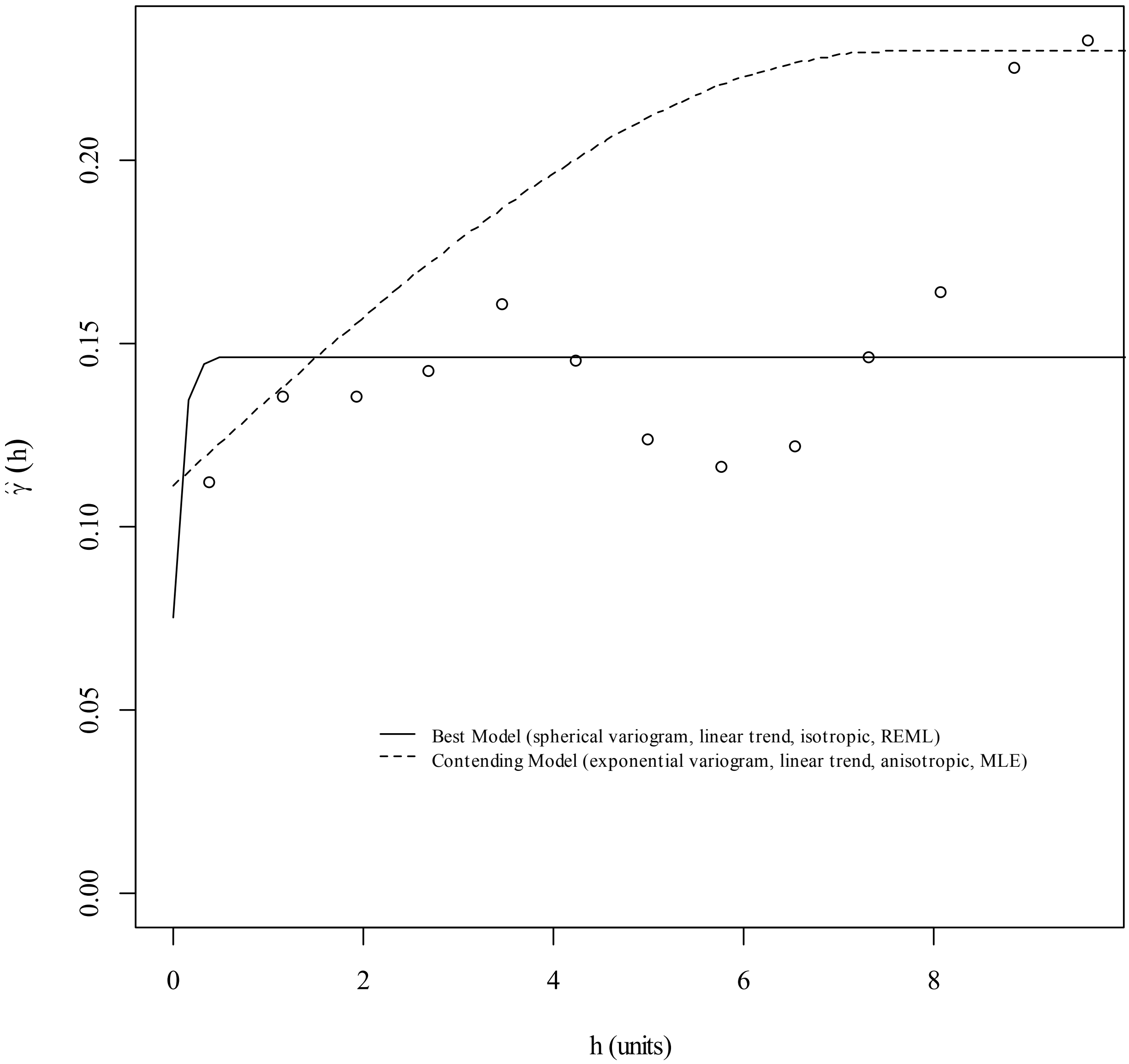

Figure 40: Final Model Fit to Pb Rural Park Data

This model is presented in Figure 41 with a Monte Carlo simulation envelope.

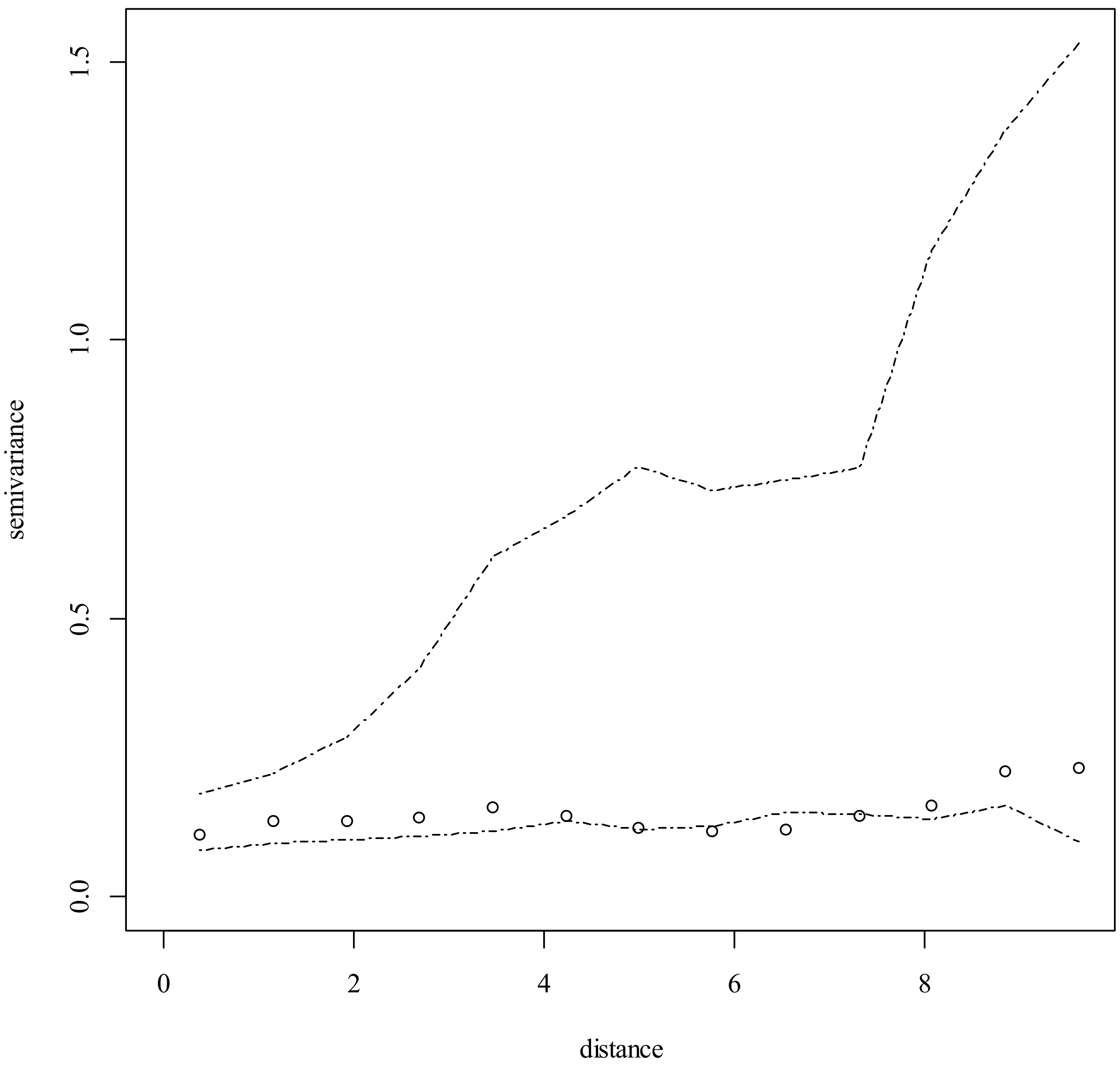

Figure 41: Monte Carlo Envelopes Around Fitted Pb Rural Park Model

Note the wide Monte Carlo envelope does not include all semi-variances. The fitted variogram is used to predict concentrations across the sampled portion of Ontario (Figure 42).

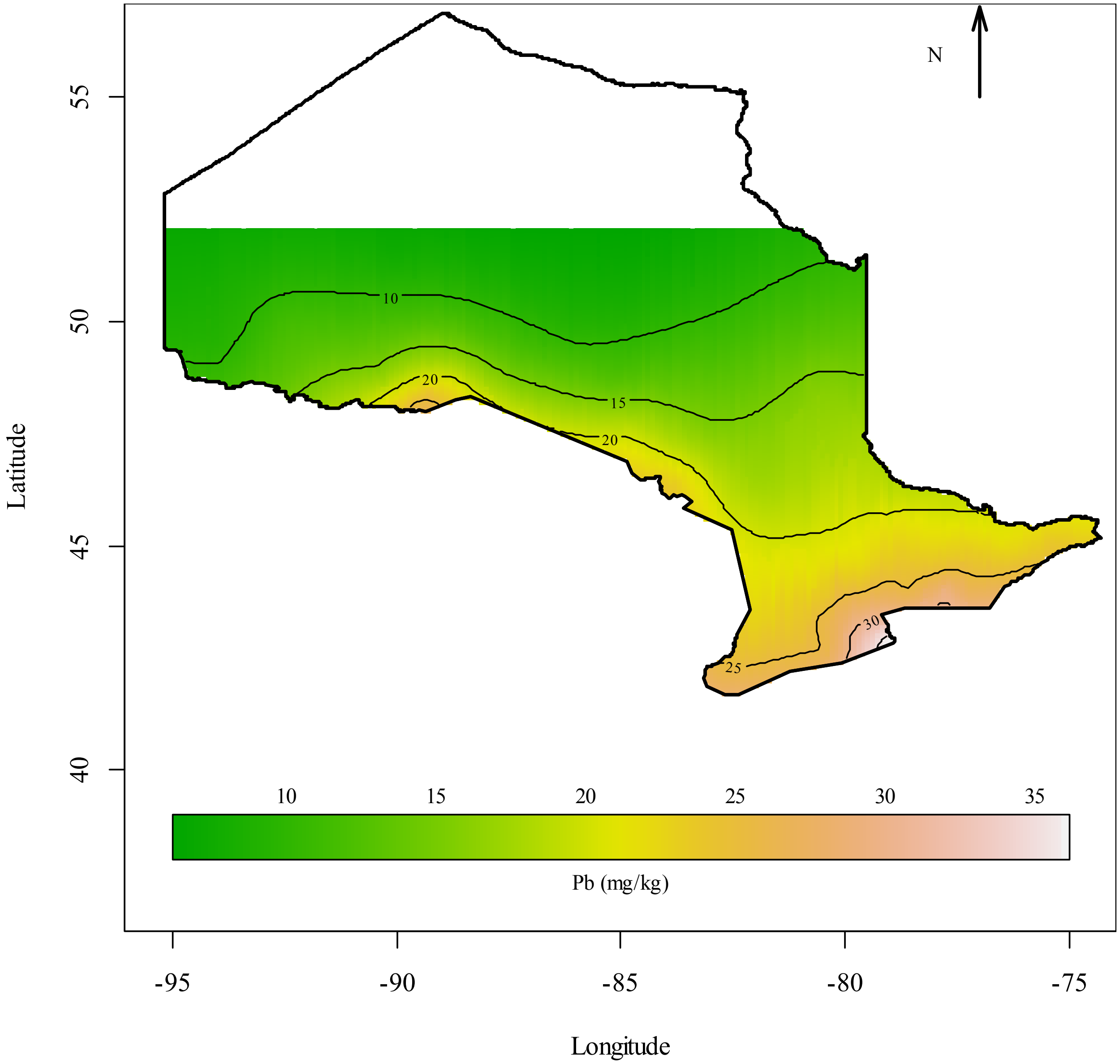

Figure 42: Predicted Pb Concentrations based on Rural Park Data

Pb concentrations appear to correspond to population density and /or the location of the Trans Canada Highway. The prediction standard errors are presented in Figure 43.

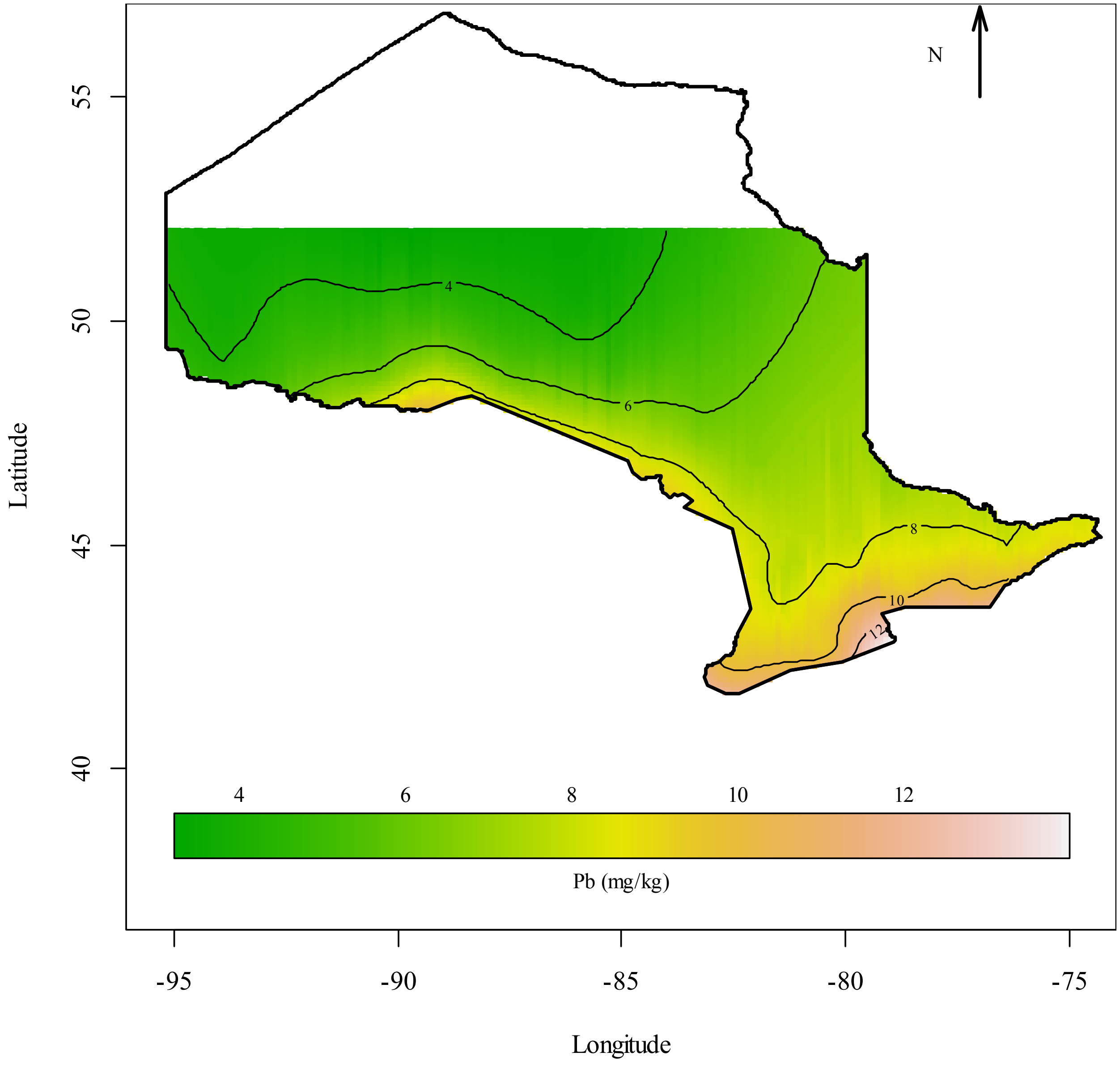

Figure 43: Prediction Standard Errors for Pb Predictions Based on Rural Park Data

The model presented for Pb in rural parks is used to present (Figure 44) the probability of exceeding the Table 1 (OMOE, 2011) value for Pb for agricultural or other property use (45 mg/kg).

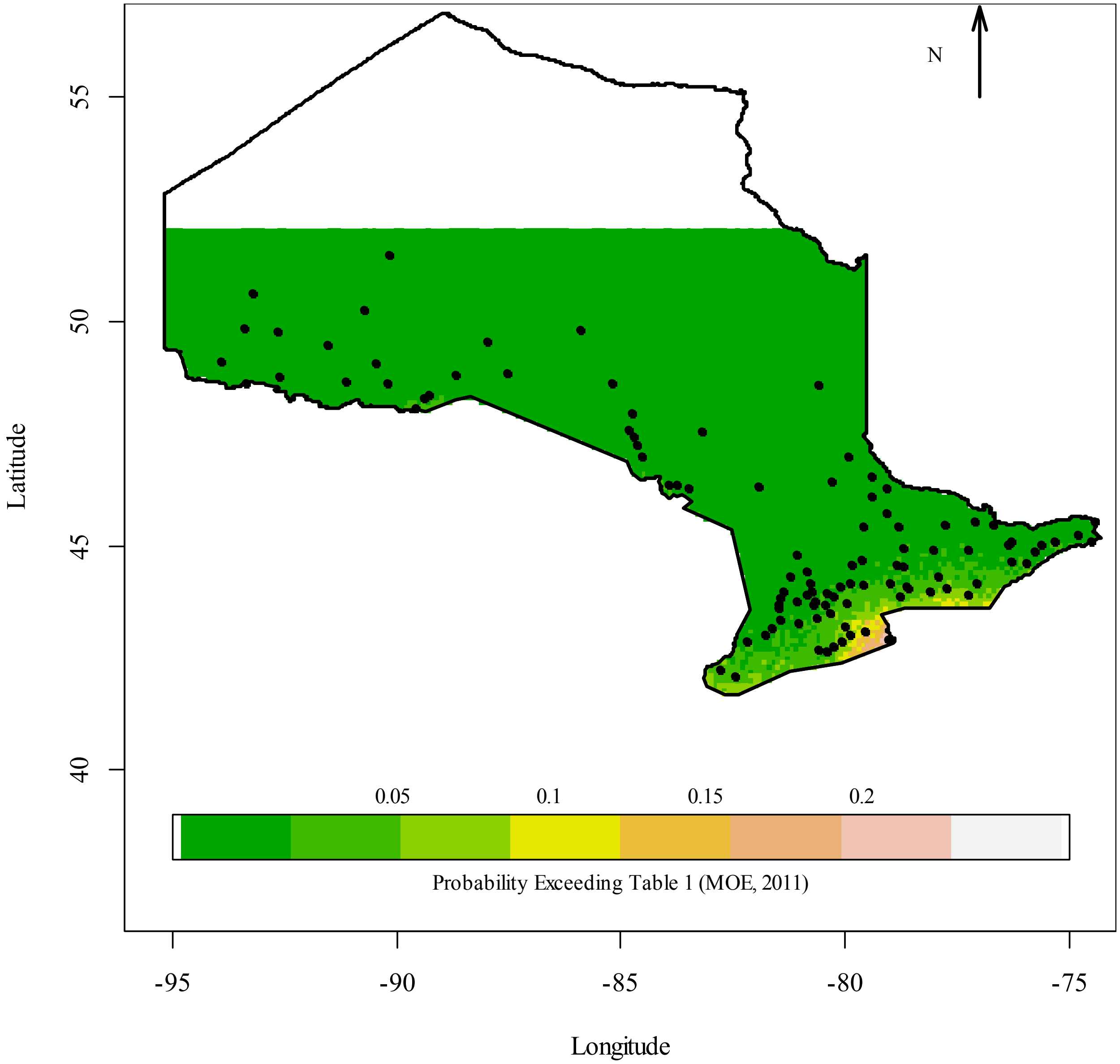

Figure 44: Probability of Exceeding Table 1(OMOE, 2011) for Pb

The probability of exceeding the Table 1 (OMOE, 2011) value for Pb for agricultural or other property is quite low over most of Ontario. The only area where the probability exceeds 10% is in the Niagara region of Ontario and possibly Kingston. The graphic is refined by plotting the area bounded by a 2.5% probability of exceeding the Table 1 value for Pb (Figure 45). This is consistent with the intended level of protection afforded by an OTR.

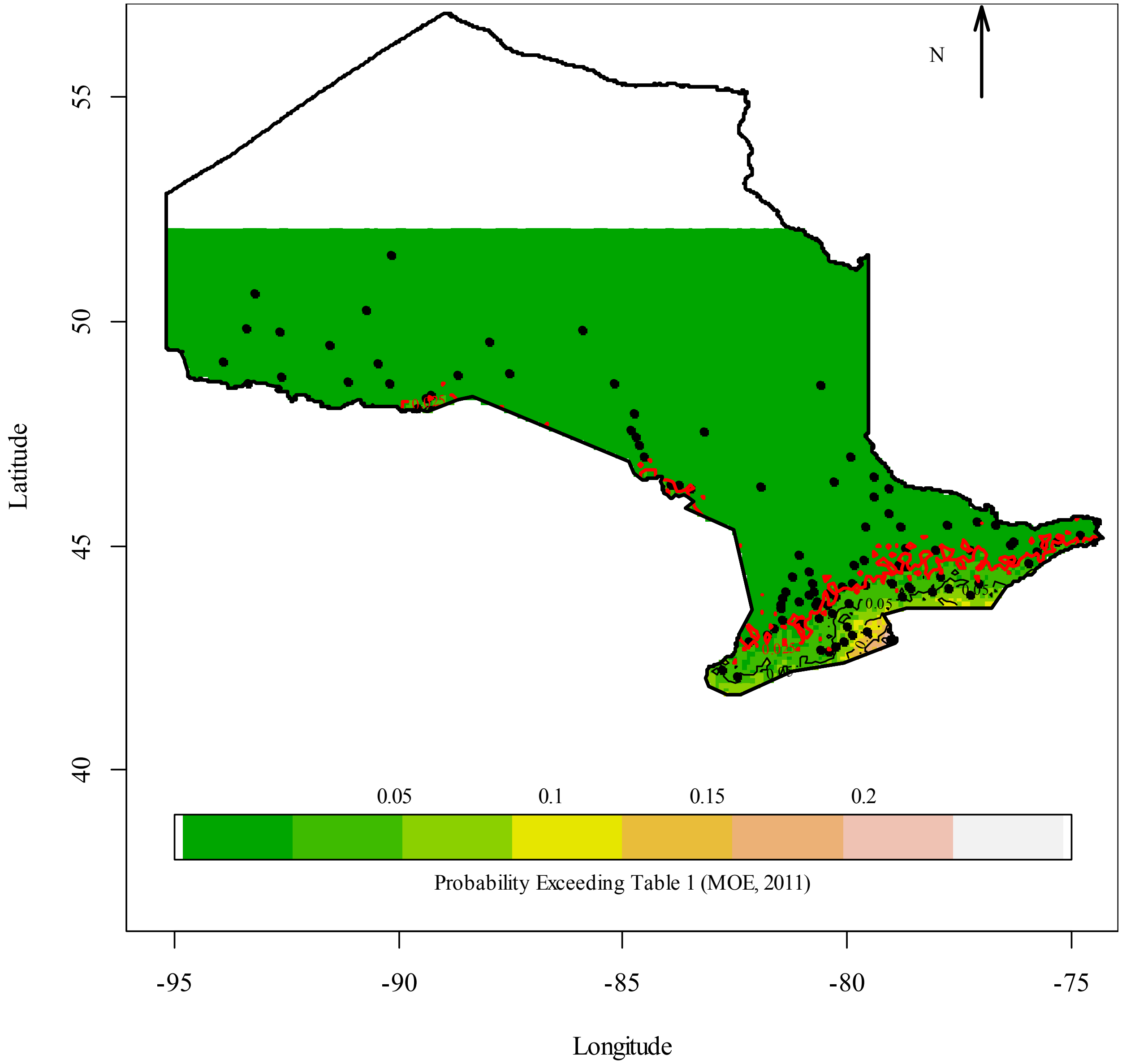

Figure 45: Probability of Exceeding Pb, Table 1, OMOE, 2011 (red line delineates the 2.5% probability isopleth)

Figure 45 shows that the location-specific probability of exceeding the Table 1 (OMOE, 2011) value for Pb for agricultural or other property is greater than 2.5% proximal to the northern shore of Lake Ontario and Lake Erie as well as in the vicinity of Thunder Bay and Sault Ste Marie. Some smaller areas are also so flagged. It may not be coincidental that the areas so identified are in the vicinity of large populations due to historic use in leaded gasoline, paints and by industry. Specifically in Hamilton, Ontario, Richardson et al., (2011) found that the primary predictor of soil Pb was proximity to industry. This delimitation further points out the inadvisability of using administrative regions as environmental management units and the failure of the OMOE (1993) paradigm that leads to a single Pb OTR over the province.

2.5 Conclusions and Recommendations Regarding OTRs

2.5.1 Geostatistical Modelling

Geostatistical models were used to predict Al concentrations in Ontario using three different datasets. Where geospatial coverage was similar (Southern Ontario) the three kriged prediction surfaces were with the exception noted above, quite similar with respect to patterns although the mean level varied by dataset. Geostatistical models were also used to predict Pb concentrations in Ontario. The geostatistical models addressed null hypotheses Ho2a and 2b:

Ho2a: Geostatistical models cannot be used with available OTR data to estimate OTRs; and,
Ho2b: Geostatistical models cannot be used with the OMAFRA field metal data to make geostatistical predictions.

Refuting these null hypotheses is more a pragmatic decision regarding utility than a probabilistic statement. Certainly geostatistical models can be fit to the three datasets but to quote the statistician George Box “All models are wrong but some are useful”. The question then is: “Are these models useful”?

One criterion of utility is whether a model provides a useful summary of the data. In this case, do the models accurately predict concentrations? The only way to verify that models accurately predict concentrations is to predict concentrations and compare those to concentrations at locations not used to build the model. This requires either *de novo* data collection or using only a portion of the data to build a model and the remaining portion for validation. Unfortunately this requires a substantive number of data and certainly the three datasets are not “large” enough to divide. Another method is to use cross-validation as described in section 2.3.3.3.2. The cross-validation prediction errors for each of the final Al models selected are presented in Table 13.

Table 13: Final Al Geostatistical Model Cross-Validation Results for Three Datasets

Dataset	Theoretical Variogram	Mean Prediction Error (mg/kg)	Mean Absolute Prediction Error (mg/kg)	Standardized Mean Squared Prediction Error
Rural Park	isotropic exponential variogram with first order trend using WLS	199.57	4777.22	1.52
Urban Park	isotropic spherical variogram with no trend using OLS	-41.23	4175.68	0.80
OMAFRA	isotropic exponential variogram with no trend using REML	157.45	4240.68	1.04

Table 13 shows that the average prediction error (at sampled locations) is quite small relative to the minimum measured Al concentrations (2000 mg/kg for OMAFRA field data, Table 7). The mean absolute prediction error is a better estimate of how well the models predict the observed data. The mean absolute prediction errors are (subjectively) moderate relative to median Al concentrations for each of the datasets (13,890, 12,000 and 15,000 mg/kg respectively for rural parks, old urban parks and OMAFRA field data).

The geostatistical models show distinct regions of localized elevated Al. In the geographically restricted area of Southern Ontario (for which three data sources are available), there is general concordance (aside from a mean shift) between the predicted concentrations using three different geostatistical models. The predicted means (for the geographically restricted datasets) are 16,576, 15,757 and 13,461 mg/kg for OMAFRA, rural and urban park data, respectively. The 97.5th percentiles used to estimate the OTR are presented in Table 14 for the various model / dataset / geographic region coverage combinations.

Table 14: Comparison of 97.5th Percentiles for Three Datasets Using Kriging and OMOE (1993) Methods

Data set	**Data subset**	**Kriged 97.5th percentile (mg/kg)**	**OMOE 1993 OTR (Following Zajdlik, 2006a) (mg/kg)**
Al in Rural Parks	All	20,293	30,050
Al in Urban Parks	All	15,053	25,886
OMAFRA Field Data	OMAFRA geographic extent (defined by bounding box)	21,536	NA
Al in Rural Parks		21,104	NA
Al in Urban Parks		15,804	NA

The predicted 97.5th percentiles in Table 14 are substantively lower than the OTRs. The kriged 97.5th percentiles are based on predicted Al concentrations over a grid delimited by the bounding box for the respective dataset with the exception of rural and urban park data subset to the geographic coverage of the OMAFRA dataset. The number of predictions varies with dataset but ranges from more than 35,000 to less than 8,500 for the three datasets limited to the OMAFRA geographic extent. The OTR 97.5th percentiles are measurements from no more than 110 discrete locations. The difference in 97.5th percentiles is due to smoothing of data due to measurement error embedded in the nugget (covariance between observations as distance → 0, see equation 3.2.28, Cressie, 1993).

Assuming that the kriged prediction surface for Al in Ontario reflects ambient Al concentrations, the 97.5th percentiles estimated using kriging suggest that for Al at least, the single OTRs estimated following OMOE (1993) are biased upwards. The results using Al as an example illustrate how using a province wide OTR substantively over or under predicts location-specific ALs. The bias can lead to lax or unduly conservative criteria when used as a basis for ecological risk assessments or remediating brownfield sites or (OMOE, 2009, 2004). This bias can also lead to misapplication of storm water pond sediment to soils (OMOE, 2003b) or quarried rock to lakes (OMOE, 2003a). Also, because an AL is used as a source term in human health-based soil guidelines (CCME, 2006) and soil EQGs, (National Environment Protection Council, 2013), biased ALs can lead to biased human health or environmental quality guidelines. Finally, biased ALs can even lead to sites being incorrectly designated as contaminated sites because the definition relies on a concentration being elevated relative to the AL (CCME, 2006; ICMM 2007a). ICMM (2007a) recommends for a variety of reasons that specifically, variation in background levels in space “should be taken fully into account in the risk assessment process” for metals.

The Pb analyses were conducted to assess location-specific bias using a contaminant of interest to the OMOE. Assuming that the universal kriging of Pb in rural parks represents ALs and that the 97.5th percentile of this distribution is a desirable EQG (which is consistent with OTR usage) Figure 45 suggests that the Table 1 value for Pb (OMOE 2011 Table 1 value for Pb for agricultural or other property) is biased downwards in the vicinity of urbanized areas. This statement follows from the idea that in a specific area, only 2.5% of concentrations measured at discrete sampling locations should exceed the AL. Furthermore, the exceedances should occur randomly rather than in a pattern such as that delimited by the red line in Figure 45. The observation that the delimited areas are coincident with urbanization may demonstrate the influence of historic non point sources of Pb although this idea is not further explored in this thesis. This leads to the further question as to whether anthropogenically elevated Pb or other analyte concentrations proximal to historic urbanization should be used in estimating ALs in distant parts of the province.

2.5.2 Statistical Issues

Covariance model parameters estimated using likelihood methods were visually biased and at times the optimization failed to converge. Warnes and Ripley (1987) express doubts regarding

MLE estimation of covariance functions in general due to nonmonotonic likelihood surfaces. They illustrate the argument with the likelihood surface of an exponential covariance function. Mardia and Watkins (1989) suggest that the likelihood surface of a data /spherical covariance function "set" may exhibit multimodality (non-monotonicity) and hence incorrect or poor convergence. Watkins and Al-Boutiahi (1990) state that mis-specification of the trend component may lead to issues with parameter estimation. Finally, Mardia and Marshall (1984) show that MLE parameter estimates may be biased with "small" sample sizes. These issues either separately or together may explain the failure of the MLE method to provide plausible estimates or estimates at all. The defensibility of the WLS used to fit the "best" model for Al in rural parks is addressed by Zimmerman and Zimmerman (1991) who conducted a Monte Carlo comparison of WLS, MLE, REML and minimum variance quadratic unbiased estimates. Using the criteria of coverage probability of 95% confidence intervals, bias and mean square error they found that WLS sometimes was the best estimator and generally performed "well" relative to other methods.

2.5.3 Estimating OTRs

Al OTR estimates appear to be biased on a provincial basis and are certainly biased on a location-specific basis. On a provincial basis Pb OTR estimates are influenced by the higher Pb concentrations in soils associated with historic urbanization. This leads to a biased provincial level OTR as well as location specific bias. The implications of this bias are discussed in section 2.5.1. Geostatistical models and location – specific ALs not only addresses the issue of local over prediction or underprediction but can also obviate the weaknesses of the current OTR paradigm discussed in sections 2.2.1 through 2.2.6.

Reducing uncertainty in a regulatory context can minimize risks to the environment due to criteria that are too lax or minimize costs to developers due to unnecessarily stringent criteria. The degree of certainty regarding a specific kriged prediction can be assessed objectively using kriged prediction standard errors and/or residuals. Certainty can be improved by increasing the spatial coverage of the OTR samples. Additional samples may be optimally collected by sampling where kriging prediction standard errors at specific locations are unacceptably large. This presumes that the land use of interest occurs in the areas where additional data are required. The spatial coverage of the OTR samples may also be improved through use of opportunistic "background" data that are sometimes available when proponents conduct site-specific risk assessments. If in expert opinion these opportunistic data: 1) meet the background site selection criteria; 2) follow OMOE (1993) sampling and analytical protocols; and 3) generally conform to the OTR kriged surfaces, these opportunistic data might be added to the OTR database. Uncertainty in kriged predictions may also be improved by using ancillary information such as: 1) the known or posited relationships between analytes (discussed in section 2.2.7) or with regolith (discussed in section 2.4.4.3.1); and, 2) the three datasets (under the strong assumption that they represent background concentrations) via co-kriging. Co-kriging may also be used to reduce uncertainty when prediction standard errors are large but tracts of land with the desired land uses are not available in the area of interest.

Geostatistically modelling the Al and Pb data was challenged by lack of convergence. The lack of convergence can be improved by fitting fewer parameters by maximum likelihood. One parameter that could be otherwise estimated is the nugget using some quantile of the distribution of subsample (the site-specific replicates) variances. Finally, given issues with maximum likelihood estimation (see discussion in section 2.4.4) use of profile likelihoods to corroborate other criteria used to assess model fit should be considered.

2.5.4 Enhanced Relevance for Use in Toxicity-Based Assessments

Ambient levels based on measurements using an aggressive analytical digestion/extraction method and used in the context of toxicity-based assessments may not reflect either acclimation or bioavailability (ICMM, 2007a). ICMM (2007b) suggests that an *aqua regia* digestion be used for regional exposure assessments as this extraction reflects all bioavailable metals but excludes those embedded in soil crystal structures. As an example, McLaughlin and Smolders (2001) used Zn dissolved in porewater rather than total Zn in soil to assess adaptation of soil microorganisms to Zn. They suggest that when assessing Zn toxicity, that metalloregions defined by a common set of abiotic and biotic factors that affect Zn toxicity be used. US EPA (2007) declared the intent to develop the metalloregion concept taking into considerations factors affecting bioavailability that will vary in importance from substance to substance but for metals will likely include pH, cation exchange capacity, % organic matter and soil type (i.e. loam, sandy loam, etc.). Waeterschoot et al. (2003), ICMM (2007a) and US EPA (2007) recommend that large-scale (national, regional, etc.) ecological risk assessments acknowledge metalloregions (where appropriate) in order to generate appropriate management strategies (relative rankings, protection levels and mitigation targets).

The following steps are recommended for estimating metalloregions in Ontario. The word "estimate" is used to reinforce the stochastic nature of the data-driven, bioavailability model basis of the regions so defined.

1. Define areas of similar metal concentrations in surficial soils. Concentrations within these strata may form the bases for non-toxicity based regulatory endpoints.

2. Determine the most critical confounding factors affecting the toxicity of a given metal. Toxicity should likely be assessed in terms of key soil ecological processes.

3. Modify metal strata defined above to incorporate relevant confounding factors.

2.5.5 Temporal Validity

ALs are the sum of natural background concentrations and low-level non point-source inputs such as those due to long range transport (US EPA, 2002; CCME, 2006). ALs reflect the same intent as OTRs estimated using rural park data (OMOE, 1993). A measured analyte concentration at any location is a dynamic equilibrium balancing inputs and losses. Low-level non point-source inputs can change over time. In some instances banning product use such as Pb in gasoline and paints or improved management practices can lead to a reduction in these inputs over time. Other analytes such as salts may be increasing over time due to more widespread usage. Consequently specific ALs will change over time. The current OTR estimates are based on data collected between 1991 and 2002, inclusive. ICMM (2007a) recommends that variation in background levels of metals in time “should be taken fully into account in the risk assessment process”. ICMM (2007b) suggest that data collected within the last 5 years are the most “reliable and relevant” for both site-specific and diffuse ALs. It is recommended that a subset of locations be resampled so that temporal drift can be assessed to ensure that data collected more than 20 years ago still represents ALs in Ontario.

3 Estimating EQGs using Multimodal Species Sensitivity Distributions

3.1 Summary

The derivation of WQGs has evolved from best professional judgement applied to single species toxicity test responses to using the statistical distribution of species sensitivities to a contaminant to estimate a WQG. The WQG is estimated using a low percentile from the SSD (species sensitivity distribution) and depending upon the jurisdiction, the percentile or a lower confidence limit becomes the WQG. Most jurisdictions recommend only 1 or 2 unimodal statistical SSDs. The utility of these unimodal SSD models for a contaminant with multiple modes of toxic action is not clear due to the mixture of sensitivity distributions associated with each mode of toxic action. This is particularly true for modern pesticides with highly specific modes of toxic action for target organisms and non-specific modes of toxic action for non-target organisms. Options to deal with multimodality include using only the taxa corresponding to the most sensitive mode to estimate a WQG, comparing the WQG using only the targeted species with a WQG estimated using all species and choosing between the two, or separating taxa based on functional groups if multimodality is not due to known modes of toxic action. Segregating an SSD database that will be used to estimate a WQG (as opposed to testing a research hypothesis) disavows the concept underpinning the SSD – that of assessing a distribution of species sensitivities in the receiving environment. Multimodal SSD models embrace this precept. The utility of mulitimodal models to describe SSDs is invesgitated for a pesticide with a known mode of toxic action, an environmental contamiant without a specific mode of toxic action and an SSD database comprised of responses at different levels of biological integration. The percent relative difference between the lower one-sided confidence limit for an EQG and the EQG was chosen to compare the precision of EQGs estimated using multimodal and partitioned datasets.

Multimodal models were fit using likelihood methods and percentiles were estimated using the method of moments. Confidence intervals around EQGs were estimated using Monte Carlo simulations. Goodness of fit tests include observed goodness of fit using quantile-quantile plots, Monte Carlo-simulated Kolmogorov-Smirnov goodness-of-fit test critical values and likelihood ratio tests. Not surprisingly, atrazine, an herbicide with a known mode of toxic action was best described using a multimodal model. Acute aquatic nonylphenol SSDs were also best described using a multimodal model. There is limited evidence that the observed multimodality may be due to taxonomic composition. Zn toxicity in soil was also best described by a multimodal model due to multimodality induced by the opportunistic collection of data that includes reproduction, growth, developmental, mortality and population level effects. Aside from the atrazine dataset, datasets were deliberately selected to assess SSDs using non–pesticides and matrices other than soil. Unimodal distributions were poor descriptors of the SSD datasets examined. This was expected for pesticides but was not expected for nonylphenol or zinc in soil. Given that jurisdictions typically only recommend partitioning SSD datasets when known taxonomic sensitivities exist, neither the nonylphenol data nor the zinc data would be partitioned. Instead poorly fitting unimodal models would be used to estimate EQGs. Using a slightly expanded set of SSDs, EQGs were more precisely estimated using multimodal models applied to the complete SSD dataset than using the parameters fit to the more sensitive mode. Finally, for data poor substances, using data representing both modes and fitting a multimodal model may enable estimation of a low percentile that that could not be estimated using a unimodal model on a data subset.

3.2 Introduction

Indirect environmental quality guidelines use measurements taken from a surrogate environmental matrix or phase to estimate an EQG in the environmental matrix or phase of interest. For WQGs, analyte concentrations are measured in water (the surrogate environmental matrix) and calibrated to responses in aquatic species (the environmental phase of interest). Those responses are used to estimate a concentration in water to achieve the desired level of protection. Indirect guidelines are used by various jurisdictions to estimate WQGs (USEPA, 1985; OECD, 1995; ANZECC, 2000; CCME, 2007; European Commission, 2011). In Canada, the current preferred approach is to use a species sensitivity distribution to derive water quality criteria (CCME, 2007). SSDs have been used in one form or another for decades. The earliest methods of setting a guideline were based on examining the available toxicity test results for a contaminant and using expert judgment to derive a guideline, often by applying a safety factor to the lowest observed toxicity test result. This is still the fallback position of CCME (2007) when data are of insufficient quantity or quality. This *ad hoc* examination of available data was in fact an unwitting “species sensitivity distribution” approach to deriving water quality criteria since a set of toxicity test results from different species was used to derive a criterion to protect other species. This *ad hoc* approach was/is subject to criticism on the bases of: 1) subjectivity in how data were used; 2) uncertainty regarding the level of ecosystem-wide protection afforded; 3) subjectivity in choice of safety factor (Chapman et al., 1998); and, 4) strong reliance on the most sensitive species tested.

The *ad hoc* approach to developing water quality criteria was improved by creating guidelines for developing water quality criteria (Stephan, 2002). These guidelines could be referred to before derivation of a guideline, thereby forestalling the criticism of subjectivity in how data were used. In the ensuing decades, the guidelines for development of water quality criteria have evolved to address issues such as: 1) the percent of species in an ecosystem that must be protected; 2) definition of the term “protected”; 3) the use of safety factors; 4) the minimum number of species, taxonomic diversity and number of observations required; 5) the use and relative merits of “acute” and “chronic” toxicity test results; and, 6) trophic diversity in the species sensitivity distribution to afford ecosystem-relevant protection. Each of these issues has been treated differently in various jurisdictions due to differing beliefs regarding the scientific literature and the jurisdiction-specific balance between science and environmental policy.

Current approaches embrace the concept of a distribution in sensitivity of species to a contaminant as first formalized by Aldenberg and Slob (1993). This parallels the tolerance distribution concept embedded in estimation of a toxicity test endpoint for a single experiment, where individuals have differing levels of sensitivity. In the aggregate sense, the cumulative response (if mortality could be cumulated over one organism) of the individuals exposed is described by a cumulative normal or Gaussian distribution. This distribution of individual tolerances describes the sensitivity of the sample of exposed organisms to the contaminant under the prescribed conditions. The distribution is used to make inferences regarding the population of potentially exposed organisms from the same species.

One endpoint that is commonly estimated when the cumulative distribution represents mortality is the LC50, or concentration that results in 50% mortality. The utility of this endpoint has gradually decreased over the last few decades as awareness of environmental effects has led to interest in lower levels of mortality and/or estimation of smaller fractions of toxicity test organisms exhibiting non-lethal responses. Commonly estimated endpoints for single toxicity tests include IC25s and sometimes IC10's. With respect to species tolerance or sensitivity distributions, interest centers on even lower percentiles. The most common choice of percentile is 5% (USEPA, 1985; OECD, 1995; ANZECC, 2000; CCME, 2007; European Commission, 2011) although values of 1% and 10% are also sometimes used (ANZECC, 2000). The estimated x^{th} percentile may itself become a water quality guideline (CCME, 2007) but, in most jurisdictions, a lower confidence limit becomes the WQG. Choices for the level of significance range from 0% (CCME, 2007) to 50% (OECD, 1995; ANZECC, 2000).

The estimation of a toxicity test endpoint and an endpoint from a species sensitivity distribution share in common: 1) methods for model selection; 2) to a large extent, the suite of potentially useful models; 3) optimal mathematical/statistical methods for estimating endpoints, i.e. the underlying algorithm; 4) sensitivity of endpoints to model selection; and, 5) choice of relevant percentile of organisms (IC25 versus IC10 or LC20 versus LC50). Estimation of a toxicity test endpoint and an endpoint from a species sensitivity distribution differs in that: 1) the treatment of multiple observations for a single species is not relevant when estimating a toxicity test endpoint; and, 2) there is more controversy regarding the percentile to estimate in the case of multiple species tolerance or sensitivity distributions.

Statistically, the problem for either the single species or multiple species case is seemingly straightforward: estimate a quantile and associated confidence interval from a sample distribution. Aside from the ecological problems (relevance of species tested to a given ecosystem (Dowse et al., 2013, Awkerman et al., 2014), relevance of "acute" versus "chronic measurements", problem of coverage of trophic levels and critical trophic levels, keystone species, mixture toxicity (Gregorio et al., 2013), etc.) and policy problems (choice of quantile and by extension degree of environmental protection to estimate, degree of precision required for the quantile estimate etc.) the following statistical issues do arise.

Choosing the General Estimation Approach: In order to estimate a percentile from a data set, one need only rank the data and choose the observation corresponding to the desired percentile, or use an interpolation method when the available observation ranks do not coincide with the desired percentile. This approach is extremely sensitive to the sample size and the toxicity test results in the vicinity of the desired percentile. However the most severe condemnation of this method is that any guideline derived using such an approach is restricted to the range of the observed values. Another approach that does not suffer from this latter shortcoming is to model the observed data in the same way that the tolerance distribution generated by a single toxicity test is modelled. The parameters of the model are estimated and the desired percentile is predicted.

Choosing a "Model" or Tolerance Distribution: When estimating a "middle" percentile such as the median, the choice of model (tolerance distribution) will often not substantively affect the endpoint estimated. For example, LC50s estimated after assuming logistic, normal, Weibull or Gompertz tolerance distributions are virtually identical. However, when estimating an extreme percentile such as 5 or 95%, the choice of model may greatly affect the estimated endpoint. Therefore it is critical that objective tools be developed and applied for choosing the most appropriate model. Note that the phrase “correct model” is not used because we cannot know what the true distribution of sensitivities to a given contaminant, for the receiving environment of interest is, without evaluating all taxa. The idea of the “most appropriate model” is in keeping with the statement made by a famous statistician, George Box: “All models are incorrect but some are useful.” I do not necessarily believe that one model is correct and all others are incorrect but rather that one model is more “correct” than another.

Sample Sizes: The small-sample behaviour of extreme percentiles may vary from model to model. Therefore not only should a model be the most appropriate but it should also have desirable small-sample behaviour. Small-sample behaviour is largely concerned with the convergence of variance terms to asymptotic results.

3.2.1 Indirect Guidelines Research Objectives

The preceding sections describe the historic impetuses that led to the development of the modern statistical sensitivity distribution approach to estimating water quality guidelines currently used by many jurisdictions. The statistical sensitivity distribution models generally used to describe tolerance distributions (either single species or multi-species) are unimodal although Shao (2000) provides an example of multimodal modelling using mixtures of the three-parameter Burr type III distributions. No jurisdiction currently advocates using multimodal models.

The utility of unimodal SSDs for a contaminant with multiple modes of toxic action is not clear due to the mixture of sensitivity distributions associated with each mode of toxic action. This is particularly true for modern pesticides with highly specific modes of toxic action for target organisms and non-specific modes of toxic action for non-target organisms (Zajdlik, 2008; Zajdlik et al., 2009). Furthermore, methods that use all available data simultaneously, embrace the concept that the SSD represents the distribution of sensitivities in the receiving environment whereas segregating the data contravenes this fundamental precept. The first null hypotheses investigated, with respect to indirect guidelines was:

$H_0$3: An SSD for a pesticide with a known highly specific mode of toxic action is best described by a single statistical distribution.

Rejection of this null hypothesis leads to concerns with paradigms that advocate use of a single statistical distribution to estimate a WQG for this type of contaminant. Rejection of this null hypothesis leads to two additional hypotheses. These are:

$H_0$4: Is multimodality demonstrable for environmental contaminants other than pesticides?; and,

$H_0$5: Does a multimodal SSD approach improve estimates of EQGs?

The first of these latter two hypotheses can be assessed by demonstrating that multimodal species sensitivity distributions occur for contaminants other than highly specific pesticides. The last hypothesis will be answered through the use of objective criteria such as the width of confidence interval around an estimated EQG and subjective criteria such as degree of environmental protection afforded by an EQG estimated using multimodal versus unimodal approaches.

The sequence of hypotheses begins with showing that using unimodal distributions are often poor descriptors of typically encountered SSD datasets. The reasons that multimodal distributions exist are examined and then the benefits of using multimodal models are explored.

3.3 Methods

3.3.1 Model Fitting Methods

Mixture models were fit using maximum likelihood via the function “optim” in R (R Development Core Team, 2010 version 12.0). Constrained optimizations following Byrd et al., (1995) as called by “optim” were used for poorly behaved likelihoods; otherwise Nelder-Mead optimizations (Nelder and Mead, 1965) were used. The 5th percentile of the SSD or HC_5, was estimated using the Newton method with user-supplied derivatives. Confidence limits around the HC_5 and point-wise confidence limits (as described in Atkinson, 1985) around the fitted model were generated using 1000 Monte Carlo simulations. Examination of lesser numbers of simulations showed that 1000 simulations were sufficient to produce stable estimates of confidence limits. When unimodal models were investigated the HC_5 was estimated using the method of moments and confidence limits were generated using 10,000 Monte Carlo simulations with a sample size of 1000.

Mixtures of probability densities are presented on a frequency scale since a presentation on the density scale ignores the mixing proportion thereby distorting the graphic. Unimodal densities were converted to frequencies using the estimated mixing proportion. Several mixture models were usually evaluated, prior to selecting the “best” data descriptor. Criteria defining “best” include observed goodness of fit using quantile-quantile plots, Monte Carlo-simulated Kolmogorov-Smirnov goodness-of-fit test critical values and cautiously applied likelihood ratio tests. Likelihood ratio tests are used cautiously due to the degeneracy of the asymptotic $\chi 2$ distribution used to test hypotheses regarding number of mixture components with likelihood ratio tests (Everitt, 1981; McLachlan, 1987; Garel, 2007). The models used are presented below.

3.3.2 Mixture Distribution Models

Bivariate Normal

$$f(\ln(x), p, \mu_1, \sigma_1, \mu_2, \sigma_2) = p\left\{\frac{1}{\sigma_1\sqrt{2\pi}}\exp\left\{\frac{-1}{2}\left(\frac{\ln(x)-\mu_1}{\sigma_1}\right)^2\right\}\right\} + (1-p)\left\{\frac{1}{\sigma_2\sqrt{2\pi}}\exp\left\{\frac{-1}{2}\left(\frac{\ln(x)-\mu_2}{\sigma_2}\right)^2\right\}\right\},$$

where $0 \leq p \leq 1$; and x, μ_1, σ_1, μ_2, and $\sigma_2 > 0$.

Trivariate Normal

$$
\begin{aligned}
f(\ln(x), p_1, p_2, \mu_1, \sigma_1, \mu_2, \sigma_2, \mu 3, \sigma_3) = \; & p_1 \left\{ \frac{1}{\sigma_1 \sqrt{2\pi}} \exp\left\{ \frac{-1}{2} \left(\frac{\ln(x) - \mu_1}{\sigma_1} \right)^2 \right\} \right\} + \\
& (1 - p_1 - p_2) \left\{ \frac{1}{\sigma_2 \sqrt{2\pi}} \exp\left\{ \frac{-1}{2} \left(\frac{\ln(x) - \mu_2}{\sigma_2} \right)^2 \right\} \right\} + \\
& p_3 \left\{ \frac{1}{\sigma_3 \sqrt{2\pi}} \exp\left\{ \frac{-1}{2} \left(\frac{\ln(x) - \mu_3}{\sigma_3} \right)^2 \right\} \right\},
\end{aligned}
$$

where $0 \leq p_1, p_2 \leq 1$; and x, μ_1, σ_1, μ_2, σ_2, μ_3 and $\sigma_3 > 0$. The tetravariate normal is a straightforward extension of the trivariate normal and thus is not presented.

3.3.3 Hypothesis Testing

The mixture distribution models described above are fitted to SSDs for atrazine and nonylphenol in water and zinc in soil using the methods described above. The first set of hypotheses tested is:

$H_0$3: An SSD for a pesticide with a known highly specific mode of toxic action is best described by a single statistical distribution.

H_a3: An SSD for a pesticide with a known highly specific mode of toxic action is best described by multiple statistical distributions.

Testing the null hypothesis that an SSD for a pesticide with a known highly specific mode of toxic action is best described by a single statistical distribution" sets the stage for subsequent hypothesis tests. The first of these tests wether multimodality in SSDs for contaminants other than those with specific modes of toxic occurs and if so, why. This hypothesis is:

"H04: Is multimodality demonstrable for environmental contaminants other than pesticides? The final hypothesis investigates the benefits of using a multimodal distribution relative to using separate unimodal distributions on partitioned datasets. The null hypothesis "$H_0$5: Does a multimodal SSD approach "improve" estimates of WQGs?" is evaluated by comparing an objective criterion such as the percent relative difference between the lower one-sided confidence limit and the EQG under the following scenarios:

1. EQGs estimated using the entire dataset and an appropriate multimodal model;

2. EQGs estimated using the parameters corresponding to the most sensitive "population" as indicated by the multimodal model above; and,

3. EQGs estimated using a subset of the data comprised only of the targeted population (for those substances with a known target population) and an appropriate unimodal model.

A comparison between EQGs estimated by acknowledging and ignoring multimodality was not conducted because it is poor scientific practice to ignore demonstrable and objectively testable, multimodality. The percent relative difference between the lower one-sided confidence limit for an EQG was chosen as a criterion because the width of the confidence interval around an estimated value is a measure of the "strength" of the model/data combination. For a given substance, the comparison of percent relative differences reflects the precision with which the EQG is measured. For jurisdictions where a lower confidence limit becomes the EQG (all but Canada among jurisdictions that use SSDs to estimate EQGs) this results in a higher guideline but one that still affords the same level of environmental protection as the lower guideline. This is because the lower of the two confidence limits is lower solely due to imprecision in the estimated percentile.

3.3.4 Analyte Selection

Atrazine was selected as a representative of pesticides with known highly specific modes of toxic action because as a widely used herbicide, a relatively large database of toxicity test endpoints exists. Also as an herbicide, the specific mode of toxic action (disruption of electron transport in photosystem II; Moreland, 1980) in targeted taxa should induce multimodality in an SSD database. Nonylphenol in water and zinc in soil were selected to assess whether multimodality is demonstrable for environmental contaminants with a general mode of toxic action and if so, to assess why.

3.3.5 Datasets

3.3.5.1 Atrazine

The material in this section is abstracted from Zajdlik et al., (2009). The atrazine SSD dataset was compiled by searching the scientific literature and toxicity databases during the period of December 2005 to March 2006. More than 240 documents were obtained. These documents were classified as primary, secondary or unacceptable studies using criteria described in CCME (2007). The screening process retained 35 short term studies that were used herein. These observations are presented in Appendix 2. LC50s and EC50s were preferentially selected over IC50s for estimation of a short term guideline. The term “short” was defined as 96 hours for all taxa except algal and plant data. Plant exposure periods were defined on a case-by-case basis and algal results were always defined as chronic. Biochemical or physiological endpoints were not used for fish or amphibians but photosynthetic endpoints were used for plants. When more than one exposure duration was available for the same endpoint and species, the lowest value was used. When more than one life stage was available for the same endpoint, species and exposure duration, the lowest value was used. The median of replicate toxicity estimates was used in order to avoid weighting the SSD with one species. Algal species variants were treated as the same species. Using this process the final dataset of 33 observations includes 5 macrophytes, 11 invertebrates, 15 fish and 2 amphibians.

3.3.5.2 Nonylphenol

The species sensitivity data used to investigate multimodality to nonylphenol (nonylphenol isomers are Chemical Abstract Service numbers 84852-15-3 and 25154-52-3) corresponds to acute (as defined by US EPA, 2005) freshwater toxicity. The data were obtained from US EPA (2005) table 1. The species mean acute values (SMAV) are used to assess multimodality and are presented in Table 15. The use of SMAVs departs from US EPA (2005) who use genus mean acute values for guideline derivation but is consistent with data usage by CCME (2007).

Table 15: Nonylphenol Acute Freshwater Toxicity Data (Modified from US EPA 2005, table 1)

Species	**"Type"**	**SMAV (µg/L)**
Amphipod, *Hyalella azteca*	invertebrate, arthropod	55.72
Fountain darter, *Etheostoma rubrum*	vertebrate, fish	110
Boreal toad, *Bufo boreas*	vertebrate, amphibian	120
Fathead minnow, *Pimephales promelas*	vertebrate, fish	133.9
Cladoceran, *Daphnia magna*	invertebrate, arthropod	140.6
25th percentile = 150.3 µg/L		
Midge, *Chironomus tentans*	invertebrate, arthropod	160
Lahontan cutthroat trout, *Oncorhynchus clarki henshawi*	vertebrate, fish	166.6
Apache trout, *Oncorhynchus apache*	vertebrate, fish	169.7
Razorback sucker, *Xyrauchen texanus*	vertebrate, fish	174.4
Greenthroat darter, *Etheostoma lepidum*	vertebrate, fish	190
Bluegill, *Lepomis macrochirus*	vertebrate, fish	209
Rainbow trout, *Oncorhynchus mykiss*	vertebrate, fish	221
Gila topminnow, *Poeciliopsis occidentalis*	vertebrate, fish	230
Colorado squawfish, *Ptychocheilus lucius*	vertebrate, fish	254.6
75th percentile = 272.0 µg/L		
Bonytail chub, *Gila elegans*	vertebrate, fish	289.3
Annelid, *Lumbriculus variegatus*	invertebrate, polychaete	342
Green algae, *Pseudokirchneriella capitatum*	plant	410
Dragonfly, *Ophiogomphus sp.*	invertebrate, arthropod	596
Snail, *Physella virgata*	invertebrate, pulmonate	774

3.3.5.3 Zinc

The soil zinc toxicity data were compiled by the Ontario Ministry of Environment for the purpose of estimating the “no potential effects range” (NPER) or “effect concentration low” (ECL). Data screening and compilation were conducted by the OMOE. The data are presented in Appendix 3.

The Ontario Ministry of Environment follows the CCME (1999) preferred approach for estimating an NPER. This "weight of evidence approach" uses the 25th percentile of "no effects" and "effects" soil contact databases. The NPER is applicable for residential/park and agricultural land uses. A safety factor is applied to obtain a threshold effect concentration. A guideline, for commercial and industrial land uses, is the "effects concentration low" or ECL. The ECL is the 25th percentile of the "effects" database only. In this thesis the zinc dataset comprised of "no effects" and "effects" data (i.e. that used for the CCME preferred weight of evidence approach) is examined for multimodality.

3.4 Results and Discussion

Results corresponding to each null hypothesis tested are presented in separate sections, below. The utility of a multimodal model in describing the SSD for a pesticide with a known highly specific mode of toxic action is assessed in section 3.4.1. The presence of multimodality in SSDs for contaminants other than pesticides is assessed in section 3.4.2 and the improvement in EQGs estimated using multimodal versus unimodal SSDs is assessed in section3.5

3.4.1 Contaminants with a Known Specific Mode of Toxic Action

The results of testing the null hypothesis "$H_0$3: An SSD for a pesticide with a known highly specific mode of toxic action is best described by a single statistical distribution" are presented. The null hypothesis is assessed subjectively by superimposing a kernel density estimate over a frequency histogram (as a density) in Figure 46 and objectively using a formal test for multimodality, Hartigan's dip test (Hartigan and Hartigan, 1985).

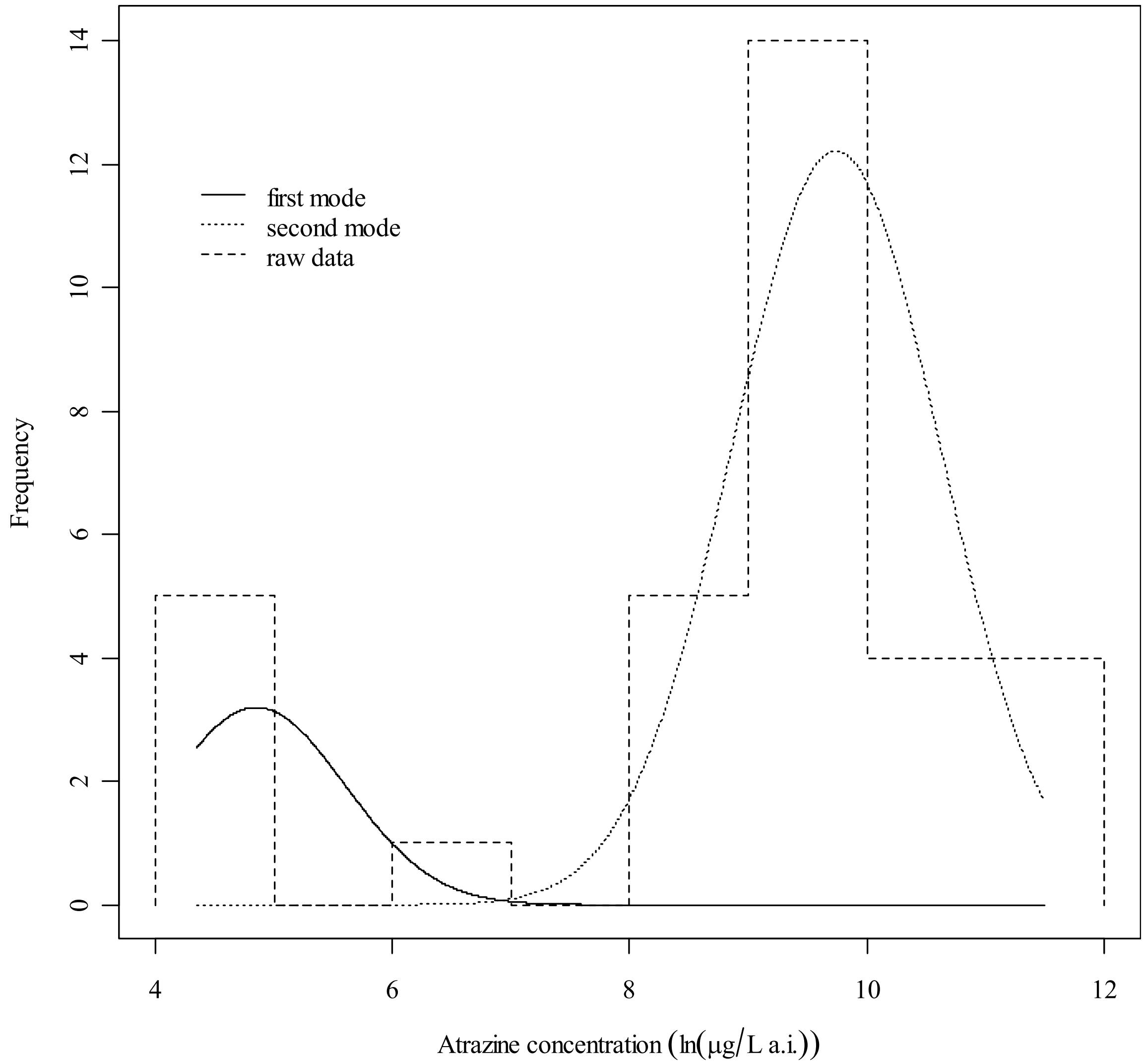

Figure 46: Fitted and empirical frequency density plots for short-term atrazine toxicity to aquatic organisms (a.i. – active ingredient) (CCME Data)

The null hypothesis that the atrazine SSD is unimodal, was rejected and the alternative hypothesis "data are multimodal" was accepted (dip-test p-value = 0.081). Using the methods described in section 3.3.1, a bivariate normal mixture model (presented in section 3.3.2) was chosen as the "best" fitting model and is presented in Figure 46.

3.4.1.1 Plausibility of Multimodality and Conclusion

The test of multimodality and the superiority of a bivariate relative to a univariate model objectively demonstrate multimodality in the atrazine SSD dataset. Examination of the organisms comprising the most sensitive mode shows that all taxa are plants. Given that the model of toxic action for targeted organisms is disruption of electron transport in photosystem II (Moreland, 1980) and the fact that all taxa comprising the most sensitive mode were plants, the finding of multimodality is plausible. The practical implications of using a multimodal distribution relative to a unimodal distribution for atrazine are discussed in Zajdlik et al., (2009).

3.4.2 Contaminants with a General Mode of Toxic Action

In this section the null hypothesis “$H_0$4: Is multimodality demonstrable for environmental contaminants other than pesticides?”. The contaminants chosen were nonylphenol in water and zinc in soil. The intent of the selection was to determine if multimodality is demonstrable in contaminants with a general mode of toxic action and if so, to assess why.

3.4.2.1 Nonylphenol in Water

The null hypothesis “H_o: The acute freshwater nonylphenol species sensitivity distribution is unimodal.” was assessed subjectively by superimposing a kernel density estimate over a frequency histogram (as a density) and objectively using a formal test for multimodality, Hartigan’s dip test (Hartigan and Hartigan, 1985). The empirical density is presented in Figure 47.

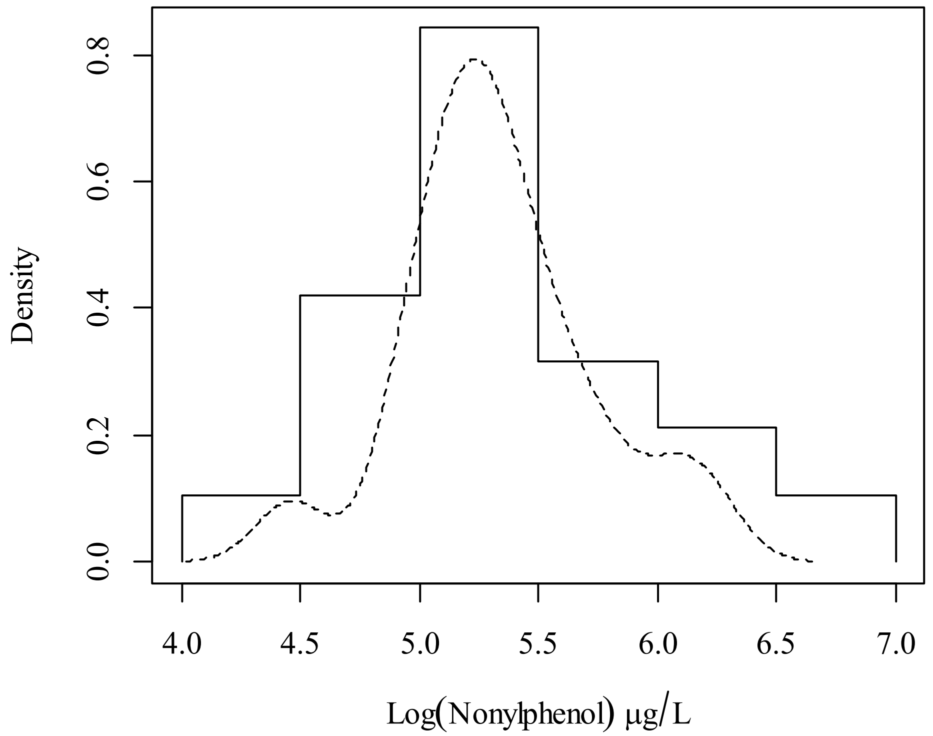

Figure 47: Nonylphenol Acute Freshwater Toxicity Empirical Density) (US EPA Data) (dotted curve is the kernel density and the solid curve is the frequency histogram as a density)

Figure 47 shows some visual evidence of multimodality which was confirmed by Hartigan's dip test (p-value for testing H_o: Data are unimodal = 0.04253). Thus the null hypothesis was rejected and the alternative hypothesis: acute freshwater nonylphenol species sensitivity distribution is multimodal, was accepted. The toxicological plausibility for the demonstrated multimodality is examined below.

3.4.2.1.1 Plausibility of Multimodality

Schüürmann (1991) and Fay et al., (2000) suggest that freshwater acute nonylphenol toxicity is due to a general narcotic syndrome. At the molecular level, the mechanism for acute toxicity in freshwater is not known (Schüürmann, 1991), although chronic exposure causes endocrine disruption (Gao, et al., 2014). Therefore a specific toxicological basis for the multimodality observed in the acute responses is not available. The taxonomic bases for observed multimodality are explored below using the SMAV data as a possible explanation of the observed multimodality. Size ranges, and life stages used by US EPA (2005) are not presented. It is important to note that any tentative explanations are merely conjectures due to a long list of caveats including: 1) the data used (like most data compiled to estimate EQGs) do not comprise an unbiased sample of species present in a specific or even a generic receiving environment; and 2) SMAVs as opposed to other levels of taxonomic identification may distort SSD due to representation biases.

Observations between 25th and 75th percentiles represent 50% of the observations in any dataset. In Table 15, the ordered data were (subjectively) separated by these percentiles as a high-level separation of the data. The central data are composed primarily of fish species which given the preponderance of fish species in the dataset, is not unexpected.

The non-fish species are not randomly distributed (not formally tested at this time) among the three data ranges created by choosing the 25th and 75th percentiles. Arthropods are found among the most and least sensitive organisms. The single amphibian tested is among the most sensitive organisms and the single plant and snail species tested are among the least sensitive organisms. Subject to the limitations expressed above, a reasonable conjecture is that there is <u>some</u> evidence of a non-random taxonomic distribution of sensitivities. In the data presented, this may account for the observed multimodality.

3.4.2.1.2   Model Fitting

Figure 47 <u>suggests</u> a trimodal normal mixture model may be appropriate. In this section, statistical models to describe the observed data are discussed. Models were fitted using methods described in 3.3.1. Attempts to fit a fully parameterized trimodal normal mixture model (presented in section 3.3.2) were unsuccessful. Mixture models are commonly fitted using the expectation-maximization algorithm of Dempster et al., (1977) (McLachlan and Peel, 2000). Attempts to fit the fully parameterized trimodal normal mixture model using the expectation-maximization algorithm (as implemented by Fraley and Raftery, 2006) were also unsuccessful.

A profile estimation strategy (fixing p_1) and observing values of the likelihood function over a range of possible values for p_1 as well as initially simplifying the trimodal normal mixture model settings by using $s_1 = s_3$ did allow estimation with three estimated means (4.02, 5.27 and 6.52 log(μg/L)) and two variances. However the mixing proportion for the smallest mean was only 0.05 suggesting that the contribution of this component to the joint distribution is negligible and that the hypothesis that the distribution is trimodal is untenable or at least not verifiable given the available data.

3.4.2.1.3 Conclusions

The nonylphenol data used is comprised of 19 observations. Fitting a trimodal normal mixture model with 8 parameters to such as small dataset is ill-advised due to overfitting and likely, identifiability of mixture components. These *a priori* concerns were borne out during model fitting when three approaches to estimating model parameters failed.

If the purpose of this research were to definitively rule out a tri-modal mixture model to describe acute freshwater toxicity of nonylphenol, additional data should be collected. However the purpose of this research is to provide evidence of multimodal SSDs for non-pesticides. This has been done objectively using Hartigan's dip test and subjectively using the empirical density. There is some very limited taxonomic support for a multimodal species sensitivity distribution but it is insufficient to partition the data objectively as recommended by some jurisdictions. Therefore the only approach to improve the model fit is to use a multimodal distribution.

3.4.2.2 Zinc in Soil

The null hypothesis "H_o: The zinc soil contact "no effects" and "effects" SSD is unimodal" was assessed subjectively by superimposing a kernel density estimate over a frequency histogram (as a density) and objectively using a formal test for multimodality, Hartigan's dip test (Hartigan and Hartigan, 1985). The empirical density is presented in Figure 48.

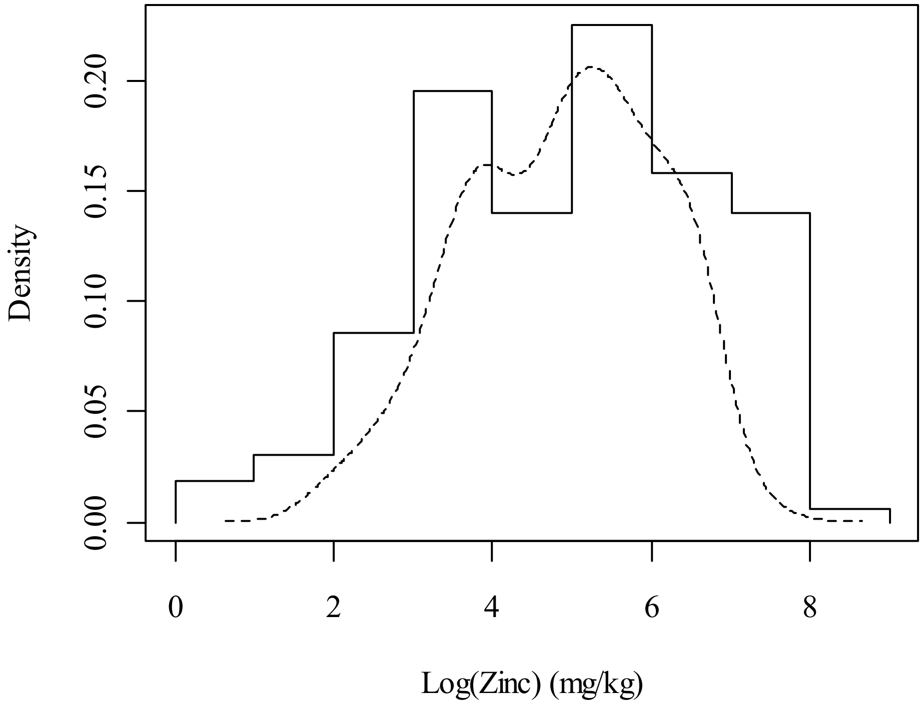

Figure 48: Zinc Soil Contact Empirical Density (OMOE NPER and ECL Zn Data) (dotted curve is the kernel density and the solid curve is the frequency histogram as a density)

Figure 48 suggests that the multimodal density is appropriate. This was confirmed by Hartigan's dip test (p-value for testing H_o: Data are unimodal = 0.03760). Thus the null hypothesis was rejected and the alternative hypothesis, the zinc soil contact "no effects" and "effects" SSD is multimodal, was accepted.

3.4.2.2.1 Plausibility of Multimodality

The dataset used to estimate an NPER is comprised of a mixture of effects classes ranging from population level effects to mortality. The empirical cumulative distributions of the effects classes are explored in Figure 49.

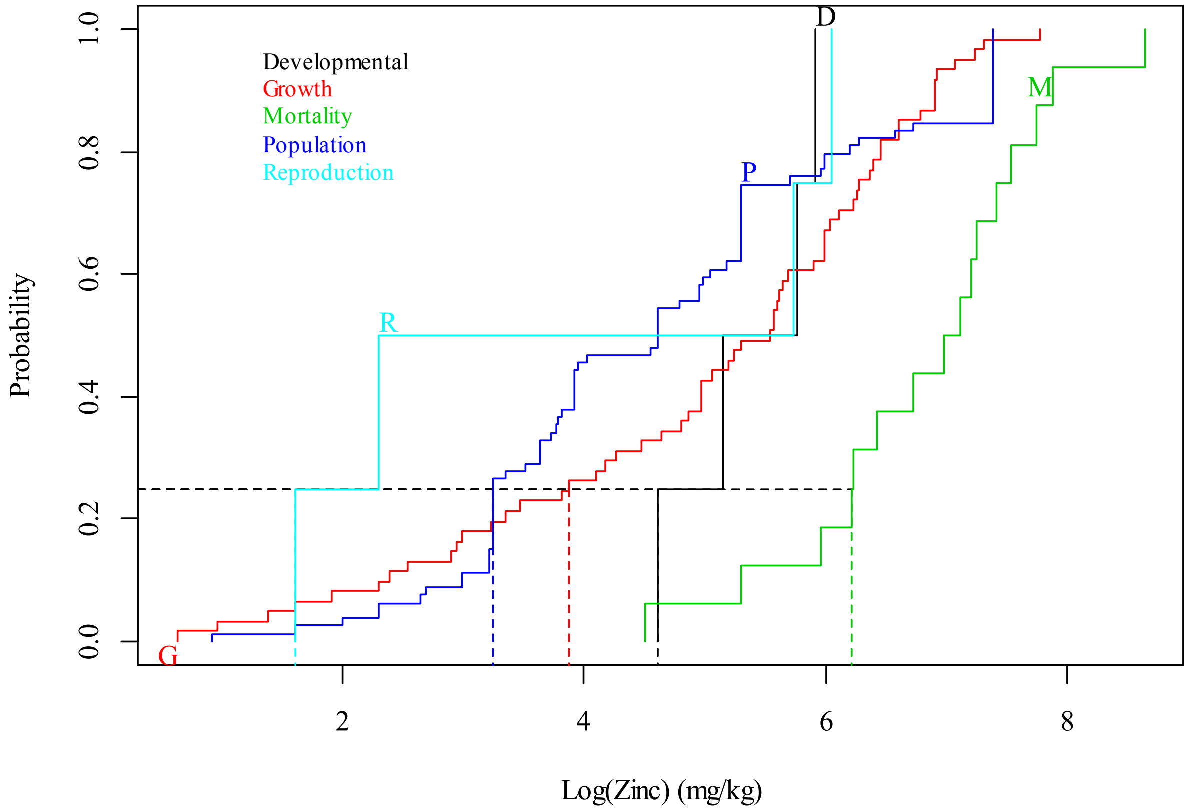

Figure 49: Empirical Cumulative Distribution Functions for Effects Classes Comprising NPER SSD Dataset (OMOE NPER and ECL Zn Data)

In Figure 49 the 25th percentiles corresponding to an effect-specific NPER range from 8.4 mg/kg (= $e^{2.13}$) for reproductive effects to 503.2 mg/kg (= $e^{6.22}$) for mortality. A crude tabulation of the effects in the soil contact Zn dataset on the basis of estimated means with the "low" group = Zn concentrations < μ_1 and the "high" group = Zn concentrations > μ_2 shows that no developmental or reproductive effects fall into the "high" group. However, the developmental and reproductive effects in the database comprise less than 5% of the data in the soil contact Zn SSD dataset. It is unlikely that these two effects are responsible for the bimodality observed in Figure 48. Because growth and population effects comprise the two largest proportions of the zinc toxicity dataset (37.2 and 48.2 respectively) and mortality comprises <10% of the zinc toxicity dataset, the empirical densities corresponding to growth and population are explored in Figure 50 to see if they contribute to the bimodality observed in Figure 48.

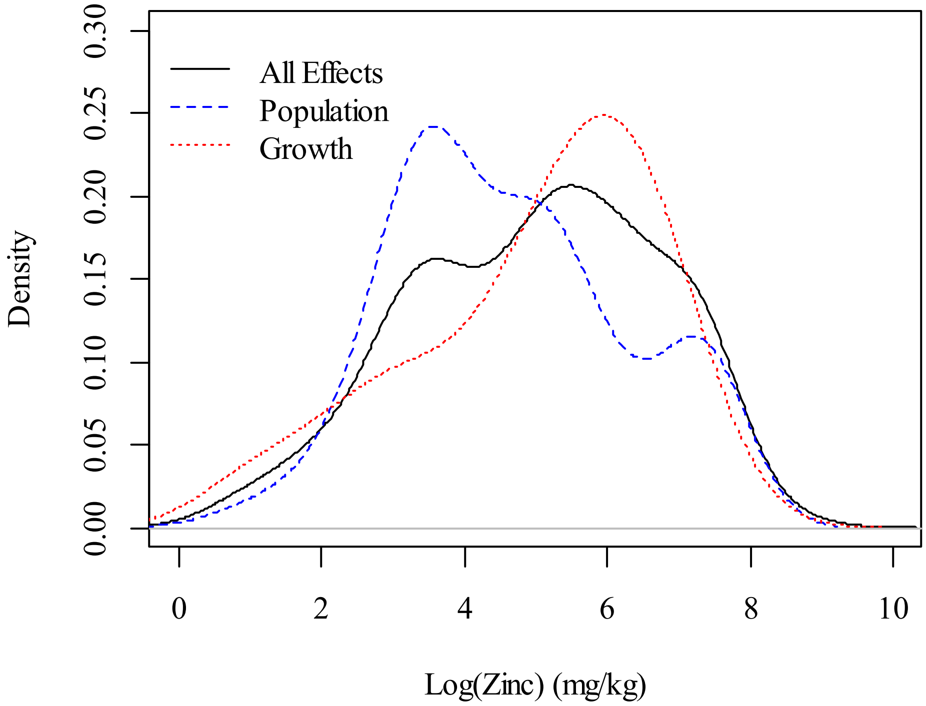

Figure 50: Empirical Densities for Effects Classes "Population" and "Growth" Comprising the NPER SSD Dataset (OMOE NPER and ECL Zn Data)

Figure 50 suggests that the observed bimodality for the complete soil contact Zn SSD dataset observed (solid black line) is attributable to the differential sensitivity of population and growth effects in the dataset to Zn. The primary peak in the population density is slightly less than 4 ln(mg/kg) and the peak in the growth density occurs at approximately 6 ln(mg/kg). These peaks correspond with the fitted peaks in the subsequent section suggesting that the multimodality in the soil contact Zn dataset is due to the mixture of effect types.

3.4.2.2.2 Model Fitting

The soil contact Zn SSD is used as is, without separating different classes of endpoints when following the CCME (1999) preferred approach for estimating an NPER. However the data are visually bimodal (Figure 48) and demonstrably multimodal using Hartigan's dip test. In keeping with this current practice of not separating different classes of endpoints a better descriptor of the data is some form of a multimodal data. Consequently, a bivariate normal mixture (as shown in 3.3.2) was fitted to the data as a possible descriptor. A Monte Carlo simulation for the Kolmogorov-Smirnov goodness of fit test was used to test the null hypothesis "H_o: Data are generated by bivariate normal mixture" against the alternative hypothesis: "H_a: Data are not generated by bivariate normal mixture". The Kolmogorov-Smirnov goodness of fit test statistic and critical values corresponding to a 95% level of significance are 0.05488 and 0.1280, respectively. Thus the null hypothesis cannot be rejected. The validity of the fitted model was also assessed using point-wise confidence limits (as described in Atkinson, 1985) around the fitted model. The fitted model and superimposed confidence limits are presented in Figure 51.

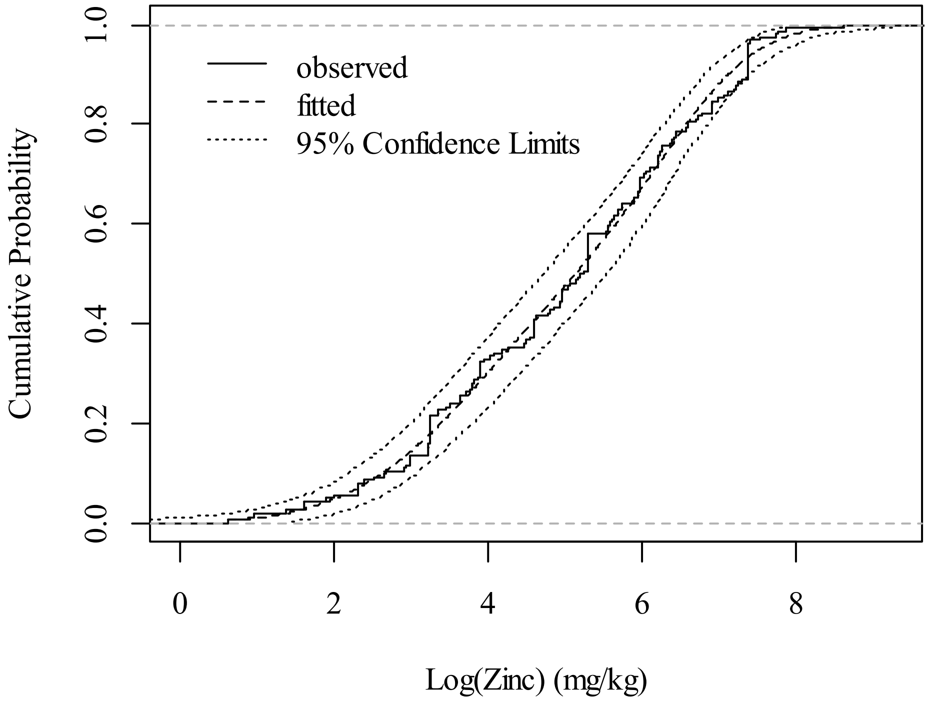

Figure 51: Bivariate Mixture Model Fitted to Zinc Soil Contact SSD Data (OMOE NPER and ECL Zn Data)

There is little to suggest that the bivariate normal mixture model presented in Figure 51 is not an adequate descriptor of these data. The model parameters and standard errors are summarized in Table 16. A large number of significant digits are presented in order to preserve accuracy if used for calculations; the implied level of precision should not be assumed for predictions.

Table 16: Summary of Fitted Parameters and Standard Errors (OMOE NPER and ECL Zn Data)

Parameter	Estimate	Standard Error
p	0.5989	0.2478
μ_1	3.9991	0.7409
σ_1	1.4110	0.3208
μ_2	6.4678	0.4495
σ_2	0.8849	0.2226

The two means appear to represent peaks in the kernel densities for effects on populations (μ_1) and growth (μ_2).

3.4.2.2.3 Comparison with Ontario Ministry of Environment Results

The Ontario Ministry of Environment follows the CCME (1999) preferred approach for estimating the Zn soil contact NPER as the 25th percentile of this dataset. No explicit guidance is given regarding estimation of percentiles however Gaudet et al., (2002) refer to the derivation of Canadian soil and sediment quality guidelines as rank-based. The rank-based quantile estimate for this dataset is 39.6 mg/kg which is very similar to the estimate of 40.6 mg/kg obtained using the multimodal approach.

This percentile itself may be used as a guideline. This is the approach adopted by CCME (2007) for water quality guidelines but, in most jurisdictions, a lower confidence limit becomes the WQG. The most common choice for the x^{th} percentile is 5% (USEPA, 1985; OECD, 1995; ANZECC, 2000; CCME, 2007) although values of 1 and 10% are also sometimes used (ANZECC, 2000). Choices for the level of confidence range from 0% (CCME, 2007) to 50% (OECD, 1995; ANZECC, 2000) for the HC_5 because larger confidence levels lead to unrealistic and statistically indefensible guidelines (Fox, 1999). The key point is that for a given level of significance, the precision of the estimated EQG drives the lower confidence limit. The lower confidence limit for a poorly estimated EQG will induce an unnecessary degree of conservancy relative to a more precisely estimated EQG.

The one-sided confidence limits corresponding to a traditional 5% level of significance are estimated for the zinc soil contact method as if the lower confidence limit would be used as the NPER. Continuing with the naïve quantile estimator, the one-sided 95% lower confidence limit for the 25th percentile estimated using a large-sample binomial approximation (Conover, 1999) is 25.6 mg/kg. Using Monte Carlo simulation of the fitted bivariate normal mixture model, the lower 95% confidence interval is 35.6 mg/kg. If the confidence limits associated with NPERs were used as EQGs, the bivariate model confidence limit is not as unnecessarily conservative as the rank-based lower confidence limit.

3.4.2.2.4 Conclusions

The Zn soil contact data are demonstrably multimodal by virtue of: 1) visual evidence provided by empirical densities; 2) formal testing using a hypothesis test; and, 3) fitting a multimodal model and being unable to reject the hypothesis that the data are adequately described by the fitted (bimodal) model. The observed multimodality is also plausible due to the presence of different classes of measurements within the Zn soil contact SSD dataset which are expected to exhibit different sensitivities to Zn. The peak densities for two of these classes of measurements (population level and growth) correspond to peaks in the empirical density for all data and are very similar to the bimodal normal mixture estimated means. Thus multimodality was observed in a non-pesticide, that is, Zn in soil. This multimodality is due to the pragmatic practice of mixing multiple measurement endpoints in a single SSD and is not unique to the Zn soil contact database. Because there is no provision for segregating data on the basis of measurement endpoint classes, soil quality guidelines should either be estimated using a multimodal model when it is appropriate to do so or the implications of segregating an SSD dataset on the measurement endpoint class should be assessed. The benefits of using the multimodal approach are explored in the section 3.5.

3.5 Conclusions and Recommendations Regarding SSDs

Unimodal distributions were poor descriptors of the SSD datasets examined. This is expected for pesticides but was not expected for nonylphenol in water or zinc in soil. Given that jurisdictions only recommend partitioning SSD datasets when known taxonomic sensitivities exist, neither the nonylphenol data nor the zinc data would be partitioned. Instead poorly fitting unimodal models would be used to estimate EQGs. This section explores how EQG estimates may be improved using multimodal distributions when appropriate, even in cases where an SSD dataset could be defensibly partitioned according to modes of toxic action.

The atrazine and zinc results presented in preceding sections were investigated below but nonylphenol was omitted due to model weakness. Additional results are extracted from

Zajdlik (2008) for the two of the four pesticides for which bimodal distributions were the "best" SSD descriptor.

Table 17: Comparing EQG Estimates and Scaled One-Sided Confidence Intervals

Scenario	Dataset	Data Subsets	Quantile	Lower One-Sided 95% CL	Type of Model	% Relative Difference[1]
1	Atrazine – all data	none	HC_5 = 82.1152 (µg/L)	51.4039	bivariate normal mixture	37.4003
2	Atrazine – target population	Subset represented by first mode in bimodal distribution.	HC_5 = 37.1772 (µg/L)	34.3598	bivariate normal mixture	7.5783
3	Atrazine – target population	Observations defined as "targeted"; i.e. plants.	HC_5 = 77.9073 (µg/L)	60.1609	none[2]	22.7789
1	Zinc – all data	none	HC_{25} = 40.6 (mg/kg)	35.5968	bivariate normal mixture	12.2379
2	Zinc – target population	Subset represented by first mode in bimodal distribution.	HC_{25} = 21.06223 (mg/kg)	19.04634	bivariate normal mixture	9.5709
3	not appropriate as there is no "target" population for zinc					

Scenario	**Dataset**	**Data Subsets**	**Quantile**	**Lower One-Sided 95% CL**	**Type of Model**	**% Relative Difference**[1]
1	Diazinon acute toxicity[3] – all data	none	HC_5 = 0.2278 (µg/L)	0.03646	bivariate exponential mixture	83.9947
2	Diazinon acute toxicity[3] – all data	Subset represented by first mode in bimodal distribution.	HC_5 = 0.04506 (µg/L)	0.009734	bivariate exponential mixture	78.3977
3	Diazinon acute toxicity[3] – target population	Observations defined as “targeted”	HC_5 = 0.08249 (µg/L)	0.02397	Weibull	70.9419
1	Diazinon chronic toxicity[3] – all data	none	HC_5 = 0.2044 (µg/L)	0.1745	exponential-Pareto mixture	14.6282
2	Diazinon chronic toxicity[3] – all data	Subset represented by first mode in bimodal distribution.	HC_5 = 0.1893 (µg/L)	0.1720	exponential-Pareto mixture	9.1389

Scenario	**Dataset**	**Data Subsets**	**Quantile**	**Lower One-Sided 95% CL**	**Type of Model**	**% Relative Difference[1]**
3	Diazinon chronic toxicity[3] – target population	Observations defined as “targeted”	HC_5 = 0.01155 (µg/L)	0.006073	Weibull	47.4199
1 100% * (HC_x – lower one-sided 95% CL) / HC_x						
2 Only 5 observations, HC_5 and confidence limited “estimated” following Harrell and Davis (1982).						
3 Analyses presented in Zajdlik, 2008.						

Table 17 shows that in all 4 cases investigated the percent relative difference between the lower one-sided confidence limit and EQG is lower when the most sensitive mode of the bimodal distribution is used to estimate the EQG. Excluding zinc for which no “target” taxa are defined, the percent relative difference between the lower one-sided confidence limit and EQG is lower when the most sensitive mode of the bimodal distribution is used to estimate the EQG relative to modelling ONLY the targeted taxa in 2 (atrazine acute data; diazinon chronic data) of 3 scenarios investigated.

To summarize, multimodality is demonstrated in SSDs for analytes with and without known modes of toxic action. The environmental contaminants and matrices investigated are presented in Table 18.

Table 18: Summary of Multimodal Hypothesis Testing: Are Distributions Multimodal?

Environmental Contaminant and Type	Matrix/ Exposure Type[1]	Comment
atrazine - pesticide	freshwater/ acute	Multimodal distribution in SSD comprised of plants and animals expected because mode of toxic action is disruption of photosynthetic electron transport system II. Multimodal distribution confirmed and is consistent with known mode of toxic action.
nonylphenol - surfactant	freshwater/ acute	Nonylphenol exhibits a general narcosis syndrome. The exact molecular mode of toxic action is unknown. Nonylphenol was investigated based on recommendation[2] and weak multimodality was demonstrated with a conjectured taxonomic basis.
zinc	soil	A multimodal distribution in the SSD was identified visually, confirmed by objective hypothesis testing and again by fitting a multimodal mixture model that could not be rejected. The observed bimodality is attributable to different classes of measurement types within Zn soil contact SSD dataset.

Multimodality as a general attribute of SSD datasets for substances without a specific mode of toxic action was demonstrable in two environmental matrices (soil and water). Multimodality occurred because different taxa in the SSD dataset appear to exhibit differential sensitivity that is not associated with a known specific mode of toxic action (nonylphenol in water). Multimodality also occurred when an SSD dataset was comprised of different classes of measurement types (Zn in soil). This latter point suggests that the degree of environmental protection afforded by such an SSD should be carefully considered as there will be varying

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[1] As defined by agency compiling data.

[2] M. Servos, University of Waterloo, pers. comm.

degrees of overprotection for all but the most sensitive measurement type within the SSD database.

The confidence intervals around the estimated 5th percentiles of the SSDs are demonstrably narrowed when multimodality is acknowledged. Because the lower confidence limit becomes the EQG in many jurisdictions, the EQG becomes higher while at the same time affording the intended level of protection.

4 General Discussion

The thesis investigated statistical tools to improve the derivation of direct and indirect EQGs. Two improvements were investigated. The first involved the use of geostatistical modelling to predict location-specific ALs for Pb and Al. The kriged ALs improve on the OTR ALs (OMOE, 1993) in several ways. The first improvement is that any effects of underlying regolith and primary pedogenic processes and massive secondary pedogenic processes such as glaciations on soil Al concentrations are not constrained by artificial administrative regions. The use of kriging also obviates the choice of test used to differentiate empirical distributions among administrative regions and logical inconsistencies when combining regions when no statistical differences among empirical distributions are detected. Another improvement is that the degree of site-specific environmental protection remains constant (inasmuch as the kriged surface is a faithful descriptor of the true but unknown AL surface) whereas a fixed or region-specific OTR affords at least the intended level of environmental protection at all but 2.5% locations over the applicable region but varying levels of protection on a local scale.

The extent to which the current OTR paradigm under or over predicts location specific concentrations was explored using Al OTRs derived using rural and urban park data as shown in Figure 22 and Figure 29; respectively. Over the locations at which site-specific 97.5th percentiles were estimated, the first quartile of the 97.5% percentiles for rural park data is 16,670 mg/kg Al or approximately 55% of the rural park OTR. On this basis, 25% of the province is under predicted by a factor of almost 2. The degree of over prediction was explored using the urban park data. The first quartile of the 97.5% percentiles for the urban park data over the grid of locations used is 25,690 mg/kg Al or approximately equal to the rural park OTR. On this basis, approximately 75% of the province is over predicted.

Conversely, the existing Al OTRs examined for rural and urban parks are less conservative than the kriged 97.5th percentiles based on predictions over a grid of locations across an area bounded by the OTR sampling locations. This seeming paradox is likely due to the naïve estimation of a percentile from a relatively small data set (maximum OTR Al dataset is 110 discrete locations) that is heavy-tailed (Figure 13) and that is demonstrably multimodal for at least one dataset (rural parks as discussed in section 2.4.4.1). Again, the kriged surfaces can provide a local AL that provides a consistent level of environmental protection, subject to the caveat of adequacy of the kriged surface. The third advantage of kriged ALs is that ancillary information such as soil texture, soil taxonomic units, co-analytes and similar datasets (other land uses, OMAFRA data, etc.) may be used to either improve estimates or impute estimates in areas where the analyte of interest has not been measured or cannot be measured because of anthropogenic activities. For example the natural background in a highly urbanized area might be predicted using co-kriging.

A Monte Carlo simulation using the Pb geostatistical model was used to estimate the probability of exceeding the Table 1 value for Pb (OMOE 2011 Table 1 value for Pb for agricultural or other property). The results show that the single Pb OTR derived following OMOE (1993) is lower than it should be in historic urbanized areas. Conversely, the Pb OTR in other parts of the province is too high. Both these statements reflect the idea that probability of exceeding an AL should be 2.5% and that higher observed probabilities should be randomly distributed over the province. The finding also illustrates that the non point sources contributing to an AL can be geographically restricted and that those point sources are not relevant source terms for distant locations.

The Al and Pb analyses illustrate that the OTR estimates are biased. As noted in section 2.5.1 possible effects are environmentally harmful application of quarried rock (OMOE, 2003a) or storm water pond sediments (OMOE, 2003b) or unnecessary restrictions on the placement of these materials. Also as source terms in human health-based soil guidelines (CCME, 2006), biased ALs lead to biased guidelines with the severity of bias being a function of the magnitude of the soil exposure term bias relative to other exposure terms. Because ALs can affect "local and regional exposure assessments, essentiality issues, acclimatization / adaptation etc.", ICMM (2007a) recommends that variation in metal background levels be considered in the metals risk assessment process.

There are disadvantages to using kriged ALs which fall into two classes; scientific and social. The "scientific" disadvantages are that kriged surfaces are more difficult to fit than estimating a simple quantile and there may be some subjectivity in choosing variogram models. However a kriged surface need only be fit once or periodically as more data become available (see discussion on opportunistic sampling in section 2.5.3). Thus, there is uncertainty associated with a kriged surface but there is also uncertainty associated with an OTR under the current estimation paradigm. Arguably, the uncertainty in a kriged ALs is less because features of the data that affect quantile estimation (heavy-tails and multimodality) are less critical when using kriging. The "social" disadvantage of kriged ALs is one of optics because a single value is not available for OTR users. This disadvantage can be sidestepped by making user-accessible prediction models available. This tool would allow an OTR user to predict the AL at a specific location of interest. A recommendation is to use the geometric mean of predictions over a grid within a site-specific "zone of influence". The zone of influence may be subjectively prescribed or objectively estimated in consideration of applicable environmental fate and degradation processes and local mitigating factors.

Another improvement to EQGs investigated in this thesis pertains to the use of multimodal SSDs when estimating indirect EQGs. Some substances such as pesticides have very specific modes of toxic action for targeted organisms and therefore SSDs for pesticides should exhibit multimodality. The two pesticide SSDs examined using objective tools are demonstrably multimodal (i.e. atrazine; Zajdlik et al., 2009 and diazinon; Zajdlik, 2008). Rather than being an expected attribute only of SSDs for contaminants with different modes of toxic action such as pesticides, multimodality is shown to exist in the aquatic nonylphenol SSD (despite the fact that no specific mode of toxic action has been identified for nonylphenol, Schüürmann, 1991) and the terrestrial Zn SSD. The multimodality observed in nonylphenol may be due to taxonomic groupings that are not (yet) linked to specific metabolic pathways whereas the multimodality observed in Zn is due to the pragmatic compilation of datasets that include measurement endpoints at different levels of biological integration that not unexpectedly, vary in sensitivity. This latter observation shows how multimodality may affect how a derived HCx is used in an environmental management context. For example, the Ontario Ministry of Environment approach for estimating NPERs and ECLs that follows the CCME (1999) preferred approach for soil quality guidelines generates an NPER that can be driven by one class of measurement endpoints such as effects on populations. If this class of measurement endpoint does not reflect the primary measurement type within a land use category the NPER may not result in the desired level of environmental protection. The datasets examined suggest that multimodality in SSDs may occur more often than expected even in non-pesticide datasets due to the common practice of pragmatically mixing measurement endpoints in a single SSD.

Acknowledging observed multimodality through explicit modelling leads to demonstrably improved estimates (where “improved” is defined by narrower confidence intervals of the EQG when all data are considered (4 of 4 cases) or when EQGs estimated using a data subset are compared to those estimated using the entire dataset (2 of 3 cases). For jurisdictions where a lower confidence limit becomes the EQG (all but Canada among jurisdictions that use SSDs to estimate EQGs) this results in a higher guideline but one that still affords the same level of environmental protection as the lower guideline. Thus, an EQG that does not acknowledge multimodality when it exists may be unnecessarily conservative.

Another advantage of using a multimodal model estimated from all data meeting data quality requirements (with the implication that a taxonomically diverse dataset is obtained) as opposed to a subset, embraces the concept underpinning the SSD – that of assessing a distribution of species sensitivities in the receiving environment. A taxonomically diverse dataset may therefore generate a more compelling EQG than one based upon a subset of the most sensitive organisms. This is not to suggest that all available data meeting inclusion criteria should automatically be used to generate an EQG (especially if unimodal models are used). Reasoned partitioning of data, based on specific functional groups and ecologic processes (Brix et al., 2001; Posthuma et al., 2002; Traas et al., 2002) or known toxicologic properties (ANZECC, 2000; Solomon and Takacs 2002; Maltby et al., 2005; Van den Brink et al., 2006; CCME, 2007; Giddings et al., 2014) may in some respects lead to equally or even more compelling EQGs. Other authors recommend a more pragmatic approach, where all the data are modelled simultaneously (i.e. regardless of functional group, ecologic process, mode of toxic action, etc.). Taxa responding due to a known mode of toxic action (European Commission, 2011) or that are visually more sensitive TenBrook et al., (2009) are also modelled separately. Then, if the two distributions exhibit a “break” or the overall model fits poorly, the HC5 is pragmatically estimated using only the more sensitive taxa. There is limited consensus on the approach to take when estimating EQGs when a contaminant exhibits specific modes of toxic action. There is almost complete silence on estimating EQGs when a SSD exhibits multimodality due to other reasons such as the inclusion of toxicity effect classes in the Zn NPER / ECL SSD database. Following the recommendations for segregating data on the bases of sensitivity or modes of toxic action is inconsistent with the primary requirement for maximum taxonomic diversity. Methods that use all available data simultaneously, embrace the concept that the SSD represents the distribution of sensitivities in the receiving environment whereas segregating the data contravenes this fundamental precept.

The modelling approach used allows the data to "speak" to the presence or absence of multimodality. In the case of the atrazine and diazinon datasets examined, the subsets identified using the bimodal model merely highlighted what is known about the specificity of the pesticide. Explicitly acknowledging the known mode of toxic action is simply good science. In the case of nonylphenol, demonstrable multimodality leads to a testable hypothesis regarding modes of toxic action. For zinc, the multimodal modelling approach highlights the pragmatic consequences of compiling datasets comprised of mixtures of measurement endpoints. Neither of these latter two nuances would have been detected had multimodality not been considered.

Finally one undeniable advantage of using an entire multimodal dataset rather than a partitioned dataset to induce unimodality is that the entire dataset may enable estimation of a small percentile such as the 5th that might not be estimable using unimodal distributions. Non-parametric methods as described by Newman et al., (2000), Van der Hoeven (2001) or Chen (2004), could be used to estimate the HC_5 however the methods based on order statistics (Van der Hoeven 2001; Chen 2004) require a sample size of 19 or more and Newman et al., (2000) suggest that approximately 15 or more observations are required to provide stable variance estimates.

In conclusion, this research demonstrates improvements in the estimates of EQGs. The value of the OTR research to the research community is that as a generally applicable methodology, geostatistically derived site-specific ALs reduce bias in ALs and hence bias in derivatized guidelines. The methodology is extensible and allows for testing hypotheses regarding observed spatial patterns using ancillary information. The demonstrably useful methodology is also the first step toward application of more complicated tools such as cokriging and block kriging that allow for testing hypotheses regarding observed spatial patterns using ancillary information. The value of the multimodal research to the research community is that the thorny problem of estimating an EQG that purports to represent a receiving environment but uses only a subset of taxa to estimate an EQG has been solved. The multimodal model approach also allows for estimation of a small percentile such as the 5th that might not be estimable using unimodal distributions on partitioned datasets.

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Appendix 1: OTR Data

Land use 3 = old urban park

Land use 9 = rural park

Locations are based on North American Datum of 1983

All concentrations are on a mg/kg basis.

Table 19: OTR Data: Ag - Cl

Station	Land Use	Year	Ag	Al	As	B	Ba	Be	Ca	Cd	Cl	DATUM	ZONE	latitude	longitude
1008001	9	1991	0.08	19000	5.6	3.71	55.6	0.6	13270	0.56	0.5	82	17	44.816458	-81.097171
1008001	9	1991	0.08	17520	5.2	3.2	53.9	0.5	11730	0.56	0.5	82	17	44.816458	-81.097171
1008001	9	1991	0.1	17350	3.6	4.01	44	0.6	9500	0.43	0.5	82	17	44.816458	-81.097171
1008002	3	1991	0.08	14410	6.8	12.7	38.4	0.5	33900	0.22	0.5	82	17	44.74259	-81.143784
1008002	3	1991	0.08	15800	7	14.63	40.3	0.5	32500	0.19	0.5	82	17	44.74259	-81.143784
1008002	3	1991	0.22	13790	5.4	14.45	30.5	0.5	32000	0.18	0.5	82	17	44.74259	-81.143784
1008003	3	1991	0.02	15140	3.8	0.85	71.9	1	22300	0.39	0.5	82	17	44.560393	-80.929447
1008003	3	1991	0.18	22300	10.9	0.82	75.2	1.1	21300	0.42	0.5	82	17	44.560393	-80.929447
1008003	3	1991	0.09	24000	9	0.83	76	0.8	22000	0.35	0.5	82	17	44.560393	-80.929447
1008004	9	1991	0.09	15670	9	9.79	54.7	0.5	17730	0.22	17.6	82	17	44.443944	-80.877824
1008004	9	1991	0.1	15260	9	6.23	56.3	0.6	17520	0.25	16.2	82	17	44.443944	-80.877824
1008004	9	1991	0.1	15170	9	13.26	57.6	0.6	15780	0.23	14.9	82	17	44.443944	-80.877824

Station	Land Use	Year	Ag	Al	As	B	Ba	Be	Ca	Cd	Cl	DATUM	ZONE	latitude	longitude
1008005	9	1991	0.11	12960	5.8	11.15	44.3	0.5	59100	0.16	16.8	82	17	44.318789	-81.243305
1008005	9	1991	0.12	12020	5.4	12.18	42.5	0.5	53400	0.12	19.7	82	17	44.318789	-81.243305
1008005	9	1991	0.13	12740	5.2	11.19	44.5	0.5	47600	0.12	14.1	82	17	44.318789	-81.243305
1008006	3	1991	0.1	22100	8.8	19.51	89.1	1	8870	0.39	15.4	82	17	44.176422	-81.618168
1008006	3	1991	0.1	22200	8.4	14.41	89.3	1	9010	0.39	14.8	82	17	44.176422	-81.618168
1008006	3	1991	0.1	22000	7.8	0.87	88.1	1	8470	0.4	14.2	82	17	44.176422	-81.618168
1008007	9	1991	0.18	15820	10.8	14.19	79.1	0.6	64500	0.61	26	82	17	44.180986	-80.803078
1008007	9	1991	0.14	15720	8.8	11.19	73.6	0.6	66900	0.58	27.5	82	17	44.180986	-80.803078
1008007	9	1991	0.15	15080	13	7.4	72.9	0.6	60100	0.6	24	82	17	44.180986	-80.803078
1008008	9	1991	0.12	25100	7	19.25	110	1.2	20800	0.16	23.1	82	17	43.671966	-80.722085
1008008	9	1991	0.11	25500	6.4	19.33	107	1.1	19680	0.16	24.2	82	17	43.671966	-80.722085
1008008	9	1991	0.1	26000	8.2	16.24	111	1.2	19030	0.2	20	82	17	43.671966	-80.722085
1008009	3	1991	0.02	17780	3.1	12.52	61.9	0.5	22900	0.31	9	82	17	42.759005	-81.189634
1008009	3	1991	0.02	14460	3.5	12.47	65.2	0.6	20900	0.31	6	82	17	42.759005	-81.189634
1008009	3	1991	0.16	18990	7.9	14.4	60	0.5	21000	0.33	6.4	82	17	42.759005	-81.189634
1008010	9	1991	0.12	11860	3.9	6.03	50.6	0.4	4390	0.3	4.5	82	17	42.088945	-82.438773
1008010	9	1991	0.12	12660	3.6	7.24	53.1	0.4	4050	0.25	4.4	82	17	42.088945	-82.438773
1008010	9	1991	0.16	15040	3.2	3.9	64.9	0.5	4460	0.32	5	82	17	42.088945	-82.438773
1008011	9	1991	0.13	22200	4.2	6.97	80.8	0.9	4930	0.45	30	82	17	42.228615	-82.795621
1008011	9	1991	0.15	17410	4.5	6.03	76.5	0.8	4810	0.4	24.8	82	17	42.228615	-82.795621
1008011	9	1991	0.13	17940	3.9	7.17	76.7	0.8	4740	0.35	23.4	82	17	42.228615	-82.795621
1008012	3	1991	0.15	15380	7.9	9.91	88.3	0.8	4690	0.18	32.5	82	17	42.300366	-83.05255
1008012	3	1991	0.16	17520	10	6.62	73.9	0.7	4270	0.6	33.5	82	17	42.300366	-83.05255
1008012	3	1991	0.12	12020	3.8	2.67	78.7	0.8	4400	0.54	32	82	17	42.300366	-83.05255
1008013	3	1991	0.12	12020	3.8	12.45	43.4	0.4	32000	0.27	12.7	82	17	42.402413	-82.149764

Station	Land Use	Year	Ag	Al	As	B	Ba	Be	Ca	Cd	Cl	DATUM	ZONE	latitude	longitude
1008013	3	1991	0.11	11420	3.8	11.45	42.2	0.4	33100	0.16	11.7	82	17	42.402413	-82.149764
1008013	3	1991	0.12	12190	4.4	11.37	45.1	0.5	30100	0.16	11.7	82	17	42.402413	-82.149764
1008014	3	1991	0.28	17390	3.8	5.74	79.2	0.8	14580	0.39	28.4	82	17	42.589542	-82.4052
1008014	3	1991	0.11	18710	3.7	8.75	77.5	0.7	14810	0.38	27.2	82	17	42.589542	-82.4052
1008014	3	1991	0.23	18860	3.8	6.58	84.8	0.8	14490	0.4	30.4	82	17	42.589542	-82.4052
1008015	9	1991	0.23	17920	3.6	13.32	68.9	0.6	53900	0.24	30.6	82	17	42.881862	-82.18226
1008015	9	1991	0.25	15120	3.7	13.38	64.2	0.6	53600	0.18	27.2	82	17	42.881862	-82.18226
1008015	9	1991	0.26	16350	3.8	13.39	65.3	0.6	58300	0.19	29	82	17	42.881862	-82.18226
1008016	3	1991	0.21	16850	3.4	20.89	67	0.7	20400	0.52	27.2	82	17	42.965156	-82.392349
1008016	3	1991	0.2	17060	3.4	17.5	70.4	0.7	15190	0.5	27.8	82	17	42.965156	-82.392349
1008016	3	1991	0.26	18160	3.5	20.71	71.2	0.7	14150	0.57	26	82	17	42.965156	-82.392349
1008017	9	1991	0.3	15730	4.6	0.99	73.1	0.5	5270	0.36	3.6	82	17	43.018985	-81.801795
1008017	9	1991	0.19	16980	4.7	0.99	75.8	0.6	5730	0.36	5.5	82	17	43.018985	-81.801795
1008017	9	1991	0.17	16160	4.8	0.96	80	0.6	5590	0.39	3.8	82	17	43.018985	-81.801795
1008018	9	1991	0.2	17840	2.3	0.82	72.5	0.6	5950	0.26	11	82	17	43.164124	-81.658251
1008018	9	1991	0.08	18900	2.4	0.85	74.5	0.7	6070	0.26	10	82	17	43.164124	-81.658251
1008018	9	1991	0.07	16890	2.2	0.84	64	0.6	5640	0.25	11.8	82	17	43.164124	-81.658251
1008019	9	1991	0.05	13450	4.4	0.75	60	0.4	4430	0.27	8	82	17	43.982597	-81.394438
1008019	9	1991	0.06	13540	3.9	0.79	54.2	0.4	4280	0.29	7.4	82	17	43.982597	-81.394438
1008019	9	1991	0.1	13890	7.4	0.82	53	0.4	5330	0.27	9.7	82	17	43.982597	-81.394438
1008020	3	1991	0.22	9710	2.9	41.25	53.4	0.4	44600	0.35	28.5	82	17	42.975671	-81.251887
1008020	3	1991	0.19	9400	2.8	52.21	50.5	0.4	43700	0.33	25	82	17	42.975671	-81.251887
1008020	3	1991	0.21	9470	2.7	51.21	50.9	0.4	44400	0.36	30.7	82	17	42.975671	-81.251887
1008021	9	1991	0.02	13050	4	0.83	74	0.5	35100	0.5	13.7	82	17	43.827738	-81.464929
1008021	9	1991	0.02	12480	2.9	0.84	70.6	0.4	33700	0.47	12.1	82	17	43.827738	-81.464929

Station	Land Use	Year	Ag	Al	As	B	Ba	Be	Ca	Cd	Cl	DATUM	ZONE	latitude	longitude
1008021	9	1991	0.03	13590	3.4	0.89	74.3	0.5	33300	0.51	14.4	82	17	43.827738	-81.464929
1008022	9	1991	0.03	10560	3.9	4.59	42.7	0.3	4360	0.25	4.6	82	17	43.748683	-81.102879
1008022	9	1991	0.08	10140	3.8	3.37	42.7	0.2	5100	0.28	4.6	82	17	43.748683	-81.102879
1008022	9	1991	0.06	10290	3.2	2.45	43	0.3	6090	0.27	8.3	82	17	43.748683	-81.102879
1008023	9	1991	0.06	13200	3.2	0.95	54	0.5	4890	0.33	2.5	82	17	43.265706	-81.053305
1008023	9	1991	0.06	13740	3.6	1.1	53.3	0.5	4510	0.33	2.7	82	17	43.265706	-81.053305
1008023	9	1991	0.05	13160	3.2	1.06	51.8	0.5	4400	0.32	2.5	82	17	43.265706	-81.053305
1008024	9	1991	0.07	18380	6	0.95	71.9	0.6	19490	0.39	4	82	17	43.6972	-81.477918
1008024	9	1991	0.04	17890	4.6	0.97	71.7	0.6	17920	0.35	3.2	82	17	43.6972	-81.477918
1008024	9	1991	0.07	18120	4.8	0.87	71.4	0.6	16320	0.21	3.2	82	17	43.6972	-81.477918
1008025	9	1991	0.04	20900	6.7	1.04	83.4	0.7	12870	0.26	23.4	82	17	43.357332	-81.456201
1008025	9	1991	0.04	21600	6.2	1.09	85.2	0.7	12160	0.33	23	82	17	43.357332	-81.456201
1008025	9	1991	0.06	21600	6	1.03	83.7	0.6	11310	0.19	23.4	82	17	43.357332	-81.456201
1008026	9	1991	0.04	23500	5.3	0.89	106	0.8	20500	0.33	6.6	82	17	43.622784	-81.502427
1008026	9	1991	0.05	23900	5.9	21.34	110	0.9	17150	0.37	6.2	82	17	43.622784	-81.502427
1008026	9	1991	0.05	24900	6	26.3	114	0.8	18770	0.38	6.2	82	17	43.622784	-81.502427
1008027	3	1991	0.02	21800	3.2	5.96	85.7	0.8	10520	0.36	15.2	82	17	43.356494	-80.988141
1008027	3	1991	0.04	21500	4.8	12.27	88.5	0.8	9680	0.38	14.7	82	17	43.356494	-80.988141
1008027	3	1991	0.02	20800	5.2	8.76	84.9	0.7	9330	0.35	32.2	82	17	43.356494	-80.988141
1008557	3	1993	0.08	9600	3.1	11	56	0.5	9100	0.54	49	82	17	43.129473	-80.758462
1008557	3	1993	0.09	10000	3.2	2.2	56	0.5	14000	0.59	54	82	17	43.129473	-80.758462
1008561	3	1993	0.05	12000	4.2	9.8	99	0.5	28000	0.45	36	82	17	43.74293	-81.710213
1008561	3	1993	0.07	11000	4	11	97	0.5	27000	0.54	34	82	17	43.74293	-81.710213
1008565	3	1993	0.09	15000	6.6	19	120	0.7	29000	0.37	NA	82	17	42.880863	-82.146804
1008565	3	1993	0.09	14000	6.3	18	120	0.7	28000	0.4	NA	82	17	42.880863	-82.146804

Station	Land Use	Year	Ag	Al	As	B	Ba	Be	Ca	Cd	Cl	DATUM	ZONE	latitude	longitude
1008569	3	1993	0.05	9400	4.2	7.1	48	0.5	11000	0.2	12	82	17	42.590103	-82.182446
1008569	3	1993	0.05	9900	4.3	7	50	0.5	12000	0.27	12	82	17	42.590103	-82.182446
1008573	3	1993	0.05	9500	3.5	6	61	0.5	25000	0.2	14	82	17	43.036371	-80.878788
1008573	3	1993	0.05	9200	3.5	5.1	60	0.5	27000	0.2	14	82	17	43.036371	-80.878788
1008577	3	1993	0.05	7100	2.5	2.6	30	0.5	3400	0.2	17	82	17	42.868375	-80.732977
1008577	3	1993	0.06	7100	2.3	2	31	0.5	3400	0.2	14	82	17	42.868375	-80.732977
2008001	9	1991	0.07	12660	2.6	3.67	53.9	0.5	3370	0.22	0.5	82	17	43.671864	-80.448376
2008001	9	1991	0.07	13040	2.6	0.76	55.3	0.5	3070	0.25	0.5	82	17	43.671864	-80.448376
2008001	9	1991	0.06	18000	2.4	1.58	60	0.5	4500	0.23	0.5	82	17	43.671864	-80.448376
2008001	9	1996	NA	12000	NA	NA	120	0.5	12000	0.8	NA	82	17	43.671864	-80.448376
2008001	9	1996	NA	12000	NA	NA	110	0.5	12000	1.1	NA	82	17	43.671864	-80.448376
2008002	9	1991	0.13	12540	2	11.25	53.8	0.5	62700	0.17	51.5	82	17	43.754512	-80.661085
2008002	9	1996	NA	11000	NA	NA	180	0.6	7400	1.1	NA	82	17	43.754512	-80.661085
2008002	9	1991	0.11	13580	3	11.2	57.6	0.5	58500	0.21	44.6	82	17	43.754512	-80.661085
2008002	9	1991	0.1	12390	3	13.16	54.6	0.5	57800	0.21	56	82	17	43.754512	-80.661085
2008002	9	1996	NA	12000	NA	NA	190	0.6	7800	0.8	NA	82	17	43.754512	-80.661085
2008003	9	1991	0.13	15110	4.1	7.76	55.5	0.6	24800	0.22	31	82	17	43.909576	-80.873879
2008003	9	1991	0.12	14140	3.6	8.99	51.4	0.4	28200	0.26	27.9	82	17	43.909576	-80.873879
2008003	9	1991	0.11	14010	3	6.83	54.2	0.5	32600	0.18	26.7	82	17	43.909576	-80.873879
2008003	9	1996	NA	12000	NA	NA	91	0.5	9400	0.4	NA	82	17	43.909576	-80.873879
2008003	9	1996	NA	12000	NA	NA	86	0.6	9300	0.5	NA	82	17	43.909576	-80.873879
2008004	9	1991	0.13	16600	14.2	7.48	59.1	0.5	23800	0.21	14.5	82	17	43.982017	-80.735219
2008004	9	1991	0.12	15580	9.3	6.98	57.3	0.5	25700	0.2	17	82	17	43.982017	-80.735219
2008004	9	1991	0.09	16930	10.2	7.9	61.4	0.6	25800	0.16	14.6	82	17	43.982017	-80.735219
2008005	9	1991	0.12	20200	3.2	7.03	74.1	0.6	14090	0.29	30.8	82	17	43.880183	-80.270894

Station	Land Use	Year	Ag	Al	As	B	Ba	Be	Ca	Cd	Cl	DATUM	ZONE	latitude	longitude
2008005	9	1991	0.12	19530	3.5	9.61	73.6	0.6	14860	0.29	25	82	17	43.880183	-80.270894
2008005	9	1991	0.07	19130	2.8	5.41	74.3	0.7	15320	0.24	28.7	82	17	43.880183	-80.270894
2008006	9	1991	0.31	34000	4.2	11.19	131	1.2	15680	0.2	17.1	82	17	43.109197	-79.558093
2008006	9	1991	0.34	35200	4	13.2	133	1.2	19220	0.19	18.5	82	17	43.109197	-79.558093
2008006	9	1991	0.27	38000	4.6	11.21	136	1.2	11480	0.25	14.6	82	17	43.109197	-79.558093
2008007	9	1991	0.12	8050	2.3	4.06	25.3	0.3	16420	0.13	15.6	208	17	42.75062	-80.26525
2008007	9	1991	0.04	7870	1.65	2.48	24.2	0.3	16080	0.14	12.6	208	17	42.75062	-80.26525
2008007	9	1991	0.12	7920	1.75	3.09	24.1	0.3	16860	0.11	12.6	208	17	42.75062	-80.26525
2008008	9	1991	0.11	10960	2.5	1.2	31.1	0.3	4870	0.16	66.5	82	17	42.668177	-80.412623
2008008	9	1991	0.17	10500	3.4	3.52	29.7	0.3	3940	0.14	44.4	82	17	42.668177	-80.412623
2008008	9	1991	0.06	9960	2.4	4.08	31	0.3	4360	0.19	61.5	82	17	42.668177	-80.412623
2008009	9	1991	0.2	28200	4.7	11.16	116	1	7990	0.21	22.6	82	17	42.885126	-80.100468
2008009	9	1991	0.21	32200	4.5	9.44	129	1.1	7690	0.22	23	82	17	42.885126	-80.100468
2008009	9	1991	0.2	29400	5.5	14.13	119	1	7890	0.28	21.2	82	17	42.885126	-80.100468
2008010	9	1991	0.08	10800	5.2	3.06	37.6	0.4	2230	0.2	11.8	82	17	43.196477	-80.010295
2008010	9	1991	0.12	10600	4.9	4.49	38.8	0.4	2570	0.22	14	82	17	43.196477	-80.010295
2008010	9	1991	0.06	10700	3.6	2.86	34.6	0.4	2260	0.21	13.5	82	17	43.196477	-80.010295
2008011	9	1991	0.23	28900	7.7	11.52	164	1.1	6690	0.78	14.8	82	17	43.011399	-79.915842
2008011	9	1991	0.24	30000	7	9.89	161	1.2	7360	0.69	12.3	82	17	43.011399	-79.915842
2008011	9	1991	0.25	31900	7.5	8.36	182	1.3	7360	0.89	30	82	17	43.011399	-79.915842
2008012	9	1991	0.17	10400	2.8	2.14	31.5	0.2	2200	0.18	8.7	208	17	42.678923	-80.62216
2008012	9	1991	0.07	10010	2.1	1.06	30	0.2	2180	0.2	11.6	208	17	42.678923	-80.62216
2008012	9	1991	0.06	10600	2.3	1.26	35.6	0.3	2670	0.21	8.3	208	17	42.678923	-80.62216
2008013	9	1991	0.22	12360	3.1	8.71	81.6	0.5	26200	0.61	3.4	82	17	43.398527	-80.625449
2008013	9	1991	0.2	14430	3.5	10.27	102	0.6	10010	0.64	3.4	82	17	43.398527	-80.625449

Station	Land Use	Year	Ag	Al	As	B	Ba	Be	Ca	Cd	Cl	DATUM	ZONE	latitude	longitude
2008013	9	1991	0.21	13140	3	9.18	83	0.5	10560	0.58	2.2	82	17	43.398527	-80.625449
2008014	9	1991	0.27	19860	4.6	5.29	88.9	0.5	1429	0.42	9.7	82	17	42.901284	-79.040713
2008014	9	1991	0.27	16790	7	5.69	84.3	0.4	1532	0.46	7.5	82	17	42.901284	-79.040713
2008014	9	1991	0.27	17290	9	5.54	67	0.4	1286	0.36	9	82	17	42.901284	-79.040713
2008015	9	1991	0.02	15260	5.4	10	78.6	0.5	37600	0.66	5.2	82	17	44.10093	-80.137487
2008015	9	1991	0.09	14600	5	16.44	77.3	0.5	40500	0.62	7.4	82	17	44.10093	-80.137487
2008015	9	1991	0.02	16490	4.9	12.39	68.9	0.5	29600	0.42	6.7	82	17	44.10093	-80.137487
2008016	9	1991	0.09	10140	5.7	5.12	34.2	0.4	8230	0.28	24	82	17	43.511826	-80.351047
2008016	9	1991	0.09	9270	5.1	4.7	30.9	0.4	7330	0.3	20.6	82	17	43.511826	-80.351047
2008016	9	1991	0.13	10390	5.3	8.54	33.3	0.4	7550	0.26	17.2	82	17	43.511826	-80.351047
2008017	9	1991	0.02	15650	2.6	3.51	55.4	0.5	8420	0.33	4.3	82	17	43.961897	-80.410923
2008017	9	1991	0.02	15710	3.2	4.43	58	0.5	11940	0.38	2.8	82	17	43.961897	-80.410923
2008017	9	1991	0.02	14920	2.8	7.13	50.1	0.5	9040	0.35	2.8	82	17	43.961897	-80.410923
2008018	3	1991	0.27	11430	2.2	5.07	50.3	0.4	18920	0.23	14.8	82	17	43.13393	-80.762489
2008018	3	1991	0.15	11790	2.5	5.61	47.8	0.4	20000	0.23	11.9	82	17	43.13393	-80.762489
2008018	3	1991	0.18	12060	2.5	6.22	52.2	0.4	20700	0.23	14.5	82	17	43.13393	-80.762489
2008019	3	1991	0.18	9850	3.1	3.25	58.5	0.4	5670	0.37	4.6	82	17	43.151025	-80.313147
2008019	3	1991	0.16	8640	2.9	2.68	54.2	0.4	5150	0.31	5	82	17	43.151025	-80.313147
2008019	3	1991	0.36	9110	2.9	3.5	50.3	0.4	5120	0.32	5.7	82	17	43.151025	-80.313147
2008020	3	1991	0.17	15320	13.2	10.05	59.9	0.6	39300	0.57	18.6	82	17	43.532327	-80.230359
2008020	3	1991	0.17	14090	10.1	7.72	56.3	0.6	39600	0.59	20.6	82	17	43.532327	-80.230359
2008020	3	1991	0.21	14720	17	8.87	58.4	0.6	37300	0.59	18.6	82	17	43.532327	-80.230359
2008021	3	1991	0.37	12080	4.7	8.28	78.6	0.5	24600	0.49	27.2	82	17	43.07213	-79.079335
2008021	3	1991	0.3	11010	4.4	9.28	74.3	0.5	26500	0.47	22.2	82	17	43.07213	-79.079335
2008021	3	1991	0.32	11400	3.2	13.28	66.6	0.4	26200	0.43	21.8	82	17	43.07213	-79.079335

Station	Land Use	Year	Ag	Al	As	B	Ba	Be	Ca	Cd	Cl	DATUM	ZONE	latitude	longitude
2008022	3	1991	0.32	18480	8.2	13.44	83.9	0.7	50900	0.34	24.6	82	17	42.988082	-79.251346
2008022	3	1991	0.33	17760	8.3	16.6	87.7	0.8	38700	0.36	31.4	82	17	42.988082	-79.251346
2008022	3	1991	0.34	18850	7.7	14.67	89.3	0.7	45200	0.39	25.8	82	17	42.988082	-79.251346
2008023	3	1991	0.41	22200	7.2	9.98	109	0.9	10470	0.33	22.4	82	17	42.887559	-79.245397
2008023	3	1991	0.39	21400	7.4	11.5	105	0.9	8430	0.31	23.6	82	17	42.887559	-79.245397
2008023	3	1991	0.41	19700	7.3	8.22	101	0.8	8290	0.32	17.8	82	17	42.887559	-79.245397
2008024	3	1991	0.19	11250	2.9	4.75	43.7	0.4	20400	0.29	9.8	82	17	43.366353	-80.332692
2008024	3	1991	0.2	11450	2.6	4.87	45.3	0.4	20400	0.26	10.5	82	17	43.366353	-80.332692
2008024	3	1991	0.19	11500	2.8	3.22	43.7	0.4	18430	0.26	11.4	82	17	43.366353	-80.332692
2008025	3	1991	0.16	10380	9.7	3.42	35.4	0.4	1381	0.32	9.3	82	17	43.238999	-79.830218
2008025	3	1991	0.17	10870	8.5	3.05	40.1	0.5	1619	0.47	8	82	17	43.238999	-79.830218
2008025	3	1991	0.18	9900	9.6	2.46	36	0.4	1364	0.34	8.3	82	17	43.238999	-79.830218
2008026	3	1991	0.03	2960	6.8	16.21	51.8	0.3	20300	1.19	90	82	17	43.45705	-80.45592
2008026	3	1991	0.02	3180	6.7	13.16	51.1	0.3	19530	1.08	61	82	17	43.45705	-80.45592
2008026	3	1991	0.05	3250	6.9	14.37	52.5	0.3	20200	1.15	46	82	17	43.45705	-80.45592
2008027	3	1991	0.21	21100	10	6.1	111	0.9	6640	0.31	11.5	82	17	43.144121	-79.238751
2008027	3	1991	0.21	22200	9.8	5.85	109	0.8	6530	0.34	11.1	82	17	43.144121	-79.238751
2008027	3	1991	0.19	21100	4.6	10.3	105	0.9	6040	0.32	9.5	82	17	43.144121	-79.238751
2008302	3	1993	0.05	10000	7.3	2	51	0.5	14000	0.36	7.9	82	17	43.356699	-80.320248
2008302	3	1993	0.05	9900	7.5	2	49	0.5	12000	0.38	10	82	17	43.356699	-80.320248
2008305	3	1993	0.05	8100	2.3	2	38	0.5	12000	0.28	18	82	17	43.453897	-80.472931
2008305	3	1993	0.05	7800	2.1	2	37	0.5	12000	0.28	31	82	17	43.453897	-80.472931
2008400	3	1993	0.08	19000	5.8	1.6	84	0.6	4400	0.69	25	82	17	42.997104	-79.258942
2008400	3	1993	0.1	20000	6	4.2	96	0.7	4900	0.65	37	82	17	42.997104	-79.258942
2008501	3	1993	0.05	10000	7.7	3.6	60	0.5	24000	1.6	13	82	17	43.55245	-80.235451

Station	Land Use	Year	Ag	Al	As	B	Ba	Be	Ca	Cd	Cl	DATUM	ZONE	latitude	longitude
2008501	3	1993	0.05	8900	8.1	1.9	56	0.5	27000	1.5	12	82	17	43.55245	-80.235451
2008505	3	1993	0.05	8000	12	1.4	88	0.5	4700	0.97	5.3	82	17	43.267713	-79.88221
2008505	3	1993	0.05	7100	9.7	2.4	76	0.5	3500	0.75	5.1	82	17	43.267713	-79.88221
3008001	9	1991	0.07	12430	7.5	2.36	48.4	0.5	5200	0.12	0.5	82	17	44.129388	-79.608149
3008001	9	1991	0.07	13560	7.3	3.84	55.2	0.6	6100	0.14	0.5	82	17	44.129388	-79.608149
3008001	9	1991	0.05	14120	7.8	2.94	55.4	0.6	7020	0.14	0.5	82	17	44.129388	-79.608149
3008002	9	1991	0.11	11690	3.2	6.22	51.8	0.4	41000	0.1	18.2	82	17	44.151916	-79.898729
3008002	9	1991	0.11	12110	3	6.2	54	0.4	40000	0.07	15	82	17	44.151916	-79.898729
3008002	9	1991	0.1	11920	3.2	8.74	55.2	0.4	37400	0.12	15.9	82	17	44.151916	-79.898729
3008003	9	1991	0.08	17580	2.8	8.71	114	0.7	8740	0.28	29.7	82	17	44.705792	-79.64149
3008003	9	1991	0.08	17860	2.4	8.48	120	0.7	9190	0.32	30.7	82	17	44.705792	-79.64149
3008003	9	1991	0.08	17700	3	9.83	118	0.6	8920	0.29	21	82	17	44.705792	-79.64149
3008004	9	1991	0.19	13290	1.1	1.93	104	0.5	5610	0.29	20.6	82	17	44.937813	-78.713223
3008004	9	1991	0.19	13710	1.5	2.58	105	0.5	6150	0.29	16.8	82	17	44.937813	-78.713223
3008004	9	1991	0.19	13660	1.6	2.3	99.1	0.4	6060	0.22	23.7	82	17	44.937813	-78.713223
3008005	9	1991	0.2	15650	1.6	5.36	58.9	0.5	14490	0.16	21	82	17	44.304494	-77.950776
3008005	9	1991	0.15	15970	1.6	5.19	59.1	0.5	14280	0.15	20.3	82	17	44.304494	-77.950776
3008005	9	1991	0.17	16790	1.6	6.39	58.5	0.5	17200	0.19	23.1	82	17	44.304494	-77.950776
3008006	9	1991	0.07	14650	39	7.11	70.3	0.5	7170	0.19	14.5	82	18	44.048525	-77.741013
3008006	9	1991	0.02	13430	37	3.84	69.8	0.5	6890	0.22	16.2	82	18	44.048525	-77.741013
3008006	9	1991	0.04	13340	15	5.09	67.8	0.5	6440	0.2	14.2	82	18	44.048525	-77.741013
3008007	9	1991	0.05	8830	8	11.36	37.9	0.3	2670	0.48	5.2	82	17	43.724712	-79.95708
3008007	9	1991	0.04	9180	7.5	9.15	35.3	0.3	2050	0.35	5.3	82	17	43.724712	-79.95708
3008007	9	1991	0.02	8530	8.2	8.89	37.5	0.3	2160	0.37	4.4	82	17	43.724712	-79.95708
3008008	9	1991	0.02	10390	2.8	2.17	128	0.3	50100	0.42	9	82	17	44.060396	-78.611093

Station	Land Use	Year	Ag	Al	As	B	Ba	Be	Ca	Cd	Cl	DATUM	ZONE	latitude	longitude
3008008	9	1991	0.02	10030	3.1	2.29	143	0.4	5550	0.51	16.8	82	17	44.060396	-78.611093
3008008	9	1991	0.15	8990	2.2	2.17	118	0.5	5190	0.45	0.5	82	17	44.060396	-78.611093
3008009	9	1991	0.03	11840	1.7	2.77	56.9	0.4	6090	0.27	6.4	82	17	44.921885	-78.064296
3008009	9	1991	0.04	10660	1.35	1.45	54.6	0.3	6580	0.29	3.8	82	17	44.921885	-78.064296
3008009	9	1991	0.09	12480	1.65	2.09	53.6	0.3	5500	0.25	3.6	82	17	44.921885	-78.064296
3008010	9	1991	0.06	12110	4	3.13	52.4	0.4	7200	0.25	3.1	82	17	44.561536	-78.862881
3008010	9	1991	0.04	12340	4.3	3.86	51.9	0.4	7230	0.29	3.3	82	17	44.561536	-78.862881
3008010	9	1991	0.05	13870	1.6	3.02	57.5	0.5	9040	0.31	2	82	17	44.561536	-78.862881
3008011	9	1991	0.09	15300	8.6	5.34	79.1	0.5	6040	0.46	5.9	82	17	44.164546	-79.005658
3008011	9	1991	0.08	15400	8.3	3.94	87.1	0.5	6620	0.48	3.7	82	17	44.164546	-79.005658
3008011	9	1991	0.06	15470	8.8	5.32	81	0.5	6720	0.43	3.9	82	17	44.164546	-79.005658
3008012	9	1991	0.16	6580	2.5	5.27	55.7	0.17	1496	0.28	7.5	82	17	43.999372	-78.127351
3008012	9	1991	0.14	6870	2.2	7.82	58.4	0.2	1610	0.25	9.3	82	17	43.999372	-78.127351
3008012	9	1991	0.18	6800	2.3	6.72	53.7	0.2	1501	0.24	12.1	82	17	43.999372	-78.127351
3008013	9	1991	0.04	18050	4.9	0.83	101	0.6	7410	0.17	7	82	17	45.443606	-78.818309
3008013	9	1991	0.08	16890	4.7	0.89	93.1	0.6	7170	0.16	7.4	82	17	45.443606	-78.818309
3008013	9	1991	0.03	18230	1.5	0.93	97.1	0.6	7750	0.21	7.8	82	17	45.443606	-78.818309
3008014	9	1991	0.02	10400	6.1	7.02	44.1	0.3	2080	0.22	4.4	82	17	43.875236	-78.778045
3008014	9	1991	0.06	10710	5.5	5.33	43.6	0.4	2190	0.19	4.4	82	17	43.875236	-78.778045
3008014	9	1991	0.02	10340	5.1	6.91	47	0.3	2120	0.22	4.4	82	17	43.875236	-78.778045
3008015	9	1991	0.06	15120	1.8	1.54	77.5	0.6	7890	0.15	33	82	17	44.086538	-78.632124
3008015	9	1991	0.06	15980	1.8	1.56	84.6	0.6	7760	0.16	31	82	17	44.086538	-78.632124
3008015	9	1991	0.11	15660	1.7	2.32	80.7	0.5	8700	0.16	0.5	82	17	44.086538	-78.632124
3008016	9	1991	0.03	11850	1.85	3.94	37.6	0.4	39100	0.17	7.8	82	17	44.579151	-79.86651
3008016	9	1991	0.02	16730	2.2	10.2	48.6	0.5	29600	0.24	6.4	82	17	44.579151	-79.86651

Station	Land Use	Year	Ag	Al	As	B	Ba	Be	Ca	Cd	Cl	DATUM	ZONE	latitude	longitude
3008016	9	1991	0.08	14760	2	7.13	35.7	0.5	38400	0.15	9.2	82	17	44.579151	-79.86651
3008017	9	1991	0.15	15040	12.1	10.06	60.9	0.5	24900	0.28	9	82	17	44.536002	-78.72486
3008017	9	1991	0.11	15970	14.4	13.1	61.1	0.5	29200	0.3	8.3	82	17	44.536002	-78.72486
3008017	9	1991	0.13	15400	12.4	7.9	66.1	0.5	29200	0.3	8.8	82	17	44.536002	-78.72486
3008018	3	1991	0.14	18550	17.1	9.69	115	0.8	3090	0.35	15.4	82	17	43.498174	-79.656502
3008018	3	1991	0.15	18960	14	6.63	110	0.8	3640	0.35	11	82	17	43.498174	-79.656502
3008018	3	1991	0.16	18150	16.8	11.33	99.6	0.8	3930	0.26	18.5	82	17	43.498174	-79.656502
3008019	3	1991	0.1	13120	7	8.77	73.8	0.5	50800	0.27	412	82	17	44.043621	-79.463372
3008019	3	1991	0.1	14350	6.9	7.03	75	0.5	52000	0.2	365	82	17	44.043621	-79.463372
3008019	3	1991	0.12	14170	10	7.36	77.9	0.6	52100	0.15	452	82	17	44.043621	-79.463372
3008020	3	1991	0.12	16300	17	11.55	90.6	1.1	5630	0.44	25.4	82	17	43.597849	-79.518004
3008020	3	1991	0.11	19850	17.4	4.89	101	1	6390	0.28	19.6	82	17	43.597849	-79.518004
3008020	3	1991	0.12	18440	2.6	9.54	104	1.2	5960	0.41	18	82	17	43.597849	-79.518004
3008021	3	1991	0.16	11510	2.2	5.36	57.8	0.5	23200	0.14	74	82	17	44.295616	-78.317542
3008021	3	1991	0.15	11190	2.1	5.9	57	0.5	21800	0.13	132	82	17	44.295616	-78.317542
3008021	3	1991	0.16	11920	2.6	7.34	56.8	0.5	23900	0.14	111	82	17	44.295616	-78.317542
3008021	3	1993	0.12	7400	2.2	5	45	0.5	38000	0.77	16	82	17	44.295616	-78.317542
3008021	3	1993	0.15	7500	2.8	6.2	52	0.5	38000	0.57	15	82	17	44.295616	-78.317542
3008022	3	1991	0.02	8420	1.4	3.68	42.9	0.4	7640	0.33	5.8	82	17	43.885342	-78.883481
3008022	3	1991	0.06	8230	4.8	3.1	42.7	0.4	8630	0.26	5.7	82	17	43.885342	-78.883481
3008022	3	1991	0.04	9000	4.7	3.82	43.3	0.4	8580	0.26	7.9	82	17	43.885342	-78.883481
3008023	3	1991	0.15	9410	1.3	2.04	55.8	0.3	2390	0.2	7.5	82	17	45.323151	-79.210841
3008023	3	1991	0.14	8760	1.5	0.73	67.5	0.3	2670	0.31	9.3	82	17	45.323151	-79.210841
3008023	3	1991	0.16	10220	1.3	3.58	58.2	0.4	2950	0.3	10.6	82	17	45.323151	-79.210841
3008024	3	1991	0.09	12010	3.4	4.2	35.3	0.5	2490	0.17	9.7	82	17	43.721321	-79.399879

Station	Land Use	Year	Ag	Al	As	B	Ba	Be	Ca	Cd	Cl	DATUM	ZONE	latitude	longitude
3008024	3	1991	0.08	12060	5.2	4.11	35.6	0.4	2700	0.09	9.7	82	17	43.721321	-79.399879
3008024	3	1991	0.05	12300	3.4	5.53	38	0.5	3370	0.15	8.2	82	17	43.721321	-79.399879
3008025	3	1991	0.05	9740	3.9	NA	42	0.5	15270	0.19	34.5	82	17	43.553012	-79.58218
3008025	3	1991	0.08	10060	5.8	9.44	42.8	0.5	15190	0.15	41	82	17	43.553012	-79.58218
3008025	3	1991	0.04	10740	4	6.34	45.9	0.5	15250	0.19	40.2	82	17	43.553012	-79.58218
3008026	3	1991	0.12	19530	9	11.2	72.3	0.7	42500	0.27	10.2	82	17	44.358722	-78.745777
3008026	3	1991	0.07	19440	9.9	9.63	70.7	0.7	39800	0.24	11	82	17	44.358722	-78.745777
3008026	3	1991	0.1	17590	11.1	11.39	65	0.6	40000	0.36	9.8	82	17	44.358722	-78.745777
3008027	3	1991	0.04	13940	2.7	5.7	70.4	0.5	3140	0.22	12.7	82	17	44.396812	-79.710565
3008027	3	1991	0.03	13680	2.6	5.3	75.5	0.4	3260	0.22	10	82	17	44.396812	-79.710565
3008027	3	1991	0.08	15060	4	3.49	72.7	0.5	3840	0.2	13.9	82	17	44.396812	-79.710565
3008226	3	1993	0.21	9800	2.4	7.7	51	0.5	14000	0.49	NA	82	17	43.958879	-78.164203
3008226	3	1993	0.09	9200	2.6	3.9	50	0.5	14000	0.63	NA	82	17	43.958879	-78.164203
3008265	3	1992	0.05	9300	4	4.9	46	0.5	7700	0.49	NA	82	17	43.598699	-79.514811
3008265	3	1992	0.05	9200	3.9	7.7	48	0.5	8700	0.54	NA	82	17	43.598699	-79.514811
3008274	3	1993	0.05	12000	3.9	2	91	0.6	11000	0.41	NA	82	17	43.683568	-79.759257
3008274	3	1993	0.05	11000	4	2	79	0.6	12000	0.31	NA	82	17	43.683568	-79.759257
3008278	3	1993	0.27	10000	3.2	6.7	120	0.5	14000	0.89	NA	82	17	44.920577	-79.369853
3008278	3	1993	0.05	8900	3.3	1.5	170	0.5	12000	0.7	NA	82	17	44.920577	-79.369853
3008282	3	1993	0.05	8700	1.6	6.3	33	0.5	8900	0.2	NA	82	17	44.105212	-79.117971
3008282	3	1993	0.05	8400	1.5	2.6	33	0.5	8800	0.45	NA	82	17	44.105212	-79.117971
3008292	3	1993	0.05	6900	3.3	2.8	22	0.5	8500	0.2	NA	82	17	43.339049	-79.778521
3008292	3	1993	0.05	7200	3.7	8.8	21	0.5	8600	0.25	NA	82	17	43.339049	-79.778521
3008296	3	1993	0.05	14000	2.8	3.4	100	0.5	12000	0.33	NA	82	17	44.617938	-79.41336
3008296	3	1993	0.08	14000	2.7	1.7	99	0.5	13000	0.45	NA	82	17	44.617938	-79.41336

Station	Land Use	Year	Ag	Al	As	B	Ba	Be	Ca	Cd	Cl	DATUM	ZONE	latitude	longitude
3008600	3	1993	0.12	7200	4.5	3.6	44	0.5	3800	0.54	NA	82	17	43.676257	-79.347374
3008600	3	1993	0.12	8000	3.9	2.5	50	0.5	3900	0.63	NA	82	17	43.676257	-79.347374
3008604	3	1993	0.05	7700	2.4	3.7	39	0.5	11000	0.55	NA	82	17	43.670165	-79.299798
3008604	3	1993	0.12	7900	2.3	1.9	39	0.5	13000	0.56	NA	82	17	43.670165	-79.299798
3008608	3	1993	0.05	4800	1.7	1.5	23	0.5	31000	0.5	NA	82	17	43.644607	-79.46282
3008608	3	1993	0.05	4500	1.6	4.2	22	0.5	29000	0.38	NA	82	17	43.644607	-79.46282
3008612	3	1993	0.05	8400	2.7	16	110	0.6	21000	4.5	NA	82	17	43.60657	-79.494296
3008612	3	1993	0.05	8400	2.9	5	66	0.5	38000	0.69	NA	82	17	43.60657	-79.494296
3008616	3	1993	0.05	24000	3.4	10	120	1	15000	0.55	NA	82	17	43.698639	-79.518663
3008616	3	1993	0.05	23000	3.7	11	120	1	17000	0.7	NA	82	17	43.698639	-79.518663
4008001	9	1991	0.12	15650	1.1	3.11	66.9	0.6	4240	0.17	11.3	82	18	45.559201	-74.457786
4008001	9	1991	0.12	15740	1.3	2.36	71.7	0.6	4410	0.23	11.2	82	18	45.559201	-74.457786
4008001	9	1991	0.15	16370	1	3.33	73.2	0.4	5000	0.21	0.5	82	18	45.559201	-74.457786
4008002	3	1991	0.05	9810	1	2.21	47.3	0.4	5290	0.05	10.8	82	18	45.604983	-74.6027
4008002	3	1991	0.07	10150	1	1.62	49.7	0.4	4970	0.09	12.3	82	18	45.604983	-74.6027
4008002	3	1991	0.06	13010	0.6	0.81	49.7	0.5	5310	0.13	0.5	82	18	45.604983	-74.6027
4008003	9	1991	0.1	16190	2.6	5.42	69.8	0.8	8830	0.26	12.7	82	18	45.249984	-74.822395
4008003	9	1991	0.1	15090	2.6	7.15	63	0.7	8870	0.29	12.2	82	18	45.249984	-74.822395
4008003	9	1991	0.14	17200	2.8	6.39	64	0.5	8140	0.36	0.5	82	18	45.249984	-74.822395
4008004	9	1991	0.13	23900	5.1	14.44	113	0.9	8070	0.17	11.2	82	18	45.089424	-74.520196
4008004	9	1991	0.13	24300	5.3	8.59	105	1	8290	0.19	10.6	82	18	45.089424	-74.520196
4008004	9	1991	0.17	18970	4.5	14.34	86.6	0.5	7090	0.22	0.5	82	18	45.089424	-74.520196
4008005	9	1991	0.09	17370	5.4	4.69	68.8	0.5	6430	0.19	13.6	82	18	45.086498	-74.530971
4008005	9	1991	0.1	17210	5	5.12	70.1	0.5	6170	0.18	9	82	18	45.086498	-74.530971
4008005	9	1991	0.13	18100	2.3	5.16	71.7	0.5	5510	0.25	0.5	82	18	45.086498	-74.530971

Station	Land Use	Year	Ag	Al	As	B	Ba	Be	Ca	Cd	Cl	DATUM	ZONE	latitude	longitude
4008006	3	1991	0.07	16590	3.2	4.28	70.8	0.6	10940	0.2	13	82	18	45.001218	-74.7707
4008006	3	1991	0.06	16770	3.5	5.41	72.7	0.6	12440	0.18	16.8	82	18	45.001218	-74.7707
4008006	3	1991	0.14	18530	2.8	6.24	76.1	0.7	12460	0.21	0.5	82	18	45.001218	-74.7707
4008007	9	1991	0.15	28300	3.6	27.33	103	0.9	11570	0.26	16.2	82	18	45.088272	-75.35089
4008007	9	1991	0.14	31200	3.7	15.38	109	1	12520	0.25	19	82	18	45.088272	-75.35089
4008007	9	1991	0.17	23700	3.1	13.59	101	0.9	14490	0.26	0.5	82	18	45.088272	-75.35089
4008008	3	1991	0.24	13760	15.3	7.26	53	0.7	10770	0.32	15.2	82	18	44.704585	-75.520366
4008008	3	1991	0.24	14310	13.3	7.13	57	0.7	9790	0.45	19.4	82	18	44.704585	-75.520366
4008008	3	1991	0.23	16400	28	4.62	69.7	0.7	12310	0.39	0.5	82	18	44.704585	-75.520366
4008009	9	1991	0.08	12160	1.2	4.86	91.1	0.5	3930	0.16	0.5	82	18	44.646813	-76.319666
4008009	9	1991	0.14	12880	1.2	4.36	97.7	0.5	4370	0.15	0.5	82	18	44.646813	-76.319666
4008009	9	1991	0.11	13540	0.8	6.54	102	0.5	3740	0.13	0.5	82	18	44.646813	-76.319666
4008010	9	1991	0.22	10400	2.4	6.31	86	0.5	4630	0.65	0.5	82	18	44.62183	-75.987331
4008010	9	1991	0.15	10210	2.5	4.94	93.7	0.6	5120	0.7	0.5	82	18	44.62183	-75.987331
4008010	9	1991	0.13	9770	3.4	2.37	74.6	0.6	5000	0.6	0.5	82	18	44.62183	-75.987331
4008012	3	1991	0.18	14050	2.6	4.36	95.5	0.6	7560	0.22	0.5	82	18	44.892349	-76.018265
4008012	3	1991	0.15	13780	2.6	7.99	94.6	0.6	8250	0.25	0.5	82	18	44.892349	-76.018265
4008012	3	1991	0.17	14530	2.4	9.71	83.3	0.6	5930	0.18	0.5	82	18	44.892349	-76.018265
4008013	9	1991	0.15	9020	0.6	2.88	52.5	0.5	16900	0.14	0.5	82	18	45.017301	-76.361732
4008013	9	1991	0.14	8630	0.6	3.27	51.2	0.5	17080	0.14	0.5	82	18	45.017301	-76.361732
4008013	9	1991	0.09	9480	0.5	3	56	0.5	14510	0.11	0.5	82	18	45.017301	-76.361732
4008014	9	1991	0.17	17390	1.8	2.72	203	0.5	5150	0.36	0.5	82	18	45.085887	-76.30224
4008014	9	1991	0.2	15740	2	2.8	216	0.5	4760	0.45	0.5	82	18	45.085887	-76.30224
4008014	9	1991	0.16	16160	1.8	3.5	208	0.5	4860	0.33	0.5	82	18	45.085887	-76.30224
4008015	3	1991	0.13	26500	2.6	7.43	165	0.9	6010	0.3	0.5	82	18	44.246348	-76.535246

Station	Land Use	Year	Ag	Al	As	B	Ba	Be	Ca	Cd	Cl	DATUM	ZONE	latitude	longitude
4008015	3	1991	0.13	27400	2.6	4.41	166	0.9	5910	0.24	0.5	82	18	44.246348	-76.535246
4008015	3	1991	0.15	28400	2.5	5.74	156	1	5390	0.21	0.5	82	18	44.246348	-76.535246
4008016	3	1991	0.02	12310	2.9	5.59	57	0.4	6980	0.25	7.8	82	18	44.590904	-75.741375
4008016	3	1991	0.02	10300	3	2.82	48.9	0.4	6500	0.22	7.9	82	18	44.590904	-75.741375
4008016	3	1991	0.02	12340	2.9	3.8	56.6	0.4	7960	0.21	8.4	82	18	44.590904	-75.741375
4008017	9	1991	0.02	15810	2.7	3.06	71.7	0.5	3670	0.23	3.7	82	18	44.871667	-75.799318
4008017	9	1991	0.02	16010	2.2	2.98	70.6	0.5	5370	0.24	4.2	82	18	44.871667	-75.799318
4008017	9	1991	0.03	17090	2.3	2	70.9	0.5	4790	0.22	4.3	82	18	44.871667	-75.799318
4008018	3	1991	0.04	29200	2.8	5.76	146	0.8	3980	0.37	8.1	82	18	45.37362	-75.657498
4008018	3	1991	0.05	25000	3.6	7.7	144	0.7	3730	0.4	8.6	82	18	45.37362	-75.657498
4008018	3	1991	0.03	26800	3.1	6.4	156	0.8	3880	0.41	6.9	82	18	45.37362	-75.657498
4008019	9	1991	0.11	11590	4.1	2.77	81.4	0.5	5930	0.18	5.7	82	18	45.010163	-75.639392
4008019	9	1991	0.04	13000	3.7	2.3	91.2	0.4	6430	0.16	8.3	82	18	45.010163	-75.639392
4008019	9	1991	0.02	13110	3.8	0.9	90.5	0.4	6630	0.18	8.1	82	18	45.010163	-75.639392
4008020	3	1991	0.24	7800	2.7	7.33	27	0.2	121000	0.26	40.6	82	18	44.098285	-77.575918
4008020	3	1991	0.18	7060	3.1	9.85	26.5	0.3	108000	0.23	40.2	82	18	44.098285	-77.575918
4008020	3	1991	0.17	7910	2.7	8.13	29.6	0.2	102000	0.22	41.2	82	18	44.098285	-77.575918
4008021	9	1991	0.1	19500	2.4	6.42	110	0.5	11400	0.21	11.3	82	18	44.186567	-77.073722
4008021	9	1991	0.16	19200	2.4	6.51	94.3	0.5	12200	0.21	11.6	82	18	44.186567	-77.073722
4008021	9	1991	0.17	18300	2.3	10.29	105	0.5	11800	0.18	11	82	18	44.186567	-77.073722
4008022	9	1991	0.14	11980	1.6	2.18	34.9	0.5	4700	0.19	2.9	82	18	43.905627	-77.262997
4008022	9	1991	0.14	12720	2.1	3.99	35.1	0.5	5140	0.21	9.7	82	18	43.905627	-77.262997
4008022	9	1991	0.17	12260	1.8	3.83	35.6	0.5	4840	0.16	30.7	82	18	43.905627	-77.262997
4008023	3	1991	0.12	9570	1.2	1.14	35.6	0.3	3730	0.11	7.5	82	18	44.140203	-77.419554
4008023	3	1991	0.09	10280	1.3	1.18	34.9	0.3	3810	0.09	6	82	18	44.140203	-77.419554

Station	Land Use	Year	Ag	Al	As	B	Ba	Be	Ca	Cd	Cl	DATUM	ZONE	latitude	longitude
4008023	3	1991	0.12	9050	1	1.31	33.2	0.2	3270	0.12	8.2	82	18	44.140203	-77.419554
4008024	9	1991	0.21	8130	3.1	0.79	150	0.2	3230	0.39	3.6	82	18	44.902411	-77.256303
4008024	9	1991	0.15	7780	3.2	0.65	106	0.2	2950	0.24	4.1	82	18	44.902411	-77.256303
4008024	9	1991	0.19	8390	6.7	0.66	215	0.2	3440	0.42	4.1	82	18	44.902411	-77.256303
4008025	9	1991	0.28	18000	1	14.15	179	0.9	13580	0.23	45	82	18	45.465583	-76.698821
4008025	9	1991	0.29	18200	0.7	11.22	179	0.9	14510	0.27	48	82	18	45.465583	-76.698821
4008025	9	1991	0.32	18500	1.1	9.88	175	0.9	14540	0.27	47.4	82	18	45.465583	-76.698821
4008026	9	1991	0.15	16490	1.1	5.4	93.5	0.7	9220	0.15	2	82	18	45.543051	-77.110919
4008026	9	1991	0.18	16720	0.8	4.77	92.3	0.7	9090	0.12	2.2	82	18	45.543051	-77.110919
4008026	9	1991	0.21	16640	1	4.6	91.3	0.6	9640	0.14	1.8	82	18	45.543051	-77.110919
4008027	9	1991	0.15	11410	1.4	0.81	103	0.4	4850	0.38	2.2	82	18	45.454238	-77.796318
4008027	9	1991	0.17	12710	1.1	0.76	102	0.4	4390	0.38	4.5	82	18	45.454238	-77.796318
4008027	9	1991	0.22	11730	1.2	1.14	91	0.3	3920	0.33	4.3	82	18	45.454238	-77.796318
4008440	3	1993	0.08	27000	5.3	11	210	1	11000	0.2	24	82	18	44.224103	-76.489546
4008440	3	1993	0.07	20000	4.5	9.8	160	0.8	14000	0.2	15	82	18	44.224103	-76.489546
4008441	3	1993	0.32	11000	1.9	5.8	68	0.5	4600	0.87	4.5	82	18	44.235394	-76.530303
4008444	3	1993	0.07	10000	2.3	4	50	0.5	14000	0.2	4.4	82	18	44.585105	-75.694376
4008444	3	1993	0.07	12000	2.5	11	55	0.5	12000	0.21	5.5	82	18	44.585105	-75.694376
4008451	3	1993	0.17	17000	2	3.9	180	0.6	6200	0.26	13	82	18	45.393469	-75.675908
4008451	3	1993	0.38	15000	1.7	3.7	160	0.6	6100	0.2	11	82	18	45.393469	-75.675908
4008455	3	1993	0.09	15000	3.1	7.4	160	0.7	17000	0.2	16	82	18	45.133005	-76.147588
4008455	3	1993	0.05	14000	2.6	2.6	160	0.7	17000	0.2	16	82	18	45.133005	-76.147588
4008459	3	1993	0.1	15000	1.1	3.7	97	0.6	6600	0.24	23	82	18	45.46997	-76.676655
4008459	3	1993	0.08	16000	1.1	4	100	0.6	7600	0.29	33	82	18	45.46997	-76.676655
4008463	3	1993	0.07	10000	1.1	3.2	73	0.5	5400	0.26	10	82	18	45.82101	-77.112958

Station	Land Use	Year	Ag	Al	As	B	Ba	Be	Ca	Cd	Cl	DATUM	ZONE	latitude	longitude
4008463	3	1993	0.09	8900	0.89	2	66	0.5	4700	0.34	10	82	18	45.82101	-77.112958
5008001	3	1991	0.06	6470	1.6	0.78	28.7	0.5	3080	0.21	0.5	82	17	46.30619	-78.561954
5008001	3	1991	0.07	5940	1.4	0.68	27.8	0.5	2820	0.17	0.5	82	17	46.30619	-78.561954
5008001	3	1991	0.08	5430	0.9	1.32	21.2	0.5	2550	0.16	0.5	82	17	46.30619	-78.561954
5008002	9	1991	0.25	17870	1.6	0.58	68.4	0.6	3220	0.25	0.5	82	17	46.31845	-81.947994
5008002	9	1991	0.37	24700	1.8	2.23	82.7	0.8	3480	0.23	0.5	82	17	46.31845	-81.947994
5008002	9	1991	0.15	16670	1	0.5	60.5	0.4	2440	0.13	0.5	82	17	46.31845	-81.947994
5008003	3	1991	0.06	11360	2	2.1	30.5	0.5	3520	0.14	0.5	82	17	46.357565	-79.945339
5008003	3	1991	0.06	10430	2	2.02	33.8	0.5	3220	0.15	0.5	82	17	46.357565	-79.945339
5008003	3	1991	0.13	9070	1.3	1.09	27.9	0.3	2560	0.15	0.5	82	17	46.357565	-79.945339
5008004	9	1991	0.08	25900	2.4	7.3	128	0.8	17780	0.1	0.5	82	17	46.445992	-80.304536
5008004	9	1991	0.09	27400	2.6	9.58	132	0.8	16630	0.09	0.5	82	17	46.445992	-80.304536
5008004	9	1991	0.13	24300	0.5	8.37	140	0.8	16630	0.1	0.5	82	17	46.445992	-80.304536
5008006	9	1991	0.09	13370	1.6	1.57	43.3	0.5	4910	0.25	0.5	82	17	45.728694	-79.069427
5008006	9	1991	0.08	14550	1.8	0.7	34.2	0.5	4920	0.1	0.5	82	17	45.728694	-79.069427
5008006	9	1991	0.05	14480	1.8	0.5	42.2	0.5	4660	0.19	0.5	82	17	45.728694	-79.069427
5008007	9	1991	0.18	11210	2.4	2.22	58.2	0.5	2170	0.23	0.5	82	17	46.11506	-79.408956
5008007	9	1991	0.15	7370	2.2	2.07	49	0.5	1434	0.17	0.5	82	17	46.11506	-79.408956
5008007	9	1991	0.11	8510	2.2	0.61	52.2	0.5	1539	0.16	0.5	82	17	46.11506	-79.408956
5008008	9	1991	0.09	9200	0.8	0.63	59.2	0.5	2240	0.1	0.5	82	17	46.301179	-79.099259
5008008	9	1991	0.11	14300	0.8	0.62	82.4	0.5	2540	0.12	0.5	82	17	46.301179	-79.099259
5008008	9	1991	0.1	10990	0.4	0.6	77.8	0.5	2490	0.07	0.5	82	17	46.301179	-79.099259
5008009	9	1991	0.09	51800	3.7	0.68	85	1.8	1785	0.12	0.5	82	17	46.539147	-79.432149
5008009	9	1991	0.07	6530	2.2	0.71	43	0.12	1903	0.23	8.8	82	17	46.539147	-79.432149
5008009	9	1991	0.07	7710	1.9	0.68	44.6	0.18	2370	0.13	9	82	17	46.539147	-79.432149

Station	Land Use	Year	Ag	Al	As	B	Ba	Be	Ca	Cd	Cl	DATUM	ZONE	latitude	longitude
5008010	9	1991	0.13	5880	1.5	0.78	41.5	0.5	1778	0.14	0.5	82	17	46.980897	-79.92933
5008010	9	1991	0.1	14350	3.6	0.69	40	0.2	3460	0.12	13.6	82	17	46.980897	-79.92933
5008010	9	1991	0.14	12280	4	0.72	32.2	0.16	2240	0.11	12.3	82	17	46.980897	-79.92933
5008011	3	1991	0.11	20200	5.7	3.67	126	0.6	15960	0.3	18	82	17	47.451131	-79.637923
5008011	3	1991	0.12	21000	6.9	5.76	121	0.5	16260	0.26	16	82	17	47.451131	-79.637923
5008011	3	1991	0.21	18450	4.5	6.46	122	0.5	11920	0.17	0.5	82	17	47.451131	-79.637923
5008012	3	1991	0.12	7850	1.9	4.68	38.3	0.2	18530	0.19	48.8	82	17	47.508078	-79.667526
5008012	3	1991	0.14	8390	1.1	4.7	33.6	0.2	17340	0.18	34.6	82	17	47.508078	-79.667526
5008012	3	1991	0.06	9040	1.3	2	40.4	0.5	15440	0.12	0.5	82	17	47.508078	-79.667526
5008013	3	1991	0.06	8840	1.5	1.05	33.6	0.18	2790	0.15	10.5	82	17	47.83559	-80.101092
5008013	3	1991	0.05	8500	1.6	0.74	38.5	0.12	3200	0.17	8.7	82	17	47.83559	-80.101092
5008013	3	1991	0.12	7900	1.1	0.74	43.7	0.5	3070	0.1	0.5	82	17	47.83559	-80.101092
5008014	9	1991	0.13	12850	6.1	13.24	51.4	0.5	2680	0.18	0.5	82	17	48.565575	-80.608452
5008014	9	1991	0.08	26200	2.6	12.21	111	1	14910	0.24	18	82	17	48.565575	-80.608452
5008014	9	1991	0.09	25300	2.7	14.25	104	1	14740	0.28	22.6	82	17	48.565575	-80.608452
5008015	3	1991	0.04	8660	3.2	1.76	38.3	0.3	13280	0.36	25.2	82	17	48.460868	-81.330359
5008015	3	1991	0.05	7120	3.5	1.29	31.1	0.3	12100	0.29	20.6	82	17	48.460868	-81.330359
5008015	3	1991	0.09	7860	2.6	0.72	37.3	0.5	11810	0.23	0.5	82	17	48.460868	-81.330359
5008016	3	1991	0.11	15340	2.1	12.22	54.2	0.6	41000	0.14	25.5	82	17	49.063897	-81.005791
5008016	3	1991	0.1	14580	1.9	11.21	23.7	0.6	39700	0.12	25.7	82	17	49.063897	-81.005791
5008016	3	1991	0.06	16110	2.1	13.21	53.3	0.5	36100	0.13	0.5	82	17	49.063897	-81.005791
5008017	9	1991	0.09	24200	2.9	2.33	109	0.9	11680	0.2	0.5	82	17	47.544459	-83.214844
5008017	9	1991	0.03	8460	0.9	1.02	33.4	0.2	2480	0.03	10.3	82	17	47.544459	-83.214844
5008017	9	1991	0.03	8150	1.2	2.93	35.4	0.2	2330	0.01	12.7	82	17	47.544459	-83.214844
5008018	9	1991	0.05	10060	0.9	1.37	49.9	0.5	2900	0.05	0.5	82	16	47.937297	-84.751363

Station	Land Use	Year	Ag	Al	As	B	Ba	Be	Ca	Cd	Cl	DATUM	ZONE	latitude	longitude
5008018	9	1991	0.06	15340	7.6	3.15	73.4	0.5	6400	0.26	17.1	82	16	47.937297	-84.751363
5008018	9	1991	0.07	15230	8.5	2.65	73.8	0.6	6600	0.25	16	82	16	47.937297	-84.751363
5008019	9	1991	0.12	15790	8.9	0.68	76.4	0.5	6530	0.22	0.5	82	16	48.619034	-85.218563
5008019	9	1991	0.05	5660	1.4	0.64	19	0.2	1698	0.08	11.4	82	16	48.619034	-85.218563
5008019	9	1991	0.05	6350	1.3	0.9	20.4	0.2	2070	0.03	9.2	82	16	48.619034	-85.218563
5008020	9	1991	0.09	4930	0.6	0.75	27.8	0.5	1247	0.06	0.5	82	16	46.979136	-84.517184
5008020	9	1991	0.1	4360	1.2	1.46	34	0.17	1137	0.18	9.8	82	16	46.979136	-84.517184
5008020	9	1991	0.15	6100	1	3.09	22	0.2	1426	0.23	7.7	82	16	46.979136	-84.517184
5008021	3	1991	0.17	22600	4.3	12.51	120	0.8	12500	0.35	19.2	82	16	46.539687	-84.341401
5008021	3	1991	0.15	24800	4.4	12.79	124	0.9	12090	0.37	20.4	82	16	46.539687	-84.341401
5008021	3	1991	0.09	23800	4.5	14.48	131	0.9	9790	0.26	0.5	82	16	46.539687	-84.341401
5008022	9	1991	0.08	6960	0.9	14.19	36.3	0.5	1398	0.16	0.5	82	17	46.339724	-83.93706
5008022	9	1991	0.17	30700	3.6	14.23	153	1.1	9760	0.34	29.4	82	17	46.339724	-83.93706
5008022	9	1991	0.19	31000	3.4	16.18	146	1.1	15480	0.23	58.5	82	17	46.339724	-83.93706
5008023	9	1991	0.1	24200	2.2	4.46	137	1	8330	0.25	0.5	82	17	46.34766	-83.740843
5008023	9	1991	0.26	36600	1.3	4.29	156	0.9	7160	0.49	15.7	82	17	46.34766	-83.740843
5008023	9	1991	0.13	32700	1	3.36	145	0.8	8260	0.46	15.2	82	17	46.34766	-83.740843
5008024	9	1991	0.13	31100	1.1	1.84	154	0.8	7250	0.32	0.5	82	17	46.282293	-83.502618
5008024	9	1991	0.13	15270	1.6	1.3	71.9	0.5	3080	0.17	10.2	82	17	46.282293	-83.502618
5008024	9	1991	0.08	13760	1.7	2.89	57.4	0.5	2680	0.13	9.5	82	17	46.282293	-83.502618
5008025	3	1991	0.06	8330	1.1	2.2	39.1	0.3	4010	0.16	12.4	82	17	46.190093	-82.944934
5008025	3	1991	0.06	9020	1.7	2.67	40.7	0.3	4220	0.14	12	82	17	46.190093	-82.944934
5008025	3	1991	0.06	10460	1.1	2.2	40.1	0.5	4420	0.15	0.5	82	17	46.190093	-82.944934
5008026	3	1991	0.09	11350	4	2.49	58.1	0.4	5790	0.37	209	82	17	45.341226	-80.028451
5008026	3	1991	0.11	13100	4.2	2.07	53.8	0.5	6870	0.34	179	82	17	45.341226	-80.028451

Station	Land Use	Year	Ag	Al	As	B	Ba	Be	Ca	Cd	Cl	DATUM	ZONE	latitude	longitude
5008026	3	1991	0.09	13550	7.9	2.2	69.1	0.2	4270	0.4	0.5	82	17	45.341226	-80.028451
5008027	9	1991	0.08	14920	1.6	1.33	72.8	0.4	2280	0.18	0.5	82	17	45.433773	-79.596785
5008027	9	1991	0.1	4100	1.4	1.15	42.3	0.17	1254	0.18	11.2	82	17	45.433773	-79.596785
5008027	9	1991	0.08	4410	1.8	0.62	52.5	0.16	1410	0.18	9.2	82	17	45.433773	-79.596785
5008070	3	1993	0.05	19000	3.5	11	77	0.7	30000	0.67	NA	82	17	49.271505	-81.612876
5008070	3	1993	0.05	18000	3.2	11	76	0.7	49000	0.7	NA	82	17	49.271505	-81.612876
5008076	3	1993	0.05	25000	5	12	110	0.8	13000	1.3	NA	82	17	49.416328	-82.428144
5008076	3	1993	0.05	23000	4.6	10	110	0.8	12000	1.2	NA	82	17	49.416328	-82.428144
5008079	3	1993	0.05	12000	2.4	5.8	50	0.5	25000	0.74	NA	82	17	49.077928	-81.023046
5008079	3	1993	0.05	13000	2.4	5.8	48	0.5	18000	0.68	NA	82	17	49.077928	-81.023046
5008084	3	1993	0.05	6000	1.8	0.5	20	0.5	7800	0.38	NA	82	17	48.76983	-80.679949
5008084	3	1993	0.05	9500	6.9	4	34	0.5	8800	0.76	NA	82	17	48.76983	-80.679949
5008086	3	1993	0.05	7400	2.3	0.5	23	0.5	5400	0.61	NA	82	17	48.482196	-81.213579
5008086	3	1993	0.05	7600	2.2	0.5	28	0.5	6700	0.74	NA	82	17	48.482196	-81.213579
5008090	3	1993	0.05	6000	0.96	2.3	30	0.5	2400	0.22	NA	82	17	47.674839	-81.728496
5008090	3	1993	0.05	5700	1.1	1.1	20	0.5	2300	0.49	NA	82	17	47.674839	-81.728496
5008135	9	1995	0.2	3610	0.2	1.2	47.5	0.5	1215	0.22	0.5	82	16	47.236424	-84.649335
5008135	9	1995	0.1	9200	2.1	1.1	37	0.5	6200	0.2	8.7	82	16	47.236424	-84.649335
5008136	9	1995	0.1	6700	3.7	0.5	28	0.5	1200	0.2	17	82	16	47.585374	-84.821282
5008136	9	1995	0.2	4100	2.3	0.7	21	0.5	800	0.2	23	82	16	47.585374	-84.821282
5008137	9	1995	0.1	5000	1.2	1	17	0.5	3100	0.2	3	82	16	47.433315	-84.729431
5008137	9	1995	0.1	4600	2.3	1	23	0.5	2600	0.4	6.5	82	16	47.433315	-84.729431
6008001	3	1991	0.02	13150	4.6	1.92	69.4	0.4	7040	0.31	12.4	82	16	48.375002	-89.291434
6008001	3	1991	0.02	12820	4.5	0.76	72.2	0.4	7190	0.28	16.4	82	16	48.375002	-89.291434
6008001	3	1991	0.02	13240	5.5	0.67	73.2	0.4	7310	0.28	12.4	82	16	48.375002	-89.291434

Station	Land Use	Year	Ag	Al	As	B	Ba	Be	Ca	Cd	Cl	DATUM	ZONE	latitude	longitude
6008002	9	1991	0.02	24700	2.8	0.5	85.8	0.4	2970	0.27	16	82	16	48.788737	-88.671654
6008002	9	1991	0.02	22200	2.8	0.8	82.2	0.4	2480	0.3	13	82	16	48.788737	-88.671654
6008002	9	1991	0.02	38600	3.2	0.5	82.9	0.5	2460	0.16	14.4	82	16	48.788737	-88.671654
6008003	3	1991	0.06	28400	2.7	6.87	106	0.6	15470	0.15	9.6	82	16	49.010234	-88.268798
6008003	3	1991	0.08	27900	2.7	6.43	114	0.7	15020	0.19	10.4	82	16	49.010234	-88.268798
6008003	3	1991	0.05	28100	2.3	8.36	96.9	0.6	15180	0.2	9.6	82	16	49.010234	-88.268798
6008004	9	1991	0.03	8190	1	0.85	37.9	0.3	3420	0.06	9.5	82	16	48.839262	-87.521727
6008004	9	1991	0.02	9390	0.65	1.2	37.7	0.4	3200	0.05	7.2	82	16	48.839262	-87.521727
6008004	9	1991	0.02	7890	1	1.79	33.2	0.3	3550	0.06	17.4	82	16	48.839262	-87.521727
6008005	3	1991	0.07	13070	4.5	3.7	95.6	0.4	9030	0.87	6.2	82	16	48.713733	-86.380552
6008005	3	1991	0.05	12210	4.4	3.37	89.9	0.4	8340	0.81	7.2	82	16	48.713733	-86.380552
6008005	3	1991	0.05	14140	4.4	6.56	97.4	0.4	8730	0.93	6.8	82	16	48.713733	-86.380552
6008006	3	1991	0.04	5500	1.1	0.77	31.5	0.14	2400	0.15	7	82	16	49.124168	-85.82926
6008006	3	1991	0.04	5950	1.15	0.85	29.4	0.16	2570	0.12	7.8	82	16	49.124168	-85.82926
6008007	9	1991	0.08	4440	2	3.13	16.2	0.16	52900	0.1	4.2	82	16	49.79431	-85.921562
6008007	9	1991	0.02	4050	2	2.11	15.2	0.21	57200	0.1	4.5	82	16	49.79431	-85.921562
6008007	9	1991	0.02	4540	1.9	3.24	17.5	0.16	55100	0.09	5.9	82	16	49.79431	-85.921562
6008008	3	1991	0.02	5540	9	3.47	17.3	0.19	63800	0.05	15.2	82	16	49.713871	-86.953989
6008008	3	1991	0.03	5670	8.4	4.47	20.6	0.2	67900	0.02	192	82	16	49.713871	-86.953989
6008008	3	1991	0.07	6380	15.7	3.38	20	0.2	64600	0.03	315	82	16	49.713871	-86.953989
6008009	9	1991	0.03	14260	9.8	0.56	36.4	0.3	3700	0.07	15.2	82	16	49.562205	-87.981578
6008009	9	1991	0.02	16280	10.5	0.76	39.2	0.4	4010	0.05	13.7	82	16	49.562205	-87.981578
6008009	9	1991	0.08	16260	9.1	1.7	34	0.3	3740	0.05	13.4	82	16	49.562205	-87.981578
6008010	9	1991	0.09	11400	4.6	2.18	143	0.3	7030	1	23.4	82	16	48.271324	-89.389897
6008010	9	1991	0.1	13130	5	3.6	141	0.3	7400	1.03	24	82	16	48.271324	-89.389897

Station	Land Use	Year	Ag	Al	As	B	Ba	Be	Ca	Cd	Cl	DATUM	ZONE	latitude	longitude
6008010	9	1991	0.09	12130	5.4	3.3	135	0.4	4860	0.74	16.6	82	16	48.271324	-89.389897
6008011	9	1991	0.13	11520	5	3.3	183	0.4	11920	1.09	35.8	82	16	48.069741	-89.578564
6008011	9	1991	0.1	17710	4.4	4.4	137	0.5	7030	1.04	24.2	82	16	48.069741	-89.578564
6008011	9	1991	0.15	12370	4.5	8.77	137	0.3	6160	1	22.8	82	16	48.069741	-89.578564
6008012	9	1991	0.02	14780	1.4	1.85	80.4	0.4	5080	0.11	8.3	82	15	48.614356	-90.219652
6008012	9	1991	0.02	16550	1.3	0.63	82.9	0.2	6020	0.15	6.7	82	15	48.614356	-90.219652
6008012	9	1991	0.02	14890	1.5	1.54	77.4	0.3	5440	0.11	7	82	15	48.614356	-90.219652
6008013	9	1991	0.03	11650	2.4	0.63	81.6	0.3	3860	0.13	9.4	82	15	48.671443	-91.130731
6008013	9	1991	0.03	8920	2.8	1.87	74.7	0.2	3510	0.14	8.6	82	15	48.671443	-91.130731
6008013	9	1991	0.03	8830	3	1.24	72.8	0.3	3080	0.16	5.9	82	15	48.671443	-91.130731
6008014	9	1991	0.02	5380	1.1	2.8	37.6	0.17	10580	0.12	12.6	82	15	48.759752	-92.620144
6008014	9	1991	0.05	5590	1.2	2.9	20.2	0.18	11190	0.11	18.4	82	15	48.759752	-92.620144
6008014	9	1991	0.02	5480	1.2	0.66	39.9	0.19	12000	0.12	11	82	15	48.759752	-92.620144
6008015	3	1991	0.03	10220	5.8	7.09	107	0.4	10600	0.16	21	82	15	48.612106	-93.411525
6008015	3	1991	0.02	8640	2.4	9.02	109	0.3	10780	0.19	18.3	82	15	48.612106	-93.411525
6008015	3	1991	0.03	10740	3	7.82	106	0.4	12060	0.13	23.4	82	15	48.612106	-93.411525
6008016	9	1991	0.02	8660	2	0.95	24.9	0.16	5140	0.1	9.5	82	15	49.107977	-93.922574
6008016	9	1991	0.02	7950	1.9	1.55	23.2	0.14	3700	0.04	9.1	82	15	49.107977	-93.922574
6008016	9	1991	0.02	9430	1.8	0.66	26	0.17	5180	0.06	8.9	82	15	49.107977	-93.922574
6008017	3	1991	0.02	9610	1.6	4.88	56.7	0.3	5600	0.04	21.6	82	15	49.762874	-94.481346
6008017	3	1991	0.02	9440	1.3	3.37	54.3	0.3	5340	0.04	19.1	82	15	49.762874	-94.481346
6008017	3	1991	0.02	14040	2.2	2.84	80.7	0.4	6470	0.07	27.4	82	15	49.762874	-94.481346
6008018	9	1991	0.04	5270	1.1	0.58	31.7	0.16	1321	0.07	8.4	82	15	49.858922	-93.393495
6008018	9	1991	0.02	4880	1	0.54	30	0.11	1194	0.07	9.4	82	15	49.858922	-93.393495
6008018	9	1991	0.02	4550	1	1.01	29.6	0.17	1199	0.08	9.7	82	15	49.858922	-93.393495

Station	Land Use	Year	Ag	Al	As	B	Ba	Be	Ca	Cd	Cl	DATUM	ZONE	latitude	longitude
6008019	9	1991	0.09	20600	2.4	2.5	113	0.5	6910	0.2	19.4	82	15	49.758324	-92.649888
6008019	9	1991	0.05	20400	2	1.98	97.6	0.5	6680	0.13	15	82	15	49.758324	-92.649888
6008019	9	1991	0.06	23400	2.3	2.94	120	0.6	7990	0.16	13.4	82	15	49.758324	-92.649888
6008020	3	1991	0.02	12750	1.6	0.62	39.8	0.3	1792	0.06	9.8	82	15	49.412425	-91.659047
6008020	3	1991	0.02	13760	1.6	0.58	42.1	0.4	2650	0.06	7.8	82	15	49.412425	-91.659047
6008020	3	1991	0.02	14010	1.6	0.59	41.4	0.3	2530	0.07	9.8	82	15	49.412425	-91.659047
6008021	9	1991	0.02	21300	1	0.9	48.5	0.3	9560	0.04	13.3	82	15	49.04911	-90.482225
6008021	9	1991	0.02	19310	1	0.6	45.3	0.3	7860	0.05	13.1	82	15	49.04911	-90.482225
6008021	9	1991	0.02	17230	0.9	1.18	43.5	0.4	6770	0.06	14.7	82	15	49.04911	-90.482225
6008022	9	1991	0.15	8420	1.8	0.77	53.1	0.3	4440	0.08	15.6	82	15	50.629722	-93.205481
6008022	9	1991	0.02	6370	1.8	1.5	51.2	0.16	3480	0.12	8.4	82	15	50.629722	-93.205481
6008022	9	1991	0.02	7810	1.6	0.66	51.4	0.18	3740	0.1	13.9	82	15	50.629722	-93.205481
6008023	3	1991	0.15	14410	59	3.93	239	0.5	9210	0.93	20.6	82	15	51.015499	-93.822331
6008023	3	1991	0.15	11690	66	0.79	154	0.4	6320	0.67	15.4	82	15	51.015499	-93.822331
6008023	3	1991	0.21	16150	59	2.17	211	0.6	7290	0.83	18.2	82	15	51.015499	-93.822331
6008024	3	1991	0.03	10400	4.6	1.13	58.9	0.2	3280	0.14	10.4	82	15	50.101921	-91.921662
6008024	3	1991	0.04	11410	4.8	1.13	66.4	0.2	3490	0.1	13.2	82	15	50.101921	-91.921662
6008024	3	1991	0.03	11350	5.1	0.68	71.9	0.3	3650	0.13	12.4	82	15	50.101921	-91.921662
6008025	9	1991	0.02	13710	2	0.62	38.5	0.2	1898	0.03	8.3	82	15	49.487828	-91.534788
6008025	9	1991	0.02	10300	2	1.7	55.8	0.17	2240	0.07	10	82	15	49.487828	-91.534788
6008025	9	1991	0.02	13840	1.7	0.65	43.4	0.4	2130	0.06	10	82	15	49.487828	-91.534788
6008026	9	1991	0.02	3600	0.8	0.62	14.5	0.1	1044	0.02	5.3	82	15	51.463813	-90.163646
6008026	9	1991	0.02	6600	1.5	0.58	20	0.11	1739	0.02	7	82	15	51.463813	-90.163646
6008026	9	1991	0.02	4370	1.2	0.62	20.4	0.07	1392	0.04	8	82	15	51.463813	-90.163646
6008027	9	1991	0.02	6970	1.9	0.56	27.3	0.13	2880	0.08	9.3	82	15	50.243543	-90.709469

Station	Land Use	Year	Ag	Al	As	B	Ba	Be	Ca	Cd	Cl	DATUM	ZONE	latitude	longitude
6008027	9	1991	0.02	7130	2.1	0.59	27.1	0.13	3010	0.05	10	82	15	50.243543	-90.709469
6008027	9	1991	0.02	6950	2	0.58	27.9	0.14	3230	0.09	8.6	82	15	50.243543	-90.709469
6008078	9	1992	0.5	26000	9.4	NA	200	0.56	8800	0.5	18	82	16	48.289464	-89.396784
6008078	9	1992	0.5	29000	11	NA	190	0.69	7800	0.5	16	82	16	48.289464	-89.396784
6008108	3	1993	0.5	11000	3.4	0	91	0.26	30000	0.5	NA	82	16	48.942155	-88.256145
6008108	3	1993	0.5	12000	2.8	0	91	0.3	19000	0.4	NA	82	16	48.942155	-88.256145
6008129	9	1993	0.5	25000	7	0	96	0.5	2400	0.4	4.5	82	16	48.344791	-89.285423
6008129	9	1993	0.5	23000	7.6	0	100	0.5	3400	0.4	NA	82	16	48.344791	-89.285423
6008133	9	1994	0.5	7500	2.2	7	56	0.32	18000	0.5	6	82	15	48.620287	-93.359622
6008133	9	1994	0.5	7000	2.1	6	53	0.29	18000	0.5	5.9	82	15	48.620287	-93.359622
6008150	3	1995	NA	18000	46	NA	120	0.4	5800	0.4	NA	82	15	48.758671	-91.611566
6008150	3	1995	NA	18000	53	NA	130	0.4	5700	0.4	NA	82	15	48.758671	-91.611566

Table 20: OTR Data: Co - Mn

Station	Land Use	Year	Co	Cr	Cu	F	Fe	Hg	K	Mg	Mn	DATUM	ZONE	latitude	longitude
1008001	9	1991	5.9	22.7	12.5	4.7	24200	0.1	1246	6460	619	82	17	44.816458	-81.097171
1008001	9	1991	5.8	22.5	14.3	7.2	21900	0.1	1251	4710	637	82	17	44.816458	-81.097171
1008001	9	1991	4.8	18.2	11.4	12.5	19780	0.08	1197	4390	505	82	17	44.816458	-81.097171
1008002	3	1991	5.7	17.2	24	65	20900	0.06	2270	10550	456	82	17	44.74259	-81.143784
1008002	3	1991	6	18.6	24.9	63	22200	0.06	2540	10370	479	82	17	44.74259	-81.143784
1008002	3	1991	5.5	11.6	20.6	63	20200	0.05	1935	8680	374	82	17	44.74259	-81.143784
1008003	3	1991	10.2	23.5	40.2	87	35100	0.07	6450	10770	953	82	17	44.560393	-80.929447
1008003	3	1991	10.8	22.4	38.9	83	35700	0.06	6880	10600	1002	82	17	44.560393	-80.929447
1008003	3	1991	9.2	21	40	87	37000	0.07	6600	10500	1300	82	17	44.560393	-80.929447
1008004	9	1991	6.8	18.8	19.1	17	22600	0.04	2320	11010	1091	82	17	44.443944	-80.877824
1008004	9	1991	7.3	20.5	20.7	17	22800	0.05	2230	10700	1067	82	17	44.443944	-80.877824
1008004	9	1991	6.7	19.7	18.3	18	21400	0.06	2290	10190	3590	82	17	44.443944	-80.877824
1008005	9	1991	5.9	18.6	13.4	35	17860	0.04	2580	17110	529	82	17	44.318789	-81.243305
1008005	9	1991	6	18.2	13.6	28	17560	0.03	2300	16870	534	82	17	44.318789	-81.243305
1008005	9	1991	5.7	18.7	13.4	28	17720	0.03	2460	17260	523	82	17	44.318789	-81.243305
1008006	3	1991	11	38.2	24.5	58	24800	0.11	4170	6410	714	82	17	44.176422	-81.618168
1008006	3	1991	10.9	38	40.3	56	25100	0.11	4390	6460	775	82	17	44.176422	-81.618168
1008006	3	1991	10.3	35.3	21.2	60	23500	0.07	4300	6390	735	82	17	44.176422	-81.618168
1008007	9	1991	7.1	23.8	17.1	22	29400	0.11	2250	35800	2150	82	17	44.180986	-80.803078
1008007	9	1991	7.1	22.7	16.6	25	29300	0.12	2240	37500	2010	82	17	44.180986	-80.803078
1008007	9	1991	6.6	23.4	15.7	26	27000	0.11	2130	35000	1871	82	17	44.180986	-80.803078

Station	Land Use	Year	Co	Cr	Cu	F	Fe	Hg	K	Mg	Mn	DATUM	ZONE	latitude	longitude
1008008	9	1991	11.7	36	33.1	20	28800	0.06	6220	12060	663	82	17	43.671966	-80.722085
1008008	9	1991	11.9	36.4	28.1	21	29100	0.06	6200	11480	665	82	17	43.671966	-80.722085
1008008	9	1991	11.4	36.8	33.4	20	28700	0.06	6270	11390	650	82	17	43.671966	-80.722085
1008009	3	1991	5.3	19.4	18	91	14560	0.1	2080	7120	221	82	17	42.759005	-81.189634
1008009	3	1991	6.1	21.9	17.7	88	15870	0.09	2570	7060	251	82	17	42.759005	-81.189634
1008009	3	1991	5.1	18.9	17.3	90	13430	0.09	2030	7200	215	82	17	42.759005	-81.189634
1008010	9	1991	4.2	15.8	10	9.8	14430	0.07	2270	2290	220	82	17	42.088945	-82.438773
1008010	9	1991	4.3	16.1	9.2	9.6	14590	0.07	2410	2320	219	82	17	42.088945	-82.438773
1008010	9	1991	4.9	19.6	10.3	10	16300	0.07	3330	2740	252	82	17	42.088945	-82.438773
1008011	9	1991	8	31.6	18.1	15	21700	0.05	5660	4000	285	82	17	42.228615	-82.795621
1008011	9	1991	7.8	26	17.4	15	21200	0.04	3790	3640	295	82	17	42.228615	-82.795621
1008011	9	1991	7.8	27.2	16	15	21900	0.05	4120	3790	292	82	17	42.228615	-82.795621
1008012	3	1991	8	31.6	22.5	74	22500	0.06	4520	3680	260	82	17	42.300366	-83.05255
1008012	3	1991	7.5	26.9	24.2	75	22100	0.06	3040	3400	242	82	17	42.300366	-83.05255
1008012	3	1991	7.5	28	24.4	75	23200	0.06	3700	3590	243	82	17	42.300366	-83.05255
1008013	3	1991	5.5	16.2	13.1	45	14970	0.04	2330	10820	325	82	17	42.402413	-82.149764
1008013	3	1991	5.1	15.3	13.7	46	14830	0.04	2210	11040	313	82	17	42.402413	-82.149764
1008013	3	1991	5.6	16.5	14	45	14880	0.04	2290	10700	333	82	17	42.402413	-82.149764
1008014	3	1991	8.2	27.9	24.4	65	21300	0.03	4410	9290	198	82	17	42.589542	-82.4052
1008014	3	1991	8	27.5	25.7	64	21900	0.05	4240	9420	197	82	17	42.589542	-82.4052
1008014	3	1991	8.4	28.5	24.5	62	21000	0.05	4780	9260	200	82	17	42.589542	-82.4052
1008015	9	1991	6.9	23.6	16.3	27	19250	0.06	4910	21600	336	82	17	42.881862	-82.18226
1008015	9	1991	6.9	22.6	18.3	24	19130	0.05	4340	21700	343	82	17	42.881862	-82.18226
1008015	9	1991	7	23	17.2	27	20100	0.05	4240	23000	352	82	17	42.881862	-82.18226

Station	Land Use	Year	Co	Cr	Cu	F	Fe	Hg	K	Mg	Mn	DATUM	ZONE	latitude	longitude
1008016	3	1991	5.2	24.4	28.1	38	16760	0.1	4030	8970	164	82	17	42.965156	-82.392349
1008016	3	1991	5.6	25.3	27.7	38	17620	0.12	4030	8140	163	82	17	42.965156	-82.392349
1008016	3	1991	5.6	25.5	28.1	38	18160	0.11	4170	8110	166	82	17	42.965156	-82.392349
1008017	9	1991	9.5	25	22.1	6.8	21300	0.09	2060	3040	871	82	17	43.018985	-81.801795
1008017	9	1991	9.8	23.7	19.4	4.8	22300	0.09	2250	3150	945	82	17	43.018985	-81.801795
1008017	9	1991	9.4	22.4	20.2	7	21500	0.09	2210	3090	1006	82	17	43.018985	-81.801795
1008018	9	1991	6	27.3	19	14	16990	0.06	3570	5120	220	82	17	43.164124	-81.658251
1008018	9	1991	6.3	28.3	19.5	16	17440	0.06	3690	4700	226	82	17	43.164124	-81.658251
1008018	9	1991	5.7	22.9	15.7	6	16090	0.06	3300	4240	188	82	17	43.164124	-81.658251
1008019	9	1991	6.5	20.2	12.5	12	15020	0.1	1430	3200	739	82	17	43.982597	-81.394438
1008019	9	1991	6	19.7	11.4	14	15780	0.09	1327	2980	659	82	17	43.982597	-81.394438
1008019	9	1991	5.9	20.9	10.8	12	17010	0.08	1359	3430	645	82	17	43.982597	-81.394438
1008020	3	1991	4.6	15.5	16.5	61	17470	0.1	2080	10840	614	82	17	42.975671	-81.251887
1008020	3	1991	4.4	14.5	15.7	60	16320	0.11	1811	10950	588	82	17	42.975671	-81.251887
1008020	3	1991	4.6	14.7	15.6	60	16300	0.1	1899	11040	594	82	17	42.975671	-81.251887
1008021	9	1991	6.1	24.1	12.4	16	22200	0.09	1927	18060	1082	82	17	43.827738	-81.464929
1008021	9	1991	6.1	23.3	11.6	16	20900	0.09	1948	17650	1002	82	17	43.827738	-81.464929
1008021	9	1991	6.3	24.2	12.2	19	22100	0.1	1943	16890	1088	82	17	43.827738	-81.464929
1008022	9	1991	4.2	18.3	6.2	0.75	16020	0.05	856	2570	257	82	17	43.748683	-81.102879
1008022	9	1991	4.2	17.6	6.3	0.75	15390	0.05	848	2840	220	82	17	43.748683	-81.102879
1008022	9	1991	4.3	17.3	6.7	0.75	15880	0.05	859	3500	224	82	17	43.748683	-81.102879
1008023	9	1991	6.7	20.1	9.6	2.2	17590	0.08	1745	2750	799	82	17	43.265706	-81.053305
1008023	9	1991	6.5	21	10.4	1.2	18220	0.08	1835	2810	766	82	17	43.265706	-81.053305
1008023	9	1991	6	20	10.4	1.7	17690	0.07	1753	2520	727	82	17	43.265706	-81.053305

Station	Land Use	Year	Co	Cr	Cu	F	Fe	Hg	K	Mg	Mn	DATUM	ZONE	latitude	longitude
1008024	9	1991	7.7	25.2	16.3	3.6	22400	0.06	4310	11210	757	82	17	43.6972	-81.477918
1008024	9	1991	7.6	24.8	15	3	21500	0.05	3970	10250	741	82	17	43.6972	-81.477918
1008024	9	1991	7.9	25.5	15.6	3.3	21700	0.05	4040	10100	742	82	17	43.6972	-81.477918
1008025	9	1991	9.1	29.7	20.8	0.75	24300	0.06	3850	6470	593	82	17	43.357332	-81.456201
1008025	9	1991	9.1	30.3	17.6	0.75	24800	0.06	3830	6070	612	82	17	43.357332	-81.456201
1008025	9	1991	9.1	29.5	17.2	1.2	24300	0.06	3810	6430	575	82	17	43.357332	-81.456201
1008026	9	1991	9.4	32.1	24.4	1.5	25500	0.06	5440	12200	863	82	17	43.622784	-81.502427
1008026	9	1991	20.1	33.8	25.9	2.6	27100	0.06	5620	11090	1002	82	17	43.622784	-81.502427
1008026	9	1991	10.4	33.9	22.3	3.1	27400	0.05	5840	11880	1126	82	17	43.622784	-81.502427
1008027	3	1991	9	32.3	20.7	67	23800	0.07	3820	6200	389	82	17	43.356494	-80.988141
1008027	3	1991	8.8	30.8	19.6	70	22800	0.06	3770	6010	361	82	17	43.356494	-80.988141
1008027	3	1991	8.6	30.8	19	66	22400	0.05	3690	5860	342	82	17	43.356494	-80.988141
1008557	3	1993	4.8	15	16	64	15000	0.1	1400	4300	540	82	17	43.129473	-80.758462
1008557	3	1993	5.2	15	14	61	14000	0.1	1600	4600	510	82	17	43.129473	-80.758462
1008561	3	1993	4.7	20	17	75	15000	0.19	1400	10000	660	82	17	43.74293	-81.710213
1008561	3	1993	4.4	19	16	78	14000	0.13	1300	9900	640	82	17	43.74293	-81.710213
1008565	3	1993	8.4	25	34	100	18000	0.48	3100	9100	410	82	17	42.880863	-82.146804
1008565	3	1993	7.5	23	30	100	17000	0.46	3000	8500	410	82	17	42.880863	-82.146804
1008569	3	1993	5.9	16	16	58	15000	0.09	1600	4400	420	82	17	42.590103	-82.182446
1008569	3	1993	6	16	15	64	15000	0.09	1800	4600	430	82	17	42.590103	-82.182446
1008573	3	1993	4.9	15	14	74	15000	0.08	1400	8100	410	82	17	43.036371	-80.878788
1008573	3	1993	4.3	14	16	76	14000	0.08	1300	8300	400	82	17	43.036371	-80.878788
1008577	3	1993	3.2	11	6	36	13000	0.04	720	1700	370	82	17	42.868375	-80.732977
1008577	3	1993	2.3	10	6	42	11000	0.05	710	1700	320	82	17	42.868375	-80.732977

Station	Land Use	Year	Co	Cr	Cu	F	Fe	Hg	K	Mg	Mn	DATUM	ZONE	latitude	longitude
2008001	9	1991	5.4	15	7.2	17.2	17470	0.03	1237	2580	548	82	17	43.671864	-80.448376
2008001	9	1991	5.4	14.9	7.6	16.5	17550	0.03	1084	2370	599	82	17	43.671864	-80.448376
2008001	9	1991	6.9	18	8.5	20.7	22000	0.01	1740	3100	860	82	17	43.671864	-80.448376
2008001	9	1996	7.7	24	40	NA	21000	NA	NA	6500	730	82	17	43.671864	-80.448376
2008001	9	1996	7.8	25	39	NA	21000	NA	NA	6800	750	82	17	43.671864	-80.448376
2008002	9	1991	6.5	20.7	13.4	39	15990	0.05	3110	31200	596	82	17	43.754512	-80.661085
2008002	9	1996	9	24	53	NA	22000	NA	NA	4500	810	82	17	43.754512	-80.661085
2008002	9	1991	6.4	20.2	16.6	32	16890	0.04	3410	31500	598	82	17	43.754512	-80.661085
2008002	9	1991	6.1	18.4	16.6	34	15330	0.04	3120	31500	564	82	17	43.754512	-80.661085
2008002	9	1996	8.4	25	51	NA	22000	NA	NA	4700	760	82	17	43.754512	-80.661085
2008003	9	1991	5.5	21	13.5	23	19730	0.06	2430	13670	407	82	17	43.909576	-80.873879
2008003	9	1991	5.3	17.9	10.1	27	19020	0.06	2220	15460	369	82	17	43.909576	-80.873879
2008003	9	1991	7.1	24.6	10	32	18440	0.06	2140	16120	469	82	17	43.909576	-80.873879
2008003	9	1996	9.5	20	41	NA	22000	NA	NA	5600	780	82	17	43.909576	-80.873879
2008003	9	1996	9.3	20	43	NA	22000	NA	NA	5600	790	82	17	43.909576	-80.873879
2008004	9	1991	6.6	21.8	16.8	18	20500	0.08	2530	14620	577	82	17	43.982017	-80.735219
2008004	9	1991	6	19.6	16.7	20	20600	0.07	2610	15210	512	82	17	43.982017	-80.735219
2008004	9	1991	7.8	25.4	17.2	24	20000	0.08	2790	14150	661	82	17	43.982017	-80.735219
2008005	9	1991	7.9	24	12.2	23	24200	0.05	2790	8110	557	82	17	43.880183	-80.270894
2008005	9	1991	8.3	37.3	13.6	21	24100	0.05	2760	8860	612	82	17	43.880183	-80.270894
2008005	9	1991	9.3	30	12.8	26	24300	0.05	2480	8210	725	82	17	43.880183	-80.270894
2008006	9	1991	16.7	35	25.8	12	37000	0.05	5630	9360	1211	82	17	43.109197	-79.558093
2008006	9	1991	15.3	36.1	28.8	14	34300	0.04	7000	9960	1159	82	17	43.109197	-79.558093
2008006	9	1991	17.2	37.2	36.9	11	36800	0.05	6720	8960	1319	82	17	43.109197	-79.558093

Station	Land Use	Year	Co	Cr	Cu	F	Fe	Hg	K	Mg	Mn	DATUM	ZONE	latitude	longitude
2008007	9	1991	3.9	12	8.4	30	13950	0.04	1132	4320	408	208	17	42.75062	-80.26525
2008007	9	1991	3.9	11.4	7.5	34	14240	0.03	918	4230	400	208	17	42.75062	-80.26525
2008007	9	1991	3.8	11.4	7.1	37	13980	0.03	995	4320	392	208	17	42.75062	-80.26525
2008008	9	1991	3.5	11.6	7.7	13	11790	0.05	1492	1783	136	82	17	42.668177	-80.412623
2008008	9	1991	3.5	11.1	7.3	13	11590	0.05	1350	1600	138	82	17	42.668177	-80.412623
2008008	9	1991	3.4	11.4	7.8	13	11470	0.05	1420	1694	128	82	17	42.668177	-80.412623
2008009	9	1991	11.2	31.2	16.6	14	32100	0.06	6220	6870	742	82	17	42.885126	-80.100468
2008009	9	1991	13.8	37	19.4	15	34900	0.06	7060	7680	849	82	17	42.885126	-80.100468
2008009	9	1991	12.8	35.3	17.1	14	33900	0.06	6660	7200	812	82	17	42.885126	-80.100468
2008010	9	1991	5.5	13.4	26.1	23	16300	0.03	2100	2650	730	82	17	43.196477	-80.010295
2008010	9	1991	5.6	14	26.3	32	17100	0.02	2490	2790	762	82	17	43.196477	-80.010295
2008010	9	1991	5.5	13.7	24.7	32	16600	0.03	2210	2670	740	82	17	43.196477	-80.010295
2008011	9	1991	16.9	29.9	18.4	11	28600	0.13	5060	7580	2570	82	17	43.011399	-79.915842
2008011	9	1991	19.2	31.3	17.7	10	29400	0.1	5080	7390	2710	82	17	43.011399	-79.915842
2008011	9	1991	20.8	35.8	18.4	11	31200	0.14	5230	8010	3190	82	17	43.011399	-79.915842
2008012	9	1991	4.1	12	4.7	11	15400	0.07	746	1572	306	208	17	42.678923	-80.62216
2008012	9	1991	4	11.8	4.5	9.8	15600	0.05	788	1613	275	208	17	42.678923	-80.62216
2008012	9	1991	4.5	14	5.1	11	15700	0.06	906	1788	371	208	17	42.678923	-80.62216
2008013	9	1991	5.5	17.4	17.4	15	21300	0.09	1817	9820	1709	82	17	43.398527	-80.625449
2008013	9	1991	6.1	17.9	15.4	13	21700	0.12	1692	4300	2120	82	17	43.398527	-80.625449
2008013	9	1991	5.9	17.6	15.1	13	21100	0.1	1581	5050	1651	82	17	43.398527	-80.625449
2008014	9	1991	7.1	23.9	25.1	4.6	21300	0.23	1935	2640	1112	82	17	42.901284	-79.040713
2008014	9	1991	6	19.3	24.8	4.6	18160	0.25	1422	2020	1094	82	17	42.901284	-79.040713
2008014	9	1991	5.2	17.9	25	4	20300	0.24	1101	1764	932	82	17	42.901284	-79.040713

Station	Land Use	Year	Co	Cr	Cu	F	Fe	Hg	K	Mg	Mn	DATUM	ZONE	latitude	longitude
2008015	9	1991	6.3	18.4	27.8	3.7	23700	0.12	2400	15590	1245	82	17	44.10093	-80.137487
2008015	9	1991	6.3	17.8	27.9	4.1	23900	0.12	2280	15160	1092	82	17	44.10093	-80.137487
2008015	9	1991	6.5	19.8	21.9	4.7	25700	0.09	1975	11270	646	82	17	44.10093	-80.137487
2008016	9	1991	4.3	13.6	8.1	16	16140	0.05	822	3410	410	82	17	43.511826	-80.351047
2008016	9	1991	4.2	13.3	6.8	18	14920	0.06	753	3000	377	82	17	43.511826	-80.351047
2008016	9	1991	4.7	14.6	7.4	15	16040	0.05	877	3230	416	82	17	43.511826	-80.351047
2008017	9	1991	6.1	20.4	10.5	2	20900	0.08	1463	4200	585	82	17	43.961897	-80.410923
2008017	9	1991	6.4	21	13.1	7.5	20800	0.08	1579	6710	598	82	17	43.961897	-80.410923
2008017	9	1991	5.9	19.7	9	1.5	20200	0.07	1192	4280	571	82	17	43.961897	-80.410923
2008018	3	1991	5.3	16.2	12.5	67	16860	0.09	1788	6560	526	82	17	43.13393	-80.762489
2008018	3	1991	5.2	15.8	12.6	63	17720	0.07	1884	6580	547	82	17	43.13393	-80.762489
2008018	3	1991	5.5	17	13	66	19170	0.08	1988	6690	568	82	17	43.13393	-80.762489
2008019	3	1991	5	17.3	12.1	18	20300	0.06	798	2410	641	82	17	43.151025	-80.313147
2008019	3	1991	4.1	14.1	12.6	19	16110	0.06	674	2230	566	82	17	43.151025	-80.313147
2008019	3	1991	4.4	15.6	11.4	20	18200	0.06	690	2110	578	82	17	43.151025	-80.313147
2008020	3	1991	6.1	21.5	15.8	78	21000	0.1	2700	22800	762	82	17	43.532327	-80.230359
2008020	3	1991	5.7	20.2	14.8	78	19020	0.1	2160	23100	756	82	17	43.532327	-80.230359
2008020	3	1991	6	21.4	15	85	20800	0.09	2360	22000	742	82	17	43.532327	-80.230359
2008021	3	1991	6.2	25.3	24.8	110	19700	0.14	2730	12370	490	82	17	43.07213	-79.079335
2008021	3	1991	5.9	24	24	120	18600	0.11	2380	12670	488	82	17	43.07213	-79.079335
2008021	3	1991	5.7	24.2	21.6	110	17890	0.11	2370	13000	456	82	17	43.07213	-79.079335
2008022	3	1991	9.9	34	32.8	140	27200	0.24	5250	17340	783	82	17	42.988082	-79.251346
2008022	3	1991	10.1	32.5	34.9	140	29100	0.23	4560	13980	753	82	17	42.988082	-79.251346
2008022	3	1991	9.3	31.7	30	150	26800	0.22	5180	15840	741	82	17	42.988082	-79.251346

Station	Land Use	Year	Co	Cr	Cu	F	Fe	Hg	K	Mg	Mn	DATUM	ZONE	latitude	longitude
2008023	3	1991	20.4	27.2	11	50	26800	0.09	4390	6710	536	82	17	42.887559	-79.245397
2008023	3	1991	18.3	26.3	10.6	50	26500	0.08	3920	6250	477	82	17	42.887559	-79.245397
2008023	3	1991	18.6	24.6	11.9	52	25800	0.07	3410	6240	504	82	17	42.887559	-79.245397
2008024	3	1991	5	17.1	24.8	53	19840	0.03	1544	9130	663	82	17	43.366353	-80.332692
2008024	3	1991	5.2	17.6	24.1	50	19780	0.04	1562	9110	674	82	17	43.366353	-80.332692
2008024	3	1991	5.1	16.5	26	53	20000	0.02	1416	8360	659	82	17	43.366353	-80.332692
2008025	3	1991	5.2	19.5	21.4	62	21900	0.12	1202	2000	527	82	17	43.238999	-79.830218
2008025	3	1991	5.8	22.4	17.4	75	21800	0.14	1259	2100	622	82	17	43.238999	-79.830218
2008025	3	1991	5.5	21.5	20.6	62	21000	0.11	1159	2000	516	82	17	43.238999	-79.830218
2008026	3	1991	1.7	7.5	39.9	21	3670	0.31	576	3630	293	82	17	43.45705	-80.45592
2008026	3	1991	1.7	7.5	18.4	20	3720	0.26	616	3320	266	82	17	43.45705	-80.45592
2008026	3	1991	1.8	8	17.8	21	3810	0.3	661	3450	287	82	17	43.45705	-80.45592
2008027	3	1991	17.5	29.5	8.3	28	27900	0.11	4690	6520	953	82	17	43.144121	-79.238751
2008027	3	1991	17.1	29	10.2	30	27000	0.11	4790	6260	976	82	17	43.144121	-79.238751
2008027	3	1991	17.6	29	9	31	27300	0.1	4600	6190	1012	82	17	43.144121	-79.238751
2008302	3	1993	4.4	17	18	56	16000	0.04	1100	7000	630	82	17	43.356699	-80.320248
2008302	3	1993	4.4	18	22	53	15000	0.03	1000	6000	580	82	17	43.356699	-80.320248
2008305	3	1993	3.3	13	7	56	13000	0.03	1100	5900	450	82	17	43.453897	-80.472931
2008305	3	1993	3.9	13	8	69	12000	0.02	1200	5500	440	82	17	43.453897	-80.472931
2008400	3	1993	7.5	30	17	41	19000	0.06	2200	4500	460	82	17	42.997104	-79.258942
2008400	3	1993	7.9	32	17	46	19000	0.06	2500	4800	600	82	17	42.997104	-79.258942
2008501	3	1993	6.2	16	24	56	14000	0.09	1200	11000	570	82	17	43.55245	-80.235451
2008501	3	1993	5.1	14	24	52	13000	0.09	970	13000	530	82	17	43.55245	-80.235451
2008505	3	1993	5.3	15	33	82	16000	0.4	910	2800	760	82	17	43.267713	-79.88221

Station	Land Use	Year	Co	Cr	Cu	F	Fe	Hg	K	Mg	Mn	DATUM	ZONE	latitude	longitude
2008505	3	1993	4.7	14	27	69	14000	0.39	790	2200	680	82	17	43.267713	-79.88221
3008001	9	1991	6.6	22.6	12.4	23.9	17240	0.03	846	2500	551	82	17	44.129388	-79.608149
3008001	9	1991	7.5	21.7	11.6	21.5	20400	0.04	939	2710	598	82	17	44.129388	-79.608149
3008001	9	1991	7.7	24.2	12	23.5	21400	0.04	1033	2960	647	82	17	44.129388	-79.608149
3008002	9	1991	6	19.5	19.2	26	19320	0.04	2200	5850	483	82	17	44.151916	-79.898729
3008002	9	1991	6	19.6	21.6	21	18850	0.04	2260	5910	482	82	17	44.151916	-79.898729
3008002	9	1991	5.9	19.3	19.5	27	19060	0.04	2250	5810	489	82	17	44.151916	-79.898729
3008003	9	1991	10.6	36	12.3	42	23700	0.05	2960	6410	407	82	17	44.705792	-79.64149
3008003	9	1991	10.7	37.9	11.5	23	23600	0.05	3050	6600	411	82	17	44.705792	-79.64149
3008003	9	1991	10.1	34	11.9	40	22700	0.06	2760	6380	369	82	17	44.705792	-79.64149
3008004	9	1991	8.5	22.9	8.1	75	22300	0.05	1379	6320	522	82	17	44.937813	-78.713223
3008004	9	1991	8.2	21.5	8.2	64	23500	0.05	1365	6590	475	82	17	44.937813	-78.713223
3008004	9	1991	8.2	22.1	8.4	120	22400	0.05	1442	6420	484	82	17	44.937813	-78.713223
3008005	9	1991	6.1	19.1	8.8	17	23300	0.04	1688	3660	513	82	17	44.304494	-77.950776
3008005	9	1991	6	19.5	9.5	16	24400	0.04	1762	3670	519	82	17	44.304494	-77.950776
3008005	9	1991	6.4	20.5	9.4	17	24700	0.04	2090	3890	519	82	17	44.304494	-77.950776
3008006	9	1991	7.6	22.7	5.5	33	20900	0.04	2540	3930	426	82	18	44.048525	-77.741013
3008006	9	1991	7.4	21.9	5.4	28	20300	0.04	2510	3860	405	82	18	44.048525	-77.741013
3008006	9	1991	7.6	22.9	5.5	11	20500	0.05	2290	3740	426	82	18	44.048525	-77.741013
3008007	9	1991	4.4	14.4	8	15	18990	0.08	655	1593	719	82	17	43.724712	-79.95708
3008007	9	1991	4	12.9	8.2	13	18380	0.06	583	1471	642	82	17	43.724712	-79.95708
3008007	9	1991	4.1	12.8	6.6	14	18150	0.07	578	1424	692	82	17	43.724712	-79.95708
3008008	9	1991	8.2	14	6.2	14	24500	0.07	928	2540	645	82	17	44.060396	-78.611093
3008008	9	1991	7.9	13.7	6.9	18	26400	0.08	1157	2610	758	82	17	44.060396	-78.611093

Station	Land Use	Year	Co	Cr	Cu	F	Fe	Hg	K	Mg	Mn	DATUM	ZONE	latitude	longitude
3008008	9	1991	9.2	14.9	6.4	0.5	21100	0.09	783	2180	655	82	17	44.060396	-78.611093
3008009	9	1991	6.3	16.7	8.8	3.2	20800	0.06	939	2630	587	82	17	44.921885	-78.064296
3008009	9	1991	6.4	17.5	9.5	1.7	21600	0.06	936	2640	550	82	17	44.921885	-78.064296
3008009	9	1991	6.1	17.3	9.1	5.9	18850	0.06	938	2610	453	82	17	44.921885	-78.064296
3008010	9	1991	5.8	16.8	9.7	24	18440	0.07	1072	2580	665	82	17	44.561536	-78.862881
3008010	9	1991	5.2	15.3	9.4	30	16720	0.07	1085	2560	703	82	17	44.561536	-78.862881
3008010	9	1991	7.2	21.1	8.8	6.9	22200	0.08	1459	3220	754	82	17	44.561536	-78.862881
3008011	9	1991	7.7	21.1	6.5	23	29200	0.09	895	3500	1530	82	17	44.164546	-79.005658
3008011	9	1991	8	24.2	7.4	24	30600	0.08	991	3790	1664	82	17	44.164546	-79.005658
3008011	9	1991	8.3	23.3	6.5	22	29800	0.08	1051	3770	1480	82	17	44.164546	-79.005658
3008012	9	1991	4.1	13.3	19.3	3.9	20800	0.08	555	1010	385	82	17	43.999372	-78.127351
3008012	9	1991	4.5	13.8	13.7	3	21700	0.11	567	1087	509	82	17	43.999372	-78.127351
3008012	9	1991	4.4	13.1	15	4.3	21300	0.08	546	1046	428	82	17	43.999372	-78.127351
3008013	9	1991	9.4	27.8	4.8	39	25600	0.03	2760	4860	387	82	17	45.443606	-78.818309
3008013	9	1991	9.1	26.7	5.1	38	24800	0.04	2750	4750	379	82	17	45.443606	-78.818309
3008013	9	1991	9.5	26.9	4.8	1.8	26700	0.04	2790	4780	385	82	17	45.443606	-78.818309
3008014	9	1991	4.6	14.3	13.8	15	23100	0.03	591	1742	896	82	17	43.875236	-78.778045
3008014	9	1991	4.9	16.2	15.3	18	26400	0.04	639	1831	929	82	17	43.875236	-78.778045
3008014	9	1991	4.3	14.6	12.8	18	22800	0.04	606	1727	972	82	17	43.875236	-78.778045
3008015	9	1991	8.2	23.8	7.5	31	19660	0.09	2910	4140	432	82	17	44.086538	-78.632124
3008015	9	1991	8.1	23.9	8.6	29	19800	0.04	3140	4390	437	82	17	44.086538	-78.632124
3008015	9	1991	8.3	22.9	6.7	30.5	21200	0.04	3450	4200	444	82	17	44.086538	-78.632124
3008016	9	1991	4.8	15.3	96.8	14	18070	0.04	2640	3430	626	82	17	44.579151	-79.86651
3008016	9	1991	6.6	19.6	93.3	9.7	23200	0.05	3240	4120	871	82	17	44.579151	-79.86651

Station	Land Use	Year	Co	Cr	Cu	F	Fe	Hg	K	Mg	Mn	DATUM	ZONE	latitude	longitude
3008016	9	1991	5.9	17.6	78.1	32	18760	0.03	2870	3700	566	82	17	44.579151	-79.86651
3008017	9	1991	8.5	16.9	13.9	26	23100	0.08	2550	10320	1313	82	17	44.536002	-78.72486
3008017	9	1991	8.1	16.7	14.5	24	26500	0.07	2720	11370	1355	82	17	44.536002	-78.72486
3008017	9	1991	8.3	18.4	3.4	21	26300	0.08	2700	11380	1356	82	17	44.536002	-78.72486
3008018	3	1991	12.1	23.3	23.3	42	30400	0.1	4550	3530	3380	82	17	43.498174	-79.656502
3008018	3	1991	11.8	23.6	23.6	37	29900	0.1	4520	3670	3050	82	17	43.498174	-79.656502
3008018	3	1991	10.7	21.8	21.8	36	28700	0.1	4180	3850	2660	82	17	43.498174	-79.656502
3008019	3	1991	6.7	84.2	84.2	110	20100	0.07	2160	5730	431	82	17	44.043621	-79.463372
3008019	3	1991	6.7	79.2	79.2	110	20800	0.07	2460	6110	440	82	17	44.043621	-79.463372
3008019	3	1991	6.9	85.4	85.4	110	19930	0.07	2400	5960	490	82	17	44.043621	-79.463372
3008020	3	1991	9.7	24.4	24.4	54	27100	0.15	4470	4130	405	82	17	43.597849	-79.518004
3008020	3	1991	10.5	27.8	27.8	53	29100	0.17	6130	4730	455	82	17	43.597849	-79.518004
3008020	3	1991	10.5	26.7	26.7	50	29700	0.08	4290	4520	401	82	17	43.597849	-79.518004
3008021	3	1991	5.4	17	17	130	21100	0.05	1487	3360	461	82	17	44.295616	-78.317542
3008021	3	1991	5.5	17	17	130	20000	0.04	1511	3310	452	82	17	44.295616	-78.317542
3008021	3	1991	6.1	18.2	18.2	130	21000	0.05	1772	3710	498	82	17	44.295616	-78.317542
3008021	3	1993	3.9	14	14	120	16000	0.16	1300	2800	240	82	17	44.295616	-78.317542
3008021	3	1993	4.2	15	15	140	16000	0.16	1400	2900	250	82	17	44.295616	-78.317542
3008022	3	1991	4.6	14	14	74	16690	0.05	1105	1981	360	82	17	43.885342	-78.883481
3008022	3	1991	4.6	14.4	14.4	76	15060	0.03	1258	2130	354	82	17	43.885342	-78.883481
3008022	3	1991	5.1	15.5	15.5	80	15610	0.05	1317	2270	370	82	17	43.885342	-78.883481
3008023	3	1991	6.3	12.8	12.8	49	19600	0.08	712	2080	349	82	17	45.323151	-79.210841
3008023	3	1991	6.8	12.9	12.9	51	18340	0.1	719	2050	400	82	17	45.323151	-79.210841
3008023	3	1991	7.9	14.1	14.1	48	21200	0.09	790	2390	465	82	17	45.323151	-79.210841

Station	Land Use	Year	Co	Cr	Cu	F	Fe	Hg	K	Mg	Mn	DATUM	ZONE	latitude	longitude
3008024	3	1991	6.6	18.4	18.4	55	18240	0.05	1684	2380	286	82	17	43.721321	-79.399879
3008024	3	1991	6.6	18.9	18.9	52	18520	0.05	1694	2490	284	82	17	43.721321	-79.399879
3008024	3	1991	7.1	20	20	52	21000	0.05	2040	2600	322	82	17	43.721321	-79.399879
3008025	3	1991	5.4	15.5	15.5	NA	14700	0.08	1760	3580	269	82	17	43.553012	-79.58218
3008025	3	1991	5.6	16.6	16.6	88	15300	0.16	1859	3770	277	82	17	43.553012	-79.58218
3008025	3	1991	6	17	17	95	16300	0.07	2300	3820	293	82	17	43.553012	-79.58218
3008026	3	1991	7.7	23.7	23.7	90	26100	0.16	3310	5920	603	82	17	44.358722	-78.745777
3008026	3	1991	7.4	24	24	91	25200	0.16	3850	6100	602	82	17	44.358722	-78.745777
3008026	3	1991	6.8	21.9	21.9	96	23200	0.16	3400	5610	489	82	17	44.358722	-78.745777
3008027	3	1991	5.7	16.1	16.1	30	20400	0.16	960	2080	785	82	17	44.396812	-79.710565
3008027	3	1991	5.6	16.8	16.8	26	20300	0.16	1023	2090	840	82	17	44.396812	-79.710565
3008027	3	1991	5.9	18.5	18.5	31	21600	0.16	1028	2390	810	82	17	44.396812	-79.710565
3008226	3	1993	4.2	16	9	94	15000	0.16	1200	2800	350	82	17	43.958879	-78.164203
3008226	3	1993	3.8	15	8	92	14000	0.16	1000	2700	350	82	17	43.958879	-78.164203
3008265	3	1992	4.9	14	19	67	13000	0.16	1600	3000	250	82	17	43.598699	-79.514811
3008265	3	1992	5.2	14	19	63	14000	0.16	1500	3200	250	82	17	43.598699	-79.514811
3008274	3	1993	7.1	25	25	99	19000	0.16	2300	4600	640	82	17	43.683568	-79.759257
3008274	3	1993	7.1	22	23	100	18000	0.16	2100	4300	610	82	17	43.683568	-79.759257
3008278	3	1993	6.5	37	49	89	21000	0.16	1400	3500	400	82	17	44.920577	-79.369853
3008278	3	1993	5.1	32	42	96	23000	0.16	1300	2800	370	82	17	44.920577	-79.369853
3008282	3	1993	3.2	12	8	56	14000	0.16	600	1800	180	82	17	44.105212	-79.117971
3008282	3	1993	2.8	12	5	52	14000	0.16	540	1700	170	82	17	44.105212	-79.117971
3008292	3	1993	3.3	13	11	53	14000	0.16	630	2000	270	82	17	43.339049	-79.778521
3008292	3	1993	3.4	13	11	64	13000	0.16	710	2100	270	82	17	43.339049	-79.778521

Station	Land Use	Year	Co	Cr	Cu	F	Fe	Hg	K	Mg	Mn	DATUM	ZONE	latitude	longitude
3008296	3	1993	7	22	16	100	21000	0.16	2200	4500	520	82	17	44.617938	-79.41336
3008296	3	1993	6.5	22	18	91	20000	0.16	2100	4200	530	82	17	44.617938	-79.41336
3008600	3	1993	3.3	12	12	67	10000	0.16	690	1800	200	82	17	43.676257	-79.347374
3008600	3	1993	3.5	13	12	70	11000	0.16	780	1900	230	82	17	43.676257	-79.347374
3008604	3	1993	3.3	14	15	110	11000	0.16	990	2900	210	82	17	43.670165	-79.299798
3008604	3	1993	4	13	16	120	12000	0.16	1100	3200	210	82	17	43.670165	-79.299798
3008608	3	1993	2.4	10	8	110	10000	0.16	600	3200	240	82	17	43.644607	-79.46282
3008608	3	1993	2.2	9	8	110	9600	0.16	550	3000	220	82	17	43.644607	-79.46282
3008612	3	1993	8.2	68	180	100	29000	0.16	1100	6200	390	82	17	43.60657	-79.494296
3008612	3	1993	4.2	16	21	110	14000	0.16	1900	4900	270	82	17	43.60657	-79.494296
3008616	3	1993	11	33	22	84	26000	0.16	4300	8300	640	82	17	43.698639	-79.518663
3008616	3	1993	11	32	23	83	25000	0.16	4200	8900	620	82	17	43.698639	-79.518663
4008001	9	1991	10.9	43	10.4	23	20100	0.05	2100	5800	549	82	18	45.559201	-74.457786
4008001	9	1991	11	49.2	11	27	20200	0.04	2180	5890	671	82	18	45.559201	-74.457786
4008001	9	1991	7.1	37.2	1.5	24.5	20700	0.04	2400	5910	602	82	18	45.559201	-74.457786
4008002	3	1991	6.7	27.7	16	120	15460	0.02	1261	3400	259	82	18	45.604983	-74.6027
4008002	3	1991	6.2	27.8	16	120	15790	0.02	1306	3340	258	82	18	45.604983	-74.6027
4008002	3	1991	3.4	22.9	8.1	130	19820	0.02	894	3790	303	82	18	45.604983	-74.6027
4008003	9	1991	6.4	22.2	21.4	6.3	21500	0.08	2430	3820	565	82	18	45.249984	-74.822395
4008003	9	1991	6.9	23.8	23	5.8	20300	0.08	2210	3880	590	82	18	45.249984	-74.822395
4008003	9	1991	3.7	20	12.3	35	23200	0.07	2140	3870	576	82	18	45.249984	-74.822395
4008004	9	1991	9.7	34.4	14.6	8.5	24800	0.06	6160	5960	1070	82	18	45.089424	-74.520196
4008004	9	1991	9.8	38.6	12.9	8.8	25500	0.07	6280	5980	1072	82	18	45.089424	-74.520196
4008004	9	1991	4.2	23.2	15.6	126	20900	0.05	4270	4650	682	82	18	45.089424	-74.520196

Station	Land Use	Year	Co	Cr	Cu	F	Fe	Hg	K	Mg	Mn	DATUM	ZONE	latitude	longitude
4008005	9	1991	8	30.5	15.9	24	19630	0.05	1507	4200	378	82	18	45.086498	-74.530971
4008005	9	1991	8	30.5	16	29	19200	0.07	1467	4150	371	82	18	45.086498	-74.530971
4008005	9	1991	8.2	27.8	18.6	26.2	20000	0.05	1325	4380	337	82	18	45.086498	-74.530971
4008006	3	1991	7.4	24.1	36.2	94	21900	0.07	2950	6290	390	82	18	45.001218	-74.7707
4008006	3	1991	7.6	25.2	39.3	97	22200	0.09	3340	6900	408	82	18	45.001218	-74.7707
4008006	3	1991	7.6	23.5	30.8	110	23600	0.07	3040	6350	403	82	18	45.001218	-74.7707
4008007	9	1991	11.4	40.2	384	135	29500	0.13	9720	9240	1095	82	18	45.088272	-75.35089
4008007	9	1991	12.2	44.2	438	130	31100	0.15	10550	9870	1112	82	18	45.088272	-75.35089
4008007	9	1991	10.9	31.7	304	168	29700	0.12	7080	8800	935	82	18	45.088272	-75.35089
4008008	3	1991	9.2	26.4	4.2	54	29600	0.12	1988	7200	752	82	18	44.704585	-75.520366
4008008	3	1991	9	25.4	4.9	50	29200	0.1	1953	6740	724	82	18	44.704585	-75.520366
4008008	3	1991	9.5	24.7	9.9	55	33500	0.12	1914	7310	694	82	18	44.704585	-75.520366
4008009	9	1991	5.6	21	7.9	29	16330	0.04	1650	2780	373	82	18	44.646813	-76.319666
4008009	9	1991	5.6	22.2	8.6	28	11680	0.03	1780	3060	377	82	18	44.646813	-76.319666
4008009	9	1991	6.5	24.8	11.4	11	15560	0.03	1698	3080	387	82	18	44.646813	-76.319666
4008010	9	1991	3.5	13.4	16.5	4	15280	0.18	990	1513	4660	82	18	44.62183	-75.987331
4008010	9	1991	3.7	13.6	17.3	6.5	16080	0.18	996	1587	5140	82	18	44.62183	-75.987331
4008010	9	1991	3.3	12.1	22.6	11.2	13170	0.18	1059	1644	4160	82	18	44.62183	-75.987331
4008012	3	1991	6.3	22.8	7.9	48	20400	0.07	2280	4670	1096	82	18	44.892349	-76.018265
4008012	3	1991	6.3	22.1	8	53	20200	0.06	2260	4320	912	82	18	44.892349	-76.018265
4008012	3	1991	5.8	19.9	10.1	55	18880	0.06	2000	3740	896	82	18	44.892349	-76.018265
4008013	9	1991	7	16.7	8.9	47.5	18210	0.02	1000	7230	399	82	18	45.017301	-76.361732
4008013	9	1991	5.8	14.6	9.9	42.5	16070	0.01	939	7140	391	82	18	45.017301	-76.361732
4008013	9	1991	7.9	17.2	12.7	44.5	17210	0.01	1088	6570	387	82	18	45.017301	-76.361732

Station	Land Use	Year	Co	Cr	Cu	F	Fe	Hg	K	Mg	Mn	DATUM	ZONE	latitude	longitude
4008014	9	1991	10.1	25.3	16	11	31800	0.09	1155	4580	1747	82	18	45.085887	-76.30224
4008014	9	1991	9	22	15.6	13	30400	0.09	1055	3950	1918	82	18	45.085887	-76.30224
4008014	9	1991	8.8	20.4	18	18	25800	0.09	1145	4410	1360	82	18	45.085887	-76.30224
4008015	3	1991	13.7	41.6	10.6	73	34100	0.08	4470	8180	489	82	18	44.246348	-76.535246
4008015	3	1991	13.6	41.9	9.6	82	34400	0.08	4730	8250	485	82	18	44.246348	-76.535246
4008015	3	1991	13.3	37.6	11.4	79	29600	0.08	4430	7240	455	82	18	44.246348	-76.535246
4008016	3	1991	5.2	16.9	8.7	73	19030	0.11	1545	3280	575	82	18	44.590904	-75.741375
4008016	3	1991	4.5	14.5	7.5	62	16110	0.1	1170	3010	377	82	18	44.590904	-75.741375
4008016	3	1991	5.4	16.5	8.2	65	18780	0.1	1588	3670	488	82	18	44.590904	-75.741375
4008017	9	1991	7	22.9	17.2	3.2	21500	0.05	1337	3170	743	82	18	44.871667	-75.799318
4008017	9	1991	6.2	15.6	15.8	3.4	12960	0.06	1637	3780	821	82	18	44.871667	-75.799318
4008017	9	1991	7	25	20.2	5	20500	0.06	1652	3700	801	82	18	44.871667	-75.799318
4008018	3	1991	8.9	30.5	11.2	44	21800	0.15	4790	4690	796	82	18	45.37362	-75.657498
4008018	3	1991	8.6	27	13.2	42	20800	0.14	3840	4040	797	82	18	45.37362	-75.657498
4008018	3	1991	8.7	29.5	12.7	35	22500	0.15	4020	4580	856	82	18	45.37362	-75.657498
4008019	9	1991	5.2	22.7	18.1	27	15910	0.08	1795	3520	303	82	18	45.010163	-75.639392
4008019	9	1991	5.8	23.7	11.5	27	17600	0.07	2140	4080	350	82	18	45.010163	-75.639392
4008019	9	1991	5.7	23.2	7.9	17	17510	0.08	2060	4110	347	82	18	45.010163	-75.639392
4008020	3	1991	2.7	9.9	12.4	94	13800	0.18	1790	4020	197	82	18	44.098285	-77.575918
4008020	3	1991	2.8	11	11.2	98	13200	0.08	1660	3930	189	82	18	44.098285	-77.575918
4008020	3	1991	3.1	11.5	15	96	14000	0.07	1660	3760	194	82	18	44.098285	-77.575918
4008021	9	1991	9.9	28.5	8.3	34	21200	0.11	3370	6690	502	82	18	44.186567	-77.073722
4008021	9	1991	8.8	27	5.9	35	21200	0.07	3200	6470	452	82	18	44.186567	-77.073722
4008021	9	1991	9.2	27.5	6.9	32	20200	0.07	3300	6270	497	82	18	44.186567	-77.073722

Station	Land Use	Year	Co	Cr	Cu	F	Fe	Hg	K	Mg	Mn	DATUM	ZONE	latitude	longitude
4008022	9	1991	4.8	19.6	5.2	24	12870	0.06	1850	2650	372	82	18	43.905627	-77.262997
4008022	9	1991	4.8	17.5	5.1	21	12870	0.06	2080	2650	388	82	18	43.905627	-77.262997
4008022	9	1991	4.6	16.7	6	17	12400	0.06	1814	2600	387	82	18	43.905627	-77.262997
4008023	3	1991	4.4	15	8.4	46	14600	0.02	960	2160	183	82	18	44.140203	-77.419554
4008023	3	1991	4.9	16.1	8.6	42	15830	0.02	1015	2270	225	82	18	44.140203	-77.419554
4008023	3	1991	4	14.8	6.7	52	13730	0.02	890	2020	181	82	18	44.140203	-77.419554
4008024	9	1991	6.2	14.4	40.1	12	21400	0.09	856	1945	1585	82	18	44.902411	-77.256303
4008024	9	1991	6.4	18.7	28.5	15	21600	0.07	1030	2280	947	82	18	44.902411	-77.256303
4008024	9	1991	6	13.7	29.9	14	21300	0.09	870	1905	1929	82	18	44.902411	-77.256303
4008025	9	1991	16.6	66.6	14.9	11	38400	0.04	7910	14220	945	82	18	45.465583	-76.698821
4008025	9	1991	16.2	56.5	15.5	35	38000	0.05	8050	14680	968	82	18	45.465583	-76.698821
4008025	9	1991	16	55.9	15.5	8.5	38200	0.05	7720	14370	938	82	18	45.465583	-76.698821
4008026	9	1991	9.6	22.8	17.5	105	34800	0.05	1753	4740	1490	82	18	45.543051	-77.110919
4008026	9	1991	10.8	23.5	13.5	112	34200	0.05	1663	4760	1476	82	18	45.543051	-77.110919
4008026	9	1991	9.8	27.2	11.7	128	35100	0.05	1610	5400	1499	82	18	45.543051	-77.110919
4008027	9	1991	9	24.9	4.9	11	32700	0.08	916	2990	1023	82	18	45.454238	-77.796318
4008027	9	1991	8.3	24.9	4.1	12	32600	0.08	866	3020	905	82	18	45.454238	-77.796318
4008027	9	1991	7.3	23.4	1.1	13	32600	0.08	775	2870	801	82	18	45.454238	-77.796318
4008440	3	1993	15	43	26	77.3	31000	0.23	5100	8500	660	82	18	44.224103	-76.489546
4008440	3	1993	13	33	23	95.7	26000	0.17	3900	7600	620	82	18	44.224103	-76.489546
4008441	3	1993	5.2	43	13	88.15	16000	0.06	1700	3000	210	82	18	44.235394	-76.530303
4008444	3	1993	5.5	16	12	92.4	14000	0.05	1500	7700	340	82	18	44.585105	-75.694376
4008444	3	1993	6.3	18	14	88.5	16000	0.06	1800	7300	360	82	18	44.585105	-75.694376
4008451	3	1993	11	38	17	143	25000	0.05	3100	6300	1400	82	18	45.393469	-75.675908

Station	Land Use	Year	Co	Cr	Cu	F	Fe	Hg	K	Mg	Mn	DATUM	ZONE	latitude	longitude
4008451	3	1993	8.9	33	13	158.6	23000	0.04	2800	5700	1100	82	18	45.393469	-75.675908
4008455	3	1993	6.5	25	11	60.35	21000	0.04	2200	9600	1100	82	18	45.133005	-76.147588
4008455	3	1993	6.4	23	10	62.05	20000	0.04	1700	9800	1100	82	18	45.133005	-76.147588
4008459	3	1993	8.2	29	12	124.5	21000	0.02	2500	6400	510	82	18	45.46997	-76.676655
4008459	3	1993	8.9	31	12	122.5	23000	0.01	2900	6900	560	82	18	45.46997	-76.676655
4008463	3	1993	6.4	27	9	110	16000	0.03	1900	4300	320	82	18	45.82101	-77.112958
4008463	3	1993	6	24	9	110	15000	0.03	1600	3800	270	82	18	45.82101	-77.112958
5008001	3	1991	3.3	15	6.8	53	8660	0.04	437	1255	136	82	17	46.30619	-78.561954
5008001	3	1991	3.4	13.8	12.6	41	7830	0.04	386	1202	132	82	17	46.30619	-78.561954
5008001	3	1991	0.2	8	1	41	7490	0.02	428	1190	93.8	82	17	46.30619	-78.561954
5008002	9	1991	7.2	33.7	4.8	24	20500	0.08	1297	3100	772	82	17	46.31845	-81.947994
5008002	9	1991	14.5	48.6	4	24	22500	0.11	1636	4630	1466	82	17	46.31845	-81.947994
5008002	9	1991	4	26.9	8.1	20	17190	0.02	746	3860	587	82	17	46.31845	-81.947994
5008003	3	1991	5.5	33.5	50.3	38	14040	0.08	577	3140	160	82	17	46.357565	-79.945339
5008003	3	1991	4.7	29.6	44.1	33	12150	0.06	594	2560	144	82	17	46.357565	-79.945339
5008003	3	1991	5.4	22	28.8	39	11110	0.04	460	2770	138	82	17	46.357565	-79.945339
5008004	9	1991	16	81.1	11.7	92	36000	0.02	4200	14890	489	82	17	46.445992	-80.304536
5008004	9	1991	16.6	85.8	7.4	94	37000	0.02	4340	14850	512	82	17	46.445992	-80.304536
5008004	9	1991	12.1	70.2	5.5	89	32900	0.01	4120	16200	518	82	17	46.445992	-80.304536
5008006	9	1991	8.5	37.2	5.1	27	17870	0.04	713	3990	213	82	17	45.728694	-79.069427
5008006	9	1991	8.7	37.9	3.5	15	18940	0.04	758	3900	211	82	17	45.728694	-79.069427
5008006	9	1991	4.9	33	16.5	25	18920	0.02	867	4470	222	82	17	45.728694	-79.069427
5008007	9	1991	13.9	23.1	2.4	48	30100	0.06	760	2130	320	82	17	46.11506	-79.408956
5008007	9	1991	6.3	17.3	5	39	25600	0.07	560	1207	174	82	17	46.11506	-79.408956

Station	Land Use	Year	Co	Cr	Cu	F	Fe	Hg	K	Mg	Mn	DATUM	ZONE	latitude	longitude
5008007	9	1991	7.7	17.9	7.8	35	29200	0.1	546	1414	188	82	17	46.11506	-79.408956
5008008	9	1991	2.9	18.7	9.9	10	7160	0.06	816	1212	89.2	82	17	46.301179	-79.099259
5008008	9	1991	3.7	25.6	10.7	3.4	10480	0.07	1270	1697	96.1	82	17	46.301179	-79.099259
5008008	9	1991	3.2	19.4	21.3	3.2	8510	0.06	958	1527	84.6	82	17	46.301179	-79.099259
5008009	9	1991	6.7	44.8	10.3	7	57200	0.2	878	2580	147	82	17	46.539147	-79.432149
5008009	9	1991	3.8	15.9	18.5	8.2	12210	0.06	502	748	158	82	17	46.539147	-79.432149
5008009	9	1991	4.3	16.5	25.9	3.2	11880	0.06	644	869	144	82	17	46.539147	-79.432149
5008010	9	1991	3.7	15.9	27.3	4.4	10130	0.07	535	863	208	82	17	46.980897	-79.92933
5008010	9	1991	6	29.6	35.5	4.6	16940	0.06	735	1927	173	82	17	46.980897	-79.92933
5008010	9	1991	5.5	28.4	51.6	4.6	16210	0.06	512	1824	143	82	17	46.980897	-79.92933
5008011	3	1991	13.9	64.2	12.7	86	24200	0.1	3450	9410	456	82	17	47.451131	-79.637923
5008011	3	1991	14.5	70.9	11.2	92	26200	0.09	3520	9670	469	82	17	47.451131	-79.637923
5008011	3	1991	11.8	60.3	13.9	88	24600	0.11	2880	7980	442	82	17	47.451131	-79.637923
5008012	3	1991	5.1	26.6	8.4	45	10210	0.05	994	4050	190	82	17	47.508078	-79.667526
5008012	3	1991	5.7	32.8	15.9	44	11120	0.05	811	4210	209	82	17	47.508078	-79.667526
5008012	3	1991	6.2	32.4	10	45	11190	0.05	1034	4540	230	82	17	47.508078	-79.667526
5008013	3	1991	5.2	23	37.6	34	11430	0.04	842	2220	206	82	17	47.83559	-80.101092
5008013	3	1991	5.3	23.4	31.6	34	11850	0.05	900	2190	269	82	17	47.83559	-80.101092
5008013	3	1991	4.6	20.2	29.5	34	11340	0.05	920	2160	258	82	17	47.83559	-80.101092
5008014	9	1991	5.2	28.7	30.2	86	17390	0.1	710	1933	185	82	17	48.565575	-80.608452
5008014	9	1991	13.1	57.6	22.5	91	30100	0.06	5010	10060	481	82	17	48.565575	-80.608452
5008014	9	1991	12.4	53	19	85	29900	0.06	4350	9450	471	82	17	48.565575	-80.608452
5008015	3	1991	6.1	30.4	33.6	44	13590	0.07	750	3310	224	82	17	48.460868	-81.330359
5008015	3	1991	5.1	25.4	26.2	50	11370	0.06	581	2940	182	82	17	48.460868	-81.330359

Station	Land Use	Year	Co	Cr	Cu	F	Fe	Hg	K	Mg	Mn	DATUM	ZONE	latitude	longitude
5008015	3	1991	4.8	23.7	22.2	45	11860	0.07	803	3470	192	82	17	48.460868	-81.330359
5008016	3	1991	8.2	38.1	2.9	91	18340	0.03	3090	14580	302	82	17	49.063897	-81.005791
5008016	3	1991	8.2	37.3	8.7	87	17120	0.03	3100	13580	296	82	17	49.063897	-81.005791
5008016	3	1991	7.4	31.7	8.5	88	17910	0.02	2690	13000	255	82	17	49.063897	-81.005791
5008017	9	1991	12.8	53.4	27.7	14	30400	0.06	4370	9060	506	82	17	47.544459	-83.214844
5008017	9	1991	3.1	16.4	36.9	10	9840	0.03	473	1203	188	82	17	47.544459	-83.214844
5008017	9	1991	3.2	16.8	47.2	19	10310	0.04	467	1257	172	82	17	47.544459	-83.214844
5008018	9	1991	4.5	18.8	28.6	96	10580	0.04	472	1647	325	82	16	47.937297	-84.751363
5008018	9	1991	10.2	39.3	9.8	90	22300	0.08	1003	5490	659	82	16	47.937297	-84.751363
5008018	9	1991	11	39.9	15.5	81	22100	0.09	991	5400	683	82	16	47.937297	-84.751363
5008019	9	1991	11.2	38	14.5	4.3	20400	0.09	1060	5520	652	82	16	48.619034	-85.218563
5008019	9	1991	3.7	17	16.6	9.4	13150	0.01	408	1195	88.5	82	16	48.619034	-85.218563
5008019	9	1991	4	18	16.6	3.1	13090	0.01	462	1291	99.9	82	16	48.619034	-85.218563
5008020	9	1991	1.8	9	15	4.4	5880	0.01	345	562	71.4	82	16	46.979136	-84.517184
5008020	9	1991	2	10.5	34.3	7.8	8240	0.04	314	540	72.4	82	16	46.979136	-84.517184
5008020	9	1991	2.4	14.1	43.1	3.3	11120	0.05	393	728	94.4	82	16	46.979136	-84.517184
5008021	3	1991	14.7	49.4	42.6	63	30500	0.08	4260	8870	628	82	16	46.539687	-84.341401
5008021	3	1991	16.4	59	38.9	71	33400	0.07	4360	9640	833	82	16	46.539687	-84.341401
5008021	3	1991	14.6	53.2	26.4	66	34800	0.09	4350	9080	695	82	16	46.539687	-84.341401
5008022	9	1991	2.6	12.4	32	73	12660	0.06	426	823	101	82	17	46.339724	-83.93706
5008022	9	1991	16.3	57	34.1	76	34200	0.04	5410	10170	593	82	17	46.339724	-83.93706
5008022	9	1991	15.9	59.4	39.5	65	33700	0.04	6140	11840	567	82	17	46.339724	-83.93706
5008023	9	1991	14.5	51.9	34	35	27400	0.05	4830	8960	618	82	17	46.34766	-83.740843
5008023	9	1991	10.4	62.9	47.8	38	21300	0.08	2090	5520	180	82	17	46.34766	-83.740843

Station	Land Use	Year	Co	Cr	Cu	F	Fe	Hg	K	Mg	Mn	DATUM	ZONE	latitude	longitude
5008023	9	1991	10.8	58.6	12.4	35	22900	0.07	2230	6200	190	82	17	46.34766	-83.740843
5008024	9	1991	10.5	55.5	20.4	15	21800	0.08	2100	6160	199	82	17	46.282293	-83.502618
5008024	9	1991	7.3	29.5	14.7	13	24700	0.08	1022	2600	254	82	17	46.282293	-83.502618
5008024	9	1991	7.1	27.7	9.9	16	22100	0.06	878	2410	240	82	17	46.282293	-83.502618
5008025	3	1991	4.1	17.1	128	70	9110	0.05	904	2220	106	82	17	46.190093	-82.944934
5008025	3	1991	4.4	19.7	37.1	69	8920	0.04	970	2280	120	82	17	46.190093	-82.944934
5008025	3	1991	4.1	17.9	39	79	9720	0.05	1150	2470	107	82	17	46.190093	-82.944934
5008026	3	1991	22.2	20.6	5.8	34	26800	0.1	747	2480	915	82	17	45.341226	-80.028451
5008026	3	1991	13.9	25.3	16.6	40	28600	0.15	833	3400	510	82	17	45.341226	-80.028451
5008026	3	1991	10.9	17.1	1	38	31800	0.12	882	2750	639	82	17	45.341226	-80.028451
5008027	9	1991	3	22.9	21.8	6.7	23600	0.06	900	2430	235	82	17	45.433773	-79.596785
5008027	9	1991	3.2	9.1	17.7	7.1	17180	0.05	379	618	212	82	17	45.433773	-79.596785
5008027	9	1991	3.6	10.4	21	6.4	20100	0.05	440	706	213	82	17	45.433773	-79.596785
5008070	3	1993	11	45	30	90.4	21000	0.02	3600	13000	480	82	17	49.271505	-81.612876
5008070	3	1993	9.4	41	29	101	20000	0.01	3400	17000	370	82	17	49.271505	-81.612876
5008076	3	1993	14	55	29	64.1	27000	0.04	4400	11000	500	82	17	49.416328	-82.428144
5008076	3	1993	15	54	32	64.1	26000	0.04	4200	10000	520	82	17	49.416328	-82.428144
5008079	3	1993	6.8	29	17	86.9	14000	0.03	1900	12000	320	82	17	49.077928	-81.023046
5008079	3	1993	6.8	30	18	83	14000	0.03	2100	9800	300	82	17	49.077928	-81.023046
5008084	3	1993	3.4	16	13	70.2	7000	0.03	370	2800	110	82	17	48.76983	-80.679949
5008084	3	1993	4.8	22	15	72.1	11000	0.04	1300	4400	190	82	17	48.76983	-80.679949
5008086	3	1993	3.6	19	14	71.3	8700	0.04	820	2500	140	82	17	48.482196	-81.213579
5008086	3	1993	3.4	19	15	80.7	8200	0.05	880	2500	170	82	17	48.482196	-81.213579
5008090	3	1993	3.3	16	8	36.4	8400	0.03	290	1600	110	82	17	47.674839	-81.728496

Station	Land Use	Year	Co	Cr	Cu	F	Fe	Hg	K	Mg	Mn	DATUM	ZONE	latitude	longitude
5008090	3	1993	3.5	16	8	51	7800	0.03	300	1800	100	82	17	47.674839	-81.728496
5008135	9	1995	0.2	4.5	18.8	53	15070	0.04	396	647	234	82	16	47.236424	-84.649335
5008135	9	1995	8.4	31	20	50	24000	0.05	590	4200	320	82	16	47.236424	-84.649335
5008136	9	1995	2.8	18	4	8.1	16000	0.07	540	1500	200	82	16	47.585374	-84.821282
5008136	9	1995	1.9	9	2	4.2	5100	0.02	430	610	94	82	16	47.585374	-84.821282
5008137	9	1995	1.5	14	1	3.3	17000	0.02	220	850	160	82	16	47.433315	-84.729431
5008137	9	1995	1.5	14	2	4.5	9200	0.06	320	800	100	82	16	47.433315	-84.729431
6008001	3	1991	8	35.8	80.4	58	28200	0.07	1084	3520	237	82	16	48.375002	-89.291434
6008001	3	1991	8.7	39	86.1	63	28300	0.07	1240	3770	254	82	16	48.375002	-89.291434
6008001	3	1991	8.5	36.8	93.8	67	29000	0.07	1115	3660	253	82	16	48.375002	-89.291434
6008002	9	1991	7.9	20.8	38.8	7.4	29000	0.1	863	2640	158	82	16	48.788737	-88.671654
6008002	9	1991	7.6	17.8	35.6	7.4	26000	0.12	748	2010	141	82	16	48.788737	-88.671654
6008002	9	1991	7.9	28.2	32.6	6.8	31600	0.13	900	3650	138	82	16	48.788737	-88.671654
6008003	3	1991	16.8	62.7	13.6	78	33600	0.04	3740	14950	503	82	16	49.010234	-88.268798
6008003	3	1991	17.2	62.1	13.7	78	33300	0.04	3860	15180	502	82	16	49.010234	-88.268798
6008003	3	1991	17	53.9	12.2	88	35000	0.04	3480	14570	469	82	16	49.010234	-88.268798
6008004	9	1991	5.9	19.3	27.8	69	15210	0.04	580	2990	232	82	16	48.839262	-87.521727
6008004	9	1991	6.4	20.8	24.2	68	16020	0.05	674	3370	244	82	16	48.839262	-87.521727
6008004	9	1991	5.9	19.2	26.4	61	15770	0.03	589	3320	192	82	16	48.839262	-87.521727
6008005	3	1991	7.6	46.4	8.4	23	26500	0.13	1124	4050	574	82	16	48.713733	-86.380552
6008005	3	1991	7.2	42.5	9.6	24	22900	0.1	1072	3780	489	82	16	48.713733	-86.380552
6008005	3	1991	7.8	48	8.1	27	25400	0.12	1187	4100	497	82	16	48.713733	-86.380552
6008006	3	1991	3	13.4	8.9	26	7520	0.04	479	1297	178	82	16	49.124168	-85.82926
6008006	3	1991	3.2	12.6	9.8	20	7510	0.04	541	1429	159	82	16	49.124168	-85.82926

Station	Land Use	Year	Co	Cr	Cu	F	Fe	Hg	K	Mg	Mn	DATUM	ZONE	latitude	longitude
6008007	9	1991	4.2	13.2	9.3	55	8660	0.02	601	8050	219	82	16	49.79431	-85.921562
6008007	9	1991	4.4	14.2	9.7	61	9180	0.02	644	8810	205	82	16	49.79431	-85.921562
6008007	9	1991	4.5	14.2	9.9	53	10130	0.02	631	8200	231	82	16	49.79431	-85.921562
6008008	3	1991	4.5	16.7	30.2	91	10940	0.04	652	15470	171	82	16	49.713871	-86.953989
6008008	3	1991	4.7	17.6	29.5	92	11900	0.02	850	16040	177	82	16	49.713871	-86.953989
6008008	3	1991	4.8	17.1	24.5	89	11700	0.02	840	15220	178	82	16	49.713871	-86.953989
6008009	9	1991	13.6	56.1	27.8	52	22700	0.03	836	6210	260	82	16	49.562205	-87.981578
6008009	9	1991	15.1	61.8	35.8	46	24000	0.03	966	6410	285	82	16	49.562205	-87.981578
6008009	9	1991	13.8	55.2	25.5	47	20800	0.03	826	6030	257	82	16	49.562205	-87.981578
6008010	9	1991	8.2	30	45.4	9.4	17100	0.13	1223	3060	952	82	16	48.271324	-89.389897
6008010	9	1991	8.6	28.5	49	11	17190	0.14	1552	3220	909	82	16	48.271324	-89.389897
6008010	9	1991	10.9	32.5	28.4	12	19320	0.1	1181	3430	1028	82	16	48.271324	-89.389897
6008011	9	1991	13.2	27.1	17.1	10	17820	0.13	1791	3120	1839	82	16	48.069741	-89.578564
6008011	9	1991	16.9	38.7	19.2	12	25000	0.11	1788	4060	1604	82	16	48.069741	-89.578564
6008011	9	1991	12.5	30.2	18.4	36	21600	0.1	1518	2700	1261	82	16	48.069741	-89.578564
6008012	9	1991	13.5	33.6	7.2	20	26200	0.02	872	3720	508	82	15	48.614356	-90.219652
6008012	9	1991	13.5	34.7	7.9	18	26500	0.02	949	3980	510	82	15	48.614356	-90.219652
6008012	9	1991	13.5	33	5.6	18	26000	0.01	942	3870	473	82	15	48.614356	-90.219652
6008013	9	1991	7.5	25.2	14.2	20	22100	0.05	938	2340	1347	82	15	48.671443	-91.130731
6008013	9	1991	6	21.6	15.9	25	18670	0.04	778	2010	1226	82	15	48.671443	-91.130731
6008013	9	1991	5.6	19.7	13.2	21	16220	0.05	795	1802	1266	82	15	48.671443	-91.130731
6008014	9	1991	2.5	9.7	16	40	7010	0.03	590	2430	66.7	82	15	48.759752	-92.620144
6008014	9	1991	2.5	10	17.4	45	6900	0.03	588	2650	69.6	82	15	48.759752	-92.620144
6008014	9	1991	2.3	9.3	16.5	43	7530	0.03	613	2300	70.8	82	15	48.759752	-92.620144

Station	Land Use	Year	Co	Cr	Cu	F	Fe	Hg	K	Mg	Mn	DATUM	ZONE	latitude	longitude
6008015	3	1991	5	20.4	16.9	54	12660	0.05	1895	6090	216	82	15	48.612106	-93.411525
6008015	3	1991	4.6	19.4	17.6	63	11400	0.05	1627	5530	189	82	15	48.612106	-93.411525
6008015	3	1991	4.9	20.4	20.4	53	14230	0.05	1868	5920	205	82	15	48.612106	-93.411525
6008016	9	1991	7.5	33	9.5	38	14110	0.02	641	3660	232	82	15	49.107977	-93.922574
6008016	9	1991	6.7	28.8	8.9	42	13160	0.02	569	3350	194	82	15	49.107977	-93.922574
6008016	9	1991	7.5	31.7	15.1	42	14660	0.01	635	3750	229	82	15	49.107977	-93.922574
6008017	3	1991	7	23.9	3.8	71	13950	0.01	2220	3880	299	82	15	49.762874	-94.481346
6008017	3	1991	6.9	25	4.1	90	12670	0.01	2130	3880	297	82	15	49.762874	-94.481346
6008017	3	1991	8.3	30.8	3.1	87	16190	0.02	3070	5080	415	82	15	49.762874	-94.481346
6008018	9	1991	2.7	12.3	39.9	16	12370	0.01	463	740	218	82	15	49.858922	-93.393495
6008018	9	1991	2.3	10.8	23.7	14	9520	0.01	438	720	192	82	15	49.858922	-93.393495
6008018	9	1991	2.3	10.9	17.2	11	8280	0.01	440	704	182	82	15	49.858922	-93.393495
6008019	9	1991	15.5	48	6.9	40	25000	0.06	2960	8180	1139	82	15	49.758324	-92.649888
6008019	9	1991	15.1	49.9	9	40	25400	0.05	2720	8620	814	82	15	49.758324	-92.649888
6008019	9	1991	18.2	60.2	8.7	35	28900	0.05	3640	9350	1140	82	15	49.758324	-92.649888
6008020	3	1991	4.9	15.6	18	10	14290	0.04	414	1545	123	82	15	49.412425	-91.659047
6008020	3	1991	5.6	17.1	18.8	9.1	14180	0.05	558	1842	152	82	15	49.412425	-91.659047
6008020	3	1991	6	17.3	19.3	9.6	14380	0.04	552	1840	159	82	15	49.412425	-91.659047
6008021	9	1991	13.3	32.6	16.6	66	23100	0.02	859	6520	274	82	15	49.04911	-90.482225
6008021	9	1991	11.7	29.1	8.1	66	22300	0.02	718	5040	228	82	15	49.04911	-90.482225
6008021	9	1991	10.2	25.8	6.4	69	19510	0.02	658	4440	194	82	15	49.04911	-90.482225
6008022	9	1991	6.2	21	56.6	34	10370	0.03	1287	2900	503	82	15	50.629722	-93.205481
6008022	9	1991	4.3	14.9	29.7	37	8210	0.02	948	1992	370	82	15	50.629722	-93.205481
6008022	9	1991	4.4	17	24.1	39	8650	0.02	1066	2320	383	82	15	50.629722	-93.205481

Station	Land Use	Year	Co	Cr	Cu	F	Fe	Hg	K	Mg	Mn	DATUM	ZONE	latitude	longitude
6008023	3	1991	16.4	28.6	41.6	68	18460	0.12	2840	4420	2000	82	15	51.015499	-93.822331
6008023	3	1991	11.5	26.1	42	69	16100	0.1	1948	3900	880	82	15	51.015499	-93.822331
6008023	3	1991	17.4	31.4	53.2	72	18690	0.09	2450	4760	1670	82	15	51.015499	-93.822331
6008024	3	1991	10.1	25.1	4.3	31	17770	0.04	491	3130	378	82	15	50.101921	-91.921662
6008024	3	1991	10.7	23.2	5.4	23	16920	0.05	478	2920	412	82	15	50.101921	-91.921662
6008024	3	1991	9.8	25	4.8	28	18560	0.05	623	3050	364	82	15	50.101921	-91.921662
6008025	9	1991	4.8	16	3.4	6.8	15400	0.05	389	1496	122	82	15	49.487828	-91.534788
6008025	9	1991	4.3	14.4	6.4	5.6	13720	0.05	466	1350	224	82	15	49.487828	-91.534788
6008025	9	1991	5.2	16	7.3	6.8	15430	0.04	427	1524	155	82	15	49.487828	-91.534788
6008026	9	1991	2.1	10.3	17.2	5.6	7330	0.01	230	642	45.6	82	15	51.463813	-90.163646
6008026	9	1991	4	17.5	18.2	8.1	10740	0.01	414	1329	76.8	82	15	51.463813	-90.163646
6008026	9	1991	2.5	10.8	19.8	3.9	6820	0.03	315	793	77.3	82	15	51.463813	-90.163646
6008027	9	1991	5.4	17.1	NA	46	11600	0.01	771	2510	130	82	15	50.243543	-90.709469
6008027	9	1991	5.6	18.3	NA	47	12110	0.01	770	2590	134	82	15	50.243543	-90.709469
6008027	9	1991	5.5	17.3	NA	47	11510	0.01	811	2590	134	82	15	50.243543	-90.709469
6008078	9	1992	14	42	43	20.7	29000	0.14	4000	7200	930	82	16	48.289464	-89.396784
6008078	9	1992	15	47	60	21.1	32000	0.13	3900	7300	1200	82	16	48.289464	-89.396784
6008108	3	1993	7	28	43	65.9	16000	0.1	1900	7000	310	82	16	48.942155	-88.256145
6008108	3	1993	9	39	42	76.6	18000	0.08	1900	7500	300	82	16	48.942155	-88.256145
6008129	9	1993	13	45	46	19.4	47000	0.06	1500	3100	270	82	16	48.344791	-89.285423
6008129	9	1993	11	39	39	NA	43000	0.07	1800	3200	310	82	16	48.344791	-89.285423
6008133	9	1994	4	16	9	84	9700	0.02	1200	9100	160	82	15	48.620287	-93.359622
6008133	9	1994	4	15	8	81	9400	0.01	1100	8900	160	82	15	48.620287	-93.359622
6008150	3	1995	21	72	32	NA	68000	0.07	1900	7500	2900	82	15	48.758671	-91.611566

Station	Land Use	Year	Co	Cr	Cu	F	Fe	Hg	K	Mg	Mn	DATUM	ZONE	latitude	longitude
6008150	3	1995	23	74	42	NA	73000	0.08	2000	7800	3400	82	15	48.758671	-91.611566

Table 21: OTR Data: Mo - Se

Station	Land Use	Year	Mo	Na	Ni	TKN	P	Pb	S	Sb	Se	DATUM	ZONE	latitude	longitude
1008001	9	1991	0.2	94	12	4.25	0.6	27.8	0.023	0.3	2.8	82	17	44.816458	-81.097171
1008001	9	1991	0.2	99	11.5	4.52	0.53	26.2	0.024	0.2	2.8	82	17	44.816458	-81.097171
1008001	9	1991	0.2	118	9.5	3.74	0.54	29	0.026	0.2	0.4	82	17	44.816458	-81.097171
1008002	3	1991	0.2	172	10.8	1.89	0.74	16.5	0.023	0.2	1.2	82	17	44.74259	-81.143784
1008002	3	1991	0.2	174	11.3	1.75	0.75	17.2	0.028	0.2	1	82	17	44.74259	-81.143784
1008002	3	1991	0.2	85	6.9	1.8	0.69	15	0.03	0.2	0.3	82	17	44.74259	-81.143784
1008003	3	1991	0.2	175	20.2	4.42	1.01	33.1	0.052	0.2	0.5	82	17	44.560393	-80.929447
1008003	3	1991	0.2	182	20.4	4.17	0.95	32.9	0.049	0.2	0.4	82	17	44.560393	-80.929447
1008003	3	1991	0.05	166	21	4.24	0.97	32	0.047	0.4	0.6	82	17	44.560393	-80.929447
1008004	9	1991	0.18	183	11.6	1.72	0.58	17.3	0.044	0.3	0.3	82	17	44.443944	-80.877824
1008004	9	1991	0.05	167	11.5	1.92	0.59	17.6	0.045	0.4	0.4	82	17	44.443944	-80.877824
1008004	9	1991	0.05	174	11.6	1.82	0.58	17.1	0.034	0.4	0.3	82	17	44.443944	-80.877824
1008005	9	1991	0.05	199	9.8	2.01	0.63	13	0.054	0.3	0.3	82	17	44.318789	-81.243305
1008005	9	1991	0.05	180	10.2	1.86	0.6	12.7	0.056	0.4	0.3	82	17	44.318789	-81.243305
1008005	9	1991	0.05	205	10.6	1.82	0.57	11.6	0.035	0.6	0.19	82	17	44.318789	-81.243305
1008006	3	1991	0.05	157	23	3.02	0.64	35.2	0.051	0.3	0.6	82	17	44.176422	-81.618168
1008006	3	1991	0.05	170	22.5	3.11	0.61	34.5	0.051	0.05	0.5	82	17	44.176422	-81.618168
1008006	3	1991	0.05	172	22.1	2.96	0.57	35.3	0.041	0.8	0.6	82	17	44.176422	-81.618168
1008007	9	1991	0.05	170	11.5	3.76	0.86	17.5	0.052	0.4	0.7	82	17	44.180986	-80.803078
1008007	9	1991	0.05	209	11.6	3.72	0.86	19.8	0.049	0.18	0.5	82	17	44.180986	-80.803078
1008007	9	1991	0.05	195	11.7	3.48	0.81	17.1	0.054	0.4	0.5	82	17	44.180986	-80.803078

Station	Land Use	Year	Mo	Na	Ni	TKN	P	Pb	S	Sb	Se	DATUM	ZONE	latitude	longitude
1008008	9	1991	0.16	192	22.4	3.06	0.78	26.5	0.054	0.4	0.3	82	17	43.671966	-80.722085
1008008	9	1991	0.05	196	23	2.98	0.77	24.9	0.064	0.2	0.3	82	17	43.671966	-80.722085
1008008	9	1991	0.05	198	22.3	3.05	0.74	24.8	0.048	0.6	0.3	82	17	43.671966	-80.722085
1008009	3	1991	0.05	139	10.1	2.67	0.77	23.2	0.073	0.05	0.4	82	17	42.759005	-81.189634
1008009	3	1991	0.05	170	11.1	2.65	0.77	26.4	0.066	0.18	0.5	82	17	42.759005	-81.189634
1008009	3	1991	0.05	142	10.2	2.51	0.72	22.7	0.077	0.05	0.4	82	17	42.759005	-81.189634
1008010	9	1991	1.3	57	9.4	2.13	0.49	21.9	0.063	0.1	0.4	82	17	42.088945	-82.438773
1008010	9	1991	1.3	55	9.6	2.26	0.53	22.4	0.066	0.05	0.4	82	17	42.088945	-82.438773
1008010	9	1991	1.4	83	11	2.26	0.53	23.8	0.06	0.05	0.3	82	17	42.088945	-82.438773
1008011	9	1991	1.2	111	19.2	2.38	0.55	21.4	0.074	0.3	0.6	82	17	42.228615	-82.795621
1008011	9	1991	1.3	74	18.3	2.67	0.57	19.3	0.082	0.2	0.6	82	17	42.228615	-82.795621
1008011	9	1991	1.2	77	19.8	2.57	0.55	19.3	0.066	0.2	0.5	82	17	42.228615	-82.795621
1008012	3	1991	0.7	139	18	2.59	0.54	49.9	0.086	0.3	0.75	82	17	42.300366	-83.05255
1008012	3	1991	0.9	87	17	2.57	0.54	48.3	0.084	0.3	0.7	82	17	42.300366	-83.05255
1008012	3	1991	0.9	113	18	2.38	0.49	48.6	0.088	0.2	0.7	82	17	42.300366	-83.05255
1008013	3	1991	0.8	183	11	1.75	0.57	16.2	0.056	0.3	0.3	82	17	42.402413	-82.149764
1008013	3	1991	0.8	167	11	1.71	0.59	17.3	0.084	0.2	0.3	82	17	42.402413	-82.149764
1008013	3	1991	0.9	176	11.2	1.73	0.55	17.5	0.065	0.12	0.3	82	17	42.402413	-82.149764
1008014	3	1991	0.5	119	22.4	3.17	0.76	23.7	0.05	0.05	0.6	82	17	42.589542	-82.4052
1008014	3	1991	0.7	121	23.3	3.22	0.77	24.8	0.047	0.05	0.6	82	17	42.589542	-82.4052
1008014	3	1991	0.4	141	22.7	3.21	0.76	24.1	0.045	0.05	0.6	82	17	42.589542	-82.4052
1008015	9	1991	0.9	132	16.1	2.71	0.56	19.3	0.052	0.05	0.2	82	17	42.881862	-82.18226
1008015	9	1991	0.8	117	16.9	2.7	0.56	18.5	0.039	0.3	0.3	82	17	42.881862	-82.18226
1008015	9	1991	0.8	114	17.5	2.69	0.56	19.4	0.049	0.05	0.3	82	17	42.881862	-82.18226

Station	Land Use	Year	Mo	Na	Ni	TKN	P	Pb	S	Sb	Se	DATUM	ZONE	latitude	longitude
1008016	3	1991	0.3	97	17.1	3.72	0.65	36.2	0.066	0.05	0.6	82	17	42.965156	-82.392349
1008016	3	1991	0.3	89	18.1	3.75	0.63	37	0.057	0.05	0.7	82	17	42.965156	-82.392349
1008016	3	1991	0.3	86	18.1	3.95	0.67	37.2	0.054	0.05	0.7	82	17	42.965156	-82.392349
1008017	9	1991	1	63	18.6	2.59	0.59	29.5	0.04	0.05	0.4	82	17	43.018985	-81.801795
1008017	9	1991	0.7	65	17.6	2.36	0.55	28.2	0.035	0.05	0.5	82	17	43.018985	-81.801795
1008017	9	1991	0.7	67	17	2.63	0.61	28.5	0.028	0.05	0.5	82	17	43.018985	-81.801795
1008018	9	1991	0.12	71	15.8	2.64	0.62	15.6	0.045	0.3	0.4	82	17	43.164124	-81.658251
1008018	9	1991	0.2	76	15.7	2.79	0.61	17.1	0.041	0.1	0.5	82	17	43.164124	-81.658251
1008018	9	1991	0.2	70	14.2	2.77	0.63	15.8	0.044	0.12	0.3	82	17	43.164124	-81.658251
1008019	9	1991	0.05	88	11.1	2.38	0.39	21.3	0.026	0.05	0.7	82	17	43.982597	-81.394438
1008019	9	1991	0.05	87	10.2	2.37	0.4	20.5	0.031	0.05	0.7	82	17	43.982597	-81.394438
1008019	9	1991	0.4	99	10.3	2.42	0.39	21.9	0.034	0.3	0.4	82	17	43.982597	-81.394438
1008020	3	1991	0.05	180	8.1	2.41	0.89	72.4	0.056	0.1	0.4	82	17	42.975671	-81.251887
1008020	3	1991	0.07	171	8	2.48	0.9	48.7	0.048	0.18	0.4	82	17	42.975671	-81.251887
1008020	3	1991	0.05	170	8.1	2.41	0.88	50.9	0.053	0.3	0.4	82	17	42.975671	-81.251887
1008021	9	1991	0.05	119	9.7	4.17	0.82	18.6	0.043	0.2	0.6	82	17	43.827738	-81.464929
1008021	9	1991	0.05	126	10	3.96	0.79	18.2	0.027	0.3	0.5	82	17	43.827738	-81.464929
1008021	9	1991	0.05	123	10.3	4.01	0.8	19.4	0.035	0.05	0.6	82	17	43.827738	-81.464929
1008022	9	1991	0.17	51	8.1	1.85	0.21	18.3	0.003	0.1	0.4	82	17	43.748683	-81.102879
1008022	9	1991	0.06	51	8.2	1.9	0.22	19.1	0.017	0.3	0.4	82	17	43.748683	-81.102879
1008022	9	1991	0.2	52	7.7	1.85	0.22	18.8	0.003	0.05	0.4	82	17	43.748683	-81.102879
1008023	9	1991	0.18	118	12	2.08	0.62	22.8	0.038	0.05	0.45	82	17	43.265706	-81.053305
1008023	9	1991	0.3	116	11.7	2.1	0.59	21.7	0.029	0.2	0.55	82	17	43.265706	-81.053305
1008023	9	1991	0.11	110	10.5	2.08	0.56	21.8	0.028	0.2	0.4	82	17	43.265706	-81.053305

Station	Land Use	Year	Mo	Na	Ni	TKN	P	Pb	S	Sb	Se	DATUM	ZONE	latitude	longitude
1008024	9	1991	0.05	127	14.8	3.09	0.7	18.4	0.033	0.3	0.4	82	17	43.6972	-81.477918
1008024	9	1991	0.05	121	14.5	3.12	0.72	18.2	0.027	0.1	0.3	82	17	43.6972	-81.477918
1008024	9	1991	0.05	128	15.1	2.85	0.7	19.4	0.019	0.05	0.4	82	17	43.6972	-81.477918
1008025	9	1991	0.13	101	18.7	2.38	0.56	28	0.022	0.4	0.5	82	17	43.357332	-81.456201
1008025	9	1991	0.2	110	18.3	2.48	0.59	29.6	0.024	0.2	0.5	82	17	43.357332	-81.456201
1008025	9	1991	0.6	110	18.6	2.48	0.47	26.1	0.02	0.3	0.5	82	17	43.357332	-81.456201
1008026	9	1991	0.05	130	18.8	2.34	0.62	20.3	0.022	0.05	0.4	82	17	43.622784	-81.502427
1008026	9	1991	0.05	129	19.6	2.62	0.7	24.1	0.018	0.05	0.4	82	17	43.622784	-81.502427
1008026	9	1991	0.05	133	19.8	2.67	0.71	22.5	0.02	0.12	0.4	82	17	43.622784	-81.502427
1008027	3	1991	0.05	146	18.4	3.08	0.77	41.7	0.048	0.3	0.4	82	17	43.356494	-80.988141
1008027	3	1991	0.05	151	18.1	2.97	0.75	30	0.026	0.3	0.5	82	17	43.356494	-80.988141
1008027	3	1991	0.05	145	18.2	3.09	0.78	29.3	0.022	0.4	0.5	82	17	43.356494	-80.988141
1008557	3	1993	0.5	120	10	3.2	1.06	44	NA	0.23	0.27	82	17	43.129473	-80.758462
1008557	3	1993	0.5	120	10	3.4	1.35	44	NA	0.36	0.28	82	17	43.129473	-80.758462
1008561	3	1993	0.5	100	11	4.8	1.49	68	NA	2.5	0.51	82	17	43.74293	-81.710213
1008561	3	1993	0.5	98	10	4.5	1.38	62	NA	2.3	0.52	82	17	43.74293	-81.710213
1008565	3	1993	1.5	110	23	5.8	1.8	120	0.077	0.65	0.88	82	17	42.880863	-82.146804
1008565	3	1993	1.4	100	22	5.6	1.84	110	0.076	0.94	0.81	82	17	42.880863	-82.146804
1008569	3	1993	0.7	120	13	3.1	0.7	46	NA	0.35	0.26	82	17	42.590103	-82.182446
1008569	3	1993	0.7	140	14	3.1	0.85	46	NA	0.32	0.2	82	17	42.590103	-82.182446
1008573	3	1993	0.5	150	9.2	3.5	0.78	39	NA	0.2	0.5	82	17	43.036371	-80.878788
1008573	3	1993	0.5	140	9.1	3.5	0.75	35	NA	0.2	0.49	82	17	43.036371	-80.878788
1008577	3	1993	0.5	120	6.1	1.9	0.72	17	NA	0.2	0.22	82	17	42.868375	-80.732977
1008577	3	1993	0.5	98	4.1	2.3	0.84	17	NA	0.2	0.2	82	17	42.868375	-80.732977

Station	Land Use	Year	Mo	Na	Ni	TKN	P	Pb	S	Sb	Se	DATUM	ZONE	latitude	longitude
2008001	9	1991	0.2	129	7.9	1.79	0.78	13.7	0.032	0.3	0.4	82	17	43.671864	-80.448376
2008001	9	1991	0.2	122	7.8	1.94	0.78	14.9	0.044	0.2	0.4	82	17	43.671864	-80.448376
2008001	9	1991	0.05	236	9	1.84	0.92	17	0.023	0.2	0.3	82	17	43.671864	-80.448376
2008001	9	1996	0.5	NA	18	NA	NA	240	NA	NA	NA	82	17	43.671864	-80.448376
2008001	9	1996	0.5	NA	17	NA	NA	220	NA	NA	NA	82	17	43.671864	-80.448376
2008002	9	1991	0.05	258	11.8	2.76	0.85	17	0.038	0.05	0.3	82	17	43.754512	-80.661085
2008002	9	1996	0.5	NA	20	NA	NA	300	NA	NA	NA	82	17	43.754512	-80.661085
2008002	9	1991	0.05	281	11.8	3.28	0.9	16.1	0.035	0.08	0.5	82	17	43.754512	-80.661085
2008002	9	1991	0.05	281	11.1	3.11	0.85	16.7	0.04	0.08	0.5	82	17	43.754512	-80.661085
2008002	9	1996	0.5	NA	19	NA	NA	310	NA	NA	NA	82	17	43.754512	-80.661085
2008003	9	1991	0.4	238	9.9	2.47	1.02	19.3	0.034	0.4	0.5	82	17	43.909576	-80.873879
2008003	9	1991	0.05	247	9.1	2.52	0.88	16.8	0.032	0.3	0.5	82	17	43.909576	-80.873879
2008003	9	1991	0.05	249	11.3	2.19	0.9	18.8	0.029	0.12	0.4	82	17	43.909576	-80.873879
2008003	9	1996	0.5	NA	17	NA	NA	93	NA	NA	NA	82	17	43.909576	-80.873879
2008003	9	1996	0.5	NA	17	NA	NA	130	NA	NA	NA	82	17	43.909576	-80.873879
2008004	9	1991	0.05	210	11.9	2.72	0.81	33	0.037	0.2	0.4	82	17	43.982017	-80.735219
2008004	9	1991	0.05	204	11.2	2.85	0.89	32.4	0.036	0.3	0.4	82	17	43.982017	-80.735219
2008004	9	1991	0.05	202	13.7	2.54	0.9	35.4	0.037	0.05	0.5	82	17	43.982017	-80.735219
2008005	9	1991	0.05	363	12.8	2.07	0.72	17.5	0.029	0.3	0.4	82	17	43.880183	-80.270894
2008005	9	1991	0.05	338	13.3	2.29	0.71	17.5	0.026	0.2	0.5	82	17	43.880183	-80.270894
2008005	9	1991	0.05	287	14.3	2.1	0.81	18.3	0.024	0.12	0.4	82	17	43.880183	-80.270894
2008006	9	1991	0.05	101	24.3	2.2	0.73	34.8	0.078	0.05	0.6	82	17	43.109197	-79.558093
2008006	9	1991	0.05	119	24.4	2.31	0.75	33.3	0.074	0.05	0.5	82	17	43.109197	-79.558093
2008006	9	1991	0.05	105	23.9	2.11	0.74	38.2	0.085	0.05	0.6	82	17	43.109197	-79.558093

Station	Land Use	Year	Mo	Na	Ni	TKN	P	Pb	S	Sb	Se	DATUM	ZONE	latitude	longitude
2008007	9	1991	0.05	192	5.6	1.94	0.74	12.5	0.046	0.2	0.05	208	17	42.75062	-80.26525
2008007	9	1991	0.14	176	5.5	1.72	0.64	11.4	0.052	0.3	0.11	208	17	42.75062	-80.26525
2008007	9	1991	0.05	188	5.5	2.03	0.65	12.5	0.054	0.1	0.12	208	17	42.75062	-80.26525
2008008	9	1991	0.05	134	5.3	2.19	0.71	23.8	0.063	0.4	0.3	82	17	42.668177	-80.412623
2008008	9	1991	0.05	120	5	2.32	0.71	23.7	0.073	0.2	0.09	82	17	42.668177	-80.412623
2008008	9	1991	0.05	131	4.8	2.25	0.72	22.3	0.065	0.05	0.3	82	17	42.668177	-80.412623
2008009	9	1991	0.05	117	17.4	4.36	0.78	27.5	0.089	0.05	0.4	82	17	42.885126	-80.100468
2008009	9	1991	0.05	128	21.1	4.09	0.79	30.1	0.094	0.12	0.4	82	17	42.885126	-80.100468
2008009	9	1991	0.05	116	20	5.21	0.9	29.9	0.099	0.2	0.4	82	17	42.885126	-80.100468
2008010	9	1991	0.05	88	9.6	1.28	0.7	24	0.034	0.08	0.05	82	17	43.196477	-80.010295
2008010	9	1991	0.05	107	9.7	1.26	0.67	22.2	0.036	0.3	0.05	82	17	43.196477	-80.010295
2008010	9	1991	0.05	83	9.8	1.44	0.69	22.4	0.05	0.6	0.11	82	17	43.196477	-80.010295
2008011	9	1991	0.05	79	23.3	3.27	0.92	39.9	0.082	0.05	0.5	82	17	43.011399	-79.915842
2008011	9	1991	0.05	77	21.6	3.26	0.85	44.1	0.082	0.05	0.6	82	17	43.011399	-79.915842
2008011	9	1991	0.2	74	26.2	3.73	0.97	45.8	0.065	0.08	0.3	82	17	43.011399	-79.915842
2008012	9	1991	0.05	90	5.6	1.36	0.37	16.9	0.052	0.05	0.2	208	17	42.678923	-80.62216
2008012	9	1991	0.05	93	5.8	1.32	0.38	15.8	0.035	0.05	0.2	208	17	42.678923	-80.62216
2008012	9	1991	0.05	99	6.4	1.41	0.4	16.1	0.046	0.12	0.3	208	17	42.678923	-80.62216
2008013	9	1991	0.05	133	9.7	2.88	0.94	30	0.052	0.05	0.3	82	17	43.398527	-80.625449
2008013	9	1991	0.05	114	10	3.01	0.91	35.8	0.055	0.1	0.4	82	17	43.398527	-80.625449
2008013	9	1991	0.05	112	9.5	3.49	1.02	33.2	0.045	0.05	0.3	82	17	43.398527	-80.625449
2008014	9	1991	0.5	68	45.9	3.76	1.44	59	0.068	0.05	1	82	17	42.901284	-79.040713
2008014	9	1991	0.6	46	49.3	4.25	1.42	69.8	0.101	0.12	1.6	82	17	42.901284	-79.040713
2008014	9	1991	0.7	41	49.4	4.04	1.42	62.1	0.098	0.4	2	82	17	42.901284	-79.040713

Station	Land Use	Year	Mo	Na	Ni	TKN	P	Pb	S	Sb	Se	DATUM	ZONE	latitude	longitude
2008015	9	1991	0.08	150	10.6	5.23	0.97	47.1	0.029	0.05	0.6	82	17	44.10093	-80.137487
2008015	9	1991	0.05	131	11.8	6.31	0.95	50.8	0.048	0.08	1	82	17	44.10093	-80.137487
2008015	9	1991	0.05	190	10.7	5.19	0.97	41.4	0.04	0.1	0.4	82	17	44.10093	-80.137487
2008016	9	1991	0.05	166	6.3	2.39	0.51	30.5	0.03	0.4	0.6	82	17	43.511826	-80.351047
2008016	9	1991	0.07	158	6.3	2.13	0.49	32.6	0.027	0.3	0.5	82	17	43.511826	-80.351047
2008016	9	1991	0.05	175	6.4	2.42	0.51	32	0.036	0.08	0.5	82	17	43.511826	-80.351047
2008017	9	1991	0.15	168	9.3	2.64	0.6	21.7	0.034	0.18	0.4	82	17	43.961897	-80.410923
2008017	9	1991	0.05	181	9.8	2.36	0.67	21.2	0.038	0.12	0.4	82	17	43.961897	-80.410923
2008017	9	1991	0.05	146	8.7	2.82	0.6	20.3	0.043	0.05	0.4	82	17	43.961897	-80.410923
2008018	3	1991	0.05	132	8.7	2.47	0.76	33.7	0.045	0.05	0.2	82	17	43.13393	-80.762489
2008018	3	1991	0.05	141	8.4	2.33	0.72	30.3	0.04	0.4	0.3	82	17	43.13393	-80.762489
2008018	3	1991	0.05	162	8.6	2.37	0.77	31.6	0.035	0.05	0.3	82	17	43.13393	-80.762489
2008019	3	1991	0.05	112	7.3	2.8	0.67	54.6	0.058	0.1	0.4	82	17	43.151025	-80.313147
2008019	3	1991	0.05	83	6.9	2.91	0.63	51.3	0.049	0.2	0.4	82	17	43.151025	-80.313147
2008019	3	1991	0.05	86	7.2	2.83	0.66	51.1	0.051	0.05	0.4	82	17	43.151025	-80.313147
2008020	3	1991	0.3	207	10.2	3.26	0.91	43.3	0.024	0.05	0.7	82	17	43.532327	-80.230359
2008020	3	1991	0.11	144	9.8	3.83	0.97	42.3	0.043	0.05	0.6	82	17	43.532327	-80.230359
2008020	3	1991	0.3	156	10.4	3.72	0.88	43.7	0.035	0.1	0.8	82	17	43.532327	-80.230359
2008021	3	1991	0.5	127	19.6	1.97	1.23	54.3	0.075	0.1	0.4	82	17	43.07213	-79.079335
2008021	3	1991	0.5	125	20.2	2.13	1.11	56.8	0.077	0.05	0.5	82	17	43.07213	-79.079335
2008021	3	1991	0.6	126	19.4	2.12	1	51	0.075	0.2	0.4	82	17	43.07213	-79.079335
2008022	3	1991	0.8	193	29.7	3.22	1.17	61.4	0.1	0.05	0.5	82	17	42.988082	-79.251346
2008022	3	1991	0.5	167	30.6	3.11	1.2	58.9	0.1	0.05	0.6	82	17	42.988082	-79.251346
2008022	3	1991	0.6	187	29.6	3.17	1.14	63	0.116	0.2	0.5	82	17	42.988082	-79.251346

Station	Land Use	Year	Mo	Na	Ni	TKN	P	Pb	S	Sb	Se	DATUM	ZONE	latitude	longitude
2008023	3	1991	0.1	111	7.6	3.01	0.81	41.3	0.076	0.12	1.8	82	17	42.887559	-79.245397
2008023	3	1991	0.13	96	7.8	2.94	0.79	37.9	0.082	0.05	2	82	17	42.887559	-79.245397
2008023	3	1991	0.07	84	7.6	2.96	0.81	36.7	0.077	0.05	1.7	82	17	42.887559	-79.245397
2008024	3	1991	0.13	139	10.3	2.09	0.8	22	0.046	0.05	0.17	82	17	43.366353	-80.332692
2008024	3	1991	0.05	140	13.3	1.86	0.78	21.7	0.04	0.05	0.13	82	17	43.366353	-80.332692
2008024	3	1991	0.05	123	11.8	1.91	0.77	20.5	0.04	0.15	0.15	82	17	43.366353	-80.332692
2008025	3	1991	0.3	69	6.1	0.94	0.81	81.1	0.049	0.4	0.12	82	17	43.238999	-79.830218
2008025	3	1991	0.4	69	6	1.1	0.83	95.6	0.051	0.08	0.3	82	17	43.238999	-79.830218
2008025	3	1991	0.3	63	6	0.99	0.9	80.6	0.054	0.2	0.4	82	17	43.238999	-79.830218
2008026	3	1991	0.8	144	24.9	16.07	1.14	54.4	0.012	0.3	3.2	82	17	43.45705	-80.45592
2008026	3	1991	0.7	114	23.8	17.01	1.12	57.4	0.009	0.2	2.3	82	17	43.45705	-80.45592
2008026	3	1991	0.8	108	25	17.1	1.12	52.5	0.002	0.15	2.4	82	17	43.45705	-80.45592
2008027	3	1991	0.05	86	8.7	2.54	0.53	49.6	0.085	0.05	0.05	82	17	43.144121	-79.238751
2008027	3	1991	0.05	92	10.4	2.47	0.51	49.8	0.085	0.2	0.3	82	17	43.144121	-79.238751
2008027	3	1991	0.05	86	9.5	2.42	0.51	49.5	0.096	0.05	0.3	82	17	43.144121	-79.238751
2008302	3	1993	0.5	86	9.8	2.6	0.95	50	0.039	0.78	0.35	82	17	43.356699	-80.320248
2008302	3	1993	0.5	94	10	2.8	1.08	83	0.033	0.95	0.35	82	17	43.356699	-80.320248
2008305	3	1993	0.5	92	7.4	2.6	1.02	18	0.038	0.2	0.2	82	17	43.453897	-80.472931
2008305	3	1993	0.5	97	7.3	2.8	1.15	17	0.038	0.2	0.2	82	17	43.453897	-80.472931
2008400	3	1993	1.1	54	33	6.7	1.44	42	NA	0.41	0.52	82	17	42.997104	-79.258942
2008400	3	1993	1.4	65	35	7.6	1.74	40	NA	0.45	0.61	82	17	42.997104	-79.258942
2008501	3	1993	0.6	67	13	5.8	1.08	47	0.102	0.58	1.4	82	17	43.55245	-80.235451
2008501	3	1993	0.8	61	12	6.2	1.22	49	0.105	0.71	1.3	82	17	43.55245	-80.235451
2008505	3	1993	0.5	48	14	3.6	1.13	140	0.054	2.6	0.72	82	17	43.267713	-79.88221

Station	Land Use	Year	Mo	Na	Ni	TKN	P	Pb	S	Sb	Se	DATUM	ZONE	latitude	longitude
2008505	3	1993	0.5	46	12	3.1	0.99	120	0.05	2.6	0.65	82	17	43.267713	-79.88221
3008001	9	1991	0.2	229	9.7	1.99	0.77	17.7	0.037	0.2	0.3	82	17	44.129388	-79.608149
3008001	9	1991	0.2	240	8.3	2.01	0.75	19.7	0.035	0.4	0.3	82	17	44.129388	-79.608149
3008001	9	1991	0.2	298	10.9	2.04	0.8	20.3	0.031	0.2	0.2	82	17	44.129388	-79.608149
3008002	9	1991	0.05	362	16.1	2.37	0.7	13.6	0.048	0.4	0.2	82	17	44.151916	-79.898729
3008002	9	1991	0.05	381	17.1	2.37	0.68	14	0.047	0.3	0.2	82	17	44.151916	-79.898729
3008002	9	1991	0.5	353	13.6	2.37	0.77	14	0.047	0.7	0.2	82	17	44.151916	-79.898729
3008003	9	1991	0.09	605	10.1	3.68	1.06	20.9	0.054	0.4	0.4	82	17	44.705792	-79.64149
3008003	9	1991	0.09	610	9.5	3.96	1.05	20.8	0.055	0.12	0.6	82	17	44.705792	-79.64149
3008003	9	1991	0.05	623	9.7	3.72	1.06	20	0.045	0.3	0.6	82	17	44.705792	-79.64149
3008004	9	1991	0.5	371	7.8	2.29	0.93	25.4	0.062	0.05	0.3	82	17	44.937813	-78.713223
3008004	9	1991	0.18	438	7.6	1.94	0.98	23.3	0.059	0.05	0.3	82	17	44.937813	-78.713223
3008004	9	1991	0.15	431	7.5	1.84	0.98	26.7	0.055	0.05	0.3	82	17	44.937813	-78.713223
3008005	9	1991	0.05	165	9.7	2.07	1.23	17	0.057	0.1	0.3	82	17	44.304494	-77.950776
3008005	9	1991	0.05	180	9.1	2.05	1.23	16.3	0.054	0.05	0.3	82	17	44.304494	-77.950776
3008005	9	1991	0.05	237	9.5	2.33	1.19	16.5	0.056	0.2	0.3	82	17	44.304494	-77.950776
3008006	9	1991	0.16	252	5.4	2.2	0.9	75.7	0.044	0.05	0.4	82	18	44.048525	-77.741013
3008006	9	1991	0.1	240	4.9	2.05	0.92	70.2	0.038	0.05	0.4	82	18	44.048525	-77.741013
3008006	9	1991	0.05	233	5	1.74	0.95	76.3	0.03	0.08	0.2	82	18	44.048525	-77.741013
3008007	9	1991	0.3	148	5.2	2.17	0.78	37.2	0.036	0.05	1	82	17	43.724712	-79.95708
3008007	9	1991	0.3	205	5.2	1.93	0.82	29.8	0.035	0.25	0.8	82	17	43.724712	-79.95708
3008007	9	1991	0.6	112	6.2	2.14	0.7	31.6	0.044	0.05	0.8	82	17	43.724712	-79.95708
3008008	9	1991	0.8	239	7.7	2.86	0.81	14.5	0.037	0.15	0.3	82	17	44.060396	-78.611093
3008008	9	1991	0.7	241	7.7	3.33	0.82	19.4	0.035	0.15	0.4	82	17	44.060396	-78.611093

Station	Land Use	Year	Mo	Na	Ni	TKN	P	Pb	S	Sb	Se	DATUM	ZONE	latitude	longitude
3008008	9	1991	0.2	192	6.8	3.14	0.91	22.1	0.039	0.4	0.6	82	17	44.060396	-78.611093
3008009	9	1991	0.13	231	7	1.88	0.64	16.1	0.028	0.05	0.35	82	17	44.921885	-78.064296
3008009	9	1991	0.3	241	7.1	1.86	0.6	16.1	0.042	0.05	0.4	82	17	44.921885	-78.064296
3008009	9	1991	0.05	246	8	2.42	0.8	16.5	0.042	0.05	0.3	82	17	44.921885	-78.064296
3008010	9	1991	0.3	193	9.4	2.8	0.98	18.8	0.045	0.08	0.3	82	17	44.561536	-78.862881
3008010	9	1991	0.05	188	9.8	2.75	0.96	18.6	0.05	0.05	0.6	82	17	44.561536	-78.862881
3008010	9	1991	0.05	318	9.6	2.08	1.03	20.1	0.039	0.05	0.3	82	17	44.561536	-78.862881
3008011	9	1991	0.05	128	4	2.4	0.83	32.5	0.049	0.5	0.8	82	17	44.164546	-79.005658
3008011	9	1991	0.05	154	4	2.31	0.87	33.4	0.025	0.3	0.8	82	17	44.164546	-79.005658
3008011	9	1991	0.05	166	4.2	2.21	0.8	30.7	0.042	0.5	0.8	82	17	44.164546	-79.005658
3008012	9	1991	0.06	90	13.1	3.21	0.58	24.9	0.064	0.05	0.8	82	17	43.999372	-78.127351
3008012	9	1991	0.2	98	12.7	3.32	0.62	29.1	0.077	0.05	0.7	82	17	43.999372	-78.127351
3008012	9	1991	0.11	93	13.2	3.08	0.59	27.6	0.06	0.08	0.8	82	17	43.999372	-78.127351
3008013	9	1991	0.05	274	5.3	1.62	0.66	25.9	0.044	0.4	0.5	82	17	45.443606	-78.818309
3008013	9	1991	0.05	278	5.4	1.59	0.63	26.6	0.042	0.8	0.5	82	17	45.443606	-78.818309
3008013	9	1991	0.1	290	5.1	1.39	0.69	26.1	0.042	0.2	0.2	82	17	45.443606	-78.818309
3008014	9	1991	0.05	96	12.6	1.18	0.67	26.5	0.029	0.4	0.6	82	17	43.875236	-78.778045
3008014	9	1991	0.05	108	13.4	1.11	0.65	24.4	0.019	0.6	0.4	82	17	43.875236	-78.778045
3008014	9	1991	0.05	101	13.8	1.08	0.63	23.6	0.024	0.05	0.6	82	17	43.875236	-78.778045
3008015	9	1991	0.05	521	6.1	2.14	0.78	12.2	0.031	0.05	0.3	82	17	44.086538	-78.632124
3008015	9	1991	0.05	548	8.1	2.23	0.77	12.8	0.036	0.05	0.4	82	17	44.086538	-78.632124
3008015	9	1991	0.2	469	7	2.12	0.8	13.7	0.025	0.2	0.3	82	17	44.086538	-78.632124
3008016	9	1991	0.05	226	22.7	1.92	0.9	12.7	0.056	0.05	0.19	82	17	44.579151	-79.86651
3008016	9	1991	0.05	246	22.5	1.75	0.85	15.8	0.039	0.05	0.25	82	17	44.579151	-79.86651

Station	Land Use	Year	Mo	Na	Ni	TKN	P	Pb	S	Sb	Se	DATUM	ZONE	latitude	longitude
3008016	9	1991	0.05	272	18.9	2.05	1.07	12.8	0.034	0.05	0.25	82	17	44.579151	-79.86651
3008017	9	1991	0.7	136	19.8	2.99	0.94	27.5	0.047	0.1	0.3	82	17	44.536002	-78.72486
3008017	9	1991	0.6	120	20.9	2.67	0.82	33.2	0.046	0.2	0.3	82	17	44.536002	-78.72486
3008017	9	1991	0.6	134	15.7	3.03	0.97	31.2	0.03	0.2	0.3	82	17	44.536002	-78.72486
3008018	3	1991	0.05	82	10.4	2.04	1.11	56	0.027	0.2	0.9	82	17	43.498174	-79.656502
3008018	3	1991	0.05	95	11.7	1.98	1.05	53	0.029	0.2	0.7	82	17	43.498174	-79.656502
3008018	3	1991	0.05	119	11.7	1.68	0.89	47.7	0.04	0.4	0.4	82	17	43.498174	-79.656502
3008019	3	1991	0.5	476	21.1	2.9	1.05	17.3	0.044	0.05	0.4	82	17	44.043621	-79.463372
3008019	3	1991	0.05	515	30.3	2.8	1.04	17.1	0.054	0.2	0.5	82	17	44.043621	-79.463372
3008019	3	1991	0.14	536	23.6	3.27	1.04	17	0.062	0.18	0.3	82	17	44.043621	-79.463372
3008020	3	1991	0.05	144	7	2.84	1.31	106	0.067	0.4	0.9	82	17	43.597849	-79.518004
3008020	3	1991	0.05	184	6.9	2.89	1.41	117	0.065	0.3	0.9	82	17	43.597849	-79.518004
3008020	3	1991	0.4	173	6.8	2.61	1.14	112	0.059	0.6	0.6	82	17	43.597849	-79.518004
3008021	3	1991	0.05	251	6.5	1.21	1.04	11.5	0.047	0.05	0.4	82	17	44.295616	-78.317542
3008021	3	1991	0.05	266	5.9	1.13	1.04	11.5	0.048	0.05	0.4	82	17	44.295616	-78.317542
3008021	3	1991	0.16	370	5.9	1.28	1.01	11.8	0.048	0.05	0.3	82	17	44.295616	-78.317542
3008021	3	1993	0.5	170	8.5	3	1.34	45	NA	0.48	0.3	82	17	44.295616	-78.317542
3008021	3	1993	0.5	180	8.6	3.2	1.39	51	NA	0.83	0.28	82	17	44.295616	-78.317542
3008022	3	1991	0.14	181	6.4	2.16	0.83	22.3	0.036	0.2	0.3	82	17	43.885342	-78.883481
3008022	3	1991	0.06	198	5.8	2.46	0.73	20.1	0.061	0.2	0.7	82	17	43.885342	-78.883481
3008022	3	1991	0.5	209	6.1	2.28	0.67	23	0.056	0.2	0.6	82	17	43.885342	-78.883481
3008023	3	1991	0.2	173	9.3	2.83	0.88	24.9	0.084	0.05	0.6	82	17	45.323151	-79.210841
3008023	3	1991	0.3	160	11.4	2.8	0.95	27.7	0.071	0.08	0.6	82	17	45.323151	-79.210841
3008023	3	1991	0.3	204	11.8	2.74	0.87	25	0.073	0.08	0.5	82	17	45.323151	-79.210841

Station	Land Use	Year	Mo	Na	Ni	TKN	P	Pb	S	Sb	Se	DATUM	ZONE	latitude	longitude
3008024	3	1991	0.05	133	11.9	0.98	0.74	31	0.02	0.05	0.5	82	17	43.721321	-79.399879
3008024	3	1991	0.05	173	10.8	0.99	0.65	27.5	0.029	0.2	0.2	82	17	43.721321	-79.399879
3008024	3	1991	0.05	196	12.8	0.94	0.74	32.6	0.024	0.2	0.5	82	17	43.721321	-79.399879
3008025	3	1991	0.05	220	9.4	2.22	0.94	35.7	0.042	0.05	0.4	82	17	43.553012	-79.58218
3008025	3	1991	0.15	217	10.7	2.4	0.91	37.3	0.051	0.2	0.2	82	17	43.553012	-79.58218
3008025	3	1991	0.05	294	9.8	2.31	0.92	34.9	0.042	0.05	0.4	82	17	43.553012	-79.58218
3008026	3	1991	0.5	242	8.6	3.81	1.03	39.2	0.072	0.12	0.8	82	17	44.358722	-78.745777
3008026	3	1991	0.05	288	8	3.88	1.07	36.4	0.078	0.15	0.7	82	17	44.358722	-78.745777
3008026	3	1991	0.05	228	9	3.8	1.1	38.5	0.062	0.18	0.7	82	17	44.358722	-78.745777
3008027	3	1991	0.05	219	10.7	1.58	0.68	24.5	0.024	0.05	0.5	82	17	44.396812	-79.710565
3008027	3	1991	0.05	190	10.5	1.57	0.73	24.7	0.024	0.1	0.5	82	17	44.396812	-79.710565
3008027	3	1991	0.6	268	11.4	1.51	0.61	30.3	0.028	0.05	0.3	82	17	44.396812	-79.710565
3008226	3	1993	0.5	170	8.2	3.1	1.23	29	0.029	0.28	0.39	82	17	43.958879	-78.164203
3008226	3	1993	0.5	160	7.6	3.7	1.46	24	0.048	0.3	0.41	82	17	43.958879	-78.164203
3008265	3	1992	0.5	95	14	2.3	0.8	39	0.047	0.28	0.2	82	17	43.598699	-79.514811
3008265	3	1992	0.5	100	14	2.4	0.82	39	0.044	0.2	0.31	82	17	43.598699	-79.514811
3008274	3	1993	0.5	140	16	3.4	1.37	61	0.069	0.71	0.38	82	17	43.683568	-79.759257
3008274	3	1993	0.5	140	15	3.3	1.36	55	0.059	0.48	0.33	82	17	43.683568	-79.759257
3008278	3	1993	0.5	230	68	3.8	1.37	200	0.068	0.86	0.37	82	17	44.920577	-79.369853
3008278	3	1993	0.5	160	85	4	1.41	250	0.052	0.9	0.36	82	17	44.920577	-79.369853
3008282	3	1993	0.5	190	7.5	3.5	0.79	22	0.044	0.24	0.25	82	17	44.105212	-79.117971
3008282	3	1993	0.5	160	6.4	3	0.66	22	0.044	0.2	0.22	82	17	44.105212	-79.117971
3008292	3	1993	0.5	72	7.4	2	0.75	31	0.019	0.37	0.28	82	17	43.339049	-79.778521
3008292	3	1993	0.5	89	6.3	2.4	0.85	31	0.024	0.35	0.27	82	17	43.339049	-79.778521

Station	Land Use	Year	Mo	Na	Ni	TKN	P	Pb	S	Sb	Se	DATUM	ZONE	latitude	longitude
3008296	3	1993	0.5	240	12	4.2	1.85	60	0.055	0.3	0.28	82	17	44.617938	-79.41336
3008296	3	1993	0.5	230	11	4.8	2.27	63	0.066	0.35	0.27	82	17	44.617938	-79.41336
3008600	3	1993	0.5	110	8.4	2.8	0.85	69	0.026	0.99	0.38	82	17	43.676257	-79.347374
3008600	3	1993	0.5	110	9.1	2.3	0.77	69	0.034	1.1	0.35	82	17	43.676257	-79.347374
3008604	3	1993	0.5	170	8.9	2.7	0.99	61	0.054	0.61	0.29	82	17	43.670165	-79.299798
3008604	3	1993	0.5	170	9.3	3.7	1.15	61	0.045	1.2	0.26	82	17	43.670165	-79.299798
3008608	3	1993	0.5	150	6.8	1.9	1.12	32	0.025	0.5	0.23	82	17	43.644607	-79.46282
3008608	3	1993	0.5	140	6.4	2	0.88	32	0.031	0.41	0.2	82	17	43.644607	-79.46282
3008612	3	1993	2.2	190	70	2.4	0.94	740	0.029	0.84	0.42	82	17	43.60657	-79.494296
3008612	3	1993	0.5	140	11	2.8	1.09	100	0.039	0.81	0.43	82	17	43.60657	-79.494296
3008616	3	1993	0.5	380	26	2.5	0.99	29	0.042	0.35	0.39	82	17	43.698639	-79.518663
3008616	3	1993	0.5	420	26	2.5	0.82	37	0.047	0.38	0.52	82	17	43.698639	-79.518663
4008001	9	1991	0.05	288	12.3	2.2	0.73	18.7	0.019	0.2	0.3	82	18	45.559201	-74.457786
4008001	9	1991	0.05	273	12.1	2.02	0.67	18.2	0.029	0.05	0.4	82	18	45.559201	-74.457786
4008001	9	1991	0.2	368	10.2	1.93	0.64	13.2	0.027	0.4	0.2	82	18	45.559201	-74.457786
4008002	3	1991	0.05	288	12.2	1.31	0.9	11.4	0.024	0.05	0.16	82	18	45.604983	-74.6027
4008002	3	1991	0.05	278	12.4	1.46	0.83	12.6	0.024	0.05	0.16	82	18	45.604983	-74.6027
4008002	3	1991	0.2	305	10.2	1.43	0.88	9.4	0.027	0.2	0.2	82	18	45.604983	-74.6027
4008003	9	1991	0.2	336	19.4	3.77	1.3	21.1	0.063	0.3	0.6	82	18	45.249984	-74.822395
4008003	9	1991	0.2	359	19.2	3.3	1.3	17.6	0.051	0.18	0.6	82	18	45.249984	-74.822395
4008003	9	1991	0.6	304	13.4	3.56	1.23	16.9	0.053	0.2	0.5	82	18	45.249984	-74.822395
4008004	9	1991	0.05	232	13.7	3.6	2.28	25.1	0.054	0.08	0.4	82	18	45.089424	-74.520196
4008004	9	1991	0.1	218	13.8	3.58	2.29	25.5	0.047	0.2	0.4	82	18	45.089424	-74.520196
4008004	9	1991	0.3	122	15.4	3.47	2.14	17.2	0.047	0.2	0.2	82	18	45.089424	-74.520196

Station	Land Use	Year	Mo	Na	Ni	TKN	P	Pb	S	Sb	Se	DATUM	ZONE	latitude	longitude
4008005	9	1991	0.05	226	15.3	2.78	0.83	21.3	0.053	0.1	0.4	82	18	45.086498	-74.530971
4008005	9	1991	0.11	226	15.9	2.61	0.79	21.3	0.059	0.05	0.4	82	18	45.086498	-74.530971
4008005	9	1991	0.2	201	15.6	2.7	0.76	19.4	0.045	0.05	0.3	82	18	45.086498	-74.530971
4008006	3	1991	0.05	171	24.4	2.29	0.82	22.3	0.037	0.08	0.4	82	18	45.001218	-74.7707
4008006	3	1991	0.05	181	25.8	2.19	0.87	23.6	0.032	0.05	0.4	82	18	45.001218	-74.7707
4008006	3	1991	0.2	190	23.2	2.37	0.76	22.7	0.045	0.05	0.3	82	18	45.001218	-74.7707
4008007	9	1991	0.05	179	20.8	4.33	2.16	35.5	0.056	0.2	0.5	82	18	45.088272	-75.35089
4008007	9	1991	0.05	201	20.7	4.49	2.09	38.1	0.058	0.05	0.5	82	18	45.088272	-75.35089
4008007	9	1991	0.2	147	20.2	4.37	1.94	36.3	0.068	0.2	0.3	82	18	45.088272	-75.35089
4008008	3	1991	2.2	145	8.5	4.57	1.2	114	0.066	0.2	0.8	82	18	44.704585	-75.520366
4008008	3	1991	1.5	159	8.9	4.83	1.18	121	0.08	0.4	0.9	82	18	44.704585	-75.520366
4008008	3	1991	2.9	174	10.4	4.75	1.06	107	0.088	0.4	1	82	18	44.704585	-75.520366
4008009	9	1991	0.2	123	6	2.18	0.81	20.1	0.04	0.2	0.2	82	18	44.646813	-76.319666
4008009	9	1991	0.2	136	6.4	2.46	0.86	21.9	0.037	0.2	0.2	82	18	44.646813	-76.319666
4008009	9	1991	0.2	195	6.1	2.18	1.55	23.2	0.031	0.2	0.2	82	18	44.646813	-76.319666
4008010	9	1991	0.4	19	15.5	4.32	0.75	27.8	0.053	0.2	0.4	82	18	44.62183	-75.987331
4008010	9	1991	0.4	19	15.8	4.28	0.71	29.8	0.052	0.2	0.8	82	18	44.62183	-75.987331
4008010	9	1991	0.2	32	16.3	4	0.76	35.1	0.036	0.2	0.6	82	18	44.62183	-75.987331
4008012	3	1991	0.2	201	8.6	2.65	0.88	22.3	0.045	0.4	0.2	82	18	44.892349	-76.018265
4008012	3	1991	0.2	207	7.7	2.8	0.85	22.7	0.038	0.6	0.2	82	18	44.892349	-76.018265
4008012	3	1991	0.2	186	8.6	2.65	0.91	24	0.04	0.2	0.2	82	18	44.892349	-76.018265
4008013	9	1991	0.2	384	12.2	1.15	0.73	10.2	0.028	0.2	0.2	82	18	45.017301	-76.361732
4008013	9	1991	0.2	323	11.1	1.24	0.69	9.2	0.028	0.2	0.2	82	18	45.017301	-76.361732
4008013	9	1991	0.2	449	10.7	1.11	0.91	14.9	0.022	0.2	0.2	82	18	45.017301	-76.361732

Station	Land Use	Year	Mo	Na	Ni	TKN	P	Pb	S	Sb	Se	DATUM	ZONE	latitude	longitude
4008014	9	1991	0.2	389	21	3.63	1.14	26.7	0.03	0.4	0.4	82	18	45.085887	-76.30224
4008014	9	1991	0.2	287	21.4	4.21	1.16	29.6	0.038	0.2	0.4	82	18	45.085887	-76.30224
4008014	9	1991	0.2	269	19.7	4.04	1.21	30.8	0.041	0.2	0.2	82	18	45.085887	-76.30224
4008015	3	1991	0.2	407	6.7	3.31	0.74	42.5	0.028	0.4	0.4	82	18	44.246348	-76.535246
4008015	3	1991	0.2	403	5.5	3	0.74	41.7	0.027	0.2	0.4	82	18	44.246348	-76.535246
4008015	3	1991	0.2	573	6.9	3.06	0.78	39.5	0.023	0.2	0.2	82	18	44.246348	-76.535246
4008016	3	1991	0.3	192	8	2.29	0.86	22.4	0.048	0.05	0.3	82	18	44.590904	-75.741375
4008016	3	1991	0.3	171	8.4	2.28	0.87	21.5	0.044	0.1	0.3	82	18	44.590904	-75.741375
4008016	3	1991	0.3	197	8.6	2.21	0.86	23.1	0.043	0.2	0.3	82	18	44.590904	-75.741375
4008017	9	1991	0.05	220	14	1.66	0.55	16.4	0.045	0.05	0.3	82	18	44.871667	-75.799318
4008017	9	1991	0.05	331	13	1.74	0.58	16.9	0.045	0.05	0.3	82	18	44.871667	-75.799318
4008017	9	1991	0.05	377	14.4	1.66	0.57	17.6	0.042	0.05	0.4	82	18	44.871667	-75.799318
4008018	3	1991	0.11	141	7.8	3.72	1.06	53	0.037	0.4	0.5	82	18	45.37362	-75.657498
4008018	3	1991	0.11	117	8.8	3.64	0.98	48.5	0.051	0.05	0.6	82	18	45.37362	-75.657498
4008018	3	1991	0.18	135	8.9	3.73	1.11	49.9	0.046	0.05	0.5	82	18	45.37362	-75.657498
4008019	9	1991	0.12	258	5	2.68	1.11	19.3	0.059	0.2	0.3	82	18	45.010163	-75.639392
4008019	9	1991	0.08	301	4.8	2.66	1.03	19	0.068	0.3	0.2	82	18	45.010163	-75.639392
4008019	9	1991	0.17	292	4.4	2.78	1.05	19.1	0.061	0.18	0.2	82	18	45.010163	-75.639392
4008020	3	1991	0.05	226	12.5	3.62	0.89	34.9	0.077	0.3	0.19	82	18	44.098285	-77.575918
4008020	3	1991	0.05	216	10.9	3.33	0.93	33	0.086	0.3	0.2	82	18	44.098285	-77.575918
4008020	3	1991	0.05	203	12.2	3.43	0.97	28	0.083	0.4	0.09	82	18	44.098285	-77.575918
4008021	9	1991	0.05	282	7.7	0.78	0.79	19	0.078	0.15	0.11	82	18	44.186567	-77.073722
4008021	9	1991	0.05	340	7.1	0.94	0.83	17.9	0.071	0.05	0.17	82	18	44.186567	-77.073722
4008021	9	1991	0.05	282	6.9	0.88	0.98	19	0.074	0.3	0.09	82	18	44.186567	-77.073722

Station	Land Use	Year	Mo	Na	Ni	TKN	P	Pb	S	Sb	Se	DATUM	ZONE	latitude	longitude
4008022	9	1991	0.05	201	5.9	1.6	0.61	16.6	0.041	0.05	0.3	82	18	43.905627	-77.262997
4008022	9	1991	0.05	131	6	1.67	0.66	17	0.05	0.05	0.3	82	18	43.905627	-77.262997
4008022	9	1991	0.05	157	6.3	1.67	0.58	17.4	0.053	0.05	0.3	82	18	43.905627	-77.262997
4008023	3	1991	0.05	205	5.6	1.59	0.73	13.2	0.05	0.12	0.2	82	18	44.140203	-77.419554
4008023	3	1991	0.11	279	6.8	7.07	0.77	13.3	0.054	0.05	0.2	82	18	44.140203	-77.419554
4008023	3	1991	0.3	181	5.6	1.57	0.77	14.3	0.055	0.05	0.2	82	18	44.140203	-77.419554
4008024	9	1991	0.18	166	27.6	3.12	0.71	27.9	0.048	0.3	0.6	82	18	44.902411	-77.256303
4008024	9	1991	0.2	166	22.7	2.33	0.77	18.8	0.056	0.2	0.4	82	18	44.902411	-77.256303
4008024	9	1991	0.16	154	22	2.91	0.76	26.5	0.056	0.3	0.6	82	18	44.902411	-77.256303
4008025	9	1991	0.05	1075	12.2	2.48	1.13	17.2	0.082	0.05	0.4	82	18	45.465583	-76.698821
4008025	9	1991	0.05	1073	12.6	2.44	1.19	17.9	0.07	0.05	0.4	82	18	45.465583	-76.698821
4008025	9	1991	0.05	1115	14.4	2.63	1.08	17.2	0.075	0.05	0.4	82	18	45.465583	-76.698821
4008026	9	1991	0.07	411	8.9	2.58	1.98	20.2	0.063	0.05	0.3	82	18	45.543051	-77.110919
4008026	9	1991	0.3	415	8.6	2.42	1.9	20.2	0.069	0.05	0.3	82	18	45.543051	-77.110919
4008026	9	1991	0.05	391	8.7	2.37	1.07	18	0.055	0.05	0.3	82	18	45.543051	-77.110919
4008027	9	1991	0.05	331	10.2	2.95	1.12	21.2	0.054	0.05	0.4	82	18	45.454238	-77.796318
4008027	9	1991	0.05	300	12	2.98	1.19	20.6	0.039	0.05	0.4	82	18	45.454238	-77.796318
4008027	9	1991	0.05	281	5.6	3.01	1.17	19.1	0.086	0.05	0.4	82	18	45.454238	-77.796318
4008440	3	1993	0.5	250	26	4.7	1.29	77	NA	0.48	0.62	82	18	44.224103	-76.489546
4008440	3	1993	0.5	230	21	3.9	1.2	61	NA	0.44	0.61	82	18	44.224103	-76.489546
4008441	3	1993	0.5	130	11	2.4	1.23	23	NA	0.2	0.2	82	18	44.235394	-76.530303
4008444	3	1993	0.5	170	9.3	3.1	1	30	NA	0.2	0.25	82	18	44.585105	-75.694376
4008444	3	1993	0.5	190	11	3.5	1.06	32	NA	0.2	0.27	82	18	44.585105	-75.694376
4008451	3	1993	0.5	370	20	5.1	1.3	33	NA	0.22	0.27	82	18	45.393469	-75.675908

Station	Land Use	Year	Mo	Na	Ni	TKN	P	Pb	S	Sb	Se	DATUM	ZONE	latitude	longitude
4008451	3	1993	0.5	370	18	4	1.33	23	NA	0.2	0.2	82	18	45.393469	-75.675908
4008455	3	1993	0.5	180	17	3.5	1.07	28	NA	0.34	0.31	82	18	45.133005	-76.147588
4008455	3	1993	0.5	150	15	3	1.14	24	NA	0.32	0.29	82	18	45.133005	-76.147588
4008459	3	1993	0.5	390	15	2.5	1.21	17	NA	0.2	0.25	82	18	45.46997	-76.676655
4008459	3	1993	0.5	450	15	2.5	1.16	18	NA	0.2	0.2	82	18	45.46997	-76.676655
4008463	3	1993	0.5	320	13	3.7	1.47	14	NA	0.2	0.2	82	18	45.82101	-77.112958
4008463	3	1993	0.5	280	11	2.9	1.25	13	NA	0.2	0.2	82	18	45.82101	-77.112958
5008001	3	1991	0.2	143	16.7	1.78	0.51	24.6	0.027	0.2	0.2	82	17	46.30619	-78.561954
5008001	3	1991	0.2	129	22.8	1.51	0.45	21.5	0.032	0.2	0.4	82	17	46.30619	-78.561954
5008001	3	1991	0.7	103	14.3	1.62	0.46	18.3	0.026	0.2	0.2	82	17	46.30619	-78.561954
5008002	9	1991	0.2	149	17.3	2.15	0.78	12	0.025	0.2	0.6	82	17	46.31845	-81.947994
5008002	9	1991	0.3	196	15.2	2.74	1.03	13.7	0.032	0.2	0.8	82	17	46.31845	-81.947994
5008002	9	1991	0.2	126	13.2	1.45	0.59	7.1	0.022	0.2	0.4	82	17	46.31845	-81.947994
5008003	3	1991	0.2	173	53	1.93	0.54	9.4	0.034	0.4	0.2	82	17	46.357565	-79.945339
5008003	3	1991	0.2	164	56.6	1.9	0.52	9	0.032	0.5	0.4	82	17	46.357565	-79.945339
5008003	3	1991	0.1	112	56.8	1.64	0.43	6.7	0.033	0.4	0.3	82	17	46.357565	-79.945339
5008004	9	1991	0.2	623	30.9	1.42	0.62	13.2	0.018	0.4	0.2	82	17	46.445992	-80.304536
5008004	9	1991	0.2	600	23.2	1.53	0.62	14.9	0.018	0.2	0.2	82	17	46.445992	-80.304536
5008004	9	1991	0.2	545	24	1.53	0.56	13.1	0.02	0.3	0.2	82	17	46.445992	-80.304536
5008006	9	1991	0.2	204	8.1	0.89	0.37	18.5	0.013	0.6	0.4	82	17	45.728694	-79.069427
5008006	9	1991	0.2	218	5.3	0.67	0.31	10.1	0.009	0.4	0.2	82	17	45.728694	-79.069427
5008006	9	1991	0.2	194	5.2	1.06	0.37	15.7	0.022	0.3	0.3	82	17	45.728694	-79.069427
5008007	9	1991	0.2	229	7.7	3.04	0.49	22.7	0.04	0.2	0.6	82	17	46.11506	-79.408956
5008007	9	1991	0.2	135	10.5	2.49	0.33	21.2	0.033	0.2	0.6	82	17	46.11506	-79.408956

Station	Land Use	Year	Mo	Na	Ni	TKN	P	Pb	S	Sb	Se	DATUM	ZONE	latitude	longitude
5008007	9	1991	0.2	135	8.5	2.69	0.42	25.3	0.026	0.3	0.7	82	17	46.11506	-79.408956
5008008	9	1991	0.2	115	6.7	1.36	0.45	8.4	0.029	0.2	0.2	82	17	46.301179	-79.099259
5008008	9	1991	0.2	140	5.1	1.92	1.61	11.8	0.039	0.2	0.2	82	17	46.301179	-79.099259
5008008	9	1991	0.2	109	12.3	1.76	0.67	10.9	0.031	0.2	0.2	82	17	46.301179	-79.099259
5008009	9	1991	2.8	159	5.2	1.02	2.2	37.6	0.046	0.2	0.9	82	17	46.539147	-79.432149
5008009	9	1991	0.05	78	19.3	1.88	0.32	21.1	0.026	0.3	0.5	82	17	46.539147	-79.432149
5008009	9	1991	0.09	84	20.3	2.05	0.35	19.6	0.03	0.08	0.4	82	17	46.539147	-79.432149
5008010	9	1991	0.2	66	29.3	2.23	0.41	21.9	0.028	0.2	0.4	82	17	46.980897	-79.92933
5008010	9	1991	0.05	101	35.7	1.5	0.29	20.7	0.018	0.2	0.6	82	17	46.980897	-79.92933
5008010	9	1991	0.05	75	37.1	1.51	0.31	19.3	0.021	0.3	0.6	82	17	46.980897	-79.92933
5008011	3	1991	0.05	478	16	3.98	1.15	42.7	0.054	0.4	0.5	82	17	47.451131	-79.637923
5008011	3	1991	0.05	476	18	3.67	1.1	49.9	0.046	0.3	0.4	82	17	47.451131	-79.637923
5008011	3	1991	0.2	440	18.9	3.44	1	45.9	0.05	0.2	0.2	82	17	47.451131	-79.637923
5008012	3	1991	0.9	167	11.7	7.47	0.59	9.1	0.049	0.05	0.6	82	17	47.508078	-79.667526
5008012	3	1991	1.2	161	11	6.35	0.57	8.6	0.038	0.2	0.4	82	17	47.508078	-79.667526
5008012	3	1991	0.5	189	10.3	6.34	0.6	8	0.048	0.2	0.4	82	17	47.508078	-79.667526
5008013	3	1991	0.05	118	28.2	1.4	0.4	12	0.022	0.05	0.3	82	17	47.83559	-80.101092
5008013	3	1991	0.05	125	25.9	1.57	0.44	13.1	0.022	0.12	0.3	82	17	47.83559	-80.101092
5008013	3	1991	0.2	267	27.9	1.46	0.41	13.6	0.027	0.2	0.2	82	17	47.83559	-80.101092
5008014	9	1991	0.2	161	32.9	2.2	0.38	34.7	0.017	0.2	0.5	82	17	48.565575	-80.608452
5008014	9	1991	0.05	321	21.8	2.86	0.75	19.7	0.035	0.05	0.4	82	17	48.565575	-80.608452
5008014	9	1991	0.05	285	19.1	3.1	0.77	18	0.032	0.05	0.5	82	17	48.565575	-80.608452
5008015	3	1991	0.05	187	23.6	3.33	0.62	28.4	0.07	0.05	0.4	82	17	48.460868	-81.330359
5008015	3	1991	0.05	155	23.1	3.7	0.58	21	0.071	0.05	0.4	82	17	48.460868	-81.330359

Station	Land Use	Year	Mo	Na	Ni	TKN	P	Pb	S	Sb	Se	DATUM	ZONE	latitude	longitude
5008015	3	1991	0.2	656	20.2	3.79	0.66	33.6	0.053	0.2	0.3	82	17	48.460868	-81.330359
5008016	3	1991	0.05	277	4.4	1.95	0.67	34.3	0.031	0.05	0.3	82	17	49.063897	-81.005791
5008016	3	1991	0.05	278	4.7	1.7	0.67	26.6	0.039	0.05	0.18	82	17	49.063897	-81.005791
5008016	3	1991	0.2	259	6.6	2.25	0.79	26	0.039	0.2	0.2	82	17	49.063897	-81.005791
5008017	9	1991	0.2	315	17.8	3.45	0.85	22.5	0.028	0.2	0.2	82	17	47.544459	-83.214844
5008017	9	1991	0.05	126	20.6	0.85	0.43	9.6	0.016	0.8	0.2	82	17	47.544459	-83.214844
5008017	9	1991	0.16	128	22	0.94	0.49	10.5	0.018	0.4	0.2	82	17	47.544459	-83.214844
5008018	9	1991	0.2	161	21.7	0.99	0.57	12.6	0.016	0.2	0.2	82	16	47.937297	-84.751363
5008018	9	1991	4.5	261	4.8	2.84	0.96	17.9	0.048	0.5	0.8	82	16	47.937297	-84.751363
5008018	9	1991	4.8	285	4.6	3.15	0.95	20.1	0.039	0.2	0.8	82	16	47.937297	-84.751363
5008019	9	1991	3.9	661	2.2	2.86	1.01	21	0.038	0.2	0.4	82	16	48.619034	-85.218563
5008019	9	1991	0.05	112	2.5	0.44	0.18	7.9	0.009	0.3	0.08	82	16	48.619034	-85.218563
5008019	9	1991	0.05	132	3	0.4	0.17	8.2	0.01	0.2	0.1	82	16	48.619034	-85.218563
5008020	9	1991	0.2	98	3.6	0.61	0.16	9.7	0.012	0.2	0.2	82	16	46.979136	-84.517184
5008020	9	1991	0.3	37	27.1	1.92	0.2	16	0.029	0.12	0.4	82	16	46.979136	-84.517184
5008020	9	1991	0.6	52	29.9	2.08	0.23	19.8	0.028	0.3	0.5	82	16	46.979136	-84.517184
5008021	3	1991	0.3	358	35.3	2.91	0.64	38.7	0.034	0.6	0.5	82	16	46.539687	-84.341401
5008021	3	1991	0.3	384	35.6	2.87	0.61	40.6	0.04	0.4	0.5	82	16	46.539687	-84.341401
5008021	3	1991	0.2	443	29.9	2.59	0.67	42.6	0.027	0.2	0.3	82	16	46.539687	-84.341401
5008022	9	1991	0.2	79	29.3	2.08	0.26	15.5	0.025	0.2	0.4	82	17	46.339724	-83.93706
5008022	9	1991	0.05	344	31.8	4.1	0.72	35.7	0.039	0.05	0.3	82	17	46.339724	-83.93706
5008022	9	1991	0.05	435	31.5	4.18	0.71	31.8	0.028	0.05	0.3	82	17	46.339724	-83.93706
5008023	9	1991	0.2	410	30.4	4.22	0.76	31.8	0.033	0.2	0.3	82	17	46.34766	-83.740843
5008023	9	1991	0.05	306	13	3.48	0.93	26.2	0.048	0.05	0.5	82	17	46.34766	-83.740843

Station	Land Use	Year	Mo	Na	Ni	TKN	P	Pb	S	Sb	Se	DATUM	ZONE	latitude	longitude
5008023	9	1991	0.05	285	12.7	3.44	0.83	25.6	0.046	0.1	0.4	82	17	46.34766	-83.740843
5008024	9	1991	0.2	294	10.6	3.65	0.86	23.3	0.046	0.2	0.3	82	17	46.282293	-83.502618
5008024	9	1991	0.05	98	8.9	2.61	0.37	25.8	0.031	0.12	0.4	82	17	46.282293	-83.502618
5008024	9	1991	0.05	89	9.4	1.97	0.29	19.7	0.028	0.2	0.4	82	17	46.282293	-83.502618
5008025	3	1991	0.12	157	16.6	2.91	0.9	13.6	0.044	0.05	0.3	82	17	46.190093	-82.944934
5008025	3	1991	0.16	174	14.1	3	0.92	14	0.044	0.18	0.3	82	17	46.190093	-82.944934
5008025	3	1991	0.2	483	11.8	3.54	1.17	15.4	0.039	0.2	0.3	82	17	46.190093	-82.944934
5008026	3	1991	0.4	720	4.5	4.52	0.93	57.2	0.047	0.3	0.9	82	17	45.341226	-80.028451
5008026	3	1991	0.2	852	4.8	4.26	0.91	48	0.045	0.15	1	82	17	45.341226	-80.028451
5008026	3	1991	0.5	675	2.3	3.79	0.79	48.5	0.055	0.2	0.8	82	17	45.341226	-80.028451
5008027	9	1991	0.4	105	9.4	2.07	0.27	20.8	0.024	0.2	0.4	82	17	45.433773	-79.596785
5008027	9	1991	0.6	55	17.2	1.98	0.27	21.3	0.026	0.2	0.4	82	17	45.433773	-79.596785
5008027	9	1991	0.5	70	19.7	2.33	0.29	21.5	0.03	0.8	0.4	82	17	45.433773	-79.596785
5008070	3	1993	0.5	220	29	2.8	0.65	20	0.036	0.2	0.2	82	17	49.271505	-81.612876
5008070	3	1993	0.5	240	27	2.6	0.69	22	0.031	0.2	0.2	82	17	49.271505	-81.612876
5008076	3	1993	0.5	250	34	3.5	0.71	40	0.056	0.24	0.3	82	17	49.416328	-82.428144
5008076	3	1993	0.5	240	34	4.1	0.82	39	0.054	0.26	0.3	82	17	49.416328	-82.428144
5008079	3	1993	0.5	140	18	2.1	0.68	14	0.027	0.2	0.2	82	17	49.077928	-81.023046
5008079	3	1993	0.5	150	18	1.9	0.64	12	0.03	0.2	0.2	82	17	49.077928	-81.023046
5008084	3	1993	0.5	85	14	3.1	0.52	8	0.048	0.22	0.2	82	17	48.76983	-80.679949
5008084	3	1993	0.5	120	14	2.4	0.54	9	0.039	0.22	0.2	82	17	48.76983	-80.679949
5008086	3	1993	0.5	86	12	2.6	0.62	10	0.04	0.2	0.2	82	17	48.482196	-81.213579
5008086	3	1993	0.5	90	11	3.5	0.86	13	0.065	0.2	0.2	82	17	48.482196	-81.213579
5008090	3	1993	0.5	78	9.9	0.9	0.55	15	0.02	0.22	0.2	82	17	47.674839	-81.728496

Station	Land Use	Year	Mo	Na	Ni	TKN	P	Pb	S	Sb	Se	DATUM	ZONE	latitude	longitude
5008090	3	1993	0.5	73	10	1	0.61	11	0.007	0.2	0.2	82	17	47.674839	-81.728496
5008135	9	1995	0.3	61	18.3	2.21	0.23	19.2	0.026	0.3	0.2	82	16	47.236424	-84.649335
5008135	9	1995	0.5	250	18	2.3	0.66	31	0.041	0.3	0.6	82	16	47.236424	-84.649335
5008136	9	1995	0.7	110	4.7	3.8	0.38	25	0.043	0.3	0.6	82	16	47.585374	-84.821282
5008136	9	1995	0.8	44	2.4	1.5	0.12	26	0.015	0.3	0.2	82	16	47.585374	-84.821282
5008137	9	1995	0.5	130	2.5	0.8	0.08	12	0.013	0.3	0.2	82	16	47.433315	-84.729431
5008137	9	1995	1	140	5	1.6	0.14	22	0.021	0.4	0.2	82	16	47.433315	-84.729431
6008001	3	1991	0.05	1086	10.6	1.93	0.57	17.7	0.026	0.05	0.2	82	16	48.375002	-89.291434
6008001	3	1991	0.05	1170	10	2.07	0.59	22.9	0.021	0.05	0.2	82	16	48.375002	-89.291434
6008001	3	1991	0.05	1070	13.1	1.87	0.57	17.8	0.013	0.05	0.2	82	16	48.375002	-89.291434
6008002	9	1991	0.5	575	33.3	5.11	0.48	26	0.018	0.08	0.9	82	16	48.788737	-88.671654
6008002	9	1991	0.6	557	34.1	7.77	0.77	23.5	0.01	0.2	0.95	82	16	48.788737	-88.671654
6008002	9	1991	0.7	298	32.7	5.97	0.47	24.7	0.007	0.18	1.15	82	16	48.788737	-88.671654
6008003	3	1991	0.05	1204	9	2.69	0.75	18	0.029	0.05	0.19	82	16	49.010234	-88.268798
6008003	3	1991	0.05	1125	9.8	2.67	0.73	19.3	0.018	0.05	0.25	82	16	49.010234	-88.268798
6008003	3	1991	0.05	1160	9.8	2.36	0.68	15.9	0.012	0.05	0.17	82	16	49.010234	-88.268798
6008004	9	1991	0.14	182	18.2	1.84	0.49	10.6	0.029	0.4	0.13	82	16	48.839262	-87.521727
6008004	9	1991	0.18	166	17.2	1.7	0.48	10.9	0.03	0.05	0.16	82	16	48.839262	-87.521727
6008004	9	1991	0.15	192	21.5	1.76	0.5	12.2	0.03	0.05	0.14	82	16	48.839262	-87.521727
6008005	3	1991	0.5	125	4.5	7.01	0.84	44.6	0.066	0.4	0.65	82	16	48.713733	-86.380552
6008005	3	1991	0.3	117	4.3	6.42	0.79	42.3	0.06	0.5	0.65	82	16	48.713733	-86.380552
6008005	3	1991	0.4	125	5.4	5.98	0.83	46.1	0.05	0.4	0.55	82	16	48.713733	-86.380552
6008006	3	1991	0.05	66	8.8	1.17	0.26	14.4	0.028	0.05	0.05	82	16	49.124168	-85.82926
6008006	3	1991	0.06	68	7.8	1.31	0.26	14.1	0.031	0.4	0.07	82	16	49.124168	-85.82926

Station	Land Use	Year	Mo	Na	Ni	TKN	P	Pb	S	Sb	Se	DATUM	ZONE	latitude	longitude
6008007	9	1991	0.06	71	8.9	0.75	0.3	6.3	0.016	0.08	0.05	82	16	49.79431	-85.921562
6008007	9	1991	0.4	72	9.6	0.5	0.27	6.3	0.016	0.08	0.05	82	16	49.79431	-85.921562
6008007	9	1991	0.05	65	15.8	0.71	0.27	7.1	0.024	0.12	0.05	82	16	49.79431	-85.921562
6008008	3	1991	0.06	145	50.5	0	0.24	6.7	0.028	0.05	0.06	82	16	49.713871	-86.953989
6008008	3	1991	0.08	276	36.5	0.23	0.27	6	0.022	0.05	0.06	82	16	49.713871	-86.953989
6008008	3	1991	0.05	224	42.7	0.27	0.28	7.8	0.027	0.05	0.1	82	16	49.713871	-86.953989
6008009	9	1991	0.13	146	17.6	0.54	0.25	10.1	0.035	0.05	0.25	82	16	49.562205	-87.981578
6008009	9	1991	0.05	185	17.2	0.38	0.22	10.6	0.03	0.05	0.2	82	16	49.562205	-87.981578
6008009	9	1991	0.05	151	19.1	0.48	0.19	10.2	0.021	0.05	0.3	82	16	49.562205	-87.981578
6008010	9	1991	0.2	208	25.3	6.53	0.66	31.7	0.013	0.05	0.6	82	16	48.271324	-89.389897
6008010	9	1991	0.08	313	30.1	6.49	0.64	39.8	0.012	0.18	0.6	82	16	48.271324	-89.389897
6008010	9	1991	0.05	275	19.4	5.12	0.57	27.8	0.006	0.05	0.5	82	16	48.271324	-89.389897
6008011	9	1991	0.05	198	26.1	8.29	0.93	60.1	0.006	0.1	0.7	82	16	48.069741	-89.578564
6008011	9	1991	0.05	338	28.4	4.74	0.79	37.7	0.009	0.12	0.6	82	16	48.069741	-89.578564
6008011	9	1991	0.05	185	25.8	4.34	0.75	33	0.007	0.08	0.5	82	16	48.069741	-89.578564
6008012	9	1991	0.05	630	9.4	2.24	0.89	15.5	0.027	0.05	0.2	82	15	48.614356	-90.219652
6008012	9	1991	0.05	801	8.5	2.19	0.85	17	0.037	0.05	0.14	82	15	48.614356	-90.219652
6008012	9	1991	0.05	681	6.8	2.14	0.88	15.7	0.025	0.05	0.19	82	15	48.614356	-90.219652
6008013	9	1991	0.05	201	4.9	1.55	0.73	18.6	0.034	0.05	0.13	82	15	48.671443	-91.130731
6008013	9	1991	0.05	138	5.7	1.73	0.73	17.3	0.041	0.12	0.16	82	15	48.671443	-91.130731
6008013	9	1991	0.05	146	5.8	1.41	0.58	14.5	0.034	0.1	0.2	82	15	48.671443	-91.130731
6008014	9	1991	0.08	80	10.6	3.95	0.4	8.2	0.086	0.4	0.6	82	15	48.759752	-92.620144
6008014	9	1991	0.3	82	10.8	4	0.37	9.7	0.075	0.4	0.6	82	15	48.759752	-92.620144
6008014	9	1991	0.06	81	10.5	4.02	0.38	10	0.078	0.12	0.6	82	15	48.759752	-92.620144

Station	Land Use	Year	Mo	Na	Ni	TKN	P	Pb	S	Sb	Se	DATUM	ZONE	latitude	longitude
6008015	3	1991	0.06	173	14.5	2.05	0.49	20.8	0.065	0.2	0.6	82	15	48.612106	-93.411525
6008015	3	1991	0.06	166	13.1	1.75	0.52	26.4	0.064	0.3	0.4	82	15	48.612106	-93.411525
6008015	3	1991	0.07	188	14.6	2.06	0.49	20.4	0.07	0.3	0.3	82	15	48.612106	-93.411525
6008016	9	1991	0.05	164	10.8	1.61	0.42	6.5	0.052	0.05	0.2	82	15	49.107977	-93.922574
6008016	9	1991	0.05	133	10.3	1.62	0.43	5.7	0.045	0.05	0.19	82	15	49.107977	-93.922574
6008016	9	1991	0.05	173	13.4	1.67	0.42	6	0.055	0.15	0.19	82	15	49.107977	-93.922574
6008017	3	1991	0.05	277	4.3	1.43	0.59	12	0.045	0.05	0.19	82	15	49.762874	-94.481346
6008017	3	1991	0.05	263	3.8	1.69	0.6	11	0.052	0.05	0.13	82	15	49.762874	-94.481346
6008017	3	1991	0.05	287	4	2.26	0.58	15.3	0.057	0.05	0.19	82	15	49.762874	-94.481346
6008018	9	1991	0.05	54	24.6	0.93	0.48	8.8	0.016	0.05	0.13	82	15	49.858922	-93.393495
6008018	9	1991	0.05	47	25.3	1.07	0.48	7.3	0.018	0.05	0.13	82	15	49.858922	-93.393495
6008018	9	1991	0.05	48	29.3	1.03	0.49	7.5	0.015	0.2	0.1	82	15	49.858922	-93.393495
6008019	9	1991	0.05	345	8.7	1.94	0.62	19.4	0.015	0.05	0.3	82	15	49.758324	-92.649888
6008019	9	1991	0.05	377	9.6	1.36	0.47	15.8	0.008	0.05	0.3	82	15	49.758324	-92.649888
6008019	9	1991	0.05	430	9.8	1.59	0.61	19.6	0.008	0.05	0.3	82	15	49.758324	-92.649888
6008020	3	1991	0.05	116	23.4	1.18	0.36	11.8	0.015	0.05	0.4	82	15	49.412425	-91.659047
6008020	3	1991	0.05	177	21.5	1.14	0.34	10.7	0.011	0.12	0.4	82	15	49.412425	-91.659047
6008020	3	1991	0.05	179	20.3	1.14	0.33	11.4	0.017	0.05	0.4	82	15	49.412425	-91.659047
6008021	9	1991	0.05	1983	9	1.04	0.65	8.5	0.015	0.05	0.13	82	15	49.04911	-90.482225
6008021	9	1991	0.05	1548	6.3	1.11	0.64	8.3	0.016	0.05	0.3	82	15	49.04911	-90.482225
6008021	9	1991	0.05	1287	6.8	1.05	0.66	7.8	0.011	0.05	0.2	82	15	49.04911	-90.482225
6008022	9	1991	0.14	126	20.3	1.3	0.32	11.9	0.047	0.05	0.16	82	15	50.629722	-93.205481
6008022	9	1991	0.05	101	16.2	1.16	0.27	10	0.046	0.05	0.12	82	15	50.629722	-93.205481
6008022	9	1991	0.05	126	19.2	1.01	0.26	9.1	0.04	0.05	0.11	82	15	50.629722	-93.205481

Station	Land Use	Year	Mo	Na	Ni	TKN	P	Pb	S	Sb	Se	DATUM	ZONE	latitude	longitude
6008023	3	1991	0.4	182	17.7	4.65	0.85	56.6	0.11	0.2	0.4	82	15	51.015499	-93.822331
6008023	3	1991	0.5	154	18.7	3.71	0.72	46	0.118	0.8	0.4	82	15	51.015499	-93.822331
6008023	3	1991	0.6	181	17.8	3.88	0.76	45.6	0.103	0.6	0.3	82	15	51.015499	-93.822331
6008024	3	1991	0.05	130	7.3	1.27	0.33	18.6	0.021	0.2	0.5	82	15	50.101921	-91.921662
6008024	3	1991	0.05	144	6.6	1.4	0.33	22.5	0.024	0.05	0.5	82	15	50.101921	-91.921662
6008024	3	1991	0.05	135	7.5	1.85	0.36	33	0.027	0.05	0.4	82	15	50.101921	-91.921662
6008025	9	1991	0.08	132	3.1	1.48	0.34	10.9	0.023	0.1	0.4	82	15	49.487828	-91.534788
6008025	9	1991	0.18	116	6.9	1.73	0.31	12.9	0.017	0.05	0.3	82	15	49.487828	-91.534788
6008025	9	1991	0.05	140	4.1	1.45	0.33	11.5	0.018	0.08	0.4	82	15	49.487828	-91.534788
6008026	9	1991	0.05	46	10.7	0.67	0.14	5.1	0.009	0.2	0.05	82	15	51.463813	-90.163646
6008026	9	1991	0.05	82	11.4	0.91	0.19	5.9	0.014	0.15	0.12	82	15	51.463813	-90.163646
6008026	9	1991	0.05	53	11	1.23	0.19	6.3	0.022	0.05	0.14	82	15	51.463813	-90.163646
6008027	9	1991	0.05	178	NA	0.95	0.39	10.6	0.02	0.05	0.08	82	15	50.243543	-90.709469
6008027	9	1991	0.05	185	NA	0.7	0.35	10.8	0.013	0.08	0.12	82	15	50.243543	-90.709469
6008027	9	1991	0.05	186	NA	0.86	0.35	10.5	0.02	0.4	0.11	82	15	50.243543	-90.709469
6008078	9	1992	5.5	700	39	6.5	0.95	23	NA	0.1	0.7	82	16	48.289464	-89.396784
6008078	9	1992	7	650	44	5.7	0.94	25	NA	0.1	0.8	82	16	48.289464	-89.396784
6008108	3	1993	3	920	24	12.4	1.21	46	0.15	0.1	0.5	82	16	48.942155	-88.256145
6008108	3	1993	4	960	28	10	1.34	42	0.122	0.1	0.3	82	16	48.942155	-88.256145
6008129	9	1993	9	230	29	3.7	0.57	27	0.051	0.1	0.7	82	16	48.344791	-89.285423
6008129	9	1993	7	260	27	NA	NA	33	NA	0.1	0.7	82	16	48.344791	-89.285423
6008133	9	1994	2	95	11	2.1	0.48	12	0.046	0.1	0.2	82	15	48.620287	-93.359622
6008133	9	1994	2	95	11	2.1	0.48	13	0.044	0.1	0.2	82	15	48.620287	-93.359622
6008150	3	1995	18	740	61	NA	NA	24	NA	0.2	0.4	82	15	48.758671	-91.611566

Station	Land Use	Year	Mo	Na	Ni	TKN	P	Pb	S	Sb	Se	DATUM	ZONE	latitude	longitude
6008150	3	1995	18	730	63	NA	NA	28	NA	0.2	0.4	82	15	48.758671	-91.611566

Table 22: OTR Data: Sr - Zn

Station	Land Use	Year	Sr	Ti	U	Va	Zn	DATUM	ZONE	latitude	longitude
1008001	9	1991	15.8	3080	1.5	38.9	85.3	82	17	44.816458	-81.097171
1008001	9	1991	17.4	3170	1.4	39.6	82.3	82	17	44.816458	-81.097171
1008001	9	1991	15.5	2970	0.8	36.1	75.5	82	17	44.816458	-81.097171
1008002	3	1991	37.1	2590	1.4	26.1	40.5	82	17	44.74259	-81.143784
1008002	3	1991	34.8	2630	1.4	27.7	42.1	82	17	44.74259	-81.143784
1008002	3	1991	32.9	2380	1.5	17.7	38.2	82	17	44.74259	-81.143784
1008003	3	1991	30.2	3480	2.1	35	80.2	82	17	44.560393	-80.929447
1008003	3	1991	25.9	3470	1.9	35.7	84.9	82	17	44.560393	-80.929447
1008003	3	1991	32	2150	2	32.9	80	82	17	44.560393	-80.929447
1008004	9	1991	18.1	2800	0.6	30.6	43.1	82	17	44.443944	-80.877824
1008004	9	1991	18.3	2640	0.57	29.1	44.4	82	17	44.443944	-80.877824
1008004	9	1991	18.4	2980	0.87	30.5	42.7	82	17	44.443944	-80.877824
1008005	9	1991	190	2470	0.56	26.2	41.8	82	17	44.318789	-81.243305
1008005	9	1991	142	2520	0.51	25.3	38.3	82	17	44.318789	-81.243305
1008005	9	1991	104	2120	0.62	28.1	38.8	82	17	44.318789	-81.243305
1008006	3	1991	29.1	3090	1.2	41.1	78.7	82	17	44.176422	-81.618168
1008006	3	1991	30.2	3130	1	42.9	82.6	82	17	44.176422	-81.618168
1008006	3	1991	30.2	3020	0.98	42.7	76.9	82	17	44.176422	-81.618168
1008007	9	1991	31.5	2450	0.71	35.6	82.1	82	17	44.180986	-80.803078
1008007	9	1991	31.3	2810	0.79	34.8	78.8	82	17	44.180986	-80.803078
1008007	9	1991	30.9	2320	1.1	35.9	78.4	82	17	44.180986	-80.803078
1008008	9	1991	31.9	3500	0.71	46.3	76.6	82	17	43.671966	-80.722085

Station	Land Use	Year	Sr	Ti	U	Va	Zn	DATUM	ZONE	latitude	longitude
1008008	9	1991	31.8	3740	0.72	48	76.6	82	17	43.671966	-80.722085
1008008	9	1991	32.6	2890	0.75	47.9	75.8	82	17	43.671966	-80.722085
1008009	3	1991	28.1	2780	0.75	27.7	57	82	17	42.759005	-81.189634
1008009	3	1991	29	2710	0.75	31.9	63.5	82	17	42.759005	-81.189634
1008009	3	1991	28	2590	0.8	27.3	57	82	17	42.759005	-81.189634
1008010	9	1991	19.1	4020	1.1	25.9	56.3	82	17	42.088945	-82.438773
1008010	9	1991	19.4	3990	1	26.1	56.5	82	17	42.088945	-82.438773
1008010	9	1991	23.1	3950	1.1	33.4	61.4	82	17	42.088945	-82.438773
1008011	9	1991	52.1	2490	2	49.5	70.3	82	17	42.228615	-82.795621
1008011	9	1991	48	2610	1.9	40.4	67.8	82	17	42.228615	-82.795621
1008011	9	1991	40.7	2710	2	40.9	66.6	82	17	42.228615	-82.795621
1008012	3	1991	29.6	2920	1.2	41.9	121	82	17	42.300366	-83.05255
1008012	3	1991	22.8	2770	1.2	33.5	117	82	17	42.300366	-83.05255
1008012	3	1991	24	2670	1.3	37.3	112	82	17	42.300366	-83.05255
1008013	3	1991	36.5	2090	1.1	24.8	40.7	82	17	42.402413	-82.149764
1008013	3	1991	36.5	2300	1.1	23.3	41.7	82	17	42.402413	-82.149764
1008013	3	1991	35.8	2110	1.1	25	43.2	82	17	42.402413	-82.149764
1008014	3	1991	29.8	3240	1.5	33.7	77.3	82	17	42.589542	-82.4052
1008014	3	1991	23	3270	1.2	33.2	78.6	82	17	42.589542	-82.4052
1008014	3	1991	31.4	3440	1.3	35.8	79.8	82	17	42.589542	-82.4052
1008015	9	1991	45.2	2070	1	30.2	50.2	82	17	42.881862	-82.18226
1008015	9	1991	43.8	2170	0.95	28.3	50.8	82	17	42.881862	-82.18226
1008015	9	1991	46.7	2030	0.97	28.3	52	82	17	42.881862	-82.18226
1008016	3	1991	26.8	1780	0.87	31.8	77.6	82	17	42.965156	-82.392349

Station	Land Use	Year	Sr	Ti	U	Va	Zn	DATUM	ZONE	latitude	longitude
1008016	3	1991	23.1	1980	1.1	33.5	80.8	82	17	42.965156	-82.392349
1008016	3	1991	23.2	2030	1.2	33.7	80.5	82	17	42.965156	-82.392349
1008017	9	1991	15.5	3170	0.77	29.4	81.2	82	17	43.018985	-81.801795
1008017	9	1991	16.4	3060	0.82	30.1	82.2	82	17	43.018985	-81.801795
1008017	9	1991	16.2	3030	0.72	28.8	80.5	82	17	43.018985	-81.801795
1008018	9	1991	18.4	2180	1.4	29.6	49.3	82	17	43.164124	-81.658251
1008018	9	1991	19.1	2180	1.3	30.7	50.3	82	17	43.164124	-81.658251
1008018	9	1991	15.4	2120	1.3	28.5	45.7	82	17	43.164124	-81.658251
1008019	9	1991	13.9	2850	0.72	35	59.8	82	17	43.982597	-81.394438
1008019	9	1991	13.5	2910	0.65	34.3	62.6	82	17	43.982597	-81.394438
1008019	9	1991	16.5	2470	0.32	36.3	58.5	82	17	43.982597	-81.394438
1008020	3	1991	47.3	3200	0.64	24.1	68.7	82	17	42.975671	-81.251887
1008020	3	1991	46.9	3020	0.67	22.8	67.8	82	17	42.975671	-81.251887
1008020	3	1991	46.5	2690	0.75	23.2	69	82	17	42.975671	-81.251887
1008021	9	1991	100	2540	1.3	34.9	73.4	82	17	43.827738	-81.464929
1008021	9	1991	82.6	2280	1.3	33.3	71.9	82	17	43.827738	-81.464929
1008021	9	1991	75.2	2350	1.4	35.1	75.8	82	17	43.827738	-81.464929
1008022	9	1991	11.9	2210	0.5	31.3	40.4	82	17	43.748683	-81.102879
1008022	9	1991	13	2070	0.55	30.8	38.9	82	17	43.748683	-81.102879
1008022	9	1991	12.3	3580	0.55	31.5	39.1	82	17	43.748683	-81.102879
1008023	9	1991	15.8	3170	0.7	32.7	58.3	82	17	43.265706	-81.053305
1008023	9	1991	14.8	3430	0.85	32.6	53.1	82	17	43.265706	-81.053305
1008023	9	1991	14.2	3270	0.65	30.8	52.7	82	17	43.265706	-81.053305
1008024	9	1991	24	2280	0.85	32.6	55.5	82	17	43.6972	-81.477918

Station	Land Use	Year	Sr	Ti	U	Va	Zn	DATUM	ZONE	latitude	longitude
1008024	9	1991	24.2	2870	0.4	32.5	55.6	82	17	43.6972	-81.477918
1008024	9	1991	23.7	2610	1	32.8	56.3	82	17	43.6972	-81.477918
1008025	9	1991	28.9	3390	1.3	39.4	73.6	82	17	43.357332	-81.456201
1008025	9	1991	26.3	2710	1.3	39.5	94.8	82	17	43.357332	-81.456201
1008025	9	1991	21.9	3450	1.2	40.2	57.3	82	17	43.357332	-81.456201
1008026	9	1991	28.3	4160	1.1	39.1	64.9	82	17	43.622784	-81.502427
1008026	9	1991	25.8	3200	1.2	40.6	70.7	82	17	43.622784	-81.502427
1008026	9	1991	26.1	2570	1.2	40	71.8	82	17	43.622784	-81.502427
1008027	3	1991	22.8	840	0.88	40.3	76.3	82	17	43.356494	-80.988141
1008027	3	1991	22	4710	1.2	40.5	76	82	17	43.356494	-80.988141
1008027	3	1991	22.6	3560	1.2	39.6	73.9	82	17	43.356494	-80.988141
1008557	3	1993	20	NA	0.4	27	71	82	17	43.129473	-80.758462
1008557	3	1993	28	NA	0.4	30	70	82	17	43.129473	-80.758462
1008561	3	1993	57	NA	1	33	86	82	17	43.74293	-81.710213
1008561	3	1993	52	NA	0.9	31	82	82	17	43.74293	-81.710213
1008565	3	1993	50	3000	1.4	33	150	82	17	42.880863	-82.146804
1008565	3	1993	48	3000	1.4	31	140	82	17	42.880863	-82.146804
1008569	3	1993	22	NA	0.5	28	63	82	17	42.590103	-82.182446
1008569	3	1993	24	NA	0.4	28	66	82	17	42.590103	-82.182446
1008573	3	1993	33	NA	0.3	30	66	82	17	43.036371	-80.878788
1008573	3	1993	34	NA	0.3	27	66	82	17	43.036371	-80.878788
1008577	3	1993	11	NA	0.3	29	55	82	17	42.868375	-80.732977
1008577	3	1993	10	NA	0.3	17	53	82	17	42.868375	-80.732977
2008001	9	1991	11.2	3560	1.7	32.1	48.7	82	17	43.671864	-80.448376

Station	Land Use	Year	Sr	Ti	U	Va	Zn	DATUM	ZONE	latitude	longitude
2008001	9	1991	11.4	3430	1.7	30.4	52.4	82	17	43.671864	-80.448376
2008001	9	1991	15	2960	1.8	38.4	58	82	17	43.671864	-80.448376
2008001	9	1996	28	NA	NA	31	250	82	17	43.671864	-80.448376
2008001	9	1996	29	NA	NA	30	240	82	17	43.671864	-80.448376
2008002	9	1991	44	2370	1.4	29.4	62	82	17	43.754512	-80.661085
2008002	9	1996	30	NA	NA	30	370	82	17	43.754512	-80.661085
2008002	9	1991	41.8	2280	0.69	29.1	63	82	17	43.754512	-80.661085
2008002	9	1991	41.2	2320	0.66	27.1	61.1	82	17	43.754512	-80.661085
2008002	9	1996	30	NA	NA	32	340	82	17	43.754512	-80.661085
2008003	9	1991	27.8	2880	2.1	36.3	47.8	82	17	43.909576	-80.873879
2008003	9	1991	26.3	2770	2	33.8	42.9	82	17	43.909576	-80.873879
2008003	9	1991	32.2	3040	1.8	40.2	50.3	82	17	43.909576	-80.873879
2008003	9	1996	23	NA	NA	29	120	82	17	43.909576	-80.873879
2008003	9	1996	23	NA	NA	30	130	82	17	43.909576	-80.873879
2008004	9	1991	23.5	2660	1.6	33.4	56.2	82	17	43.982017	-80.735219
2008004	9	1991	23.4	2570	1.7	33	58.9	82	17	43.982017	-80.735219
2008004	9	1991	26.4	2750	1.4	39.2	65.3	82	17	43.982017	-80.735219
2008005	9	1991	23.8	3350	2	43.4	64.7	82	17	43.880183	-80.270894
2008005	9	1991	22.9	3390	1.9	42.7	67.3	82	17	43.880183	-80.270894
2008005	9	1991	24.1	3560	1.6	49.9	70.8	82	17	43.880183	-80.270894
2008006	9	1991	38.6	5150	1.1	46.1	94.3	82	17	43.109197	-79.558093
2008006	9	1991	40.4	4800	1.1	50.7	92.1	82	17	43.109197	-79.558093
2008006	9	1991	36.3	5160	1	53.1	100	82	17	43.109197	-79.558093
2008007	9	1991	25.1	3340	0.7	23.3	35.9	208	17	42.75062	-80.26525

Station	Land Use	Year	Sr	Ti	U	Va	Zn	DATUM	ZONE	latitude	longitude
2008007	9	1991	25.5	3120	0.6	23.2	32.5	208	17	42.75062	-80.26525
2008007	9	1991	27.2	2950	0.65	22.5	34.6	208	17	42.75062	-80.26525
2008008	9	1991	17.4	2680	0.65	20.3	41.9	82	17	42.668177	-80.412623
2008008	9	1991	13.3	2610	0.7	20.1	40	82	17	42.668177	-80.412623
2008008	9	1991	15.1	2640	0.65	19.5	40.6	82	17	42.668177	-80.412623
2008009	9	1991	42.5	4020	1.1	45.6	80	82	17	42.885126	-80.100468
2008009	9	1991	48	4010	1.2	52	91.4	82	17	42.885126	-80.100468
2008009	9	1991	47.1	3890	1.2	48.8	93.1	82	17	42.885126	-80.100468
2008010	9	1991	10.6	2760	0.8	22.6	58.6	82	17	43.196477	-80.010295
2008010	9	1991	11.8	2640	0.7	24.1	56.2	82	17	43.196477	-80.010295
2008010	9	1991	9.9	2800	0.75	23.3	57.4	82	17	43.196477	-80.010295
2008011	9	1991	30.6	5370	1.3	43.3	114	82	17	43.011399	-79.915842
2008011	9	1991	34.5	5030	1.2	44.7	116	82	17	43.011399	-79.915842
2008011	9	1991	34	4940	1.3	46.7	134	82	17	43.011399	-79.915842
2008012	9	1991	8.9	3560	0.55	23.2	43.2	208	17	42.678923	-80.62216
2008012	9	1991	8.8	3300	0.6	22.6	44.7	208	17	42.678923	-80.62216
2008012	9	1991	10	3900	0.7	26	45.1	208	17	42.678923	-80.62216
2008013	9	1991	26.6	3690	0.8	32	115	82	17	43.398527	-80.625449
2008013	9	1991	16.8	3010	0.71	31.4	130	82	17	43.398527	-80.625449
2008013	9	1991	15.9	3260	0.59	32.4	121	82	17	43.398527	-80.625449
2008014	9	1991	9.9	4150	0.7	36	133	82	17	42.901284	-79.040713
2008014	9	1991	8.9	3920	0.75	29.3	132	82	17	42.901284	-79.040713
2008014	9	1991	8.3	3720	0.7	28.1	107	82	17	42.901284	-79.040713
2008015	9	1991	36.1	2590	0.7	27.7	120	82	17	44.10093	-80.137487

Station	Land Use	Year	Sr	Ti	U	Va	Zn	DATUM	ZONE	latitude	longitude
2008015	9	1991	39.8	2420	0.75	26.6	128	82	17	44.10093	-80.137487
2008015	9	1991	33.1	2980	0.56	33.3	104	82	17	44.10093	-80.137487
2008016	9	1991	13	3190	0.75	27.1	63.4	82	17	43.511826	-80.351047
2008016	9	1991	12	3240	0.5	25.4	59.5	82	17	43.511826	-80.351047
2008016	9	1991	13.4	3790	0.65	28.9	63.8	82	17	43.511826	-80.351047
2008017	9	1991	15.5	3320	0.73	34.4	55.9	82	17	43.961897	-80.410923
2008017	9	1991	17.1	3330	0.78	33.9	52.8	82	17	43.961897	-80.410923
2008017	9	1991	13.8	3340	0.71	32.8	57.9	82	17	43.961897	-80.410923
2008018	3	1991	25.9	3380	0.84	27.2	58.8	82	17	43.13393	-80.762489
2008018	3	1991	26.5	3210	0.82	27.2	56.2	82	17	43.13393	-80.762489
2008018	3	1991	26	3150	0.73	29.6	57.7	82	17	43.13393	-80.762489
2008019	3	1991	18.1	4570	0.62	37.9	87.5	82	17	43.151025	-80.313147
2008019	3	1991	15.5	3810	0.68	28.3	82.8	82	17	43.151025	-80.313147
2008019	3	1991	15.5	4020	0.61	31.7	82.2	82	17	43.151025	-80.313147
2008020	3	1991	25.3	3120	1.1	32.9	148	82	17	43.532327	-80.230359
2008020	3	1991	21.5	2990	1	28.6	147	82	17	43.532327	-80.230359
2008020	3	1991	20.8	2790	0.95	31.2	161	82	17	43.532327	-80.230359
2008021	3	1991	27.8	3410	0.9	24.8	136	82	17	43.07213	-79.079335
2008021	3	1991	26	3310	0.9	23.6	131	82	17	43.07213	-79.079335
2008021	3	1991	27	3150	0.85	24	124	82	17	43.07213	-79.079335
2008022	3	1991	50.7	3780	1.1	31.8	98.8	82	17	42.988082	-79.251346
2008022	3	1991	53	3910	1.1	32.4	107	82	17	42.988082	-79.251346
2008022	3	1991	58.4	4020	1.1	32.4	104	82	17	42.988082	-79.251346
2008023	3	1991	24.4	3670	0.85	33	107	82	17	42.887559	-79.245397

Station	Land Use	Year	Sr	Ti	U	Va	Zn	DATUM	ZONE	latitude	longitude
2008023	3	1991	21.1	3630	0.85	31.6	104	82	17	42.887559	-79.245397
2008023	3	1991	19.5	3860	0.85	28.5	104	82	17	42.887559	-79.245397
2008024	3	1991	20.3	3710	0.8	31.8	79.6	82	17	43.366353	-80.332692
2008024	3	1991	21.9	3820	0.78	32.5	77.4	82	17	43.366353	-80.332692
2008024	3	1991	20.1	3850	0.77	32.3	76.6	82	17	43.366353	-80.332692
2008025	3	1991	8.5	3900	0.85	31.2	116	82	17	43.238999	-79.830218
2008025	3	1991	9.1	3790	0.95	32.6	146	82	17	43.238999	-79.830218
2008025	3	1991	8.7	4180	1.1	31.8	116	82	17	43.238999	-79.830218
2008026	3	1991	41.8	866	1.8	11.3	114	82	17	43.45705	-80.45592
2008026	3	1991	37.5	758	1.3	11.3	110	82	17	43.45705	-80.45592
2008026	3	1991	42.2	774	1.5	11.5	110	82	17	43.45705	-80.45592
2008027	3	1991	30.8	5020	1.1	35.1	91.2	82	17	43.144121	-79.238751
2008027	3	1991	30.4	4820	0.95	35.1	91.5	82	17	43.144121	-79.238751
2008027	3	1991	29.8	1130	1	34.9	96.6	82	17	43.144121	-79.238751
2008302	3	1993	18	3200	0.4	28	110	82	17	43.356699	-80.320248
2008302	3	1993	18	3300	0.4	28	100	82	17	43.356699	-80.320248
2008305	3	1993	19	3200	0.4	26	61	82	17	43.453897	-80.472931
2008305	3	1993	17	2700	0.4	24	56	82	17	43.453897	-80.472931
2008400	3	1993	23	NA	0.9	35	110	82	17	42.997104	-79.258942
2008400	3	1993	26	NA	1.2	35	120	82	17	42.997104	-79.258942
2008501	3	1993	76	3600	2.3	30	300	82	17	43.55245	-80.235451
2008501	3	1993	78	3300	2.6	26	320	82	17	43.55245	-80.235451
2008505	3	1993	16	3600	0.3	24	180	82	17	43.267713	-79.88221
2008505	3	1993	14	3400	0.2	22	150	82	17	43.267713	-79.88221

Station	Land Use	Year	Sr	Ti	U	Va	Zn	DATUM	ZONE	latitude	longitude
3008001	9	1991	17.9	3670	1.7	42.1	44.4	82	17	44.129388	-79.608149
3008001	9	1991	20.2	3670	1.8	44.2	50.3	82	17	44.129388	-79.608149
3008001	9	1991	21.3	3500	1.9	47.6	49.6	82	17	44.129388	-79.608149
3008002	9	1991	58.8	3210	0.63	33.6	49	82	17	44.151916	-79.898729
3008002	9	1991	58	3290	1.4	33.3	47.8	82	17	44.151916	-79.898729
3008002	9	1991	57.8	2820	0.61	34.3	49.6	82	17	44.151916	-79.898729
3008003	9	1991	37.2	2600	1.4	47.7	78	82	17	44.705792	-79.64149
3008003	9	1991	39.2	2650	1.4	48	79.8	82	17	44.705792	-79.64149
3008003	9	1991	36.2	3110	1.8	46.6	72.1	82	17	44.705792	-79.64149
3008004	9	1991	26.7	3740	0.8	41	74.7	82	17	44.937813	-78.713223
3008004	9	1991	29.4	3820	1.1	41.9	73	82	17	44.937813	-78.713223
3008004	9	1991	26.6	3740	0.95	41.6	75.2	82	17	44.937813	-78.713223
3008005	9	1991	28.1	4080	0.65	34.2	53.8	82	17	44.304494	-77.950776
3008005	9	1991	27.7	4320	1.1	35.2	53.1	82	17	44.304494	-77.950776
3008005	9	1991	31.9	3890	0.65	36.1	52.5	82	17	44.304494	-77.950776
3008006	9	1991	18.5	3720	0.85	33.7	53.1	82	18	44.048525	-77.741013
3008006	9	1991	17.4	3550	0.95	32.9	52.6	82	18	44.048525	-77.741013
3008006	9	1991	16.8	3130	0.66	33.8	51.5	82	18	44.048525	-77.741013
3008007	9	1991	10.2	3610	0.75	30.9	62	82	17	43.724712	-79.95708
3008007	9	1991	8.3	4110	0.8	28.3	55.3	82	17	43.724712	-79.95708
3008007	9	1991	8.9	3700	0.75	28	55.8	82	17	43.724712	-79.95708
3008008	9	1991	17.5	6610	0.75	46.3	82.6	82	17	44.060396	-78.611093
3008008	9	1991	18.3	5260	0.8	45.4	84.4	82	17	44.060396	-78.611093
3008008	9	1991	16.8	4850	1.7	47.1	86.3	82	17	44.060396	-78.611093

Station	Land Use	Year	Sr	Ti	U	Va	Zn	DATUM	ZONE	latitude	longitude
3008009	9	1991	15	3530	0.6	37.3	55.2	82	17	44.921885	-78.064296
3008009	9	1991	14.3	3600	0.5	39.1	52.9	82	17	44.921885	-78.064296
3008009	9	1991	14.9	3720	0.55	37.2	58	82	17	44.921885	-78.064296
3008010	9	1991	18.7	3150	0.85	28.8	50.3	82	17	44.561536	-78.862881
3008010	9	1991	20	2950	0.85	26.8	57.2	82	17	44.561536	-78.862881
3008010	9	1991	24.6	3250	0.66	36	58.5	82	17	44.561536	-78.862881
3008011	9	1991	14.4	5250	1.4	49.4	89.2	82	17	44.164546	-79.005658
3008011	9	1991	16.1	5580	1.2	51.9	93.7	82	17	44.164546	-79.005658
3008011	9	1991	15.8	4940	1.2	51.3	85.9	82	17	44.164546	-79.005658
3008012	9	1991	8.8	5210	0.35	50.5	30.4	82	17	43.999372	-78.127351
3008012	9	1991	9.4	4930	0.4	49.7	34.6	82	17	43.999372	-78.127351
3008012	9	1991	9	5440	0.35	51.2	32.6	82	17	43.999372	-78.127351
3008013	9	1991	21.6	4390	1.1	41.1	59.1	82	17	45.443606	-78.818309
3008013	9	1991	21.1	3240	1.1	40.5	57	82	17	45.443606	-78.818309
3008013	9	1991	21.1	3510	0.77	39.3	53.1	82	17	45.443606	-78.818309
3008014	9	1991	8.5	3260	0.9	34.6	55.7	82	17	43.875236	-78.778045
3008014	9	1991	9.4	4160	0.85	39.4	58.9	82	17	43.875236	-78.778045
3008014	9	1991	8.3	3860	0.8	32.8	54.3	82	17	43.875236	-78.778045
3008015	9	1991	21.8	3090	0.82	40.1	52.2	82	17	44.086538	-78.632124
3008015	9	1991	22.9	3210	0.8	39.8	55.4	82	17	44.086538	-78.632124
3008015	9	1991	25	3280	1.9	41.5	55	82	17	44.086538	-78.632124
3008016	9	1991	59.8	3620	0.8	25	33.9	82	17	44.579151	-79.86651
3008016	9	1991	50.6	3730	0.7	30	48.3	82	17	44.579151	-79.86651
3008016	9	1991	65.9	3310	0.75	28.9	34.5	82	17	44.579151	-79.86651

Station	Land Use	Year	Sr	Ti	U	Va	Zn	DATUM	ZONE	latitude	longitude
3008017	9	1991	27.7	3250	0.69	26.6	61.6	82	17	44.536002	-78.72486
3008017	9	1991	26.7	3070	0.71	24.6	65.2	82	17	44.536002	-78.72486
3008017	9	1991	27.2	3270	0.78	28.2	65.6	82	17	44.536002	-78.72486
3008018	3	1991	23.3	2760	0.89	28	94.1	82	17	43.498174	-79.656502
3008018	3	1991	25.7	2860	0.78	39.9	90.6	82	17	43.498174	-79.656502
3008018	3	1991	23.5	3000	1.8	39.5	75.5	82	17	43.498174	-79.656502
3008019	3	1991	76.7	2800	0.62	30.7	51	82	17	44.043621	-79.463372
3008019	3	1991	76.9	2640	0.68	31.2	49.7	82	17	44.043621	-79.463372
3008019	3	1991	81.3	2890	0.72	3.5	51.1	82	17	44.043621	-79.463372
3008020	3	1991	40.4	3650	0.8	37.6	118	82	17	43.597849	-79.518004
3008020	3	1991	35	3520	0.86	42.4	126	82	17	43.597849	-79.518004
3008020	3	1991	44.3	3820	1.2	40.5	113	82	17	43.597849	-79.518004
3008021	3	1991	35.7	3410	0.75	31.4	33.5	82	17	44.295616	-78.317542
3008021	3	1991	39.1	3680	1.1	32.5	33	82	17	44.295616	-78.317542
3008021	3	1991	40.4	3460	1	35.5	31.5	82	17	44.295616	-78.317542
3008021	3	1993	65	NA	0.6	31	57	82	17	44.295616	-78.317542
3008021	3	1993	63	NA	0.5	32	61	82	17	44.295616	-78.317542
3008022	3	1991	19.1	2680	0.75	23.6	53.4	82	17	43.885342	-78.883481
3008022	3	1991	21.7	2860	0.8	24.6	49.4	82	17	43.885342	-78.883481
3008022	3	1991	22.3	2860	1	26.3	53.1	82	17	43.885342	-78.883481
3008023	3	1991	11.5	5720	0.75	34.5	50.6	82	17	45.323151	-79.210841
3008023	3	1991	13.9	4570	0.45	33.6	56.2	82	17	45.323151	-79.210841
3008023	3	1991	11.1	4480	0.5	36.9	46.9	82	17	45.323151	-79.210841
3008024	3	1991	11.6	3480	0.59	32.1	50.2	82	17	43.721321	-79.399879

Station	Land Use	Year	Sr	Ti	U	Va	Zn	DATUM	ZONE	latitude	longitude
3008024	3	1991	12.1	3890	1.4	35.5	44.4	82	17	43.721321	-79.399879
3008024	3	1991	14.7	3410	0.66	38.7	52.2	82	17	43.721321	-79.399879
3008025	3	1991	30.1	2640	0.58	25.5	50.2	82	17	43.553012	-79.58218
3008025	3	1991	29.4	2260	0.88	26	50.6	82	17	43.553012	-79.58218
3008025	3	1991	31.5	2560	0.64	30.5	51.5	82	17	43.553012	-79.58218
3008026	3	1991	80.1	2730	1.2	34.5	71.6	82	17	44.358722	-78.745777
3008026	3	1991	76.5	2580	1	34.2	69.3	82	17	44.358722	-78.745777
3008026	3	1991	73.8	2670	1	30.7	66.9	82	17	44.358722	-78.745777
3008027	3	1991	11.4	4090	0.55	36.9	51.1	82	17	44.396812	-79.710565
3008027	3	1991	11.6	3910	0.49	38.2	54.1	82	17	44.396812	-79.710565
3008027	3	1991	13.4	3830	0.81	43.1	51.1	82	17	44.396812	-79.710565
3008226	3	1993	32	3300	0.6	32	50	82	17	43.958879	-78.164203
3008226	3	1993	31	3300	0.8	30	48	82	17	43.958879	-78.164203
3008265	3	1992	20	3100	0.3	26	60	82	17	43.598699	-79.514811
3008265	3	1992	22	3300	0.3	27	60	82	17	43.598699	-79.514811
3008274	3	1993	32	3800	0.6	30	84	82	17	43.683568	-79.759257
3008274	3	1993	30	3700	0.5	28	77	82	17	43.683568	-79.759257
3008278	3	1993	33	4500	0.7	44	180	82	17	44.920577	-79.369853
3008278	3	1993	29	4400	0.7	50	200	82	17	44.920577	-79.369853
3008282	3	1993	22	3400	0.3	30	36	82	17	44.105212	-79.117971
3008282	3	1993	22	3000	0.2	27	36	82	17	44.105212	-79.117971
3008292	3	1993	20	3800	0.2	31	55	82	17	43.339049	-79.778521
3008292	3	1993	20	4000	0.2	30	51	82	17	43.339049	-79.778521
3008296	3	1993	27	3200	0.4	46	75	82	17	44.617938	-79.41336

Station	Land Use	Year	Sr	Ti	U	Va	Zn	DATUM	ZONE	latitude	longitude
3008296	3	1993	32	3100	0.4	43	86	82	17	44.617938	-79.41336
3008600	3	1993	16	3000	0.3	24	65	82	17	43.676257	-79.347374
3008600	3	1993	16	3000	0.4	25	67	82	17	43.676257	-79.347374
3008604	3	1993	25	2700	0.3	26	90	82	17	43.670165	-79.299798
3008604	3	1993	28	2700	0.3	27	54	82	17	43.670165	-79.299798
3008608	3	1993	53	2800	0.3	24	41	82	17	43.644607	-79.46282
3008608	3	1993	51	2700	0.3	23	39	82	17	43.644607	-79.46282
3008612	3	1993	58	3300	0.5	47	200	82	17	43.60657	-79.494296
3008612	3	1993	68	3400	0.4	27	110	82	17	43.60657	-79.494296
3008616	3	1993	39	4500	0.6	50	80	82	17	43.698639	-79.518663
3008616	3	1993	42	4400	0.5	49	91	82	17	43.698639	-79.518663
4008001	9	1991	28	3050	1.7	40.3	55.1	82	18	45.559201	-74.457786
4008001	9	1991	30.8	2900	1.7	41.6	57.7	82	18	45.559201	-74.457786
4008001	9	1991	26.7	2820	2.5	49	49.7	82	18	45.559201	-74.457786
4008002	3	1991	21.6	3070	1.6	33.1	29.2	82	18	45.604983	-74.6027
4008002	3	1991	21.3	3010	1.7	33.6	29.2	82	18	45.604983	-74.6027
4008002	3	1991	20.7	3290	1.7	44.9	28.3	82	18	45.604983	-74.6027
4008003	9	1991	37.3	3630	2.2	38.4	64.5	82	18	45.249984	-74.822395
4008003	9	1991	34.3	3560	2.1	37	64.4	82	18	45.249984	-74.822395
4008003	9	1991	30.3	3580	2.1	42.7	69.8	82	18	45.249984	-74.822395
4008004	9	1991	35.6	3330	1.7	38.6	77.3	82	18	45.089424	-74.520196
4008004	9	1991	40.5	3180	1.8	40.7	73.1	82	18	45.089424	-74.520196
4008004	9	1991	28.6	3210	1.5	32.8	61.9	82	18	45.089424	-74.520196
4008005	9	1991	27.1	2410	0.66	35.8	58.9	82	18	45.086498	-74.530971

Station	Land Use	Year	Sr	Ti	U	Va	Zn	DATUM	ZONE	latitude	longitude
4008005	9	1991	26.8	2450	0.6	36.2	59.6	82	18	45.086498	-74.530971
4008005	9	1991	23.1	2580	1.5	35.4	63.6	82	18	45.086498	-74.530971
4008006	3	1991	26.5	3580	1.8	38.2	59.6	82	18	45.001218	-74.7707
4008006	3	1991	28.5	3470	0.8	39.3	59.7	82	18	45.001218	-74.7707
4008006	3	1991	26.3	3640	1.4	42.8	64.8	82	18	45.001218	-74.7707
4008007	9	1991	31.6	3220	0.78	46.3	69.2	82	18	45.088272	-75.35089
4008007	9	1991	31.3	3320	0.69	51.3	73.8	82	18	45.088272	-75.35089
4008007	9	1991	27.1	3470	1.6	39.8	67.7	82	18	45.088272	-75.35089
4008008	3	1991	18	3840	1.5	41	264	82	18	44.704585	-75.520366
4008008	3	1991	19.3	3570	1.3	39.8	286	82	18	44.704585	-75.520366
4008008	3	1991	18.8	3830	2.3	47.1	255	82	18	44.704585	-75.520366
4008009	9	1991	30.6	3050	1.2	26.9	58.9	82	18	44.646813	-76.319666
4008009	9	1991	28.2	3240	1.3	27.6	68.8	82	18	44.646813	-76.319666
4008009	9	1991	22.8	2960	0.63	30.5	62.1	82	18	44.646813	-76.319666
4008010	9	1991	6.7	2230	1.6	32.8	81.1	82	18	44.62183	-75.987331
4008010	9	1991	7.1	2330	1.7	33.4	84.6	82	18	44.62183	-75.987331
4008010	9	1991	7.2	2300	0.77	30.4	88.6	82	18	44.62183	-75.987331
4008012	3	1991	18.6	2860	1.5	39.3	47.9	82	18	44.892349	-76.018265
4008012	3	1991	19.8	2900	1.3	39.1	48.2	82	18	44.892349	-76.018265
4008012	3	1991	18.2	2680	0.74	38.4	48.5	82	18	44.892349	-76.018265
4008013	9	1991	25.1	3810	1.5	35.7	44	82	18	45.017301	-76.361732
4008013	9	1991	21.8	3260	1.2	29.7	41.4	82	18	45.017301	-76.361732
4008013	9	1991	26	3620	0.67	38.1	41.4	82	18	45.017301	-76.361732
4008014	9	1991	23	4250	1.2	53.5	101	82	18	45.085887	-76.30224

Station	Land Use	Year	Sr	Ti	U	Va	Zn	DATUM	ZONE	latitude	longitude
4008014	9	1991	21.6	3290	1.2	47.7	102	82	18	45.085887	-76.30224
4008014	9	1991	22.7	4180	0.48	44.4	114	82	18	45.085887	-76.30224
4008015	3	1991	37.7	4650	1.5	66.8	104	82	18	44.246348	-76.535246
4008015	3	1991	37.6	4840	1.5	66	107	82	18	44.246348	-76.535246
4008015	3	1991	36	4610	0.56	65.6	102	82	18	44.246348	-76.535246
4008016	3	1991	16.2	2730	0.77	27.7	49.4	82	18	44.590904	-75.741375
4008016	3	1991	15.4	2450	0.83	24.5	38.8	82	18	44.590904	-75.741375
4008016	3	1991	17.5	2890	0.92	27.7	44.9	82	18	44.590904	-75.741375
4008017	9	1991	18.4	3420	0.96	38.4	41.7	82	18	44.871667	-75.799318
4008017	9	1991	23.2	3110	0.91	1.3	44.4	82	18	44.871667	-75.799318
4008017	9	1991	23.6	3360	0.93	29.3	44	82	18	44.871667	-75.799318
4008018	3	1991	21.9	3430	1.3	51.3	106	82	18	45.37362	-75.657498
4008018	3	1991	21.4	3500	1.1	45.2	102	82	18	45.37362	-75.657498
4008018	3	1991	21.9	3660	1.2	47.9	130	82	18	45.37362	-75.657498
4008019	9	1991	17.4	2370	1.1	28.2	42.9	82	18	45.010163	-75.639392
4008019	9	1991	19.1	2560	1	31.7	46.9	82	18	45.010163	-75.639392
4008019	9	1991	16.2	2560	1.1	32	46.9	82	18	45.010163	-75.639392
4008020	3	1991	128	2360	1.2	16.2	46.3	82	18	44.098285	-77.575918
4008020	3	1991	123	2170	1.1	15.9	44.7	82	18	44.098285	-77.575918
4008020	3	1991	124	2420	1	17.2	43.1	82	18	44.098285	-77.575918
4008021	9	1991	26.1	3960	0.65	38.4	59.9	82	18	44.186567	-77.073722
4008021	9	1991	28.4	3700	0.75	38.5	53.6	82	18	44.186567	-77.073722
4008021	9	1991	26.5	3240	0.7	36	55.4	82	18	44.186567	-77.073722
4008022	9	1991	17.7	2610	0.7	26	57	82	18	43.905627	-77.262997

Station	Land Use	Year	Sr	Ti	U	Va	Zn	DATUM	ZONE	latitude	longitude
4008022	9	1991	17.1	2120	0.5	24.9	61.1	82	18	43.905627	-77.262997
4008022	9	1991	17.2	2500	0.45	23.7	61	82	18	43.905627	-77.262997
4008023	3	1991	11.8	3320	0.65	25.8	37.6	82	18	44.140203	-77.419554
4008023	3	1991	13.3	3360	0.85	28	38	82	18	44.140203	-77.419554
4008023	3	1991	10.1	3810	0.75	23.5	35.4	82	18	44.140203	-77.419554
4008024	9	1991	14.3	4330	0.75	36.2	60.7	82	18	44.902411	-77.256303
4008024	9	1991	12	4580	0.7	37.3	47.3	82	18	44.902411	-77.256303
4008024	9	1991	16.7	4100	0.65	35.4	65.7	82	18	44.902411	-77.256303
4008025	9	1991	43.6	4210	1.3	73.3	110	82	18	45.465583	-76.698821
4008025	9	1991	44	4280	1.4	73.8	113	82	18	45.465583	-76.698821
4008025	9	1991	43.8	3990	1.2	73.1	113	82	18	45.465583	-76.698821
4008026	9	1991	72.4	4980	0.75	48	74.2	82	18	45.543051	-77.110919
4008026	9	1991	66.5	4680	0.85	48.6	68.9	82	18	45.543051	-77.110919
4008026	9	1991	71.8	4620	0.95	48.9	68	82	18	45.543051	-77.110919
4008027	9	1991	19	7350	0.35	77.8	83.6	82	18	45.454238	-77.796318
4008027	9	1991	18.1	7420	0.4	71.5	86.9	82	18	45.454238	-77.796318
4008027	9	1991	17.5	7230	0.4	74	79.4	82	18	45.454238	-77.796318
4008440	3	1993	45	NA	0.5	68	100	82	18	44.224103	-76.489546
4008440	3	1993	48	NA	0.5	56	80	82	18	44.224103	-76.489546
4008441	3	1993	19	NA	0.7	34	57	82	18	44.235394	-76.530303
4008444	3	1993	19	NA	0.3	31	48	82	18	44.585105	-75.694376
4008444	3	1993	18	NA	0.3	33	54	82	18	44.585105	-75.694376
4008451	3	1993	27	NA	1	53	86	82	18	45.393469	-75.675908
4008451	3	1993	26	NA	0.9	49	75	82	18	45.393469	-75.675908

Station	Land Use	Year	Sr	Ti	U	Va	Zn	DATUM	ZONE	latitude	longitude
4008455	3	1993	32	NA	0.5	46	60	82	18	45.133005	-76.147588
4008455	3	1993	30	NA	0.5	42	56	82	18	45.133005	-76.147588
4008459	3	1993	25	NA	0.5	49	69	82	18	45.46997	-76.676655
4008459	3	1993	29	NA	0.5	50	75	82	18	45.46997	-76.676655
4008463	3	1993	21	NA	0.5	35	55	82	18	45.82101	-77.112958
4008463	3	1993	18	NA	0.4	32	49	82	18	45.82101	-77.112958
5008001	3	1991	20.5	2330	1.2	15.7	28.9	82	17	46.30619	-78.561954
5008001	3	1991	19	2280	1.2	15.1	27.7	82	17	46.30619	-78.561954
5008001	3	1991	15.9	3440	1.3	8.6	21.8	82	17	46.30619	-78.561954
5008002	9	1991	30.9	2770	1.9	38.9	65.4	82	17	46.31845	-81.947994
5008002	9	1991	30.8	2390	2.6	47.6	75.2	82	17	46.31845	-81.947994
5008002	9	1991	20.6	2230	1.9	39.4	52.2	82	17	46.31845	-81.947994
5008003	3	1991	26.1	2890	1.7	33.5	24.7	82	17	46.357565	-79.945339
5008003	3	1991	26.3	2700	1.6	29.1	23.8	82	17	46.357565	-79.945339
5008003	3	1991	15.8	2920	1.8	35.3	18.8	82	17	46.357565	-79.945339
5008004	9	1991	52.6	2670	1.5	54.5	54	82	17	46.445992	-80.304536
5008004	9	1991	51.7	2760	1.5	57.9	55.8	82	17	46.445992	-80.304536
5008004	9	1991	35.2	2770	1.5	69.8	51.4	82	17	46.445992	-80.304536
5008006	9	1991	28.2	2450	1.3	37.2	118	82	17	45.728694	-79.069427
5008006	9	1991	32.6	2320	1.3	39.9	37.3	82	17	45.728694	-79.069427
5008006	9	1991	20.4	2490	1.4	46.9	70.3	82	17	45.728694	-79.069427
5008007	9	1991	9.4	4980	1.4	69	35.4	82	17	46.11506	-79.408956
5008007	9	1991	8.8	5060	1.2	67.7	25.6	82	17	46.11506	-79.408956
5008007	9	1991	8.2	4520	0.49	64.2	31.6	82	17	46.11506	-79.408956

Station	Land Use	Year	Sr	Ti	U	Va	Zn	DATUM	ZONE	latitude	longitude
5008008	9	1991	18.8	2320	1.5	13.5	18.7	82	17	46.301179	-79.099259
5008008	9	1991	22.4	2800	1.7	18.3	25.6	82	17	46.301179	-79.099259
5008008	9	1991	18.3	2290	0.77	11.3	24.4	82	17	46.301179	-79.099259
5008009	9	1991	13.8	3340	1.6	56.6	114	82	17	46.539147	-79.432149
5008009	9	1991	24.1	3250	1.2	28	24.7	82	17	46.539147	-79.432149
5008009	9	1991	33.4	3360	1.2	31	23.6	82	17	46.539147	-79.432149
5008010	9	1991	22.5	3180	0.53	29.4	23.9	82	17	46.980897	-79.92933
5008010	9	1991	36.6	3200	1.3	42.4	31	82	17	46.980897	-79.92933
5008010	9	1991	22.8	3580	1.2	36.7	33.9	82	17	46.980897	-79.92933
5008011	3	1991	61.6	2440	1.6	48.2	107	82	17	47.451131	-79.637923
5008011	3	1991	60.4	2660	1.7	48.3	111	82	17	47.451131	-79.637923
5008011	3	1991	53.6	2390	0.74	48.7	88.8	82	17	47.451131	-79.637923
5008012	3	1991	66	1350	1.6	21.7	35.1	82	17	47.508078	-79.667526
5008012	3	1991	62.1	1780	1.6	24.2	34	82	17	47.508078	-79.667526
5008012	3	1991	71.6	2880	0.58	25.5	39	82	17	47.508078	-79.667526
5008013	3	1991	26.4	1720	0.97	22.2	23.4	82	17	47.83559	-80.101092
5008013	3	1991	30.4	1910	1	23.4	26.9	82	17	47.83559	-80.101092
5008013	3	1991	25.7	1670	0.35	20.6	23.6	82	17	47.83559	-80.101092
5008014	9	1991	26	2960	0.5	39.4	35.3	82	17	48.565575	-80.608452
5008014	9	1991	39.2	2760	2.1	54.5	84.8	82	17	48.565575	-80.608452
5008014	9	1991	35.8	2720	2.3	51.6	80.4	82	17	48.565575	-80.608452
5008015	3	1991	27.9	1420	1.9	27.3	62.2	82	17	48.460868	-81.330359
5008015	3	1991	23.9	1270	1.7	21.6	49.9	82	17	48.460868	-81.330359
5008015	3	1991	24.1	1410	0.94	23.5	50.4	82	17	48.460868	-81.330359

Station	Land Use	Year	Sr	Ti	U	Va	Zn	DATUM	ZONE	latitude	longitude
5008016	3	1991	41.4	2170	1.4	41.6	61	82	17	49.063897	-81.005791
5008016	3	1991	40.3	1720	1.4	39.6	54.5	82	17	49.063897	-81.005791
5008016	3	1991	37.8	2000	0.76	30.8	52.9	82	17	49.063897	-81.005791
5008017	9	1991	35.1	2830	1.5	50.8	80.4	82	17	47.544459	-83.214844
5008017	9	1991	19.5	2790	1	29.5	12	82	17	47.544459	-83.214844
5008017	9	1991	21.2	2930	0.91	30.3	13.2	82	17	47.544459	-83.214844
5008018	9	1991	21.1	2600	0.47	24.1	16.2	82	16	47.937297	-84.751363
5008018	9	1991	33.3	2880	11	67	53.8	82	16	47.937297	-84.751363
5008018	9	1991	32.7	3090	11	67.8	58.9	82	16	47.937297	-84.751363
5008019	9	1991	35.1	3000	7	55.7	55	82	16	48.619034	-85.218563
5008019	9	1991	14.7	3090	1.1	46.5	17.5	82	16	48.619034	-85.218563
5008019	9	1991	19.9	2720	1	50.5	19	82	16	48.619034	-85.218563
5008020	9	1991	12.3	2430	0.42	20.2	14.4	82	16	46.979136	-84.517184
5008020	9	1991	11.4	2250	1	27.3	22.6	82	16	46.979136	-84.517184
5008020	9	1991	13.7	2310	1.1	32.2	24.7	82	16	46.979136	-84.517184
5008021	3	1991	46.4	3160	2	55.2	93.5	82	16	46.539687	-84.341401
5008021	3	1991	48.3	3310	2	57.6	97.1	82	16	46.539687	-84.341401
5008021	3	1991	42.8	3260	0.85	52.7	86.7	82	16	46.539687	-84.341401
5008022	9	1991	13.3	2380	0.59	28.3	27.4	82	17	46.339724	-83.93706
5008022	9	1991	35.1	3170	2.1	59.4	102	82	17	46.339724	-83.93706
5008022	9	1991	35.9	2810	2.2	57.6	89.7	82	17	46.339724	-83.93706
5008023	9	1991	38.4	3070	0.85	55.1	95	82	17	46.34766	-83.740843
5008023	9	1991	42.4	3030	3.2	42.5	79.5	82	17	46.34766	-83.740843
5008023	9	1991	41.6	2970	2.9	42.4	78.7	82	17	46.34766	-83.740843

Station	Land Use	Year	Sr	Ti	U	Va	Zn	DATUM	ZONE	latitude	longitude
5008024	9	1991	43.6	1770	1.8	39.8	74.9	82	17	46.282293	-83.502618
5008024	9	1991	18.9	2950	1.3	63.5	57.7	82	17	46.282293	-83.502618
5008024	9	1991	17.3	2480	1.4	56.5	39.3	82	17	46.282293	-83.502618
5008025	3	1991	21.2	1670	2.7	22	31.4	82	17	46.190093	-82.944934
5008025	3	1991	22.7	1860	2.7	22.8	31.4	82	17	46.190093	-82.944934
5008025	3	1991	28.9	1760	1.6	22.1	31.8	82	17	46.190093	-82.944934
5008026	3	1991	11.5	6490	2.1	60.2	97.1	82	17	45.341226	-80.028451
5008026	3	1991	11.6	6870	1.9	72.1	64	82	17	45.341226	-80.028451
5008026	3	1991	8.8	7390	1.4	85.3	67	82	17	45.341226	-80.028451
5008027	9	1991	15	2780	1.6	65.3	49.1	82	17	45.433773	-79.596785
5008027	9	1991	8.3	4450	1.3	33.6	27.9	82	17	45.433773	-79.596785
5008027	9	1991	10.4	4690	1.3	41.2	29.1	82	17	45.433773	-79.596785
5008070	3	1993	38	2900	0.8	49	58	82	17	49.271505	-81.612876
5008070	3	1993	47	2400	0.7	45	53	82	17	49.271505	-81.612876
5008076	3	1993	33	3600	0.3	58	81	82	17	49.416328	-82.428144
5008076	3	1993	32	3500	0.6	55	80	82	17	49.416328	-82.428144
5008079	3	1993	26	2300	0.3	32	44	82	17	49.077928	-81.023046
5008079	3	1993	23	2300	0.4	33	42	82	17	49.077928	-81.023046
5008084	3	1993	18	1600	0.5	17	21	82	17	48.76983	-80.679949
5008084	3	1993	20	2200	0.7	25	39	82	17	48.76983	-80.679949
5008086	3	1993	14	2000	0.4	21	41	82	17	48.482196	-81.213579
5008086	3	1993	15	1900	0.6	19	34	82	17	48.482196	-81.213579
5008090	3	1993	17	1600	0.2	23	29	82	17	47.674839	-81.728496
5008090	3	1993	13	1600	0.3	22	32	82	17	47.674839	-81.728496

Station	Land Use	Year	Sr	Ti	U	Va	Zn	DATUM	ZONE	latitude	longitude
5008135	9	1995	6.5	4500	1	41.4	24.1	82	16	47.236424	-84.649335
5008135	9	1995	29	3100	0.51	88	64	82	16	47.236424	-84.649335
5008136	9	1995	11	4200	0.26	50	27	82	16	47.585374	-84.821282
5008136	9	1995	10	4300	0.21	36	15	82	16	47.585374	-84.821282
5008137	9	1995	32	6500	0.2	83	10	82	16	47.433315	-84.729431
5008137	9	1995	27	5500	0.2	50	15	82	16	47.433315	-84.729431
6008001	3	1991	19.6	3070	0.9	68	56.3	82	16	48.375002	-89.291434
6008001	3	1991	20	3390	0.95	70.6	61.5	82	16	48.375002	-89.291434
6008001	3	1991	20.3	3270	1.2	71.6	59	82	16	48.375002	-89.291434
6008002	9	1991	11.8	4600	0.5	97.2	48.1	82	16	48.788737	-88.671654
6008002	9	1991	7.9	4580	0.5	82.7	44.2	82	16	48.788737	-88.671654
6008002	9	1991	10.8	4170	0.65	86.6	49.8	82	16	48.788737	-88.671654
6008003	3	1991	32.6	3930	1.1	87.1	64.3	82	16	49.010234	-88.268798
6008003	3	1991	34.2	3720	0.85	81.3	69	82	16	49.010234	-88.268798
6008003	3	1991	30.6	5060	0.95	105	61.9	82	16	49.010234	-88.268798
6008004	9	1991	16.1	1895	1.3	30.2	20	82	16	48.839262	-87.521727
6008004	9	1991	15.9	2290	1.2	31.2	21.7	82	16	48.839262	-87.521727
6008004	9	1991	17.2	2050	1	29.3	22.3	82	16	48.839262	-87.521727
6008005	3	1991	34.5	2840	0.7	55.1	106	82	16	48.713733	-86.380552
6008005	3	1991	31.4	3100	0.7	50.3	97.1	82	16	48.713733	-86.380552
6008005	3	1991	34	3010	0.7	55.9	102	82	16	48.713733	-86.380552
6008006	3	1991	13.5	2050	0.45	22	25.8	82	16	49.124168	-85.82926
6008006	3	1991	14.6	1872	0.5	20.6	26.5	82	16	49.124168	-85.82926
6008007	9	1991	38.4	2270	0.5	15.7	16.7	82	16	49.79431	-85.921562

Station	Land Use	Year	Sr	Ti	U	Va	Zn	DATUM	ZONE	latitude	longitude
6008007	9	1991	41.2	1955	0.4	17.1	16.9	82	16	49.79431	-85.921562
6008007	9	1991	38.6	1624	0.4	17.6	17.7	82	16	49.79431	-85.921562
6008008	3	1991	42.5	1564	0.6	18.5	15.9	82	16	49.713871	-86.953989
6008008	3	1991	47.5	1759	0.65	19.9	15.9	82	16	49.713871	-86.953989
6008008	3	1991	46.8	1592	0.65	20.2	19.9	82	16	49.713871	-86.953989
6008009	9	1991	21.2	2620	0.9	43.9	34.1	82	16	49.562205	-87.981578
6008009	9	1991	26.1	2800	0.9	48.1	35	82	16	49.562205	-87.981578
6008009	9	1991	24	2650	0.85	44	33.7	82	16	49.562205	-87.981578
6008010	9	1991	25.3	4060	0.75	64.1	148	82	16	48.271324	-89.389897
6008010	9	1991	26.3	3440	0.8	61.3	145	82	16	48.271324	-89.389897
6008010	9	1991	22.3	4720	0.75	76.1	144	82	16	48.271324	-89.389897
6008011	9	1991	58	3370	0.5	97	299	82	16	48.069741	-89.578564
6008011	9	1991	37.3	4880	0.75	69.6	241	82	16	48.069741	-89.578564
6008011	9	1991	26.6	5620	0.65	58.8	178	82	16	48.069741	-89.578564
6008012	9	1991	20.1	4320	0.4	110	69.8	82	15	48.614356	-90.219652
6008012	9	1991	22.4	3860	0.45	103	73.8	82	15	48.614356	-90.219652
6008012	9	1991	20.2	4330	0.45	106	68.4	82	15	48.614356	-90.219652
6008013	9	1991	29	2800	0.85	52.8	59.2	82	15	48.671443	-91.130731
6008013	9	1991	21.2	2780	0.6	41.7	52.7	82	15	48.671443	-91.130731
6008013	9	1991	22.8	2620	0.9	39	48	82	15	48.671443	-91.130731
6008014	9	1991	17.9	989	1.6	12.5	18	82	15	48.759752	-92.620144
6008014	9	1991	18.3	901	1.6	12.7	16.9	82	15	48.759752	-92.620144
6008014	9	1991	22.7	997	1.3	11.7	18.2	82	15	48.759752	-92.620144
6008015	3	1991	31.5	1800	0.6	26.6	42	82	15	48.612106	-93.411525

Station	Land Use	Year	Sr	Ti	U	Va	Zn	DATUM	ZONE	latitude	longitude
6008015	3	1991	39.9	1450	0.6	22.7	62.1	82	15	48.612106	-93.411525
6008015	3	1991	34.8	1470	0.55	26.9	39.6	82	15	48.612106	-93.411525
6008016	9	1991	29.5	1690	0.6	26.8	27.9	82	15	49.107977	-93.922574
6008016	9	1991	21.9	1830	0.55	23.3	22.8	82	15	49.107977	-93.922574
6008016	9	1991	30	1690	0.55	26.3	29.3	82	15	49.107977	-93.922574
6008017	3	1991	35.1	1930	0.85	30.7	32.9	82	15	49.762874	-94.481346
6008017	3	1991	37.1	1920	1	29.8	31.9	82	15	49.762874	-94.481346
6008017	3	1991	33.8	2110	0.85	34.8	40.2	82	15	49.762874	-94.481346
6008018	9	1991	10.6	997	0.99	25.3	30.4	82	15	49.858922	-93.393495
6008018	9	1991	10.7	977	0.39	19.9	28.4	82	15	49.858922	-93.393495
6008018	9	1991	9.8	1260	0.31	20.4	28.7	82	15	49.858922	-93.393495
6008019	9	1991	37.4	3200	0.6	55.2	119	82	15	49.758324	-92.649888
6008019	9	1991	36.8	3300	0.7	52.8	103	82	15	49.758324	-92.649888
6008019	9	1991	43.1	3450	0.75	64.2	127	82	15	49.758324	-92.649888
6008020	3	1991	10.2	2240	0.6	34.7	23.3	82	15	49.412425	-91.659047
6008020	3	1991	17.7	2330	0.55	39	26.7	82	15	49.412425	-91.659047
6008020	3	1991	17	2120	0.55	36.9	27.6	82	15	49.412425	-91.659047
6008021	9	1991	35.8	3970	0.55	83.3	32.7	82	15	49.04911	-90.482225
6008021	9	1991	29.5	2450	0.45	80.3	30.7	82	15	49.04911	-90.482225
6008021	9	1991	24.7	3910	0.5	73.8	28.6	82	15	49.04911	-90.482225
6008022	9	1991	22.8	1430	0.55	23.3	54.4	82	15	50.629722	-93.205481
6008022	9	1991	18.7	1480	0.4	17.1	38.7	82	15	50.629722	-93.205481
6008022	9	1991	22.5	1470	0.4	16.2	40.3	82	15	50.629722	-93.205481
6008023	3	1991	55.9	2490	0.8	32.9	138	82	15	51.015499	-93.822331

Station	Land Use	Year	Sr	Ti	U	Va	Zn	DATUM	ZONE	latitude	longitude
6008023	3	1991	45.6	2340	0.75	29.9	100	82	15	51.015499	-93.822331
6008023	3	1991	52.9	2460	0.75	36.5	111	82	15	51.015499	-93.822331
6008024	3	1991	17.2	2050	0.59	41.1	52.3	82	15	50.101921	-91.921662
6008024	3	1991	16.6	1970	0.46	36.1	49.2	82	15	50.101921	-91.921662
6008024	3	1991	16.4	2430	0.51	40.6	72.1	82	15	50.101921	-91.921662
6008025	9	1991	13.8	2670	0.6	39.2	21.9	82	15	49.487828	-91.534788
6008025	9	1991	15.7	2480	0.6	37.6	23.7	82	15	49.487828	-91.534788
6008025	9	1991	15	2400	0.65	40.1	24.8	82	15	49.487828	-91.534788
6008026	9	1991	9.5	1720	0.15	18.4	6.3	82	15	51.463813	-90.163646
6008026	9	1991	14.5	2170	0.25	28	11.1	82	15	51.463813	-90.163646
6008026	9	1991	10.8	1810	0.2	18.1	8.5	82	15	51.463813	-90.163646
6008027	9	1991	16.3	1540	1.2	18.6	27.7	82	15	50.243543	-90.709469
6008027	9	1991	16.6	1600	0.35	20	24.1	82	15	50.243543	-90.709469
6008027	9	1991	17.1	1540	0.45	20.1	25.3	82	15	50.243543	-90.709469
6008078	9	1992	36	990	NA	84	210	82	16	48.289464	-89.396784
6008078	9	1992	34	980	NA	85	220	82	16	48.289464	-89.396784
6008108	3	1993	72	880	0.9	54	100	82	16	48.942155	-88.256145
6008108	3	1993	56	850	0.7	55	100	82	16	48.942155	-88.256145
6008129	9	1993	19	1600	0.4	180	110	82	16	48.344791	-89.285423
6008129	9	1993	25	1400	NA	150	110	82	16	48.344791	-89.285423
6008133	9	1994	21	330	0.4	25	31	82	15	48.620287	-93.359622
6008133	9	1994	20	390	0.4	24	30	82	15	48.620287	-93.359622
6008150	3	1995	27	510	NA	76	64	82	15	48.758671	-91.611566
6008150	3	1995	28	450	NA	80	71	82	15	48.758671	-91.611566

Appendix 2: Short Term Atrazine Toxicity Data

Table 23: Short Term Atrazine Toxicity Test Data

Organism	Endpoint	Effect Concentration (µg/L)	Reference
Lepomis macrochirus	96-h LC50	48255	USEPA (2002) as cited in Giddings et al., (2005)
Ictalurus punctatus	96-h LC50	23800	Howe et at. (1998)
Ictalurus melas	96-h LC50	7600	Bathe et al., (1975)
Perca sp.	96-h LC50	16000	Bathe et al., (1975)
Poecilia reticulata	96-h LC50	4300	Ciba-Geigy (1972) as cited in Giddings et al., (2005)
Leuciscus idus forma orfus	96-h LC50	44000	Bathe et al., (1975)
Oncorhynchus kisutch	96-h LC50	16750	Wan et al., (2006)
Oncorhynchus tshawytscha	96-h LC50	18750	Wan et al., (2006)
Carrassius auratus	96-d LC50	60000	USEPA (2002) as cited in Giddings et al., (2005)

Organism	Endpoint	Effect Concentration (µg/L)	Reference
Oncorhynchus mykiss	96-h LC50	14700	Howe et at. (1998), Wan et al., (2006), Bathe et al., (1975 and 1976), Beliles and Scott (1965) as cited in Giddings et al., (2005), USEPA as cited in Giddings et al., (2005)
Pimephales promelas	96-h LC50	17500	Macek et al., (1976) as cited in Giddings et al., (2005), Dionne (1992) as cited in Giddings et al., (2005)
Cyprinus carpio	96-h LC50	18800	Neskovic et al., (1993)
Carassius carassius	96-h LC50	88000	Bathe et al., (1975 and 1976)
Notropis atherinoides	96-h LC50	15600	USEPA (2002) as cited in Giddings et al., (2005)
Salvelinus fontinalis	96-h LC50	6300	Macek et al., (1976) as cited in Giddings et al., (2005)
Daphnia carinata	48-h EC50 (immobilization)	23100	Phyu et al., (2004)
Daphnia magna	48-h LC50	72000	Wan et al., (2006), Macek et al., (1976) as cited in Giddings et al., (2005)
Daphnia pulex	48-h EC50	14892	Hartman and Martin (1985)
Ceriodaphnia dubia	96-h- IC50	10300	Oris et al., (1991)
Chironomus tentans	48-h LC50	720	Macek et al., (1976) as cited in Giddings et al., (2005)

Organism	Endpoint	Effect Concentration (µg/L)	Reference
Gammarus fasciatus	48-h LC50	5700	Macek et al., (1976) as cited in Giddings et al., (2005)
Gammarus italicus	96-h LC50	10100	Pantani et al., (1997)
Echinogammarus tibaldii	96-h LC50	3300	Pantani et al., (1997)
Utterbackia imbecillis	24-h LC50l	98450	Conners and Black (2004)
Anodonta imbecillis	48-h LC50	60000	Johnson et al., (1993)
Paratya australiensis	96-h LC50	9850	Phyu et al., (2005)
Gammarus pulex	96-h LC50	14900	Taylor et al., (1991)
Rana pipens, late larvae	96-h LC50	14500	Howe et at. (1998)
Rana catesbeiana	96-h LC50	20000	Wan et al., (2006)
Bufo americanus, late larvae	96-h LC50	10700	Howe et at. (1998)
Lemna minor	96-h EC50 frond count	92	Hartman and Martin (1985) and Fairchild et al., (1997)
Myriophyllum spicatum	24-h EC50 for photosynthesis	104	Jones and Winchell (1984)
Potamogeton perfoliatus	24-h EC50 for photosynthesis	77	Jones and Winchell (1984)

Organism	Endpoint	Effect Concentration (µg/L)	Reference
Ruppia maritima	24-h EC50 for photosynthesis	102	Jones and Winchell (1984)
Zannichellia palustris	24-h EC50 for photosynthesis	91	Jones and Winchell (1984)

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Phyu, Y.L., M. StJ Warne and R.P. Lim. 2005. Toxicity and bioavailability of atrazine and molinate to the freshwater shrimp (*Paratya australiensis*) under laboratory and simulated field conditions. Ecotox. Env. Safety 60:113-22.

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Appendix 3: Soil Zinc Toxicity Data

Table 24: Soil Zinc Toxicity Data

Organism	Effect[1]	Effect[1] Measurement	Endpoint	Effect Concentration (mg/kg)	Reference
Brassica rapa	DVP	EMRG	NOEC	50	Sheppard, S.C., W.G. Evenden, S.A. Abboud, and M. Stephenson. 1993. A plant life-cycle bioassay for contaminated soil, with comparison to other bioassays: mercury and zinc. Arch. Environ. Contam. Toxicol. 25(1):27-35.
Lactuca sativa	DVP	EMRG	NOEC	50	
Brassica rapa	DVP	EMRG	LOEC	100	
Lactuca sativa	DVP	EMRG	LOEC	100	
Brassica rapa	DVP	EMRG	NOEC	50	
Brassica rapa	DVP	EMRG	NOEC	600	
Brassica rapa	DVP	EMRG	NOEC	600	
Lactuca sativa	DVP	EMRG	NOEC	1000	
Lactuca sativa	DVP	EMRG	NOEC	1000	
Brassica rapa	DVP	EMRG	LOEC	100	
Brassica rapa	DVP	EMRG	LOEC	1000	
Brassica rapa	DVP	EMRG	LOEC	1000	

Phaseolus vulgaris	GRO	AREA	LOEC	740	Vangronsveld, J., Assche F. Van, and H. Clijsters. 1995. Reclamation of a bare industrial area contaminated by non-ferrous metals: in situ metal immobilization and revegetation. Environmental Pollution 87(1):51-59.
Hordeum vulgare	GRO	BMAS	NOEC	250	Aery, N.C., and B.L. Jagetiya. 1997. Relative toxicity of cadmium, lead and zinc on Barley. Commun.Soil Sci.Plant Anal. 28(11/12):949-960.
Zea mays	GRO	BMAS	NOEC	15000	Arriechi, E., and R. Ramirez. 1997. Soil test for available zinc in acid soils of Venezuela. Commun.Soil Sci.Plant Anal. 28(17/18):1471-1480.
Zea mays	GRO	BMAS	NOEC	15000	
Zea mays	GRO	BMAS	NOEC	15	
Zea mays	GRO	BMAS	NOEC	15000	
Zea mays	GRO	BMAS	NOEC	15000	
Trifolium alexandrinum	GRO	BMAS	NOEC	32	Bansal, R.L., and D.S. Chahal. 1997. Zinc-manganese relationships in berseem (*Trifolium alexandrinum*) grown on an alkaline soil in a pot experiment. Acta Agron. Hung. 45(4):449-454.

Medicago sativa	GRO	BMAS	NOEC	144	Biro, B., K. Koves-Pechy, I. Voros, and I. Kadar. 1998. Toxicity of some field applied heavy metal salts to the rhizobial and fungal microsymbionts of alfalfa and red clover. Agrokem. Talajtan 47(1-4):265-276.
Secale cereale	GRO	BMAS	NOEC	1009	Chlopecka, A., and D.C. Adriano. 1997. Zinc uptake by plants on amended polluted soils (Reprinted from Plant nutrition for sustainable food production and environment, 1997). Soil Science & Plant Nutrition 43(Special Issue SI):1031-1036.
Zea mays	GRO	BMAS	NOEC	1955	
Zea mays	GRO	BMAS	NOEC	1085	
Zea mays	GRO	BMAS	NOEC	58.8	Chlopecka, Anna, and Domy C. Adriano. 1996. Mimicked in-situ stabilization of metals in a cropped soil: bioavailability and chemical form of zinc. Environ. Sci. Technol. 3294-3303.
Zea mays	GRO	BMAS	NOEC	224	
Zea mays	GRO	BMAS	NOEC	83.4	
Zea mays	GRO	BMAS	NOEC	217	
Zea mays	GRO	BMAS	NOEC	51.6	
Zea mays	GRO	BMAS	NOEC	47	
Zea mays	GRO	BMAS	NOEC	254	
Hordeum vulgare	GRO	BMAS	NOEC	35.5	

Hordeum vulgare	GRO	BMAS	NOEC	260	
Hordeum vulgare	GRO	BMAS	NOEC	51.6	
Avena sp.	GRO	BMAS	NOEC	100	De Haan, S. 1985. Acceptable levels of heavy metals (Cd, Cr, Cu, Ni, Pb, Zn) in Soils. Hren (Gr), The Netherlands (Rapport 9-85) (Cited in Janus and Krajnc 1989).
Avena sp.	GRO	BMAS	NOEC	200	
Avena sp.	GRO	BMAS	NOEC	800	
Avena sp.	GRO	BMAS	NOEC	200	
Avena sp.	GRO	BMAS	NOEC	400	
Avena sp.	GRO	BMAS	NOEC	800	
Triticum sp.	GRO	BMAS	NOEC	15	Fodor, L. 1998. Effect of heavy metals on wheat and maize crop on brown forest soil. Agrokem. Talajtan 47(1-4):197-206.
Triticum sp.	GRO	BMAS	NOEC	15	
Triticum sp.	GRO	BMAS	NOEC	135	
Triticum sp.	GRO	BMAS	NOEC	30	
Triticum sp.	GRO	BMAS	NOEC	45	
Triticum sp.	GRO	BMAS	NOEC	45	
Triticum sp.	GRO	BMAS	NOEC	45	
Zea mays	GRO	BMAS	NOEC	135	
Zea mays	GRO	BMAS	NOEC	180	Giordano, P.M., J.J. Mortvedt, and D.A. Mays. 1975. Effect of municipal wastes on crop yields and uptake of heavy metals.
Zea mays	GRO	BMAS	NOEC	45	
Zea mays	GRO	BMAS	NOEC	45	

Phaseolus vulgaris	GRO	BMAS	NOEC	180	J. Environ. Qual. 4(3):394-399.
Phaseolus vulgaris	GRO	BMAS	NOEC	180	
Phaseolus vulgaris	GRO	BMAS	NOEC	180	
Phaseolus vulgaris	GRO	BMAS	NOEC	180	
Gossypium sp.	GRO	BMAS	NOEC	20	Kashyap, J., J.C. Sharma, and V.K. Gupta. 1988. Influence on Zn levels on dry matter yield, Zn and P concentration in parts of cotton genotypes at varying growth stages. J. Indian Soc. Soil Sci. 36(2):386-388.
Gossypium sp.	GRO	BMAS	NOEC	20	
Gossypium sp.	GRO	BMAS	NOEC	20	
Gossypium sp.	GRO	BMAS	NOEC	20	
Gossypium sp.	GRO	BMAS	NOEC	20	
Gossypium sp.	GRO	BMAS	NOEC	20	
Hordeum vulgare	GRO	BMAS	NOEC	100	Luo, Y., and D.L. Rimmer. 1995. Zinc-copper interaction affecting plant growth on a metal-contaminated soil. Environ Pollut 88(1):79-83.
Hordeum vulgare	GRO	BMAS	NOEC	100	

Oryza sativa	GRO	BMAS	NOEC	20	Mukhi, A.K., and U.C. Shukla. 1991. Effect of S and Zn on yield and their uptake in rice in submerged soil conditions .J. Indian Soc. Soil Sci. 39(4):730-734.
Gossypium hirsutum	GRO	BMAS	NOEC	200	Rehab, F.I., and A. Wallace. 1978. Excess trace metal effects on cotton: 2. copper, zinc, cobalt and manganese in Yolo loam soil. Commun.Soil Sci.Plant Anal. 9(6):519-527.
Gossypium barbadense	GRO	BMAS	NOEC	400	
Gossypium barbadense	GRO	BMAS	NOEC	200	
Avena sp.	GRO	BMAS	NOEC	11	Roszyk, E., S. Roszyk, and Z. Spiak. 1988. The zinc amount toxic for plants contaminated in soils. Rocz Gieboznaw T (3):57-69.
Avena sp.	GRO	BMAS	NOEC	98	
Avena sp.	GRO	BMAS	NOEC	105	
Avena sp.	GRO	BMAS	NOEC	450	
Avena sp.	GRO	BMAS	NOEC	105	
Avena sp.	GRO	BMAS	NOEC	450	
Avena sp.	GRO	BMAS	NOEC	115	
Avena sp.	GRO	BMAS	NOEC	220	
Avena sp.	GRO	BMAS	NOEC	115	
Avena sp.	GRO	BMAS	NOEC	112	

Avena sp.	GRO	BMAS	NOEC	256	
Avena sp.	GRO	BMAS	NOEC	260	
Avena sp.	GRO	BMAS	NOEC	475	
Avena sp.	GRO	BMAS	NOEC	440	
Avena sp.	GRO	BMAS	NOEC	440	
Avena sp.	GRO	BMAS	NOEC	485	
Avena sp.	GRO	BMAS	NOEC	9	
Avena sp.	GRO	BMAS	NOEC	210	
Brassica sp.	GRO	BMAS	NOEC	7	
Brassica sp.	GRO	BMAS	NOEC	420	
Brassica sp.	GRO	BMAS	NOEC	7	
Brassica sp.	GRO	BMAS	NOEC	120	
Brassica sp.	GRO	BMAS	NOEC	105	
Solanum tuberosum	GRO	BMAS	NOEC	4	Sharma, U.C., and J.S. Grewal. 1990. Potato response to zinc as influenced by genetic variability. J. Indian Potato Assoc. 17(1-2):1-5.
Solanum tuberosum	GRO	BMAS	NOEC	4	
Brassica rapa	GRO	BMAS	NOEC	600	Sheppard, S.C., W.G. Evenden, S.A. Abboud, and M. Stephenson. 1993. a plant life-cycle bioassay for contaminated soil, with comparison to other bioassays:
Brassica rapa	GRO	BMAS	NOEC	600	
Brassica rapa	GRO	BMAS	NOEC	300	

Brassica rapa	GRO	BMAS	NOEC	600	mercury and zinc. Arch. Environ. Contam. Toxicol. 25(1):27-35.
Triticum sp.	GRO	BMAS	NOEC	5	Singh, B., and R.A. Antil. 1996. Effect of zn and n levels on dry matter yield and nutrient uptake by wheat. Ann. Biol.(Ludhiana) 12(1):165-167.
Oryza sativa	GRO	BMAS	NOEC	6	
Glycine max	GRO	BMAS	NOEC	5	Vesper, S.J., and T.C. Weidensaul. 1978. Effects of cadmium, nickel, copper and zinc on nitrogen fixation by soybeans. Water Air Soil Pollut 9:413-422.
Trifolium pratense	GRO	BMAS	NOEC	275	Voros, I., B. Biro, T. Takacs, K. Koves-Pechy, and K. Bujtas. 1998. Effect of arbuscular mycorrhizal fungi on heavy metal toxicity to *Trifolium pratense* in soils contaminated with Cd, Zn and Ni salts. Agrokem. Talajtan 47(1-4):277-288.
Trifolium pratense	GRO	BMAS	NOEC	275	
Hordeum vulgare	GRO	BMAS	LOEC	1250	Aery, N.C., and B.L. Jagetiya. 1997. Relative toxicity of cadmium, lead and zinc on barley. Commun.Soil Sci.Plant Anal. 28(11/12):949-960.

Trifolium alexandrinum	GRO	BMAS	LOEC	60	Bansal, R.L., and D.S. Chahal. 1997. Zinc-manganese relationships in berseem (*Trifolium alexandrinum*) grown on an alkaline soil in a pot experiment. Acta Agron. Hung. 45(4):449-454.
Trifolium pratense	GRO	BMAS	LOEC	19	Biro, B., K. Koves-Pechy, I. Voros, and I. Kadar. 1998. Toxicity of some field applied heavy metal salts to the rhizobial and fungal microsymbionts of alfalfa and red clover. Agrokem. Talajtan 47(1-4):265-276.
Secale cereale	GRO	BMAS	LOEC	965	Chlopecka, A., and D.C. Adriano. 1997. Zinc uptake by plants on amended polluted soils (Reprinted from Plant nutrition for sustainable food production and environment, 1997). Soil Science & Plant Nutrition 43(Special Issue SI):1031-1036.
Secale cereale	GRO	BMAS	LOEC	989	
Secale cereale	GRO	BMAS	LOEC	1085	
Secale cereale	GRO	BMAS	LOEC	1824	
Zea mays	GRO	BMAS	LOEC	965	
Zea mays	GRO	BMAS	LOEC	989	
Zea mays	GRO	BMAS	LOEC	2080	

Zea mays	GRO	BMAS	LOEC	1009	
Zea mays	GRO	BMAS	LOEC	113	Chlopecka, Anna, and Domy C. Adriano. 1996. Mimicked in-situ stabilization of metals in a cropped soil: bioavailability and chemical form of zinc. Environ. Sci. Technol. :3294-3303.
Zea mays	GRO	BMAS	LOEC	58.8	
Zea mays	GRO	BMAS	LOEC	189	
Zea mays	GRO	BMAS	LOEC	77.7	
Hordeum vulgare	GRO	BMAS	LOEC	58.8	
Hordeum vulgare	GRO	BMAS	LOEC	224	
Hordeum vulgare	GRO	BMAS	LOEC	283	
Raphanus sativus	GRO	BMAS	LOEC	35.5	
Raphanus sativus	GRO	BMAS	LOEC	3.6	
Raphanus sativus	GRO	BMAS	LOEC	47	
Triticum sp.	GRO	BMAS	LOEC	45	Fodor, L. 1998. Effect of heavy metals on wheat and maize crop on brown forest soil. Agrokem. Talajtan 47(1-4):197-206.
Triticum sp.	GRO	BMAS	LOEC	45	
Triticum sp.	GRO	BMAS	LOEC	135	
Triticum sp.	GRO	BMAS	LOEC	270	
Triticum sp.	GRO	BMAS	LOEC	270	

Phaseolus vulgaris	GRO	BMAS	LOEC	45	Giordano, P.M., J.J. Mortvedt, and D.A. Mays. 1975. Effect of municipal wastes on crop yields and uptake of heavy metals. J. Environ. Qual. 4(3):394-399.
Zea mays	GRO	BMAS	LOEC	90	
Phaseolus vulgaris	GRO	BMAS	LOEC	45	
Phaseolus vulgaris	GRO	BMAS	LOEC	45	
Zea mays	GRO	BMAS	LOEC	90	
Phaseolus vulgaris	GRO	BMAS	LOEC	90	
Phaseolus vulgaris	GRO	BMAS	LOEC	90	
Phaseolus vulgaris	GRO	BMAS	LOEC	45	
Phaseolus vulgaris	GRO	BMAS	LOEC	45	
Phaseolus vulgaris	GRO	BMAS	LOEC	90	
Phaseolus vulgaris	GRO	BMAS	LOEC	45	

Phaseolus vulgaris	GRO	BMAS	LOEC	45	
Phaseolus vulgaris	GRO	BMAS	LOEC	180	
Phaseolus vulgaris	GRO	BMAS	LOEC	360	
Glycine max	GRO	BMAS	LOEC	1.25	Gupta, V.K., C.P. Singh, and P.S. Relan. 1992. Effect of Zn-enriched organic manures on Zn nutrition of wheat and residual effect on soybean. Bioresour. Technol. 42(2):155-157.
Oryza sativa	GRO	BMAS	LOEC	5	Mukhi, A.K., and U.C. Shukla. 1991. Effect of S and Zn on yield and their uptake in rice in submerged soil conditions. J. Indian Soc. Soil Sci. 39(4):730-734.
Oryza sativa	GRO	BMAS	LOEC	20	
Gossypium hirsutum	GRO	BMAS	LOEC	400	Rehab, F.I., and A. Wallace. 1978. Excess trace metal effects on cotton: 2. copper, zinc, cobalt and manganese in Yolo loam soil. Commun.Soil Sci.Plant Anal.
Gossypium hirsutum	GRO	BMAS	LOEC	400	

Gossypium barbadense	GRO	BMAS	LOEC	400	9(6):519-527.
Avena sp.	GRO	BMAS	LOEC	95	Roszyk, E., S. Roszyk, and Z. Spiak. 1988. The zinc amount toxic for plants contaminated in soils. Rocz Gieboznaw T (3):57-69.
Avena sp.	GRO	BMAS	LOEC	95	
Avena sp.	GRO	BMAS	LOEC	98	
Avena sp.	GRO	BMAS	LOEC	210	
Avena sp.	GRO	BMAS	LOEC	98	
Avena sp.	GRO	BMAS	LOEC	450	
Avena sp.	GRO	BMAS	LOEC	220	
Avena sp.	GRO	BMAS	LOEC	425	
Avena sp.	GRO	BMAS	LOEC	220	
Avena sp.	GRO	BMAS	LOEC	420	
Avena sp.	GRO	BMAS	LOEC	256	
Avena sp.	GRO	BMAS	LOEC	420	
Avena sp.	GRO	BMAS	LOEC	230	
Avena sp.	GRO	BMAS	LOEC	230	
Avena sp.	GRO	BMAS	LOEC	230	
Avena sp.	GRO	BMAS	LOEC	500	
Avena sp.	GRO	BMAS	LOEC	260	
Avena sp.	GRO	BMAS	LOEC	500	
Avena sp.	GRO	BMAS	LOEC	485	

Avena sp.	GRO	BMAS	LOEC	485	
Brassica sp.	GRO	BMAS	LOEC	95	
Brassica sp.	GRO	BMAS	LOEC	105	
Brassica sp.	GRO	BMAS	LOEC	260	
Brassica sp.	GRO	BMAS	LOEC	235	
Ornithopus compressus	GRO	BMAS	LOEC	98	
Ornithopus compressus	GRO	BMAS	LOEC	250	
Ornithopus compressus	GRO	BMAS	LOEC	115	
Ornithopus compressus	GRO	BMAS	LOEC	102	
Ornithopus compressus	GRO	BMAS	LOEC	95	
Solanum tuberosum	GRO	BMAS	LOEC	8	Sharma, U.C., and J.S. Grewal. 1990. Potato response to zinc as influenced by genetic variability. J. Indian Potato Assoc. 17(1-2):1-5.
Solanum tuberosum	GRO	BMAS	LOEC	8	
Solanum tuberosum	GRO	BMAS	LOEC	8	

Solanum tuberosum	GRO	BMAS	LOEC	4	
Brassica rapa	GRO	BMAS	LOEC	1000	Sheppard, S.C., W.G. Evenden, S.A. Abboud, and M. Stephenson. 1993. A plant life-cycle bioassay for contaminated soil, with comparison to other bioassays: mercury and zinc. Arch. Environ. Contam. Toxicol. 25(1):27-35.
Brassica rapa	GRO	BMAS	LOEC	1000	
Brassica rapa	GRO	BMAS	LOEC	600	
Brassica rapa	GRO	BMAS	LOEC	1000	
Triticum sp.	GRO	BMAS	LOEC	50	Singh, B., and R.A. Antil. 1996. Effect of Zn and N levels on dry matter yield and nutrient uptake by wheat. Ann. Biol.(Ludhiana) 12(1):165-167.
Triticum sp.	GRO	BMAS	LOEC	5	
Glycine max	GRO	BMAS	LOEC	1	Vesper, S.J., and T.C. Weidensaul. 1978. Effects of cadmium, nickel, copper and zinc on nitrogen fixation by soybeans. Water Air Soil Pollut. 9:413-422.
Glycine max	GRO	BMAS	LOEC	10	
Glycine max	GRO	BMAS	LOEC	1	

Brassica rapa	GRO	BMAS	EC50	1000	Sheppard, S.C., W.G. Evenden, S.A. Abboud, and M. Stephenson. 1993. a plant life-cycle bioassay for contaminated soil, with comparison to other bioassays: mercury and zinc. Arch. Environ. Contam. Toxicol. 25(1):27-35.
Lactuca sativa	GRO	BMAS	EC25	130	Mitchell, G.A. 1977. Relative phytotoxicity, uptake and interactive effects of Cd, Cu, Ni and Zn to plants grown on soils amended with metal-enriched sewage sludge. PhD Thesis. Univ. of Calif. Riverside, CA 38(4):95.
Triticum aestivum	GRO	BMAS	EC25	580	
Triticum sp.	GRO	GGRT	NOEC	45	Fodor, L. 1998. Effect of heavy metals on wheat and maize crop on brown forest soil. Agrokem. Talajtan 47(1-4):197-206.
Arachis hypogaea	GRO	HGHT	NOEC	20	Davis, J.G., and M.B. Parker. 1993. Zinc toxicity symptom development and partitioning of biomass and zinc in peanut plants. J. Plant Nutr. 16(12):2353-2369.
Arachis hypogaea	GRO	HGHT	NOEC	10	
Arachis hypogaea	GRO	HGHT	NOEC	10	

Brassica rapa	GRO	HGHT	NOEC	600	Sheppard, S.C., W.G. Evenden, S.A. Abboud, and M. Stephenson. 1993. A plant life-cycle bioassay for contaminated soil, with comparison to other bioassays: mercury and zinc. Arch. Environ. Contam. Toxicol. 25(1):27-35.
Brassica rapa	GRO	HGHT	NOEC	600	
Arachis hypogaea	GRO	HGHT	LOEC	40	Davis, J.G., and M.B. Parker. 1993. Zinc toxicity symptom development and partitioning of biomass and zinc in peanut plants. J. Plant Nutr. 16(12):2353-2369.
Arachis hypogaea	GRO	HGHT	LOEC	20	
Arachis hypogaea	GRO	HGHT	LOEC	20	
Brassica rapa	GRO	HGHT	LOEC	1000	Sheppard, S.C., W.G. Evenden, S.A. Abboud, and M. Stephenson. 1993. a plant life-cycle bioassay for contaminated soil, with comparison to other bioassays: mercury and zinc. Arch. Environ. Contam. Toxicol. 25(1):27-35.
Brassica rapa	GRO	HGHT	LOEC	1000	
Brassica rapa	GRO	HGHT	EC50	1000	
Brassica rapa	GRO	HGHT	EC50	1000	
Oryza sativa	GRO	HGHT	NOEC	2.62	Khan, H.R., B. Faiz, K.R. Islam, S. Rahman, T. Adachi, and I.U. Ahmed. 1991. Effect of gypsum and zinc on the growth and yield of rice grown under
Oryza sativa	GRO	HGHT	NOEC	2.59	
Oryza sativa	GRO	HGHT	NOEC	2.66	

Oryza sativa	GRO	HGHT	NOEC	2.61	saline water stress in coastal saline soil. Int. J. Trop. Agric. 9(3):182-189.
Oryza sativa	GRO	HGHT	NOEC	2.7	
Oryza sativa	GRO	HGHT	NOEC	2.67	
Hordeum vulgare	GRO	LGTH	LOEC	77.42	Aery, N.C., and B.L. Jagetiya. 1997. Relative toxicity of cadmium, lead and zinc on barley. Commun.Soil Sci.Plant Anal. 28(11/12):949-960.
Hordeum vulgare	GRO	LGTH	LOEC	380.7	
Hordeum vulgare	GRO	LGTH	LOEC	500	
Hordeum vulgare	GRO	LGTH	LOEC	521.7	
Phaseolus vulgaris	GRO	LGTH	LOEC	740	Vangronsveld, J., Assche F. Van, and H. Clijsters. 1995. Reclamation of a bare industrial area contaminated by non-ferrous metals: in situ metal immobilization and revegetation .Environmental Pollution 87(1):51-59.
Medicago sativa	GRO	NODE	NOEC	144	Biro, B., K. Koves-Pechy, I. Voros, and I. Kadar. 1998. Toxicity of some field

Trifolium pratense	GRO	NODE	NOEC	144	applied heavy metal salts to the rhizobial and fungal microsymbionts of alfalfa and red clover. Agrokem. Talajtan 47(1-4):265-276.
Pinus sylvestris	MOR	SURV	NOEC	200	Hartley-Whitaker, J., J.W.G. Cairney, and A.A. Meharg. 2000. Toxic effects of cadmium and zinc on ectomycorrhizal colonization of scots pine (*Pinus sylvestris* l.) from soil inoculum. Environ Toxicol. Chem. 19(3):694-699.
Pinus sylvestris	MOR	SURV	LOEC	500	
Allium cepa	POP	BMAS	NOEC	100	Dang, Y.P., R. Chhabra, and K.S. Verma. 1990. Effect of Cd, Ni, Pb and Zn on growth and chemical composition of onion and fenugreek. Commun.Soil Sci.Plant Anal. 21(9/10):717-735.
Trigonella foenum-graecum	POP	BMAS	NOEC	200	
Arachis hypogaea	POP	BMAS	NOEC	20	Davis, J.G., and M.B. Parker. 1993. Zinc toxicity symptom development and partitioning of biomass and zinc in peanut plants. J. Plant Nutr. 16(12):2353-2369.
Arachis hypogaea	POP	BMAS	NOEC	10	
Oryza sp.	POP	BMAS	NOEC	2.5	Khan, H.R. 1991. Effects of gypsum, zinc and saline water on the yields of and
Oryza sp.	POP	BMAS	NOEC	2.5	

Oryza sp.	POP	BMAS	NOEC	2.5	nutrient uptake by rice in a coastal saline soil. Int. J. Trop. Agric. 9(3):225-233.
Pennisetum glaucum	POP	BMAS	NOEC	20	Kumar, V., V.S. Ahlawat, and R.S. Antil. 1985. Interactions of nitrogen & zinc in pearl millet: 1. Effect of nitrogen and zinc levels on dry matter and concentration in pearl millet. Soil Sci. 139(4):351-356.
Pennisetum glaucum	POP	BMAS	NOEC	20	
Pennisetum glaucum	POP	BMAS	NOEC	20	
Phaseolus vulgaris	POP	BMAS	NOEC	5	Liang, J., R.E. Karamanos and J.W.B. Stewart. 1991. Plant availability of Zn fractions in Saskatchewan soils. Can. J. Soil Sci. 71(4):507-517.
Medicago sativa	POP	BMAS	NOEC	10	
Hordeum vulgare	POP	BMAS	NOEC	20	Monette, L.K. 1978. The effects of salinity as sodium chloride and the absorption of zinc and cadmium by barley and spinach. PhD Thesis, University of California, Davis, CA: 99 p.
Phaseolus vulgaris	POP	BMAS	NOEC	8	Moraghan, J.T. 1996. Zinc concentration of navy bean seed as affected by rate and placement of three zinc sources. J. Plant Nutr. 19(10/11):1413-1422.
Phaseolus vulgaris	POP	BMAS	NOEC	8	

Phaseolus vulgaris	POP	BMAS	NOEC	8	
Phaseolus vulgaris	POP	BMAS	NOEC	8	
Phaseolus vulgaris	POP	BMAS	NOEC	8	
Triticum aestivum	POP	BMAS	NOEC	8	
Lolium sp.	POP	BMAS	NOEC	50	Singh, B.R., and A.S. Jeng. 1993. Uptake of zinc, cadmium, mercury, lead, chromium and nickel by ryegrass grown in a sandy soil. Norw. J. Agric. Sci. 7(2):147-157.
Triticum aestivum	POP	BMAS	NOEC	20	
Triticum aestivum	POP	BMAS	NOEC	20	
Mentha arvensis	POP	BMAS	NOEC	10	Subrahmanyam, K., A.K. Nair, and D.V. Singh. 1991. Evaluation of diammonium and polyphosphates as carriers of iron and zinc in Japanese mint ratoon-mungbean cropping sequence. J Indian Soc. Soil Sci. 39(3):477-481.
Phaseolus vulgaris	POP	BMAS	NOEC	NR	Walsh, L.M., D.R. Steevens, H.D. Seibel, and G.G. Weis. 1972. Effect of high rates

Cucumis sativus	POP	BMAS	NOEC	33.8	of zinc on several crops on an irrigated plainfield sand. Commun. Soil Sci.Plant Anal. 3(3):187-195.
Glycine max	POP	BMAS	NOEC	263	White, M.C., A.M. Decker, and R.L. Chaney. 1979. Differential cultivar tolerance in soybean to phytotoxic levels of soil Zn. I. Range of Cultivar Response. Agron. J. 71:121-126.
Glycine max	POP	BMAS	NOEC	131	
Glycine max	POP	BMAS	NOEC	131	
Glycine max	POP	BMAS	NOEC	131	
Allium cepa	POP	BMAS	LOEC	200	Dang, Y.P., R. Chhabra, and K.S. Verma. 1990. Effect of Cd, Ni, Pb and Zn on growth and chemical composition of onion and fenugreek. Commun.Soil Sci.Plant Anal. 21(9/10):717-735.
Trigonella foenum-graecum	POP	BMAS	LOEC	100	
Trigonella foenum-graecum	POP	BMAS	LOEC	400	
Arachis hypogaea	POP	BMAS	LOEC	40	Davis, J.G., and M.B. Parker. 1993. Zinc toxicity symptom development and partitioning of biomass and zinc in peanut plants. J. Plant Nutr. 16(12):2353-2369.
Arachis hypogaea	POP	BMAS	LOEC	20	

Phaseolus vulgaris	POP	BMAS	LOEC	5	Liang, J., R.E. Karamanos and J.W.B. Stewart. 1991. Plant availability of Zn fractions in Saskatchewan soils. Can. J. Soil Sci. 71(4):507-517.
Glycine max	POP	BMAS	LOEC	131	White, M.C., A.M. Decker, and R.L. Chaney. 1979. Differential cultivar tolerance in soybean to phytotoxic levels of soil Zn. I. Range of Cultivar Response. Agron. J. 71:121-126.
Glycine max	POP	BMAS	LOEC	131	
Glycine max	POP	BMAS	LOEC	131	
Glycine max	POP	BMAS	LOEC	131	
Glycine max	POP	BMAS	LOEC	263	
Glycine max	POP	BMAS	LOEC	263	
Glycine max	POP	BMAS	LOEC	263	
Trigonella foenum-graecum	POP	BMAS	EC10	31.2	Dang, Y.P., R. Chhabra, and K.S. Verma. 1990. Effect of Cd, Ni, Pb and Zn on growth and chemical composition of onion and fenugreek. Commun.Soil Sci.Plant Anal. 21(9/10):717-735.
Trigonella foenum-graecum	POP	BMAS	EC10	100	
Lolium perenne	POP	PGRT	EC50	385	Korthals, G.W., I. Popovici, I. Iliev, and T.M. Lexmond. 1998. Influence of perennial ryegrass on a copper and zinc affected terrestrial nematode community. Appl. Soil Ecol. 10(1-2):73-85.

Allium cepa	REP	GERM	NOEC	10	Kumar, M., and D.K. Das. 1999. Yield and storage-life of onion (*Allium cepa* L.) as affected by zinc and sulfur application. Environ. Ecol. 17(3):580-584.
Allium cepa	REP	GERM	NOEC	10	
Allium cepa	REP	GERM	NOEC	10	
Allium cepa	REP	GERM	NOEC	10	
Allium cepa	REP	GERM	NOEC	10	
Allium cepa	REP	GERM	LOEC	5	
Allium cepa	REP	GERM	LOEC	5	
Allium cepa	REP	GERM	LOEC	5	
Allium cepa	REP	GERM	LOEC	5	
Brassica rapa	REP	NPOD	LOEC	50	Sheppard, S.C., W.G. Evenden, S.A. Abboud, and M. Stephenson. 1993. A plant life-cycle bioassay for contaminated soil, with comparison to other bioassays: mercury and zinc. Arch. Environ. Contam. Toxicol. 25(1):27-35.
Brassica rapa	REP	NPOD	NOEC	600	
Brassica rapa	REP	NPOD	NOEC	300	
Brassica rapa	REP	NPOD	LOEC	1000	
Brassica rapa	REP	NPOD	LOEC	600	

Folsomia candida	GRO	WGHT	NOEC	567	Smit, C.E., and C.A.M. Van Gestel. 1998. Effects of soil type, prepercolation, and ageing on bioaccumulation and toxicity of zinc for the springtail *Folsomia candida*. Environ. Toxicol. Chem. 17(6):1132-1141.
Folsomia candida	GRO	WGHT	NOEC	567	
Eisenia fetida	GRO	WGHT	NOEC	400	Spurgeon, D.J., and S.P. Hopkin. 1995. Extrapolation of the laboratory-based OECD earthworm toxicity test to metal contaminated field sites. Ecotoxicology 4(3):190-205.
Eisenia fetida	GRO	WGHT	NOEC	620	
Eisenia fetida	GRO	WGHT	LOEC	1200	
Folsomia candida	GRO	WGHT	EC50	1228	Smit, C.E., and C.A.M. Van Gestel. 1998. Effects of Soil Type, Prepercolation, and ageing on bioaccumulation and toxicity of zinc for the springtail *Folsomia candida*. Environ. Toxicol. Chem. 17(6):1132-1141.
Folsomia candida	GRO	WGHT	EC50	333	
Folsomia candida	GRO	WGHT	EC50	97.1	
Folsomia candida	GRO	WGHT	EC50	95	
Eisenia fetida	GRO	WGHT	EC50	400	Spurgeon, D.J., and S.P. Hopkin. 1995.

Eisenia fetida	GRO	WGHT	EC50	693	Extrapolation of the laboratory-based OECD earthworm toxicity test to metal contaminated field sites. Ecotoxicology 4(3):190-205.
Folsomia candida	GRO	WGHT	EC50	1509	Van Gestel, C.A.M., and P.J. Hensbergen. 1997. Interaction of Cd and Zn toxicity for *Folsomia candida* Willem (Collembola: Isotomidae) in relation to bioavailability in soil. Environ. Toxicol. Chem. 16(6):1177-1186.
Folsomia candida	GRO	WGHT	EC50	1220	
Folsomia candida	GRO	WGHT	EC50	1661	
Folsomia candida	GRO	WGHT	EC50	1160	
Folsomia candida	GRO	WGHT	EC50	1202	
Folsomia candida	GRO	WGHT	EC50	1444	
Folsomia candida	GRO	WGHT	EC10	738	Smit, C.E., and C.A.M. Van Gestel. 1998. Effects of Soil Type, Prepercolation, and ageing on bioaccumulation and toxicity of zinc for the springtail *Folsomia candida*. Environ. Toxicol. Chem. 17(6):1132-1141.
Folsomia candida	GRO	WGHT	EC10	124	
Folsomia candida	GRO	WGHT	EC10	34	
Folsomia candida	GRO	WGHT	EC10	13.3	
Folsomia candida	GRO	WGHT	EC10	840	Van Gestel, C.A.M., and P.J. Hensbergen. 1997. Interaction of Cd and Zn toxicity for

Folsomia candida	GRO	WGHT	EC10	882	*Folsomia candida* Willem (Collembola: Isotomidae) in relation to bioavailability in soil. Environ. Toxicol. Chem. 16(6):1177-1186.
Eisenia fetida	GRO	WGHT	NOEC	5000	Malecki, M.R., E.F. Neuhauser, and R.C. Lehr. 1982. The Effect of metals on the growth and reproduction of *Eisenia foetida* (Oligochaeta, Lumbricidae). Pedobiologia 24(3):129-137.
Eisenia fetida	GRO	WGHT	NOEC	4000	
Eisenia fetida	GRO	WGHT	LOEC	4000	
Eisenia fetida	GRO	WGHT	LOEC	2000	
Eisenia fetida	GRO	WGHT	LOEC	2000	
Eisenia fetida	GRO	WGHT	LOEC	4000	
Folsomia candida	GRO	WGHT	NOEC	1198	Smit, C.E., and C.A.M. Van Gestel. 1998. Effects of Soil Type, Prepercolation, and ageing on bioaccumulation and toxicity of zinc for the springtail *Folsomia candida*. Environ. Toxicol. Chem. 17(6):1132-1141.
Folsomia candida	GRO	WGHT	NOEC	298	
Folsomia candida	GRO	WGHT	NOEC	298	
Folsomia candida	GRO	WGHT	NOEC	457	
Folsomia candida	GRO	WGHT	NOEC	457	
Folsomia candida	GRO	WGHT	NOEC	457	
Drawida willsi	GRO	WGHT	NOEC	400	Panda, R., S.S. Pati, and S.K. Sahu. 1999.

Drawida willsi	GRO	WGHT	NOEC	400	Accumulation of zinc and its effects on the growth, reproduction and life cycle of *Drawida willsi* (Oligochaeta), a dominant earthworm in Indian crop fields. Biol. Fertil. Soils 29(4):419-423.
Drawida willsi	GRO	WGHT	NOEC	400	
Folsomia candida	GRO	WGHT	NOEC	256	Smit, C.E., I. van Overbeek, and C.A.M. Van Gestel. 1998. The influence of food supply on the toxicity of zinc for *Folsomia candida* (Collembola). Pedobiologia 42(2):154-164.
Folsomia candida	GRO	WGHT	NOEC	410	
Aporrectodea caliginosa	GRO	WGHT	NOEC	638	Spurgeon, D.J., C. Svendsen, V.R. Rimmer, S.P. Hopkin, and J.M. Weeks. 2000. Relative sensitivity of life-cycle and biomarker responses in four earthworm species exposed to zinc. Environ Toxicol. Chem. 19(7):1800-1808.
Folsomia candida	GRO	WGHT	LOEC	410	Smit, C.E., I. van Overbeek, and C.A.M. Van Gestel. 1998. The influence of food supply on the toxicity of zinc for *Folsomia candida* (Collembola). Pedobiologia 42(2):154-164.
Folsomia candida	GRO	WGHT	LOEC	655	

Aporrectodea caliginosa	GRO	WGHT	EC50	461	Khalil, M.A., H.M. Abdel-Lateif, B.M. Bayoumi, and N.M. Straalen. 1996. Analysis of separate and combined effects of heavy metals on the growth of *Aporrectodea caliginosa* (Oligochaeta; annelida) using the toxic unit approach. Applied Soil Ecology: A Section Of Agriculture, Ecosystems & Environment. 4(3):213-219.
Folsomia candida	GRO	WGHT	EC50	462	Smit, C.E., and C.A.M. Van Gestel. 1996. Comparison of the toxicity of zinc for the springtail *Folsomia candida* in artificially contaminated and polluted field soils. Appl. Soil Ecol. 3:127-136.
Folsomia candida	GRO	WGHT	EC50	170	
Folsomia candida	GRO	WGHT	EC50	20.8	
Folsomia candida	GRO	WGHT	EC50	443	Smit, C.E., and C.A.M. Van Gestel. 1997. Influence of temperature on the regulation and toxicity of zinc in *Folsomia candida* (Collembola). Ecotoxic. Environ. Saf. 37(3):213-222.
Folsomia candida	GRO	WGHT	EC50	226	
Folsomia candida	GRO	WGHT	EC50	63.7	
Folsomia candida	GRO	WGHT	EC50	81.9	
Folsomia candida	GRO	WGHT	EC50	458	

Folsomia candida	GRO	WGHT	EC50	231	
Folsomia candida	GRO	WGHT	EC50	63.3	
Folsomia candida	GRO	WGHT	EC50	85	
Folsomia candida	GRO	WGHT	EC50	526	
Folsomia candida	GRO	WGHT	EC50	280	
Folsomia candida	GRO	WGHT	EC50	86.8	
Folsomia candida	GRO	WGHT	EC50	567	
Folsomia candida	GRO	WGHT	EC50	308	
Folsomia candida	GRO	WGHT	EC50	101	
Folsomia candida	GRO	WGHT	EC50	132	
Folsomia candida	GRO	WGHT	EC50	3200	Smit, C.E., and C.A.M. Van Gestel. 1998. Effects of soil type, prepercolation, and ageing on bioaccumulation and toxicity of zinc for the springtail *Folsomia candida*. Environ. Toxicol. Chem. 17(6):1132-1141.
Folsomia candida	GRO	WGHT	EC50	526	
Folsomia candida	GRO	WGHT	EC50	280	
Folsomia candida	GRO	WGHT	EC50	86.8	

Folsomia candida	GRO	WGHT	EC50	113	
Folsomia candida	GRO	WGHT	EC50	584	
Folsomia candida	GRO	WGHT	EC50	333	
Folsomia candida	GRO	WGHT	EC50	35.9	
Folsomia candida	GRO	WGHT	EC50	27.7	
Folsomia candida	GRO	WGHT	EC50	500	Smit, C.E., I. van Overbeek, and C.A.M. Van Gestel. 1998. The influence of food supply on the toxicity of zinc for *Folsomia candida* (Collembola). Pedobiologia 42(2):154-164.
Folsomia candida	GRO	WGHT	EC50	325	
Folsomia candida	GRO	WGHT	EC50	167	
Folsomia candida	GRO	WGHT	EC50	476	
Folsomia candida	GRO	WGHT	EC50	311	
Folsomia candida	GRO	WGHT	EC50	155	
Folsomia candida	GRO	WGHT	EC50	618	
Folsomia candida	GRO	WGHT	EC50	400	
Folsomia candida	GRO	WGHT	EC50	231	

Folsomia candida	GRO	WGHT	EC50	211	
Lumbricus rubellus	GRO	WGHT	EC50	1520	Spurgeon, D.J., and S.P. Hopkin. 1999. Tolerance to zinc in populations of the earthworm *Lumbricus rubellus* from uncontaminated and metal-contaminated ecosystems. Arch. Environ. Contam. Toxicol. 37(3):332-337.
Lumbricus rubellus	GRO	WGHT	EC50	1308	
Lumbricus rubellus	GRO	WGHT	EC50	1301	
Aporrectodea caliginosa	GRO	WGHT	EC50	868	
Folsomia candida	GRO	WGHT	EC10	800	Smit, C.E., and C.A.M. Van Gestel. 1998. Effects of soil type, prepercolation, and ageing on bioaccumulation and toxicity of zinc for the springtail *Folsomia candida*. Environ. Toxicol. Chem. 17(6):1132-1141.
Folsomia candida	GRO	WGHT	EC10	79.4	
Folsomia candida	GRO	WGHT	EC10	5.47	
Folsomia candida	GRO	WGHT	EC10	1.45	
Folsomia candida	GRO	WGHT	EC10	159	
Folsomia candida	GRO	WGHT	EC10	75.4	
Folsomia candida	GRO	WGHT	EC10	10.9	
Folsomia candida	GRO	WGHT	EC10	12.3	

Folsomia candida	GRO	WGHT	EC10	305	
Folsomia candida	GRO	WGHT	EC10	123	
Folsomia candida	GRO	WGHT	EC10	27.6	
Folsomia candida	GRO	WGHT	EC10	34	
Folsomia candida	GRO	WGHT	EC10	174	Smit, C.E., I. van Overbeek, and C.A.M. Van Gestel. 1998. The influence of food supply on the toxicity of zinc for *Folsomia candida* (Collembola). Pedobiologia 42(2):154-164.
Folsomia candida	GRO	WGHT	EC10	99.7	
Folsomia candida	GRO	WGHT	EC10	35.5	
Folsomia candida	GRO	WGHT	EC10	152	
Folsomia candida	GRO	WGHT	EC10	83.8	
Folsomia candida	GRO	WGHT	EC10	24.2	
Folsomia candida	GRO	WGHT	EC10	307	
Folsomia candida	GRO	WGHT	EC10	196	
Folsomia candida	GRO	WGHT	EC10	97	
Folsomia candida	GRO	WGHT	EC10	416	

Folsomia candida	GRO	WGHT	EC10	284	
Folsomia candida	GRO	WGHT	EC10	142	
Aporrectodea caliginosa	GRO	WGHT	EC10	417	Spurgeon, D.J., C. Svendsen, V.R. Rimmer, S.P. Hopkin, and J.M. Weeks. 2000. Relative Sensitivity of life-cycle and biomarker responses in four earthworm species exposed to zinc. Environ Toxicol Chem. 19(7):1800-1808.
Eisenia fetida	MOR	MORT	NOEC	442	Spurgeon, D.J., and S.P. Hopkin. 1995. Extrapolation of the laboratory-based OECD earthworm toxicity test to metal contaminated field sites. Ecotoxicology 4(3):190-205.
Eisenia fetida	MOR	MORT	NOEC	1048	
Eisenia fetida	MOR	MORT	NOEC	23.3	
Eisenia fetida	MOR	MORT	NOEC	368	
Eisenia fetida	MOR	MORT	NOEC	26.2	
Eisenia fetida	MOR	MORT	NOEC	184	
Eisenia fetida	MOR	MORT	NOEC	7.2	
Eisenia fetida	MOR	MORT	NOEC	702	

Eisenia fetida	MOR	MORT	NOEC	26.2	
Eisenia fetida	MOR	MORT	NOEC	256	
Eisenia fetida	MOR	MORT	NOEC	13.7	
Eisenia fetida	MOR	MORT	NOEC	168	
Eisenia fetida	MOR	MORT	NOEC	8.9	
Eisenia fetida	MOR	MORT	NOEC	274	
Eisenia fetida	MOR	MORT	NOEC	21.1	
Eisenia fetida	MOR	MORT	NOEC	366	
Eisenia fetida	MOR	MORT	NOEC	37.8	
Eisenia fetida	MOR	MORT	NOEC	197	
Eisenia fetida	MOR	MORT	NOEC	20.5	

Eisenia fetida	MOR	MORT	NOEC	289	Spurgeon, D.J., S.P. Hopkin, and D.T. Jones. 1994. Effects of cadmium, copper, lead and zinc on growth, reproduction and survival of the earthworm *Eisenia foetida* (Savigny): assessing the environmental impact of point-source metal contamination in terrestrial ecosystems. Environ. Pollut. 84(2):123-130.
Eisenia fetida	MOR	MORT	LC50	662	Neuhauser, E.F., R.C. Loehr, and M.R. Malecki. 1985. Contact and artificial soil tests using earthworms to evaluate the impact of wastes in soil. In: J.K. Petros, Jr., W.J. Lacy, and R.A. Conway (Eds.), Hazardous and Industrial Solid Waste Testing: 4th Symposium, ASTM STP 886, Philadelphia, PA 886:192-203.
Eisenia fetida	MOR	MORT	LC50	662	
Caenorhabditis elegans	MOR	MORT	LC50	1643	Peredney, C.L., and P.L. Williams. 2000. comparison of the toxicological effects of nitrate versus chloride metallic salts on *Caenorhabditis elegans* in soil. In: F.T. Price, K.V. Brix, and N.K. Lane (Eds.),
Caenorhabditis elegans	MOR	MORT	LC50	1915	

Caenorhabditis elegans	MOR	MORT	LC50	1915	Recent Achievements in Environmental Fate and Transport, 9th Volume, ASTM STP 1381, West Conshohocken, PA :256-268.
Eisenia fetida	MOR	MORT	LC50	1613	Spurgeon, D.J., and S.P. Hopkin. 1996. Effects of variations of the organic matter content and ph of soils on the availability and toxicity of zinc to the earthworm *Eisenia foetida*. Pedobiologia 40(1):80-96.
Eisenia fetida	MOR	MORT	LC50	71.8	
Eisenia fetida	MOR	MORT	LC50	992	
Eisenia fetida	MOR	MORT	LC50	187.6	
Eisenia fetida	MOR	MORT	LC50	474	
Eisenia fetida	MOR	MORT	LC50	67.9	
Eisenia fetida	MOR	MORT	LC50	791	
Eisenia fetida	MOR	MORT	LC50	71.4	
Eisenia fetida	MOR	MORT	LC50	601	
Eisenia fetida	MOR	MORT	LC50	117.1	
Eisenia fetida	MOR	MORT	LC50	617	

Eisenia fetida	MOR	MORT	LC50	95	
Eisenia fetida	MOR	MORT	LC50	620	
Eisenia fetida	MOR	MORT	LC50	91.5	
Eisenia fetida	MOR	MORT	LC50	591	
Eisenia fetida	MOR	MORT	LC50	82.6	
Eisenia fetida	MOR	MORT	LC50	451	
Eisenia fetida	MOR	MORT	LC50	67.7	
Eisenia fetida	MOR	MORT	LC50	1106	Spurgeon, D.J., and S.P. Hopkin. 1996. The effects of metal contamination on earthworm populations around a smelting works: quantifying species effects. Appl. Soil Ecol. 4:147-160.
Lumbricus rubellus	MOR	MORT	LC50	728	
Aporrectodea rosea	MOR	MORT	LC50	5651	
Eisenia fetida	MOR	MORT	LC50	1010	Spurgeon, D.J., S.P. Hopkin, and D.T. Jones. 1994. Effects of cadmium, copper, lead and zinc on growth, reproduction and

Eisenia fetida	MOR	MORT	LC50	745	survival of the earthworm *Eisenia foetida* (Savigny): Assessing the environmental impact of point-source metal contamination in terrestrial ecosystems. Environ. Pollut. 84(2):123-130.
Eisenia fetida	MOR	MORT	EC50	1078	Spurgeon, D.J., and S.P. Hopkin. 1995. Extrapolation of the laboratory-based OECD earthworm toxicity test to metal contaminated field sites. Ecotoxicology 4(3):190-205.
Drawida willsi	MOR	MORT	LC50	762.87	Panda, R., S.S. Pati, and S.K. Sahu. 1999. Accumulation of zinc and its effects on the growth, reproduction and life cycle of *Drawida willsi* (Oligochaeta), a dominant earthworm in Indian crop fields. Biol. Fertil. Soils 29(4):419-423.
Drawida willsi	MOR	MORT	LC50	840.69	
Drawida willsi	MOR	MORT	LC50	907.82	
Caenorhabditis elegans	MOR	MORT	LC50	445	Peredney, C.L., and P.L. Williams. 2000. Comparison of the toxicological effects of nitrate versus chloride metallic salts on *Caenorhabditis elegans* in soil. In: F.T.
Caenorhabditis elegans	MOR	MORT	LC50	142	

Caenorhabditis elegans	MOR	MORT	LC50	540	Price, K.V. Brix, and N.K. Lane (Eds.), Recent Achievements in Environmental Fate and Transport, 9th Volume, ASTM STP 1381, West Conshohocken, PA :256-268.
Caenorhabditis elegans	MOR	MORT	LC50	157	
Folsomia candida	MOR	MORT	LC50	727	Smit, C.E., and C.A.M. Van Gestel. 1997. Influence of temperature on the regulation and toxicity of zinc in *Folsomia candida* (Collembola). Ecotoxic. Environ. Saf. 37(3):213-222.
Folsomia candida	MOR	MORT	LC50	864	
Folsomia candida	MOR	MORT	LC50	796	
Folsomia candida	MOR	MORT	LC50	821	
Folsomia candida	MOR	MORT	LC50	741	
Folsomia candida	MOR	MORT	LC50	650	
Folsomia candida	MOR	MORT	LC50	699	
Folsomia candida	MOR	MORT	LC50	580	
Folsomia candida	MOR	MORT	LC50	625	Smit, C.E., I. van Overbeek, and C.A.M. Van Gestel. 1998. The influence of food supply on the toxicity of zinc for *Folsomia candida* (Collembola). Pedobiologia
Folsomia candida	MOR	MORT	LC50	405	
Folsomia candida	MOR	MORT	LC50	210	

Folsomia candida	MOR	MORT	LC50	476	42(2):154-164.
Folsomia candida	MOR	MORT	LC50	298	
Folsomia candida	MOR	MORT	LC50	76.6	
Folsomia candida	MOR	MORT	LC50	670	
Folsomia candida	MOR	MORT	LC50	449	
Folsomia candida	MOR	MORT	LC50	254	
Folsomia candida	MOR	MORT	LC50	1085	
Folsomia candida	MOR	MORT	LC50	742	
Folsomia candida	MOR	MORT	LC50	398	
Lumbricus rubellus	MOR	MORT	LC50	1424	Spurgeon, D.J., and S.P. Hopkin. 1999. Tolerance to zinc in populations of the earthworm *Lumbricus rubellus* from uncontaminated and metal-contaminated ecosystems. Arch. Environ. Contam. Toxicol. 37(3):332-337.
Lumbricus rubellus	MOR	MORT	LC50	1264	
Lumbricus rubellus	MOR	MORT	LC50	1450	
Eisenia fetida	MOR	MORT	LC50	3172	Spurgeon, D.J., C. Svendsen, V.R.

Eisenia fetida	MOR	MORT	LC50	3150	Rimmer, S.P. Hopkin, and J.M. Weeks. 2000. Relative sensitivity of life-cycle and biomarker responses in four earthworm species exposed to zinc. Environ Toxicol Chem. 19(7):1800-1808.
Lumbricus terrestris	MOR	MORT	LC50	2378	
Lumbricus terrestris	MOR	MORT	LC50	2217	
Lumbricus rubellus	MOR	MORT	LC50	1734	
Lumbricus rubellus	MOR	MORT	LC50	1709	
Aporrectodea caliginosa	MOR	MORT	LC50	1695	
Aporrectodea caliginosa	MOR	MORT	LC50	1619	
Eisenia fetida	MOR	MORT	LC10	2511	
Eisenia fetida	MOR	MORT	LC10	2740	
Lumbricus terrestris	MOR	MORT	LC10	1870	
Lumbricus terrestris	MOR	MORT	LC10	1857	

Lumbricus rubellus	MOR	MORT	LC10	1234	
Lumbricus rubellus	MOR	MORT	LC10	1232	
Aporrectodea caliginosa	MOR	MORT	LC10	1417	
Aporrectodea caliginosa	MOR	MORT	LC10	1402	
Nemata	POP	ABND	NOEC	4722	Korthals, G.W., I. Popovici, I. Iliev, and T.M. Lexmond. 1998. Influence of perennial ryegrass on a copper and zinc affected terrestrial nematode community. Appl. Soil Ecol. 10(1-2):73-85.
Nemata	POP	ABND	NOEC	1476	
Acrobeles sp.	POP	ABND	NOEC	38	
Alaimus sp.	POP	ABND	NOEC	100	
Aporcelaimellus sp.	POP	ABND	NOEC	25	
Filenchus sp.	POP	ABND	NOEC	200	
Plectus sp.	POP	ABND	NOEC	38	
Pratylenchus sp.	POP	ABND	NOEC	400	

Tylenchorhynchus sp.	POP	ABND	NOEC	400	
Clarkus sp.	POP	ABND	NOEC	25	
Clarkus sp.	POP	ABND	NOEC	400	
Ditylenchus sp.	POP	ABND	NOEC	50	
Ditylenchus sp.	POP	ABND	NOEC	400	
Filenchus sp.	POP	ABND	NOEC	200	
Plectus sp.	POP	ABND	NOEC	50	
Pratylenchus sp.	POP	ABND	NOEC	100	
Prismatolaimus sp.	POP	ABND	NOEC	25	
Tylenchorhynchus sp.	POP	ABND	NOEC	100	
Drilocephalobus sp.	POP	ABND	NOEC	400	
Nemata	POP	ABND	LOEC	50	
Acrobeles sp.	POP	ABND	LOEC	25	

Alaimus sp.	POP	ABND	LOEC	200	
Aporcelaimellus sp.	POP	ABND	LOEC	50	
Filenchus sp.	POP	ABND	LOEC	400	
Plectus sp.	POP	ABND	LOEC	25	
Ditylenchus sp.	POP	ABND	LOEC	100	
Filenchus sp.	POP	ABND	LOEC	400	
Plectus sp.	POP	ABND	LOEC	100	
Pratylenchus sp.	POP	ABND	LOEC	200	
Prismatolaimus sp.	POP	ABND	LOEC	50	
Tylenchorhynchus sp.	POP	ABND	LOEC	200	
Nemata	POP	ABND	NOEC	200	
Nemata	POP	ABND	NOEC	25	
Nemata	POP	ABND	NOEC	200	

Nemata	POP	ABND	NOEC	25	
Nemata	POP	ABND	NOEC	25	
Nemata	POP	ABND	NOEC	38	
Nemata	POP	ABND	NOEC	200	
Nemata	POP	ABND	NOEC	25	
Nemata	POP	ABND	NOEC	200	
Nemata	POP	ABND	NOEC	25	
Nemata	POP	ABND	NOEC	400	
Nemata	POP	ABND	NOEC	25	
Nemata	POP	ABND	NOEC	400	
Nemata	POP	ABND	LOEC	400	
Nemata	POP	ABND	LOEC	50	
Nemata	POP	ABND	LOEC	400	
Nemata	POP	ABND	LOEC	50	

Nemata	POP	ABND	LOEC	50	
Nemata	POP	ABND	LOEC	200	
Nemata	POP	ABND	LOEC	25	
Nemata	POP	ABND	LOEC	400	
Nemata	POP	ABND	LOEC	50	
Nemata	POP	ABND	LOEC	50	
Tylenchus sp.	POP	PGRT	NOEC	1600	Korthals, G.W., A.van de Ende, H.van Megen, T.M. Lexmond, J.E. Kammenga, and T. Bonger. 1996. Short-term effects of cadmium, copper, nickel and zinc on soil nematodes from different feeding and life-history strategy groups. Appl. Soil Ecol. 4(2):107-117.
Pratylenchus sp.	POP	PGRT	NOEC	38	
Rotylenchus sp.	POP	PGRT	NOEC	1600	
Rhabditidae	POP	PGRT	NOEC	38	
Acrobeles sp.	POP	PGRT	NOEC	25.6	
Acrobeloides sp.	POP	PGRT	NOEC	25.6	
Cephalobus sp.	POP	PGRT	NOEC	1600	
Cervidellus sp.	POP	PGRT	NOEC	25.6	

Plectus sp.	POP	PGRT	NOEC	25.6	
Alaimus sp.	POP	PGRT	NOEC	1600	
Ditylenchus sp.	POP	PGRT	NOEC	25.6	
Clarkus sp.	POP	PGRT	NOEC	25.6	
Aporcelaimellus sp.	POP	PGRT	NOEC	25.6	
Nemata	POP	PGRT	NOEC	38	
Nemata	POP	PGRT	NOEC	38	
Nemata	POP	PGRT	NOEC	38	
Nemata	POP	PGRT	NOEC	25.6	
Nemata	POP	PGRT	NOEC	38	
Nemata	POP	PGRT	NOEC	38	
Nemata	POP	PGRT	NOEC	100	

Drawida willsi	POP	PGRT	NOEC	50	Panda, R., S.S. Pati, and S.K. Sahu. 1999. Accumulation of zinc and its effects on the growth, reproduction and life cycle of *Drawida willsi* (Oligochaeta), a dominant earthworm in Indian crop fields. Biol. Fertil. Soils 29(4):419-423.
Pratylenchus sp.	POP	PGRT	LOEC	25.6	Korthals, G.W., A.van de Ende, H.van Megen, T.M. Lexmond, J.E. Kammenga, and T. Bonger. 1996. Short-term effects of cadmium, copper, nickel and zinc on soil nematodes from different feeding and life-history strategy groups. Appl. Soil Ecol. 4(2):107-117.
Rhabditidae	POP	PGRT	LOEC	25.6	
Acrobeles sp.	POP	PGRT	LOEC	1600	
Acrobeloides sp.	POP	PGRT	LOEC	1600	
Cervidellus sp.	POP	PGRT	LOEC	1600	
Plectus sp.	POP	PGRT	LOEC	1600	
Ditylenchus sp.	POP	PGRT	LOEC	1600	
Clarkus sp.	POP	PGRT	LOEC	1600	
Aporcelaimellus sp.	POP	PGRT	LOEC	1600	
Nemata	POP	PGRT	LOEC	25.6	

Nemata	POP	PGRT	LOEC	25.6	
Nemata	POP	PGRT	LOEC	25.6	
Nemata	POP	PGRT	LOEC	100	
Nemata	POP	PGRT	LOEC	25.6	
Nemata	POP	PGRT	LOEC	200	
Drawida willsi	POP	PGRT	LOEC	200	Panda, R., S.S. Pati, and S.K. Sahu. 1999. Accumulation of zinc and its effects on the growth, reproduction and life cycle of *Drawida willsi* (Oligochaeta), a dominant earthworm in Indian crop fields. Biol. Fertil. Soils 29(4):419-423.
Filenchus sp.	POP	PGRT	EC50	141	Korthals, G.W., A.van de Ende, H.van Megen, T.M. Lexmond, J.E. Kammenga, and T. Bonger. 1996. Short-term effects of cadmium, copper, nickel and zinc on soil nematodes from different feeding and life-history strategy groups. Appl. Soil Ecol. 4(2):107-117.
Tylenchorhynchus sp.	POP	PGRT	EC50	710	
Rhabditidae	POP	PGRT	EC50	1538	
Rhabditidae	POP	PGRT	EC50	444	
Acrobeloides sp.	POP	PGRT	EC50	493	

Eucephalobus sp.	POP	PGRT	EC50	300	
Plectus sp.	POP	PGRT	EC50	52	
Aphelenchoides sp.	POP	PGRT	EC50	527	
Pseudhalenchus sp.	POP	PGRT	EC50	1600	
Clarkus sp.	POP	PGRT	EC50	100	
Aporcelaimellus sp.	POP	PGRT	EC50	145	
Folsomia candida	POP	PGRT	EC50	185	Smit, C.E., and C.A.M. Van Gestel. 1996. Comparison of the toxicity of zinc for the springtail *Folsomia candida* in artificially contaminated and polluted field soils. Appl. Soil Ecol. 3:127-136.
Folsomia candida	POP	PGRT	EC50	210	
Folsomia candida	POP	PGRT	EC50	48.6	
Folsomia candida	POP	PGRT	EC50	55.6	
Folsomia candida	POP	PGRT	EC50	2.55	
Folsomia candida	POP	PGRT	EC50	3.23	
Folsomia candida	POP	PGRT	EC50	348	

Folsomia candida	POP	PGRT	EC50	363	
Folsomia candida	POP	PGRT	EC50	64.7	
Folsomia candida	POP	PGRT	EC50	67.6	
Folsomia candida	POP	PGRT	EC50	10.1	
Folsomia candida	POP	PGRT	EC50	11.3	

1 Table Acronyms

ABND – abundance

AREA - area

BMAS – biomass

DMTR - diameter

EMRG – emergence

FEUP – Fe uptake

FTCC - fertile cocoons

GERM – germination

GINJ – injury, general

GGRO - growth, general

GGRT - general growth rate

GPOP - population changes, general

GREP – reproduction, general

HGHT - height

LGTH – length

MATR – maturity

MNUP - Mn uptake

MORT – mortality

MYCO - mycorrhizal colonization

NFIX – nitrogen fixation

NODE - # nodules per nodulated root

NPOD - pod, number of pods

POP – population

PGRT - population growth rate

PROG – progeny

SIZE – size

SURV – survival

SXDP - sexual development

VOLU - volume

WGHT - weight