

**DISTRIBUTION OF MN IN THE ENVIRONMENT; AN EXAMPLE FROM
GEOLOGY, SURFACE WATER, LAKE SEDIMENT AND TILL IN CENTRAL
NOVA SCOTIA**

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**Emeline J. Lamond
(Supervisor Dr. Don Fox)**

Abstract

This study involves an examination of Mn in the environment in central Nova Scotia. Since Mn has been mined and occurs in many localities, the study was initiated in order to determine whether Mn could possibly pose an environmental risk, and where. The aims are to: 1) examine the occurrence of Mn mineralization within Carboniferous rocks and the Meguma Supergroup, 2) develop a GIS database of Mn concentrations in surface water, lake sediment and till, in central Nova Scotia, 3) investigate the relationship between Mn in the surface environment and Mn occurrences in bedrock and, 4) gain more insight into Mn cycling in the environment. Mn is concentrated in the environment by natural as well as anthropogenic processes. High concentrations of some Mn species are toxic to some flora and fauna. In the human population, elevated Mn in municipal water supplies is considered a nuisance leading to the staining of clothes and water fixtures; in some cases expensive water treatment facilities are required. The formation of secondary Mn oxide and hydroxide minerals is an important control for the cycling of some toxic, heavy metals through the surface environment. Many variables drive Mn cycling, including oxidizing/reducing conditions, the availability of oxygen, and pH of co-existing aqueous solutions.

In central Nova Scotia, sedimentary rocks within the Carboniferous Windsor Group and Horton Group, and metasedimentary rocks of the Cambro-Ordovician Meguma Supergroup host Mn mineralization. X-ray diffraction indicates that pyrolusite and hematite are the main Mn-bearing minerals in the Carboniferous rocks studied. In the Meguma Supergroup, Mn-rich garnet, ilmenite, and in some areas, Mn-rich carbonate minerals occur. Results indicate that Mn is enriched in surface water and lake sediment overlying the Carboniferous rocks compared to surface water and lake sediment overlying the Meguma Supergroup. Till overlying the Meguma Supergroup is enriched in Mn compared with till overlying Carboniferous rocks. The mean Mn concentration of surface water (88.8 ppb) within the study area exceeds the acceptable Canadian limits for drinking water ($0.05\text{mg/L} = 5\text{ppb}$).

Key Words: Mn, geochemistry, Mn oxides, Carboniferous rocks, Meguma Supergroup, environment

CHAPTER 1

1.0.0. INTRODUCTION

1.1.0. INTRODUCTORY STATEMENT

The purpose of the thesis is to investigate the distribution of Mn in bedrock, surface water, lake sediment and till of central Nova Scotia, in order to understand the source, transport and fate of Mn and its potential impact on the environment.

Mn is common in the rocks of central Nova Scotia and concentrated in mineable amounts in some localities. High levels of Mn in water can stain clothes and plumbing fixtures as well as reduce the efficiency of ground-water remediation equipment (Thomas *et al.* 1993). In the neighbouring province of New Brunswick, the City of Fredericton has spent over 3.5 million dollars in the construction of a Mn treatment plant (Thomas *et al.* 1993). High levels of Mn also may harm wildlife and vegetation. Additionally, Mn may exercise an important control of the distribution of other toxic metals in the environment (Tebo *et al.* 1997). Therefore, understanding the cycling of Mn in the central Nova Scotia environment is important.

1.2.0. BACKGROUND

Mn is naturally present in the environment. It may exist as solids or dissolved ions in water and as particulates in air. It is also present in rocks, sediments, plants, and animals. Algae and plants may concentrate Mn whereas organisms at higher trophic levels tend to eliminate excesses (ATSDR 2000). Mn is an essential element to plants and animals but in excess, it may be toxic. High levels of Mn may negatively affect organisms of a wide range including marine plants, crops, lobsters, squirrels, and large game animals. Toxic levels of Mn exposure in humans occur most often through inhalation of Mn particulates through occupational exposure or living in close proximity to battery plants or smelters

(ATSDR 2000). Exposure to above-average levels in soil, water or air may occur in populations living in regions of natural Mn ore deposits (ATSDR 2000). In order to avoid staining clothes and plumbing fixtures, Canadian limits for Mn in drinking water are set to <0.05 mg Mn/L (CWQG 1987). It is likely that <0.05 mg Mn/L is more than adequate to protect for human health (CWQG 1987).

1.3.0. MN IN THE MEGUMA SUPERGROUP

In central Nova Scotia two geological units have elevated Mn concentrations: the Meguma Supergroup and part of the Carboniferous succession. The Meguma Supergroup, of Cambrian to early Ordovician age, dominates the bedrock of central Nova Scotia, and is made up predominately of metamorphosed deep-water sediments (Schenk 1995). An evolving continental margin was probably the depositional environment during the formation of the Meguma Supergroup (Schenk 1995). Regional deformation and metamorphism occurred in the Meguma Supergroup during its accretion as part of the Meguma Terrane onto the Avalon Terrane. Intruding plutons in the Devonian resulted in subsequent thermal metamorphism. The Meguma Supergroup is subdivided into two Groups: the Halifax Group and the Goldenville Group. The Goldenville Group forms the base of the Supergroup, made up primarily of thickly bedded quartzites (Schenk 1995). The Halifax Group, comprised mainly of shales or slates containing pyrite, rests conformably on the Goldenville Group. The transition between the Goldenville Group and the Halifax group is gradational and referred to as the Goldenville-Halifax Transition zone (GHT) (Graves and Zentilli 1988). Manganiferous calcareous argillite and black slate characterize the GHT and gold, tungsten, arsenic, antimony, and zinc-lead are all concentrated within this transition zone (Graves and Zentilli 1988). Mn is also concentrated in the GHT, mainly in spessartine garnet, ilmenite, or Mn carbonate, depending on the degree of metamorphism (Graves and Zentilli 1988).

1.4.0. MN IN CARBONIFEROUS ROCKS

Carboniferous rocks in central Nova Scotia are also characterized by the presence of Mn (Boyle 1972). The two Groups of interest with respect to Mn are the Horton Group and the Windsor Group. The Horton Group is made up of polymictic conglomerates, sandstones, mudstones, oil shales and minor non-marine evaporites (van de Poll *et al.* 1995). The Windsor Group is mainly composed of marine limestone, evaporites and intercalated redbeds (van de Poll *et al.* 1995). The contact between the Horton Group and the Windsor Group is visible from the contrast in the gray Windsor limestones with the redbeds of the Horton Group, indicating a change from marine into a non-marine depositional environment (Gibling 1995). The Windsor/Horton contact along the south shore of the Minas Basin contains most of the Mn occurrences in the Windsor Group, has associated base metal deposits (van de Poll *et al.* 1995) and has produced approximately 8,000 tons of Mn ore (Bishop and Wright 1974).

1.5.0. PURPOSE AND SCOPE

Since Mn has been mined and occurs in many localities, the study was initiated in order to determine whether Mn could possibly pose an environmental risk, and if so to what geographic extent. Understanding more about the source, extent, and distribution of Mn through the environment was also a central purpose of the study. Separate geochemical databases that include Mn analysis exist for surface water, lake sediment, and till. Integrating these data sets provides an excellent opportunity to study the relationship between the bedrock and the surficial environment, and to investigate whether Mn levels may be sufficiently high to produce negative environmental impacts. Also, as Mn is increasingly used as an anti-knock agent in gasoline, with environmental implications relatively unknown, developing a baseline database for Mn in the environment may prove useful to future studies.

The scope of the thesis is three-fold: 1) to detail the occurrence of Mn-rich rock units in central Nova Scotia; 2) to investigate the concentration and mineralization of Mn in the Meguma Supergroup and in the Carboniferous rocks of central Nova Scotia; 3) to compare Mn concentrations of surface water, lake sediment and till to the underlying bedrock geology through the construction of a G.I.S. database, and 4) to investigate Mn's possible control on other elements.

1.6.0. LOCATION

This study focuses on the cycling of Mn in central Nova Scotia (Fig. 1.1). The two rock units relevant to this work are the Meguma Supergroup and the Carboniferous sequence (Horton Group and Windsor Group). Published data are used to help identify Mn mineralization and concentrations in these rock units. Five localities within the study area are examined in some detail and are: 1) Tennycape mine, 2) Walton mine area, 3) Eastville Zn deposit, and 4) Lake Charlotte drillcore, and 5) Beaverbank Highway (Fig. 1.1). These areas were chosen primarily because of availability of data from previous studies and because Mn had been identified at each locality. This study also incorporates new data collected from the Meguma Supergroup along the Beaverbank Highway and from Carboniferous rocks nearby the Tennycape and Walton mines. Discussion of Mn in surface water, lake sediment and till is limited to regions within central Nova Scotia where data were available.

1.7.0. PREVIOUS WORK

The occurrence of Mn in Nova Scotia was investigated thoroughly by Bishop and Wright (1974), and their report includes a map that lists the type and locality of Mn occurrences throughout Nova Scotia (Fig. 1.2). The purpose of their study was to investigate the possible subsurface extensions of known ore occurrences.

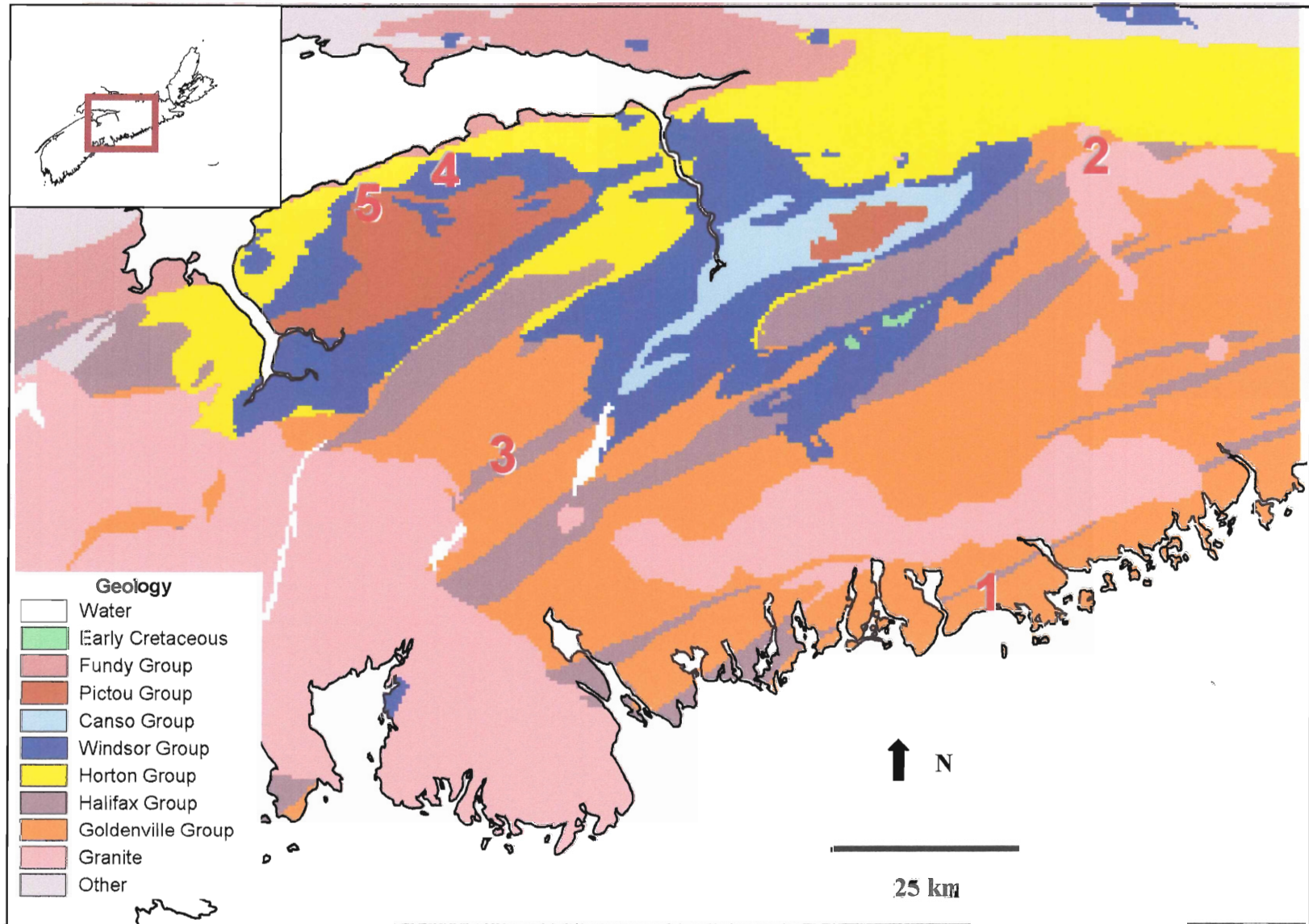


Figure 1.1 Location map of study area. Inset shows map of Nova Scotia. Maroon box on inset indicates study area. Larger map shows geology of study area. Specific areas interest are marked as follows: Lake Charlotte (1), Eastville Zn deposit (2), Beaverbank Highway (3), Tennycap Mine (4), Walton Mine (5)

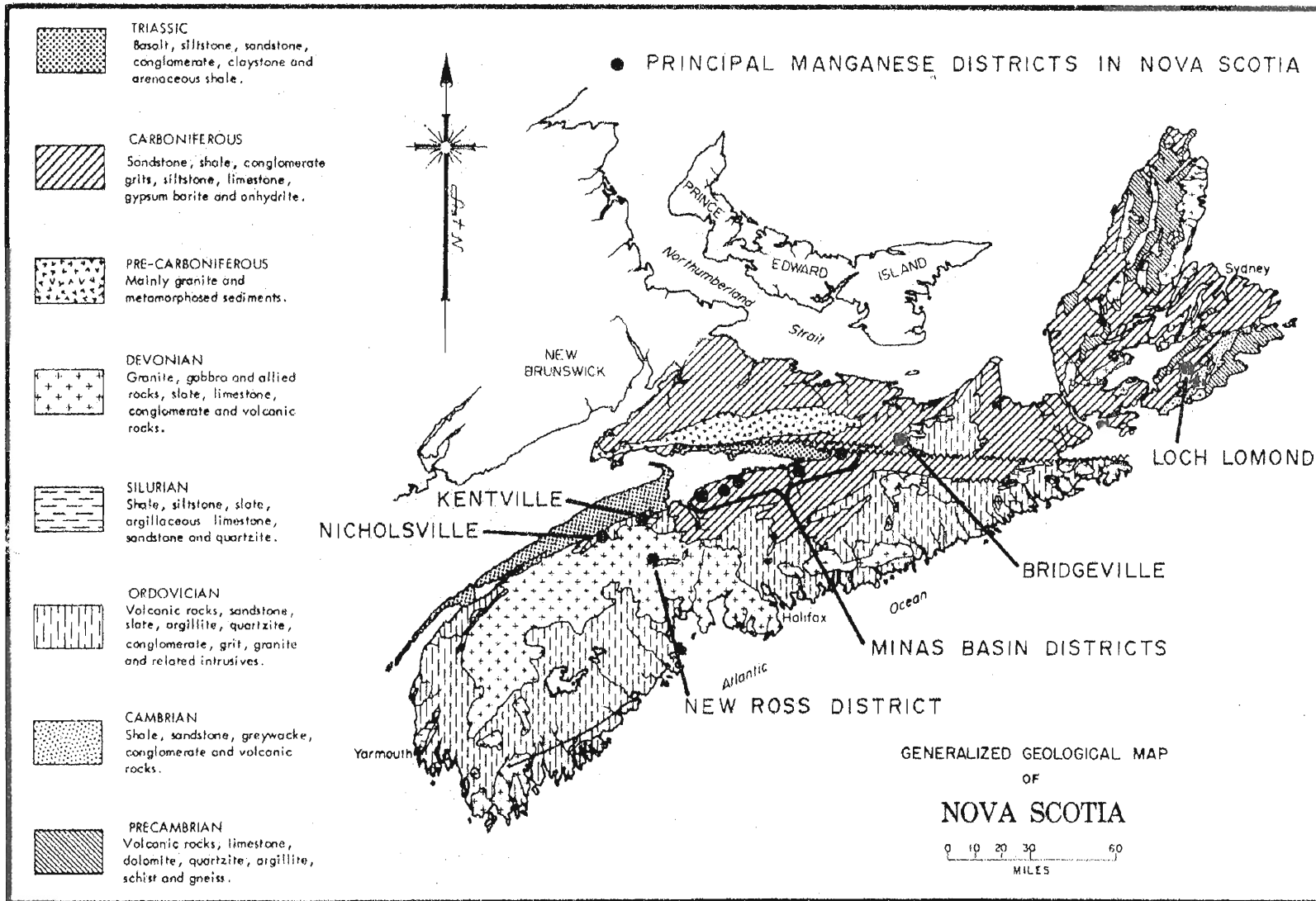


Figure 1.2: Principal Mn districts in Nova Scotia (taken from Bishop and Wright 1974).

Numerous publications exist on the Meguma Supergroup and the GHT, such as Sangster (1990), who has summarized the distribution of metals in the Meguma Terrane. The sedimentology of the Meguma Supergroup was discussed by Waldron and Graves (1987). Burns (1997) detailed the stratigraphy of the GHT at Caribou Gold District for his BSc. Thesis. Zentilli *et al.* (1984) examined the GHT as a control for metallic mineralization. Cameron and Zentilli (1997) analysed the geochemical characterization of the GHT in terms of interaction with intrusions. The lithochemistry of the metal-enriched cotucules in the GHT have also been examined (Graves and Zentilli 1988). Feetham (1996) produced a BSc. thesis on the lithochemistry of the GHT close to the Beaverbank locality of this study.

Several authors have written on various aspects of the Eastville Zn deposit within the Meguma Supergroup, including geophysical analysis by Burke (1985), and lithochemistry by Binney *et al.* (1986). In addition, there exists at the NSDNR a good data set from Open File reports for the Eastville Zn deposit, including drillcore and geochemistry. Three drill holes were completed here in 1957. Hingston (1985) examined the manganiferous slates at Lake Charlotte, Meguma Supergroup, and Mwenifumbo *et al.* (1990) also discussed the Mn prospect at Lake Charlotte.

The Tennycap mine, within the Windsor Group, is responsible for over half of the Mn extracted from the Minas Basin and several papers have highlighted the Mn deposits found here (Flynn 1935, Hanson 1932, Weeks 1948, Bishop and Wright 1974). Bishop and Wright (1974) also discuss the Mn deposits found at the Walton Mine, Horton Group. Boyle (1972) mapped the distribution of Mn in stream sediments in the Walton-Cheverie area and examined rocks in the Walton-Cheverie area with respect to several elements, including Mn.

The U.S.A. Department of Health and Human Services released a report in September of 2000 updating toxicological information on Mn (ATSDR 2000). Oral ingestion of Mn via drinking water is not perceived as a risk. In a review published by the Mineralogical Society of America, Tebo *et al.* (1997) discuss the geomicrobiology of Mn. Several other

papers have been produced detailing the response of various organisms to high levels of Mn, including studies by Sander *et al.* (1998) on fresh-water crabs, Forget (1994) on Blue Spruce, and Baden *et al.* (1995) on lobsters. Brault (1994), Loranger *et al.* (1994), and Lytle *et al.* (1995) have produced preliminary work discussing the implications of the use of Mn as a fuel additive.

Mn concentrations in lake sediments and till have been compiled for parts of central Nova Scotia and are available from the NSDNR. Dr. Gwendy Hall, through the Geological Survey of Canada (GSC), performed chemical analyses of surface waters over a large part of central Nova Scotia and granted the author permission to use this surface water chemistry data.

1.8.0. PROCEDURE AND LIMITATIONS

In an attempt to familiarize the author with the analytical tools used in the study of Mn minerals and rock, bedrock samples were collected from Beaverbank Highway in the fall of 2001 by the author, and two thin sections were prepared. Thin sections were described and examined using both transmitted and reflected light microscopy. The electron microprobe at Dalhousie University was used for detailing Mn concentrations in garnets and ilmenites. Additional hand samples were collected near Tennycape and Walton Mines by T. Goodwin and D. Fox. Mineral identification of the Minas Basin hand samples was aided by X-ray powder diffraction analysis, undertaken through the Fission Track Research lab, at Dalhousie University.

A G.I.S. database was developed in IDRISI using the following sources: 1) Rasterized version of Geology map of Nova Scotia, provided by Dr. Gunter Muecke; 2) NSDNR data on Mn concentrations in lake sediment and till; and 3) Surface water chemistry provided by Dr. Gwendy Hall. Extract in IDRISI was used in order to compare Mn concentrations within surface water, lake sediment and till with respect to geological

Groups. Minitab was used to perform basic statistics and Pearson correlations in order to gain more insight into Mn cycling.

The main limitations of the thesis are as follows: 1) Surface water, lake sediment and till data had different spatial distributions, limiting comparisons between values; 2) Total Mn concentrations within the bedrock were not available, preventing a direct comparison between amount of Mn in bedrock compared to the surficial environment; and 3) Surface water, lake sediment and till were the only media in the surficial environment measured for Mn, limiting the scope of the project.

1.9.0. ORGANIZATION

Chapter 1 introduces the topic of the thesis. An introduction to Mn and its geochemical properties is presented in Chapter 2. Chapter 3 outlines the general geology of the Meguma Supergroup and Carboniferous rocks of central Nova Scotia and presents the results from geochemical analysis. Chapter 4 presents an overview of the G.I.S. database compilation and the results of spatial and data analysis. A Discussion is presented in Chapter 5. Conclusions are listed in Chapter 6 and recommendations in Chapter 7.

CHAPTER 2

2.0.0. GEOCHEMISTRY OF MN

2.1.0. ABUNDANCE OF MANGANESE

Mn is an element that occurs naturally in the environment (Table 2.1). It is the 12th most common element (WHO 1981) and the second most abundant transition metal in the earth's crust (Tebo *et al.* 1997). Mn constitutes large surficial deposits, such as nodules, that cover vast areas of the ocean floor (NAS 1973). Air samples contain Mn as suspended particulate matter. Ambient air has between 0.01-0.07 $\mu\text{g Mn/m}^3$ (WHO 1981). Air around industries by comparison may have levels exceeding 8 $\mu\text{g Mn/m}^3$ (WHO 1981). Surface waters have Mn concentrations ranging from 1-500 $\mu\text{g Mn/L}$ and seawaters have average Mn concentrations of 0.1-5 $\mu\text{g Mn/L}$ (WHO 1981). Drinking water levels of Mn are often within 5-25 $\mu\text{g Mn/L}$ (ATSDR 2000). Mn is present in soils at concentrations around 500-850 ppm (Brault *et al.* 1993). Mn is also present in all foodstuffs. Mn in food occurs on the order of <5 mg/kg (ATSDR 2000).

MEDIA	MN CONCENTRATIONS	UNITS
Ambient Air	0.01-0.07	$\mu\text{g/m}^3$
Air around Industries	8	$\mu\text{g/m}^3$
Surface Water	1-500	mg/L
Sea Water	0.1-5	$\mu\text{g/L}$
Drinking Water	5-25.000	$\mu\text{g/L}$
Soils	500-850	ppm
Foodstuff	<5	mg/kg

a)

$\mu\text{g/m}^3$	ppt on weight to volume basis
ug/l	ppb on weight to volume basis
mg/l	ppm on weight to volume basis
ug/g	ppm on weight to weight basis
mg/kg	ppm on weight to weight basis

b)

Table 2.1 Mn various media showing (a) concentrations of Mn in various media (b) conversion table for units.

2.2.0. COMMON ROCKS AND MINERALS CONTAINING MN

Mn is present in all rocks but generally does not exceed 1% (Bishop & Wright 1974). Mn occurs most commonly in association with oxides, sulphides, carbonates and silicates (Jaques 1987). Mn is an essential constituent of over 200 minerals (Bishop & Wright 1974); Table 2.2 lists 31 common Mn minerals. Nova Scotia concentrations of Mn are recognised in three principal types of deposits: sedimentary deposits, replacement and residual deposits, and vein deposits (Bishop & Wright 1974).

MINERAL	FORMULA
Pyrolusite	MnO ₂
Manganite	Mn ₂ O ₃ , H ₂ O
Psilomelane	MnO ₂ 2H ₂ O
Hausmannite	Mn ₃ O ₄
Rhodochrosite	MnCO ₃
Rhodonite	MnSiO ₃
Braunite	3Mn ₂ O ₃ , MnSiO ₃
Alabandite	MnS
Manganosite	MnO
Franklinite	(Zn,Mn) (Fe,Mn) ₂ O ₄
Jacobsite	MnFe ₂ O ₄
Bixbyite	(Mn,Fe) ₂ O ₃
Hollandite	BaMn ₈ O ₁₆
Cryptomelane	KMn ₈ O ₁₆
Rancieite	CaMn ₄ O ₉ 3H ₂ O (?)
Lithiophorite	Li ₂ Mn ₂ Al ₈ Mn ₁₀ O ₃₅ *14H ₂ O(?)
Manganoan calcite	(Ca,Mn) CO ₃
Manganoan dolomite	Ca(Mg,Mn) (CO ₃) ₂
Manganoan siderite	(Fe,Mn) CO ₃
Rhodonite	MnSiO ₃
Bustamite	(Ca,Mn) SiO ₃
Pyroxmangite	(Mn,Fe)SiO ₃
Johannsenite	CaMn(SiO ₃) ₂
Spessartite	Mn ₃ Al ₂ (SiO ₄) ₃
Piedmontite	Ca ₂ (Al,Mn) ₃ (SiO ₄)(OH)
Tephroite	Mn ₂ SiO ₄
Alleghanyite	Mn ₅ (SiO ₄) ₂ (OH,F) ₂
Inesite	Ca ₂ Mn ₇ Si ₁₀ O ₂₈ (OH) ₂ *5H ₂ O
Bementite	8MnO*7SiO ₂ *5H ₂ O
Mangantantalite	MnTa ₂ O ₆
Huebnerite	MnWO ₄

Table 2.2 Common Mn minerals (after Bishop & Wright 1974).

2.3.0. PROPERTIES OF MN

Mn does not occur naturally as a free metal but as a compound (WHO 1981). Mn is next to iron (Fe) in the periodic table (Table 2.3), has a similar chemical behaviour to Fe and often occurs in association with Fe (NAS 1973).

	ATM #	ATOMIC MASS (AMU)	ATOMIC RADIUS (Å)
Mn	25	54.938	1.79
Fe	26	55.847	1.72

Table 2.3 Mn and Fe compared on the basis of atomic mass and atomic radius

Mn has a number of oxidation states. Oxidation states 2⁺, 3⁺, and 4⁺ are of greatest importance in the environment. Mn²⁺ is soluble, bioavailable, stable in the pH range from 6 to 9 of water, and exists in a variety of minerals (Tebo *et al.* 1997).

Mn²⁺ oxidation forms Mn oxides important to mineral phases in soils, sediments and waters (Huang 1991, Enrlich 1996a in Tebo *et al.* 1997). Table 2.4 lists some important reactions of Mn²⁺. Mn oxides commonly occur as discrete particles or as coatings on soil and sediment particles (Tebo *et al.* 1997). Mn³⁺ is thermodynamically unstable and insoluble unless in association with a strong complexing agent (Morgan and Stumm 1965, Kostka *et al.* 1995 in Tebo *et al.* 1997). Mn³⁺ and Mn⁴⁺ mostly form insoluble oxides and oxyhydroxides.

	Reaction	Oxidation State of Mineral	Examples of minerals formed
1)	$Mn^{2+} + 1/2O_2 + H_2O \rightarrow MnO_2 + 2H^+$	4	pyrolusite (MnO ₂)
2)	$Mn^{2+} + 1/4O_2 + 3/2H_2O \rightarrow MnOOH + 2H^+$	3	manganite (MnOOH)
3)	$3Mn^{2+} + 1/2O_2 + 3H_2O \rightarrow Mn_3O_4 + 6H^+$	2,6,7	hausmannite (Mn ₃ O ₄)
4)	$Mn_3O_4 + 2H^+ \rightarrow 2MnOOH + Mn^{2+}$	3	see Reaction 2
5)	$Mn_3O_4 + 4H^+ \rightarrow MnO_2 + 2Mn^{2+} + 2H_2O$	4	see Reaction 1
6)	$2MnOOH + 2H^+ \rightarrow MnO_2 + Mn^{2+} + 2H_2O$	4	see Reaction 1

Table 2.4 Important Mn²⁺ reactions (after Tebo *et al.* 1997)

pH and reduction and oxidation reactions largely influence the concentration of dissolved Mn in surface water and groundwater (Tebo *et al.* 1997). The controls pH and pE (redox potential) exert on Mn are seen in a Mn pE/pH stability diagram (Fig. 2.1). Mn^{2+} oxidation tends to be thermodynamically favourable in the natural environment but has a slow reaction rate when not in the presence of microbes (Diem & Stumm 1984, Nealson *et al.* 1988 in Tebo *et al.* 1997). Under more severe conditions, ($\text{pH} > 8.5$; $p_{\text{O}_2} \sim 1 \text{ atm}$; or $[\text{Mn}_T] > 450 \mu\text{M}$) however, Mn will oxidize within weeks to months (Tebo *et al.* 1997). Mn^{2+} oxidation helps to increase further oxidation of Mn^{2+} as Mn oxyhydroxide and Mn oxide products act as a catalyst, absorbing Mn^{2+} . Microorganisms greatly increase the rate of Mn^{2+} oxidation by up to 5 orders of magnitude, therefore much of the oxidation of Mn^{2+} in the environment is a result of microbes (Tebo *et al.* 1997)

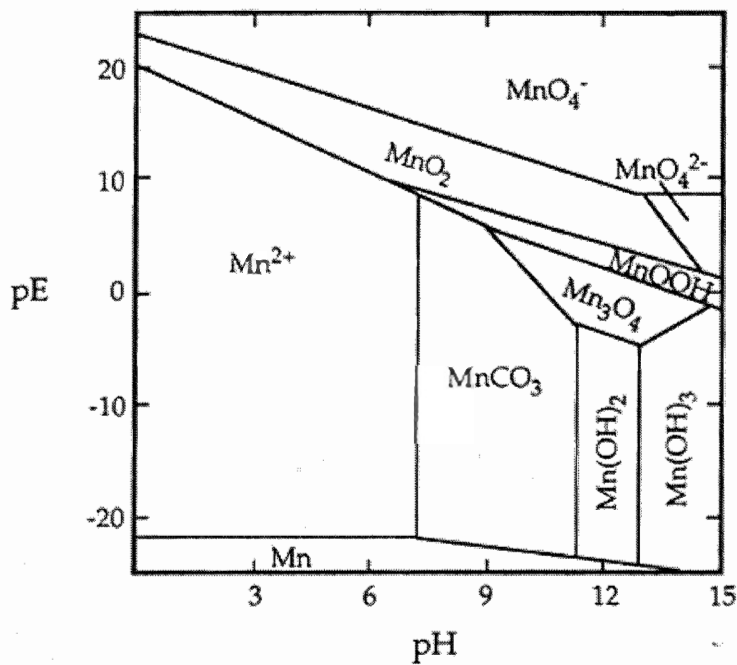


Figure 2.1 Manganese pE/pH stability diagram (taken from Tebo *et al.* 1997, redrawn from Nealson *et al.* 1989).

Mn oxides are second only to oxygen in their strength as oxidizing agents, and promote the oxidation of As^{3+} , Co^{2+} , Cr^{3+} , Pu^{3+} and possibly other trace metals (Tebo *et al.* 1997). Mn oxides can affect the fate, transport and bioavailability of organic compounds or other heavy metals (Jenne 1967, Kinniburgh & Jackson 1981, Davis & Kent 1990 in Tebo *et*

al. 1997). Mn oxides may also absorb a large number of different cations on their surfaces such as Cu, Co, Cd and Zn. Several studies have shown that geochemical cycling of Mn- and Fe-oxides control the distribution of certain radionuclides (Tebo *et al.* 1997).

2.4.0. SOURCES OF MN

2.4.1. *Natural sources of Mn*

Natural sources of Mn include bedrock, sediment and soils (Veysseyre *et al.* 1998). Additionally, Mn may come from volcanoes and natural vegetation fires (Veysseyre *et al.* 1998). Also, bacteria are able to precipitate Mn oxides from Mn salts (WHO 1981) and are therefore an important source of concentrated Mn.

2.4.2. *Anthropogenic sources of Mn*

The main anthropogenic source of Mn is the manufacture of alloys, steel and iron products (ATSDR 2000). Mn is added to steel in order to negate the harmful effects of sulphur by forming the compound MnS (ATSDR 2000). Additionally, Mn is used to help increase the strength, toughness, and hardness of the steel. A relatively new anthropogenic source of Mn is the combustion products of methylcyclopentadienyl Mn tricarbonyl (MMT). MMT is a gasoline additive used in unleaded gasoline as an antiknock agent (Loranger *et al.* 1994) and was first introduced in Canada in 1976 (Zayed *et al.* 1999). The by-products of MMT released by the exhaust include Mn-oxides, Mn-phosphates, and Mn-sulphates (Loranger *et al.* 1994). MMT combustion products are likely to be one of the main sources of urban Mn (Brault *et al.* 1993). Mn mining operations also contribute to anthropogenic emissions of manganese, as does the manufacture of dry-cell batteries.

2.4.2.1. Anthropogenic Mn emissions (Canada)

In 1984 total anthropogenic emissions of Mn in Canada were 1225 tonnes: Mn-bearing alloy production accounted for 47% of the emissions, 28% of the emissions came from

production of iron and steel, gasoline-powered vehicles accounted for 17% of the emissions, and iron and steel foundries totalled 3% of the emissions. Unidentified sources accounted for the remaining 5% (Jacques 1987).

2.5.0. ENVIRONMENTAL FATE

2.5.1. Air

Mn may exist in air as suspended particulate matter from the erosion of soils or from industrial output (ATSDR 2000). Gravitational settling (dry deposition) causes most Mn to be removed from the air. The half-life of such a particle is on the order of days. Rain and other washout mechanisms also remove some of the airborne particulate Mn (ATSDR 2000). The transport of Mn in air is largely a function of size. Mn particles with a mass median $<5\mu\text{m}$ account for close to 80% of suspended Mn and are favourable to widespread distribution of Mn, and are also within respirable range (WHO 1981). Respirable range refers to the ability of a particle to pass into the circulatory system directly from the lungs. It is an important distinction in toxicology because the toxicity of a substance may vary greatly depending on the way it is introduced into an organism.

2.5.2. Soil

Mn content in soils is related foremost to the Mn content of the parent rock (NAS 1973). There are two main mechanisms for retaining Mn in soil. The first mechanism is cation exchange reactions. In cation exchange reactions, Mn ions form Mn oxides, hydroxides and oxyhydroxides by reactions with the charged surface of soil particles (ATSDR 2000). The second mechanism is the adsorption of Mn to other oxides, hydroxides and oxyhydroxides by exchange reactions (ATSDR 2000). When saturation is reached, these minerals can precipitate and act as a new surface onto which other minerals can adsorb (Evans 1989). At lower concentrations Mn may be “fixed” and not readily released into solution. At higher concentration, for example in wastewater effluent discharge,

mobilization of Mn from bottom sediments has been documented (Paulson *et al.* 1984). There is typically a positive correlation between acidity of the soil and amount of soluble Mn (Brault *et al.* 1993).

2.5.3. Water

Mn may be introduced into the ocean hydrothermally and transported for 1000's of kilometers by buoyant plumes caught in ocean currents (Klinkhannar & Hudson in Roy 1997). Decomposing vegetation is another pathway that may introduce Mn into water as causing organic acids leach Mn, which is subsequently carried by ground and surface waters to oceans and lakes. Under aerobic conditions in surface waters, with pH above 7, dissolved Mn concentrations are low as a result of equilibrium reactions favouring the conversion to the Mn^{4+} species (Fig. 2.1) (Lasier *et al.* 1999). The Mn^{4+} species is then sequestered in insoluble Mn oxides (Stumm & Morgan 1981 in Lasier *et al.* 1999). However, under anaerobic conditions, Mn^{4+} is reduced into Mn^{2+} . Mn is liberated from the sediment as Mn^{2+} . Therefore, as a result of anaerobic conditions, transfer of Mn from sediment to the water column increases, increasing the amount of dissolved Mn in the water. When oxygen is introduced into the water again, reoxidation of Mn^{2+} is fairly slow, taking weeks (Hansen & Bjerregaard 1995). The bioavailability of Mn^{2+} can be increased from normal, $\sim 1 \mu\text{g/L}$ to close to $1,500 \mu\text{g Mn/L}$ under hypoxic concentrations, $<16\%$ oxygen saturation (Baden *et al.* 1995). For many organisms, this is significant as Mn^{2+} is bioavailable and more toxic to aquatic organisms (Lasier *et al.* 1999). Water under reducing conditions tends to have higher concentrations of Mn^{2+} and a greater tendency toward Mn pollution (Jauson 1989). Allen *et al.* (1996) (in Lasier *et al.* 1999) reported Mn concentrations up to 40 mg/L in mine drainages.

2.5.3.1. Coastal/surface water interface

Although average river water has only a few ppb Mn transported as particulates and colloids or in ionic solutions, considerable Mn is discharged from terrestrial sources via rivers into oceans (Sapozhnikov 1970, in Roy 1997). As such, coastal zones are important in the geochemical cycle of Mn (Fig. 2.2). Estuaries tend to have high salinity

and alkalinity relative to surface waters and mixing of surface and coastal waters may result in flocculation of dissolved Mn, thereby forming Mn oxide deposits (Sundby *et al.* 1981; Frakes & Bolton 1992 in Roy 1997). Bacterial concentrations also tend to be higher in coastal environments and may result in suboxic to anoxic conditions, causing the Mn oxide particulates to be reduced and therefore releasing Mn^{2+} . Mn^{2+} may then migrate out of the coastal zone towards the deeper ocean (Sunby *et al.* 1981; Trefry and Presley 1982 in Roy 1997). If, however, Mn^{2+} and dissolved bicarbonate concentrations are sufficiently high to exceed the solubility product of a carbonate phase, Mn bearing carbonates will be precipitated, effectively removing the Mn^{2+} supply into the overlying water (Fig 2.1) (Roy 1997).

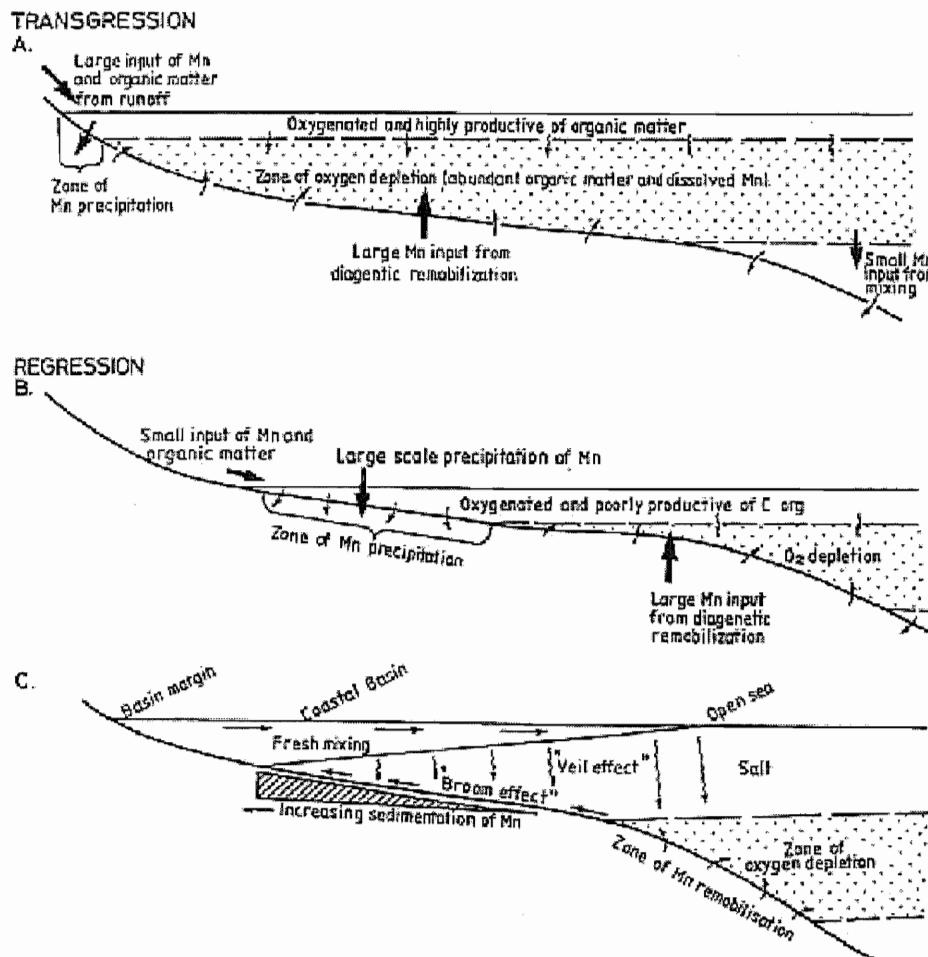


Figure 2.2 (a) Relationship during marine transgression, showing narrow zone of Mn accumulation and concentration of dissolved Mn in water column. (b) Relationship during marine regression with abundant diagenetic remobilization and wide zone of final Mn precipitation. (c) Mn sedimentation in coastal zone of intracratonic basin, showing veil effect (flocculant fallout) from saline mixing and broom effect (bottom transport and concentration) from tidal activity (from Frakes & Bolton 1984 in Roy 1997).

2.5.3. *Bioconcentration*

Bioconcentration factor (BCF) refers to the concentration of a chemical within an organism, divided by the concentration of the chemical in the surrounding environment (ATSDR 2000). There are wide variations on estimates of the BCF of Mn depending on the organism examined. A simplistic overview states that terrestrial mammals may bioconcentrate Mn by a factor of 10, fish may bioconcentrate Mn by a factor of 100 and marine plants may bioconcentrate Mn by a factor of 100,000 (NAS 1973). Regardless of the variation in BCFs the same trend is clear; bioconcentration of Mn is greatest at lower trophic levels. Trophic levels refer to the stage in a food chain from primary producers (lowest trophic level) through herbivores to carnivores (highest trophic level). Mn limits have been placed on lower trophic foods eaten by humans as a result of high BCFs (ATSDR 2000).

2.2.0. TOXICITY OF MANGANESE

2.2.1. *Plants*

Mn is an essential element necessary for plant survival. Mn is required in several enzymatic systems and in chlorophyll formation (Brault *et al.* 1993). However, excess Mn results in varying degrees of toxicity, at various Mn^{2+} concentrations in soil or water, depending on the sensitivity of the species. Plant species vary greatly in their ability to tolerate excess Mn (NAS 1973). Mn toxicity in plants often presents itself as marginal chlorosis and cupping of young leaves and speckling of older leaves (Jackson 1967 *in* NAS 1973). Mn toxicity has also been documented as causing “crinkle leaf” of cotton, (Berger & Gerloff 1947 *in* NAS. 1973) “stem streak necrosis” of Irish potatoes (Adams & Wear 1965 *in* NAS 1973) and “internal bark necrosis” in apple trees (Ferree & Thompson 1970; Shelton & Zeiger 1970; *in* NAS 1973). Also, some research experiments document Mn toxicity as responsible for causing reduced yields (NAS 1973).

2.2.2. *Animals*

In animals, Mn is needed for the formation of connective tissue and bone. It is also required for growth, as well as carbohydrate and lipid metabolism. In humans, Mn is needed in the embryonic development of inner ear, and for reproductive functions (ATSDR 2000). However, in excess Mn is a neurotoxin to animals (Hille 1992, Baden *et al.* 1995). Excessive intake of Mn can occur through inhalation and ingestion. Inhalation is the more efficient and toxic pathway of Mn absorption, followed by ingestion. Dermal absorption is not effective and at present not documented as having ill effects (ATSDR 2000). The effects of Mn toxicity include inflammatory responses in the lung, increased prevalence of infectious lung diseases, lower mean blood pressure, an increase in sudden death mortality, impotence, and loss of libido (ATSDR 2000). Damage to the brain, liver, kidneys and developing fetus are also documented effects (ATSDR 2000). Environmental level (low-dose) health effects of Mn have not been thoroughly studied (Manzo 2001).

2.2.2.1. Manganism in humans

Toxicity in humans associated with inhalation of Mn, is displayed initially by a weakness and stiffness in legs associated with muscle pain, nervousness, irritability and headaches. Mn toxicity symptoms progress to apathy and dullness with slow or halting speech without tone or inflection, and dull and emotionless facial expressions. Finally, walking becomes difficult and a staggering gait develops with movements accompanied by tremors. This disabling syndrome is called Manganism with symptoms of altered gait, fine tremors and possible psychiatric disturbances (ATSDR 2000). Manganism is a common ailment in primitive Mn mines in the developing world (M. Zentilli, pers. comm.). Work conditions, particularly in terms of protective wear, have not changed over the past 50 years in some developing countries (Fig. 2.3), even with the increased knowledge of health risks (ATSDR 2000).



Figure 2.3: Photo of a Mn miner in Chile, note the lack of protective clothing (from Zentilli 1963).

2.7.0. ACCETABLE LIMITS

The Canadian Drinking Water Quality Guidelines has set the maximum allowable level of Mn in drinking water at 0.05 mg/L (CWQG 1987). This limit is set for aesthetic considerations, as Mn may stain plumbing fixtures and laundry and adds an unpleasant taste to water (CWQG 1987). In the U.S.A., the Occupational Safety and Health Administration (OSHA) has set a limit of 5 mg Mn/m³ in the workplace for an 8-hour workday of a 40-hour workweek (ATSDR 2000). Safe and adequate intake levels of Mn, according to U.S.A. guidelines, range from 0.3-1 mg/day for children under 1 year, 1-2 mg/day for children under 10 and 2 to 5 mg/day for children 10 and older (ASTDR 2000). Table 2.5 indicates Mn limits for health and aesthetic considerations.

MEDIA	CONCENTRATION	REASON FOR LIMIT
Drinking water	0.05 mg/L	Aesthetic considerations
Intake levels	0.3-1mg/day	Health (Children under 1 year)
Intake levels	1-2mg/day	Health (Children under 10)
Intake levels	2-5mg/day	Health (Children >10 and adults)
Air (workplace)	5mg/m ³	Health (U.S. workplaces)

Table 2.5 Mn exposure limits for health and aesthetic considerations.

2.8.0. SUMMARY

A thorough review of Mn geochemistry was necessary in order to: 1) become familiar with concentrations of Mn in the environment; 2) gain information on the toxicity of Mn and what levels may constitute a health or pollution threat; 3) further understanding of the causes driving Mn reactions; 4) illustrate the fundamentals of Mn cycling; and 5) recognize Mn's influence on other elements. The information gained from Chapter 2 is applied to Chapter 5 and Chapter 6 in order to help explain the results and the importance of the findings.

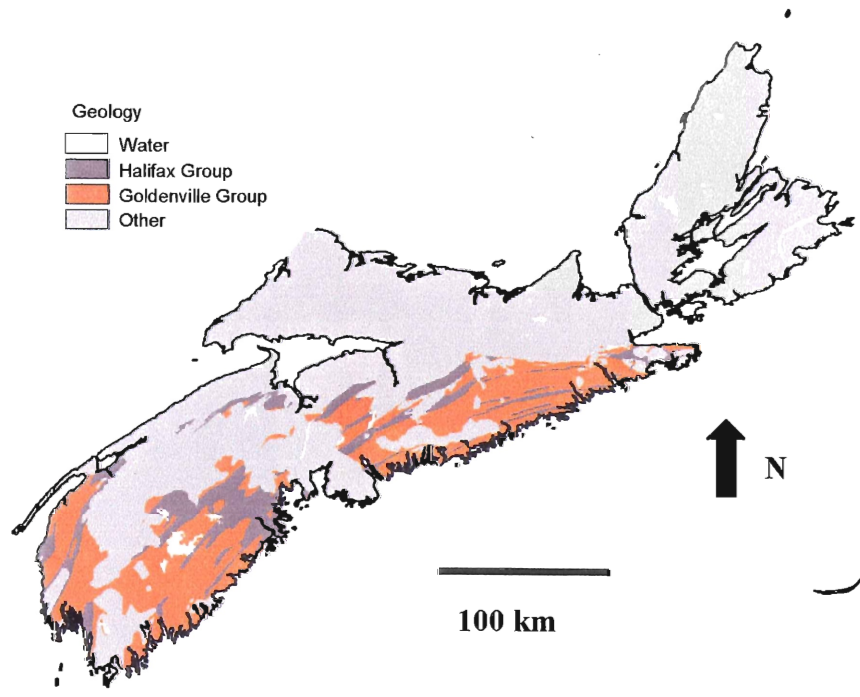
CHAPTER 3

3.0.0. REGIONAL GEOLOGY

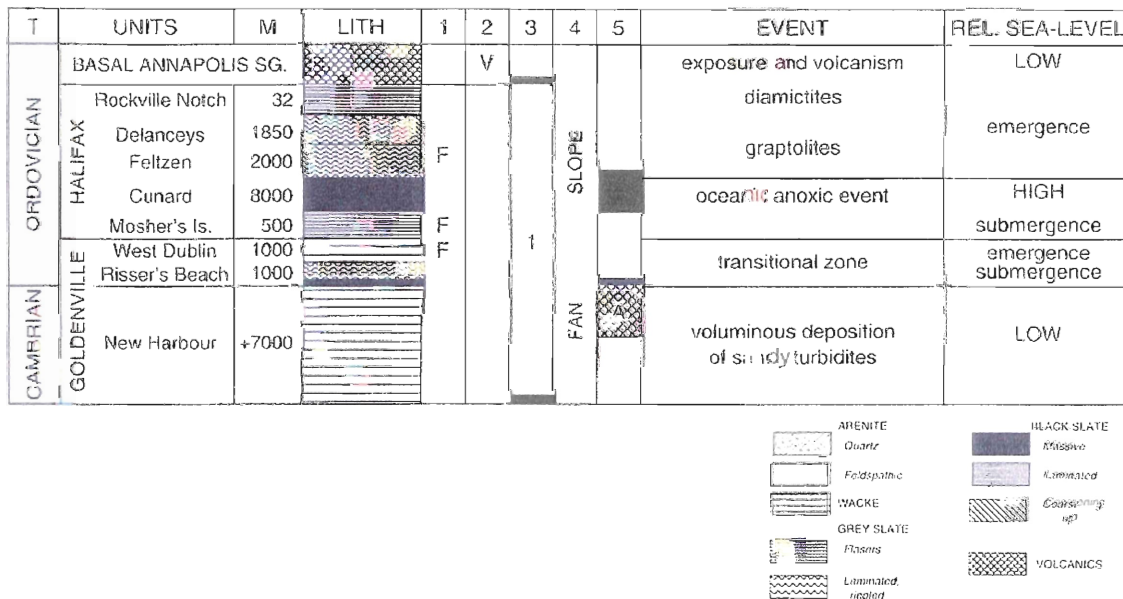
3.1.0. MEGUMA SUPERGROUP

The Meguma Supergroup is a metamorphosed sedimentary assemblage of late Cambrian to early Ordovician age, with a total aerial extent of approximately 200,000km² (Schenk 1995), found throughout mainland Nova Scotia, from Yarmouth to Canso (Fig. 3.1). The Annapolis Supergroup overlies the Meguma Supergroup. The contact between the two Supergroups is normally a para-unconformity but occurs locally as a disconformity or an angular unconformity (Schenk 1991). The Meguma Supergroup consists of metamorphosed deep-water sedimentary rocks (Schenk 1995). Overall, the Meguma Supergroup is thought to represent an evolving continental margin, with turbidity currents having acted as the main force of deposition, with sediment reworking by bottom currents (Schenk 1995).

Dextral shear sense deformation is common throughout the metamorphic evolution of the Meguma Terrane. It is likely that this stress regime was maintained from the Late Devonian through to Permian (Dallmeyer and Keppie 1987). The deformation and accompanying metamorphism was most likely the product of westward accretion and oblique obduction of the Meguma Terrane onto the Avalon Composite Terrane during the Acadian Orogeny (Keppie 1982, 1985, Dallmeyer and Keppie 1987). Asymmetric folds in the Meguma Supergroup are the result of these deformation events. During the Devonian, the Meguma Supergroup was subjected to metamorphism of greenschist to amphibolite grade, with peak metamorphism during the Devonian accompanied by granitoid plutonism (Schenk 1995). Two main units comprise the Meguma Supergroup: the Goldenville Group and the Halifax Group.



a)



(b)

Figure 3.1 a) Map of Nova Scotia showing extent of Halifax Group and Goldenville Group (modified by author from Muecke unpublished modified from Keppie 1979). Summary of stratigraphy, event stratigraphy, and relative sea-level changes in the Meguma Supergroup. T refers to the geological time and M to maximum measured thicknesses in meters. Thicknesses of stratigraphic units are scaled except where noted by numbers. Blocks with single crosses indicate measured covered intervals. The lithological column gives predominant lithologies represented by patterns used in legend except for the sandstones, where arenites are shown by grid. Column 1 indicated fossil-bearing intervals; column 2 shows episodes of volcanism; column 3 identifies unconformities by heavy horizontal lines (sequences are numbered); column 4 summarizes general depositional environments; and column 5 displays (1) times of global anoxic events (black) and (2) the Andean glacial episode (A). Major events and relative sea-level changes in the Meguma Zone are listed in the next two columns (modified from Schenk 1995).

3.2.1. *Goldenville Group*

The Goldenville Group forms the lower section of the Meguma Supergroup. The maximum known thickness of the Goldenville Group (6.7km) occurs close to Liverpool (Faribault 1914). The Goldenville Group has been subdivided into 3 Formations, in the southwest (Schenk 1995). The Goldenville Group is mainly composed of thickly bedded gray-green quartzites interbedded with slates, siltstones and micaceous slates (Schenk 1995). A possible environment of deposition is that of an abyssal-plain fan resulting in Bouma-type sequences (Schenk 1970).

3.2.2. *Halifax Group*

The Halifax Group conformably overlies the Goldenville Group forming the upper section of the Meguma Supergroup. The Halifax Group is composed of pyritic, commonly carbonaceous, shales or slates. The Halifax Group has a maximum thickness of 11.8 km in the Halifax area (Clint Milligan pers.comm. 1990, *in* Schenk 1995). Oxidation of the sulphide-rich rocks has resulted in acid rock drainage problems, especially along road cuts and other areas where they have been exposed (Fox *et al.* 1997). Muddy deep-sea fan deposits are likely to have produced the Halifax Group (Schenk 1981).

3.2.3. *Goldenville-Halifax Transition Zone*

The contact between the Goldenville and Halifax Group is transitional in nature and is termed the Goldenville-Halifax Transition Zone (GHT) (Cameron & Zentilli 1997). Faribault (1914) and Taylor (1967, 1969) used the highest exposed bed of greywacke to demarcate the contact between the Goldenville and Halifax Groups. Schenk (1970) used sand/shale ratios to define the contact, but literature explaining the precise ratio used is not often provided in the associated papers. Both guides to identifying the GHT in the field are in use, and therefore the location of the contact is not well constrained. The GHT forms a sharper contact in the east than in the central and western part of Nova

Scotia, where contacts are more gradational (Graves & Zentilli 1988). The GHT appears to be a significant control for the concentration of metals, as it is enriched in Au, W, As, Sb, and Zn-Pb (Graves & Zentilli 1988). Manganiferous calcareous argillite and black slate dominate the GHT and are preferentially enriched in Mn, C, Ba, Pb, Zn, Cu, Mo, W, and Au (Graves & Zentilli 1988). There also appears to be a relationship between metal enrichment and anoxic, sedimentary-diagenetic processes at work during GHT development (Graves & Zentilli 1988). The GHT may be identified using geochemistry and is typified by finely laminated beds, enriched in Mn, calcareous or calc-silicate nodules, spessartine quartzites and sulphides (Graves & Zentilli 1988). Protoliths of the GHT are likely deep-sea terrigenous sediments (Graves & Zentilli 1988). Coticules, spessartine quartzites, are abundant in the GHT and were probably the result of Mn carbonate precipitation (Graves & Zentilli 1988). Later, during regional metamorphism, spessartine garnets developed at the expense of the carbonate (Graves & Zentilli 1988), accompanied by the growth of pyrrhotite, making the GHT a strongly magnetic unit, mappable using geophysical techniques (Fox & Zentilli 1997).

3.3.0. GEOCHEMISTRY AND MINERALOGY IN THE MEGUMA SUPERGROUP

3.3.1. Previous Work

Mn concentrations are high in the Meguma Supergroup and appear to be most highly concentrated within the GHT (Cameron & Zentilli 1997). Garnet and ilmenite are two minerals that have been shown to have very high Mn/MnO concentrations (>18 wt. %) in the Meguma Supergroup (Cameron & Zentilli 1997).

Near Eastville, there is a significant Zn-Pb occurrence in the GHT (MacInnes 1986). This area is comprised of quartz semi-pelite, calcareous quartzite and pelite. The depositional environment is interpreted as middle to outer fan and basin plain deposits (Binney *et al.* 1986). Mn is concentrated in the calcareous quartzite member, which forms the upper unit of the Goldenville Group (Binney *et al.* 1986). Cameron and

Zentilli (1997) found spessartine garnets with concentrations of MnO up to 29.63% away from the granitoid intrusion, compared with MnO concentrations of 3.55 wt. % near the granitoid intrusion. Cameron and Zentilli (1997) also noted that Mn concentration in biotites, and chlorite decreased with increasing metamorphic grade.

The Beaverbank Highway locality lies at the base of the Halifax Group. The rocks have been subjected to greenschist facies metamorphism and are characterized by numerous calcareous coticule layers (Graves & Zentilli 1988). Feetham (1996) studied this area intensively and found Mn concentrations to be highest in the upper layer of the GHT within a coticule layer. This unit had up to 12 wt. % MnO that was mainly in spessartine garnets with an average 2.5 wt. % coreward increase in MnO (Feetham 1996). Ilmenites contained between 13.96 wt. % and 18.39 wt. % MnO. Below the coticule layer, average MnO dropped significantly but spessartine garnets with coreward increases in MnO are still present as are ilmenites containing relatively high amounts of MnO.

The Lake Charlotte drillcore (LC86-1) intercepts the GHT. The hole was drilled as part of a Mn project in the area. The drillcore passed through carbonaceous, pyrrhotite and pyrite-rich black slates and Mn-rich, calcareous banded argillite (Mwenifumbo *et al.* 1990). The goal of the drilling work was to produce a stratigraphic section through the GHT and to map the Mn mineralization along this contact. Mwenifumbo *et al.* (1990) report that most of the mineralization occurs in the argillites as Mn-bearing calcite ($\text{CaMn}(\text{CO}_3)_2$), Mn oxides, mainly Mn-bearing ilmenite (FeTiMn oxides), and as silicates such as spessartine garnet. Alteration of these minerals is common often producing Mn oxides such as manganite and pyrolusite. Graves and Zentilli (1988) reported Mn concentrations in the lower part of the core of 1.78-23.55 wt. % averaging 2.96 wt. %, and in the upper part of the core, values averaging 11.17 wt. % as compared with values below 0.35 wt. % in the other units.

3.3.2. *Mn Geochemistry in the Meguma Supergroup: this study*

Samples taken along the Beaverbank Highway confirm high Mn mineralization within the garnets and ilmenites (Fig. 3.2). Thin section analysis under a polarizing microscope revealed slide DF-01 to have over 60% by volume composition of garnet and close to 25% by volume of fine-grained granular quartz (Fig. 3.3). Petrographic descriptions of the slides can be found in Appendix D. Slide EL-01 had close to 40% quartz by volume and 10% ilmenite by volume (Fig. 3.4). Microprobe data revealed high values of Mn in garnet cores with DF-01 having average values of 31.30% Mn and EL-01 values of 29.65% Mn (Table 3.1). The garnet rims had slightly decreased values of Mn: DF-01 28.98% Mn and EL-01 25.65%. Both thin sections also had Mn-rich ilmenite with 9.64% and 13.98% in DF-01 and EL-01 respectively.



Figure 3.2 Photo showing bedrock (GHT) by Mount Uniacke, about 1km from where hand samples were taken along Beaverbank Highway, and from the same unit.

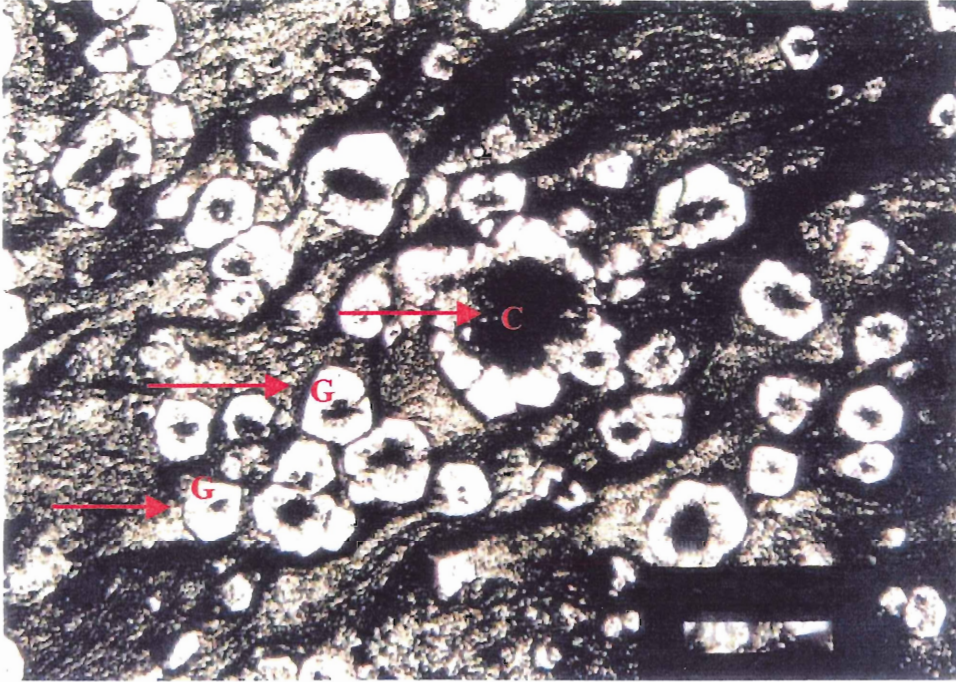


Figure 3.3 Slide DF-01 at 5x magnification. Note high abundance of garnet (G) and black cores of the garnets made up of carbon (C).

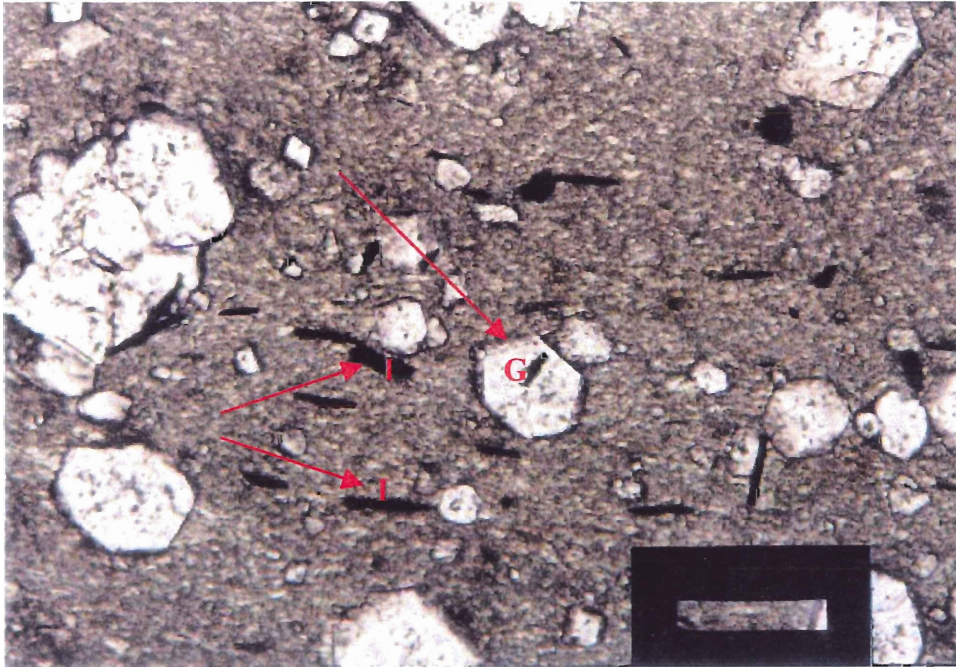


Figure 3.4 Slide EL-01 at 5x magnification. Note high abundance of garnet (G) and large, euhedral ilmenites (I).

	SLIDE	GARNET CORE	GARENT RIM	ILMENITE
Average Mn %	DF - 01	31.30	28.98	9.64
Average Mn %	EL - 01	29.65	25.65	13.98

Table 3.1 Probe results. Averages calculated from 6 garnet cores and 6 garnet rims per slide. Ilmenite average DF-01 calculated from 5 ilmenites and EL-01 calculated from 4 ilmenites.

3.4.0. CARBONIFEROUS BASIN

3.4.1. Horton Group

The Horton Group is of late Devonian to early Carboniferous age (van de Poll *et al.* 1995) and extends approximately from the Minas Basin to the tip of Cape Breton (Fig. 3.5). With a maximum onshore thickness of 3.3 km, the Horton Group includes red and grey-green polymictic conglomerates, arkosic sandstones, mudstones, oil shales and minor non-marine evaporates, overlying pre-Acadian metamorphic basement in an angular unconformity (van de Poll *et al.* 1995).

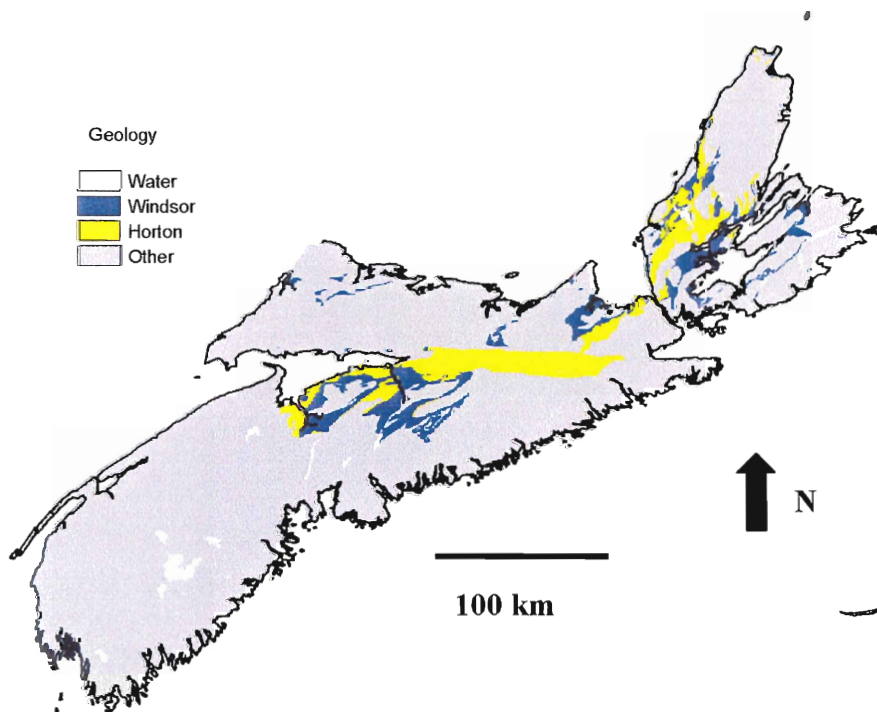


Figure 3.5 Map of Windsor Group and Horton Group showing extent of Groups in Nova Scotia (modified by author from Muecke unpublished modified from Keppie 1979).

Fish, amphibians, ostracodes and in-situ vascular plants are common in the Horton Group and are indicative of a non-marine depositional setting (Gibling 1995). The Horton Group was probably produced as the result of continental deposition in to a subsiding basin (Gibling 1995).

3.4.2. *Windsor Group*

The Windsor Group is of early Carboniferous age (Utting 1987) and composed of marine limestones, evaporites, and intercalated redbeds (van de Poll *et al.* 1995). Carbonates comprise a small fraction of the Windsor Group (Giles 1982 in Lavoie *et al.* 1995). The Windsor Group is widespread in the subsurface but poorly exposed at the surface (Fig. 3.5), with thickness varying from around 0.3 km close to Minas Basin to 1.0 km in Cape Breton (Lavoie *et al.* 1995). The Windsor Group overlies conformably and paraconformably the Horton Group and in other areas it unconformably overlies the Meguma Group. Early to late Carboniferous to Jurassic siliciclastics overlie the Windsor Group (Lavoie *et al.* 1995). The Windsor Group represents the only identified marine incursion into the Maritime basin before the Late Carboniferous (van de Poll *et al.* 1995). Schenk (1976a) suggested the alternating redbeds, evaporites and carbonate facies might indicate transgression-regression cycles or seasonal and climatic fluctuations (Schenk 1969). The Windsor Group, mainly along the Windsor/Horton contact, has associated base metal deposits and Mn occurrences are common in the Windsor carbonates (Lavoie *et al.* 1995). Table 3.2 illustrates the age, stratigraphic position, and lithostratigraphic description of the Windsor Group and the Horton Group.

	Hopewell Group		Hopewell Conglomerate and Maringouin Formation. Mainly redbeds.		
Lower Carboniferous	Windsor Group	Subzones A & B	Evaporite dominated facies sequence (Upperton, Cassidy Lake, Clover Hill formations and overlying red mudstones.)		
			Carbonate Dominated facies sequence (Macumber, Gays River, Parleeville formations, Swamp Hill Beds, Demoiselle Creek Beds.)		
	Horton Group	Moncton Formation	red conglomerates, coarse to fine arkosic sandstone, mudstone, Hillsborough Member, Boyd Creek Tuff, Weldon Member		
		Albert Formation	Round Hill Member	Gautreau Member non marine evaporites	
				Hiram Brook Member calcareous hale sandstone	
Frederick Brook Member oil shale, calcareous siltstone					
Dawson Settlement Member Grey sandstone, shale conglomerate					
	Memramcook Formation		Arkosic redbeds		
Upper Devonian	Angular unconformity (Acadian Orogeny)				
	pre-Acadian metamorphic basement				

Table 3.2 Age, stratigraphic position and lithostratigraphic position of the Windsor Group and Horton Group, Moncton Basin (after McCutcheon 1981; Carter & Pickerill 1985 in van de Poll *et al.* 1995).

3.5.0. MN MINERALOGY IN CARBONIFEROUS BASIN

3.5.1. Overview of Carboniferous Mn deposits

Mining of Mn in central Nova Scotia has occurred in Colchester, Hants and Lunenburg counties and the following information on Mn mining in Nova Scotia is taken from Bishop and Wright (1974), except where indicated. The majority of Mn deposits in Nova Scotia are either replacement and residual deposits or vein deposits, though sedimentary bog type deposits also occur. Most of the ores have come from one of three environments: 1) Carboniferous strata 2) pre-Carboniferous strata containing fissure fillings 3) surface bog deposits.

In Hants county replacement ore bodies occur in conglomerates and sandstones. Complete and extensive replacement is found in calcium-rich or dolomitic limestone. Mining of replacement ore bodies from limestone has been undertaken at Cheverie, Pembroke, Walton and Tennycape. Mn replacement deposits are found in the Pembroke Formation (Windsor Group), close to its contact with the underlying Macumber

Formation (Windsor Group), where lenses and nodules of Mn oxides replace the limestone conglomerate (Bishop and Wright 1974). Fissure deposits occur in the Macumber formation, which consists of shaly limestone, and can reach a considerable size. One fissure deposit at Tennycaple yielded 1,000 tons of ore (Bishop and Wright 1974).

3.5.2. Walton Area

The Walton area has had several Mn mines in the past. The three mines in close vicinity of Walton were: 1) the Shaw and Churchill Mine, 2) South Bank, and 3) Walton River and Wild Cat Prospect. Several small Mn occurrences exist in the Walton area, mainly of the bog variety (Boyle 1972). The Mn mineralization in the Walton area occurs primarily along the contact between the Windsor Group and the Horton Group. Most of the mines were located within the Macumber limestone, a sandy-red limestone containing veinlets of calcite, and Pembroke limestone. Ore minerals included porous and crystallized manganite and some pyrolusite (Bishop and Wright 1974).

3.5.2.1. This Study

Hand samples were taken along the old Walton Mine road over 1km past the old Walton Mine (Fig. 3.6). The hand samples from the Walton locality were fairly uniform sandstone with no bedding or grading present at the hand sample scale though bedding was obvious in the field (Fig. 3.7). The hand samples are composed of well-rounded and well-sorted sand grains (Fig. 3.8, Fig. 3.9). The samples are brownish-orange in colour, except where oxide minerals are present. The oxide minerals occur as a penetrative staining that appears gradational with a dark black coating grading into a brown layer further away from the exposed surface.



Figure 3.6 Photo along Walton Mine road. Hand sample collected where arrow indicates (Photo courtesy of T. Goodwin, NSDNR).



Figure 3.7 Field photo showing area where hand samples were taken. Notice dark Mn mineralization. (Photo courtesy of T. Goodwin, NSDNR).

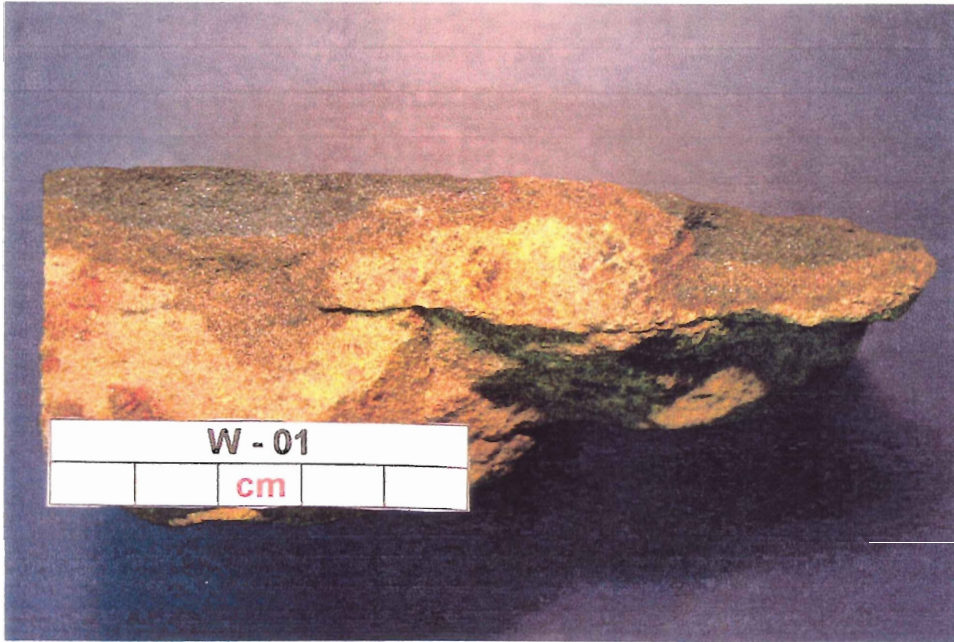


Figure 3.8 Walton hand sample W - 01 showing dark staining on top of sample. Below the dark staining is a lighter brown staining and below the brown staining the brownish-orange colour of the rock.

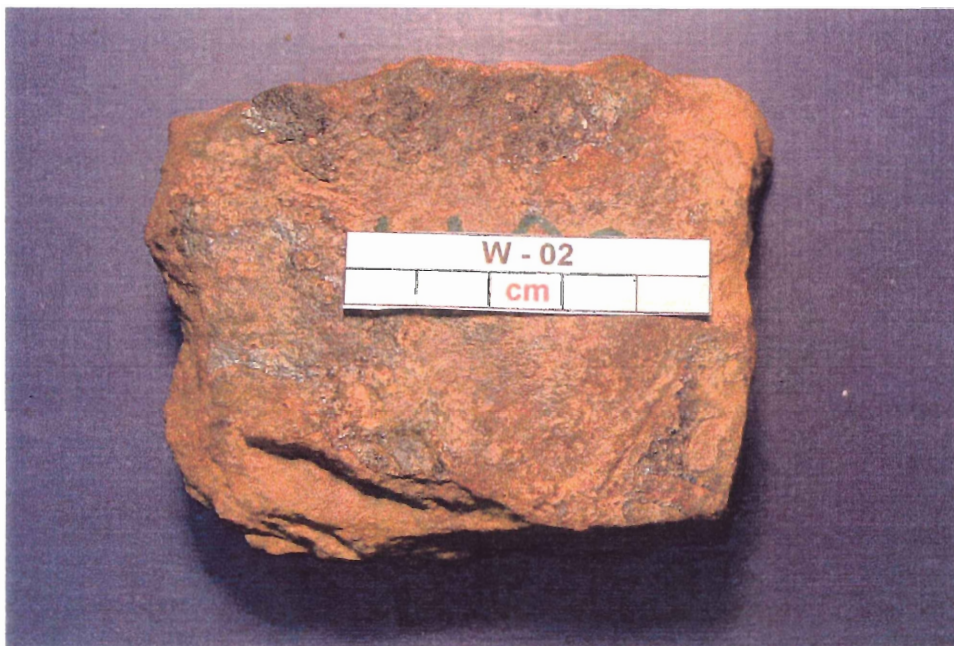


Figure 3.9 Walton hand sample W - 02. Dark mineralization identified as hematite

Mineral identification results from the XRD on the Walton rocks were difficult to obtain because of the nature of the oxide coating. One successful XRD sample identified the surface mineralization as hematite (Fig. 3.10).

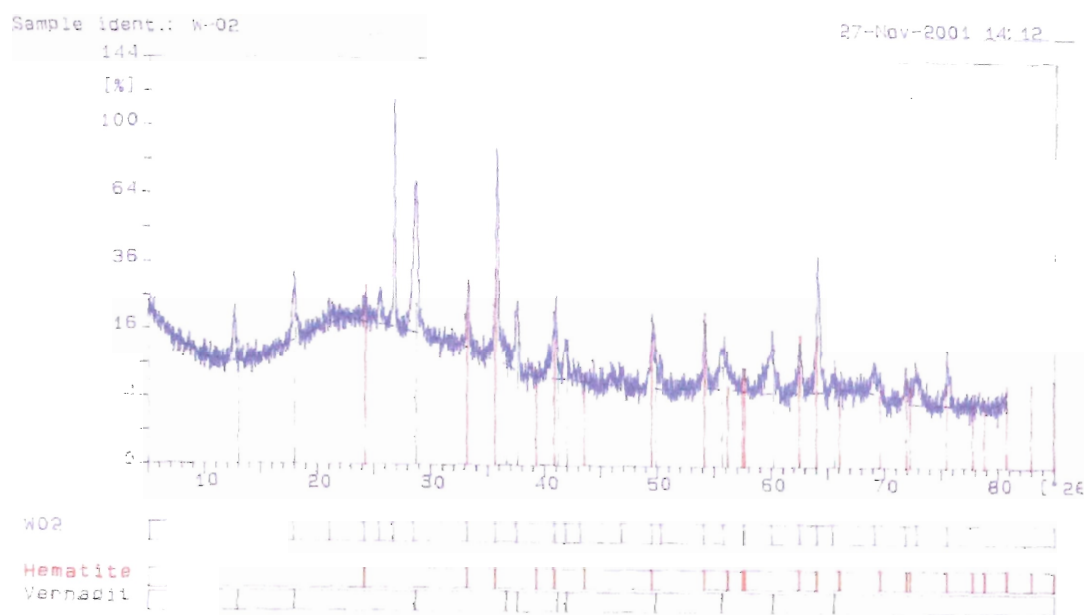


Figure 3.10 XRD of W02 identifying the dark mineralization as hematite.

3.5.3. Tennycapc Area

Tennycapc is located close to Windsor, approximately 35km to the northeast, on the south side of the Minas Basin. Tennycapc mine was the largest producer of Mn in Nova Scotia and produced over one-half of the total 8,000 tons of Mn ore extracted from the south shore of the Minas Basin (Bishop and Wright 1974). The Tennycapc mine deposit is found in rocks of Horton and Windsor age in the north limb of a syncline (Bishop and Wright 1974). Upper Horton rocks of the Cheverie Formation in the mining area are made up of red sandy and slightly micaceous shales (Bishop and Wright 1974). The Macumber Formation overlies the Cheverie Formation and comprises 16 feet of shaly limestone. In places, overlying the Macumber Formation are the conglomerates and breccias of the Pembroke Formation.

The economic minerals extracted from the Tennycape deposits included pyrolusite with some manganite and psilomelane, and are associated with calcite, limonite, barite and selenite (Bishop and Wright 1974). The Mn deposits occur both in the Pembroke limestone conglomerate and in the shaly limestone of the Macumber Formation. The best ore was found directly above the Macumber Formation. In the lowermost Pembroke Formation, lenticular and nodular bodies of Mn minerals replaced the limestone conglomerate, and resulted in disconnected bodies of Mn deposits. The shaly limestone (Macumber Formation) was not involved with replacement, and Mn deposits filled pre-existing openings.

3.5.3.1 This Study

The Tennycape hand samples were taken from the north side of a now-overgrown open cut (Fig. 3.11). The hand samples ranged from pinkish/orange limestone (Fig. 3.12) to breccia, with limestone clasts (Fig. 3.13). The associated mineralization is black and formed along some fractures and also as a surface coating. Some of the black mineralization has a definite crystal habit of shiny lath shaped crystals. Results from the XRD identified the mineralization as pyrolusite (Fig. 3.14).

3.6.0. SUMMARY

Microprobe results from the Beaverbank Highway samples confirmed the known Mn enrichment in garnets and ilmenites in the Meguma Supergroup. Samples from the Carboniferous indicated the main two Mn oxides coating the samples were pyrolusite and hematite. However, manganite was also found in the Walton area through previous work (Bishop & Wright 1974), and there were most likely other Mn minerals on the Carboniferous samples that were not detected. This study served to confirm mineralization and geochemical results of previous work.



Figure 3.11 Field photos by old Tennycap mine workings. Arrow indicates area where hand samples were taken (Photo courtesy of T. Goodwin, NSDNR)

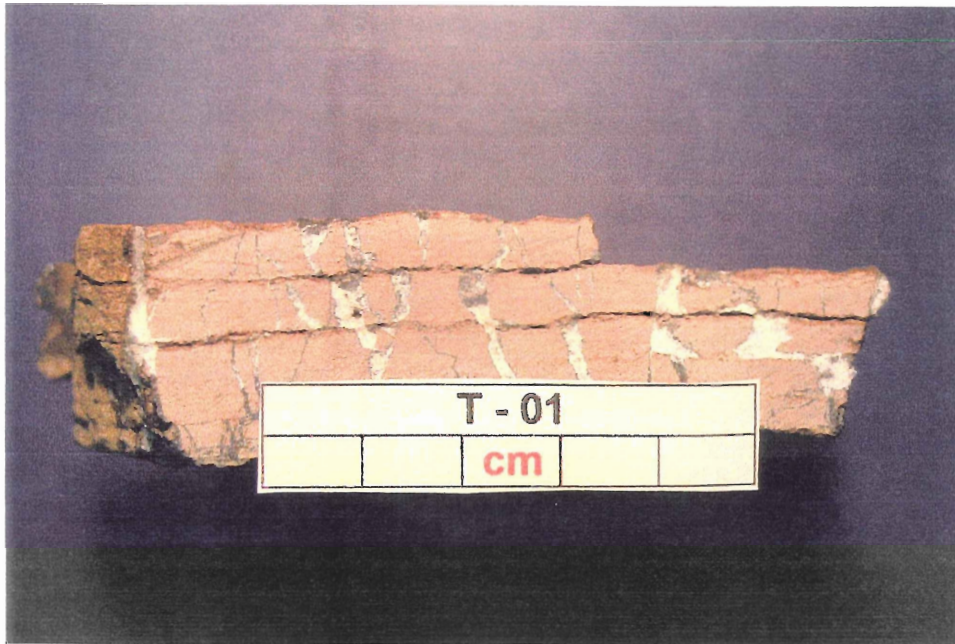


Figure 3.12 Hand sample T-01 from Tennycape showing limestone with carbonate filling in fissures.



Figure 3.13 Hand sample T-02 from Tennycape. Brecciated rock with limestone from Fig. 3.9 making up the majority of the clasts. Note abundance of black mineralization surrounding clasts.

Sample ident.: Tenny01

27-Nov-2001 14:40

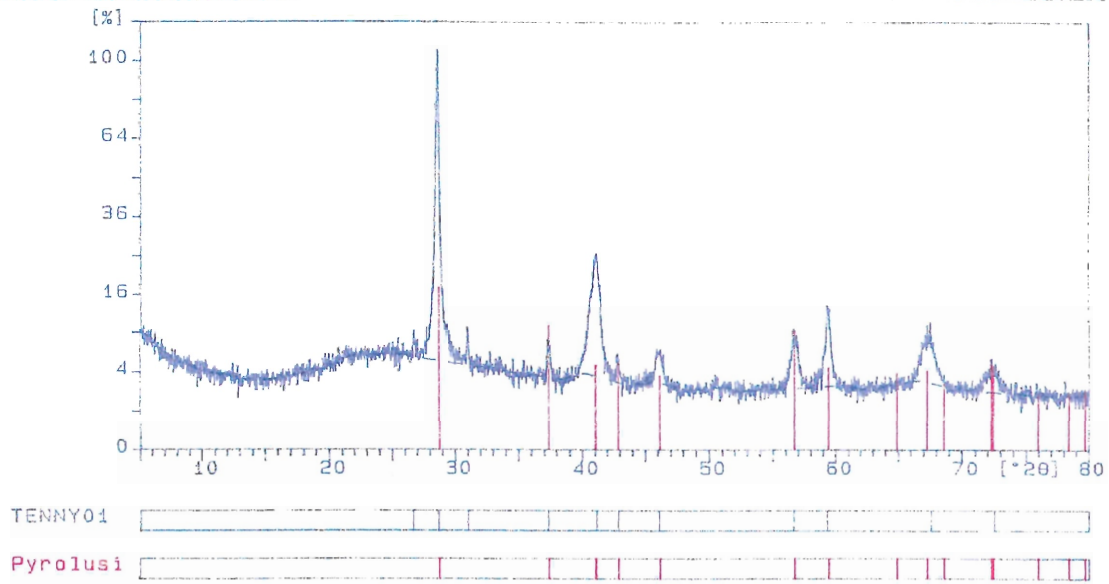


Figure 3.14 XRD T-01 identified the dark mineralization as pyrolusite.

CHAPTER 4

4.0.0. G.I.S. Compilation

4.1.0. SOFTWARE PACKAGE USED

Two G.I.S. packages were used to visualize, query, and analyze the data. ARCVIEW was utilized in the preliminary stages in order to eliminate unnecessary data points. ARCVIEW was used for this purpose because: 1) the data was already in ARCVIEW friendly format; and 2) selecting and eliminated data points in order to produce a new table is straightforward in ARCVIEW. IDRISI was used secondarily because: 1) the Geology Department at Dalhousie University uses IDRISI, making it accessible to the author; and 2) the author was most familiar with the IDRISI package over other desktop G.I.S. packages.

4.2.0. DATA SOURCES

Pre-existing digital data was downloaded from the NSDNR website, in order to create a geological map of Nova Scotia in ArcView. This map was only used in order to eliminate data points and was not used in the analysis of the data. A separate geological map of Nova Scotia was used in IDRISI called Nsgeo5u. The information used to rasterize Nsgeo5u was initially downloaded from the Geological Map of the Province of Nova Scotia, version 1, 1997, compiled by J. D. Keppie (1979) provided by the NSDNR. Dr. Gunter Muecke of Dalhousie University rasterized the map. Nsgeo5u is a 1:500,000 map with a resolution of 500m. In this study, Nsgeo5u was modified and renamed MnMap1. MnMap1 was used to display and analyze the data.

Dr. Gwendy Hall provided surface water analysis in an EXCEL file. Each surface water sample taken had referenced Northings and Eastings, facilitating its transfer into both

ARCVIEW and IDRISI. The surface water analyses also listed concentrations of various other elements as well as manganese. The lake sediment data set and till data set were downloaded from the NSDNR website from the regional geochemical datasets (biogeochemical, lake and stream sediment, lake and stream water, soil, rock and till geochemical surveys), version 1, 1996. The lake sediment and till files were initially downloaded as .dbf files and later saved into EXCEL formats. The NSDNR lake sediment and till data contained Eastings and Northings of each sample location, plus results for Mn analysis and numerous other elements.

4.3.0. DATA MANIPULATION

4.3.1. Map Creation

The geological legend of Nsgeo5u was simplified by using only the geological units that fell within the study area and omitting those that did not. The legend was further simplified by displaying the geology on the basis of Groups. All geological units fell into one of seven geological Groups except for Early Cretaceous rocks and granite and granitoid complexes. The Early Cretaceous was left as Early Cretaceous and all granite and granitoid complexes of various ages were amalgamated as granitoids of various ages. The simplified map was then renamed MnMap1. The Mn concentrations in surface water, lake sediment and till were then added to MnMap1. The Mn concentrations for each data set were imported into IDRISI by: 1) deleting all data from the original tables except Eastings, Northings and Mn concentration; 2) saving the new tables as .csv (comma delimited files); 3) importing the tables into IDRISI as XYZfiles with utm coordinates of 20N; and 4) adding the newly created point vector files to the MnMap. Mn concentrations for surface water are presented in Chapter 5, Figure 5.1, as colour-filled, proportional symbols based on 7 equal interval class breaks. The same approach was used for lake sediment and till data.

4.3.2. Editing of Data

The three data sets used were surface water, lake sediment and till. The geographic area that defines the boundaries of the three data sets is different for each survey. The author chose the boundaries of the study area. The western boundary of the study area was well defined as the contact with the large granitoid complex, however, data points that overlapped with the granitoid complex and the study area were retained. To the east the boundary was more arbitrary. Although the lake sediment and till data continued up to the Cobequid-Chedabucto fault, the surface water data did not. Therefore, in order to maximize overlap of the three data sets, while still retaining a large proportion of the data, the lake sediment data and till data were retained up to the Easting 536000. Data points lying to the east of this co-ordinate were deleted. The northern boundary on the east side was the Minas Basin. The northern boundary on the west side was the outer margin of the Horton Group. Points lying north of the Horton Group were omitted. The southern boundary was the shoreline.

4.3.2.1. Surface Water

Dr. Gwendy Hall of the GSC kindly provided surface water data set consisting of 729 sample sites. Some of the surface water samples were outside the area of this study and were, therefore omitted. In total 26 data points were omitted for this reason and, results for 713 surface water samples were used in this study (Fig. 4.1).

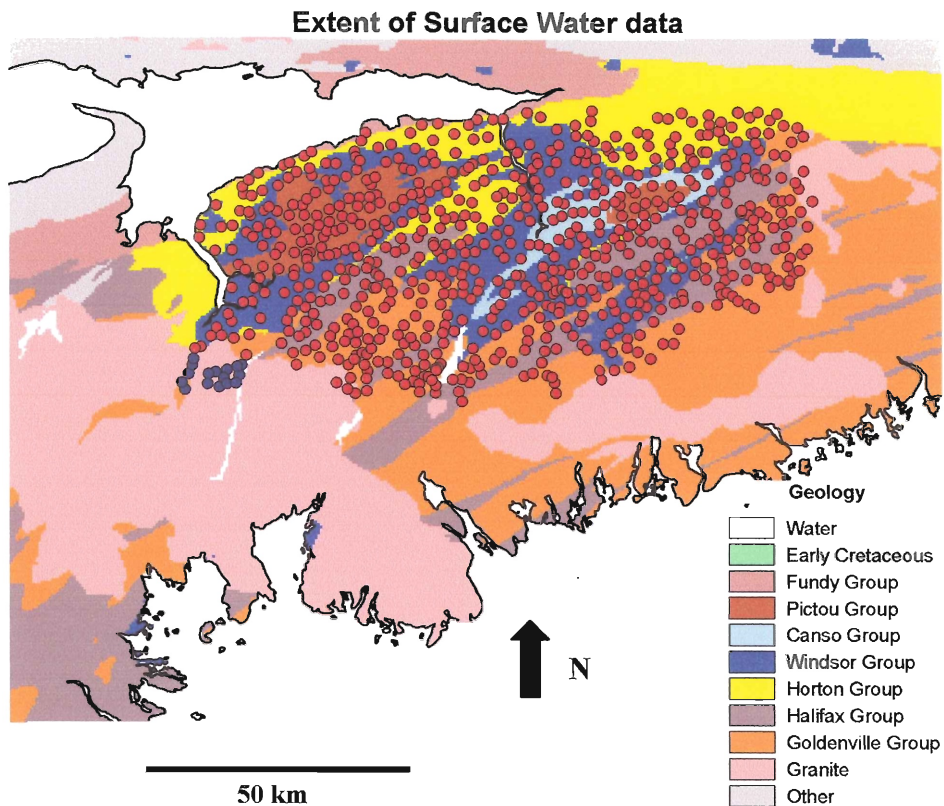


Figure 4.1 Spatial distribution of data points used for Mn concentrations in surface water shown in red. Original extent of data set includes red and blue points.

4.3.2.2. Lake sediment

Lake sediment data are available for most of Nova Scotia. The lake sediment data set downloaded from the NSDNR was reduced from 3,999 to 650 samples that fall within the study area (Appendix A). Figure 4.2 indicates the original size of the data set and highlights in red the points that are used for this study.

4.3.2.3. Till

The till data set downloaded from the NSDNR contained 1,891 data points. The till data set was reduced to 366 points (Appendix B) by selecting only the points that fell within the study area (Fig. 4.3).

Extent of Lake Sediment data

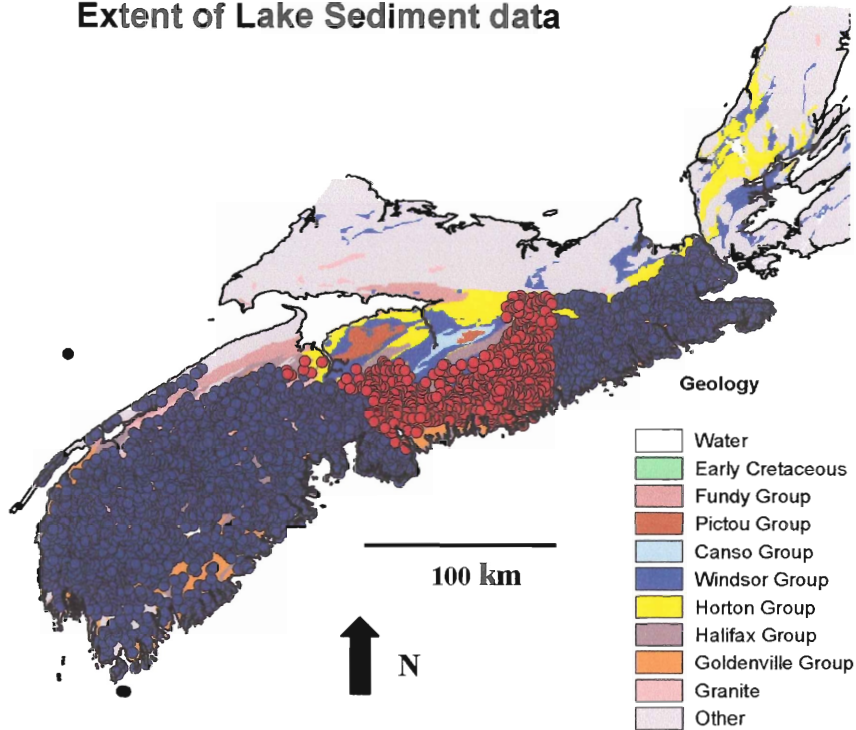


Figure 4.2 Provincial coverage of lake sediment sample locations (blue and red points). Only the data points in red were used in this study.

4.4.0. CORRELATIONS OF ELEMENTS

All of the data point for Mn concentrations were actual values, however, several of the other elements had negative numbers entered instead of actual concentrations. Negative numbers were recorded for various reasons, such as the value was lost, or concentrations were below detection limits. Therefore, in order to perform meaningful correlations, negative data points needed to be deleted. For some elements in the data sets, nearly the entire column was filled with negative numbers. When this was the case the entire column was removed and the element was not included in the correlation. Where correlations results are presented, N (sample number) will appear to indicate the size of the data set correlated.

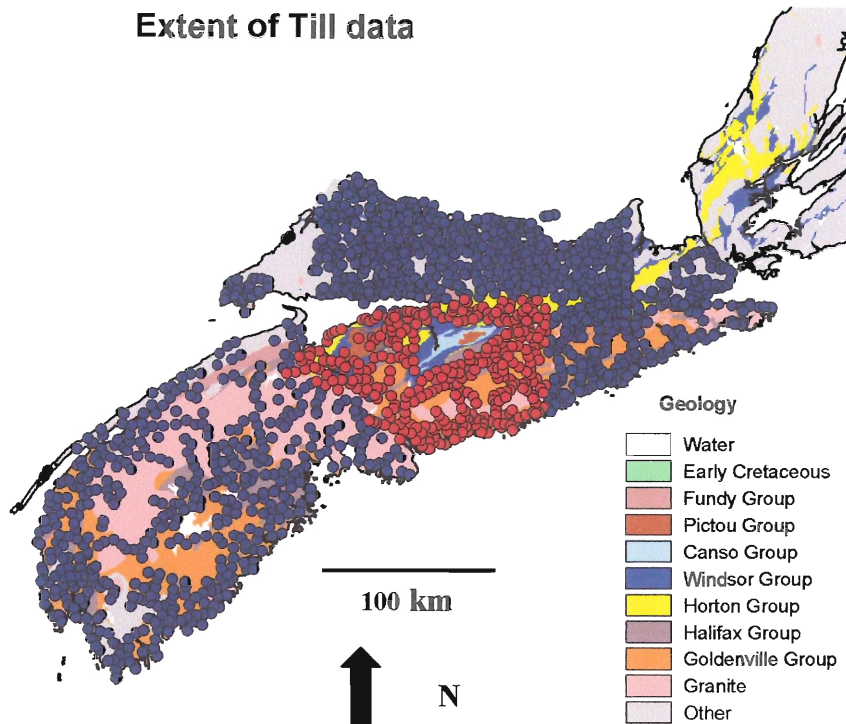


Figure 4.3 Spatial distribution of data points used for Mn concentrations in till shown in red. Original extent of data set includes red and blue points.

4.5.0. ANALYSIS

Basic statistics were performed for all the data sets of Mn concentrations in surface water, lake sediment and till. Correlations of elements in the data sets were completed where possible. Basic statistics were also calculated for Mn concentrations in surface water, lake sediment and till based on the bedrock geology in the area where the sample was taken. Only statistics for media overlying the Windsor Group, Horton Group, Halifax Group and Goldenville Group were calculated, as these were the Groups of interest within the study area. The surface water data set was unique in that each sample location listed the associated bedrock geology. The Mn concentrations in surface water with respect to geology were therefore calculated by manipulating the original EXCEL table as well as using the extract feature in IDRISI. The lake sediment and till data sets

did not contain associated geological information, and therefore only the extract feature in IDRISI was used. The extract module analyzed the data by calculating any data points falling inside a particular geological group and providing summary statistics with respect to that geological group.

4.6.0. ERROR

The G.I.S. method of extracting data is subject to some degree of error. The MnMap1 is a rasterized version of a vector map. A raster image requires that each pixel on the image contains a value. Curved lines are not possible in the raster system. Therefore, errors are introduced because a raster image does not represent the actual boundary but has a jagged line in the form of pixels marking this boundary. The resolution of MnMap1 is 500m. Therefore, data points lying close to geological boundaries may be wrongly classified. Using the Extract method, some of the data points are located within the ocean. The data points that were located in the ocean most likely belonged to a geological Group that fell close to the shoreline, and the program was not able to place them accurately. This error was thought to be minimal as the number of data points falling in the ocean were 1, 2 and 13 for surface water, lake sediment and till respectively, out of sample sizes >366. It is also likely that points misclassified on the basis of geological Groups did not greatly affect the statistics as the misclassified points would be small relative to N.

CHAPTER 5

5.0.0. G.I.S. and Database analysis

5.1.0. MN CONCENTRATIONS AND CORRELATIONS

5.1.1. Concentrations

The surface water data set contains the greatest number of sample points followed by lake sediment and then till (Table 5.1). The mean and median concentration of Mn is highest in the till, followed by the lake sediment, and lastly surface water (Table 5.2). The variability of the data, measured by a sample standard deviation, is highest for the till, followed by lake sediment and then surface water; the maximum value was 27,800 ppm for tills, 14,620 ppm for lake sediment and 2,090 ppb for surface water. Figure 5.1 shows the study area and the Mn concentrations associated with each sample point for the surface water, lake sediment and till.

	SURACE WATER (ppb)	LAKE SEDIMENT (ppm)	TILL (ppm)
N	713	650	366
Mean	88.8	302.1	2064.0
Median	41.1	168.0	1380.0
StDev	179.5	676.6	2454.0
Minimum	1.9	4.0	100.0
Maximum	2089.8	14620.0	27800.0
Q1	22.7	86.0	858.0
Q3	78.2	337.0	2620.0
IQR	55.5	251.0	1762.0

Table 5.1: Basic statistics for Mn concentrations in surface water, lake sediment and till within study area.

	Mean	Median	Maximum
Surface Water	3	3	3
Lake sediment	2	2	2
Till	1	1	1

Table 5.2: Ranking of Mean, Median and Maximum (highest to lowest) for surface water, lake sediment and till Mn concentrations

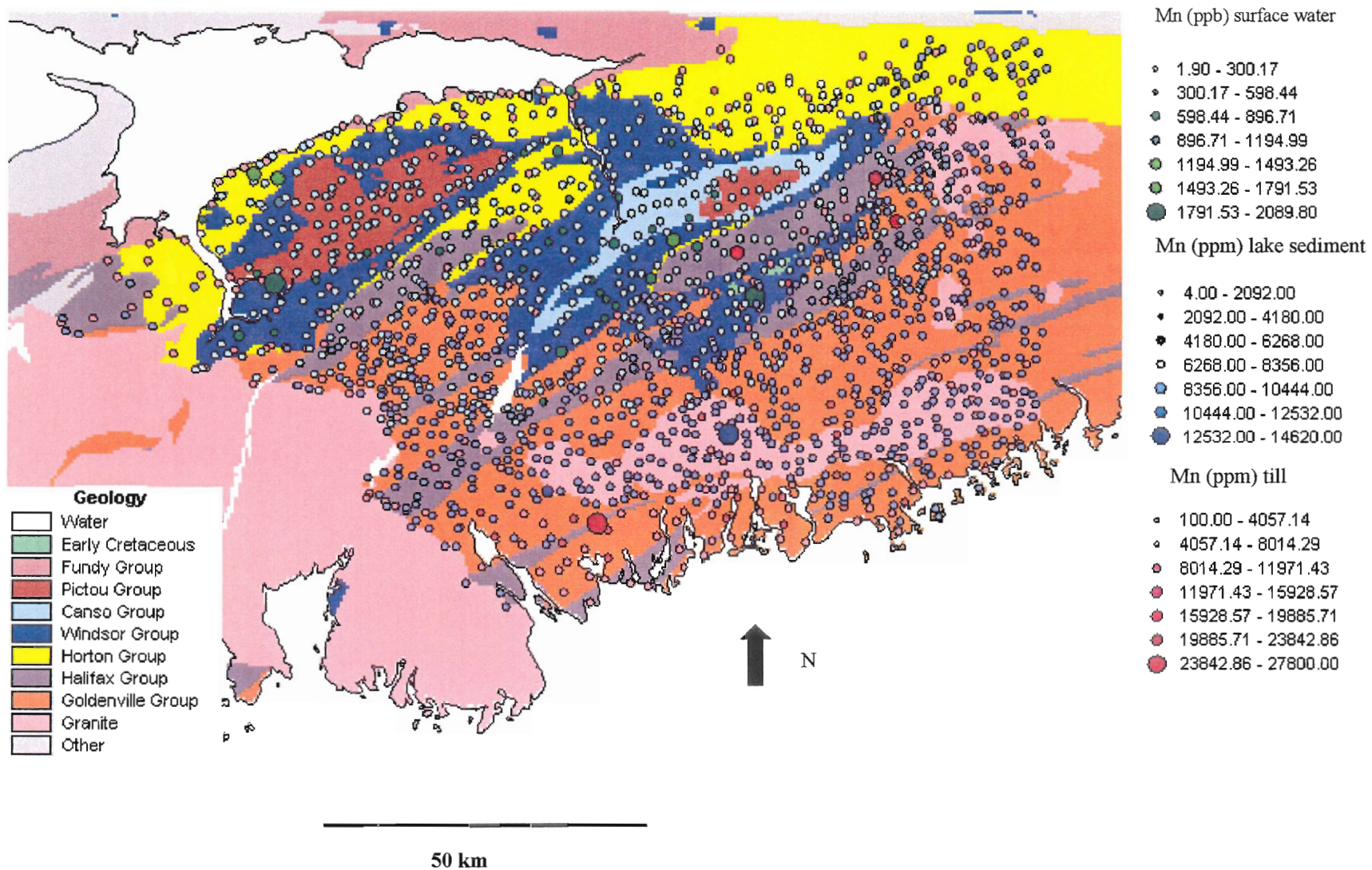


Figure 5.1 Map of study area showing Mn concentrations of surface water, lake sediment and till.

5.1.2. Surface Water

The values of Mn concentration in surface water range from 1.9-2089.8 ppb. The mean value of the surface water data set is 88.82 ppb and the median value is 41.1 ppb. The mean value of the surface water exceeds the Guidelines for Canadian Drinking Water Quality (0.05mg/L) by more than 1.5% (CWQG 1987). In fact, Pockwock Lake and Lake Major, water supply sources for Halifax and Dartmouth respectively, have raw water values of 0.06 mg Mn/L and 0.007 mg Mn/L (HRWC 2000). The histogram for the surface water data is strongly skewed to the right (Fig. 5.2). The boxplot indicates that there are 83 outliers. Outliers were determined based on values that are $> Q3 + (1.5 * IQR)$ or $< Q1 - (1.5 * IQR)$. Pearson correlations were calculated for Na, K, Ca, Mg, Mn, Fe, Ba and Cu with N = 592 (Table 5.3). P-values were also calculated for each r-value and r-values with associated p-values of < 0.05 were considered significant. For this study, stronger positive correlations were selected using an arbitrarily selected "r" coefficient of > 0.3 . Both Ba (0.32) and Fe (0.31) displayed positive correlations above this cut off.

	Na	K	Ca	Mg	Mn	Fe	Ba
K	0.71						
	0.00						
Ca	0.31	0.32					
	0.00	0.00					
Mg	0.62	0.68	0.68				
	0.00	0.00	0.00				
Mn	0.17	0.23	0.14	0.27			
	0.00	0.00	0.00	0.00			
Fe	-0.02	-0.03	-0.20	-0.14	0.31		
	0.71	0.41	0.00	0.00	0.00		
Ba	0.34	0.44	0.40	0.61	0.32	-0.05	
	0.00	0.00	0.00	0.00	0.00	0.26	
Cu	0.04	0.04	0.07	0.07	0.09	0.09	0.12
	0.35	0.34	0.09	0.11	0.04	0.03	0.01

Table 5.3 Pearson correlation coefficients (r) for elements in surface water (p-values appear directly below r-value). Bolded r-values represent $r > 0.30$ and statistically significant p-values < 0.05 . N = 592

5.1.3. Lake sediment

The mean value of the Mn concentration of lake sediment was 302.1 ppm and the median value was 168.0 ppm. The minimum value of the data set was 4 ppm and the maximum

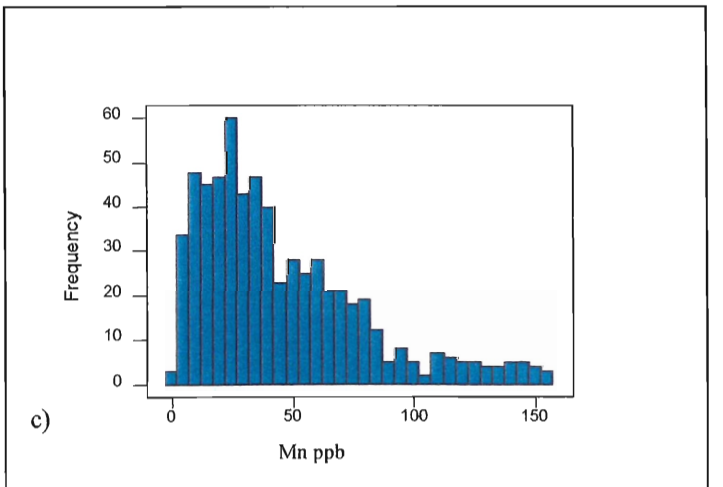
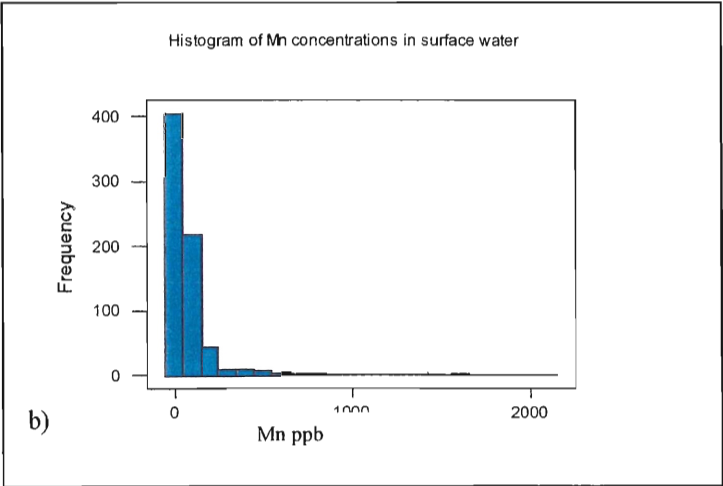
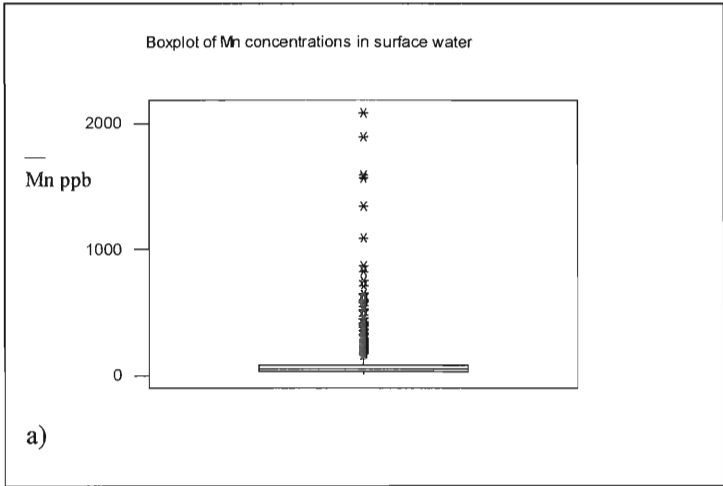


Figure 5.2 Boxplot and Histograms showing Mn concentrations in surface water a) boxplot b) histogram of all data c) histogram with outliers removed.

value was 14,620.0 ppm. The histogram of lake sediment data was strongly skewed to the right (Fig. 5.3). There are 43 outliers in total for lake sediment. All of the outliers lie below 5,000 ppm with the exception of the maximum value, which is close to 15,000 ppm. All the outliers have very high Mn concentrations when compared to average soil values of 500-850ppm (Brault *et al.* 1993). A more useful comparison would have been to compare the results to lake sediment from different regions, but data were not available for this comparison. Lake sediment Mn concentrations were correlated for all elements in the data set; Cu, Ni, Pb, Zn, Co, Fe, Ca, Mg, Mo, Hg, U and As (Table 5.4). Only one location had to be omitted as a result of a negative number (N=649). Lake sediment concentrations of Mn showed stronger positive correlations with Ni (0.41) and Zn (0.44), Co (0.42), Fe (0.594) and As (0.338). Understanding Mn may therefore be an important control on the cycling of these elements, some of which are more toxic than Mn.

	Cu	Ni	Pb	Zn	Co	Fe	Mn	Ca	Mg	Mo	Hg	U
Ni	0.52											
	0.00											
Pb	0.20	0.03										
	0.00	0.47										
Zn	0.40	0.62	0.14									
	0.00	0.00	0.00									
Co	0.42	0.66	0.19	0.50								
	0.00	0.00	0.00	0.00								
Fe	0.30	0.55	0.09	0.56	0.54							
	0.00	0.00	0.02	0.00	0.00							
Mn	0.20	0.41	0.11	0.44	0.42	0.59						
	0.00	0.00	0.01	0.00	0.00	0.00						
Ca	0.11	-0.01	0.07	-0.04	-0.09	0.01	0.09					
	0.01	0.76	0.09	0.30	0.02	0.73	0.02					
Mg	0.34	0.40	0.13	0.45	0.40	0.41	0.28	0.00				
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.94				
Mo	0.03	0.09	0.00	0.09	0.02	0.08	0.18	0.42	-0.01			
	0.50	0.02	0.97	0.02	0.54	0.04	0.00	0.00	0.74			
Hg	0.00	-0.05	0.15	-0.03	0.01	0.01	0.03	0.03	-0.06	0.04		
	0.96	0.18	0.00	0.46	0.83	0.81	0.51	0.39	0.12	0.35		
U	0.00	-0.04	0.08	0.03	0.12	-0.04	0.10	-0.05	-0.14	0.11	-0.11	
	0.94	0.33	0.04	0.50	0.00	0.33	0.01	0.23	0.00	0.01	0.01	
As	0.13	0.20	0.21	0.20	0.22	0.24	0.34	-0.02	0.09	0.09	0.01	0.09
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.68	0.02	0.02	0.77	0.02

Table 5.4 Pearson correlation coefficients (r) for elements in lake sediments (p-values appear directly below r-value). Bolded r-values represent $r > 0.30$ and statistically significant p-values < 0.05 . N = 649

5.1.4 Till

The maximum Mn concentration in till was 27,800 ppm and the minimum concentration was 100 ppm. The mean value for Mn concentration in till sediments was 2,064 ppm and

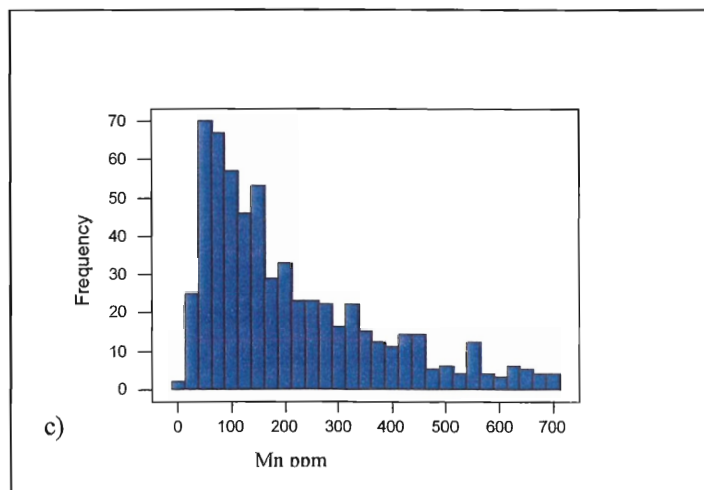
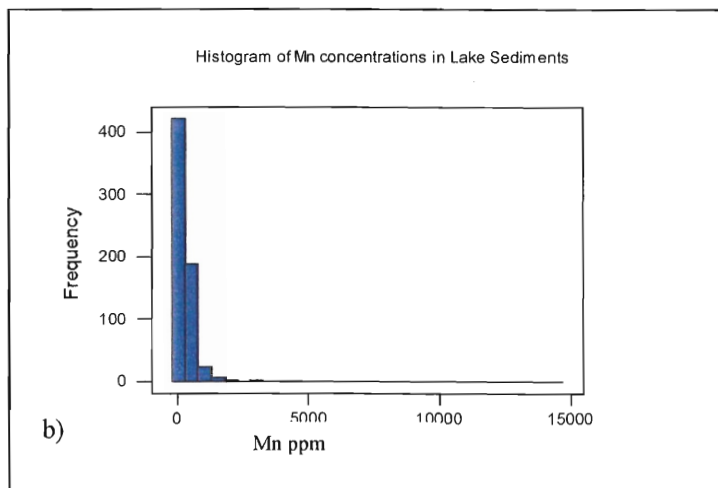
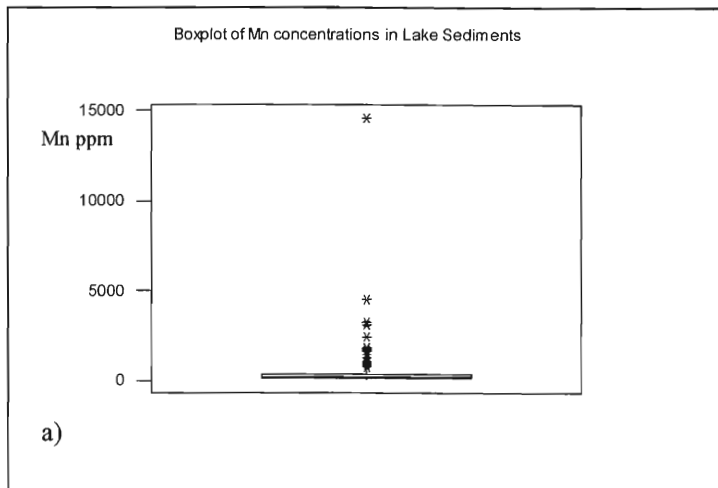


Figure 5.3 Boxplot and Histograms showing Mn concentrations in lake sediment a) boxplot b) histogram of all data c) histogram with outliers removed.

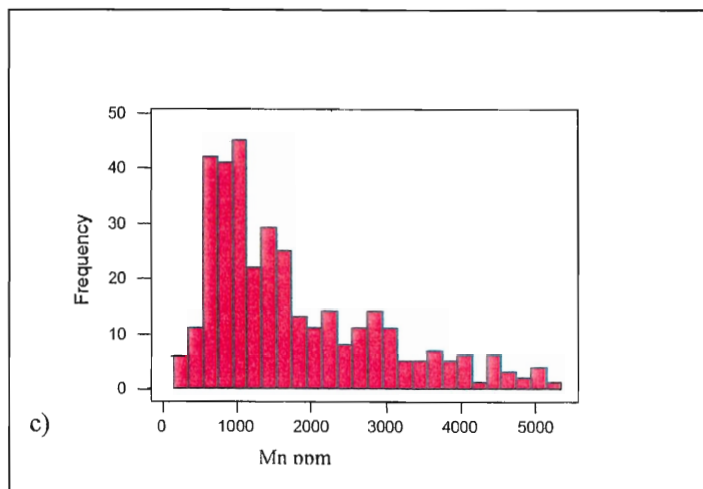
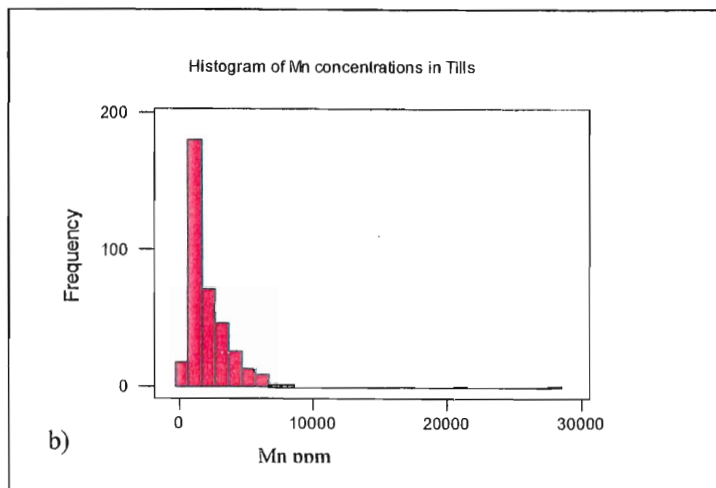
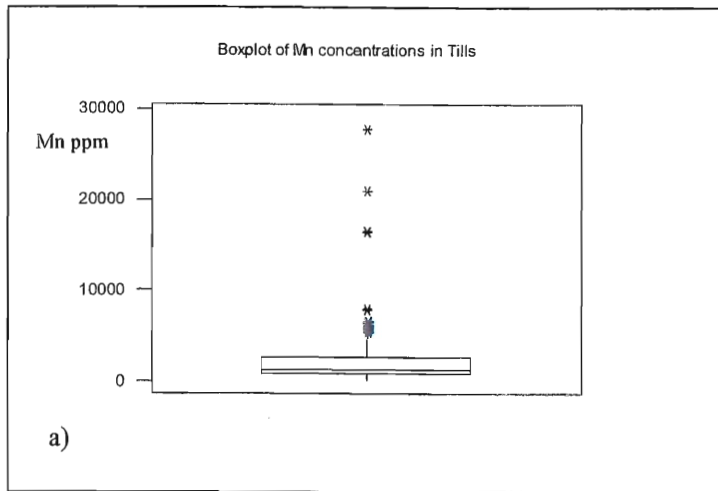


Figure 5.4 Boxplot and Histograms showing Mn concentrations in till a) boxplot b) histogram of all data c) histogram with outliers removed.

the median value was 1,380 ppm. Mean and median till values have very high Mn concentrations when compared to average soil values of 500-850ppm, and may affect the flora able to grow on the till. The histogram for till sediment data indicates that the data is strongly skewed to the right (Fig. 5.4). There are 18 data points forming the outliers on the boxplot. Mn concentration in the till was correlated against Pb, Zn, Ni, Co, Fe, Ca, Mg and U. Mn was positively correlated with Cu (0.63), Ni (0.54), and Pb (0.32) with a sample size of 385 samples (Table 5.5).

	Cu	Pb	Zn	Ni	Co	Fe	Mn	Ca	Mg
Pb	0.43								
	0.00								
Zn	0.27	0.54							
	0.00	0.00							
Ni	0.59	0.18	0.23						
	0.00	0.00	0.00						
Co	0.06	0.02	-0.02	0.06					
	0.30	0.71	0.75	0.23					
Fe	0.39	0.44	0.22	0.15	-0.02				
	0.00	0.00	0.00	0.01	0.72				
Mn	0.63	0.32	0.18	0.54	0.08	0.22			
	0.00	0.00	0.00	0.00	0.15	0.00			
Ca	-0.18	-0.19	-0.27	-0.11	-0.04	-0.26	-0.22		
	0.00	0.00	0.00	0.03	0.41	0.00	0.00		
Mg	0.23	0.04	0.25	0.20	0.01	-0.01	-0.01	0.32	
	0.00	0.50	0.00	0.00	0.91	0.92	0.79	0.00	
U	-0.14	-0.08	-0.08	-0.11	-0.02	-0.24	-0.15	0.06	-0.16
	0.01	0.13	0.12	0.05	0.66	0.00	0.00	0.24	0.00

Table 5.5 Pearson correlation coefficients (r) for elements in till (p-values appear directly below r-value). Bolded r-values represent $r > 0.30$ and statistically significant p-values < 0.05 . N = 385.

5.1.5. Correlations between data sets

Significant Mn correlations with $r > 0.30$ were compared for each of the 3 data sets (Table 5.6). Cu and Pb were only found to correlate > 0.321 with Mn in the till. Zn was only found to correlate with Mn in the lake sediment. Ni and As, however, showed some correlation with Mn both in lake sediment and in till. Co and Fe also both showed some correlation with Mn in both the surface water and the lake sediment. The highest correlation with Mn in both the surface water and the lake sediment. The highest correlation with Mn of elements computed was that of Cu in the till (0.634), followed by an association of Fe with Mn in lake sediment (0.594) and Ni with Mn in till (0.535). All other correlations were below 0.50.

5.1.6. Other Correlations

Table 5.7 summarizes correlations, which had r-values equal to, or exceeding 0.30 for all elements in the 3 media. There were no negative correlations (< -0.30) in any of the data sets.

	Surface Water (ppb)	Lake sediment (ppm)	Till (ppm)
Ba	0.321	-	-
Cu	0.085	0.20	0.634
Pb	-	0.11	0.324
Ni	0.157*	0.41	0.535
Zn	-	0.44	0.18
Co	0.41	0.42	-
Fe	0.32	0.594	0.223
As	-	0.338	0.34**

Table 5.6 Pearson correlations compared across data sets (all r-values statistically significant with p < 0.05). * Ni – Mn correlated with N = 252, ** Ar – Mn correlated with N = 272.

Surface water			Lake sediment			Till		
Element	Element	r	Element	Element	r	Element	Element	r
Na	K	0.71	Ni	Co	0.661	Cu	Ni	0.59
K	Mg	0.68	Ni	Zn	0.62	Pb	Zn	0.54
Ca	Mg	0.68	Zn	Fe	0.56	Pb	Fe	0.44
Na	Mg	0.62	Ni	Fe	0.55	Cu	Pb	0.428
Mg	Ba	0.61	Co	Fe	0.541	Cu	Fe	0.39
K	Ba	0.44	Cu	Ni	0.522	Ca	Mg	0.32
Ca	Ba	0.40	Zn	Co	0.503			
Na	Ba	0.34	Zn	Mg	0.451			
K	Ca	0.32	Ca	Mo	0.424			
Na	Ca	0.31	Cu	Co	0.415			
			Fe	Mg	0.406			
			Ni	Mg	0.404			
			Cu	Zn	0.40			
			Co	Mg	0.395			
			Cu	Mg	0.344			
			Cu	Fe	0.3			

Table 5.7 Correlations between all elements where r > 0.30, all have p-values < 0.05. For Mn correlations refer to Table 5.6.

5.3.0. MN CONCENTRATIONS BASED ON GEOLOGY GROUPS

5.3.1. Surface Water

Mean results for Mn in surface water with respect to geology were generated by two different methods. Using the extract method in IDRISI, the Windsor Group had the highest mean Mn value (108 ppb), followed by the Horton Group (96 ppb), the Halifax Group (70 ppb) and the Goldenville Group (56 ppb). Mean values for the Windsor and Horton were 112 ppb and 98 ppb respectively, while the Halifax Group and the Goldenville Group had mean values of 70 ppb and 56 ppb respectively (Table 5.9) (Data provided by Dr. Gwendy Hall). The maximum Mn values in decreasing order were 2,090 ppb for the Windsor Group, 1565 ppb for the Horton Group, 651 ppb for the Halifax Group and 421 ppb for the Goldenville Group. Table 5.10 ranks the Groups and the basis on their maximum and mean values. 127 sample points were within the study area but not within the Groups of interest and the results for these Groups are therefore not included.

	WINDSOR GROUP	HORTON GROUP	HALIFAX GROUP	GOLDENVILLE GROUP
Mean	108	96	70	56
N	226	106	108	146
Minimum	2	2	2	5
Maximum	2090	1565	651	421
Range	2088	1563	649	416
Std Dev	217	229	91	49

Table 5.8 Data computed by Extract on IDRISI (all units ppb except N)

	WINDSOR GROUP	HORTON GROUP	HALIFAX GROUP	GOLDENVILLE GROUP
Mean	112	98	70	56
N	268	105	108	149
Minimum	2	3	2	5
Maximum	2090	1565	651	421
Range	2088	1562	649	416
StDev	208	230	91	48

Table 5.9 Data computed using raw data (all units ppb except N)

	Mean	Max
Windsor Group	1	1
Horton Group	2	2
Halifax Group	3	3
Goldenville Group	4	4

Table 5.10 Rank of data, (surface water) from highest values to lowest (same results using raw data or extract method)

5.3.2. Lake sediment

Lake sediment comparisons to geology were obtained by using the IDRISI extraction method. This method was chosen because the data was not already categorized according to geology. The Windsor Group and the Horton Group had the highest mean concentrations of Mn at 566 ppm and 546 ppm, respectively (Table 5.11). The Halifax Group had the third highest mean of 354 ppm and the Goldenville Group the lowest at 240 ppm. The highest single value (maximum) of the four Groups did not follow the same pattern of the highest means. Instead the Goldenville Group had the highest single value out of the four Groups, followed by the Horton Group, the Windsor Group and the Halifax Group. 185 sample points were within the study area but not within the Groups of interest and the results for these Groups are therefore not included. The maximum value of the data set actually fell in the granitoid category with a high value 14,620 ppm.

	WINDSOR	HORTON	HALIFAX	GOLDENVILLE
	Group	Group	Group	Group
Mean	566	546	354	240
N	23	34	70	338
Minimum	102	118	18	4
Maximum	1754	2380	1280	4500
Range	1652	2262	1262	4496
Std Dev.	497	444	274	314

Table 5.11 Lake sediment data extracted by G.I.S. (all units ppm except N)

	Mean	Max
Windsor Group	1	3
Horton Group	2	2
Halifax Group	3	4
Goldenville Group	4	1

Table 5.12 Rank of data, (lake sediment) from highest values to lowest.

5.3.3. Till

Mn in the till appeared to be most highly concentrated in the Goldenville Group and Halifax Group with respective means of 2580.50 ppm and 2651.18 ppm (Table 5.13). The Windsor and Horton Group had lower mean Mn concentrations of 1496.45 ppm and 1460.48 ppm. The highest single concentration value of Mn was found in the Halifax Group with a concentration of 27,800 ppb. Table 5.14 shows the ranking of mean and maximum values for the till data. 185 sample points were within the study area but not within the Groups of interest and the results for these Groups are therefore not included.

	WINDSOR Group	HORTON Group	HALIFAX Group	GOLDENVILLE Group
Mean	1460	1496	2651	2581
N	52	62	55	121
Minimum	200	120	100	400
Maximum	8000	5400	27800	16380
Range	7800	5280	27700	15980
Std Dev	1503	1159	4914	2009

Table 5.13 Till data extracted by G.I.S. (all units ppm except N)

	Mean	Max
Windsor Group	4	3
Horton Group	3	4
Halifax Group	2	1
Goldenville Group	1	2

Table 5.14 Rank of data (till), from highest values to lowest.

5.4.0. SUMMARY

Mean values of surface water within the study area exceed the Guidelines for Canadian Drinking Water Quality. Surface water values were highest overlying the Carboniferous rocks. All outliers of lake sediment values, greatly exceed normal Mn values found in soils (500-800 ppm). Lake sediment values were also highest overlying the Carboniferous rocks. Median till values (1,380 ppm) are also substantially higher than Mn concentrations commonly found in soils (500-800 ppm). Till values were the highest overlying the Meguma Supergroup. Mn was also found to correlate positively with some metals (Ba, Cu, Pb, Ni, Zn, Co, Fe and, As) and may therefore have an influence on their transport in the environment.

CHAPTER 6

6.0.0. SUMMARY

6.1.0. CONCLUSIONS

1. Elevated Mn levels in drinking water are unlikely to cause toxic human health effects in any region (Chapter 2).
2. The mean Mn concentration of surface water (88.8 ppb) within the study area exceeds the acceptable Canadian limits for drinking water ($0.05\text{mg/L} = 5\text{ppb}$). Some areas have exceptionally high Mn concentrations (up to 2,089.8 ppb) (Chapter 4/5).
3. Mn concentrations in surface waters in Nova Scotia are problematic aesthetically, and could be costly to residents if used as a potable water supply (Chapter 4/5).
4. Mn in the 3 different media examined showed positive correlations to other heavy metals such as Co, Fe, Ni, Zn, Fe, As, Cu, Pb. Secondary Mn minerals may therefore exert a control on the transport of other metals in the environment (Chapter 5).
5. The surface water values overlying the Carboniferous rocks in the study area had significantly higher Mn values than the surface water values overlying the Meguma rocks (Chapter 5).
6. Mn concentrations of till overlying the Meguma rocks in the study area had significantly higher Mn values than the till values overlying the Carboniferous rocks (Chapter 5).
7. The lake sediment values overlying the Carboniferous rocks in the study area were enriched in Mn concentration compared to the lake sediment values overlying the Meguma rocks (Chapter 5).
8. It appears the Mn from the Carboniferous rocks enters more readily into surface water and lake sediments, while Mn from the Meguma rocks enters more readily into till (Chapter 5).
9. The Mn in the Carboniferous rocks appears as mineral oxide coatings while the Mn in the Meguma Supergroup occurs in minerals such as garnet, and ilmenite. Therefore, the accessibility of the Mn to the environment may depend upon the solubility of the mineral (Chapter 3).

6.2.0. RECOMMENDATIONS:

- 1) This study should be expanded to look at different sources of Mn in the environment including ground water, air, and soil, in order to achieve an increased understanding of Mn cycling in the environment.
- 2) Further research is recommended on the potential of secondary Mn minerals to control the distribution of other metals in the environment.
- 3) Mn values from this study should be compared with till, water and lake sediment values of other areas in Canada.
- 4) More in-depth analysis using G.I.S. would be beneficial, especially the use of interpolation modules, which could infer Mn concentrations in the different media over the entire study area.
- 5) An investigative study into the amount of Mn in the air in Nova Scotia would be beneficial because the most toxic pathway of Mn to humans is via inhalation. With widespread use of MMT in fuels in Canada, it is important to monitor the increasing abundance of Mn in the air.

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APPENDIX A: LAKE SEDIMENT DATA

TEMP_	NUMBER	MN_ZONE	MN_EAST	MN_NORTH	Cu	Ni	Pb	Zn	Co	Fe	Mn	Ca	Mg	Mo	Hg	U	As
223	97	20	417090	4975690	7.40	9.60	2.00	58.00	1.00	0.68	124.00	3800.00	1760.00	2.80	0.16	1.70	2.40
224	98	20	419200	4979280	14.80	18.20	10.00	92.00	9.60	2.46	322.00	5180.00	3440.00	2.80	0.20	3.90	3.20
225	99	20	420900	4973200	5.60	1.00	2.00	26.00	1.00	0.18	70.00	6760.00	880.00	2.80	0.16	1.90	0.50
226	100	20	398990	4982240	12.80	20.60	2.00	210.00	2.00	0.56	196.00	2140.00	600.00	2.80	0.12	1.50	2.20
229	104	20	387630	4981040	4.60	9.60	2.00	44.00	1.00	0.26	60.00	4440.00	420.00	2.80	0.28	2.10	1.00
230	105	20	385220	4983440	9.60	44.20	2.00	112.00	14.00	1.58	214.00	1340.00	3200.00	2.80	0.20	2.60	5.20
231	107	20	385680	4981500	15.80	10.00	2.00	68.00	10.20	1.50	178.00	2240.00	2140.00	3.60	0.28	2.10	1.80
241	2	20	501950	4952850	6.00	5.40	8.40	16.00	1.00	0.40	140.00	2400.00	600.00	3.20	5.10	1.00	0.50
242	3	20	502280	4954920	10.00	32.40	16.00	78.00	12.80	2.20	1280.00	560.00	3200.00	3.60	0.64	3.30	2.80
243	4	20	511950	4954910	4.00	5.40	11.20	38.00	6.40	1.00	720.00	1900.00	1120.00	2.80	5.02	1.90	2.60
244	5	20	513000	4952390	14.00	10.80	14.00	70.00	6.40	0.80	200.00	2160.00	1000.00	3.60	0.80	1.90	1.00
245	7	20	518900	4953100	4.00	3.60	14.00	22.00	3.20	1.60	80.00	3840.00	4960.00	3.60	0.20	3.60	0.50
246	8	20	518420	4954340	18.00	3.60	11.20	34.00	3.20	0.20	120.00	3060.00	980.00	3.60	1.74	2.60	0.50
247	3	20	453250	4955000	18.00	14.80	102.00	76.00	4.60	0.34	122.00	3940.00	220.00	3.20	0.28	6.00	22.40
248	4	20	450850	4952900	12.00	18.20	4.00	120.00	6.40	1.30	308.00	1020.00	2980.00	3.20	0.16	2.80	1.80
249	5	20	453920	4949850	18.60	14.20	14.00	92.00	2.40	0.24	124.00	4640.00	520.00	3.20	0.40	2.10	0.50
250	6	20	459700	4950050	8.20	21.00	2.00	74.00	11.20	1.28	334.00	620.00	2540.00	3.20	0.01	2.60	1.20
251	7	20	458900	4948900	21.20	39.00	4.00	152.00	19.60	3.38	696.00	1080.00	1280.00	3.20	0.32	2.70	9.80
252	3	20	459060	4957080	17.40	9.60	24.00	102.00	34.60	4.94	4500.00	2020.00	1340.00	3.20	0.56	11.00	18.00
253	4	20	458620	4959780	10.20	6.80	14.00	74.00	1.00	0.34	150.00	2380.00	260.00	3.20	0.56	22.30	0.50
254	5	20	459200	4961820	10.60	9.60	4.00	46.00	1.00	0.32	76.00	1780.00	1040.00	3.20	0.16	16.70	1.00
255	6	20	459470	4964000	15.40	9.60	6.00	92.00	4.40	0.32	202.00	4020.00	380.00	3.20	0.48	16.90	2.00
256	7	20	459220	4966240	35.60	24.80	16.00	108.00	2.60	0.68	86.00	1280.00	1180.00	3.20	0.48	2.90	0.50
257	8	20	459100	4973750	27.00	28.80	38.00	140.00	13.40	2.92	502.00	1800.00	5280.00	3.20	0.76	3.50	150.00
258	9	20	455750	4972100	13.60	12.40	12.00	104.00	1.00	0.18	62.00	4440.00	540.00	3.20	0.12	1.40	1.00
259	10	20	456200	4969100	13.00	19.80	6.00	102.00	4.00	2.56	80.00	4200.00	540.00	3.20	0.32	2.80	3.00
260	11	20	455150	4968550	9.80	34.00	6.00	168.00	24.00	5.58	434.00	1820.00	2220.00	3.20	0.36	3.20	8.60
261	12	20	455000	4968400	15.80	32.80	4.00	140.00	21.00	5.16	536.00	1060.00	2840.00	3.20	0.12	2.70	4.40
262	13	20	453600	4968750	19.00	25.20	2.00	92.00	9.00	2.20	256.00	2340.00	840.00	3.20	0.16	2.70	1.80
263	14	20	451800	4965600	25.00	34.00	12.00	228.00	24.80	2.12	1252.00	2260.00	1740.00	3.20	0.16	6.90	30.00
264	15	20	449800	4963300	11.20	9.40	6.00	142.00	1.00	0.26	176.00	3100.00	1060.00	3.20	0.28	10.70	1.20
265	16	20	451300	4961650	18.20	20.40	24.00	166.00	17.00	2.46	694.00	2180.00	1840.00	3.20	0.20	3.20	34.00
266	17	20	452900	4963300	19.80	18.80	16.00	114.00	19.60	3.88	924.00	2140.00	1320.00	3.20	1.60	5.70	8.00
267	18	20	452950	4961850	30.40	90.60	10.00	48.00	79.80	5.36	562.00	1680.00	3400.00	3.20	0.12	10.90	22.60
268	20	20	454800	4961350	35.00	52.80	26.00	246.00	48.40	5.30	898.00	2020.00	740.00	3.20	0.12	17.30	8.80
269	22	20	454620	4963300	16.60	22.40	10.00	102.00	9.00	1.46	428.00	2020.00	1220.00	3.20	0.36	6.20	2.80

TEMP_	NUMBER	MN_ZONE	MN_EAST	MN_NORTH	Cu	Ni	Pb	Zn	Co	Fe	Mn	Ca	Mg	Mo	Hg	U	As
270	23	20	456550	4966230	20.40	20.60	10.00	92.00	9.40	1.20	266.00	6120.00	1460.00	3.20	0.12	2.20	3.40
271	24	20	455450	4964900	14.20	21.20	4.00	84.00	12.20	0.86	318.00	3720.00	1100.00	3.20	0.32	2.30	2.80
272	25	20	456600	4964050	14.40	9.80	8.00	44.00	1.00	0.46	128.00	1580.00	660.00	3.20	0.12	6.60	1.00
273	26	20	457450	4962000	12.80	3.20	6.00	30.00	1.00	0.02	34.00	1960.00	380.00	3.20	0.12	18.40	0.50
274	27	20	456600	4959900	6.20	2.40	2.00	42.00	1.00	0.02	60.00	2520.00	560.00	3.20	0.44	5.50	0.50
275	28	20	454800	4959350	15.00	3.80	2.00	44.00	1.00	0.16	116.00	5220.00	780.00	3.20	0.32	1.10	0.50
276	29	20	453200	4960050	18.60	11.20	10.00	98.00	1.00	0.14	82.00	4920.00	520.00	3.20	0.12	2.20	4.00
277	30	20	451750	4957550	13.00	10.60	10.00	102.00	2.00	0.52	230.00	3600.00	540.00	3.20	0.64	1.60	15.60
278	31	20	454200	4956800	18.20	10.40	16.00	140.00	13.60	3.22	1016.00	3360.00	1020.00	2.80	0.28	1.80	29.80
279	32	20	457400	4955700	28.40	13.20	10.00	144.00	11.80	2.30	570.00	3540.00	780.00	2.40	0.36	2.00	4.80
280	33	20	456850	4956750	23.80	8.20	2.00	62.00	1.00	0.50	150.00	3980.00	340.00	2.40	0.32	1.50	0.50
281	34	20	448700	4982150	10.20	14.00	4.00	62.00	2.40	0.54	104.00	2860.00	1460.00	2.80	0.20	1.30	0.50
282	35	20	447150	4979350	10.00	18.60	4.00	102.00	3.40	1.14	182.00	2140.00	2300.00	3.20	0.16	2.20	1.20
283	37	20	445150	4979300	13.60	9.40	2.00	54.00	1.00	0.54	88.00	3660.00	1100.00	2.80	0.28	1.50	1.20
284	38	20	444600	4979550	13.00	11.60	2.00	52.00	1.00	0.36	116.00	3980.00	1020.00	3.20	0.20	1.90	0.50
285	40	20	445650	4980800	13.60	13.40	4.00	82.00	3.00	0.58	152.00	4020.00	1360.00	2.80	0.32	2.10	4.40
286	42	20	443980	4982800	8.20	12.40	2.00	56.00	2.00	0.88	136.00	1680.00	2480.00	2.80	0.40	1.60	1.80
287	44	20	432850	4982500	20.20	23.00	8.00	110.00	8.40	1.36	458.00	3700.00	1880.00	2.80	0.40	2.50	5.00
288	45	20	434800	4981200	11.00	6.80	2.00	58.00	1.00	0.18	168.00	5040.00	600.00	2.80	0.36	1.40	2.00
289	46	20	432900	4980200	15.80	21.20	4.00	92.00	6.00	1.58	334.00	2240.00	2760.00	2.80	0.16	3.60	4.00
290	47	20	434400	4979500	14.80	15.80	4.00	86.00	2.80	1.04	140.00	3640.00	1900.00	2.80	0.20	2.40	5.00
291	48	20	436200	4980800	14.80	13.40	2.00	50.00	6.20	0.54	104.00	2900.00	360.00	2.80	0.01	2.20	0.50
292	49	20	438150	4980250	9.00	11.60	2.00	102.00	3.80	1.04	198.00	1200.00	2780.00	2.80	0.36	2.20	5.60
293	50	20	437000	4978730	19.00	13.80	10.00	96.00	3.20	0.80	772.00	2200.00	1640.00	2.80	0.56	3.40	3.00
294	51	20	438600	4977000	40.20	21.00	26.00	94.00	8.40	4.90	448.00	11680.00	3100.00	2.80	0.48	5.20	1.60
295	52	20	440250	4978350	17.80	20.20	4.00	94.00	3.00	0.78	112.00	1860.00	2160.00	2.80	0.16	3.50	1.40
296	53	20	445450	4977200	11.20	6.80	2.00	40.00	1.00	0.46	102.00	8260.00	740.00	2.80	0.28	1.50	0.50
297	54	20	449700	4977700	28.20	22.80	4.00	162.00	7.00	4.66	96.00	1480.00	1240.00	2.80	0.36	4.10	3.20
298	56	20	451100	4978700	19.00	13.40	2.00	64.00	7.00	4.68	466.00	14540.00	3060.00	4.00	0.20	4.80	1.20
299	57	20	455080	4979860	3.60	9.80	2.00	80.00	7.20	1.44	200.00	1100.00	1140.00	2.80	0.01	1.90	3.40
300	58	20	453550	4978090	13.20	26.60	6.00	136.00	20.40	2.78	452.00	1320.00	3360.00	2.80	0.16	3.10	3.60
301	59	20	449560	4974230	13.20	14.00	2.00	62.00	3.20	0.50	128.00	2540.00	840.00	2.40	0.36	2.00	0.50
302	60	20	450730	4972410	14.80	48.20	2.00	156.00	33.00	1.92	414.00	1060.00	3500.00	2.80	0.28	3.50	0.50
303	62	20	448900	4971930	12.40	9.80	2.00	48.00	2.60	0.70	108.00	1520.00	500.00	2.40	0.32	1.80	0.50
304	63	20	449320	4969590	32.60	18.60	12.00	108.00	7.20	0.60	166.00	5960.00	1020.00	2.40	0.36	8.20	0.50
305	64	20	447740	4968600	22.60	19.20	16.00	118.00	4.00	0.96	168.00	2680.00	960.00	2.40	0.28	2.50	0.50

TEMP_	NUMBER	MN_ZONE	MN_EAST	MN_NORTH	Cu	Ni	Pb	Zn	Co	Fe	Mn	Ca	Mg	Mo	Hg	U	As
306	65	20	447670	4970000	8.00	11.80	4.00	96.00	6.60	4.00	212.00	1320.00	2240.00	3.20	0.52	1.80	0.50
307	66	20	446260	4970640	9.80	14.40	4.00	60.00	1.00	0.60	86.00	1940.00	1220.00	3.20	0.44	1.80	0.50
308	67	20	442800	4969040	15.80	14.60	2.00	64.00	1.00	0.44	82.00	2920.00	720.00	3.20	0.48	1.50	0.50
309	68	20	441920	4967720	6.20	7.60	6.00	62.00	4.40	0.80	350.00	2360.00	1420.00	3.20	0.48	1.40	0.50
310	69	20	441260	4965860	11.40	7.00	2.00	36.00	1.00	0.34	82.00	3620.00	680.00	3.20	0.32	1.10	0.50
311	70	20	443250	4965780	9.80	18.00	2.00	78.00	5.20	0.96	262.00	2160.00	1660.00	3.20	0.20	1.70	0.50
312	72	20	444870	4967210	15.00	15.00	2.00	88.00	4.20	1.14	204.00	2300.00	1820.00	3.20	0.20	2.30	0.50
313	73	20	447430	4966660	7.20	13.60	2.00	66.00	6.60	1.14	206.00	1960.00	2620.00	3.20	0.28	2.20	0.50
314	74	20	445700	4965240	13.60	17.60	6.00	106.00	11.80	2.98	974.00	1960.00	2900.00	3.20	0.48	2.80	0.50
315	75	20	443340	4963630	12.40	25.80	2.00	142.00	14.00	1.80	434.00	2220.00	2920.00	3.20	0.28	2.40	0.50
316	76	20	441410	4962800	12.80	28.00	4.00	156.00	13.40	3.10	438.00	1540.00	3540.00	3.20	0.20	2.10	0.50
317	78	20	440720	4961080	19.00	21.00	4.00	100.00	7.40	3.06	142.00	1260.00	1800.00	3.60	0.56	2.20	0.50
318	79	20	444430	4962320	13.20	20.20	2.00	124.00	10.60	2.46	408.00	1660.00	1600.00	3.60	0.01	1.80	0.50
319	80	20	448200	4964370	21.60	45.80	8.00	108.00	32.40	2.72	626.00	1800.00	5560.00	3.60	0.01	4.60	0.50
320	82	20	448240	4961000	11.40	18.20	2.00	104.00	7.20	1.44	282.00	3420.00	3240.00	3.60	0.44	2.70	0.50
321	83	20	445900	4961350	15.00	17.80	4.00	90.00	7.20	1.46	346.00	3700.00	2020.00	3.60	0.20	2.40	1.20
322	85	20	445130	4960000	8.00	10.00	2.00	76.00	5.60	1.58	286.00	660.00	2940.00	3.20	0.16	1.90	0.50
323	86	20	447620	4957460	11.00	17.40	6.00	80.00	7.00	1.38	356.00	660.00	3500.00	3.20	0.01	4.60	0.50
324	87	20	447560	4959000	19.40	27.60	8.00	90.00	13.40	3.00	680.00	1700.00	6100.00	3.20	0.01	3.10	0.50
325	88	20	442570	4957960	11.20	11.00	4.00	40.00	5.00	0.76	156.00	1140.00	1420.00	3.20	0.20	1.70	0.50
327	90	20	439430	4956390	27.80	89.60	6.00	232.00	32.40	2.80	418.00	1140.00	2340.00	3.20	0.20	4.70	3.80
328	92	20	440450	4958500	17.20	27.60	8.00	148.00	17.40	2.80	454.00	1080.00	3240.00	3.20	0.12	2.30	4.00
329	93	20	438640	4959350	10.40	9.40	6.00	66.00	2.80	0.50	240.00	2280.00	2180.00	3.20	0.28	1.70	8.60
330	94	20	438780	4963790	18.60	12.00	8.00	56.00	2.40	0.36	156.00	2980.00	260.00	3.20	0.28	1.30	1.00
331	95	20	436870	4964020	8.80	5.80	2.00	34.00	1.00	0.20	62.00	1820.00	2160.00	3.20	0.16	0.60	0.50
332	96	20	437630	4965690	11.60	10.00	2.00	60.00	2.20	0.58	200.00	2860.00	960.00	3.20	0.01	1.50	1.20
333	97	20	438860	4966350	18.80	6.60	6.00	40.00	1.00	0.20	92.00	4080.00	160.00	3.20	0.32	1.00	0.50
334	98	20	439910	4967930	6.40	7.40	12.00	28.00	1.00	0.20	24.00	1700.00	960.00	3.20	0.16	0.50	1.80
335	99	20	440790	4971390	12.60	11.20	14.00	46.00	2.40	1.16	162.00	4520.00	2440.00	3.20	0.52	1.30	1.40
336	100	20	439600	4972580	15.20	22.20	12.00	96.00	7.40	2.86	444.00	1740.00	2440.00	3.20	0.16	2.10	4.40
337	102	20	440440	4974400	14.00	11.60	14.00	52.00	2.80	0.44	198.00	3900.00	2020.00	3.20	0.28	1.80	0.50
338	103	20	438460	4974470	8.80	15.20	14.00	80.00	7.00	2.02	254.00	940.00	2320.00	3.20	0.01	2.50	1.40
339	105	20	436460	4977290	12.60	10.20	12.00	60.00	3.80	0.62	232.00	2740.00	2520.00	2.80	0.20	2.00	1.80
340	106	20	435000	4977840	42.00	36.60	16.00	144.00	11.20	2.60	464.00	1940.00	6800.00	2.80	0.01	10.30	0.50
341	107	20	432910	4976790	14.40	7.00	14.00	42.00	1.00	0.06	96.00	4180.00	1140.00	2.80	0.28	2.00	1.80
342	108	20	431090	4977560	20.20	20.40	16.00	72.00	5.00	0.74	244.00	5960.00	2000.00	2.80	0.20	3.10	0.50

TEMP_	NUMBER	MN_ZONE	MN_EAST	MN_NORTH	Cu	Ni	Pb	Zn	Co	Fe	Mn	Ca	Mg	Mo	Hg	U	As
343	109	20	427200	4979260	15.00	27.00	16.00	98.00	6.80	2.26	722.00	1100.00	2300.00	2.80	0.16	2.70	0.50
344	110	20	426200	4978730	17.80	20.40	14.00	68.00	3.40	1.04	264.00	3160.00	1540.00	3.60	0.28	2.10	0.50
345	111	20	427430	4974440	13.60	19.60	14.00	56.00	1.00	0.98	188.00	760.00	2340.00	3.20	0.12	3.60	1.80
346	112	20	428810	4973640	24.80	22.40	18.00	128.00	6.40	1.00	334.00	3120.00	2940.00	3.20	0.32	4.30	5.40
347	113	20	430500	4975340	15.40	15.20	16.00	82.00	5.20	1.76	400.00	2500.00	3440.00	3.20	0.12	2.60	8.00
348	114	20	432300	4975390	16.40	13.00	18.00	68.00	9.40	2.02	710.00	2860.00	2360.00	3.20	0.28	1.80	9.40
349	116	20	435380	4974290	25.00	15.80	16.00	94.00	6.80	0.78	598.00	5740.00	700.00	3.20	0.32	3.60	11.20
350	117	20	435870	4972630	10.40	6.00	14.00	30.00	1.00	0.46	32.00	4700.00	160.00	3.20	0.20	1.10	0.50
351	118	20	433910	4972350	17.40	11.00	12.00	50.00	2.00	0.46	74.00	2220.00	960.00	3.20	0.44	2.00	0.50
352	119	20	433770	4971910	23.80	22.40	14.00	132.00	7.80	1.86	410.00	1920.00	3920.00	3.20	0.16	4.40	0.50
353	120	20	434350	4970000	16.80	7.00	14.00	60.00	1.00	0.74	96.00	6280.00	420.00	3.20	0.40	6.70	1.00
354	122	20	436040	4969870	10.80	18.00	14.00	98.00	9.20	1.22	468.00	1800.00	2660.00	3.20	0.16	1.50	0.50
355	123	20	435250	4968860	66.40	139.20	12.00	278.00	90.00	2.16	512.00	1680.00	6740.00	3.20	0.20	14.30	8.00
356	124	20	434620	4966180	11.20	17.80	14.00	90.00	11.00	1.10	268.00	2920.00	640.00	3.20	0.20	4.40	5.80
359	127	20	434200	4959830	6.60	10.00	14.00	104.00	3.00	0.92	208.00	1540.00	2180.00	3.20	0.48	3.60	0.50
360	128	20	436490	4960580	12.20	7.40	14.00	60.00	1.00	0.32	124.00	1620.00	340.00	3.20	0.56	1.20	0.50
361	129	20	436390	4959320	15.80	25.80	14.00	110.00	14.00	1.78	220.00	1420.00	2060.00	3.20	0.40	2.20	4.60
362	131	20	435950	4957650	9.00	5.00	16.00	46.00	1.00	0.14	72.00	1580.00	400.00	2.80	0.28	1.00	0.50
363	133	20	433433	4956440	11.00	11.20	14.00	52.00	1.00	0.50	84.00	1220.00	420.00	3.20	0.28	1.00	1.00
364	134	20	431900	4959270	11.80	10.20	12.00	88.00	9.00	2.22	850.00	2200.00	1660.00	3.60	0.28	5.50	0.50
373	144	20	430470	4972180	10.00	6.20	16.00	38.00	1.00	0.18	16.00	1260.00	120.00	2.80	0.40	1.00	0.50
399	175	20	422720	4972810	8.20	9.60	14.00	56.00	2.00	0.30	108.00	2780.00	1260.00	2.80	0.28	3.50	0.50
400	176	20	421120	4973420	6.40	2.00	12.00	42.00	1.00	0.26	90.00	5660.00	440.00	2.80	0.36	2.30	0.50
401	177	20	419350	4978850	18.00	20.20	12.00	92.00	8.80	2.96	358.00	4440.00	3060.00	2.80	0.32	3.60	1.60
402	2	20	473320	4980850	18.00	12.60	14.00	66.00	4.80	0.60	220.00	5940.00	1320.00	1.00	0.20	3.30	0.50
403	3	20	474320	4980230	12.00	18.00	11.20	58.00	4.80	1.00	240.00	16400.00	1300.00	6.40	0.01	2.80	0.50
404	4	20	474550	4974820	24.00	27.00	21.00	78.00	20.80	1.80	440.00	1620.00	1920.00	3.20	0.40	3.20	2.60
405	5	20	474850	4973170	24.00	27.00	21.00	78.00	19.20	2.00	440.00	1360.00	2180.00	3.60	0.44	3.50	2.80
406	6	20	475470	4971080	10.00	14.40	7.00	28.00	3.20	0.20	80.00	1560.00	1460.00	1.00	0.16	1.40	0.50
407	7	20	476480	4971000	10.00	16.20	8.40	32.00	1.00	0.20	60.00	1720.00	1300.00	1.00	0.20	1.80	0.50
408	8	20	474960	4969040	14.00	16.20	7.00	46.00	3.20	0.20	80.00	2060.00	760.00	1.00	0.16	2.10	1.00
409	9	20	477920	4968540	16.00	14.40	14.00	76.00	4.80	0.60	300.00	1720.00	340.00	2.80	0.01	16.70	4.40
410	11	20	477080	4972240	26.00	23.40	12.60	90.00	9.60	0.60	120.00	1840.00	1840.00	2.00	0.40	3.40	0.50
411	12	20	479580	4969770	12.00	10.80	7.00	64.00	4.80	0.20	120.00	3800.00	440.00	2.00	0.28	15.50	2.80
412	13	20	481810	4970970	12.00	7.20	5.60	20.00	1.00	0.20	80.00	2860.00	600.00	1.00	0.16	5.60	0.50
413	14	20	483000	4971860	18.00	9.00	5.60	24.00	1.00	0.20	40.00	2200.00	340.00	2.80	0.36	3.60	0.50

TEMP_	NUMBER	MN_ZONE	MN_EAST	MN_NORTH	Cu	Ni	Pb	Zn	Co	Fe	Mn	Ca	Mg	Mo	Hg	U	As
414	15	20	484670	4969080	10.00	9.00	7.00	24.00	1.00	0.40	100.00	2840.00	660.00	1.00	0.36	9.50	0.50
415	16	20	484790	4970210	10.00	9.00	8.40	56.00	3.20	0.60	160.00	2540.00	1000.00	1.00	0.40	13.20	1.20
416	17	20	485780	4970470	8.00	9.00	8.40	28.00	3.20	0.60	60.00	1920.00	680.00	1.00	0.20	5.10	0.50
417	18	20	484270	4973390	10.00	10.80	8.40	58.00	3.20	0.60	160.00	2360.00	1180.00	2.00	0.64	2.80	0.50
418	20	20	483530	4974760	24.00	25.20	22.40	102.00	8.00	1.20	420.00	6000.00	2000.00	3.20	0.48	4.10	2.60
419	23	20	485300	4976350	12.00	16.20	12.60	34.00	3.20	1.00	180.00	1640.00	1780.00	2.00	0.64	1.70	0.50
420	24	20	484400	4977100	8.00	16.20	8.40	32.00	3.20	0.80	180.00	1940.00	1720.00	1.00	1.12	2.30	0.50
421	25	20	476750	4981480	20.00	34.20	14.00	64.00	11.20	4.00	760.00	12580.00	1680.00	2.80	0.84	4.10	0.50
422	26	20	478780	4981540	48.00	39.60	25.20	52.00	14.40	5.00	620.00	16580.00	5100.00	1.00	0.16	3.30	0.50
423	27	20	478160	4980000	28.00	34.20	14.00	64.00	4.80	2.00	180.00	9660.00	1660.00	1.00	0.16	3.50	0.50
424	28	20	478840	4979780	26.00	30.60	19.60	64.00	9.60	2.20	300.00	2760.00	4600.00	1.00	0.01	3.30	1.80
425	29	20	481800	4982430	16.00	19.80	9.80	54.00	3.20	0.80	220.00	3820.00	1800.00	1.00	0.32	2.50	0.50
426	30	20	484400	4978880	12.00	21.60	12.60	40.00	3.20	1.40	800.00	45800.00	1460.00	27.20	0.01	4.00	0.50
427	31	20	485880	4978100	18.00	16.20	12.60	46.00	4.80	0.80	140.00	3720.00	1680.00	1.00	0.12	2.40	0.50
428	32	20	487960	4977760	16.00	21.60	15.40	40.00	6.40	1.00	280.00	2620.00	2420.00	1.00	0.16	2.50	0.50
429	33	20	488620	4978790	12.00	16.20	7.00	26.00	4.80	0.80	120.00	2580.00	1160.00	1.00	0.12	2.30	1.00
430	34	20	491140	4979310	42.00	34.20	14.00	86.00	11.20	1.20	380.00	2000.00	2820.00	1.00	0.01	5.60	1.80
431	36	20	489610	4974950	22.00	18.00	12.60	32.00	4.80	0.80	120.00	1760.00	1300.00	2.00	0.16	1.70	0.50
432	37	20	491530	4974600	24.00	23.40	8.40	54.00	6.40	0.40	80.00	2380.00	1060.00	1.00	0.16	1.70	0.50
433	38	20	491940	4973100	26.00	21.60	7.00	54.00	6.40	0.40	80.00	2600.00	980.00	1.00	0.16	1.70	0.50
434	39	20	493280	4973910	70.00	19.80	12.60	64.00	6.40	1.00	80.00	880.00	660.00	2.80	0.16	2.20	0.50
435	40	20	493510	4972590	28.00	16.20	7.00	22.00	3.20	0.40	60.00	800.00	680.00	2.40	0.16	1.60	0.50
436	42	20	495150	4972470	36.00	21.60	12.60	62.00	4.80	0.60	120.00	1060.00	1460.00	3.60	0.28	2.20	0.50
437	43	20	493500	4971070	24.00	16.20	14.00	68.00	9.60	1.40	200.00	1240.00	1500.00	1.00	0.12	1.80	0.50
438	44	20	495530	4970070	18.00	18.00	7.00	28.00	3.20	0.20	80.00	1600.00	860.00	1.00	0.01	1.10	0.50
439	45	20	496890	4970000	24.00	9.00	8.40	78.00	6.40	1.00	80.00	1960.00	700.00	4.00	0.01	2.00	0.50
440	46	20	495480	4968290	18.00	10.80	7.00	24.00	3.20	0.60	60.00	1760.00	740.00	1.00	0.28	1.00	0.50
441	47	20	496830	4967150	12.00	9.00	5.60	36.00	3.20	0.60	60.00	1760.00	800.00	1.00	0.01	0.70	0.50
442	48	20	496830	4965430	12.00	16.20	5.60	16.00	1.00	0.40	60.00	1820.00	560.00	1.00	0.01	1.10	0.50
443	50	20	495980	4965060	18.00	12.60	8.40	56.00	6.40	0.60	140.00	1580.00	960.00	2.80	0.01	3.70	3.60
444	51	20	495230	4963670	20.00	12.60	7.00	94.00	8.00	0.40	260.00	2760.00	1300.00	3.20	0.01	87.80	4.40
445	52	20	497510	4963660	12.00	10.80	7.00	24.00	3.20	0.20	40.00	2080.00	560.00	1.00	0.20	6.50	0.50
446	53	20	499700	4965350	16.00	10.80	7.00	34.00	4.80	0.20	40.00	1820.00	680.00	3.20	0.16	0.90	3.60
447	54	20	487550	4976400	42.00	14.40	12.60	38.00	4.80	0.20	60.00	1960.00	920.00	2.80	0.56	2.60	0.50
448	55	20	488000	4972500	8.00	10.80	5.60	38.00	4.80	1.20	60.00	1920.00	500.00	2.00	0.28	0.70	0.50
449	56	20	488400	4970900	6.00	16.20	7.00	82.00	8.00	0.20	280.00	720.00	3020.00	1.00	0.01	3.10	0.50

TEMP_	NUMBER	MN_ZONE	MN_EAST	MN_NORTH	Cu	Ni	Pb	Zn	Co	Fe	Mn	Ca	Mg	Mo	Hg	U	As
450	57	20	488300	4968250	10.00	9.00	5.60	22.00	3.20	0.20	80.00	1420.00	720.00	1.00	0.01	5.70	0.50
451	58	20	490400	4968150	10.00	10.80	5.60	32.00	3.20	0.20	80.00	2360.00	900.00	1.00	0.20	7.80	0.50
452	59	20	493200	4969000	14.00	10.80	5.60	22.00	4.80	0.20	80.00	1560.00	980.00	1.00	0.20	0.90	0.50
453	60	20	493900	4966900	16.00	10.80	7.00	32.00	4.80	1.00	100.00	1700.00	780.00	1.00	0.20	1.30	0.50
454	62	20	491500	4966150	18.00	10.80	8.40	44.00	6.40	0.60	120.00	1420.00	1100.00	1.00	0.28	5.50	1.40
455	63	20	492500	4965300	16.00	9.00	11.20	24.00	4.80	0.60	100.00	1500.00	800.00	1.00	0.32	6.80	0.50
456	64	20	493200	4964200	14.00	5.40	7.00	32.00	4.80	0.40	120.00	1800.00	620.00	1.00	0.28	17.70	1.40
457	65	20	489600	4964200	18.00	5.40	8.40	80.00	8.00	0.60	180.00	2380.00	660.00	2.00	0.28	28.60	3.00
458	66	20	489400	4965800	14.00	5.40	5.60	30.00	4.80	0.20	40.00	1080.00	320.00	1.00	0.40	9.50	0.50
459	67	20	487200	4967400	12.00	5.40	7.00	38.00	4.80	0.40	80.00	1620.00	360.00	1.00	0.20	8.50	0.50
460	69	20	485150	4966900	16.00	7.20	12.60	38.00	3.20	0.80	200.00	2060.00	460.00	1.00	0.28	16.60	4.80
461	71	20	486700	4965700	12.00	9.00	8.40	50.00	3.20	0.60	14620.00	680.00	36.40	0.16	19.60	4.20	-9.00
463	73	20	485100	4962700	14.00	9.00	21.00	68.00	6.40	0.40	240.00	1680.00	760.00	3.20	0.28	27.20	3.40
464	74	20	487000	4962000	14.00	25.20	7.00	70.00	17.60	2.00	1060.00	1600.00	4000.00	1.00	0.28	4.10	1.00
465	75	20	489300	4962300	8.00	9.00	12.60	50.00	6.40	0.40	180.00	1300.00	980.00	1.00	0.20	16.30	1.00
466	76	20	491470	4961100	8.00	3.60	5.60	16.00	3.20	0.20	20.00	960.00	240.00	1.00	0.16	14.00	0.50
467	77	20	492830	4960980	14.00	9.00	7.00	48.00	6.40	0.60	140.00	1040.00	2160.00	1.00	0.12	9.80	0.50
468	78	20	496080	4958910	12.00	7.20	7.00	34.00	3.20	0.20	600.00	2840.00	520.00	2.40	0.16	11.30	0.50
469	79	20	497660	4959970	16.00	10.80	11.20	62.00	4.80	0.40	140.00	1060.00	920.00	2.80	0.16	17.70	1.80
470	80	20	499650	4962180	18.00	9.00	9.80	26.00	3.20	0.20	100.00	3200.00	420.00	1.00	0.01	7.20	0.50
471	82	20	497500	4961520	26.00	9.00	12.60	56.00	4.80	0.60	120.00	2220.00	660.00	1.00	0.01	48.50	1.60
472	83	20	495430	4961000	16.00	9.00	9.80	34.00	3.20	0.60	100.00	1300.00	620.00	1.00	0.01	21.80	1.60
473	84	20	493430	4956000	24.00	14.40	12.60	66.00	9.60	1.00	160.00	2060.00	520.00	2.80	0.01	2.50	1.60
474	85	20	486040	4956380	18.00	16.20	8.40	68.00	8.00	0.80	380.00	2720.00	760.00	1.00	0.01	2.00	2.60
475	86	20	484900	4955160	18.00	16.20	7.00	74.00	8.00	0.80	220.00	1640.00	1340.00	1.00	0.01	4.50	7.40
476	87	20	484380	4957140	18.00	50.40	12.60	104.00	19.20	2.20	920.00	2080.00	2900.00	2.00	0.12	18.50	10.60
477	88	20	481760	4955320	8.00	9.00	14.00	40.00	4.80	0.20	200.00	1640.00	680.00	2.00	0.01	9.50	4.00
478	89	20	482350	4957550	14.00	16.20	12.60	82.00	11.20	1.00	300.00	1500.00	1120.00	2.00	0.01	20.50	18.80
479	91	20	480200	4959740	13.80	10.80	18.20	160.00	9.60	0.60	158.00	2060.00	300.00	3.20	0.01	40.70	6.00
480	92	20	481610	4959390	9.00	9.00	7.00	20.00	9.60	0.20	94.00	1580.00	400.00	1.00	0.56	14.00	4.40
481	93	20	483700	4959060	14.60	16.20	19.60	80.00	24.00	1.20	478.00	1920.00	1140.00	2.40	0.60	16.10	19.00
482	95	20	486040	4959350	8.60	12.40	14.00	80.00	19.20	0.60	286.00	1180.00	1620.00	2.00	0.56	17.30	9.20
483	96	20	483550	4962000	10.00	11.70	23.80	80.00	36.80	2.80	3240.00	1440.00	760.00	4.00	0.76	25.60	33.60
484	97	20	472100	4977500	23.00	23.80	19.60	80.00	28.80	1.80	84.00	3440.00	1540.00	2.00	0.98	2.70	2.60
485	98	20	472100	4975950	26.00	40.00	25.20	160.00	44.80	2.40	318.00	1000.00	2080.00	1.00	0.60	3.90	1.20
486	99	20	472700	4970800	13.60	23.90	23.80	60.00	32.00	1.60	236.00	1300.00	800.00	3.20	0.56	2.80	3.40

TEMP_	NUMBER	MN_ZONE	MN_EAST	MN_NORTH	Cu	Ni	Pb	Zn	Co	Fe	Mn	Ca	Mg	Mo	Hg	U	As
487	100	20	473800	4966000	9.80	8.10	7.00	20.00	12.80	0.20	34.00	780.00	540.00	2.80	0.80	2.30	0.50
488	102	20	476100	4965600	7.80	7.20	8.40	20.00	14.40	0.20	188.00	1300.00	480.00	4.40	0.12	8.70	1.00
489	103	20	478100	4966150	7.00	10.60	18.20	100.00	16.00	0.20	166.00	1820.00	400.00	2.00	0.16	43.90	4.00
490	104	20	480100	4968300	6.80	11.20	14.00	80.00	19.20	0.20	142.00	2040.00	580.00	4.00	0.28	25.40	4.40
491	105	20	481100	4967400	9.00	7.20	8.40	20.00	8.00	0.20	28.00	1100.00	400.00	5.20	0.12	7.40	3.40
492	106	20	480000	4966000	6.00	6.80	8.40	60.00	12.80	0.20	296.00	1120.00	380.00	2.40	0.01	45.60	6.80
493	107	20	481600	4965700	9.60	7.20	14.00	40.00	9.60	0.20	30.00	800.00	340.00	4.00	0.44	11.50	1.80
494	108	20	479900	4963700	5.20	6.30	7.00	40.00	8.00	0.20	40.00	920.00	280.00	1.00	0.20	14.30	3.00
495	109	20	481340	4963230	15.00	9.90	9.80	220.00	14.40	0.20	150.00	2120.00	640.00	1.00	0.20	47.40	6.10
496	110	20	481140	4962000	5.00	5.90	12.60	40.00	8.00	0.20	34.00	1300.00	360.00	4.80	0.12	17.80	3.10
497	111	20	478820	4960760	9.60	8.30	8.40	40.00	11.20	0.20	48.00	1300.00	440.00	3.20	0.01	33.60	3.60
498	113	20	477100	4964500	6.00	5.40	7.00	40.00	16.00	0.20	22.00	900.00	260.00	1.00	0.01	19.20	0.50
499	114	20	474800	4962230	4.60	5.40	5.60	20.00	14.40	0.20	20.00	960.00	300.00	1.00	0.01	9.20	2.60
500	115	20	476300	4961360	4.60	6.50	14.00	40.00	20.80	0.20	204.00	1460.00	440.00	1.00	0.12	16.10	4.60
501	116	20	479950	4957920	6.00	7.20	12.60	20.00	14.40	0.20	126.00	1660.00	320.00	1.00	0.01	10.30	3.00
502	117	20	478200	4957400	2.00	6.30	8.40	40.00	14.40	0.40	198.00	1020.00	1800.00	1.00	0.12	4.20	3.30
503	118	20	476000	4958000	5.00	5.40	7.00	20.00	12.80	0.20	36.00	2480.00	500.00	1.00	0.01	17.00	1.10
504	119	20	474720	4958840	7.00	7.20	12.60	20.00	11.20	0.20	56.00	940.00	360.00	3.60	0.12	25.00	1.80
505	120	20	472800	4959300	11.00	4.50	8.40	20.00	12.80	0.20	94.00	3920.00	560.00	3.60	0.12	26.40	0.50
506	122	20	471370	4959510	11.20	15.30	19.60	40.00	17.60	0.60	288.00	2280.00	2840.00	2.40	0.12	5.10	0.50
507	124	20	472940	4961490	9.20	7.20	15.40	20.00	4.80	0.20	126.00	3780.00	500.00	2.40	0.36	13.30	1.40
508	125	20	472940	4963780	9.20	5.90	14.00	20.00	3.20	0.20	38.00	1140.00	400.00	2.00	0.20	10.40	1.00
509	126	20	471130	4964210	37.80	19.80	15.40	80.00	16.00	1.00	216.00	1020.00	4180.00	1.00	0.44	11.30	4.40
510	127	20	468420	4965850	22.00	10.80	14.00	40.00	8.00	0.20	4.00	1620.00	600.00	4.40	0.44	1.80	2.20
511	128	20	467500	4964790	22.00	26.10	21.00	100.00	22.40	1.60	384.00	1820.00	2540.00	5.20	0.48	4.40	1.20
512	129	20	465780	4961640	19.60	9.90	15.40	80.00	8.00	0.20	368.00	2580.00	1020.00	4.40	0.44	22.60	4.00
513	130	20	468120	4960940	9.80	14.40	14.00	40.00	8.00	0.20	90.00	2460.00	420.00	4.80	0.48	22.00	1.20
514	132	20	468610	4960260	8.00	10.80	14.00	20.00	4.80	0.20	42.00	2420.00	420.00	3.60	0.56	9.80	0.50
515	133	20	472350	4956550	12.40	14.20	15.40	20.00	6.40	0.20	72.00	1760.00	520.00	3.60	0.60	1.80	1.20
516	134	20	471370	4957290	18.00	16.20	26.60	40.00	12.80	0.80	140.00	1400.00	260.00	3.60	0.56	12.80	6.80
517	135	20	470830	4955740	12.00	24.30	22.40	40.00	22.40	1.40	244.00	9100.00	1380.00	4.80	0.52	10.90	15.80
518	136	20	469000	4955310	7.80	12.60	15.40	20.00	3.20	0.20	38.00	1540.00	240.00	2.40	0.52	10.30	2.20
519	137	20	468620	4957720	7.00	12.10	14.00	20.00	3.20	0.20	48.00	2260.00	420.00	2.40	0.52	10.80	0.50
520	138	20	466300	4959290	11.80	17.10	16.80	20.00	8.00	0.20	138.00	1940.00	680.00	2.40	0.48	8.40	2.20
521	140	20	465540	4957300	16.80	18.00	22.40	80.00	14.40	0.40	72.00	1080.00	400.00	3.20	0.40	61.50	3.20
522	142	20	466440	4955170	10.40	13.50	8.40	20.00	4.80	0.20	40.00	3040.00	360.00	1.00	0.44	2.30	0.50

TEMP_	NUMBER	MN_ZONE	MN_EAST	MN_NORTH	Cu	Ni	Pb	Zn	Co	Fe	Mn	Ca	Mg	Mo	Hg	U	As
523	143	20	464740	4955220	12.60	16.20	25.20	60.00	12.80	0.40	190.00	1600.00	1540.00	2.00	0.60	14.40	2.80
524	144	20	464220	4957280	9.00	14.40	15.40	10.00	8.00	0.20	32.00	1260.00	340.00	1.00	0.48	14.50	1.00
525	145	20	463780	4958520	6.40	13.10	15.40	10.00	4.80	0.20	82.00	1960.00	300.00	1.00	0.68	12.50	1.80
527	147	20	463860	4963140	17.00	19.80	18.20	40.00	9.60	0.20	124.00	1580.00	1580.00	2.80	0.52	2.60	2.80
528	148	20	466090	4964520	7.20	15.30	8.40	10.00	4.80	0.20	72.00	2120.00	480.00	3.20	0.60	0.80	1.00
529	149	20	465980	4965310	13.20	15.30	12.60	10.00	3.20	0.20	62.00	3480.00	480.00	1.00	0.60	1.10	1.00
530	150	20	463800	4965760	11.80	21.80	14.00	20.00	8.00	0.20	140.00	1920.00	1280.00	1.00	0.64	2.10	2.60
531	152	20	461820	4965230	40.00	18.00	14.00	20.00	9.60	0.20	94.00	2980.00	460.00	2.40	0.88	2.50	1.80
532	153	20	462220	4963120	13.40	9.00	14.00	10.00	3.20	0.20	52.00	3780.00	680.00	1.00	0.56	2.60	2.40
533	154	20	461880	4961360	5.80	5.40	8.40	10.00	8.00	0.20	38.00	1440.00	220.00	2.40	0.56	11.20	0.50
535	156	20	461100	4956960	18.00	10.80	22.40	60.00	27.20	1.20	558.00	1540.00	800.00	2.00	0.48	78.40	10.60
536	158	20	462220	4967770	14.20	9.00	14.00	10.00	11.20	0.20	76.00	2880.00	800.00	1.00	0.56	1.70	1.60
537	159	20	461870	4971230	13.80	8.10	14.00	20.00	14.40	0.40	88.00	1000.00	1680.00	5.60	0.56	3.00	3.60
538	160	20	463260	4972630	17.20	7.20	21.00	40.00	20.80	1.20	416.00	800.00	3560.00	6.00	0.44	3.20	3.60
539	162	20	462400	4973000	9.40	11.70	18.20	20.00	14.40	0.20	80.00	1620.00	840.00	6.80	0.88	5.30	2.80
540	163	20	462160	4974850	13.80	10.80	21.00	20.00	14.40	0.20	194.00	1360.00	1580.00	5.60	0.56	1.60	1.60
541	164	20	463230	4975780	17.40	17.30	21.00	20.00	14.40	0.20	96.00	6240.00	660.00	12.80	0.56	1.90	6.20
542	165	20	464050	4976960	15.20	16.20	18.20	40.00	11.20	0.20	130.00	6380.00	600.00	3.20	0.56	2.00	1.40
543	166	20	468670	4981620	12.80	18.00	16.80	20.00	12.80	0.20	70.00	3120.00	1320.00	3.20	0.56	2.30	0.50
544	167	20	466250	4967950	12.00	28.80	14.00	40.00	14.40	0.20	124.00	2400.00	1740.00	1.00	0.56	2.30	2.60
545	168	20	468400	4968340	17.80	12.60	12.60	10.00	11.20	0.20	88.00	6180.00	500.00	3.20	0.56	1.20	1.80
546	169	20	470300	4968750	14.00	18.50	14.00	10.00	14.40	0.20	64.00	2980.00	760.00	1.00	0.48	1.30	1.20
547	171	20	477650	4955490	26.80	10.80	2.00	58.00	2.40	0.58	196.00	3520.00	880.00	1.00	0.80	14.50	1.80
548	172	20	491900	4977700	10.80	10.00	12.00	244.00	3.20	3.06	478.00	3240.00	2520.00	9.20	1.28	8.10	3.60
549	173	20	493700	4978160	12.60	11.40	8.00	154.00	2.00	3.20	666.00	1040.00	2160.00	2.80	1.04	2.30	3.40
550	174	20	494830	4977760	27.80	38.40	4.00	108.00	2.60	0.58	132.00	6760.00	520.00	2.80	0.88	4.10	1.80
551	175	20	493680	4976080	8.20	14.20	10.00	74.00	2.70	0.62	320.00	6700.00	1920.00	7.20	0.88	1.90	2.20
552	176	20	497160	4973740	11.80	32.80	10.00	78.00	10.40	1.12	282.00	3600.00	2080.00	6.80	0.88	1.60	2.20
553	177	20	498260	4975660	9.00	15.40	2.00	108.00	7.00	0.76	288.00	4680.00	820.00	1.00	1.22	1.70	3.60
554	178	20	498490	4977000	8.40	14.00	6.00	138.00	1.00	1.16	350.00	4360.00	2060.00	1.00	1.16	3.10	4.40
555	179	20	497050	4979000	11.00	10.40	6.00	44.00	2.60	0.36	158.00	13000.00	840.00	2.00	1.12	1.90	1.40
556	180	20	495520	4979390	12.60	12.80	12.00	62.00	3.20	0.56	322.00	13000.00	1340.00	6.80	0.94	1.20	3.60
557	182	20	494160	4981090	21.00	15.60	2.00	58.00	5.40	0.70	198.00	1200.00	1740.00	1.00	0.56	1.70	1.00
558	184	20	496630	4981360	24.00	22.20	14.00	110.00	5.40	1.64	450.00	3140.00	1300.00	2.40	1.28	2.10	2.40
559	185	20	498100	4982060	13.80	11.80	6.00	58.00	2.40	0.74	202.00	6960.00	1380.00	4.00	0.84	2.00	0.50
560	186	20	499330	4982390	12.80	12.00	8.00	90.00	4.40	0.48	104.00	1480.00	1120.00	3.60	1.02	2.00	1.00

TEMP_	NUMBER	MN_ZONE	MN_EAST	MN_NORTH	Cu	Ni	Pb	Zn	Co	Fe	Mn	Ca	Mg	Mo	Hg	U	As
561	2	20	504440	4955340	35.40	67.80	19.60	272.00	49.30	3.80	1460.00	2760.00	680.00	4.80	1.28	2.90	14.00
562	3	20	504550	4956000	24.40	35.60	14.00	158.00	16.30	1.20	638.00	2060.00	600.00	1.00	1.24	1.50	0.50
563	4	20	502410	4956320	14.20	30.40	12.60	122.00	21.90	2.00	318.00	1800.00	1340.00	3.20	1.02	1.90	1.40
564	5	20	500890	4956590	14.20	15.60	47.60	88.00	21.20	1.60	544.00	1720.00	780.00	1.00	0.94	1.20	7.00
565	6	20	500800	4958300	33.40	14.80	12.60	98.00	5.40	0.40	122.00	3760.00	720.00	8.80	1.22	3.30	2.80
566	7	20	501460	4959520	11.80	11.60	8.40	42.00	4.00	0.20	110.00	2560.00	380.00	7.20	0.68	2.10	1.80
567	8	20	504700	4959180	2.00	8.60	7.00	38.00	4.60	0.40	164.00	580.00	820.00	2.00	0.16	1.50	6.00
568	9	20	507530	4956600	10.40	10.20	8.40	40.00	3.20	0.20	558.00	2680.00	680.00	4.00	0.84	1.60	1.20
569	10	20	507860	4955650	13.60	8.80	9.80	26.00	2.90	0.20	348.00	3200.00	520.00	4.00	0.80	1.90	1.20
570	11	20	507850	4955660	16.80	16.20	12.60	72.00	6.60	0.20	264.00	2780.00	380.00	6.00	1.24	2.00	1.20
571	12	20	508380	4956710	13.80	7.80	7.00	30.00	2.10	0.20	162.00	7820.00	720.00	4.00	0.80	1.60	0.50
572	13	20	511830	4956670	13.00	8.20	8.40	34.00	1.00	0.20	82.00	4420.00	580.00	4.00	0.76	1.60	2.80
573	14	20	510590	4959170	9.80	17.20	12.60	52.00	6.70	0.60	358.00	2200.00	1960.00	3.20	0.84	1.90	1.40
574	15	20	507870	4962480	13.00	7.60	12.60	58.00	2.20	0.20	144.00	1180.00	800.00	4.00	0.44	20.80	1.60
575	16	20	506890	4962650	11.20	5.80	9.80	36.00	1.00	0.20	74.00	2580.00	420.00	4.00	0.68	6.80	2.80
576	17	20	509900	4963600	13.20	8.60	15.40	42.00	3.00	1.20	344.00	2380.00	420.00	4.00	0.60	27.70	5.00
577	19	20	513840	4965850	7.60	2.20	11.20	20.00	1.00	0.20	26.00	1200.00	300.00	4.00	0.64	13.30	0.50
578	20	20	513700	4967280	8.20	7.00	8.40	34.00	1.00	0.20	52.00	940.00	600.00	1.00	0.28	13.50	7.00
579	22	20	515580	4967610	12.00	6.40	12.60	50.00	5.90	0.60	422.00	2180.00	420.00	4.00	0.40	16.80	6.00
580	23	20	516500	4965290	11.80	7.20	14.00	28.00	17.60	0.20	34.00	860.00	300.00	4.00	0.28	15.10	1.20
581	24	20	516300	4964180	4.20	2.60	7.00	16.00	1.00	0.20	36.00	1980.00	320.00	4.00	0.20	7.20	0.50
582	25	20	517930	4962910	11.20	6.80	12.60	20.00	2.10	0.20	240.00	1660.00	400.00	2.40	0.40	7.10	0.50
583	26	20	513550	4963730	5.00	4.60	7.00	16.00	1.00	0.20	30.00	1800.00	440.00	4.00	0.36	8.60	1.20
584	27	20	512090	4963600	7.60	3.80	8.40	18.00	6.60	0.20	54.00	2360.00	500.00	1.00	0.52	10.10	0.50
585	28	20	511470	4962540	18.40	5.80	12.60	24.00	17.60	0.20	130.00	1700.00	320.00	4.00	0.48	12.30	1.40
586	29	20	513450	4962180	39.00	6.40	12.60	58.00	2.10	0.20	104.00	1980.00	320.00	7.60	0.48	21.70	6.20
587	30	20	515600	4961480	17.60	11.80	15.40	66.00	6.10	0.20	150.00	1480.00	1280.00	4.00	0.01	12.70	4.00
588	31	20	516620	4960090	22.00	13.50	14.00	74.00	6.70	0.40	160.00	1780.00	980.00	1.00	0.76	3.30	0.50
589	32	20	517200	4960600	78.00	21.80	12.60	88.00	11.50	0.80	278.00	1380.00	2840.00	1.00	0.44	10.00	4.00
590	33	20	517580	4959500	14.60	7.90	11.20	22.00	1.00	0.20	62.00	2700.00	500.00	4.00	0.48	1.50	0.50
591	34	20	520200	4962170	20.00	9.20	8.40	20.00	1.00	0.20	44.00	1400.00	620.00	3.20	0.40	1.40	1.20
592	37	20	520060	4964560	12.00	8.10	12.60	30.00	1.00	0.20	60.00	1420.00	500.00	4.00	0.92	10.90	0.50
593	38	20	520000	4966000	6.20	4.70	12.60	24.00	1.00	0.20	50.00	2460.00	420.00	3.60	0.52	11.00	0.50
594	39	20	518700	4966830	5.40	3.60	7.00	20.00	1.00	0.20	48.00	1000.00	540.00	1.00	0.01	7.20	0.50
595	40	20	518400	4968270	14.40	19.30	16.80	106.00	14.70	1.00	326.00	1180.00	1320.00	4.00	0.98	12.60	2.00
596	42	20	500150	4980800	12.80	11.70	21.00	44.00	3.70	0.20	140.00	740.00	620.00	3.60	0.44	1.70	1.40

TEMP_	NUMBER	MN_ZONE	MN_EAST	MN_NORTH	Cu	Ni	Pb	Zn	Co	Fe	Mn	Ca	Mg	Mo	Hg	U	As
597	43	20	503250	4981850	15.40	39.40	18.20	122.00	23.80	2.40	498.00	3040.00	2000.00	6.80	0.60	2.50	2.60
598	44	20	504450	4981800	6.20	15.10	12.60	42.00	5.40	0.20	208.00	1500.00	2500.00	6.40	0.48	1.70	2.60
599	45	20	505850	4982320	16.00	25.20	12.60	128.00	13.10	2.20	328.00	1020.00	2220.00	4.00	0.94	2.70	4.00
600	46	20	508050	4981950	9.60	6.70	11.20	18.00	2.10	0.20	106.00	2280.00	600.00	3.60	0.84	2.90	3.00
601	47	20	511450	4980650	11.00	11.70	12.60	36.00	3.00	0.20	132.00	1520.00	1360.00	3.60	0.48	1.70	1.20
602	48	20	513400	4981200	8.00	13.10	12.60	48.00	6.10	0.20	118.00	1220.00	1680.00	4.00	0.68	0.90	1.60
603	49	20	516150	4980850	7.80	6.80	8.40	24.00	2.60	0.20	100.00	1760.00	700.00	4.00	0.48	2.00	2.00
604	50	20	522050	4982150	7.00	4.00	7.00	14.00	1.00	0.20	38.00	1820.00	520.00	1.00	0.48	2.70	5.40
605	52	20	524400	4982000	17.20	16.60	5.60	28.00	4.60	0.20	80.00	1360.00	1360.00	1.00	0.72	0.90	0.50
606	53	20	526980	4982650	5.60	7.00	5.60	14.00	2.40	0.20	54.00	1680.00	1080.00	3.60	0.52	1.20	0.50
607	54	20	527900	4982350	16.40	16.20	7.00	34.00	5.00	0.20	86.00	1600.00	1500.00	3.20	0.44	1.60	32.00
608	55	20	529580	4982700	6.80	8.30	7.00	22.00	3.80	0.40	108.00	2000.00	1260.00	4.00	0.88	1.60	29.40
609	56	20	531650	4981600	13.40	11.00	9.80	32.00	1.00	0.20	108.00	4240.00	340.00	1.00	0.60	0.90	1.60
610	57	20	534350	4981350	10.30	8.60	8.40	24.00	1.00	0.20	48.00	2300.00	340.00	1.00	0.56	0.90	0.50
616	66	20	533350	4979250	12.60	10.80	5.60	40.00	4.50	0.20	272.00	4180.00	440.00	4.00	1.54	1.20	4.60
617	67	20	531800	4979900	18.00	11.70	7.00	34.00	2.40	0.20	70.00	2320.00	500.00	3.20	0.60	1.10	1.80
618	68	20	533450	4977100	24.60	7.90	8.40	30.00	2.10	0.20	56.00	2960.00	320.00	2.00	0.64	1.30	0.50
619	69	20	531050	4977450	7.00	8.00	8.40	36.00	3.20	0.20	144.00	1060.00	1900.00	2.00	0.32	1.80	1.80
620	70	20	524800	4979280	6.40	5.80	7.00	22.00	1.00	0.20	60.00	1760.00	480.00	2.00	0.60	0.90	1.40
621	71	20	526000	4978150	7.80	7.70	12.60	36.00	5.00	0.20	350.00	1940.00	800.00	2.00	0.94	2.20	2.80
622	73	20	527200	4976830	10.80	8.80	8.40	26.00	1.00	0.20	82.00	2160.00	500.00	2.00	0.28	1.00	0.50
623	74	20	528850	4977430	14.80	25.00	11.20	90.00	13.30	0.60	162.00	1600.00	1160.00	1.00	1.54	3.60	2.80
624	75	20	529000	4974700	8.20	7.20	8.40	26.00	1.00	0.20	66.00	1380.00	700.00	4.00	0.60	5.10	2.80
625	76	20	526400	4974330	11.60	10.90	12.60	62.00	7.80	0.20	122.00	1380.00	400.00	4.80	1.34	10.60	1.80
626	77	20	524950	4974900	10.00	4.90	7.00	18.00	1.00	0.20	34.00	1800.00	400.00	4.00	0.56	7.00	0.50
627	78	20	524480	4976430	6.80	4.30	5.60	14.00	1.00	0.20	38.00	1600.00	380.00	1.00	0.68	0.50	0.50
628	79	20	522450	4977250	8.40	10.10	5.60	22.00	1.00	0.20	40.00	1260.00	460.00	3.60	0.94	0.80	1.80
629	80	20	517650	4974800	7.60	4.90	7.00	14.00	1.00	0.20	98.00	1920.00	420.00	3.60	0.64	4.10	3.60
632	84	20	533000	4968400	8.20	5.00	7.00	20.00	1.00	0.20	40.00	1660.00	400.00	3.60	0.36	16.80	1.20
633	85	20	531080	4968970	8.60	5.60	11.20	28.00	1.00	0.20	32.00	1000.00	280.00	4.00	0.44	16.70	2.80
634	86	20	529180	4968160	7.00	5.80	5.60	24.00	1.00	0.20	50.00	1280.00	400.00	6.80	0.12	42.40	1.80
635	87	20	530650	4967100	21.40	12.40	8.40	48.00	8.70	0.20	58.00	1180.00	860.00	6.80	0.32	5.10	3.60
636	90	20	531300	4963750	6.00	5.40	5.60	18.00	1.00	0.20	26.00	2140.00	640.00	3.20	0.16	1.80	0.50
637	91	20	528680	4964700	8.80	4.90	1.00	46.00	3.80	0.18	42.00	880.00	780.00	3.60	0.76	0.90	1.20
638	92	20	527700	4964000	12.00	9.50	2.80	78.00	4.80	1.02	108.00	1340.00	420.00	3.60	0.72	1.10	7.20
639	93	20	527480	4961520	7.00	5.00	2.80	42.00	3.20	0.22	126.00	1900.00	540.00	4.00	0.32	1.00	6.00

TEMP_	NUMBER	MN_ZONE	MN_EAST	MN_NORTH	Cu	Ni	Pb	Zn	Co	Fe	Mn	Ca	Mg	Mo	Hg	U	As
640	94	20	525000	4957400	20.80	15.30	2.80	58.00	4.80	1.08	150.00	1880.00	1040.00	3.60	0.32	1.50	1.40
641	95	20	524500	4961180	15.60	20.20	8.40	82.00	4.80	0.66	174.00	4080.00	880.00	4.00	1.78	0.90	0.50
642	96	20	523620	4962540	15.40	11.80	1.00	34.00	3.20	0.88	268.00	4140.00	340.00	4.00	0.01	1.40	7.40
643	97	20	524400	4964000	14.80	21.60	1.00	78.00	4.80	1.20	62.00	980.00	780.00	4.40	0.28	1.70	2.00
644	98	20	522800	4963850	13.80	22.40	1.00	64.00	6.40	2.42	272.00	940.00	140.00	3.60	0.01	1.80	1.40
645	99	20	525100	4966460	8.60	17.40	2.80	50.00	6.40	2.14	652.00	1440.00	480.00	3.60	0.20	18.70	2.80
646	100	20	527430	4966280	13.40	23.60	2.80	72.00	6.40	2.16	248.00	1320.00	420.00	4.00	0.16	1.20	1.20
647	102	20	527000	4968430	13.80	35.40	4.20	86.00	6.40	4.50	3060.00	2180.00	360.00	8.80	0.20	28.70	7.00
648	103	20	528930	4970380	10.00	16.60	1.00	26.00	1.00	0.42	94.00	5180.00	500.00	4.00	0.32	17.30	1.20
649	104	20	531200	4970560	7.40	13.40	1.00	22.00	1.00	0.34	68.00	2600.00	300.00	2.40	0.16	21.00	0.50
650	105	20	533400	4970510	23.20	24.40	7.00	32.00	1.00	1.26	144.00	5600.00	640.00	3.20	0.28	6.10	1.80
651	106	20	532900	4971960	9.60	17.60	5.60	40.00	3.20	0.94	136.00	5180.00	840.00	4.00	0.16	48.70	2.60
652	107	20	531760	4972300	14.40	15.00	1.00	28.00	3.20	0.24	38.00	4200.00	560.00	10.40	0.16	33.90	1.60
653	109	20	531300	4974900	10.00	12.00	2.80	28.00	27.20	0.42	82.00	3300.00	500.00	2.40	0.16	1.20	3.80
654	110	20	528800	4972600	12.00	28.00	8.40	108.00	3.20	2.20	304.00	1080.00	2800.00	4.40	0.01	27.40	0.50
655	113	20	527330	4970830	6.40	18.60	4.20	32.00	4.80	0.70	176.00	2220.00	920.00	3.60	0.01	9.70	0.50
656	114	20	525200	4968700	6.20	16.00	4.20	32.00	1.00	0.30	64.00	1800.00	680.00	3.20	0.20	14.20	1.20
657	115	20	524700	4970800	6.60	21.00	2.80	60.00	3.20	0.58	130.00	1900.00	1060.00	6.00	0.01	15.10	0.50
658	116	20	524370	4973100	7.00	21.00	4.20	40.00	3.20	1.26	240.00	1480.00	2200.00	1.00	0.12	6.30	1.40
659	117	20	522380	4972950	16.20	21.80	4.20	50.00	1.00	0.82	870.00	2760.00	240.00	1.00	0.48	9.60	0.50
660	118	20	521100	4972360	16.00	28.00	7.00	82.00	27.20	0.72	330.00	2800.00	1240.00	2.00	0.16	5.60	3.80
661	119	20	522860	4970680	7.40	15.60	1.00	40.00	4.80	0.08	38.00	1460.00	220.00	3.60	0.12	12.80	1.20
662	120	20	521760	4968430	10.20	10.20	8.40	50.00	9.60	0.28	66.00	940.00	220.00	7.60	0.16	22.60	2.00
663	122	20	520570	4970550	12.20	33.60	8.00	98.00	3.20	0.30	406.00	860.00	3240.00	3.60	0.01	4.30	4.20
664	123	20	518100	4972380	8.00	16.00	8.00	26.00	3.20	0.94	100.00	1420.00	460.00	3.20	0.20	4.30	2.00
665	124	20	517840	4971000	4.20	16.80	8.00	42.00	3.20	0.84	148.00	620.00	500.00	4.40	0.16	7.70	2.80
666	125	20	516820	4970070	11.00	17.60	12.00	56.00	3.20	1.04	302.00	620.00	80.00	1.00	0.16	21.70	5.20
667	127	20	516200	4974000	10.40	26.60	12.00	38.00	4.80	2.38	572.00	1600.00	480.00	2.80	0.28	11.10	7.00
668	128	20	515600	4973150	16.80	22.80	12.00	62.00	6.40	0.86	88.00	1340.00	420.00	6.00	0.20	10.40	5.20
669	129	20	514000	4972440	10.60	21.80	10.00	26.00	3.20	0.76	154.00	2540.00	380.00	2.80	0.20	5.40	1.00
670	131	20	513470	4970300	9.80	37.00	16.00	118.00	6.40	4.38	838.00	7180.00	680.00	5.20	0.16	16.80	4.00
671	132	20	511000	4967670	9.60	15.60	12.00	42.00	3.20	0.62	120.00	1120.00	280.00	3.20	0.16	14.20	0.50
672	133	20	510440	4966250	10.80	16.00	8.00	34.00	3.20	0.46	134.00	1520.00	480.00	3.60	0.48	17.60	0.50
673	134	20	509000	4967090	7.60	16.00	8.00	22.00	1.00	0.24	88.00	2000.00	240.00	4.00	0.20	9.00	1.40
674	135	20	508850	4966300	10.60	8.60	8.00	106.00	1.00	1.84	432.00	740.00	1820.00	8.40	0.20	22.20	7.80
675	136	20	507520	4965470	12.80	16.80	12.00	40.00	3.20	0.56	134.00	1160.00	260.00	6.80	0.12	23.70	1.80

TEMP_	NUMBER	MN_ZONE	MN_EAST	MN_NORTH	Cu	Ni	Pb	Zn	Co	Fe	Mn	Ca	Mg	Mo	Hg	U	As
676	137	20	504840	4966280	8.00	26.20	16.00	70.00	3.20	1.28	360.00	2140.00	2660.00	2.40	0.01	3.30	5.20
677	138	20	503110	4964590	10.40	26.20	8.00	122.00	3.20	2.12	330.00	1880.00	2120.00	4.00	0.20	51.90	8.60
678	139	20	504220	4963570	23.80	38.80	16.00	146.00	4.80	5.26	3200.00	8900.00	700.00	11.60	0.16	47.70	56.00
679	140	20	504590	4962100	11.60	20.80	12.00	54.00	4.80	0.64	296.00	3100.00	1160.00	3.60	0.12	5.20	2.60
680	142	20	502600	4961980	24.80	51.00	22.00	168.00	25.60	3.86	1778.00	1280.00	1680.00	3.60	0.20	6.90	130.00
681	143	20	500200	4964300	16.80	19.60	12.00	46.00	4.80	0.54	112.00	3880.00	520.00	6.40	0.28	11.80	6.60
682	144	20	502800	4967930	13.60	20.80	8.00	58.00	6.40	0.44	104.00	2480.00	520.00	3.60	0.12	1.20	0.50
683	145	20	500900	4974200	15.40	17.20	12.00	48.00	6.40	0.32	106.00	3000.00	320.00	3.60	0.68	1.10	0.50
684	146	20	501800	4975000	12.40	28.00	12.00	70.00	9.60	1.32	402.00	1880.00	1860.00	2.40	0.20	2.10	24.20
685	147	20	503200	4978400	19.40	33.20	12.00	124.00	14.40	2.04	554.00	2280.00	720.00	3.60	0.01	2.20	10.00
686	148	20	504200	4977800	15.80	31.60	8.00	94.00	9.60	1.26	398.00	2200.00	1080.00	3.60	1.16	1.10	1.40
687	149	20	505000	4979000	13.20	26.00	8.00	50.00	8.00	1.22	216.00	3920.00	2040.00	3.20	0.28	1.40	21.60
688	150	20	508400	4979200	13.20	19.60	6.00	30.00	6.40	0.52	142.00	4820.00	1080.00	3.60	0.16	1.50	0.50
689	151	20	509300	4978150	21.20	18.40	16.00	62.00	3.20	0.96	150.00	2060.00	1860.00	3.60	0.28	1.80	1.60
690	153	20	510300	4977400	17.20	44.80	12.00	116.00	14.40	3.64	562.00	1660.00	3720.00	3.60	0.20	2.10	4.00
691	155	20	510800	4979330	13.40	23.40	8.00	30.00	3.20	0.72	132.00	2580.00	1520.00	1.00	0.20	1.60	2.00
692	156	20	512900	4975640	17.60	39.80	10.00	112.00	12.80	2.80	522.00	1600.00	1240.00	3.60	0.01	1.50	5.20
693	157	20	511000	4974700	14.60	41.60	8.00	86.00	9.60	5.06	1622.00	2400.00	760.00	3.60	1.16	1.10	5.40
694	158	20	510090	4975230	11.80	17.00	12.00	32.00	3.20	0.52	74.00	2520.00	460.00	4.00	0.28	1.20	2.60
695	159	20	507000	4977150	31.80	34.40	6.00	32.00	3.20	0.86	100.00	3380.00	700.00	5.20	0.20	2.30	7.00
696	160	20	510520	4970800	15.80	28.20	14.00	168.00	9.60	0.92	532.00	2620.00	580.00	5.60	0.01	6.50	17.00
697	162	20	510670	4971880	9.00	18.20	10.00	50.00	3.20	1.02	230.00	4180.00	460.00	4.00	0.01	6.50	26.40
698	163	20	509300	4972600	5.80	23.20	2.00	58.00	4.80	1.54	300.00	360.00	1400.00	4.00	0.20	1.90	1.40
699	164	20	508300	4970900	10.40	19.20	2.00	32.00	1.00	0.46	122.00	3020.00	480.00	4.00	0.16	1.20	0.50
700	166	20	506700	4970470	7.40	16.80	16.00	34.00	1.00	0.32	112.00	5060.00	320.00	5.20	0.12	0.70	1.40
701	167	20	505150	4968850	31.60	43.40	8.00	200.00	8.00	2.02	278.00	1720.00	2100.00	5.60	0.16	7.50	15.40
702	168	20	504000	4972150	14.20	26.60	8.00	104.00	6.40	0.98	170.00	2240.00	700.00	5.20	0.36	1.50	11.00
703	169	20	505250	4974460	17.00	22.40	12.00	50.00	3.20	0.54	104.00	2460.00	660.00	5.20	0.01	0.90	1.60
704	170	20	506250	4972750	10.20	21.60	6.00	78.00	4.80	1.48	1040.00	880.00	1900.00	5.60	0.20	2.30	0.50
910	2	20	500650	4992450	17.80	14.90	28.00	122.00	2.00	0.86	232.00	5000.00	780.00	4.40	0.44	3.50	0.50
911	3	20	501960	4992920	22.20	29.50	26.00	176.00	30.40	2.20	858.00	1400.00	2620.00	4.00	1.28	2.40	0.50
912	4	20	502260	4995570	18.00	25.00	12.00	114.00	16.60	3.68	896.00	1280.00	5200.00	1.00	0.44	4.30	2.60
913	5	20	505620	4995560	9.20	8.80	40.00	62.00	2.80	0.14	176.00	4620.00	4640.00	2.80	0.20	3.20	0.50
914	6	20	507060	4997020	44.00	46.40	20.00	144.00	24.60	3.50	892.00	1140.00	10260.00	2.00	0.01	4.70	7.00
915	8	20	508850	4997600	15.20	10.40	58.00	74.00	1.00	0.20	82.00	4340.00	600.00	1.00	0.40	1.80	1.80
916	9	20	508900	4999100	19.60	15.10	42.00	96.00	1.00	0.74	244.00	3660.00	760.00	6.00	0.16	1.90	0.50

TEMP_	NUMBER	MN_ZONE	MN_EAST	MN_NORTH	Cu	Ni	Pb	Zn	Co	Fe	Mn	Ca	Mg	Mo	Hg	U	As
917	10	20	510730	4999830	5.20	4.80	12.00	36.00	1.00	0.50	230.00	4220.00	740.00	2.00	0.28	1.00	1.60
918	11	20	509600	5001210	8.80	5.80	28.00	44.00	1.00	0.06	148.00	2180.00	280.00	1.00	0.44	1.30	4.20
919	12	20	510680	5001540	18.80	12.10	60.00	80.00	1.00	0.60	230.00	4040.00	440.00	1.00	0.32	1.70	8.00
920	13	20	510950	5004240	11.20	11.30	30.00	106.00	2.20	0.58	200.00	780.00	820.00	2.00	0.44	1.80	2.00
921	15	20	512810	5004200	4.60	5.00	1.00	36.00	1.00	0.18	12.00	1240.00	180.00	1.00	0.20	1.20	0.50
922	16	20	512870	5005790	3.00	4.50	6.00	34.00	1.00	0.36	170.00	1320.00	620.00	3.20	0.01	1.30	3.60
923	17	20	515580	5004610	13.20	15.10	4.00	64.00	5.20	0.70	88.00	1700.00	1740.00	6.00	0.32	1.60	0.50
924	18	20	515670	5006280	9.40	22.50	14.00	126.00	12.60	2.06	700.00	660.00	5060.00	1.00	0.16	3.10	3.20
925	19	20	517430	5005880	4.00	14.20	2.00	100.00	9.60	2.62	648.00	540.00	4060.00	1.00	0.01	1.70	3.00
926	20	20	515880	5008620	8.80	13.10	6.00	102.00	10.60	2.48	562.00	1420.00	2360.00	6.00	0.01	2.80	3.80
927	22	20	516230	5010000	6.20	4.70	2.00	74.00	1.00	0.22	90.00	3200.00	400.00	3.60	0.12	2.00	0.50
928	23	20	517430	5009930	5.80	3.20	2.00	42.00	1.00	0.20	66.00	2980.00	660.00	2.00	0.20	6.50	0.50
929	24	20	519580	5009910	5.40	4.90	10.00	104.00	1.00	0.14	26.00	1000.00	300.00	1.00	0.16	7.60	0.50
930	25	20	518560	5008450	4.00	2.90	1.00	116.00	1.00	0.12	28.00	2720.00	220.00	4.00	0.16	1.40	0.50
931	26	20	519680	5008000	11.00	7.20	6.00	54.00	1.00	0.44	230.00	1840.00	340.00	1.00	0.16	2.80	0.50
932	27	20	519750	5006870	6.80	6.30	2.00	34.00	1.00	0.14	48.00	920.00	540.00	1.00	0.32	1.00	0.50
933	28	20	520430	5004570	5.80	6.30	6.00	58.00	3.20	0.32	146.00	1120.00	620.00	1.00	0.28	0.80	1.60
934	29	20	521530	5005810	4.80	5.80	4.00	66.00	2.00	0.46	70.00	1180.00	500.00	3.20	0.12	2.30	1.60
935	30	20	521710	5008140	5.00	5.40	6.00	46.00	1.00	0.28	80.00	1460.00	500.00	1.00	0.16	3.10	0.50
936	31	20	523000	5009780	5.60	7.40	20.00	112.00	1.00	0.86	242.00	1040.00	1020.00	4.40	0.28	6.40	0.50
937	32	20	523760	5009660	11.60	14.40	28.00	100.00	9.40	1.78	352.00	1160.00	4360.00	1.00	0.12	3.00	1.40
938	33	20	524240	5008910	7.20	6.70	14.00	64.00	1.00	0.66	52.00	820.00	240.00	3.20	0.28	2.60	0.50
939	34	20	525740	5010000	5.00	6.30	18.00	52.00	1.00	0.44	122.00	380.00	400.00	3.20	0.16	7.20	1.20
940	35	20	526000	5008000	9.00	10.80	26.00	184.00	4.80	1.22	334.00	960.00	1780.00	3.20	0.20	10.30	1.20
941	36	20	526340	5006350	6.80	9.40	22.00	114.00	4.80	1.26	386.00	760.00	1220.00	3.20	0.12	6.90	1.00
942	37	20	524390	5006120	9.00	8.10	18.00	118.00	3.40	1.14	276.00	980.00	880.00	3.20	0.28	18.70	0.50
943	38	20	525460	5003630	6.80	16.00	16.00	124.00	4.00	1.14	306.00	900.00	1620.00	3.20	0.01	5.00	3.00
944	40	20	526470	5003290	6.80	14.60	22.00	138.00	5.80	1.22	378.00	820.00	2060.00	2.00	0.12	4.20	1.80
945	42	20	528140	5003600	11.00	10.10	8.00	52.00	1.00	0.42	88.00	2100.00	420.00	4.00	0.32	0.90	1.60
946	43	20	529170	5006070	7.60	5.90	8.00	56.00	1.00	0.30	64.00	1020.00	780.00	3.20	0.20	2.30	2.20
947	44	20	531480	5008670	5.60	4.70	14.00	58.00	1.00	0.30	84.00	1060.00	840.00	2.80	0.40	4.60	0.50
948	45	20	530730	5010440	8.00	8.80	6.00	40.00	3.00	0.16	58.00	1320.00	400.00	2.00	0.28	5.90	0.50
949	46	20	533270	5010160	11.20	9.50	14.00	76.00	1.00	0.20	136.00	1000.00	480.00	7.60	0.32	9.90	0.50
950	47	20	535630	5010050	5.40	4.10	2.00	66.00	1.00	0.42	52.00	760.00	560.00	1.00	0.40	6.70	0.50
954	51	20	532820	5006810	8.20	10.30	20.00	74.00	4.00	1.04	280.00	960.00	1460.00	1.00	0.20	4.50	1.20
959	58	20	533550	5004260	7.60	14.20	10.00	112.00	7.40	0.28	72.00	900.00	1760.00	2.40	0.48	0.80	1.80

TEMP_	NUMBER	MN_ZONE	MN_EAST	MN_NORTH	Cu	Ni	Pb	Zn	Co	Fe	Mn	Ca	Mg	Mo	Hg	U	As
960	59	20	531500	5002130	6.20	10.40	18.00	80.00	3.00	0.74	116.00	1000.00	2140.00	2.40	0.40	0.90	2.00
963	63	20	529250	5001510	30.00	40.30	18.00	148.00	25.80	4.70	1018.00	620.00	4420.00	3.20	0.20	4.50	4.80
964	64	20	526221	4998130	31.80	33.10	10.00	154.00	11.00	2.68	310.00	860.00	3040.00	3.20	0.32	4.90	2.80
965	65	20	526370	5001380	6.40	11.90	8.00	120.00	4.80	1.16	162.00	1000.00	2080.00	3.20	0.16	3.80	3.60
966	66	20	524140	5000750	8.40	6.70	2.00	32.00	1.00	0.08	30.00	1160.00	300.00	3.20	0.01	0.50	1.80
967	68	20	524460	5000150	15.80	19.80	6.00	140.00	8.60	3.14	236.00	1240.00	1160.00	3.20	0.28	1.80	0.50
968	69	20	523330	4998120	6.20	7.90	2.00	46.00	1.00	0.64	160.00	1020.00	700.00	3.20	0.20	1.80	1.80
969	70	20	521950	4998240	9.40	9.20	6.00	34.00	1.00	0.36	50.00	1380.00	300.00	3.20	0.16	0.70	1.20
970	71	20	520130	4997310	22.20	44.80	2.00	122.00	33.00	2.40	346.00	1020.00	1300.00	3.20	0.20	2.60	2.40
971	72	20	518220	4998700	6.00	7.40	2.00	26.00	2.80	1.28	100.00	2240.00	6600.00	3.20	0.52	1.50	0.50
972	73	20	520730	4999080	7.20	6.30	1.00	32.00	1.00	0.26	50.00	1140.00	400.00	3.20	0.20	0.50	1.20
973	74	20	521750	5001900	3.20	7.00	8.00	44.00	3.00	0.68	224.00	980.00	660.00	3.20	0.01	1.80	0.50
974	75	20	519950	5001770	7.40	4.00	1.00	26.00	1.00	0.14	38.00	760.00	160.00	3.20	0.32	1.00	1.40
975	76	20	517180	5002600	5.80	10.60	2.00	48.00	2.20	0.96	168.00	1460.00	2200.00	3.20	0.28	1.10	1.20
976	77	20	517310	5003630	7.20	9.20	6.00	88.00	6.80	1.58	430.00	900.00	720.00	3.20	0.40	0.90	1.40
977	79	20	514660	5001090	3.60	4.70	6.00	34.00	1.00	0.20	178.00	1360.00	480.00	3.20	0.20	0.60	0.50
978	80	20	515550	4996210	13.00	11.90	6.00	70.00	2.40	0.76	208.00	1720.00	2100.00	3.20	0.44	1.90	1.80
979	82	20	512850	4996250	29.60	2.70	1.00	48.00	1.00	0.20	86.00	2500.00	1500.00	3.20	0.44	0.10	0.50
980	83	20	522900	4995000	6.20	9.20	2.00	72.00	2.00	0.68	144.00	820.00	1980.00	3.20	0.28	1.40	0.50
981	84	20	524750	4995700	23.40	63.40	6.00	222.00	51.60	2.38	450.00	900.00	6600.00	3.20	0.01	4.50	3.40
982	86	20	526200	4994400	23.40	33.70	6.00	174.00	21.00	1.74	396.00	1340.00	5760.00	2.80	0.60	6.30	3.20
983	87	20	525450	4993350	14.80	18.70	4.00	122.00	6.00	1.94	224.00	1180.00	1920.00	3.20	0.32	1.70	1.60
984	88	20	523300	4992550	32.80	37.60	16.00	150.00	21.40	2.56	430.00	700.00	6360.00	3.20	0.48	3.60	6.40
985	89	20	520950	4992750	8.20	7.90	2.00	36.00	2.80	0.38	72.00	1660.00	1080.00	3.20	0.40	0.80	0.50
986	90	20	518280	4992500	94.00	56.20	18.00	146.00	21.20	2.40	240.00	1280.00	3300.00	3.20	0.28	6.80	7.80
987	91	20	516500	4992500	9.80	8.60	4.00	54.00	1.00	0.76	148.00	1320.00	1680.00	2.40	0.48	1.40	2.00
988	92	20	512850	4995050	18.20	24.80	14.00	142.00	17.80	5.70	630.00	1120.00	3600.00	4.40	1.18	3.00	0.50
989	93	20	516060	4989110	28.60	9.00	12.00	54.00	2.20	0.72	216.00	2620.00	1180.00	1.00	0.44	1.30	1.00
990	95	20	516500	4991000	10.20	6.20	8.00	38.00	1.00	0.40	106.00	2480.00	700.00	1.00	1.04	1.00	0.50
991	96	20	518350	4991330	18.00	13.40	20.00	42.00	1.00	1.16	314.00	7040.00	860.00	1.00	0.32	1.80	1.20
992	97	20	520100	4991080	12.60	5.20	4.00	26.00	1.00	0.50	96.00	2780.00	860.00	1.00	0.36	1.40	0.50
993	98	20	522300	4990300	9.80	7.00	14.00	38.00	1.00	0.84	158.00	1980.00	1760.00	1.00	0.16	1.30	3.80
994	99	20	527330	4993470	27.60	67.60	16.00	294.00	34.40	1.86	616.00	1760.00	3520.00	2.00	0.28	6.50	3.00
995	100	20	528370	4995050	7.00	5.60	2.00	38.00	1.00	0.50	144.00	1360.00	1060.00	2.00	1.22	2.50	1.00
996	102	20	528130	4996870	16.60	10.00	10.00	198.00	4.60	0.80	286.00	2380.00	1600.00	1.00	0.01	5.00	1.80
997	103	20	530730	4996800	16.20	11.40	4.00	82.00	2.80	0.80	170.00	2360.00	2200.00	2.00	0.28	1.90	0.50

TEMP_	NUMBER	MN_ZONE	MN_EAST	MN_NORTH	Cu	Ni	Pb	Zn	Co	Fe	Mn	Ca	Mg	Mo	Hg	U	As
998	104	20	532300	4995860	7.60	10.20	6.00	78.00	4.80	1.28	308.00	1340.00	880.00	2.80	0.01	0.60	1.40
999	105	20	533170	4995170	12.60	6.60	4.00	26.00	1.00	0.64	116.00	1440.00	1280.00	1.00	0.32	1.10	0.50
1004	110	20	533330	4991450	10.20	8.20	2.00	24.00	3.80	0.22	128.00	1480.00	260.00	4.00	0.01	1.70	0.50
1005	111	20	531750	4992650	24.00	14.80	8.00	146.00	10.00	1.36	568.00	2180.00	2020.00	3.60	0.01	3.70	5.00
1007	114	20	531320	4991650	12.40	9.00	8.00	44.00	2.20	0.44	102.00	1880.00	1700.00	3.20	0.32	1.20	0.50
1008	115	20	529150	4990950	13.80	5.20	2.00	22.00	1.00	0.32	132.00	4540.00	1080.00	3.20	0.16	1.10	1.20
1009	116	20	528650	4987500	5.00	10.60	2.00	64.00	9.60	1.66	244.00	580.00	4740.00	3.20	0.20	1.30	1.80
1010	117	20	533120	4987880	12.20	11.80	8.00	74.00	5.60	1.36	238.00	1000.00	2500.00	3.20	0.32	1.50	1.00
1011	118	20	534220	4986700	16.00	12.80	10.00	66.00	6.40	2.24	582.00	1160.00	2780.00	3.20	0.32	2.10	1.20
1019	129	20	531600	4985550	11.00	7.20	6.00	32.00	2.20	0.36	90.00	3780.00	800.00	2.40	0.16	1.00	0.50
1020	130	20	530200	4985240	10.20	7.40	12.00	28.00	1.00	0.12	72.00	3760.00	540.00	2.40	0.28	0.90	0.50
1021	131	20	528480	4983320	13.20	12.80	14.00	44.00	3.60	0.08	42.00	3240.00	500.00	2.40	0.32	1.80	3.60
1022	132	20	527350	4984000	12.00	6.40	6.00	24.00	1.00	0.22	56.00	2640.00	540.00	2.40	0.36	1.00	1.60
1023	133	20	526650	4985430	10.00	8.20	8.00	26.00	1.00	0.48	70.00	2060.00	500.00	2.40	0.20	0.70	2.60
1024	134	20	524950	4985330	9.60	3.40	2.00	24.00	1.00	0.08	42.00	2040.00	500.00	2.40	0.44	0.80	0.50
1025	135	20	522330	4986450	15.40	3.80	6.00	36.00	1.00	0.28	50.00	3040.00	600.00	2.40	0.40	0.80	2.80
1026	136	20	521100	4986420	20.20	8.20	6.00	56.00	1.00	0.38	34.00	1000.00	720.00	2.40	0.12	4.80	0.50
1027	137	20	523000	4987450	11.80	2.20	6.00	14.00	1.00	0.26	84.00	3440.00	940.00	2.40	0.16	0.70	0.50
1028	138	20	520300	4984500	8.20	7.80	10.00	32.00	2.40	0.72	176.00	1500.00	2680.00	2.40	0.48	3.50	0.50
1029	140	20	518500	4983880	7.60	5.80	10.00	52.00	2.80	0.82	226.00	1260.00	1240.00	2.40	0.16	9.50	3.00
1030	142	20	518200	4985900	5.40	6.00	2.00	36.00	2.80	0.74	208.00	1080.00	2820.00	2.40	0.20	2.80	4.20
1031	143	20	515400	4985300	16.00	13.20	12.00	100.00	3.00	0.80	70.00	1680.00	1340.00	2.40	0.28	1.90	1.60
1032	144	20	515900	4983550	19.60	4.80	8.00	24.00	1.00	0.12	84.00	2040.00	660.00	2.40	0.16	1.30	1.40
1033	146	20	514200	4983250	12.60	6.60	22.00	46.00	2.60	0.48	222.00	2220.00	1440.00	2.00	0.28	1.30	1.40
1034	147	20	513300	4985800	11.80	11.80	10.00	64.00	4.40	1.10	322.00	1160.00	3860.00	2.00	0.16	2.10	1.20
1035	148	20	512350	4986250	9.20	7.00	14.00	36.00	2.20	1.04	234.00	3780.00	1820.00	1.00	0.32	1.60	0.50
1036	149	20	512100	4984300	11.60	7.20	16.00	14.00	1.00	0.20	68.00	5480.00	780.00	1.00	0.20	1.20	1.80
1037	150	20	509800	4983900	13.00	5.00	10.00	28.00	1.00	0.22	130.00	3180.00	1000.00	1.00	0.20	1.50	1.30
1038	151	20	509400	4986400	17.20	6.60	14.00	22.00	3.00	0.48	196.00	2940.00	660.00	2.80	0.40	1.00	2.60
1039	152	20	506500	4984400	14.40	29.60	44.00	170.00	10.20	1.82	324.00	1500.00	1820.00	2.80	0.40	2.70	3.00
1040	153	20	504300	4984000	13.60	15.20	16.00	48.00	3.20	0.88	270.00	2220.00	2160.00	2.80	0.60	2.00	10.80
1041	154	20	502350	4983500	14.40	29.80	22.00	168.00	19.20	2.84	682.00	1560.00	3760.00	2.80	0.44	3.00	1.30
1042	156	20	500900	4983000	11.60	23.00	10.00	50.00	3.80	0.66	168.00	2560.00	1660.00	2.80	0.52	2.20	1.20
1043	157	20	502600	4986950	21.20	39.40	22.00	140.00	10.20	3.54	416.00	1260.00	3220.00	2.80	0.40	2.90	2.40
1044	158	20	502400	4988000	15.60	23.20	12.00	160.00	14.00	2.32	650.00	1700.00	2640.00	2.80	0.60	2.10	7.20
1045	159	20	504250	4986850	15.80	10.80	10.00	108.00	13.40	4.60	370.00	1460.00	2420.00	2.80	0.48	1.80	4.00

TEMP_	NUMBER	MN_ZONE	MN_EAST	MN_NORTH	Cu	Ni	Pb	Zn	Co	Fe	Mn	Ca	Mg	Mo	Hg	U	As
1046	160	20	505700	4986900	11.80	13.40	10.00	44.00	1.00	0.60	158.00	2180.00	1400.00	2.80	0.44	1.80	0.50
1047	162	20	506800	4987300	11.40	11.20	18.00	76.00	3.00	1.04	240.00	1060.00	2880.00	2.80	0.32	1.90	0.50
1048	163	20	509000	4988250	11.60	12.00	8.00	54.00	2.80	1.22	344.00	1140.00	3820.00	2.80	0.28	2.20	0.50
1049	164	20	511600	4989800	10.60	12.60	12.00	76.00	4.20	0.96	270.00	1100.00	2760.00	2.80	0.20	2.40	0.50
1050	165	20	512000	4988950	20.60	4.80	18.00	20.00	1.00	0.30	110.00	2200.00	1100.00	2.80	0.64	1.90	0.50
1051	166	20	514100	4988000	17.80	12.40	42.00	94.00	3.40	0.78	236.00	1560.00	2800.00	2.80	0.48	2.10	0.50
1052	168	20	513850	4989500	9.40	4.60	24.00	26.00	1.00	0.40	144.00	6580.00	1120.00	3.20	0.52	1.00	0.50
1053	169	20	509400	4994450	25.00	37.80	14.00	248.00	10.40	1.92	444.00	1160.00	4580.00	3.20	0.16	3.20	0.50
1054	170	20	510700	4993500	24.60	41.00	24.00	220.00	63.20	23.60	1082.00	580.00	1460.00	3.20	0.28	2.90	28.40
1055	171	20	506050	4991330	24.80	17.60	20.00	150.00	6.60	5.78	316.00	460.00	3860.00	3.20	0.52	3.90	2.20
1056	173	20	505550	4991800	30.60	19.60	22.00	154.00	7.60	1.78	268.00	1180.00	2340.00	3.20	0.48	2.60	1.20
1057	174	20	505400	4989800	15.20	13.80	22.00	42.00	3.40	0.42	106.00	2980.00	580.00	3.20	0.40	1.10	4.00
1058	175	20	504250	4988100	21.60	20.40	46.00	102.00	14.00	5.06	340.00	1220.00	2840.00	3.20	5.10	2.70	0.50
1059	2	20	475220	4986990	26.00	28.00	16.00	366.00	15.60	4.52	778.00	4280.00	4660.00	3.20	0.20	4.10	0.50
1060	3	20	476200	4985150	19.60	26.20	10.00	114.00	18.20	3.94	1754.00	7140.00	4340.00	2.80	0.20	4.50	2.60
1061	4	20	476280	4983000	27.60	34.20	4.00	134.00	12.40	3.62	1722.00	11180.00	2060.00	2.80	0.32	4.60	0.50
1062	5	20	479240	4983400	14.60	22.40	8.00	106.00	6.20	2.22	334.00	2620.00	3080.00	3.20	0.52	2.90	1.20
1063	7	20	480600	4983900	29.80	30.40	4.00	170.00	8.80	2.90	620.00	10140.00	2460.00	3.20	0.20	5.20	0.50
1064	8	20	490860	4985800	15.20	17.80	6.00	72.00	4.20	1.24	386.00	4480.00	2720.00	3.20	0.20	3.00	0.50
1065	9	20	495800	4987800	24.20	112.80	14.00	234.00	22.20	4.30	656.00	1040.00	2460.00	3.20	0.32	4.50	0.50
1066	10	20	496950	4988600	51.40	142.60	8.00	264.00	37.40	4.10	378.00	2540.00	2080.00	3.20	0.28	7.00	0.50
1067	11	20	499990	4992500	13.80	16.40	6.00	74.00	3.00	0.18	98.00	2780.00	540.00	3.20	0.72	2.50	0.50
1068	12	20	497400	4992100	20.60	24.80	4.00	94.00	4.80	1.30	262.00	4820.00	1080.00	3.20	0.44	3.20	0.50
1069	13	20	491200	4988350	15.60	20.60	4.00	102.00	4.80	1.00	440.00	4100.00	2080.00	3.20	0.48	2.20	0.50
1070	14	20	484350	4987000	12.60	18.00	12.00	96.00	9.40	2.50	540.00	1420.00	4300.00	3.20	0.44	3.70	2.20
1071	15	20	472100	4983680	20.40	22.00	14.00	130.00	8.40	3.16	1606.00	14080.00	4380.00	3.20	0.20	2.90	0.50
1072	16	20	473800	4986950	19.40	26.80	12.00	142.00	10.00	3.34	556.00	2700.00	3820.00	3.20	0.40	3.50	0.50
1073	17	20	499320	4986290	17.00	37.00	10.00	178.00	13.60	4.68	624.00	780.00	4240.00	3.20	0.20	4.70	0.50
1074	18	20	496500	4984550	20.60	13.80	10.00	82.00	3.20	0.92	178.00	940.00	3780.00	3.20	0.20	3.20	1.80
1075	2	20	424610	4984250	13.20	11.20	4.00	62.00	3.40	0.72	172.00	11100.00	900.00	3.60	0.40	2.70	2.40
1076	3	20	436250	4984000	20.00	14.00	4.00	60.00	3.80	0.70	198.00	4780.00	1040.00	3.60	0.44	4.30	7.60
1077	4	20	438400	4984850	3.60	10.20	2.00	62.00	3.80	0.68	174.00	1000.00	1980.00	3.60	0.40	1.20	1.00
1078	5	20	440360	4986440	13.20	18.40	2.00	110.00	5.00	0.98	290.00	2760.00	1080.00	3.60	0.52	1.30	3.60
1079	6	20	440100	4986750	11.00	10.60	2.00	58.00	2.40	0.58	210.00	3180.00	580.00	3.60	0.16	1.10	3.00
1080	8	20	440000	4988600	21.20	74.60	4.00	198.00	2.00	4.14	1086.00	1180.00	1380.00	3.60	0.56	1.60	82.00
1081	9	20	441220	4987600	13.80	19.40	6.00	54.00	3.20	0.48	310.00	6580.00	620.00	3.60	0.40	0.60	3.00

TEMP_	NUMBER	MN_ZONE	MN_EAST	MN_NORTH	Cu	Ni	Pb	Zn	Co	Fe	Mn	Ca	Mg	Mo	Hg	U	As
1082	10	20	442030	4986520	14.80	11.20	6.00	56.00	2.00	0.26	148.00	5200.00	180.00	3.60	0.40	1.70	2.20
1083	11	20	443100	4986050	16.80	20.20	6.00	92.00	3.40	0.44	158.00	2240.00	740.00	3.60	0.20	2.10	3.60
1084	13	20	441400	4983700	13.20	9.60	6.00	32.00	3.00	0.30	260.00	2400.00	380.00	3.20	0.32	1.40	1.80
1085	14	20	444300	4983400	10.00	20.40	4.00	86.00	4.80	1.00	180.00	1340.00	2780.00	3.60	0.36	1.80	2.40
1086	15	20	446500	4984300	10.20	18.60	2.00	96.00	6.80	1.66	400.00	1980.00	1640.00	3.60	0.60	3.70	2.40
1087	16	20	447500	4984200	14.20	11.00	2.00	44.00	1.00	0.30	150.00	6960.00	780.00	3.60	0.20	1.80	2.00
1088	17	20	449150	4987500	18.80	21.60	4.00	96.00	8.40	1.18	180.00	1560.00	3220.00	3.60	0.52	5.10	4.80
1089	18	20	449400	4983950	16.40	14.40	16.00	60.00	3.20	0.50	156.00	5940.00	1220.00	3.60	5.40	2.50	2.60
1090	19	20	452400	4983700	41.40	23.00	38.00	86.00	9.00	2.28	380.00	8440.00	8060.00	3.60	0.01	2.30	6.80
1091	2	20	525100	5025350	13.80	29.60	2.00	98.00	6.80	2.12	262.00	1720.00	680.00	2.80	0.36	1.60	1.40
1092	3	20	523650	5024850	7.80	13.00	2.00	46.00	2.40	0.58	366.00	1280.00	180.00	2.80	0.48	1.10	0.50
1093	4	20	519290	5024650	13.00	12.20	2.00	20.00	1.00	0.06	600.00	520.00	80.00	2.80	0.44	0.90	0.50
1094	5	20	517350	5026250	12.20	33.00	4.00	124.00	10.20	3.06	722.00	1860.00	1980.00	2.80	0.32	1.90	1.20
1095	6	20	517100	5024390	29.60	62.40	2.00	168.00	14.40	2.76	354.00	560.00	1840.00	2.80	0.32	3.00	2.80
1096	7	20	516200	5023500	13.40	37.80	2.00	114.00	5.80	2.42	508.00	1040.00	780.00	2.80	0.28	1.50	1.80
1097	8	20	515650	5022200	17.60	59.80	2.00	166.00	9.20	3.12	936.00	740.00	480.00	2.80	0.28	1.70	2.60
1098	9	20	513420	5025560	12.00	20.40	2.00	52.00	4.00	0.90	320.00	1380.00	780.00	2.80	0.20	1.10	0.50
1099	10	20	512350	5021350	7.60	19.60	2.00	42.00	1.00	0.38	334.00	1840.00	680.00	2.80	0.32	1.00	0.50
1100	11	20	512450	5020500	6.20	11.80	2.00	26.00	1.00	0.12	198.00	2580.00	480.00	2.80	0.16	0.50	0.50
1101	12	20	509750	5019900	8.60	16.60	2.00	58.00	2.80	0.70	540.00	2020.00	860.00	2.80	0.20	1.50	0.50
1102	13	20	511900	5018040	28.40	82.80	4.00	162.00	18.20	1.98	504.00	1580.00	920.00	2.80	0.40	2.50	0.50
1103	14	20	510000	5013880	16.00	22.80	6.00	112.00	8.00	2.16	336.00	5180.00	2600.00	2.80	0.01	3.00	0.50
1104	17	20	509700	5014160	13.80	24.20	2.00	54.00	4.60	1.04	102.00	9000.00	1460.00	3.20	0.28	2.20	0.50
1105	18	20	517680	5012100	11.00	8.80	6.00	102.00	1.00	0.12	70.00	2460.00	260.00	3.20	0.20	1.90	0.50
1106	19	20	519440	5013300	6.60	6.60	10.00	86.00	1.00	0.44	158.00	1880.00	640.00	3.20	0.40	4.20	1.00
1107	20	20	520770	5014280	7.80	4.80	4.00	22.00	1.00	0.02	48.00	1260.00	400.00	3.20	0.20	3.00	0.50
1108	22	20	525370	5013900	12.00	9.20	12.00	202.00	3.80	0.74	388.00	1340.00	860.00	3.20	0.20	16.90	0.50
1109	23	20	525170	5014270	12.20	8.80	8.00	194.00	3.80	0.88	450.00	1560.00	800.00	3.20	0.16	15.60	0.50
1110	24	20	522000	5015870	16.00	26.20	6.00	98.00	9.80	1.98	418.00	500.00	3380.00	3.20	0.16	3.50	2.60
1111	26	20	518300	5016900	15.80	21.40	8.00	384.00	8.40	1.34	376.00	5480.00	2080.00	3.20	0.40	5.70	2.60
1112	27	20	516450	5016770	9.80	11.60	24.00	212.00	2.80	0.42	492.00	5760.00	1000.00	3.20	0.28	1.30	0.50
1113	28	20	513630	5019440	13.80	22.40	2.00	84.00	4.60	0.68	198.00	1140.00	640.00	3.20	0.16	1.30	0.50
1114	29	20	515450	5020200	13.20	67.00	2.00	130.00	3.00	9.12	1220.00	500.00	1200.00	3.20	0.28	2.40	3.00
1115	31	20	516750	5020850	8.40	26.40	2.00	38.00	2.20	0.54	152.00	780.00	780.00	2.40	0.44	1.60	0.50
1116	32	20	522550	5019580	7.60	24.20	2.00	78.00	9.00	0.32	398.00	560.00	2100.00	2.80	0.01	1.90	0.50
1117	33	20	523980	5021980	11.20	25.60	2.00	58.00	5.50	1.40	240.00	1140.00	700.00	2.40	0.40	1.30	0.50

TEMP_	NUMBER	MN_ZONE	MN_EAST	MN_NORTH	Cu	Ni	Pb	Zn	Co	Fe	Mn	Ca	Mg	Mo	Hg	U	As
1118	34	20	526500	5021400	18.80	40.40	2.00	108.00	10.80	5.74	556.00	1280.00	1180.00	2.00	0.28	1.80	4.40
1119	35	20	527200	5020650	17.20	62.00	2.00	142.00	22.60	10.40	2380.00	1040.00	1620.00	2.40	0.16	2.80	4.40
1120	36	20	529970	5020800	18.60	67.80	10.00	228.00	20.80	4.84	904.00	700.00	2680.00	2.80	0.16	3.50	4.80
1121	37	20	529860	5022000	11.20	25.00	2.00	66.00	3.60	1.52	204.00	1780.00	1200.00	3.20	0.12	1.60	0.50
1122	38	20	531620	5022300	11.20	48.20	4.00	164.00	16.80	5.84	822.00	680.00	1860.00	3.60	0.28	2.60	1.80
1123	39	20	532880	5020070	9.40	25.60	2.00	98.00	3.60	0.98	282.00	1100.00	1260.00	3.20	0.01	1.60	0.50
1124	40	20	533500	5020930	11.80	25.80	4.00	74.00	3.80	0.84	396.00	2160.00	640.00	2.80	0.32	1.10	1.80
1125	42	20	527000	5023360	11.00	30.80	4.00	96.00	14.20	4.62	670.00	740.00	1120.00	2.80	0.64	1.90	5.00
1126	43	20	529000	5023900	15.60	64.00	4.00	188.00	28.00	5.60	1416.00	420.00	2480.00	2.80	0.28	2.70	2.60
1127	44	20	530600	5025250	24.00	35.20	4.00	172.00	12.40	2.16	554.00	1580.00	920.00	2.80	0.56	1.70	2.40
1128	45	20	531820	5025790	13.00	18.40	2.00	128.00	5.20	1.08	452.00	5500.00	640.00	2.80	0.48	1.20	2.00
1129	46	20	533900	5024200	9.80	16.40	2.00	22.00	6.60	0.40	118.00	1100.00	420.00	2.80	0.16	1.40	1.80
1130	47	20	535120	5021740	19.00	41.80	30.00	214.00	13.60	3.18	516.00	360.00	3280.00	2.80	0.12	3.40	1.20
1133	52	20	531500	5017530	6.00	66.00	2.00	8.00	1.00	0.12	120.00	420.00	180.00	3.20	0.12	0.10	2.20
1134	53	20	529670	5011670	5.80	1.00	2.00	14.00	1.00	0.01	72.00	1820.00	500.00	3.20	0.36	2.90	0.50
1135	54	20	534500	5013760	10.60	9.80	6.00	38.00	1.00	0.14	104.00	2160.00	440.00	3.20	0.20	6.90	1.80
1136	55	20	534810	5011880	10.20	7.20	4.00	26.00	1.00	0.36	152.00	2060.00	300.00	3.20	0.16	7.70	1.60
1603	2	20	394700	4983920	23.80	10.00	6.00	50.00	1.00	0.30	18.00	300.00	200.00	3.20	0.16	2.90	2.00
1604	3	20	395480	4988910	6.40	6.80	4.00	56.00	3.40	1.00	418.00	1280.00	2780.00	3.20	0.16	3.50	2.00
1605	4	20	405190	4988330	19.80	26.40	4.00	56.00	11.60	2.44	718.00	1520.00	4560.00	3.20	0.20	3.30	3.60
2937	55	20	438310	4951660	14.00	11.00	32.00	100.00	8.20	1.80	40.00	1500.00	3140.00	1.00	0.46	2.40	6.70
2938	56	20	439060	4952580	7.00	6.40	6.40	70.00	5.20	1.20	50.00	1260.00	1960.00	1.00	0.46	1.90	3.40
2939	57	20	437660	4954000	10.00	8.00	8.00	60.00	3.60	0.90	60.00	1500.00	480.00	1.00	0.43	1.00	2.00
2940	58	20	437670	4954690	11.00	4.70	8.80	20.00	2.20	0.60	70.00	2700.00	1400.00	3.60	0.40	1.50	2.40
2941	59	20	439000	4955120	6.00	5.80	10.00	20.00	2.00	0.40	60.00	1360.00	1000.00	1.00	0.36	1.00	2.90
2942	60	20	441570	4953290	6.00	3.60	25.20	50.00	2.00	0.90	70.00	6800.00	620.00	1.00	0.46	0.90	1.00
2943	62	20	444400	4953500	8.00	9.00	10.00	40.00	4.00	0.60	60.00	2340.00	1980.00	1.00	0.79	14.90	4.80
2944	63	20	444445	4955000	7.00	8.00	16.80	60.00	5.60	0.80	60.00	2980.00	1600.00	3.20	0.56	1.50	1.10
2945	64	20	445000	4954500	8.00	8.00	14.80	60.00	5.80	0.60	180.00	2560.00	1800.00	2.00	0.48	2.10	1.00
2963	85	20	446735	4943200	4.00	3.60	10.00	40.00	1.00	1.00	80.00	400.00	300.00	1.00	0.61	6.10	4.60
2967	89	20	443525	4948820	4.00	6.80	13.60	40.00	1.00	0.20	100.00	2880.00	500.00	1.00	0.65	6.60	2.80
2968	90	20	445320	4948740	4.00	3.20	20.00	30.00	2.00	0.20	80.00	3020.00	400.00	1.00	0.57	4.20	5.90
2969	92	20	445340	4951410	2.00	7.00	40.00	30.00	8.40	0.80	60.00	1320.00	820.00	1.00	0.44	3.80	4.80
2970	94	20	446165	4953795	4.00	5.40	24.00	100.00	4.00	0.40	80.00	2680.00	520.00	2.40	0.61	1.40	4.80
2971	95	20	441000	4951300	8.00	10.20	1.00	20.00	1.00	0.40	240.00	1740.00	600.00	1.00	0.70	0.90	13.70
2984	109	20	452150	4941610	5.00	3.80	8.80	20.00	1.00	0.20	50.00	4500.00	360.00	3.20	0.68	4.50	6.20

TEMP_	NUMBER	MN_ZONE	MN_EAST	MN_NORTH	Cu	Ni	Pb	Zn	Co	Fe	Mn	Ca	Mg	Mo	Hg	U	As
2985	110	20	452650	4939560	4.00	4.00	27.60	40.00	1.00	0.20	60.00	2280.00	440.00	2.80	0.92	11.10	8.00
3026	157	20	434680	4954800	8.00	9.80	13.20	84.00	1.00	0.90	40.00	2240.00	880.00	1.00	0.74	1.50	5.20

APPENDIX B: TILL DATA

TILLCD	SAMPLENO	UTME	UTMN	DEPT-	Ag	Cu	Pb	Zn	Cd	Ni	Co	Fe	Mn	Ca	Mg	Hg	As	Mb	U	Sn	W
296	T-77 271A	531804.61	5007180.30	1.0	0.10	29.40	22.00	190.00	0.10	37.60	11.00	6.42	540.00	74.00	6660.00	0.18	9.00	0.95	0.20	1.00	20.00
297	T-77 272A	530208.23	5010328.70	1.0	0.10	47.40	28.00	222.00	0.10	39.60	15.40	6.94	1380.00	130.00	6800.00	0.14	12.40	0.55	0.20	-99.00	-99.00
298	T-77 273A	521571.16	5008643.60	1.0	0.10	40.80	22.00	168.00	0.10	37.00	13.40	5.84	1020.00	60.00	7520.00	0.18	5.80	0.80	0.20	5.00	14.00
299	T-77 274A	522481.94	5005931.70	4.0	0.10	38.20	112.00	334.00	0.10	28.00	13.20	5.46	1840.00	392.00	9000.00	-99.00	-99.00	0.95	0.20	-99.00	-99.00
300	T-77 275A	522975.35	5003265.00	1.0	0.10	45.20	42.00	270.00	0.10	31.80	13.40	6.26	1640.00	86.00	8560.00	-99.00	10.00	0.75	0.20	-99.00	-99.00
301	T-77 276A	525348.35	5000035.80	1.0	0.10	79.20	160.00	140.00	0.10	24.20	18.00	14.76	2180.00	192.00	5240.00	-99.00	5.40	5.45	0.20	1.00	16.00
302	T-77 277A	528474.88	5000127.90	1.0	0.10	88.60	52.00	196.00	0.10	54.00	18.20	8.40	940.00	134.00	7220.00	-99.00	-99.00	1.95	0.20	1.00	10.00
303	T-77 278A	531088.30	5000972.20	1.0	0.10	106.00	48.00	226.00	0.10	57.00	19.00	7.56	2860.00	74.00	8580.00	-99.00	42.00	1.20	0.20	-99.00	-99.00
304	T-77 279A	524961.14	4997553.50	1.0	0.10	79.80	48.00	180.00	0.10	59.80	27.20	8.72	2060.00	136.00	8160.00	-99.00	-99.00	-99.00	0.20	1.00	6.00
305	T-77 280A	523658.13	4995019.00	2.0	0.10	72.00	62.00	186.00	0.10	37.40	13.00	8.06	1200.00	52.00	9120.00	0.11	30.60	1.60	0.20	10.00	60.00
306	T-77 281A	525753.83	4993659.70	1.0	0.10	96.80	50.00	166.00	0.10	46.60	26.20	7.88	1380.00	134.00	7380.00	-99.00	-99.00	-99.00	0.20	5.00	10.00
307	T-77 282A	527535.32	4990551.00	2.0	0.10	125.80	60.00	140.00	0.10	55.40	44.80	6.40	1880.00	364.00	7180.00	-99.00	-99.00	1.35	0.20	-99.00	-99.00
309	T-77 284A	528460.12	5006920.00	1.0	0.10	130.60	332.00	396.00	0.10	46.80	39.00	7.36	5900.00	278.00	10200.00	-99.00	-99.00	-99.00	0.20	1.00	2000.00
310	T-77 285A	526930.95	5003309.50	2.0	0.10	20.40	650.00	516.00	0.10	46.40	29.60	6.72	3040.00	198.00	8860.00	-99.00	28.60	1.20	0.20	-99.00	-99.00
311	T-77 286A	529080.71	5012671.90	1.0	0.10	78.40	78.00	198.00	0.10	47.80	34.20	7.90	5840.00	116.00	6760.00	-99.00	-99.00	-99.00	0.20	1.00	10.00
312	T-77 287A	526981.45	5014497.90	1.0	0.10	38.40	34.00	240.00	0.10	37.40	14.40	6.88	1140.00	356.00	7240.00	0.14	11.20	0.40	0.20	1.00	50.00
313	T-77 287B	526981.45	5014497.90	1.0	0.10	46.20	118.00	262.00	0.10	33.60	15.00	6.50	2020.00	92.00	7640.00	0.24	9.40	0.70	0.20	-99.00	-99.00
314	T-77 288A	530267.40	5014365.00	1.0	0.10	95.20	130.00	462.00	0.10	50.20	22.20	6.78	4360.00	74.00	7880.00	-99.00	30.60	1.05	0.20	1.00	6.00
319	T-77 293A	523834.65	5013960.90	2.0	0.10	40.80	64.00	252.00	0.10	39.60	14.80	6.56	1860.00	70.00	7180.00	0.20	6.80	0.55	0.20	-99.00	-99.00
320	T-77 294A	520475.22	5012313.80	2.0	0.10	64.80	114.00	346.00	0.10	41.60	22.40	6.46	1980.00	174.00	7120.00	-99.00	11.00	0.75	0.20	5.00	16.00
321	T-77 295A	518558.14	5008727.40	1.0	0.10	7.80	98.00	130.00	0.10	3.80	4.40	5.18	1880.00	140.00	2240.00	-99.00	7.40	0.60	0.20	-99.00	-99.00
322	T-77 296A	516957.53	5003462.70	1.0	0.10	87.80	40.00	174.00	0.10	46.80	23.80	8.30	2080.00	66.00	7860.00	-99.00	-99.00	-99.00	0.20	5.00	14.00
323	T-77 297A	519195.65	5006876.30	0.0	0.10	28.60	18.00	86.00	0.10	11.80	14.80	4.92	700.00	170.00	7280.00	-99.00	-99.00	-99.00	0.20	-99.00	-99.00
327	T-77 301A	531911.39	4976393.10	1.0	0.10	216.00	50.00	172.00	0.10	60.60	30.40	7.16	900.00	478.00	8140.00	-99.00	-99.00	-99.00	0.20	5.00	14.00
328	T-77 302A	528473.29	4974731.70	2.0	0.10	56.80	86.00	92.00	0.10	9.40	24.00	11.42	1580.00	106.00	9740.00	-99.00	-99.00	-99.00	0.20	-99.00	-99.00
329	T-77 303A	530007.90	4972112.60	2.0	0.10	53.20	30.00	170.00	0.10	48.20	17.80	6.74	1380.00	230.00	2440.00	-99.00	-99.00	-99.00	0.20	1.00	28.00
330	T-77 305A	526043.86	4980040.20	1.0	0.10	66.40	154.00	126.00	0.10	10.00	4.40	15.40	1300.00	64.00	9940.00	0.26	35.60	6.15	0.20	10.00	16.00
331	T-77 306A	523823.87	4978214.20	2.0	0.10	100.20	48.00	168.00	0.10	60.80	30.40	7.62	3980.00	230.00	9180.00	-99.00	-99.00	0.60	0.20	-99.00	-99.00
332	T-77 307A	519867.19	4977555.20	1.0	0.10	58.40	40.00	140.00	0.10	35.80	16.60	10.32	1580.00	76.00	5300.00	-99.00	16.00	1.15	0.20	-99.00	-99.00
333	T-77 308A	518151.40	4976755.90	1.0	0.10	64.80	22.00	156.00	0.10	48.00	16.40	6.86	1980.00	112.00	8320.00	0.14	17.80	0.45	0.20	5.00	14.00
334	T-77 309A	522968.43	4982504.60	1.0	0.10	248.00	56.00	168.00	0.10	75.40	62.20	6.60	2420.00	462.00	9640.00	-99.00	-99.00	-99.00	0.20	-99.00	-99.00
335	T-77 310A	522588.13	4985951.40	1.0	0.10	19.00	18.00	68.00	0.10	5.60	1.60	6.46	880.00	58.00	1440.00	-99.00	-99.00	-99.00	0.20	1.00	28.00
336	T-77 311A	522733.09	4989042.40	1.0	0.10	130.40	56.00	162.00	0.10	59.80	22.60	8.76	1180.00	92.00	9760.00	-99.00	70.00	1.20	0.20	1.00	28.00
337	T-77 312A	521572.14	4992619.90	2.0	0.10	118.40	62.00	162.00	0.10	41.20	16.60	8.02	1360.00	76.00	8540.00	0.08	27.60	0.75	0.20	-99.00	-99.00
338	T-77 313A	520332.46	4996376.20	2.0	0.10	89.60	104.00	148.00	0.10	30.60	12.40	10.18	1700.00	38.00	8020.00	0.18	35.20	1.55	0.20	1.00	6.00
339	T-77 314A	515613.85	4998458.00	1.0	0.10	116.00	74.00	150.00	0.10	45.00	28.40	8.66	2760.00	76.00	8060.00	-99.00	42.00	0.80	0.20	1.00	10.00

TILLCD	SAMPLENO	UTME	UTMN	DEPT-	Ag	Cu	Pb	Zn	Cd	Ni	Co	Fe	Mn	Ca	Mg	Hg	As	Mb	U	Sn	W
340	T-77 315A	512332.33	4998333.00	1.0	0.10	362.00	306.00	168.00	0.10	25.80	46.20	12.66	16380.00	64.00	6860.00	-99.00	-99.00	-99.00	0.20	1.00	16.00
341	T-77 316A	507380.58	4996246.90	2.0	0.10	55.80	22.00	126.00	0.10	40.00	16.80	5.22	3500.00	196.00	7820.00	0.18	18.60	0.15	0.20	-99.00	-99.00
342	T-77 317A	520617.45	4983882.90	2.0	0.10	48.60	52.00	218.00	0.10	28.20	13.40	6.42	2840.00	604.00	8120.00	-99.00	5.60	0.15	4.10	5.00	36.00
343	T-77 318A	516122.44	4986690.50	2.0	0.10	248.00	68.00	222.00	0.10	56.20	29.80	8.20	3480.00	194.00	7720.00	-99.00	-99.00	-99.00	0.82	5.00	20.00
344	T-77 319A	512782.52	4989096.90	1.0	0.10	82.60	38.00	162.00	0.10	42.80	15.80	6.52	2220.00	70.00	7840.00	0.18	28.40	0.50	0.82	25.00	24.00
345	T-77 320A	510002.93	4992666.70	1.0	0.10	79.40	38.00	178.00	0.10	47.20	17.60	6.34	2900.00	60.00	7720.00	0.20	25.80	0.15	0.20	1.00	16.00
346	T-77 322A	504714.72	4998898.20	2.0	0.10	60.40	18.00	112.00	0.10	33.60	32.00	4.76	3100.00	64.00	5660.00	0.16	7.60	0.05	0.82	10.00	24.00
354	T-77 329A	531064.34	4964429.30	2.0	0.40	59.20	42.00	114.00	0.10	35.20	20.00	4.08	2860.00	258.00	6100.00	-99.00	-99.00	-99.00	0.20	-99.00	-99.00
355	T-77 330A	529853.39	4963741.50	1.0	0.40	86.80	36.00	192.00	0.10	48.80	37.60	5.40	3040.00	456.00	9840.00	-99.00	-99.00	-99.00	0.43	1.00	10.00
356	T-77 330B	529853.39	4963741.50	3.0	0.10	67.00	24.00	226.00	0.10	56.00	17.60	6.46	1340.00	142.00	9920.00	0.11	23.00	0.90	0.40	1.00	14.00
357	T-77 331A	527427.63	4961051.40	8.0	0.10	29.40	18.00	146.00	0.10	24.60	12.80	4.12	1120.00	112.00	6720.00	0.11	22.80	0.55	0.20	-99.00	-99.00
358	T-77 332A	525728.61	4962495.10	1.0	0.10	63.60	18.00	172.00	0.10	49.80	13.00	5.40	2340.00	84.00	9000.00	0.11	16.60	0.70	0.43	7.00	36.00
359	T-77 333A	525577.95	4965975.90	1.0	0.10	88.80	48.00	178.00	0.10	51.40	14.60	6.30	5620.00	130.00	7760.00	-99.00	-99.00	1.05	0.20	1.00	20.00
360	T-77 334A	523586.76	4971062.70	2.0	0.10	69.80	28.00	180.00	0.10	57.40	13.80	5.76	2480.00	82.00	8940.00	0.14	28.60	0.65	0.20	1.00	24.00
361	T-77 335A	520647.58	4973320.90	2.0	0.10	58.60	90.00	166.00	0.10	41.60	14.60	5.52	3460.00	422.00	9320.00	-99.00	-99.00	-99.00	0.43	1.00	20.00
362	T-77 336A	506681.10	5000252.00	2.0	0.40	37.20	68.00	106.00	0.10	20.20	17.00	4.82	880.00	48.00	5340.00	0.14	17.00	2.10	0.43	-99.00	-99.00
363	T-77 337A	508837.78	5003735.00	2.0	0.40	22.20	52.00	100.00	0.10	0.00	17.90	7.10	280.00	70.00	4360.00	-99.00	16.20	4.60	0.43	5.00	-99.00
364	T-77 338A	510828.18	5005275.60	1.0	0.60	64.00	68.00	256.00	0.10	52.20	18.60	4.94	2660.00	116.00	7560.00	0.16	34.20	0.55	0.20	1.00	10.00
365	T-77 339A	512114.06	5005995.60	1.0	0.40	68.80	64.00	140.00	0.10	19.80	22.20	14.02	1740.00	58.00	6740.00	0.22	66.00	6.75	0.43	1.00	8.00
366	T-77 340A	515267.58	5008387.50	1.0	0.10	111.40	260.00	112.00	0.10	1.40	18.60	31.80	260.00	30.00	4500.00	-99.00	171.00	10.70	0.20	1.00	24.00
367	T-77 341A	516027.20	5006320.90	1.0	0.10	46.20	16.00	130.00	0.10	32.60	17.20	4.82	900.00	334.00	7220.00	-99.00	-99.00	-99.00	1.23	1.00	14.00
368	T-77 342A	504107.56	5001681.70	1.0	0.10	57.20	16.00	158.00	0.10	48.60	18.60	5.08	3540.00	140.00	7360.00	0.14	13.60	0.20	0.20	1.00	28.00
369	T-77 343A	501271.04	4999964.20	1.0	0.10	128.80	20.00	116.00	0.10	33.80	17.60	3.62	3080.00	62.00	6140.00	0.11	8.60	0.70	0.80	1.00	6.00
370	T-77 344A	499844.25	4995329.40	1.0	0.10	69.20	20.00	160.00	0.10	55.60	14.80	5.24	3140.00	58.00	7300.00	0.22	22.80	0.80	0.20	1.00	14.00
371	T-77 345A	502770.27	4995802.20	2.0	0.10	68.40	22.00	96.00	0.10	46.00	19.80	5.80	2120.00	52.00	12620.00	0.14	14.80	1.55	0.43	1.00	20.00
372	T-77 346A	503007.25	4991999.70	2.0	0.10	89.00	38.00	126.00	0.10	63.20	24.40	6.16	3140.00	94.00	9360.00	0.14	106.00	0.85	0.20	1.00	32.00
373	T-77 347A	504193.59	4989178.80	2.0	0.10	65.20	22.00	124.00	0.10	55.60	21.80	6.22	2500.00	112.00	9260.00	0.11	21.00	0.90	0.43	1.00	10.00
374	T-77 348A	524364.81	4968707.20	1.0	0.10	66.20	26.00	154.00	0.10	48.40	20.00	6.50	2760.00	198.00	7440.00	0.08	32.00	1.20	0.43	1.00	12.00
375	T-77 349A	518532.57	4974531.90	1.0	0.10	47.20	22.00	172.00	0.10	47.80	16.20	5.68	2620.00	44.00	8600.00	0.14	11.00	0.80	0.43	5.00	6.00
376	T-77 350A	513808.49	4977440.40	1.0	0.10	70.40	34.00	196.00	0.10	48.40	24.20	5.90	2200.00	70.00	8220.00	0.18	10.40	1.25	0.43	15.00	6.00
377	T-77 351A	510967.12	4979731.10	1.0	0.10	69.80	32.00	176.00	0.10	53.40	23.20	6.30	2340.00	104.00	8500.00	0.14	16.20	1.05	0.20	1.00	60.00
378	T-77 352A	507644.81	4981180.30	1.0	0.10	75.80	32.00	244.00	0.10	56.20	26.00	6.74	2760.00	198.00	7980.00	0.20	28.00	1.15	0.20	1.00	6.00
379	T-77 353A	504194.70	4980294.00	1.0	0.10	65.20	38.00	206.00	0.10	46.80	25.20	7.92	2820.00	78.00	9200.00	0.20	55.00	1.30	0.20	1.00	10.00
380	T-77 354A	503336.25	4982919.60	2.0	0.10	96.00	52.00	172.00	0.10	70.00	25.00	8.80	4020.00	58.00	6360.00	-99.00	35.20	2.20	0.20	1.00	32.00
381	T-77 355A	501332.07	4986271.50	2.0	0.10	83.60	24.00	198.00	0.10	43.80	26.60	7.40	2220.00	129.00	7020.00	0.20	37.00	1.95	0.20	1.00	32.00
382	T-77 356A	504539.20	4985930.80	2.0	0.10	65.60	20.00	160.00	0.10	42.20	13.60	6.92	1480.00	62.00	6140.00	0.09	11.00	1.10	0.20	-99.00	-99.00

TILLCD	SAMPLENO	UTME	UTMN	DEPTH	Ag	Cu	Pb	Zn	Cd	Ni	Co	Fe	Mn	Ca	Mg	Hg	As	Mb	U	Sn	W
383	T-77 357A	507164.30	4984341.30	2.0	0.10	185.40	52.00	238.00	0.10	84.80	47.00	7.44	4960.00	288.00	9300.00	-99.00	-99.00	-99.00	0.20	-99.00	-99.00
384	T-77 358A	512313.49	4975881.10	2.0	0.10	59.00	26.00	176.00	0.10	51.40	21.40	5.64	2200.00	190.00	9020.00	0.14	13.00	1.10	0.20	-99.00	-99.00
385	T-77 359A	511072.59	4973463.80	1.0	0.10	58.00	26.00	146.00	0.10	45.00	25.60	7.42	1440.00	98.00	7400.00	-99.00	-99.00	1.50	0.20	1.00	16.00
386	T-77 360A	509078.45	4972566.40	2.0	0.10	73.40	38.00	162.00	0.10	53.60	26.60	5.80	3440.00	90.00	8660.00	0.14	47.80	1.60	0.20	1.00	16.00
387	T-77 361A	505806.91	4971853.90	1.0	0.60	62.20	34.00	206.00	0.10	55.00	24.20	6.60	1760.00	222.00	8620.00	0.11	13.00	0.70	0.20	1.00	10.00
388	T-77 362A	502238.01	4970367.60	1.0	0.40	183.40	124.00	182.00	0.10	71.20	20.00	5.98	4380.00	340.00	12580.00	-99.00	-99.00	1.45	0.20	1.00	-99.00
389	T-77 363A	501719.86	4967811.40	1.0	0.10	84.60	36.00	168.00	0.10	55.60	21.80	6.30	1980.00	190.00	10240.00	-99.00	-99.00	1.50	0.20	1.00	20.00
390	T-77 364A	503177.70	4965691.30	2.0	0.10	145.40	52.00	204.00	0.10	61.60	24.40	5.48	4800.00	278.00	10300.00	-99.00	-99.00	-99.00	0.20	5.00	6.00
391	T-77 365A	503168.21	4962513.30	1.0	0.10	62.80	32.00	218.00	0.10	45.80	23.80	6.06	1620.00	90.00	8900.00	-99.00	14.20	1.15	0.20	1.00	20.00
392	T-77 366A	505037.54	4967299.90	2.0	0.10	100.60	38.00	222.00	0.10	86.00	24.80	6.90	2600.00	90.00	8840.00	-99.00	-99.00	1.45	0.20	1.00	4.00
393	T-77 367A	508628.67	4969487.70	1.0	0.10	58.40	30.00	204.00	0.10	47.80	24.40	6.26	1680.00	132.00	8760.00	0.11	11.00	1.60	0.20	10.00	6.00
394	T-77 368A	504325.95	4956326.60	2.0	0.10	57.20	82.00	116.00	0.60	25.00	19.80	5.68	2280.00	138.00	3920.00	-99.00	125.00	1.85	0.20	1.00	120.00
395	T-77 369A	508442.25	4959283.30	1.0	0.20	89.80	142.00	176.00	0.10	74.20	17.40	6.78	3120.00	224.00	6960.00	-99.00	-99.00	-99.00	0.20	1.00	36.00
396	T-77 370A	511232.69	4960443.90	1.0	0.20	87.00	42.00	178.00	0.10	64.40	38.00	6.88	3080.00	162.00	5900.00	-99.00	-99.00	1.95	0.20	-99.00	-99.00
397	T-77 371A	514888.68	4957569.90	1.0	0.10	188.00	40.00	194.00	0.10	68.80	37.60	6.16	3580.00	370.00	10880.00	-99.00	-99.00	1.35	0.20	5.00	50.00
398	T-77 372A	514959.08	4956900.20	2.0	0.10	73.40	32.00	194.00	0.10	53.80	19.40	5.72	1180.00	112.00	9740.00	-99.00	12.20	1.10	0.20	5.00	24.00
399	T-77 373A	513727.37	4955206.80	1.0	0.10	78.60	76.00	104.00	0.20	33.20	19.80	4.10	4060.00	214.00	5440.00	-99.00	-99.00	1.95	0.20	1.00	16.00
400	T-77 374A	512423.69	4962153.50	1.0	0.10	128.20	50.00	244.00	0.10	23.80	17.80	5.48	2680.00	368.00	6680.00	-99.00	-99.00	-99.00	0.20	10.00	1200.00
401	T-77 375A	516338.17	4957935.50	2.0	0.10	80.60	30.00	198.00	0.10	55.60	16.60	5.50	2020.00	364.00	9780.00	-99.00	17.00	1.25	0.20	5.00	90.00
402	T-77 376A	520213.18	4959351.70	4.0	0.10	79.40	26.00	214.00	0.10	52.80	17.60	6.54	1780.00	208.00	9620.00	0.11	17.80	1.00	0.20	10.00	36.00
403	T-77 377A	524392.15	4961086.90	2.0	0.10	199.60	160.00	230.00	0.10	182.00	19.40	8.32	5060.00	266.00	10540.00	-99.00	-99.00	-99.00	0.20	1.00	100.00
404	T-77 378A	525784.18	4960270.30	1.0	0.10	95.80	32.00	186.00	0.10	62.20	24.20	6.04	2820.00	140.00	9760.00	-99.00	-99.00	-99.00	0.20	1.00	50.00
405	T-77 379A	503157.03	4959506.20	2.0	0.10	89.20	88.00	168.00	0.60	39.60	25.00	6.28	6520.00	326.00	6980.00	-99.00	99.00	2.30	0.20	5.00	60.00
406	T-77 380A	499736.43	4955704.30	1.0	0.10	96.20	122.00	184.00	0.10	59.80	28.80	5.54	1640.00	148.00	8500.00	-99.00	55.60	0.60	0.20	1.00	32.00
407	T-77 381A	496388.08	4958020.20	1.0	0.10	122.60	42.00	204.00	0.10	47.80	34.00	5.40	3000.00	304.00	9420.00	-99.00	-99.00	0.65	0.20	1.00	16.00
408	T-77 382A	495035.87	4955953.90	0.0	0.10	120.20	54.00	290.00	0.10	63.20	29.80	6.18	4660.00	284.00	9100.00	-99.00	-99.00	0.40	0.20	-99.00	-99.00
409	T-77 383A	498634.89	4949328.30	1.0	0.10	88.80	60.00	218.00	0.10	57.20	27.60	6.08	2780.00	210.00	9160.00	-99.00	15.00	0.35	0.20	1.00	20.00
410	T-77 383B	498634.89	4949328.30	3.0	0.10	82.00	36.00	238.00	0.10	56.80	23.40	5.68	1640.00	158.00	9980.00	0.20	9.60	0.20	0.20	-99.00	-99.00
411	T-77 384A	495927.58	4954245.90	1.0	0.10	29.80	204.00	152.00	0.10	52.20	36.40	7.32	2180.00	532.00	8820.00	-99.00	-99.00	-99.00	0.20	1.00	6.00
412	T-77 385A	495245.71	4951792.60	0.0	0.10	133.60	144.00	176.00	0.10	68.60	60.60	5.88	5960.00	290.00	7440.00	-99.00	-99.00	0.70	0.20	1.00	8.00
413	T-77 386A	494737.10	4949656.90	1.0	0.10	80.60	16.00	164.00	0.20	47.00	44.40	5.72	3720.00	240.00	6280.00	-99.00	-99.00	0.40	0.20	1.00	24.00
414	T-77 387A	491625.74	4953778.00	1.0	0.10	132.00	36.00	154.00	0.20	85.40	73.80	5.16	3860.00	162.00	8020.00	-99.00	-99.00	-99.00	0.20	1.00	14.00
415	T-77 388A	491733.05	4957189.20	2.0	0.10	103.20	82.00	252.00	0.10	96.40	64.80	6.48	3980.00	292.00	9980.00	-99.00	-99.00	-99.00	0.20	1.00	12.00
416	T-77 389A	489568.90	4959707.20	2.0	0.10	134.60	220.00	250.00	0.10	37.60	54.60	14.66	3700.00	130.00	5420.00	-99.00	-99.00	4.40	0.20	1.00	20.00
417	T-77 390A	488113.91	4956112.90	1.0	0.10	135.80	34.00	146.00	0.10	75.20	74.40	5.58	4760.00	178.00	11700.00	-99.00	-99.00	-99.00	0.20	-99.00	-99.00
418	T-77 391A	487252.53	4949968.40	1.0	0.10	49.00	40.00	218.00	0.10	49.40	21.20	6.20	1380.00	98.00	9500.00	0.18	12.40	0.05	0.20	5.00	14.00

TILLCD	SAMPLENO	UTME	UTMN	DEPT-	Ag	Cu	Pb	Zn	Cd	Ni	Co	Fe	Mn	Ca	Mg	Hg	As	Mb	U	Sn	W
419	T-77 392A	487190.23	4957282.10	1.0	0.10	177.40	304.00	252.00	0.10	93.80	50.60	18.78	1060.00	90.00	7640.00	-99.00	-99.00	-99.00	0.20	1.00	28.00
420	T-77 393A	506288.58	4952381.50	4.0	0.10	73.00	34.00	230.00	0.10	53.80	21.40	6.00	1820.00	364.00	10840.00	0.16	7.60	0.30	0.20	1.00	16.00
421	T-77 394A	486478.24	4952847.00	1.0	0.10	84.40	46.00	244.00	0.10	72.60	32.80	5.62	4480.00	136.00	8540.00	-99.00	-99.00	-99.00	0.20	1.00	12.00
422	T-77 395A	484150.10	4953463.20	2.0	0.60	100.20	46.00	166.00	0.10	68.60	42.60	8.20	2420.00	70.00	4840.00	-99.00	-99.00	0.50	0.20	10.00	6.00
423	T-77 396A	482948.10	4947146.90	1.0	0.10	50.00	38.00	186.00	0.10	45.60	13.80	6.16	1040.00	4320.00	10380.00	0.14	7.40	0.05	0.20	-99.00	-99.00
424	T-77 397A	484222.91	4949567.40	2.0	0.10	58.00	28.00	202.00	0.10	48.80	17.60	5.68	1200.00	132.00	9700.00	0.11	6.80	0.25	0.20	1.00	12.00
425	T-77 398A	479892.61	4953961.60	2.0	0.10	96.00	66.00	164.00	0.10	68.60	13.80	6.16	2980.00	192.00	12100.00	-99.00	-99.00	3.90	0.20	1.00	-99.00
426	T-77 399A	485584.38	4958571.90	1.0	0.10	45.80	34.00	186.00	0.10	42.20	19.60	5.64	1220.00	88.00	8860.00	0.14	6.80	0.25	0.20	5.00	10.00
427	T-77 400A	483287.45	4957281.10	1.0	0.10	127.60	64.00	286.00	0.10	87.00	16.60	6.66	3460.00	230.00	8460.00	-99.00	-99.00	-99.00	0.20	1.00	10.00
428	T-77 401A	478586.78	4952450.70	2.0	0.10	52.40	32.00	206.00	0.10	52.80	22.20	6.44	1120.00	190.00	9900.00	0.11	9.80	0.25	0.20	1.00	32.00
429	T-77 402A	479185.96	4948183.20	1.0	0.10	53.80	38.00	200.00	0.10	48.20	24.40	5.66	1780.00	136.00	9140.00	0.11	8.60	0.05	0.20	-99.00	-99.00
430	T-77 403A	479796.63	4945552.00	3.0	0.10	40.40	26.00	164.00	0.10	47.80	25.00	5.72	1020.00	4660.00	10020.00	0.11	7.40	0.30	0.20	1.00	4.00
431	T-77 404A	474403.02	4942641.80	2.0	0.10	104.40	58.00	210.00	0.10	73.00	25.00	6.02	3960.00	218.00	8740.00	-99.00	23.00	0.40	0.20	1.00	32.00
432	T-77 404B	474403.02	4942641.80	2.0	0.10	33.20	28.00	170.00	0.10	50.20	24.00	5.94	980.00	4760.00	10060.00	0.08	6.00	0.15	0.20	1.00	32.00
433	T-77 405A	475714.58	4950160.30	2.0	0.10	52.60	32.00	178.00	0.10	42.00	24.80	4.92	960.00	98.00	8800.00	0.20	7.60	0.50	0.20	1.00	14.00
434	T-77 406A	475208.53	4953705.80	1.0	0.10	330.00	110.00	254.00	0.10	178.00	58.80	7.02	2060.00	318.00	11720.00	-99.00	76.00	0.25	0.20	-99.00	-99.00
435	T-77 407A	471798.51	4943034.80	3.0	0.10	45.40	24.00	188.00	0.10	46.20	17.60	6.26	1040.00	358.00	8620.00	0.16	11.00	0.40	0.43	1.00	20.00
436	T-77 408A	467922.96	4943887.10	2.0	0.10	46.20	166.00	178.00	0.10	42.20	18.80	6.24	860.00	530.00	8620.00	0.14	16.00	0.05	0.20	-99.00	-99.00
437	T-77 409A	468306.58	4946921.10	1.0	0.10	292.00	178.00	184.00	0.10	82.40	17.80	5.54	4340.00	218.00	8460.00	-99.00	-99.00	-99.00	0.20	7.00	50.00
438	T-77 410A	464827.42	4948162.10	0.0	0.10	175.60	138.00	198.00	0.10	110.80	22.20	7.26	2620.00	112.00	10680.00	-99.00	-99.00	0.35	0.43	-99.00	-99.00
439	T-77 411A	462129.90	4946413.40	1.0	0.10	45.60	82.00	182.00	0.10	51.60	24.20	6.12	980.00	366.00	8480.00	0.14	11.00	0.10	0.43	1.00	14.00
440	T-77 412A	465375.21	4944058.00	2.0	0.10	138.40	30.00	214.00	0.10	104.40	104.80	6.08	3440.00	178.00	8260.00	-99.00	-99.00	-99.00	0.43	5.00	36.00
441	T-77 413A	465631.17	4940144.30	1.0	0.10	50.80	190.00	188.00	0.10	50.20	18.40	5.80	1000.00	164.00	4120.00	0.16	18.60	0.40	0.20	1.00	6.00
442	T-77 413B	465631.17	4940144.30	2.0	0.10	41.00	30.00	172.00	0.10	31.00	6.80	4.84	860.00	138.00	8680.00	0.11	26.80	0.15	0.20	15.00	-99.00
443	T-77 414A	461586.25	4941765.50	0.0	0.10	38.20	18.00	186.00	0.10	49.80	16.40	5.82	820.00	662.00	7440.00	0.14	8.00	0.05	0.20	-99.00	-99.00
444	T-77 415A	460879.69	4945081.20	0.0	0.10	55.20	18.00	212.00	0.10	56.40	17.60	6.00	960.00	250.00	7640.00	0.14	15.80	0.10	0.20	-99.00	-99.00
445	T-77 416A	468280.96	4951221.20	1.0	0.10	177.00	74.00	220.00	0.10	82.60	70.80	5.70	4600.00	210.00	11900.00	-99.00	46.00	0.25	0.20	5.00	32.00
446	T-77 417A	470314.35	4953654.30	1.0	0.10	134.00	158.00	228.00	0.10	81.80	78.40	6.14	2960.00	138.00	8120.00	-99.00	-99.00	-99.00	0.20	1.00	110.00
447	T-77 418A	466721.10	4952095.50	1.0	0.10	396.00	144.00	186.00	0.10	378.00	111.80	10.50	27800.00	242.00	8800.00	-99.00	-99.00	-99.00	0.20	1.00	20.00
448	T-77 419A	463098.12	4952848.40	1.0	0.10	256.00	88.00	178.00	0.10	84.40	70.00	6.02	6080.00	290.00	11260.00	-99.00	-99.00	0.25	0.20	1.00	80.00
449	T-77 420A	461335.97	4949117.40	2.0	0.10	152.00	72.00	176.00	0.10	100.60	55.60	8.00	5120.00	150.00	7680.00	-99.00	62.00	1.05	0.20	-99.00	-99.00
450	T-77 421A	485897.05	4961533.80	1.0	0.10	42.40	74.00	128.00	0.10	33.60	21.20	4.80	3560.00	408.00	7840.00	-99.00	24.60	0.15	0.20	5.00	40.00
451	T-77 422A	483983.75	4963290.00	1.0	0.10	72.60	46.00	138.00	0.10	49.20	17.60	6.48	3540.00	104.00	7640.00	-99.00	-99.00	-99.00	0.20	-99.00	-99.00
452	T-77 423A	482403.55	4968541.80	2.0	0.10	59.00	74.00	170.00	0.10	41.80	19.80	5.94	5380.00	156.00	7520.00	-99.00	-99.00	-99.00	0.20	-99.00	-99.00
453	T-77 424A	483701.03	4973049.50	3.0	0.10	51.80	30.00	180.00	0.10	52.60	19.40	5.94	2100.00	162.00	8540.00	0.18	12.60	0.30	0.20	-99.00	-99.00
454	T-77 425A	487301.66	4971997.20	1.0	0.40	140.00	92.00	192.00	0.10	77.00	37.00	6.60	4220.00	308.00	11140.00	-99.00	-99.00	0.70	0.20	-99.00	-99.00

TILLCD	SAMPLENO	UTME	UTMN	DEPT	Ag	Cu	Pb	Zn	Cd	Ni	Co	Fe	Mn	Ca	Mg	Hg	As	Mb	U	Sn	W
455	T-77 426A	490638.94	4969867.50	1.0	0.40	144.40	114.00	178.00	0.10	52.80	35.80	5.80	2860.00	210.00	9340.00	-99.00	-99.00	0.65	0.20	1.00	50.00
456	T-77 427A	492167.92	4965985.30	1.0	0.20	161.60	32.00	170.00	0.10	60.40	23.60	5.68	2700.00	264.00	8720.00	-99.00	-99.00	-99.00	0.20	1.00	36.00
457	T-77 428A	473710.40	4956202.20	2.0	0.60	46.40	42.00	212.00	0.10	52.20	17.60	6.06	2960.00	4060.00	10360.00	0.11	8.00	0.15	0.20	1.00	330.00
458	T-77 429A	471187.40	4958897.90	2.0	0.60	66.40	52.00	158.00	0.10	49.20	21.20	5.35	2900.00	290.00	4960.00	-99.00	15.20	0.65	0.43	1.00	16.00
459	T-77 430A	469502.89	4961362.90	1.0	0.60	44.20	48.00	194.00	0.10	44.80	19.60	4.92	2500.00	322.00	8620.00	-99.00	-99.00	-99.00	1.08	1.00	6.00
460	T-77 431A	479844.91	4975808.80	1.0	0.40	50.00	28.00	124.00	0.10	55.60	18.80	6.40	1580.00	292.00	8860.00	0.34	8.80	0.30	0.20	-99.00	-99.00
461	T-77 432A	476356.10	4976754.90	3.0	0.40	53.80	28.00	186.00	0.10	49.80	15.80	5.28	1240.00	82.00	7780.00	0.32	10.40	0.60	0.20	-99.00	-99.00
462	T-77 433A	473857.58	4976183.70	2.0	0.10	45.40	52.00	168.00	0.10	53.80	21.60	5.48	860.00	202.00	8460.00	0.32	6.40	0.25	0.20	5.00	20.00
463	T-77 434A	470108.24	4974667.10	1.0	0.40	45.00	24.00	178.00	0.10	50.00	19.20	5.40	980.00	90.00	8000.00	0.30	7.40	0.35	0.43	1.00	20.00
464	T-77 435A	466921.41	4972518.80	2.0	0.10	42.00	20.00	170.00	0.10	51.40	17.00	5.94	840.00	970.00	9240.00	0.24	7.00	0.25	0.20	1.00	16.00
465	T-77 436A	464467.82	4971252.20	2.0	0.10	36.60	18.00	126.00	0.10	49.00	16.00	5.70	680.00	190.00	7680.00	0.18	9.80	0.20	0.20	1.00	70.00
466	T-77 438A	455538.19	4953706.00	2.0	-99.00	151.80	88.00	170.00	####	71.20	29.60	5.50	2500.00	278.00	9700.00	-99.00	-99.00	-99.00	0.20	1.00	24.00
467	T-77 439A	458433.42	4952170.30	2.0	-99.00	53.80	26.00	176.00	####	62.60	22.80	5.76	1100.00	936.00	9460.00	0.22	17.60	0.15	0.20	3.00	20.00
468	T-77 440A	457922.12	4944804.20	1.0	-99.00	47.20	22.00	186.00	####	54.00	17.40	5.74	1040.00	156.00	7940.00	0.24	14.80	0.15	0.20	1.00	16.00
469	T-77 441A	455318.96	4949031.80	2.0	-99.00	45.80	26.00	222.00	####	54.20	17.20	6.04	1060.00	486.00	8720.00	0.20	-99.00	0.05	0.20	3.00	20.00
470	T-77 442A	451179.09	4950126.00	0.0	-99.00	168.60	262.00	154.00	####	90.20	82.80	5.82	5560.00	334.00	9700.00	-99.00	11.00	-99.00	0.20	3.00	28.00
471	T-77 443A	448864.18	4953932.10	1.0	-99.00	116.40	110.00	224.00	####	71.80	57.00	6.86	4540.00	216.00	9400.00	-99.00	-99.00	-99.00	0.20	-99.00	-99.00
472	T-77 444A	504540.14	4954481.70	2.0	0.10	48.00	58.00	186.00	0.10	20.20	38.60	3.02	6380.00	106.00	2040.00	-99.00	-99.00	-99.00	0.20	1.00	50.00
473	T-77 445A	508254.75	4954356.60	6.0	0.10	54.40	34.00	176.00	0.10	58.80	24.20	5.50	3600.00	130.00	8580.00	-99.00	24.80	0.70	0.20	1.00	20.00
474	T-77 446A	511766.63	4953480.00	2.0	0.10	65.60	24.00	186.00	0.10	57.80	20.80	6.04	2020.00	136.00	9760.00	0.18	13.00	0.50	0.20	5.00	20.00
475	T-77 447A	512614.84	4950946.80	2.0	0.10	62.00	26.00	212.00	0.10	59.20	21.00	6.06	1740.00	310.00	11060.00	0.22	8.80	0.05	0.20	10.00	20.00
476	T-77 448A	480296.27	4970685.20	2.0	0.10	107.80	64.00	178.00	0.10	59.00	36.60	6.98	7820.00	188.00	7380.00	-99.00	-99.00	0.85	0.20	1.00	6.00
477	T-77 449A	481635.09	4977129.70	3.0	0.10	43.40	30.00	186.00	0.10	62.20	23.00	5.60	8000.00	2940.00	10300.00	0.26	10.80	0.25	0.20	-99.00	-99.00
478	T-77 450A	483934.54	4980219.50	2.0	0.20	40.60	28.00	172.00	0.10	49.00	18.60	5.58	1100.00	850.00	8940.00	0.14	9.80	0.70	0.20	1.00	14.00
479	T-77 451A	478930.19	4982443.60	2.0	0.20	40.20	22.00	176.00	0.10	56.60	15.80	7.78	780.00	218.00	7840.00	0.16	4.40	0.70	0.43	5.00	12.00
480	T-77 452A	477164.91	4980335.70	2.0	0.10	46.00	22.00	241.00	0.10	49.00	16.60	6.18	960.00	190.00	8020.00	0.14	8.80	0.75	0.20	-99.00	-99.00
481	T-77 453A	488643.80	4985312.80	2.0	0.10	39.40	24.00	198.00	0.10	46.40	15.80	5.38	1300.00	106.00	7420.00	0.16	7.80	0.35	0.20	1.00	16.00
482	T-77 454A	489515.21	4981973.10	1.0	0.10	39.40	22.00	194.00	0.10	51.80	16.20	5.62	1620.00	796.00	8260.00	0.18	8.60	0.60	0.20	1.00	16.00
483	T-77 455A	492933.74	4991745.20	2.0	0.10	41.20	22.00	168.00	0.10	45.00	15.80	5.38	1360.00	96.00	7340.00	0.22	8.00	0.35	0.20	1.00	12.00
484	T-77 456A	498032.45	4989544.30	2.0	0.10	42.40	20.00	158.00	0.10	59.60	28.00	5.56	2120.00	210.00	7880.00	0.24	12.60	0.25	0.20	-99.00	-99.00
485	T-77 457A	495647.98	4988932.20	1.0	0.10	60.00	70.00	128.00	0.10	97.80	32.00	6.80	6480.00	102.00	5920.00	-99.00	-99.00	1.95	0.20	5.00	6.00
486	T-77 458A	490290.77	4989157.00	2.0	0.10	42.80	24.00	160.00	0.10	54.60	18.00	5.78	1380.00	968.00	8880.00	0.22	10.40	1.35	0.20	1.00	14.00
487	T-77 459A	488413.81	4990547.60	2.0	0.10	49.00	28.00	180.00	0.10	52.20	18.60	6.04	1420.00	516.00	8580.00	0.20	10.40	1.10	0.20	1.00	14.00
488	T-77 460A	487845.61	4993523.60	1.0	0.10	130.20	10.00	152.00	0.10	51.00	25.20	7.40	16600.00	80.00	5940.00	-99.00	-99.00	-99.00	0.20	1.00	20.00
489	T-77 461A	497516.34	4994567.80	1.0	0.10	39.00	16.00	186.00	0.10	50.60	17.60	5.86	2120.00	354.00	7700.00	0.36	9.60	0.70	0.20	1.00	50.00
490	T-77 462A	498170.02	4997027.10	2.0	0.10	40.20	26.00	194.00	0.10	48.60	16.20	5.48	1620.00	210.00	7340.00	0.32	10.00	1.00	0.20	-99.00	-99.00

TILLCD	SAMPLENO	UTME	UTMN	DEPT-	Ag	Cu	Pb	Zn	Cd	Ni	Co	Fe	Mn	Ca	Mg	Hg	As	Mb	U	Sn	W
491	T-77 463A	491354.26	4984893.00	1.0	0.10	49.60	26.00	192.00	0.10	60.20	22.40	6.26	3000.00	124.00	8100.00	-99.00	12.40	0.90	0.20	15.00	14.00
492	T-77 464A	482916.79	4987655.00	0.0	0.10	45.00	14.00	192.00	0.10	57.60	18.00	6.00	1580.00	256.00	9180.00	0.20	9.80	0.25	0.20	-99.00	-99.00
493	T-77 465A	479222.02	4986615.10	2.0	0.10	41.40	26.00	200.00	0.10	43.20	18.20	5.34	1140.00	106.00	7420.00	0.24	10.40	0.55	0.20	1.00	40.00
494	T-77 466A	482624.13	4983144.50	2.0	0.10	47.20	28.00	244.00	0.10	51.60	18.60	5.82	2580.00	334.00	7360.00	0.22	12.20	0.80	0.20	1.00	20.00
495	T-77 467A	478466.39	4983282.70	2.0	0.10	39.80	22.00	250.00	0.10	50.40	17.00	6.06	920.00	804.00	9360.00	0.14	8.80	0.35	0.20	1.00	16.00
496	T-77 468A	474780.34	4985278.00	2.0	0.10	37.40	26.00	240.00	0.10	50.80	17.60	5.28	1580.00	108.00	8180.00	0.11	7.20	0.65	0.20	1.00	50.00
497	T-77 469A	469687.15	4984052.70	1.0	0.10	40.20	28.00	232.00	0.10	54.00	15.20	5.64	880.00	536.00	8660.00	0.20	9.40	0.30	0.20	10.00	12.00
498	T-77 470A	469676.30	4979274.80	2.0	0.10	41.20	26.00	188.00	0.10	48.80	16.20	6.06	940.00	498.00	8800.00	0.34	8.40	0.40	0.20	1.00	10.00
499	T-77 471A	472721.02	4980528.60	2.0	0.10	40.60	36.00	194.00	0.10	47.40	14.80	5.48	880.00	164.00	8480.00	0.32	2.80	0.15	0.20	1.00	40.00
500	T-77 472A	465137.38	4981526.40	1.0	0.40	21.80	20.00	198.00	0.10	52.20	15.80	6.02	540.00	7700.00	9520.00	0.52	7.40	0.75	0.20	5.00	8.00
501	T-77 473A	461238.44	4978587.20	1.0	0.40	31.40	20.00	202.00	0.10	55.80	20.20	5.66	1020.00	368.00	9000.00	0.44	5.60	0.40	0.20	10.00	12.00
502	T-77 474A	459398.17	4973339.60	1.0	0.40	41.80	18.00	218.00	####	52.00	17.20	5.82	840.00	280.00	8200.00	0.48	10.40	0.60	0.20	3.00	36.00
503	T-77 475A	461026.34	4969390.30	1.0	0.40	34.40	16.00	234.00	0.10	51.00	20.20	5.72	720.00	344.00	7080.00	0.24	5.40	0.60	0.20	1.00	6.00
504	T-77 476A	452016.75	4957391.50	2.0	-99.00	346.00	206.00	226.00	####	109.60	90.60	7.18	6560.00	270.00	9680.00	-99.00	-99.00	-99.00	0.20	-99.00	-99.00
505	T-77 477A	452065.94	4960700.50	1.0	-99.00	50.00	216.00	200.00	####	57.80	16.00	5.90	980.00	158.00	7680.00	0.34	12.20	0.50	0.20	-99.00	-99.00
506	T-77 478A	456865.86	4966887.50	1.0	-99.00	41.80	20.00	200.00	####	46.60	16.40	5.24	960.00	70.00	7280.00	0.36	10.40	0.50	0.20	-99.00	-99.00
507	T-77 479A	452144.52	4965090.20	1.0	-99.00	54.40	24.00	128.00	####	53.60	18.40	6.00	1520.00	96.00	7900.00	0.30	4.00	0.65	0.20	-99.00	-99.00
508	T-77 480A	452450.82	4969624.80	2.0	-99.00	49.80	32.00	138.00	####	54.20	18.00	5.92	1020.00	364.00	8120.00	0.34	9.00	0.70	0.20	-99.00	-99.00
509	T-77 481A	454495.12	4972093.90	2.0	-99.00	46.60	22.00	164.00	####	49.40	18.20	5.62	1180.00	180.00	8140.00	0.32	7.60	0.60	0.20	-99.00	-99.00
510	T-77 485A	509079.39	5005081.80	1.0	0.10	270.00	152.00	194.00	0.10	141.60	87.40	7.10	21000.00	138.00	7240.00	-99.00	-99.00	-99.00	0.20	5.00	10.00
513	T-77 493A	507060.98	4987988.20	2.0	0.10	64.60	22.00	158.00	0.10	44.80	17.40	5.84	1920.00	48.00	7160.00	0.16	21.80	2.05	0.20	-99.00	-99.00
689	T-78 1A	403684.93	4995399.70	1.0	-99.00	40.00	16.80	98.00	####	41.60	12.60	5.20	560.00	3780.00	11540.00	0.20	9.20	3.00	1.10	-99.00	-99.00
690	T-78 2A	417577.34	4984859.50	1.0	-99.00	50.00	24.00	144.00	####	42.60	17.00	4.40	840.00	4300.00	8080.00	0.10	10.40	2.60	0.70	-99.00	-99.00
691	T-78 3A	403651.85	4985033.40	3.0	-99.00	46.00	14.40	72.00	####	59.80	22.80	5.40	800.00	700.00	3760.00	0.20	9.80	3.00	1.10	195.00	14.00
692	T-78 4A	408943.18	4988986.80	1.0	-99.00	42.00	17.60	100.00	####	38.80	14.20	4.00	520.00	4160.00	8760.00	0.20	7.60	3.00	0.80	-99.00	-99.00
693	T-78 5A	406154.85	4990000.50	2.0	-99.00	29.00	10.00	76.00	####	40.20	12.20	4.00	400.00	2860.00	10040.00	0.20	7.80	2.00	0.40	-99.00	-99.00
694	T-78 5B	406154.85	4990000.50	2.0	-99.00	40.00	21.20	112.00	####	46.00	19.60	4.00	440.00	7540.00	9520.00	0.20	-99.00	1.60	1.60	-99.00	-99.00
695	T-78 6A	412205.79	4989174.30	3.0	-99.00	38.00	20.40	108.00	####	35.60	16.00	3.60	600.00	6620.00	9540.00	0.20	8.40	2.80	0.60	100.00	10.00
696	T-78 7A	411573.82	4988016.40	2.0	-99.00	37.00	21.60	104.00	####	41.60	14.60	3.60	400.00	#####	8500.00	0.20	3.20	2.00	1.40	-99.00	-99.00
697	T-78 8A	417830.25	4994625.80	1.0	-99.00	38.00	24.00	140.00	####	41.20	14.00	4.80	500.00	5120.00	7800.00	0.20	9.40	3.60	1.10	215.00	14.00
698	T-78 9A	410596.20	4989924.50	3.0	-99.00	32.00	17.20	106.00	####	38.40	15.40	2.20	500.00	4380.00	7980.00	0.10	6.40	3.00	0.60	25.00	10.00
699	T-78 10A	415463.56	4989313.60	2.0	-99.00	28.00	23.60	110.00	####	43.20	16.80	4.20	600.00	6560.00	8360.00	0.20	5.40	3.60	0.10	18.00	12.00
700	T-78 11A	407968.43	5000979.70	1.0	-99.00	38.00	20.40	110.00	####	38.40	15.80	4.00	620.00	8760.00	7780.00	0.20	6.40	3.40	1.00	-99.00	-99.00
701	T-78 12A	418376.09	4986306.90	9.0	-99.00	37.00	21.20	120.00	####	47.00	19.80	4.20	620.00	7780.00	8440.00	0.20	3.60	2.80	1.10	13.00	20.00
702	T-78 13A	408919.37	5004462.70	5.0	-99.00	31.00	21.20	126.00	####	47.00	20.00	4.00	800.00	#####	10340.00	0.20	-99.00	2.40	1.20	3.00	16.00
703	T-78 14A	410854.78	5005648.60	0.0	-99.00	27.00	16.40	112.00	####	50.60	15.60	4.80	960.00	640.00	7880.00	0.20	5.40	3.00	1.90	-99.00	-99.00

TILLCD	SAMPLENO	UTME	UTMN	DEPTH	Ag	Cu	Pb	Zn	Cd	Ni	Co	Fe	Mn	Ca	Mg	Hg	As	Mb	U	Sn	W
704	T-78 15A	412769.36	5006686.40	0.0	-99.00	51.00	20.40	160.00	####	49.60	15.40	5.00	800.00	980.00	7820.00	0.20	9.00	1.80	0.60	-99.00	-99.00
705	T-78 16A	416222.81	5007749.80	1.0	-99.00	34.00	24.00	130.00	####	44.20	19.60	4.40	1400.00	3540.00	7780.00	0.20	-99.00	2.20	1.30	1.00	20.00
706	T-78 17A	433663.39	5002890.30	1.0	-99.00	58.00	31.60	170.00	####	48.00	18.60	5.00	1000.00	560.00	4940.00	0.10	4.20	2.40	0.10	3.00	14.00
707	T-78 18A	435453.37	5002030.80	1.0	-99.00	41.00	19.60	120.00	####	49.80	17.60	5.40	700.00	1560.00	5660.00	0.10	3.20	1.20	0.10	1.00	80.00
708	T-78 19A	432286.19	4998203.00	1.0	-99.00	117.00	105.20	218.00	####	54.80	27.40	5.80	2500.00	20.00	4620.00	-99.00	-99.00	2.00	1.30	1.00	14.00
709	T-78 20A	438066.00	5003991.20	1.0	-99.00	16.00	16.00	90.00	####	46.40	17.80	5.00	300.00	1800.00	4180.00	0.10	4.80	0.80	0.80	1.00	10.00
710	T-78 21A	425842.28	5002642.40	2.0	-99.00	62.00	36.00	150.00	####	47.20	18.80	5.60	600.00	1800.00	4220.00	0.20	5.40	0.80	0.70	1.00	12.00
711	T-78 22A	432645.59	4985999.20	2.0	-99.00	70.00	22.80	120.00	####	46.00	28.40	5.00	500.00	280.00	4900.00	0.30	3.00	4.20	2.60	-99.00	-99.00
712	T-78 22B	432645.59	4985999.20	2.0	-99.00	72.00	16.20	210.00	####	272.00	38.40	4.60	2100.00	1740.00	6040.00	0.20	7.20	5.60	1.40	-99.00	-99.00
713	T-78 23A	429840.12	4984089.60	1.0	-99.00	68.00	38.00	110.00	####	23.40	5.80	8.00	100.00	60.00	3300.00	0.30	19.00	21.60	3.90	1.00	8.00
714	T-78 24A	425598.09	4984617.60	3.0	-99.00	140.00	368.00	184.00	####	84.80	21.20	14.00	1000.00	1220.00	3700.00	-99.00	-99.00	-99.00	1.00	12.00	
715	T-78 25A	434889.97	4991747.50	2.0	-99.00	34.00	28.00	140.00	####	51.60	14.80	4.80	700.00	2680.00	6600.00	0.10	4.80	3.20	0.70	1.00	24.00
716	T-78 26A	423610.25	4989728.50	2.0	-99.00	38.00	31.60	130.00	####	53.00	15.80	5.20	800.00	2780.00	7300.00	0.20	7.20	2.40	0.80	1.00	10.00
717	T-78 27A	425819.04	4988300.30	2.0	-99.00	30.00	28.00	130.00	####	47.00	13.20	4.80	300.00	5180.00	7920.00	0.10	6.60	3.60	1.20	8.00	28.00
718	T-78 28A	443674.27	4991243.80	2.0	-99.00	43.00	31.60	120.00	####	51.80	17.60	4.40	1200.00	280.00	5900.00	0.20	4.80	2.80	0.90	20.00	10.00
719	T-78 29A	443642.05	4984031.70	2.0	-99.00	48.00	32.80	140.00	####	56.00	18.80	5.20	800.00	760.00	7000.00	0.10	9.80	3.60	2.00	-99.00	-99.00
720	T-78 30A	448783.46	4991953.90	2.0	-99.00	74.00	40.00	150.00	####	30.00	20.00	4.00	2300.00	320.00	5840.00	0.30	-99.00	3.60	1.00	1.00	8.00
721	T-78 31A	451552.27	4991301.20	1.0	-99.00	56.00	33.20	124.00	####	48.80	18.40	4.80	1000.00	180.00	6880.00	0.20	5.40	2.40	0.80	5.00	8.00
722	T-78 32A	453099.97	4988640.00	2.0	-99.00	38.00	26.40	120.00	####	48.00	15.80	4.80	640.00	2000.00	7100.00	0.20	3.60	1.60	1.10	5.00	14.00
723	T-78 33A	443287.14	5000527.20	2.0	-99.00	34.00	28.00	120.00	####	53.20	18.00	5.20	520.00	4020.00	7920.00	0.20	4.60	1.00	0.60	3.00	20.00
724	T-78 34A	441642.47	5008361.30	2.0	-99.00	56.00	27.20	104.00	####	46.20	15.20	5.00	600.00	380.00	7600.00	0.10	-99.00	2.20	1.10	3.00	14.00
725	T-78 35A	445926.07	5001647.40	1.0	-99.00	20.00	24.80	82.00	####	41.60	12.60	3.80	300.00	160.00	6540.00	0.30	-99.00	2.40	1.60	8.00	8.00
726	T-78 36A	447567.62	5001047.00	2.0	-99.00	28.00	26.00	130.00	####	46.40	14.00	4.20	440.00	240.00	7800.00	0.20	4.00	3.60	0.80	3.00	10.00
727	T-78 37A	447733.53	4997901.60	2.0	-99.00	60.00	34.40	70.00	####	56.00	61.80	5.80	5400.00	160.00	2900.00	-99.00	-99.00	-99.00	-99.00	1.00	16.00
728	T-78 38A	453419.75	4995855.50	2.0	-99.00	38.00	26.00	12.00	####	31.60	20.20	4.80	900.00	1740.00	7040.00	0.10	12.80	3.20	0.80	1.00	16.00
729	T-78 39A	456934.52	4997276.00	1.0	-99.00	33.00	23.20	10.00	####	43.00	13.60	4.40	600.00	2060.00	7320.00	0.10	5.40	1.20	0.60	1.00	10.00
730	T-78 40A	457222.19	5002388.90	2.0	-99.00	30.00	19.20	90.00	####	53.00	15.20	4.40	600.00	1040.00	7100.00	0.10	5.00	2.80	1.00	-99.00	-99.00
731	T-78 41A	456063.21	5005801.90	2.0	-99.00	38.00	30.00	126.00	####	49.60	15.40	4.80	640.00	1500.00	8200.00	0.20	6.40	2.40	0.60	1.00	300.00
732	T-78 42A	452293.29	5007983.30	2.0	-99.00	32.00	25.60	100.00	####	44.00	15.20	4.20	540.00	920.00	6720.00	0.10	-99.00	1.80	0.60	1.00	50.00
733	T-78 43A	444572.94	5006529.60	4.0	-99.00	50.00	28.80	120.00	####	50.60	18.20	4.80	600.00	1520.00	8200.00	0.10	3.20	2.00	1.60	1.00	36.00
734	T-78 44A	444608.89	5009294.60	2.0	-99.00	30.00	25.60	90.00	####	43.80	16.00	4.20	640.00	200.00	6700.00	0.10	5.80	3.40	0.70	1.00	12.00
735	T-78 45A	449688.10	5005590.40	3.0	-99.00	36.00	30.00	130.00	####	44.00	15.20	4.40	700.00	3100.00	9180.00	0.10	4.60	2.40	0.80	1.00	14.00
736	T-78 46A	456820.20	4989925.80	9.0	-99.00	30.00	37.20	120.00	####	53.60	18.20	4.80	200.00	7140.00	10600.00	0.10	4.80	2.80	1.60	1.00	20.00
737	T-78 47A	439216.89	4992634.60	3.0	-99.00	58.00	39.20	120.00	####	57.00	15.40	4.40	800.00	3340.00	7160.00	-99.00	-99.00	4.00	-99.00	1.00	16.00
738	T-78 48A	457234.45	4984421.70	1.0	-99.00	36.00	21.60	110.00	####	49.20	18.00	4.80	500.00	1040.00	7300.00	0.20	4.20	3.20	0.60	4.00	20.00
739	T-78 49A	443121.57	4978858.20	3.0	-99.00	44.00	32.00	250.00	####	50.00	19.00	5.20	1000.00	2440.00	9360.00	0.20	3.00	3.20	2.10	5.00	16.00

TILLCD	SAMPLENO	UTME	UTMN	DEPTF	Ag	Cu	Pb	Zn	Cd	Ni	Co	Fe	Mn	Ca	Mg	Hg	As	Mb	U	Sn	W
740	T-78 50A	438909.61	4974394.40	2.0	-99.00	60.00	37.60	130.00	####	56.40	16.80	5.20	400.00	120.00	8000.00	0.30	-99.00	3.80	2.10	4.00	16.00
741	T-78 51A	436363.03	4974766.90	1.0	-99.00	56.00	52.00	110.00	####	82.20	23.20	5.40	500.00	320.00	6560.00	-99.00	-99.00	-99.00	2.70	-99.00	-99.00
742	T-78 52A	431186.82	4978942.20	1.0	-99.00	84.00	24.00	140.00	####	69.80	27.60	5.00	1300.00	580.00	9000.00	0.10	4.80	3.60	2.10	1.00	16.00
743	T-78 53A	429659.68	4979511.00	3.0	-99.00	86.00	24.00	140.00	####	59.40	21.00	4.80	1400.00	1520.00	8760.00	0.20	3.80	3.00	1.70	3.00	20.00
744	T-78 54A	425102.13	4979553.80	3.0	-99.00	116.00	34.40	130.00	####	65.60	33.00	5.80	2400.00	180.00	6960.00	0.20	8.80	7.00	2.90	3.00	28.00
745	T-78 56A	443629.44	4958079.40	2.0	-99.00	44.00	24.00	140.00	####	67.20	16.20	4.80	800.00	1080.00	8860.00	-99.00	-99.00	-99.00	-99.00	3.00	300.00
747	T-78 58A	428933.52	4972069.80	1.0	-99.00	68.00	40.00	160.00	####	68.20	21.60	5.40	1200.00	160.00	9900.00	0.10	-99.00	4.80	1.60	4.00	32.00
748	T-78 59A	424860.87	4974320.50	2.0	-99.00	130.00	86.00	270.00	####	81.20	28.20	6.40	1500.00	240.00	18600.00	-99.00	-99.00	-99.00	5.20	5.00	50.00
749	T-78 60A	421316.63	4976832.90	2.0	-99.00	50.00	26.00	60.00	####	18.80	7.40	7.20	140.00	160.00	3300.00	0.20	10.20	13.40	2.40	1.00	8.00
750	T-78 61A	444245.23	4970120.80	1.0	-99.00	76.00	44.00	130.00	####	62.20	23.00	5.00	900.00	100.00	7200.00	0.20	3.20	1.80	2.10	1.00	28.00
751	T-78 62A	422366.15	4978851.00	2.0	-99.00	46.00	30.00	124.00	####	47.20	17.60	4.80	800.00	5240.00	8320.00	1.90	3.80	1.80	1.10	5.00	24.00
752	T-78 63A	417053.48	4979291.00	1.0	-99.00	38.00	27.20	130.00	####	56.80	17.60	4.80	700.00	2320.00	9260.00	0.10	3.80	2.00	0.60	3.00	40.00
753	T-78 64A	416240.79	4979032.70	5.0	-99.00	16.00	27.60	120.00	####	42.20	14.80	4.00	120.00	2260.00	7300.00	0.20	4.40	1.80	1.30	-99.00	-99.00
754	T-78 65A	407032.95	4976027.80	2.0	-99.00	30.00	55.60	300.00	####	45.80	18.00	5.80	1500.00	2280.00	12040.00	-99.00	-99.00	6.00	-99.00	8.00	6.00
760	T-78 71A	446364.03	4964888.10	2.0	-99.00	64.00	28.80	160.00	####	50.00	15.80	5.00	600.00	700.00	7680.00	0.30	3.40	2.40	1.40	8.00	20.00
761	T-78 72A	445669.10	4962817.70	1.0	-99.00	120.00	56.00	180.00	####	63.60	26.00	12.00	600.00	80.00	4000.00	-99.00	-99.00	21.60	5.70	5.00	16.00
762	T-78 74A	445684.74	4951728.50	1.0	-99.00	172.00	160.00	290.00	####	90.00	50.00	5.20	1400.00	1048.00	7340.00	-99.00	-99.00	4.60	-99.00	1.00	16.00
763	T-78 76A	440518.15	4953722.70	3.0	-99.00	76.00	24.80	200.00	####	64.00	21.60	6.20	700.00	3780.00	13700.00	0.20	3.20	4.80	2.40	-99.00	-99.00
764	T-78 77A	435881.04	4954759.20	2.0	-99.00	66.00	28.00	190.00	####	60.00	28.20	5.00	1100.00	600.00	12500.00	0.20	5.00	7.20	3.60	3.00	16.00
765	T-78 78A	434431.07	4955508.10	2.0	-99.00	56.00	26.00	170.00	####	52.00	19.20	4.60	800.00	1080.00	12220.00	0.30	3.40	4.80	2.00	5.00	16.00
766	T-78 79A	432081.31	4956697.80	1.0	-99.00	30.00	100.00	170.00	####	40.00	32.00	3.00	1500.00	2400.00	480.00	-99.00	-99.00	8.80	4.20	6.00	28.00
767	T-78 80A	431675.02	4956003.30	1.0	-99.00	10.00	54.40	174.00	####	37.80	14.40	5.00	1000.00	320.00	500.00	-99.00	-99.00	-99.00	10.30	10.00	28.00
792	T-78 104A	442019.09	4960621.00	1.0	-99.00	56.00	34.40	170.00	####	58.80	18.60	4.60	600.00	2780.00	9300.00	0.20	2.80	4.00	1.10	1.00	12.00
793	T-78 105A	436283.25	4968485.20	1.0	-99.00	150.00	140.00	150.00	####	65.40	23.40	8.40	900.00	180.00	11720.00	0.60	-99.00	13.00	-99.00	8.00	14.00
794	T-78 106A	434934.84	4970453.00	1.0	-99.00	106.00	48.00	210.00	####	81.40	29.60	7.00	1200.00	700.00	17200.00	0.40	2.60	3.40	2.40	3.00	24.00
796	T-78 108A	430592.86	4973848.10	1.0	-99.00	98.00	34.80	180.00	####	71.60	27.20	6.00	1300.00	440.00	12400.00	0.20	8.80	2.40	3.40	4.00	24.00
804	T-78 117A	398434.18	4994920.30	2.0	-99.00	220.00	9.60	72.00	####	47.40	34.00	5.40	460.00	#####	22800.00	0.10	2.80	3.00	1.90	6.00	16.00
805	T-78 118A	398078.97	4992296.90	2.0	-99.00	80.00	29.20	72.00	####	59.80	41.20	4.40	3800.00	500.00	6600.00	0.50	-99.00	2.40	-99.00	8.00	14.00
806	T-78 119A	398140.05	4987250.20	1.0	-99.00	48.00	15.60	40.00	####	29.60	18.00	3.20	900.00	480.00	3340.00	0.30	3.00	3.00	2.20	5.00	28.00
807	T-78 120A	395648.34	4985209.20	1.0	-99.00	60.00	18.40	78.00	####	38.20	18.00	4.20	700.00	5400.00	9780.00	0.10	2.40	2.80	1.10	3.00	16.00
808	T-78 121A	393501.12	4989775.00	1.0	-99.00	46.00	16.80	80.00	####	38.00	16.60	4.00	580.00	5000.00	10200.00	0.10	2.60	2.00	1.10	5.00	14.00
809	T-78 123A	389918.46	4983493.10	1.0	-99.00	70.00	19.00	108.00	####	43.00	22.00	5.35	1450.00	4240.00	9800.00	-99.00	64.00	3.00	1.90	-99.00	-99.00
812	T-78 126A	401118.18	4986018.80	1.0	-99.00	50.00	14.80	70.00	####	37.40	16.00	4.80	580.00	2840.00	7460.00	0.20	2.80	3.20	2.90	1.00	12.00
813	T-78 127A	392198.13	4992367.10	2.0	-99.00	50.00	15.20	70.00	####	34.20	15.00	4.00	500.00	4020.00	9740.00	0.20	2.00	1.60	1.30	1.00	28.00
814	T-78 128A	407966.30	4981978.60	2.0	-99.00	44.00	26.40	90.00	####	38.20	19.00	5.00	3600.00	480.00	6340.00	0.20	1.80	3.00	1.90	-99.00	-99.00
815	T-78 129A	411327.42	4978661.20	2.0	-99.00	42.00	22.00	104.00	####	44.00	16.40	4.20	400.00	#####	8520.00	0.10	2.80	2.20	1.30	1.00	10.00

TILLCD	SAMPLENO	UTME	UTMN	DEPT	Ag	Cu	Pb	Zn	Cd	Ni	Co	Fe	Mn	Ca	Mg	Hg	As	Mb	U	Sn	W
816	T-78 130A	414181.15	4973443.70	1.0	-99.00	60.00	40.80	200.00	####	42.80	20.20	4.60	600.00	2440.00	10500.00	0.10	2.40	3.20	1.80	5.00	10.00
820	T-78 134A	402093.51	4978077.00	1.0	-99.00	32.00	22.00	110.00	####	53.40	19.00	4.60	1000.00	3860.00	8400.00	0.10	3.00	2.80	2.90	1.00	50.00
834	T-78 149A	384943.72	4982814.10	3.0	-99.00	68.00	14.00	82.00	####	34.00	15.00	4.45	860.00	4780.00	10020.00	115.00	23.00	2.00	1.20	-99.00	-99.00
864	T-78 186A	449079.52	4945494.40	1.0	-99.00	128.00	72.40	196.00	####	73.20	50.00	3.80	1280.00	1220.00	9180.00	0.40	-99.00	3.20	4.70	-99.00	-99.00
1643	T-83-00078	427946.19	5013080.90	0.0	0.05	25.00	19.00	84.00	0.10	36.00	15.00	3.30	795.00	2100.00	7700.00	-99.00	16.00	0.50	0.80	10.00	8.00
1644	T-83-00079	430177.06	5013893.70	0.0	0.05	22.00	16.00	67.00	0.10	24.00	10.00	2.80	530.00	#####	8800.00	-99.00	13.00	0.50	0.80	15.00	4.00
1645	T-83-00082	432101.45	5012515.00	0.0	0.05	28.00	17.00	85.00	0.10	34.00	13.00	3.40	650.00	#####	9800.00	-99.00	15.00	0.50	0.90	10.00	8.00
1646	T-83-00083	432101.45	5012515.00	2.0	0.05	37.00	18.00	83.00	0.10	37.00	15.00	3.30	550.00	3700.00	7200.00	-99.00	14.00	0.50	0.30	10.00	8.00
1647	T-83-00084	432101.45	5012515.00	0.0	0.05	20.00	11.00	63.00	0.30	29.00	13.00	3.90	550.00	200.00	9800.00	-99.00	10.00	1.00	1.10	10.00	12.00
1648	T-83-00085	435163.91	5013823.90	0.0	0.05	27.00	11.00	99.00	0.10	32.00	13.00	3.60	750.00	1300.00	6900.00	-99.00	13.00	0.50	0.80	15.00	16.00
1649	T-83-00086	436723.33	5015933.50	0.0	0.05	30.00	19.00	85.00	0.10	33.00	12.00	3.20	910.00	2000.00	8400.00	-99.00	14.00	0.50	1.00	10.00	8.00
1652	T-83-00089	442164.56	5014201.50	0.0	0.05	39.00	28.00	94.00	0.10	46.00	23.00	4.20	1700.00	1900.00	8000.00	-99.00	22.00	0.50	3.20	15.00	4.00
1653	T-83-00090	443863.79	5012817.50	0.0	0.05	28.00	17.00	89.00	0.10	37.00	15.00	3.30	640.00	500.00	10200.00	-99.00	17.00	1.00	0.80	5.00	2.00
1654	T-83-00091	444953.13	5015835.40	0.0	0.05	33.00	16.00	92.00	0.10	40.00	15.00	3.60	800.00	1100.00	7800.00	-99.00	10.00	1.00	1.10	10.00	4.00
1655	T-83-00092	447970.80	5011091.40	0.0	0.05	29.00	21.00	86.00	0.10	38.00	15.00	3.40	505.00	400.00	10200.00	-99.00	16.00	0.50	1.30	25.00	8.00
1656	T-83-00093	448790.64	5016780.80	0.0	0.05	25.00	12.00	79.00	0.30	38.00	15.00	3.70	620.00	200.00	7700.00	-99.00	16.00	0.50	0.80	5.00	1.00
1657	T-83-00094	446293.45	5014656.20	0.0	0.05	40.00	23.00	105.00	1.10	34.00	17.00	3.90	1650.00	400.00	6300.00	-99.00	14.00	1.00	0.80	60.00	12.00
1662	T-83-00100	453784.20	5014107.00	0.0	0.05	40.00	30.00	106.00	0.10	34.00	15.00	3.70	910.00	100.00	7800.00	-99.00	17.00	0.50	1.10	10.00	2.00
1663	T-83-00102	452048.75	5018078.40	0.0	0.05	32.00	24.00	100.00	1.60	33.00	13.00	3.30	850.00	2700.00	8400.00	-99.00	13.00	1.00	1.10	10.00	2.00
1667	T-83-00106	453238.46	5017839.50	0.0	0.05	26.00	20.00	86.00	0.60	33.00	14.00	3.20	820.00	#####	9200.00	-99.00	11.00	1.00	1.10	15.00	8.00
1668	T-83-00107	453238.46	5017839.50	3.0	0.05	28.00	25.00	79.00	0.10	28.00	12.00	3.30	945.00	2600.00	7300.00	-99.00	12.00	0.50	1.10	10.00	12.00
1669	T-83-00108	453238.46	5017839.50	1.0	0.05	34.00	36.00	91.00	0.10	29.00	14.00	3.30	1400.00	500.00	5800.00	-99.00	22.00	0.50	1.80	5.00	8.00
1670	T-83-00110	455116.74	5017960.30	0.0	0.05	35.00	30.00	128.00	0.60	32.00	15.00	3.40	1500.00	3200.00	7500.00	-99.00	18.00	0.50	1.10	10.00	8.00
1671	T-83-00111	458349.40	5016885.00	0.0	0.05	38.00	31.00	110.00	0.50	36.00	18.00	3.00	1500.00	200.00	7300.00	-99.00	16.00	1.00	1.50	10.00	8.00
1672	T-83-00112	459866.21	5015244.30	0.0	0.05	45.00	32.00	145.00	0.60	37.00	17.00	3.60	950.00	2000.00	8500.00	-99.00	11.00	1.00	0.80	10.00	12.00
1673	T-83-00113	458342.13	5010780.30	0.0	0.05	29.00	18.00	81.00	0.90	27.00	13.00	2.90	575.00	800.00	7300.00	-99.00	13.00	1.00	1.10	15.00	16.00
1747	T-83-00209	467109.93	5019185.20	2.5	0.05	27.00	24.00	108.00	0.10	32.00	13.00	3.10	650.00	6200.00	8200.00	-99.00	10.00	0.50	1.50	40.00	4.00
1748	T-83-00210	464167.09	5013092.00	4.0	0.05	12.00	6.00	56.00	0.10	26.00	9.00	2.20	460.00	#####	19400.00	-99.00	8.00	1.00	1.00	25.00	2.00
1771	T-83-00256	468882.30	5020386.00	2.0	0.05	47.00	42.00	157.00	0.10	33.00	15.00	3.60	730.00	1400.00	8800.00	-99.00	6.00	1.00	1.50	30.00	8.00
1772	T-83-00257	469460.24	5017566.90	1.0	0.05	41.00	34.00	125.00	0.10	34.00	15.00	3.50	1350.00	200.00	7200.00	-99.00	16.00	0.50	1.10	5.00	16.00
1773	T-83-00258	473221.19	5014198.20	1.0	0.05	45.00	20.00	94.00	0.10	39.00	17.00	3.60	600.00	1100.00	13200.00	-99.00	4.00	1.00	1.00	5.00	16.00
1774	T-83-00259	463146.17	5017741.70	3.5	0.05	22.00	15.00	77.00	3.10	29.00	12.00	3.00	835.00	8000.00	7600.00	-99.00	2.00	0.50	1.50	1.00	16.00
1775	T-83-00260	462656.25	5016150.40	2.0	0.05	30.00	25.00	105.00	0.50	36.00	14.00	3.00	930.00	2300.00	8100.00	-99.00	4.00	0.50	2.30	3.00	4.00
1783	T-83-00269	477353.76	5014878.60	1.0	0.10	38.00	20.00	107.00	0.10	32.00	14.00	3.20	910.00	1300.00	6700.00	-99.00	7.00	1.00	1.70	5.00	8.00
1784	T-83-00270	478755.51	5018018.80	2.0	0.10	24.00	12.00	80.00	0.10	34.00	15.00	3.10	970.00	1300.00	7400.00	-99.00	7.00	0.50	1.20	35.00	4.00
1785	T-83-00271	479182.54	5020348.10	3.0	0.10	27.00	14.00	83.00	0.10	31.00	14.00	3.20	800.00	4400.00	8800.00	-99.00	7.00	1.00	1.30	10.00	2.00

TILLCD	SAMPLENO	UTME	UTMN	DEPT	Ag	Cu	Pb	Zn	Cd	Ni	Co	Fe	Mn	Ca	Mg	Hg	As	Mb	U	Sn	W
1786	T-83-00272	479620.18	5021453.20	1.0	0.10	31.00	13.00	72.00	0.10	27.00	11.00	3.20	1550.00	300.00	6700.00	-99.00	5.00	0.50	1.70	5.00	4.00
1787	T-83-00273	489618.15	5017370.60	1.0	0.10	48.00	12.00	96.00	2.80	29.00	21.00	4.70	1850.00	50.00	5000.00	-99.00	1.30	0.50	10.00	5.00	2.00
1788	T-83-00274	486736.35	5015778.40	1.0	0.05	37.00	15.00	98.00	0.10	33.00	14.00	3.40	830.00	1600.00	6900.00	-99.00	8.00	0.50	0.30	5.00	450.00
1789	T-83-00275	484391.01	5018272.30	1.0	0.05	14.00	13.00	52.00	0.10	31.00	23.00	3.10	4300.00	200.00	6700.00	-99.00	12.00	0.50	0.70	1.00	4.00
1790	T-83-00276	485450.30	5012651.80	1.0	0.05	154.00	96.00	40.00	1.70	22.00	31.00	3.50	5050.00	100.00	2700.00	-99.00	15.00	0.50	1.50	5.00	12.00
1791	T-83-00278	481650.07	5012044.00	1.0	0.05	31.00	16.00	63.00	6.10	35.00	18.00	3.60	2500.00	700.00	6200.00	-99.00	18.00	0.50	0.70	10.00	2.00
1792	T-83-00279	486770.99	5023326.10	1.5	0.05	20.00	11.00	90.00	0.30	37.00	1818.00	3.20	1600.00	300.00	7500.00	-99.00	10.00	0.50	0.70	-99.00	480.00
1793	T-83-00280	493029.17	5019072.30	1.0	0.05	47.00	12.00	77.00	0.30	38.00	24.00	3.80	1300.00	50.00	5000.00	-99.00	11.00	1.00	1.70	5.00	4.00
1794	T-83-00282	492848.83	5015526.40	2.5	0.20	57.00	38.00	84.00	1.70	30.00	16.00	5.60	2150.00	50.00	3300.00	-99.00	23.00	2.00	2.50	5.00	4.00
1795	T-83-00283	490442.72	5013685.40	1.5	0.10	42.00	10.00	59.00	0.60	33.00	17.00	3.50	2700.00	50.00	4000.00	-99.00	16.00	0.50	1.70	5.00	2.00
1796	T-83-00284	495895.13	5020336.20	1.0	0.05	42.00	13.00	113.00	3.40	37.00	30.00	4.50	1300.00	50.00	5200.00	-99.00	14.00	1.00	3.10	5.00	1.00
1797	T-83-00285	498762.21	5017241.10	1.0	0.05	59.00	54.00	120.00	0.70	40.00	18.00	4.40	4050.00	100.00	3600.00	-99.00	30.00	1.00	3.30	1.00	2.00
1798	T-83-00286	499039.92	5013400.60	2.0	0.05	36.00	13.00	77.00	0.10	37.00	20.00	3.50	1350.00	900.00	6000.00	-99.00	12.00	0.50	1.00	15.00	4.00
1799	T-83-00287	501975.90	5015775.90	1.5	0.05	32.00	18.00	105.00	0.20	44.00	22.00	3.50	1200.00	1700.00	8000.00	-99.00	12.00	0.50	1.00	5.00	1.00
1803	T-83-00292	505096.41	5012081.70	1.0	0.10	54.00	20.00	76.00	0.20	35.00	13.00	3.30	1050.00	1200.00	8300.00	-99.00	12.00	0.50	1.80	5.00	2.00
1804	T-83-00293	508583.67	5013857.30	2.0	0.05	32.00	22.00	101.00	0.10	38.00	18.00	3.80	1200.00	3800.00	7200.00	-99.00	10.00	0.50	1.20	5.00	1.00
1805	T-83-00294	511024.88	5022169.80	1.5	0.05	50.00	30.00	132.00	4.20	56.00	25.00	4.30	2750.00	50.00	4600.00	-99.00	15.00	2.00	2.30	-99.00	-99.00
1806	T-83-00296	510653.73	5019771.70	3.0	0.05	62.00	31.00	152.00	1.30	42.00	26.00	5.00	5000.00	50.00	3400.00	-99.00	29.00	0.50	1.60	5.00	4.00
1812	T-83-00303	507001.78	5023662.70	1.0	0.05	48.00	19.00	101.00	0.30	53.00	22.00	4.60	2400.00	50.00	3900.00	-99.00	32.00	1.00	2.80	1.00	1.00
1813	T-83-00304	505092.17	5019288.20	1.0	0.05	48.00	20.00	102.00	1.70	38.00	13.00	4.00	1300.00	100.00	5400.00	-99.00	20.00	0.50	1.50	5.00	2.00
1814	T-83-00305	503360.43	5017574.00	1.0	0.05	49.00	18.00	110.00	0.30	33.00	17.00	3.70	1300.00	100.00	5600.00	-99.00	16.00	0.50	2.00	1.00	2.00
1815	T-83-00306	510038.67	5012329.80	1.0	1.70	34.00	19.00	105.00	0.30	33.00	15.00	3.40	1225.00	300.00	7500.00	-99.00	17.00	0.50	2.00	5.00	2.00
1816	T-83-00307	514172.08	5013477.50	1.0	0.20	57.00	17.00	101.00	0.10	35.00	14.00	4.00	890.00	300.00	7100.00	-99.00	13.00	0.50	1.50	5.00	1.00
1817	T-83-00308	515703.39	5015924.00	1.0	0.10	120.00	373.00	928.00	15.00	53.00	28.00	4.40	1650.00	200.00	11200.00	-99.00	15.00	2.00	2.50	1.00	110.00
1818	T-83-00309	518674.81	5015739.90	1.5	0.05	87.00	121.00	325.00	0.40	40.00	20.00	3.80	1650.00	400.00	11300.00	-99.00	12.00	1.00	5.80	5.00	1.00
1819	T-83-00310	518534.85	5018275.80	1.0	0.05	53.00	24.00	117.00	0.40	52.00	22.00	5.30	3150.00	100.00	4100.00	-99.00	33.00	2.00	3.30	1.00	1.00
1820	T-83-00311	518344.37	5024211.00	1.0	0.05	49.00	16.00	83.00	0.10	41.00	26.00	4.60	1900.00	50.00	2800.00	-99.00	42.00	2.00	2.20	1.00	1.00
1852	T-83-00349	485477.28	5024714.30	1.0	0.05	14.00	13.00	73.00	0.10	19.00	8.00	2.40	815.00	600.00	5400.00	-99.00	11.00	0.50	1.20	10.00	16.00
1946	T-84-00089	523134.50	5022879.10	1.0	0.10	27.00	17.00	117.00	0.10	46.00	20.00	3.10	500.00	90.00	5650.00	0.00	39.00	2.00	2.30	4.00	6.00
1947	T-84-00090	523386.65	5021200.30	1.0	0.50	75.00	30.00	112.00	0.10	55.00	32.00	3.40	3750.00	90.00	4950.00	0.00	36.00	2.00	2.30	4.00	6.00
1948	T-84-00091	526538.83	5024447.90	1.0	0.05	59.00	26.00	120.00	0.20	51.00	20.00	3.20	1300.00	850.00	7300.00	0.00	24.00	2.00	0.60	0.00	0.00
1953	T-84-00096	531693.26	5014830.80	1.0	0.10	63.00	61.00	370.00	0.20	42.00	17.00	2.80	1550.00	60.00	5900.00	0.00	32.00	2.00	1.60	5.00	6.00
1956	T-84-00099	524737.14	5014433.10	1.0	0.10	53.00	108.00	270.00	0.10	44.00	21.00	2.70	1425.00	160.00	6950.00	0.00	25.00	2.00	3.10	5.00	1.00
1957	T-84-00100	520743.92	5012671.30	1.5	0.10	40.00	58.00	240.00	0.10	38.00	17.00	2.60	1250.00	500.00	7500.00	0.00	18.00	2.00	5.40	6.00	4.00
1958	T-84-00102	524539.82	5017380.80	1.0	0.40	73.00	14.00	70.00	0.10	41.00	26.00	3.10	2250.00	70.00	4750.00	0.00	30.00	3.00	1.70	5.00	6.00
1960	T-84-00104	520810.86	5019975.90	1.0	0.05	42.00	20.00	116.00	0.10	47.00	18.00	3.00	900.00	630.00	6800.00	0.00	17.00	1.00	1.30	10.00	6.00

TILLCD	SAMPLENO	UTME	UTMN	DEPT	Ag	Cu	Pb	Zn	Cd	Ni	Co	Fe	Mn	Ca	Mg	Hg	As	Mb	U	Sn	W
1971	T-84-00116	527105.37	5014498.40	1.0	0.05	19.00	64.00	220.00	0.10	27.00	21.00	4.30	2700.00	760.00	9600.00	0.00	23.00	1.00	4.40	7.00	2.00
1972	T-84-00117	527105.33	5014506.20	2.0	0.05	41.00	33.00	166.00	0.30	47.00	19.00	3.80	1005.00	780.00	6600.00	0.00	18.00	0.50	1.10	25.00	6.00
1973	T-84-00118	531297.77	5010595.00	1.0	0.05	32.00	39.00	176.00	0.20	33.00	18.00	2.70	1375.00	480.00	5400.00	0.00	14.00	1.00	11.40	8.00	1.00
1975	T-84-00120	531289.91	5010599.40	1.0	0.05	35.00	41.00	182.00	0.20	40.00	17.00	2.70	1500.00	580.00	6100.00	0.00	10.00	1.00	11.30	7.00	2.00
2100	T-85-00094	531347.56	5019539.50	2.0	0.05	84.00	53.00	398.00	0.20	41.00	22.00	5.30	4400.00	1350.00	20000.00	0.00	9.00	1.00	0.10	0.00	0.00
2101	T-85-00096	531337.30	5019555.00	0.0	0.05	41.00	23.00	152.00	0.20	42.00	17.00	3.40	990.00	2790.00	10520.00	0.00	14.00	0.50	0.50	0.00	0.00

APPENDIX C – THIN SECTION DESCRIPTION

DF-1

- fine grained, melanocratic rock with sub cm scale close-tight fold defined by garnet concentration
- 60% garnet, euhedral, fine-grained, high relief, cores of garnet often anisotropic surrounded by slightly lighter rims and birefringent particles
- 25% very fine grained granular quartz
- 15% opaues and moderately birefringent mica? Both granular and anhedral
- lighter bands composed of some high birefringence minerals

EL – 1

- 38% garnet
- 10% ilmenite
- 50% matrix
- 2% miscellaneous

Area 1:

- very fine matrix dominated by porphyroblasts of garnet
- also large quantity of ilmenite – roughly ½ the size of the garnet
- ilmenite in N/S orientation
- matrix too small to see under microscope
- some ilmenites surrounded by garnet
- matrix wrapped around phophyrobasts of garnet
- some garnets appear polymictic (ie. lots together)
- green/brown slightly pleochroic matrix
- smaller ilmenites have bladed structure, larger ilmenites less well shaped more blobby

Area 2:

- bands of lighter (more quartz rich?) matrix, highly deformed
- concentration of larger ilmenites
- large amount of brown, pleochroic mineral (resembles iron staining, possibly biotite)
- smaller garnets in this area of the slide
- banding of Area 1 and Area 2 occurs a few times
- other notable feature is blebs/boundain looking pinch out structures
- completely isotropic in crossed-nichols

Area 3:

- matrix have some more birefringent minerals, less isotropic
- surrounding pinch out blebs = higher birefringent minerals

Area 4:

- less well defined garnets, poorer crystal habits

- matrix fabric trending N/S
- mesocratic matrix
- leucocratic blebs
- definite fabric

APPENDIX D – HAND SAMPLE DESCRIPTIONS

Hand sample descriptions:

TENNYCAPE

1) T-01

Tennycap hand sample

- fracturing along bedding plane
- pinky/orange matrix of probable silt/mudstone composition
- fractures also running sub-perpendicular to bedding, infilled with white mineral resembling calcite
- black mineralization along some fractures (eg. in place associated with calcite)
- also forms surface coating
- black mineralization also occurs as shiny lath like minerals

2) T-02

Tennycap hand sample

-light pink/orange breccia 0.5 – 1cm scale

-matrix – melanocratic with shiny lath shaped crystals

-brecciated rock seems to preferentially weather out faster than matrix as there are holes in the matrix where brecciated pieces should have been

- some white mineralization surrounded breccia, possibly calcite
- hands stained black from handling

WALTON

3) W-01

- fairly uniform rock, no bedding, grading etc. present
- composed of well rounded and well sorted sand grains
- rock not in contact with staining is a brownish-orange in colour
- contact with stained area is gradational, appearing as a brown layer
- brown layer not uniform in thickness, varies roughly from 0.5 cm – 2cm
- stained area is black and penetrates roughly 1cm in places to 3cm extending as blebs

4) W-02

- fairly uniform rock, no obvious bedding, purple/ orange colour
- composed of well rounded and well sorted sand grains
- surface contains small

APPENDIX E – MICROPROBE RESULTS

MICROPROBE RESULTS

Thin section DF-01

Garnets	Core (1)	Rim (1)	Core (2)	Rim (2)	Core (3)	Rim (3)	Core (4)	Rim (4)	Core (5)	Rim (5)	Core (6)	Rim (6)
MnO	34.46	31.16	25.32	29.12	33.52	27.33	35.35	28.82	34.26	29.64	24.91	27.85
FeO	5.43	8.35	6.28	10.68	6.81	12.26	5.88	10.69	5.85	10.30	4.06	11.19
SiO ₂	35.57	36.69	47.25	36.76	36.99	36.92	36.56	36.66	36.26	36.64	55.14	36.40
Al ₂ O ₃	20.55	20.64	15.98	20.65	20.42	20.48	21.03	21.10	20.69	20.54	13.96	20.28
CaO	2.29	2.92	2.04	2.93	3.07	2.98	2.97	3.40	2.69	2.98	2.21	3.15
MgO	-	0.28	-	0.33	-	0.53	-	0.33	-	0.45	-	0.51
<i>Total</i>	98.30	100.04	96.88	100.46	100.81	100.49	101.79	101.00	99.74		100.27	99.38

Thin section EL-01

Garnets	Core (1)	Rim (1)	Core (2)	Rim (2)	Core (3)	Rim (3)	Core (4)	Rim (4)	Core (5)	Rim (5)	Core (6)	Rim (6)
MnO	31.66	27.65	33.23	25.11	26.85	26.47	25.78	24.66	30.45	25.46	29.92	24.57
FeO	7.74	13.78	7.19	13.79	10.00	14.68	14.94	16.41	10.16	15.64	10.96	16.59
SiO ₂	38.75	37.06	37.17	35.36	25.39	37.24	37.24	37.42	36.24	37.54	37.32	37.41
Al ₂ O ₃	19.78	20.41	20.74	17.92	14.20	20.67	20.80	20.67	20.43	21.00	20.63	20.81
CaO	2.66	2.09	2.74	4.90	10.84	2.26	2.46	2.38	3.86	2.56	2.79	2.74
MgO	-	0.26	-	0.54	0.46	0.27	0.26	0.37	-	0.46	-	0.52
P ₂ O ₅	-	-	-	-	-	-	-	-	0.83	-	0.23	-
Cl	-	-	-	-	-	-	-	-	-	-	0.12	-
<i>Total</i>	100.60	101.26	101.06	97.62	87.74	101.58	101.47	101.92	101.96	102.64	101.97	102.63

Thin section DF-01

Ilmenite	#1	#2	#3	#4	#5
SiO ₂	6.59	1.01	2.03	0.39	4.77
TiO ₂	47.07	51.12	50.49	53.05	50.14
FeO	32.57	37.15	35.09	35.22	33.01
MnO	10.05	8.88	10.47	9.96	8.85
Al ₂ O ₃	5.64	0.43	1.64	-	3.24
K ₂ O	1.35	0.17	0.48	-	0.97
SO ₄	-	3.43	-	-	-
<i>Total</i>	103.26	102.18	100.19	98.63	100.98

Thin section EL-01

Ilmenite	#1	#2	#3	#4
SiO ₂	0.86	0.47	0.58	0.37
TiO ₂	23.88	52.44	53.40	52.21
FeO	11.22	28.92	31.55	30.67
MnO	7.50	17.27	15.18	15.97
CaO	32.03	0.20	-	-
P ₂ O ₅	24.62	-	-	-
<i>Total</i>	100.11	99.29	100.70	99.23