DEVELOPMENT OF THE ONTARIO PROVINCIAL SEDIMENT QUALITY GUIDELINES FOR ARSENIC, CADMIUM, CHROMIUM, COPPER, LEAD, MANGANESE, MERCURY, NICKEL, AND ZINC

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TABLE OF CONTENTS

APPENDICES

LIST OF TABLES

LIST OF FIGURES

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PREAMBLE

The Provincial Sediment Quality Guidelines are a set of numerical guidelines developed for the protection of aquatic biological resources. The procedures used in setting the guidelines, and the calculation and data evaluation methods are described in detail in the Protocol for Setting Provincial Sediment Quality Guidelines (Persaud *et al.* 1992).

The guidelines set out in this document have defined two levels of ecotoxic effects.

1. A Lowest Effect Level indicating a level of sediment contamination at which the majority of benthic organisms are unaffected.

2. A Severe Effect Level indicating a level at which pronounced disturbance of the sediment-dwelling community can be expected. This is the sediment concentration of a compound that would be detrimental to the majority of benthic species.

Both of these guideline levels are derived by the Screening Level Concentration method described in Persaud *et al* (1992). The SLC method makes use of field data on sediment concentrations of contaminants and the co-occurrence of benthic invertebrate species. The calculation of the SLC is a two step process and is calculated separately for each parameter. In the first step, for each parameter the individual SLCs (termed Species SLCs) are calculated for each of the benthic species. The sediment concentrations at all locations at which that species was present are plotted in order of increasing concentration. From this plot, the 90th percentile of this concentration distribution is determined. The 90th percentile was chosen to provide a conservative estimate of the tolerance range for that species. This would serve to eliminate extremes in concentrations that may be due to specific and unusual sediment characteristics. The 90th percentile is that locus below which 90 percent of the sediment concentrations fall.

In the second step, the 90th percentiles for all of the species present are plotted, also in order of increasing concentration. From this plot, the 5th percentile and the 95th percentile are calculated. These represent the concentrations below which 5 percent and 95 % of the concentrations fall. The concentration at the 5th percentile becomes the Lowest Effect Level and the concentration at the 95th percentile becomes the Severe Effect Level.

This document details the derivation of the metals guidelines and summarizes the data used to derive the guideline values. The document also summarizes the properties and fate of the metals, describes the various forms in which metals can exist in sediments and provides the necessary details of the calculations used to arrive at the sediment quality guidelines (PSQGs).

INTRODUCTION

Metals in aquatic systems can originate from natural sources through the weathering of mineral-rich rock, and from anthropogenic sources, principally municipal or industrial discharges and urban runoff.

In aquatic systems most metals will form complexes with ligands and although they can remain in solution for extended periods of time, their ultimate fate is deposition in the sediments.

The behaviour of metals in sediments is very complex and cannot be easily characterized. Part of the difficulty in attempting to characterize metal behaviour lies with the number of different forms in which metals can exist. These forms, and the sediment components in which they can reside, have direct implications on their bioavailability and rate of uptake by aquatic biota.

The remainder of this document describes the fate of each metal in the aquatic system and details the derivation of the Lowest Effect Levels and the Severe Effect Levels.

ARSENIC

i. Aquatic Fate

Arsenic occurs naturally as arsenic minerals, generally in combination with sulphur, iron and nickel (CCREM 1987). It is released into aquatic systems through the natural weathering of arsenic minerals. Anthropogenic sources to the aquatic environment are the smelting of sulphide minerals and the combustion of fossil fuels, principally coal.

The major commercial uses of arsenic are in glassmaking and the manufacture of medicinal compounds, pesticides, electronics, and in alloys with lead and copper (CCREM 1987).

Arsenic most commonly exists in the oxidation states As(III) and As(V). In surface waters and sediments, the oxidation state of arsenic is sensitive to changes in pH, Eh and dissolved oxygen. While As(III) is the dominant form under anaerobic conditions, As(V) becomes more prevalent under aerobic conditions.

Arsenic in the water column can be sorbed to organic matter or co-precipitated with hydrated iron, manganese and aluminum oxides and deposited in the sediments. Iron and manganese oxides/hydroxides appear to be the most important scavengers of arsenic, particularly in coarser sediments low in organic matter. In fine grained sediments, sorption to organic matter appears to be the most significant fate (Brook & Moore 1988). In oxidized sediments both of these fractions serve to strongly bind arsenic in the sediments. Under reducing conditions arsenic can be released to the water column or can form sulphides as the Fe and Mn oxides dissolve. Under reducing conditions, organic bound arsenic generally forms insoluble sulphides.

Arsenic can also exist in sediments as free ions in the sediment pore water, as well as bound to other sediment fractions. Arsenic in the sediment pore water seems to be controlled by the solubility of iron and manganese oxyhydroxides in the oxidized layer (particularly as these dissolve under the advent of reducing conditions) and metal sulphides in the sulphide layer (Moore *et al* 1988). These differences account for the low concentrations of arsenic generally observed in the pore water in the oxidized zone and the relatively much higher levels in pore water below the redox boundary.

Arsenic can also form a number of organo-arsenical compounds in the presence of organic matter, of which the methylated arsenic (V) species (formed by the biological methylation of inorganic arsenic compounds) are the most important (CCREM 1987). The most common of the methylarsines is dimethylarsinic acid. Methylarsine compounds can also be demethylated in the sediments.

Availability of arsenic to biota from sediments appears to be low under oxidizing conditions. Bioaccumulation of arsenic has been observed in numerous aquatic organisms, though there is no evidence that arsenic can be biomagnified through the food chain. While the metallo-organic forms of As may be more bioavailable to organisms, these also appear to be more readily excreted.

ii Sediment Guidelines

Lowest Effect Level

The Lowest Effect Level for arsenic is calculated as the 5^{th} percentile of the Species Screening Level Concentrations (SSLCs). Each SSLC is the calculated 90th percentile of the concentration distribution for that species. The Screening Level Concentration (SLC) is a plot of the concentration distribution of all the SSLCs for that compound, and for arsenic was calculated on the basis of sediment concentrations from 442 locations in and adjacent to the Great Lakes region. The sediment concentrations ranged from 2 µg/g to 56 µg/g. The SLC was calculated from the Species SLCs for 92 species. The actual species used in the calculation, the concentration mean and range, and the 90^{th} percentile of the Species Screening Level Concentration (SSLC) for each species are presented in Table 1. A detailed plot of the SLC is provided in Figure 1.

The 5^{th} percentile of the SLC is calculated as 5.5 µ*g/g* which is rounded to 6 µg/g and this value becomes the Lowest Effect Level.

Severe Effect Level

The Severe Effect Level has been calculated as the 95^{th} percentile of the Species Screening Level Concentration distribution. The data used are the same as for the Lowest Effect Level Guideline which are presented in Table 1. Figure 1 also shows the 95^{th} percentile of the Species SLC distribution.

The 95^{th} percentile of the SLC plot is calculated as 32.6 µg/g which is rounded to 33 µg/g and this value becomes the Severe Effect Level.

CADMIUM

i Aquatic Fate

Cadmium in nature commonly occurs as a sulphide ore, usually found in association with zinc ores such as sphalerite (CCREM 1987). Cadmium is economically recoverable only when it occurs in association with zinc-, lead- and copper-bearing ores.

The principal use of cadmium is as an alloy in electroplating, in nickel-cadmium batteries, solders, electronic equipment, photography supplies, glass, ceramics, and plastics (CCREM 1987).

The major anthropogenic sources to the aquatic environment are through emissions to air and water from mining and smelting and in the manufacture of the products noted above. Additional losses occur from agricultural uses and from the burning of fossil fuels (CCREM 1987).

In water, cadmium generally occurs in the Cd(II) form as a constituent of inorganic (halides, sulphides, oxides) and organic compounds (CCREM 1987). Cadmium in the water column can exist as free ions (small amount) or complexed to various ligands such as humic acids, organic particles and various oxides. Transport of cadmium to the sediments occurs mainly through sorption to organic matter and subsequent settling, and through co-precipitation with iron, aluminum, and manganese oxides. Cadmium can also be deposited in sediments through ion exchange (mainly with calcium) on minerals. These phases account for most of the sediment-bound cadmium.

Cadmium can also exist in sediments as free ions in the sediment pore water, as well as bound to other sediment fractions. Sediment pore water concentrations seem to be controlled by the solubility of iron and manganese oxyhydroxides in the oxidized layer (particularly as these dissolve under the advent of reducing conditions) and metal sulphides in the sulphide layer (Moore *et al* 1988).

The availability of sediment cadmium to aquatic organisms depends on such factors as pH, redox potential, and water hardness (presence of calcium) and the presence of other complexing agents. Uptake by biota appears to depend on the availability of free ions (uptake through adsorption), and strength of binding to sediment solid phases (uptake through absorption). Studies suggest that cadmium generally has a long residence time in biological tissues.

ii <u>Sediment Quality Guidelines</u>

Lowest Effect Level

The Lowest Effect Level for cadmium is calculated as the 5th percentile of the Species Screening Level Concentrations (SSLCs). Each SSLC is the calculated 90th percentile of the concentration distribution for that species. The Screening Level Concentration (SLC) is a plot of the concentration distribution of all the SSLCs for that compound, and for cadmium was calculated on the basis of sediment concentrations from 429 locations in and adjacent to the Great Lakes region. The sediment concentrations ranged from 2 µg/g to 46 *µg/g.* The SLC was calculated from the Species SLCs for 95 species. The actual species used in the calculation, the concentration mean and range, and the 90th percentile of the Species Screening Level Concentration (SSLC) for each species are presented in Table 2. A detailed plot of the SLC is provided in Figure 2.

The 5th percentile of the SLC is calculated as 0.6 µg/g and this value becomes the Lowest Effect Level Guideline.

Severe Effect Level

The Severe Effect Level has been calculated as the 95th percentile of the Species Screening Level concentration distribution. The data used are the same as for the Lowest Effect Level Guideline which are presented in Table 2. Figure 2 also shows the 95th percentile of the Species SLC distribution.

The 95th percentile of the SLC plot is calculated as 9.5 µg/g, rounded to 10 µg/g and this value becomes the Severe Effect Level.

CHROMIUM

i <u>Aquatic Fate</u>

The principal source of chromium is the mineral chromite (chromium-iron oxide). In rocks and soils, chromium is usually present as an insoluble chromium oxide (CCREM 1987).

The main commercial uses of chromium (Cr(VI) are as a chrome alloy in chromium metal products and in chrome plating, and to a lesser extent, as compounds in paints, dyes, explosives, ceramics and paper. Cr(III) is used in dyeing, the manufacture of glass and ceramics, and in photography. Chromium can also be present in some fertilizers and pesticides (CCREM 1987).

The major anthropogenic sources of chromium to the aquatic environment are the ferrochromium production industry, metal plating, and to a lesser extent, cement production and the burning of fossil fuels.

In aquatic systems, chromium is present mainly in the Cr(III) (chromic compounds) and the Cr(VI) (chromate and dichromate) states (CCREM 1987). The Cr(VI) form is relatively soluble and is not sorbed to any significant degree by particulate matter. In water, Cr(VI) reacts strongly with oxidizable, usually organic, molecules with the resultant formation of Cr(III). Cr(III) can be transported to the sediments through sorption to organic particles and co-precipitation with hydrous iron and manganese oxides. Under anaerobic conditions Cr(VI) is reduced to Cr(III). Under anoxic conditions in the sediment, Cr can form insoluble sulphides.

Cr(VI) is more readily bioaccumulated than Cr(III) and is considered the more toxic form. Tissue residue levels however, are generally lower than sediment levels (CCREM 1987). There is no evidence that chromium can biomagnify through the food chain.

ii Sediment Quality Guidelines

Lowest-Effect Level

The Lowest Effect Level for chromium is calculated as the 5th percentile of the Species Screening Level Concentrations (SSLCs). Each SSLC is the calculated 90th percentile of the concentration distribution for that species. The Screening Level Concentration (SLC) is a plot of the concentration distribution of all the SSLCs for that compound, and for chromium was calculated on the basis of sediment concentrations from 463 locations in and adjacent to the Great Lakes region. The sediment concentrations ranged from 3 µg/g to 1700 µg/g. The SLC was calculated from the Species SLCs for 92 species. The actual species used in the calculation, the concentration mean and range, and the 90th percentile of the Species Screening Level Concentration (SSLC) for each species are presented in Table 3. A detailed plot of the SLC is provided in Figure 3.

The 5th percentile of the SLC is calculated as 25.6 µg/g which is rounded to 26 µg/g. This value becomes the Lowest Effect Level Guideline.

Severe Effect Level

The Severe Effect Level has been calculated as the 95th percentile of the Species Screening Level concentration distribution. The data used are the same as for the Lowest Effect Level Guideline which are presented in Table 3. Figure 3 also shows the 95th percentile of the Species SLC distribution.

The 95th percentile of the SLC plot is calculated as 113.8 µg/g which is rounded to 110 µg/g and this value becomes the Severe Effect Level.

COPPER

i Aquatic Fate

Copper occurs naturally in rocks and minerals either as native copper, or, more commonly, as a mineral ore. More than 160 copper containing minerals have been described (CCREM 1987). Since copper is a common element in rock, weathering of rock can release significant amounts to water.

The uses of copper are highly varied, but principal uses are in alloys, electroplating, electrical wiring, paints, and pesticides.

Copper in aquatic systems can exist in four oxidation states, of which Cu(I) and Cu(H) are the most common. Cu(I) under aerobic conditions is readily oxidized to Cu(II). In natural waters copper undergoes complex reactions and can be present in solution, either as cupric ions or complexed with inorganic or organic ligands. Copper is transported to the sediments most often in association with organic matter, and as precipitates of hydroxides, phosphates and sulphides. Copper in sediments has a high affinity for hydrous iron and manganese oxides, clays, carbonate materials and organic matter, though the formation of these complexes is pH and redox dependent. Under normal pH and inorganic carbon, most of the copper appears to be present in the form of organic complexes, cupric carbonate complexes and coprecipitates with iron and manganese oxides (Brook & Moore 1988; CCREM 1987).

Copper in reducing sediments is primarily in the form of sulphide complexes, while in the oxidized zone it is mainly present as organic complexes or bound to hydrous iron and manganese oxides. Therefore, under anaerobic conditions, Cu is generally immobilized in the sediments.

Release of copper from sediments can be either through ion exchange, solubilization of the matrix (e.g. flux of Fe/Mn oxides under reducing conditions) or decomposition of the matrix (e.g. organic matter).

Since copper is an essential micronutrient it is readily accumulated by aquatic organisms, especially the lower animals, but no evidence exists for biomagnification. Some evidence exists to suggest that some organisms can limit the uptake of copper generally through increases in depuration rates (Luoma 1983).

ii Sediment Quality Guidelines

Lowest Effect Level

The Lowest Effect Level for copper is calculated as the 5th percentile of the Species Screening Level Concentrations (SSLCs). Each SSLC is the calculated 90th percentile of the concentration distribution for that species. The Screening Level Concentration (SLC) is a plot of the concentration distribution of all the SSLCs for that compound, and for copper was calculated on the basis of sediment concentrations from 493 locations in and adjacent to the Great Lakes region. The sediment concentrations ranged from 5 µg/g to 28,000 µg/g. The SLC was calculated from the Species SLCs for 95 species. The actual species used in the calculation, the concentration mean and range, and the 90th percentile of the Species Screening Level Concentration (SSLC) for each species are presented in Table 4. A detailed plot of the SLC is provided in Figure 4.

The 5th percentile of the SLC is calculated as 16.4 µg/g which is rounded to 16 µg/g.

Severe Effect Level

The Severe Effect Level has been calculated as the 95th percentile of the Species Screening Level concentration distribution. The data used are the same as for the Lowest Effect Level Guideline which are presented in Table 4. Figure 4 also shows the 95th percentile of the Species SLC distribution.

The 95th percentile of the SLC plot is calculated as 106.8 µg/g which is rounded to 110 µg/g and this value becomes the Severe Effect Level.

IRON

i Aquatic Fate

Iron is one of the most abundant elements in the earth's crust. Iron exists as iron oxides and sulphides in igneous, sedimentary and metamorphic rock.

Sources to the aquatic environment are through natural weathering of rock, while the principal anthropogenic sources are mineral processing, smelting and processing of iron, sewage, and burning of coke and coal.

Iron exists in two main oxidation states in water: Fe(II) and Fe(III). The Fe(III) form is insoluble in aerobic waters and usually forms precipitates (as hydrated oxides). Under anoxic conditions, the more highly soluble Fe(II) form predominates.

Iron in the water column forms oxides which themselves are important scavengers of other trace metals. Iron in aerobic sediments usually exists in the form of hydrated oxides. Under anaerobic conditions, it can form complexes with sulphides, and together with desorption and release of iron to the water column, appear to be the principal mechanisms under anaerobic conditions.

No information was available on the toxicity of iron to aquatic biota.

ii Sediment Quality Guidelines

Lowest Effect Level

The Lowest Effect Level for iron is calculated as the 5^{th} percentile of the Species Screening Level Concentrations (SSLCs). Each SSLC is the calculated 90^{th} percentile of the concentration distribution for that species. The Screening Level Concentration (SLC) is a plot of the concentration distribution of all the SSLCs for that compound, and for iron was calculated on the basis of sediment concentrations from 493 locations in and adjacent to the Great Lakes region. The sediment concentrations ranged from 13 µg/g to 210,000 µg/g. The SLC was calculated from the Species SLCs for 95 species. The actual species used in the calculation, the concentration mean and range, and the 90^{th} percentile of the Species Screening Level Concentration (SSLC) for each species are presented in Table 5. A detailed plot of the SLC is provided in Figure 5.

The 5^{th} percentile of the SLC is calculated as 21,200 µ*g/g* (2.0%) and this value becomes the Lowest Effect Level Guideline.

Severe Effect Level

The Severe Effect Level has been calculated as the 95^{th} percentile of the Species Screening Level concentration distribution. The data used are the same as for the Lowest Effect Level Guideline which are presented in Table 5. Figure 5 also shows the 95^{th} percentile of the Species SLC distribution.

The 95^{th} percentile of the SLC plot is calculated as 43,766 µg/g (4%) and this value becomes the Severe Effect Level.

LEAD

i Aquatic Fate

Lead occurs naturally as a constituent in a variety of minerals. The single largest use of lead is in the production of lead-acid batteries, and secondarily, in the production of chemical compounds such as tetraethyl lead. Other uses include ammunition manufacture, paints, glassware, electroplating, electronic equipment, plastics, solder, specialized containers and construction materials.

Weathering of lead minerals is the principal natural source of lead to the environment. Anthropogenic sources include street runoff, mining and smelting operations, and sewage treatment plants.

Three oxidation states are of particular environmental importance in aquatic systems, though of these, Pb(II) is the most stable ionic species. Transport of lead to sediments is mainly through co-precipitation with hydrous iron and manganese oxides, complexation with clays (which can also contain appreciable amounts of iron and manganese hydroxides) and sorption to organic matter. In sediments, much of the lead is found in association with the Fe/Mn hydroxides. In oxidized sediments lead is strongly bound to the hydroxide and organic matter fractions of the sediments. Under reducing conditions lead can be released to the water column or can form sulphides as the Fe and Mn oxides dissolve.

Lead can be bioaccumulated by aquatic organisms. Organisms held at lower pH (approx. 6.0) accumulated more lead than at higher pH presumably due to the greater availability of divalent lead at these pH levels. Pb(II) appears to be the most bioavailable species. In general, the organic forms (e.g. tetraethyl lead) appear to be the most bioavailable.

ii Sediment Quality Guidelines

Lowest Effect Level

The Lowest Effect Level for lead is calculated as the 5th percentile of the Species Screening Level Concentrations (SSLCs). Each SSLC is the calculated 90th percentile of the concentration distribution for that species. The Screening Level Concentration (SLC) is a plot of the concentration distribution of all the SSLCs for that compound, and for lead was calculated on the basis of sediment concentrations from 448 locations in and adjacent to the Great Lakes region. The sediment concentrations ranged from 5 µg/g to 20,000 *µg/g.* The SLC was calculated from the Species SLCs for 95 species. The actual species used in the calculation, the concentration mean and range, and the 90th percentile of the Species Screening Level Concentration (SSLC) for each species are presented in Table 6. A detailed plot of the SLC is provided in Figure 6.

The 5th percentile of the SLC is calculated as 31 µ*g/g* and this value becomes the Lowest Effect Level Guideline.

Severe Effect Level

The Severe Effect Level has been calculated as the 95th percentile of the Species Screening Level concentration distribution. The data used are the same as for the Lowest Effect Level Guideline which are presented in Table 6. Figure 6 also shows the 95th percentile of the Species SLC distribution.

The 95th percentile of the SLC plot is calculated as 250 µg/g which is not rounded and this value becomes the Severe Effect Level.

MANGANESE

i Aquatic Fate

Manganese occurs naturally as oxide and carbonate minerals and as ferromanganese minerals.

Natural sources are soils, sediments and metamorphic and sedimentary rocks, all of which can contribute Mn to aquatic systems. Anthropogenic sources are primarily the iron and steel industry and mining activity. Municipal wastewater systems can also contribute significant amounts.

Though manganese can exist in a number of oxidation states, the most important forms in aquatic systems are Mn(II) and Mn (IV). Under anoxic conditions, the Mn(II) form predominates, while under oxic conditions the Mn(II) rapidly oxidizes to Mn(IV). In water, Mn(II) oxidizes to manganese oxides which are precipitated. In sediments manganese forms stable hydroxides under aerobic conditions (Moore *et al* 1988). Under anaerobic conditions, manganese can be released from the sediments and can form sulphides or be released back to the water column.

Manganese is an essential micronutrient. No information was available on the toxicity of manganese to aquatic biota.

ii Sediment Quality Guidelines

Lowest Effect Level

The Lowest Effect Level for manganese is calculated as the 5th percentile of the Species Screening Level Concentrations (SSLCs). Each SSLC is the calculated 90th percentile of the concentration distribution for that species. The Screening Level Concentration (SLC) is a plot of the concentration distribution of all the SSLCs for that compound, and for manganese was calculated on the basis of sediment concentrations from 256 locations in and adjacent to the Great Lakes region. The sediment concentrations ranged from 30 µg/g to 2,000 µg/g. The SLC was calculated from the Species SLCs for 38 species. The actual species used in the calculation, the concentration mean and range, and the 90th percentile of the Species Screening Level Concentration (SSLC) for each species are presented in Table 7. A detailed plot of the SLC is provided in Figure 7.

The 5th percentile of the SLC is calculated as 457 µg/*g* which was rounded to 460 µg/g and this becomes the Lowest Effect Level Guideline.

Severe Effect Level

The Severe Effect Level has been calculated as the 95th percentile of the Species Screening Level concentration distribution. The data used are the same as for the Lowest Effect Level Guideline which are presented in Table 7. Figure 7 also shows the 95th percentile of the Species SLC distribution.

The 95th percentile of the SLC plot is calculated as 1060 µg/g which is rounded to 1100 µg/g and this value becomes the Severe Effect Level.

MERCURY

i Aquatic Fate

Mercury occurs most commonly as the ore cinnabar, but can also be present in more than 30 other common ores and minerals.

Mercury is used in the production of chlorine, caustic soda and hydrogen, in the paint industry, the pulp and paper industry, for electrical equipment, in medicinal compounds and thermometers (CCREM 1987).

Significant anthropogenic sources to aquatic systems include mining and smelting, coal combustion, paints and, in the past, the chloralkali industry.

In aquatic systems mercury is generally sorbed to particulate matter. Mercury can exist in three oxidation states: elemental, Hg(I) and Hg(II). In natural waters at low redox potential, Hg(II) is the predominant species. Mercury tends to combine with sediment organic matter. In anaerobic sediments, mercury can combine with sulphur to produce insoluble sulphides (Rudd *et al* 1983). Both Hg(I) and Hg(II) can be methylated by microorganisms under aerobic and anaerobic conditions. Where pH is high and elemental mercury concentrations are low, the dimethyl form predominates, while under conditions of low pH and high concentrations of elemental mercury, the monomethyl form predominates. Both forms may also be demethylated by bacteria in sediments.

Rates of methylmercury production are strongly affected by oxygen. Production can be orders of magnitude higher in anoxic sediments, but this can be effectively reduced by the presence of sulphides through the binding of inorganic Hg.

The methylated forms of mercury are

usually the more highly bioavailable forms. However, plankton appear to accumulate mostly the inorganic forms of mercury (Rudd *et al* 1983).

Bioaccumulation and bioconcentration of organic forms is high, and methylmercury can be biomagnified. Accumulation in most aquatic organisms occurs due to a rapid rate of uptake coupled with a slow depuration rate. Since rate of solubility and methylation increase at lower pH, uptake can be higher under acidic conditions (CCREM 1987). Uptake of elemental mercury appears to be low (Rudd *et al* 1983).

ii <u>Sediment Quality Guidelines</u>

Lowest Effect Level

The Lowest Effect Level for mercury is calculated as the 5th percentile of the Species Screening Level Concentrations (SSLCs). Each SSLC is the calculated 90th percentile of the concentration distribution for that species. The Screening Level Concentration (SLC) is a plot of the concentration distribution of all the SSLCs for that compound, and for mercury was calculated on the basis of sediment concentrations from 473 locations in and adjacent to the Great Lakes region. The sediment concentrations ranged from 0.1 µg/g to 304 µg/g. The SLC was calculated from the Species SLCs for 95 species. The actual species used in the calculation, the concentration mean and range, and the 90th percentile of the Species Screening Level Concentration (SSLC) for each species are presented in Table 8. A detailed plot of the SLC is provided in Figure 8.

The 5th percentile of the SLC is calculated as 0.16 µg/g which is rounded to 0.2 µg/g and this value becomes the Lowest Effect Level Guideline.

Severe Effect Level

The Severe Effect Level has been calculated as the 95th percentile of the Species Screening Level concentration distribution. The data used are the same as for the Lowest Effect Level Guideline which are presented in Table 8. Figure 8 also shows the 95th percentile of the Species SLC distribution.

The 95th percentile of the SLC plot is calculated as 2.0 µg/g and this value becomes the Severe Effect Level.

NICKEL

i <u>Aquatic Fate</u>

Nickel occurs naturally as either sulphide ores or arsenides. In ore deposits it commonly occurs with iron and copper.

Nickel is used primarily in the manufacture of stainless steel and other nickel alloys. It is also used as a catalyst in industrial processes and in oil refining (CCREM 1987).

Natural sources of nickel to aquatic systems are through the weathering of minerals and rocks. Anthropogenic sources are the burning of fossil fuels, which can have high nickel content, smelting and refining of nickel ores and alloys, and the electroplating industry.

In aquatic systems nickel occurs primarily in the Ni(II) form. In the water column, nickel occurs as relatively soluble salts that form a large number of complexes with organic materials. Nickel is deposited in the sediments through coprecipitation with iron and manganese oxides and sorption to organic matter.

At neutral pH, nickel in sediments forms complexes with iron and manganese oxides, though mobility from the sediments increases below pH 6.0 (CCREM 1987). Under anaerobic conditions, nickel can form insoluble complexes with sulphides.

Nickel can be bioaccumulated by some organisms, though bioconcentration factors decrease from algae to fish. There is no evidence for biomagnification (CCREM 1987).

ii Sediment Quality Guidelines

Lowest Effect Level

The Lowest Effect Level for nickel is calculated as the 5th percentile of the Species Screening Level Concentrations (SSLCs). Each SSLC is the calculated 90th percentile of the concentration distribution for that species. The Screening Level Concentration (SLC) is a plot of the concentration distribution of all the SSLCs for that compound, and for nickel was calculated on the basis of sediment concentrations from 422 locations in and adjacent to the Great Lakes region. The sediment concentrations ranged from 4 µg/g to 930 µg/g. The SLC was calculated from the Species SLCs for 92 species. The actual species used in the calculation, the concentration mean and range, and the 90th percentile of the Species Screening Level Concentration (SSLC) are presented in Table 9. A detailed plot of the SLC is provided in Figure 9.

The 5th percentile of the SLC is calculated as 16 µg/g which is not rounded, and this value becomes the Lowest Effect Level Guideline.

Severe Effect Level

The Severe Effect Level has been calculated as the 95th percentile of the Species Screening Level concentration distribution. The data used are the same as for the Lowest Effect Level Guideline which are presented in Table 9. Figure 9 also shows the 95th percentile of the Species SLC distribution.

The 95th percentile of the SLC plot is calculated as 75.2 µg/g which is rounded to 75 µg/g and this value becomes the Severe Effect Level.

ZINC

i Aquatic Fate

Zinc occurs naturally as sulphide, carbonate and silicate minerals. In sulphides it is commonly found in combination with iron, copper and lead.

Zinc is used in the smelting and production of alloys for a variety of uses.

In aquatic systems, zinc occurs as Zn(II), which is amphoteric. It can also form organozinc compounds. At neutral pH, zinc is deposited in the sediments through sorption to hydrous iron and manganese oxides, clay minerals, and organic matter. Below pH 6.0, adsorption is very low.

Zinc in the water column can be sorbed to organic matter or co-precipitated with hydrated iron and aluminum oxides and deposited in the sediments. Iron and manganese oxides/hydroxides appear to be the most important scavengers of zinc, particularly in coarser sediments low in organic matter, while in fine grained sediments, sorption to organic matter appears to be the most significant fate (Brook & Moore 1988). In oxidized sediments both of these fractions serve to strongly bind zinc in the sediments. Under reducing conditions zinc can be released to the water column or can form sulphides as the Fe and Mn oxides dissolve(?). Under reducing conditions, organic bound zinc generally forms insoluble sulphides (Moore *et al* 1988).

Zinc can also exist in sediments as free ions in the sediment pore water, as well as bound to other sediment fractions. Zinc in the sediment pore water seems to be controlled by the solubility of iron and manganese oxyhydroxides in the oxidized layer (particularly as these dissolve under the advent of reducing conditions) and metal sulphides in the sulphide layer (Moore *et al* 1988).

Zinc is an essential micronutrient and uptake in most aquatic organisms appears to be independent of environmental concentrations. It has been found to bioaccumulate in some organisms, though there is no evidence of biomagnification.

ii <u>Sediment Quality Guidelines</u>

Lowest Effect Level

The Lowest Effect Level for zinc is calculated as the 5th percentile of the Species Screening Level Concentrations (SSLCs). Each SSLC is the calculated 90th percentile of the concentration distribution for that species. The Screening Level Concentration (SLC) is a plot of the concentration distribution of all the SSLCs for that compound, and for zinc was calculated on the basis of sediment concentrations from 493 locations in and adjacent to the Great Lakes region. The sediment concentrations ranged from 4 µg/g to 11,000 µg/g. The SLC was calculated from the Species SLCs for 95 species. The actual species used in the calculation, the concentration mean and range, and the 90th percentile of the Species Screening Level Concentration (SSLC) are presented in Table 10. A detailed plot of the SLC is provided in Figure 10.

The 5th percentile of the SLC is calculated as 120 µg/g and this becomes the Lowest Effect Level Guideline.

Severe Effect Level

The Severe Effect Level has been calculated as the 95th percentile of the Species Screening Level concentration distribution. The data used are the same as for the Lowest Effect Level Guideline which are presented in Table 10. Figure 10 also shows the 95th percentile of the Species SLC distribution.

The 95th percentile of the SLC plot is calculated as 822 µg/g which is rounded to 820 µg/g and this value becomes the Severe Effect Level.

RESEARCH NEEDS

As is apparent, limitations of the data have in some cases resulted in conservative guideline values. In particular, the SLC method as described in Persaud *et al* (1992) requires that the full tolerance range for each species be sampled and that the data for the species are not biased towards lightly or heavily contaminated areas. It has not been possible in all cases to satisfy these requirements. The sediment concentrations for some of the metals were generally rather low, with only a few species present in areas of high contaminant concentrations. In those cases it is likely that the full tolerance range has not been sampled and the guideline, as derived, may be conservative.

Nonetheless, the values derived compare closely with the lowest effect levels as described from both laboratory studies and field co-occurrence studies, similar to the SLC approach (Long and Morgan 1990).

This points to the necessity for future effort to be directed towards incorporating additional data, particularly data from highly contaminated sites. There is also a need to concentrate efforts towards sediment bioassay procedures to verify the results of the SLC process.

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APPENDIX I - TABLES

Species Screening Level Calculations

Explanation of Abbreviations:

N=	- Number of observations used for the calculation of the SSLC.
Mean	- Mean concentration (dry weight) at sites at which the species was present.
%	- Percentile at which the concentration is calculated.
Conc.	- Concentration (dry weight) of the contaminant at the percentile noted.
.	- Insufficient number of observations to calculate percentiles.

Table 1: ARSENIC - Species Screening Level Concentrations (µg/g).

Spp No.	Species	N=	Mean	Std. Dev.	Minimum	Maximum	%	Conc.
1	Ablabesmyia sp	35	9.17	13.53	0.40	43.00	90	37.40
2	Aelosoma sp	14	4.33	3.37	2.08	12.09	90	12.05
3	Amnicola limosa	100	3.88	3.17	0.40	18.73	90	8.69
4	Asellus sp	79	5.81	5.66	0.60	36.00	90	12.40
5	Aulodrilus limnobius	26	3.93	3.25	1.11	14.00	90	10.49
6	Aulodrilus pigueti	32	2.93	1.48	1.11	8.07	90	5.32
7	Aulodrilus pleuriseta	30	4.71	3.68	0.01	14.00	90	11.87
8	Bithynia tentaculata	33	5.58	5.07	0.40	18.73	90	15.60
9	Branchiura sowerbyi	13	8.91	4.52	2.08	16.00	90	15.60
10	Caenis sp	34	5.64	9.44	0.96	56.00	90	11.35
11	Ceraclea sp	64	5.06	7.15	1.10	56.00	90	8.77
12	Chaetogaster diaphanus	32	3.19	1.94	0.79	8.90	90	6.67
13	Cheumatopsyche sp	87	4.65	6.37	1.11	56.00	90	8.76
14	Chironomus sp	103	6.01	5.46	1.00	27.00	90	14.80
15	Cladopelma sp	22	3.49	2.47	1.10	9.05	90	8.86
16	Cladotanytarsus sp	48	4.44	7.97	0.40	56.00	90	8.14
17	Coelotanypus sp	13	8.74	6.92	1.86	24.70	90	20.82
18	Cricotopus sp	60	6.46	9.15	0.01	43.00	90	12.35
19	Cricotopus vierriensis	0						
20	Cryptochironomus sp	128	4.37	4.43	0.40	27.00	90	10.00
21	Dicrotendipes sp	43	4.75	6.59	0.46	36.00	90	10.60
22	Eukiefferiella sp	53	4.49	7.48	1.21	56.00	90	6.16
23	Gammarus fasciatus	218	4.88	5.59	0.01	56.00	90	12.00
24	Glossiphonia heteroclita	4	6.05	2.77	3.60	10.00	90	.
25	Glossosoma sp	40	7,99	11.95	1.75	56.00	90	33.67
26	Glyptotendipes sp	19	5.49	7.00	0.94	27.00	90	19.00
27	Gyraulus parvus	33	4.64	3.24	0.40	12.40	90	9.92
28	Helisoma anceps	12	3.40	2.07	1.11	8.76	90	7.91
29	Heterotrissocladius sp	18	5.30	2.91	1.74	12.00	90	10.03
30	Hyalella azteca	44	5.18	3.64	0.60	15.00	90	11.00
31	Hydropsyche sp	50	3.79	2.29	1.21	12.70	90	5.89
32	Hydroptila sp	38	4.80	8.83	1.11	56.00	90	8.76
33	Ilyodrilus templetoni	18	3.44	2.45	1.11	9.05	90	8.79
34	Limnodrilus hoffmeisteri	189	4.41	4.12	0.01	30.00	90	9.40
35	Limnodrilus sp	63	14.94	11.82	1.00	46.00	90	37.00
36	Limnodrilus udekemianus	38	5.26	7.96	0.40	41.00	90	10.58
37	Lumbriculus variegatus	38	5.47	8.84	0.73	56.00	90	9.90
38	Manayunkia speciosa	68	4.55	4.49	0.57	27.00	90	9.83
39	Microtendipes sp	14	10.02	8.50	1.00	27.00	90	23.50
40	Mystacides sp	15	3.02	1.58	1.46	6.46	90	6.41
41	Nais behningi	27	3.76	2.23	1.21	12.68	90	6.06
42	Nais communis	38	3.55	2.57	0.40	12.68	90	6.48
43	Nais variabilus	70	3.87	2.56	0.01	12.68	90	8.46
44	Nanocladius sp	35	5.26	9.15	1.21	56.00	90	9.02
45	Neureclipsis sp	36	3.54	1.86	1.21	9.81	90	5.66
46	Oecetis sp	38	5.03	5.54	0.46	27.00	90	15.10
47	Parachironomus sp	21	3.47	2.68	0.01	12.00	90	7.60
48	Paralauterborniella sp	16	4.00	1.32	2.25	7.00	90	6.34
49	Paratendipes sp	25	4.05	2.84	0.40	14.00	90	7.16
50	Phaenopsectra sp	41	6.86	11.03	0.46	43.00	90	30.55
51	Phallodrilus sp	24	2.76	2.08	1.50	12.09	90	3.87
52	Physella gyrina	95	4.50	6.08	0.94	56.00	90	8.60
53	Piguetiella michiganensi	48	3.70	2.84	0.40	12.68	90	8.52

54	Pisidium casertanum	179	4.00	2.87	0.01	18.73	90	8.49
55	Pisidium compressum	17	4.26	3.77	0.01	14.00	90	12.40
56	Pisidium conventus	14	3.83	3.13	0.40	12.00	90	9.55
57	Pisidium fallax	94	4.61	6.45	0.57	56.00	90	8.63
58	Pisidium henslowanum	33	3.77	3.94	0.01	18.73	90	10.00
59	Pisidium lilljeborgi	24	3.89	3.29	0.40	14.00	90	9.50
60	Pisidium nitidum	23	3.59	2.12	0.40	8.00	90	7.00
61	Pisidium variabile	23	3.82	3.48	0.01	14.00	90	10.04
62	Pleurocera acuta	78	4.96	6.57	0.57	56.00	90	8.80
63	Polypedilum scalaenum	13	2.65	1.08	1.40	5.40	90	4.72
64	Polypedilum sp	115	6.80	9.55	0.65	56.00	90	13.80
65	Pontoporeia hoyi	41	3.92	3.12	0.40	14.00	90	8.54
66	Potamothrix moldaviensis	66	3.55	2.63	0.01	13.00	90	7.00
67	Potamothrix vejdovskyi	62	4.55	4.26	0.01	27.50	90	10.63
68	Pristina foreli	13	3.33	1.27	1.86	6.37	90	5.76
69	Pristina osborni	46	3.70	2.83	1.11	18.73	90	5.70
70	Procladius sp	215	7.51	8.32	0.01	46.00	90	16.00
71	Prostoma rubrum	116	4.26	5.58	0.57	56.00	90	8.29
72	Pseudocloeon sp	16	7.73	13.15	1.50	56.00	90	22.94
73	Quistadrilus multisetosu	72	5.29	4.54	0.46	25.40	90	10.30
74	Slavina appendiculata	36	3.60	2.59	1.40	12.09	90	8.59
75	Specaria josinae	29	3.16	2.76	0.40	14.00	90	8.07
76	Sphaerium nitidum	17	4.27	3.16	0.40	14.00	90	8.40
77	Sphaerium striatinum	65	5.24	7.24	0.65	56.00	90	9.73
78	Spirosperma ferox	105	4.37	3.32	0.01	18.73	90	9.18
79	Stenonema sp	55	5.14	7.66	0.57	56.00	90	8.76
80	Stictochironomus sp	14	2.88	2.51	0.46	10.00	90	8.03
81	Stylaria lacustris	55	3.87	2.82	0.01	15.00	90	8.03
82	Stylodrllus heringianus	86	4.92	6.45	0.40	56.00	90	9.17
83	Tanytarsus sp	95	3.58	2.50	0.40	14.00	90	6.86
84	Thienemannimyia sp	64	5.47	7.85	1.00	56.00	90	11.40
85	Tubifex sp	36	16.72	11.54	1.00	43.00	90	37.30
86	Turbellaria	100	4.41	5.94	0.57	56.00	90	8.46
87	Uncinais uncinata	21	2.83	1.58	0.79	7.00	90	5.36
88	Valvata sincera	75	3.59	2.70	0.60	14.00	90	7.00
89	Valvata tricarinata	68	4.38	4.54	0.40	27.00	90	10.00
90	Vejdovskyella intermedia	58	3.71	3.01	0.01	14.00	90	8.77
91	Elliptio complanata	1	3.60		3.60	3.60	90	.
92	Sphaerium simile	0						
93	Chironomus plumosus	79	4.97	4.09	0.90	24.70	90	11.00
94	Cricotopus bicinctus	5	3.54	1.56	1.70	5.19	90	.
95	Ephemera sp	3	3.36	2.37	1.86	6.10	90	.
96	Helobdella stagnalis	25	7.78	6.44	1.43	27.00	90	17.20
97	Hexagenia limbata	23	5.61	5.74	0.66	25.40	90	13.60
98	Hexagenia sp	1	0.65		0.65	0.65	90	.
99	Tanypus sp	0						
100	Tubifex tubifex	62	5.40	4.50	0.73	24.70	90	10.79

Table 2: **CADMIUM** - Species Screening Level Concentrations (µg/g).

Spp No.	Species	N=	Mean	Std. Dev.	Minimum	Maximum	%	Conc.
1	Ablabesmyia sp	36	3.68	8.89	0.08	46.00	90	14.30
2	Aelosoma sp	14	0.61	1.03	0.10	4.10	90	2.55
3	Amnicola limosa	89	0.48	0.44	0.01	2.50	90	1.20
4	Asellus sp	58	1.09	1.90	0.10	14.00	90	2.32
5	Aulodrilus limnobius	35	0.64	0.51	0.10	2.50	90	1.20
6	Aulodrilus pigueti	31	0.49	0.32	0.10	1.20	90	1.07
7	Aulodrilus pleuriseta	24	0.73	0.91	0.01	4.10	90	1.95
8	Bithynia tentaculata	43	0.61	0.65	0.10	4.00	90	1.00
9	Branchiura sowerbyi	14	0.82	0.56	0.05	2.00	90	1.75
10	Caenis sp	30	0.74	0.95	0.10	4.10	90	1.48
11	Ceraclea sp	61	0.61	0.81	0.01	3.90	90	1.16
12	Chaetogaster diaphanus	32	0.35	0.30	0.08	1.40	90	0.85
13	Cheumatopsyche sp	86	0.62	0.74	0.10	3.90	90	1.35
14	Chironomus sp	90	0.77	0.68	0.05	3.60	90	1.59
15	Cladopelma sp	22	0.58	0.68	0.05	3.30	90	1.13
16	Cladotanytarsus sp	47	0.61	0.69	0.05	3.30	90	1.64
17	Coelotanypus sp	17	1.11	0.92	0.12	3.40	90	2.68
18	Cricotopus sp	59	2.71	6.93	0.01	46.00	90	9.00
19	Cricotopus vierriensis	0						
20	Cryptochironomus sp	128	0.53	0.57	0.05	3.40	90	1.20
21	Dicrotendipes sp	36	1.01	2.29	0.05	14.00	90	1.58
22	Eukiefferiella sp	53	0.54	0.68	0.10	3.90	90	0.94
23	Gammarus fasciatus	227	0.68	0.74	0.01	4.00	90	1.54
24	Glossiphonia heteroclita	13	0.86	0.97	0.50	4.00	90	2.88
25	Glossosoma sp	40	2.43	7.59	0.10	46.00	90	3.84
26	Glyptotendipes sp	23	0.82	0.74	0.10	2.50	90	2.18
27	Gyraulus parvus	24	0.71	1.01	0.08	3.90	90	2.75
28	Helisoma anceps	11	0.64	0.64	0.05	2.20	90	2.00
29	Heterotrissocladius sp	17	0.53	0.95	0.05	4.10	90	1.54
30	Hyalella azteca	47	1.82	2.14	0.05	9.00	90	4.80
31	Hydropsyche sp	45	0.47	0.57	0.10	3.90	90	0.86
32	Hydroptila sp	38	0.49	0.54	0.01	3.30	90	0.91
33	Ilyodrilus templetoni	17	0.73	0.81	0.10	3.30	90	2.42
34	Limnodrilus hoffmeisteri	188	0.96	2.30	0.01	26.00	90	1.71
35	Limnodrilus sp	63	4.32	7.27	0.10	46.00	90	12.00
36	Limnodrilus udekemianus	33	1.13	2.27	0.10	12.00	90	1.80
37	Lumbriculus variegatus	37	0.53	0.61	0.01	3.30	90	1.04
38	Manayunkia speciosa	69	0.47	0.48	0.01	2.20	90	1.00
39	Microtendipes sp	13	0.93	0.70	0.10	2.00	90	2.00
40	Mystacides sp	12	0.51	0.22	0.10	0.85	90	0.81
41	Nais behningi	27	0.45	0.55	0.10	3.00	90	0.72
42	Nais communis	38	0.29	0.20	0.05	0.90	90	0.60
43	Nais variabilus	70	0.56	0.74	0.01	3.90	90	1.20
44	Nanocladius sp	35	0.43	0.41	0.01	2.20	90	0.91
45	Neureclipsis sp	36	0.39	0.37	0.10	2.20	90	0.86
46	Oecetis sp	38	0.57	0.56	0.10	2.20	90	1.55
47	Parachironomus sp	20	0.70	1.00	0.01	4.10	90	2.39
48	Paralauterborniella sp	16	0.55	0.71	0.05	3.00	90	1.53
49	Paratendipes sp	24	0.64	0.86	0.05	3.90	90	1.80
50	Phaenopsectra sp	40	2.76	8.17	0.10	46.00	90	11.02
51	Phallodrilus sp	24	0.32	0.19	0.01	0.95	90	0.55
52	Physella gyrina	91	0.51	0.62	0.01	4.10	90	0.89

53	Piguetiella michiganensi	46	0.48	0.70	0.05	3.30	90	1.03
54	Pisidium casertanum	160	0.77	2.14	0.01	26.00	90	1.39
55	Pisidium compressum	33	0.72	0.95	0.01	4.10	90	1.86
56	Pisidium conventus	14	0.53	1.06	0.08	4.10	90	2.60
57	Pisidium fallax	92	0.53	0.66	0.01	3.90	90	1.11
58	Pisidium henslowanum	31	0.46	0.83	0.01	4.10	90	1.29
59	Pisidium lilljeborgi	22	0.67	1.11	0.08	4.10	90	2.94
60	Pisidium nitidum	23	0.31	0.29	0.08	1.10	90	0.94
61	Pisidium variabile	36	0.57	0.75	0.01	4.10	90	1.13
62	Pleurocera acuta	77	0.57	0.74	0.01	3.90	90	1.04
63	Polypedilum scalaenum	13	0.10	0.06	0.05	0.20	90	0.20
64	Polypedilum sp	118	1.67	5.08	0.05	46.00	90	3.00
65	Pontoporeia hoyi	36	0.52	0.62	0.05	2.50	90	1.40
66	Potamothrix moldaviensis	57	1.24	3.98	0.01	26.00	90	2.20
67	Potamothrix vejdovskyi	56	0.49	0.70	0.01	4.10	90	1.10
68	Pristina foreli	13	0.52	033	0.20	1.20	90	1.10
69	Pristina osborni	46	0.46	0.49	0.10	3.30	90	0.83
70	Procladius sp	201	1.79	4.44	0.01	46.00	90	3.08
71	Prostoma rubrum	116	0.54	0.73	0.01	4.10	90	0.97
72	Pseudocloeon sp	16	0.97	1.15	0.01	3.90	90	3.48
73	Quistadrilus multisetosu	61	0.78	0.88	0.10	4.10	90	2.20
74	Slavina appendiculata	35	0.47	0.31	0.10	1.20	90	0.97
75	Specaria josinae	29	0.64	0.70	0.10	3.30	90	1.20
76	Sphaerium nitidum	16	0.46	0.61	0.10	2.50	90	1.52
77	Sphaerium striatinum	62	0.62	0.78	0.01	3.90	90	1.20
78	Spirosperma ferox	111	0.55	0.65	0.01	4.10	90	0.97
79	Stenonema sp	55	0.61	0.77	0.01	3.90	90	1.20
80	Stictochironomus sp	16	0.48	0.21	0.12	1.00	90	0.77
81	Stylaria lacustris	55	0.70	0.94	0.01	4.50	90	1.90
82	Stylodrilus heringianus	85	0.60	0.89	0.01	5.00	90	1.08
83	Tanytarsus sp	96	0.51	0.46	0.05	2.50	90	1.10
84	Thienemannimyia sp	59	0.63	0.85	0.05	3.90	90	1.90
85	Tubifex sp	36	5.23	8.51	0.10	46.00	90	14.30
86	Turbellaria	100	0.54	0.66	0.01	3.90	90	1.00
87	Uncinais uncinata	21	0.16	0.11	0.05	0.40	90	0.38
88	Valvata sincera	72	0.86	1.95	0.08	16.00	90	1.34
89	Valvata tricarinata	58	0.56	0.55	0.10	3.13	90	1.20
90	Vejdovskyella intermedia	58	0.40	0.68	0.01	4.10	90	0.92
91	Elliptio complanata	11	0.82	1.06	0.50	4.00	90	3.30
92	Sphaerium simile	20	0.68	0.78	0.50	4.00	90	0.50
93	Chironomus plumosus	66	1.67	2.61	0.05	16.00	90	4.50
94	Cricotopus bicinctus	1	0.15		0.15	0.15	90	.
95	Ephemera sp	1	0.10		0.10	0.10	90	.
96	Helobdella stagnalis	25	1.09	0.70	0.23	2.50	90	2.20
97	Hexagenia limbata	12	1.02	1.13	0.10	3.10	90	3.07
98	Hexagenia sp	4	0.39	0.09	0.28	0.50	90	.
99	Tanypus sp	0						
100	Tubifex tubifex	48	1.58	4.27	0.10	26.00	90	2.30

Table 3: **CHROMIUM** - Species Screening Level Concentration (µg/g).

Spp No.	Species	N=	Mean	Std. Dev.	Minimum	Maximum	%	Conc.
1	Ablabesmyia sp	37	38.39	45.29	5.20	240.00	90	98.00
2	Aelosoma sp	14	26.00	27.79	11.00	120.00	90	77.50
3	Amnicola limosa	100	28.60	29.31	4.10	200.00	90	56.30
4	Asellus sp	85	42.23	29.57	8.60	200.00	90	75.20
5	Aulodrilus limnobius	26	22.39	13.49	9.00	67.00	90	41.60
6	Aulodrilus pigueti	32	24.00	8.77	14.00	57.00	90	36.10
7	Aulodrilus pleuriseta	30	34.49	27.03	0.01	120.00	90	68.80
8	Bithynia tentaculata	33	28.54	14.92	7.00	67.00	90	46.60
9	Branchiura sowerbyi	14	2935	16.44	13.00	62.00	90	61.00
10	Caenis sp	34	23.24	18.77	5.30	120.00	90	33.50
11	Ceraclea sp	64	19.05	12.16	6.90	100.00	90	28.50
12	Chaetogaster diaphanus	32	17.74	11.05	1.50	48.00	90	33.70
13	Cheumatopsyche sp	87	22.67	23.38	6.90	200.00	90	33.00
14	Chironomus sp	110	30.81	17.72	7.00	95.20	90	53.90
15	Cladopelma sp	22	25.37	18.29	5.20	100.00	90	36.10
16	Cladotanytarsus sp	48	25.38	29.31	6.60	200.00	90	3830
17	Coelotanypus sp	17	34.51	20.42	9.67	83.00	90	77.40
18	Cricotopus sp	60	40.51	59.47	0.01	270.00	90	120.00
19	Cricotopus vierriensis	0						
20	Cryptochironomus sp	137	152.16	1450.23	4.30	17000.00	90	62.20
21	Dicrotendipes sp	46	29.89	23.70	4.10	106.40	90	62.67
22	Eukiefferiella sp	53	16.93	5.91	6.90	33.00	90	26.20
23	Gammarus fasciatus	219	25.48	22.39	0.01	200.00	90	47.00
24	Glossiphonia heteroclita	4	29.75	13.67	16.00	42.00	90	.
25	Glossosoma sp	40	26.24	39.34	7.10	240.00	90	27.00
26	Glyptotendipes sp	19	39.09	43.75	7.70	200.00	90	85.00
27	Gyraulus parvus	33	23.14	19.00	5.20	100.00	90	47.00
28	Helisoma anceps	12	25.56	14.11	5.20	58.00	90	51.70
29	Heterotrissocladius sp	24	35.03	35.73	5.20	122.90	90	106.75
30	Hyalella azteca	46	39.69	57.12	6.00	270.00	90	106.00
31	Hydropsyche sp	50	19.05	7.87	6.90	46.00	90	27.00
32	Hydroptila sp	38	19.98	8.20	5.20	37.00	90	33.10
33	Ilyodrilus templetoni	18	25.28	22.05	10.00	100.00	90	62.20
34	Limnodrilus hoffmeisteri	201	129.43	1197.51	0.01	17000.00	90	85.00
35	Limnodrilus sp	59	54.52	44.67	7.00	240.00	90	100.00
36	Limnodrilus udekemianus	40	53.90	108.66	5.50	670.00	90	145.00
37	Lumbriculus variegatus	54	35.71	34.81	7.10	157.90	90	96.55
38	Manayunkia speciosa	69	2335	14.09	6.90	98.00	90	40.00
39	Microtendipes sp	14	30.24	16.87	6.90	54.00	90	53.00
40	Mystacides sp	15	20.06	9.77	9.90	37.00	90	34.60
41	Nais behningi	27	19.94	16.99	6.90	98.00	90	27.40
42	Nais communis	38	15.66	8.45	1.50	37.00	90	30.10
43	Nais variabilus	70	20.08	14.73	0.01	100.00	90	33.90
44	Nanocladius sp	35	19.47	15.38	6.90	98.00	90	32.40
45	Neureclipsis sp	36	1659	6.08	6.90	33.00	90	27.00
46	Oecetis sp	38	22.68	14.88	4.10	74.00	90	42.10
47	Parachironomus sp	21	27.13	28.38	0.01	120.00	90	78.40
48	Paralauterborniella sp	16	17.63	8.07	9.00	34.00	90	33.30
49	Paratendipes sp	25	20.49	12.70	4.30	67.00	90	32.40
50	Phaenopsectra sp	41	31.66	42.39	4.10	240.00	90	91.00
51	Phallodrilus sp	24	21.67	17.07	11.00	98.00	90	27.00
52	Physella gyrina	95	19.86	14.36	4.50	120.00	90	33.00
53	Piguetiella michiganensi	48	12.80	5.31	3.50	27.00	90	20.10

54	Pisidium casertanum	195	34.24	53.62	0.01	670.00	90	69.04
55	Pisidium compressum	18	35.40	28.94	0.01	120.00	90	74.19
56	Pisidium conventus	16	27.97	35.90	4.50	120.00	90	110.48
57	Pisidium fallax	94	20.57	14.37	6.60	98.00	90	33.50
58	Pisidium henslowanum	45	35.45	33.35	0.01	122.90	90	95.94
59	Pisidium lilljeborgi	26	29.22	32.85	3.50	120.00	90	101.64
60	Pisidium nitidum	24	20.95	18.42	5.60	78.80	90	53.00
61	Pisidium variabile	24	24.07	26.11	0.01	120.00	90	58.45
62	Pleurocera acuta	78	20.02	14.48	6.90	100.00	90	31.10
63	Polypedilum scalaenum	13	10.03	4.02	4.30	19.00	90	17.00
64	Polypedilum sp	122	27.63	30.34	5.20	240.00	90	46.80
65	Pontoporeia hoyi	59	41.22	33.81	1.50	157.90	90	93.50
66	Potamothrix moldaviensis	76	264.4	1947.34	0.01	17000.00	90	87.41
67	Potamothrix vejdovskyi	69	30.82	33.12	0.01	157.90	90	93.50
68	Pristina foreli	13	20.28	9.13	8.60	37.00	90	35.40
69	Pristina osborni	46	19.84	13.72	6.90	98.00	90	29.30
70	Procladius sp	224	43.80	36.05	0.01	240.00	90	90.25
71	Prostoma rubrum	116	20.73	16.16	5.20	120.00	90	31.30
72	Pseudocloeon sp	16	15.23	5.32	8.60	30.00	90	24.40
73	Quistadrilus multisetosu	74	271.11	1971.71	4.10	17000.00	90	105.00
74	Slavina appendiculata	36	17.95	6.91	5.20	37.00	90	28.20
75	Specaria josinae	29	27.24	18.97	6.90	100.00	90	57.00
76	Sphaerium nitidum	26	39.76	36.15	5.60	122.90	90	101.64
77	Sphaerium striatinum	65	21.44	18.29	5.20	110.00	90	48.20
78	Spirosperma ferox	114	27.64	23.92	0.01	140.00	90	62.55
79	Stenonema sp	55	16.86	6.52	4.30	32.00	90	27.00
80	Stictochironomus sp	18	16.91	8.89	4.10	41.00	90	30.20
81	Stylaria lacustris	55	22.52	15.60	0.01	120.00	90	33.00
82	Stylodrllus heringianus	87	21.18	20.55	4.50	126.50	90	32.00
83	Tanytarsus sp	95	23.44	16.76	3.50	85.00	90	48.60
84	Thienemannimyia sp	64	20.72	21.61	4.30	160.00	90	32.00
85	Tubifex sp	36	59.38	49.53	7.00	240.00	90	127.55
86	Turbellaria	100	20.69	13.88	6.90	100.00	90	32.00
87	Uncinais uncinata	21	12.21	5.76	1.50	25.00	90	19.00
88	Valvata sincera	79	34.61	46.84	5.60	400.00	90	63.00
89	Valvata tricarinata	71	25.89	18.30	4.10	100.00	90	53.60
90	Vejdovskyella intermedia	58	17.00	18.38	0.01	120.00	90	31.10
91	Elliptic complanata	1	42.00		42.00	42.00	90	.
92	Sphaerium simile	0						
93	Chironomus plumosus	79	261.74	1908.30	5.50	17000.00	90	85.00
94	Cricotopus bicinctus	5	25.50	16.06	3.50	45.00	90	
95	Ephemera sp	3	15.53	10.00	8.60	27.00	90	
96	Helobdella stagnalis	25	32.12	13.63	12.00	55.00	90	53.40
97	Hexagenia limbata	23	27.67	19.91	9.50	79.00	90	62.20
98	Hexagenia sp	5	17.30	6.53	10.00	24.42	90	.
99	Tanypus sp	0						
100	Tubifex tubifex	64	66.12	97.41	5.50	670.00	90	140.00

Table 4: **COPPER** - Species Screening Level Concentrations (µg/g).

Spp. No.	Species	N=	Mean	Std. Dev.	Minimum	Maximum	%	Conc.
1	Ablabesmyia sp	37	31.64	43.82	2.00	170	90	106.0
2	Aelosoma sp	14	17.07	26.50	1.25	92	90	77.5
3	Amnicola limosa	106	23.45	35.79	1.25	320	90	50.5
4	Asellus sp	85	36.01	22.21	3.30	100	90	69.8
5	Aulodrilus limnobius	26	14.79	14.65	1.25	67	90	40.5
6	Aulodrilus pigueti	32	15.27	10.15	1.25	44	90	32.4
7	Aulodrilus pleuriseta	30	25.96	25.18	0.01	100	90	65.4
8	Bithynia tentaculata	53	23.61	18.56	1.25	100	90	49.6
9	Branchiura sowerbyi	14	23.60	11.56	2.50	47	90	40.5
10	Caenis sp	34	16.02	16.41	2.50	92	90	25.5
11	Ceraclea sp	64	11.00	18.06	1.25	130	90	16.5
12	Chaetogaster diaphanus	32	12.69	11.13	1.50	51	90	26.8
13	Cheumatopsyche sp	87	13.62	18.85	1.25	130	90	33.0
14	Chironomus sp	119	26.07	21.89	2.50	160	90	50.5
15	Cladopelma sp	22	19.78	26.27	3.50	130	90	35.8
16	Cladotanytarsus sp	48	15.01	14.76	1.25	69	90	36.3
17	Coelotanypus sp	17	37.00	20.81	10.24	94	90	73.2
18	Cricotopus sp	59	38.33	77.69	0.01	390	90	150.0
19	Cricotopus vierriensis	0						
20	Cryptochironomus sp	146	139.71	1405.34	1.25	17000	90	47.6
21	Dicrotendipes sp	48	24.31	20.80	2.50	95	90	54.7
22	Eukiefferiella sp	53	9.99	11.65	1.25	63	90	21.2
23	Gammarus fasciatus	244	20.87	25.21	0.01	278	90	44.0
24	Glossiphonia heteroclita	15	24.33	15.16	4.00	61	90	53.8
25	Glossosoma sp	40	18.25	35.74	1.25	170	90	61.1
26	Glyptotendipes sp	25	25.27	17.89	3.90	74	90	51.9
27	Gyraulus parvus	33	21.97	22.19	2.10	100	90	50.8
28	Helisoma anceps	12	21.73	19.51	1.25	76	90	63.1
29	Heterotrissocladius sp	24	17.71	22.01	1.25	92	90	55.1
30	Hyalella azteca	56	43.51	74.28	3.70	390	90	93.7
31	Hydropsyche sp	50	14.77	14.70	1.25	63	90	35.7
32	Hydroptila sp	38	9.86	8.72	1.25	36	90	24.0
33	Ilyodrilus templetoni	18	23.28	31.82	1.25	130	90	81.4
34	Limnodrilus hoffmeisteri	220	115.41	1144.66	0.01	17000	90	75.4
35	Limnodrilus sp	64	486.90	3493.94	6.00	28000	90	110.0
36	Limnodrilus udekemianus	40	44.91	73.87	2.50	340	90	125.3
37	Lumbriculus variegatus	54	17.93	19.22	1.25	85	90	49.8
38	Manayunkia speciosa	69	15.63	19.95	1.25	113	90	40.0
39	Microtendipes sp	14	40.54	26.38	3.00	78	90	76.0
40	Mystacides sp	15	11.76	6.23	1.25	24	90	19.8
41	Nais behningi	27	9.19	10.84	1.25	44	90	33.6
42.	Nais communis	38	10.93	17.99	2.00	113	90	17.7
43	Nais variabilus	69	14.72	19.37	0.01	130	90	36.0
44	Nanocladius sp	35	10.09	8.91	1.25	44	90	18.2
45	Neureclipsis sp	36	9.05	11.82	1.25	63	90	16.0
46	Oecetis sp	38	20.97	21.23	1.50	78	90	62.0
47	Parachironomus sp	21	21.41	21.69	0.01	92	90	49.0
48	Paralauterborniella sp	16	10.24	7.60	1.25	24	90	24.0
49	Paratendipes sp	25	11.63	13.26	1.25	67	90	23.2
50	Phaenopsectra sp	41	23.05	33.00	1.25	170	90	74.6
51	Phallodrilus sp	24	10.21	14.35	1.25	63	90	31.0
52	Physella gyrina	103	14.43	14.50	1.25	92	90	30.2

53	Piguetiella michiganensi	47	6.57	4.48	1.25	22	90	13.2
54	Pisidium casertanum	195	24.27	38.48	0.01	340	90	50.94
55	Pisidium compressum	37	20.91	17.85	0.01	92	90	41.2
56	Pisidium conventus	16	18.43	23.53	1.40	92	90	63.23
57	Pisidium fallax	94	13.02	18.85	1.25	113	90	35.0
58	Pisidium henslowanum	45	19.47	20.53	0.01	92	90	50.94
59	Pisidium lilljeborgi	26	22.34	22.88	1.50	92	90	55.73
60	Pisidium nitidum	24	11.21	10.86	1.25	38.2	90	29.0
61	Pisidium variabile	38	18.42	18.11	0.01	92	90	36.2
62	Pleurocera acuta	78	12.97	20.83	1.25	130	90	22.7
63	Polypedilum scalaenum	13	7.37	3.59	2.00	14	90	13.6
64	Polypedilum sp	123	21.97	32.33	1.25	170	90	45.8
65	Pontoporeia hoyi	59	24.30	20.93	1.40	85	90	51.0
66	Potamothrix moldaviensis	76	250.68	1947.54	0.01	17000	90	71.1
67	Potamothrix vejdovskyi	69	20.73	25.63	0.01	130	90	54.0
68	Pristina foreli	13	9.64	8.61	1.25	33	90	27.0
69	Pristina osborni	46	9.97	11.49	1.25	63	90	24.6
70	Procladius sp	229	159.74	1848.17	0.01	28000	90	86.0
71	Prostoma rubrum	116	13.32	20.09	1.25	130	90	25.3
72	Pseudocloeon sp	16	12.67	27.15	1.25	113	90	47.9
73	Quistadrilus multisetosu	74	271.29	1971.89	3.00	17000	90	93.0
74	Slavina appendiculata	36	12.05	9.29	2.50	39	90	29.5
75	Specaria josinae	29	20.23	25.30	1.25	130	90	44.0
76	Sphaerium nitidum	26	21.52	19.31	2.50	67	90	55.19
77	Sphaerium striatinum	66	13.53	17.17	1.25	100	90	35.9
78	Spirosperma ferox	127	19.69	19.85	0.01	130	90	41.6
79	Stenonema sp	55	9.63	11.82	1.25	63	90	18.2
80	Stictochironomus sp	19	15.86	14.81	1.25	61	90	33.81
81	Stylaria lacustris	54	17.14	15.03	0.01	92	90	35.65
82	Stylodrllus heringianus	93	12.71	16.20	1.25	113	90	25.6
83	Tanytarsus sp	99	17.36	14.10	1.40	67	90	39.0
84	Thienemannimyia sp	63	15.04	21.84	1.25	130	90	41.6
85	Tubifex sp	36	827.44	4658.32	6.00	28000	90	129.0
86	Turbellaria	100	13.47	19.33	1.25	130	90	33.0
87	Uncinais uncinata	20	7.30	4.02	1.40	16	90	13.9
88	Valvata sincera	86	25.53	32.01	1.25	260	90	50.5
89	Valvata tricarinata	71	21.06	19.11	1.25	100	90	41.8
90	Vejdovskyella intermedia	57	13.23	18.20	0.01	92	90	30.2
91	Elliptio complanata	12	19.17	5.59	11.00	33	90	30.0
92	Sphaerium simile	20	19.05	7.52	4.00	36	90	34.9
93	Chironomus plumosus	79	264.24	1908.23	3.90	17000	90	94.0
94	Cricotopus bicinctus	5	24.68	12.44	4.40	38	90	.
95	Ephemera sp	3	15.30	18.03	3.00	36	90	.
96	Helobdella stagnalis	27	38.89	20.77	11.00	100	90	71.6
97	Hexagenia limbata	23	25.79	19.57	3.90	82	90	59.4
98	Hexagenia sp	5	13.80	7.38	3.30	22.56	90	.
99	Tanypus sp	0						
100	Tubifex tubifex	64	54.30	66.55	2.00	340	90	100.0

Table 5: **IRON** - Species Screening Level Concentrations (µg/g).

Spp No.	Species	N=	Mean	Std. Dev.	Minimum	Maximum	%	Conc.
1	Ablabesmyia sp	37	16682.14	8522.41	19	35000	90	28400
2	Aelosoma sp	14	22214.29	7505.68	10000	31000	90	31000
3	Amnicola limosa	106	16202.07	9404.92	19	48000	90	30300
4	Asellus sp	85	18867.41	11300.51	29	79000	90	31664.3
5	Aulodrilus limnobius	26	19365.39	7986.94	10000	35000	90	34300
6	Aulodrilus pigueti	32	17376.00	7612.36	13	35000	90	30700
7	Aulodrilus pleuriseta	30	20806.67	14410.99	0.005	79000	90	33700
8	Bithynia tentaculata	53	21360.55	21164.86	2700	140000	90	35900
9	Branchiura sowerbyi	14	20236.43	6896.74	12000	35000	90	33500
10	Caenis sp	34	14348.54	8143.89	19	35000	90	26000
11	Ceraclea sp	64	20673.73	12191.03	19	85000	90	34500
12	Chaetogaster diaphanus	32	13000.00	7871.47	2700	35000	90	25200
13	Cheumatopsyche sp	87	19921.84	10984.66	6700	85000	90	34200
14	Chironomus sp	119	17869.21	9927.15	19	59000	90	30000
15	Cladopelma sp	22	16977.86	10156.67	13	36000	90	35000
16	Cladotanytarsus sp	48	15638.54	7687.24	2800	38000	90	29100
17	Coelotanypus sp	17	19229.50	9952.08	31.5	35000	90	33400
18	Cricotopus sp	59	19530.51	12334.80	0.005	85000	90	34000
19	Cricotopus vierriensis	0						
20	Cryptochironomus sp	146	16431.41	9303.46	1800	48000	90	30078.21
21	Dicrotendipes sp	48	16808.54	9910.42	4500	48000	90	31011.34
22	Eukiefferiella sp	53	19519.23	12353.81	19	85000	90	32000
23	Gammarus fasciatus	244	18451.52	17408.76	0.005	170000	90	31000
24	Glossiphonia heteroclita	15	21360.60	17153.89	1800	58000	90	56560
25	Glossosoma sp	40	20080.00	8649.83	9200	38000	90	31900
26	Glyptotendipes sp	25	12149.62	8229.70	31.5	29000	90	26800
27	Gyraulus parvus	33	15872.73	13596.88	4500	79000	90	30600
28	Helisoma anceps	12	17766.67	9365.73	3500	35000	90	33800
29	Heterotrissocladius sp	24	17802.77	8148.08	5700	39436.9	90	29703.7
30	Hyalella azteca	56	15507.66	12063.33	1800	79000	90	31300
31	Hydropsyche sp	50	19500.00	12829.53	6700	85000	90	31000
32	Hydroptila sp	38	19123.68	8429.50	3500	38000	90	34100
33	Ilyodrilus templetoni	18	18244.44	8812.71	7400	36000	90	35100
34	Limnodrilus hoffmeisteri	220	20497.79	20983.20	0.005	170000	90	34000
35	Limnodrilus sp	64	20735.96	10518.81	0.05	35000	90	31500
36	Limnodrilus udekemianus	40	20212.25	22391.38	4500	110000	90	34900
37	Lumbriculus variegatus	54	21479.42	11968.44	7900	85000	90	31997
38	Manayunkia speciosa	69	19828.68	8509.72	19	38000	90	34000
39	Microtendipes sp	14	17816.54	10245.36	31.5	31000	90	30500
40	Mystacides sp	15	15793.33	7297.01	6900	31000	90	30400
41	Nais behningi	27	22051.85	15738.62	6700	85000	90	36400
42	Nais communis	38	14260.53	7129.33	2700	35000	90	21600
43	Nais variabilus	69	15433.61	8308.54	0.005	36000	90	30000
44	Nanocladius sp	35	17131.43	7170.64	6700	34000	90	30400
45	Neureclipsis sp	36	19761.11	8605.52	6700	38000	90	32900
46	Oecetis sp	38	19121.05	10444.50	4100	48000	90	35000
47	Parachironomus sp	21	13209.52	7727.35	0.005	30000	90	25800
48	Paralauterborniella sp	16	14081.25	4179.03	8200	21000	90	21000
49	Paratendipes sp	25	15560.00	8135.47	2800	31000	90	29400
50	Phaenopsectra sp	41	17688.27	9198.11	19	48000	90	31800
51	Phallodrilus sp	24	22750.00	8409.36	10000	38000	90	36000
52	Physella gyrina	103	15957.55	9682.72	19	59400	90	29600

53	Piguetiella michiganensi	47	12108.51	5595.41	2800	28000	90	19400
54	Pisidium casertanum	195	17966.74	9408.62	0.005	48000	90	32000
55	Pisidium compressum	37	18866.11	15556.16	0.005	59400	90	42669.52
56	Pisidium conventus	16	12585.01	8203.73	2000	29127.5	90	26238.25
57	Pisidium fallax	94	18657.45	8569.21	4800	38000	90	33000
58	Pisidium henslowanum	45	16510.03	8793.58	0.005	31994	90	30556.42
59	Pisidium lilljeborgi	26	14789.15	9354.41	3700	34000	90	29821.4
60	Pisidium nitidum	24	16100.35	8308.00	3700	31000	90	30000
61	Pisidium variabile	38	14937.82	22279.88	0.005	140000	90	25300
62	Pleurocera acuta	78	18657.94	8349.25	19	38000	90	31100
63	Polypedilum scalaenum	13	9084.62	6045.36	2800	27000	90	21000
64	Polypedilum sp	123	18822.27	10513.72	13	85000	90	31000
65	Pontoporeia hoyi	59	17626.80	11131.87	2000	58096.3	90	31440.5
66	Potamothrix moldaviensis	76	16595.59	13341.09	0.005	85000	90	32300
67	Potamothrix vejdovskyi	69	16685.83	12152.68	0.005	93000	90	28000
68	Pristina foreli	13	17015.39	8629.97	8700	38000	90	34800
69	Pristina osborni	46	21265.22	12621.41	6700	85000	90	35000
70	Procladius sp	229	20190.65	11633.09	0.005	93000	90	33000
71	Prostoma rubrum	116	18907.92	10443.17	19	85000	90	32000
72	Pseudocloeon sp	16	16431.25	7715.59	9200	35000	90	32900
73	Quistadrilus multisetosu	74	20217.61	17016.62	13	130000	90	34500
74	Slavina appendiculata	36	14606.08	5797.50	19	30000	90	21200
75	Specaria josinae	29	17766.17	8450.85	19	36000	90	34000
76	Sphaerium nitidum	26	17220.76	8776.78	3700	33239.9	90	31606.55
77	Sphaerium striatinum	66	16757.58	8340.08	2900	38000	90	29600
78	Spirosperma ferox	127	18572.92	14884.14	0.005	140000	90	31289.52
79	Stenonema sp	55	17605.80	7798.86	19	38000	90	29800
80	Stictochironomus sp	19	15070.53	10615.18	6000	48000	90	35000
81	Stylaria lacustris	54	17109.61	7435.22	0.005	35000	90	28500
82	Stylodrilus heringianus	93	18367.19	16312.43	19	140000	90	31000
83	Tanytarsus sp	99	15683.02	8538.28	19	48000	90	27000
84	Thienemannimyia sp	63	17842.86	14732.41	3500	110000	90	31600
85	Tubifex sp	36	23428.59	9491.76	0.05	35000	90	33000
86	Turbellaria	100	19805.00	10499.29	6700	85000	90	33800
87	Uncinais uncinata	20	11175.00	7380.05	2000	31000	90	26100
88	Valvata sincera	86	15579.45	8694.81	19	35000	90	29300
89	Valvata tricarinata	71	17835.79	12188.63	19	79000	90	31000
90	Vejdovskyella intermedia	57	11950.88	7298.41	0.005	35000	90	21000
91	Elliptio complanata	12	33909.08	37888.36	5300	140000	90	115400
92	Sphaerium simile	20	25395.45	32931.09	1800	140000	90	59260
93	Chironomus plumosus	79	17747.63	8423.89	13	38000	90	28000
94	Cricotopus bicinctus	5	11300.00	5591.96	3700	17000	90	.
95	Ephemera sp	3	15333.33	10408.33	7000	27000	90	.
96	Helobdella stagnalis	27	18907.74	9147.69	5800	35000	90	34200
97	Hexagenia limbata	23	17143.48	16472.73	4700	67000	90	48200
98	Hexagenia sp	5	10362.00	3182.31	6300	14160	90	.
99	Tanypus sp	0						
100	Tubifex tubifex	64	21835.33	18206.17	13	130000	90	35500

Table 6: **LEAD** - Species Screening Level Concentrations (µg/g).

Spp. No.	Species	N=	Mean	Std. Dev	Minimum	Maximum	%	Conc.
1	Ablabesmyia sp	36	104.03	333.69	0.75	2000	90	212.0
2	Aelosoma sp	14	41.84	55.36	2.00	180	90	145.0
3	Amnicola limosa	89	30.48	38.97	1.00	221	90	75.0
4	Asellus sp	62	63.93	64.31	3.62	350	90	154.0
5	Aulodrilus limnobius	35	32.40	37.78	2.50	180	90	81.8
6	Aulodrilus pigueti	31	33.38	40.85	3.00	221	90	71.0
7	Aulodrilus pleuriseta	24	37.28	46.82	0.01	221	90	101.0
8	Bithynia tentaculata	43	44.20	68.98	2.70	350	90	148.0
9	Branchiura sowerbyi	14	27.19	14.75	2.50	53	90	49.0
10	Caenis sp	30	24.47	30.33	3.00	134	90	72.5
11	Ceraclea sp	61	20.30	31.40	2.00	200	90	42.0
12	Chaetogaster diaphanus	32	25.52	39.12	0.75	221	90	42.0
13	Cheumatopsyche sp	86	29.78	44.42	2.00	221	90	76.3
14	Chironomus sp	95	44.35	55.36	3.00	350	90	118.0
15	Cladopelma sp	22	44.63	59.60	1.50	221	90	173.0
16	Cladotanytarsus sp	47	30.54	44.87	0.75	221	90	75.4
17	Coelotanypus sp	17	56.11	45.37	3.62	160	90	139.2
18	Cricotopus sp	58	72.78	154.10	0.01	760	90	247.0
19	Cricotopus vierriensis	0						
20	Cryptochironomus sp	131	37.28	52.39	0.01	350	90	95.0
21	Dicrotendipes sp	38	46.44	54.20	1.00	240	90	133.0
22	Eukiefferiella sp	53	18.66	21.82	2.00	110	90	42.0
23	Gammarus fasciatus	228	32.68	44.80	0.01	350	90	74.1
24	Glossiphonia heteroclita	13	42.04	55.27	5.00	190	90	166.0
25	Glossosoma sp	40	35.88	66.23	2.50	310	90	106.6
26	Glyptotendipes sp	23	60.99	58.05	8.10	190	90	160.0
27	Gyraulus parvus	24	28.82	39.24	1.80	160	90	93.5
28	Helisoma anceps	11	28.61	31.43	0.01	110	90	97.4
29	Heterotrissocladius sp	23	20.67	24.73	3.00	110	90	56.7
30	Hyalella azteca	47	80.66	159.60	3.00	760	90	192.0
31	Hydropsyche sp	45	24.80	25.65	2.00	110	90	72.8
32	Hydroptila sp	38	20.82	21.88	2.70	110	90	43.4
33	Ilyodrilus templetoni	17	38.35	51.38	3.00	200	90	128.0
34	Limnodrilus hoffmeisteri	194	44.97	50.87	0.01	430	90	110.0
35	Limnodrilus sp	64	120.44	252.63	0.06	2000	90	225.0
36	Limnodrilus udekemianus	33	41.25	77.72	1.00	430	90	98.8
37	Lumbriculus variegatus	53	22.67	23.50	2.50	114	90	54.3
38	Manayunkia speciosa	69	31.30	44.20	2.50	221	90	110.0
39	Microtendipes sp	13	107.69	82.34	3.00	230	90	218.0
40	Mystacides sp	12	13.42	9.34	3.00	32	90	31.1
41	Nais behningi	27	18.51	23.96	2.00	110	90	44.0
42	Nais communis	38	17.06	21.13	1.80	110	90	33.0
43	Nais variabilus	69	24.09	38.34	0.01	221	90	47.0
44	Nanocladius sp	35	19.40	20.77	3.00	77	90	54.2
45	Neureclipsis sp	36	19.14	37.68	2.50	221	90	39.2
46	Oecetis sp	38	44.20	61.58	1.00	230	90	162.0
47	Parachironomus sp	19	33.70	33.49	0.01	110	90	96.0
48	Paralauterborniella sp	16	23.89	53.15	0.01	221	90	85.9
49	Paratendipes sp	24	15.00	19.62	0.75	92	90	35.5
50	Phaenopsectra sp	40	45.66	73.23	3.00	310	90	197.0
51	Phallodrilus sp	24	34.48	47.77	2.70	221	90	93.0
52	Physella gyrina	91	23.09	28.85	2.00	140	90	55.8

53	Piguetiella michiganensi	45	8.86	8.13	0.01	35	90	20.4
54	Pisidium casertanum	176	34.39	41.78	0.01	221	90	92.5
55	Pisidium compressum	34	32.36	40.40	0.01	190	90	101.0
56	Pisidium conventus	16	22.21	29.17	2.80	110	90	79.9
57	Pisidium fallax	92	21.06	28.20	1.80	180	90	42.7
58	Pisidium henslowanum	43	28.08	35.03	0.01	180	90	69.4
59	Pisidium lilljeborgi	24	32.75	34.77	1.00	110	90	91.5
60	Pisidium nitidum	24	17.78	13.61	1.80	49.4	90	38.5
61	Pisidium variabile	37	27.65	36.43	0.01	190	90	69.6
62	Pleurocera acuta	77	20.20	32.58	2.00	200	90	42.0
63	Polypedilum scalaenum	13	3.92	2.66	0.01	9	90	8.6
64	Polypedilum sp	121	37.96	63.73	2.00	320	90	76.8
65	Pontoporeia hoyi	54	30.81	31.34	1.00	130	90	81.5
66	Potamothrix moldaviensis	64	31.07	39.72	0.01	210	90	103.0
67	Potamothrix vejdovskyi	63	24.73	37.26	0.01	221	90	44.7
68	Pristina foreli	13	25.73	28.38	3.00	110	90	84.8
69	Pristina osborni	46	20.83	30.34	2.00	180	90	39.2
70	Procladius sp	206	67.37	149.32	0.01	2000	90	160.0
71	Prostoma rubrum	116	23.63	36.01	2.00	221	90	43.5
72	Pseudocloeon sp	16	8.70	8.56	2.50	37	90	23.4
73	Quistadrilus multisetosu	61	50.67	55.14	1.00	260	90	128.0
74	Slavina appendiculata	35	19.43	18.69	2.50	77	90	44.6
75	Specaria josinae	29	36.17	51.28	4.90	221	90	92.0
76	Sphaerium nitidum	25	26.89	23.52	3.50	92	90	64.8
77	Sphaerium striatinum	62	23.35	34.58	1.80	180	90	71.7
78	Spirosperma ferox	116	31.63	44.16	0.01	260	90	72.2
79	Stenonema sp	55	18.54	32.01	2.00	221	90	37.4
80	Stictochironomus sp	16	20.90	30.82	3.00	130	90	65.6
81	Stylaria lacustris	54	27.89	27.25	0.01	110	90	76.0
82	Stylodrllus heringianus	85	18.54	2633	2.50	190	90	35.2
83	Tanytarsus sp	96	28.19	30.95	0.01	190	90	71.0
84	Thienemannimyia sp	58	19.53	29.82	0.01	190	90	42.1
85	Tubifex sp	36	139.60	327.59	11.00	2000	90	226.0
86	Turbellaria	100	24.16	36.55	2.00	221	90	42.9
87	Uncinais uncinata	20	11.23	16.01	0.01	71	90	30.9
88	Valvata sincera	76	41.27	48.14	1.80	260	90	100.2
89	Valvata tricarinata	61	38.27	46.40	1.00	200	90	120.2
90	Vejdovskyella intermedia	57	20.75	36.68	0.01	221	90	48.6
91	Elliptio complanata	11	19.32	11.70	8.50	51	90	45.8
92	Sphaerium simile	20	35.40	45.23	5.00	190	90	113.5
93	Chironomus plumosus	66	78.59	134.84	0.01	760	90	133.0
94	Cricotopus bicinctus	1	1.00		1.00	1	90	.
95	Ephemera sp	1	3.00		3.00	3	90	.
96	Helobdella stagnalis	25	84.68	79.90	8.10	350	90	188.0
97	Hexagenia limbata	12	42.03	47.01	6.70	160	90	139.3
98	Hexagenia sp	4	19.08	5.49	13.69	24.46	90	.
99	Tanypus sp	0						
100	Tubifex tubifex	50	48.78	47.08	2.50	210	90	120.0

Table 7: **MANGANESE** - Species Screening Level Concentrations (µg/g).

Spp. No.	Species	N=	Mean	Std. Dev.	Minimum	Maximum	%	Conc.
1	Ablabesmyia sp	6	687.50	152.18	455	850	90	.
2	Aelosoma sp	0						
3	Amnicola limosa	29	242.52	137.56	30	620	90	440
4	Asellus sp	60	426.99	227.02	30	1250	90	668.08
5	Aulodrilus limnobius	9	253.33	39.05	180	290	90	.
6	Aulodrilus pigueti	0						
7	Aulodrilus pleuriseta	0						
8	Bithynia tentaculata	8	224.63	114.80	88	442	90	.
9	Branchiura sowerbyi	11	414.64	126.64	172	595	90	588
10	Caenis sp	8	222.13	118.96	77	465	90	.
11	Ceraclea sp	0						
12	Chaetogaster diaphanus	0						
13	Cheumatopsyche sp	7	306.71	249.37	30	660	90	.
14	Chironomus sp	54	438.90	320.74	88	2000	90	709.5
15	Cladopelma sp	4	335.00	91.47	200	400	90	.
16	Cladotanytarsus sp	11	319.55	197.14	30	595	90	582
17	Coelotanypus sp	10	443.70	155.39	170	710	90	704
18	Cricotopus sp	20	538.60	145.09	350	850	90	734.5
19	Cricotopus vierriensis	0						
20	Cryptochironomus sp	61	398.53	296.45	30	2000	90	694.16
21	Dicrotendipes sp	21	347.47	249.80	69	951.2	90	826.12
22	Eukiefferiella sp	0						
23	Gammarus fasciatus	73	336.17	172.42	30	951.2	90	586
24	Glossiphonia heteroclita	2	285.00	7.07	280	290	90	.
25	Glossosoma sp	3	750.00	111.36	630	850	90	.
26	Glyptotendipes sp	17	295.00	155.20	30	710	90	518
27	Gyraulus parvus	7	215.71	83.24	140	370	90	.
28	Helisoma anceps	0						
29	Heterotrissocladius sp	6	760.18	136.64	568	986.5	90	.
30	Hyalella azteca	29	493.62	216.93	150	1250	90	730
31	Hydropsyche sp	9	310.00	172.26	140	610	90	.
32	Hydroptila sp	0						
33	Ilyodrilus templetoni	0						
34	Limnodrilus hoffmeisteri	109	416.37	209.85	30	1143.6	90	700
35	Limnodrilus sp	64	414.31	263.25	88	2000	90	692.9
36	Limnodrilus udekemianus	15	306.67	230.42	130	1000	90	784
37	Lumbriculus variegatus	16	827.36	166.73	568	1143.6	90	1066.67
38	Manayunkia speciosa	3	326.67	40.42	290	370	90	.
39	Microtendipes sp	11	288.00	92.61	88	390	90	386
40	Mystacides sp	0						
41	Nais behningi	0						
42	Nais communis	0						
43	Nais variabilus	0						
44	Nanocladius sp	0						
45	Neureclipsis sp	0						
46	Oecetis sp	20	274.45	150.35	69	640	90	463.5
47	Parachironomus sp	3	356.67	140.12	200	470	90	.
48	Paralauterborniella sp	0						
49	Paratendipes sp	0						
50	Phaenopsectra sp	9	484.44	224.95	170	850	90	.
51	Phallodrilus sp	0						
52	Physella gyrina	17	272.77	133.82	77	620	90	508

53	Piguetiella michiganensi	0						
54	Pisidium casertanum	67	484.09	250.56	33	1033.7	90	833.84
55	Pisidium compressum	1	986.50		986.5	986.5	90	.
56	Pisidium conventus	3	552.67	331.67	170	757.4	90	.
57	Pisidium fallax	1	660.00		660	660.0	90	.
58	Pisidium henslowanum	12	761.79	125.27	568	1033.7	90	991.55
59	Pisidium lilljeborgi	9	510.88	362.98	170	1250.0	90	.
60	Pisidium nitidum	3	446.93	149.08	330	614.8	90	.
61	Pisidium variabile	2	504.40	303.21	290	718.8	90	.
62	Pleurocera acuta	0						
63	Polypedilum scalaenum	0						
64	Polypedilum sp	34	441.01	221.87	94	1033.7	90	775.1
65	Pontoporeia hoyi	31	652.27	335.74	130	1591.2	90	1033.06
66	Potamothrix moldaviensis	20	524.77	404.31	33	1591.2	90	1033.38
67	Potamothrix vejdovskyi	14	555.16	304.18	170	986.5	90	981.35
68	Pristina foreli	0						
69	Pristina osborni	0						
70	Procladius sp	139	406.40	186.40	30	1033.7	90	650
71	Prostoma rubrum	0						
72	Pseudocloeon sp	0						
73	Quistadrilus multisetosu	43	324.93	167.66	30	670.0	90	602
74	Slavina appendiculata	0						
75	Specaria josinae	0						
76	Sphaerium nitidum	9	780.20	106.14	650.8	1030.5	90	.
77	Sphaerium striatinum	15	331.33	172.83	140	630.0	90	624
78	Spirosperma ferox	21	446.41	250.81	140	1033.7	90	914.34
79	Stenonema sp	0						
80	Stictochironomus sp	4	342.00	220.07	88	620	90	.
81	Stylaria lacustris	9	580.56	262.14	380	1250	90	.
82	Stylodrilus heringianus	1	735.00		735	735	90	.
83	Tanytarsus sp	36	381.31	159.51	69	860	90	623
84	Thienemannimyia sp	10	334.00	329.18	30	1000	90	971
85	Tubifex sp	36	407.53	171.39	107	850	90	661.5
86	Turbellaria	0						
87	Uncinais uncinata	0						
88	Valvata sincera	31	361.42	218.55	33	1033.7	90	626.96
89	Valvata tricarinata	25	448.42	438.25	69	2000	90	1120.22
90	Vejdovskyella intermedia	0						
91	Elliptio complanata	0						
92	Sphaerium simile	0						
93	Chironomus plumosus	63	418.86	170.36	30	860	90	646
94	Cricotopus bicinctus	0						
95	Ephemera sp	0						
96	Helobdella stagnalis	23	338.09	137.17	150	620	90	582
97	Hexagenia limbata	12	320.25	198.73	89	710	90	668
98	Hexagenia sp	0						
99	Tanypus sp	0						
100	Tubifex tubifex	47	440.00	179.96	110	976.2	90	660

Table 8: **MERCURY** - Species Screening Level Concentrations (µg/g).

No.	Spp Species	N=	Mean	Std. Dev.	Minimum	Maximum	%	Conc.
1	Ablabesmyia sp	37	0.233	0.293	0.005	1.5	90	0.554
2	Aelosoma sp	14	0.061	0.087	0.010	0.32	90	0.250
3	Amnicola limosa	106	0.218	0.349	0.001	2	90	0.496
4	Asellus sp	81	0.696	3.387	0.001	30.4	90	0.988
5	Aulodrilus limnobius	26	0.170	0.168	0.020	0.81	90	0.374
6	Aulodrilus pigueti	33	0.406	0.845	0.010	4.7	90	1.224
7	Aulodrilus pleuriseta	30	0.270	0.340	0.005	1.5	90	0.772
8	Bithynia tentaculata	53	0.856	4.169	0.005	30.4	90	0.848
9	Branchiura sowerbyi	14	0.131	0.141	0.010	0.49	90	0.445
10	Caenis sp	34	0.262	0.390	0.001	1.6	90	0.795
11	Ceraclea sp	64	0.105	0.253	0.005	1.5	90	0.205
12	Chaetogaster diaphanus	32	0.127	0.155	0.005	0.81	90	0.281
13	Cheumatopsyche sp	87	0.128	0.261	0.005	1.5	90	0.260
14	Chironomus sp	108	0.271	0.444	0	2.6	90	0.592
15	Cladopelma sp	23	0.505	1.014	0.005	4.7	90	1.500
16	Cladotanytarsus sp	48	0.189	0.330	0.005	1.5	90	0.378
17	Coelotanypus sp	15	0.398	0.410	0.050	1.6	90	1.126
18	Cricotopus sp	62	0.163	0.322	0.005	1.7	90	0.400
19	Cricotopus vierriensis	0						
20	Cryptochironomus sp	144	0.401	2.544	0.005	30.4	90	0.470
21	Dicrotendipes sp	47	1.032	4.447	0.005	30.4	90	1.500
22	Eukiefferiella sp	53	0.053	0.067	0.010	0.31	90	0.162
23	Gammarus fasciatus	245	0.345	1.986	0.001	30.4	90	0.494
24	Glossiphonia heteroclita	15	2.272	7.807	0.005	30.4	90	13.66
25	Glossosoma sp	40	0.050	0.065	0.010	0.25	90	0.197
26	Glyptotendipes sp	24	0.236	0.419	0.005	1.6	90	1.00
27	Gyraulus parvus	33	0.232	0.357	0.001	1.5	90	0.852
28	Helisoma anceps	12	0.363	0.441	0.005	1.5	90	1.293
29	Heterotrissocladius sp	18	0.119	0.097	0.005	0.32	90	0.284
30	Hyalella azteca	56	0.186	0.451	0.005	3.25	90	0.403
31	Hydropsyche sp	50	0.100	0.287	0.005	2	90	0.242
32	Hydroptila sp	38	0.308	0.809	0.005	4.7	90	0.879
33	Ilyodrilus templetoni	18	0.562	1.099	0	4.7	90	1.820
34	Limnodrilus hoffmeisteri	212	0.305	0.751	0	8.5	90	0.678
35	Limnodrilus sp	64	0.831	3.788	0.005	30.4	90	1.169
36	Limnodrilus udekemianus	42	0.595	1.475	0.005	8.5	90	1.346
37	Lumbriculus variegatus	38	0.060	0.074	0.010	0.25	90	0.200
38	Manayunkia speciosa	69	0.631	3.647	0.005	30.4	90	0.600
39	Microtendipes sp	15	2.535	7.730	0.005	30.4	90	13.12
40	Mystacides sp	15	0.497	1.194	0.010	4.7	90	2.540
41	Nais behningi	27	0.090	0.232	0.010	1.22	90	0.174
42	Nais communis	38	0.112	0.244	0.005	1.5	90	0.191
43	Nais variabilus	69	0.232	0.619	0.005	4.7	90	0.440
44	Nanocladius sp	35	0.120	0.256	0.010	1.5	90	0.254
45	Neureclipsis sp	36	0.048	0.055	0.010	0.2	90	0.153
46	Oecetis sp	39	1.033	4.841	0.005	30.4	90	1.300
47	Parachironomus sp	21	0.252	0.430	0.005	1.5	90	1.272
48	Paralauterborniella sp	16	0.137	0.103	0.005	0.33	90	0.316
49	Paratendipes sp	25	0.123	0.122	0.005	0.43	90	0.338
50	Phaenopsectra sp	43	0.122	0.100	0.005	0.44	90	0.220
51	Phallodrilus sp	24	0.098	0.172	0.010	0.81	90	0.255
52	Physella gyrina	101	0.122	0.250	0.005	1.8	90	0.282

53	Piguetiella michiganensi	47	0.162	0.690	0.005	4.7	90	0.166
54	Pisidium casertanum	178	0.167	0.271	0.001	1.8	90	0.382
55	Pisidium compressum	36	0.116	0.104	0.005	0.43	90	0.299
56	Pisidium conventus	14	0.063	0.088	0.005	0.32	90	0.250
57	Pisidium fallax	94	0.173	0.528	0.010	4.7	90	0.235
58	Pisidium henslowanum	33	0.087	0.126	0.005	0.49	90	0.280
59	Pisidium lilljeborgi	24	0.234	0.655	0.005	3.25	90	0.420
60	Pisidium nitidum	23	0.077	0.076	0.005	0.22	90	0.190
61	Pisidium variabile	37	0.092	0.120	0.005	0.48	90	0.312
62	Pleurocera acuta	78	0.091	0.153	0.005	0.92	90	0.200
63	Polypedilum scalaenum	13	0.013	0.010	0.005	0.03	90	0.030
64	Polypedilum sp	124	0.144	0.258	0.005	1.5	90	0.275
65	Pontoporeia hoyi	41	0.082	0.096	0.005	0.43	90	0.212
66	Potamothrix moldaviensis	70	0.153	0.296	0.001	2.0	90	0.356
67	Potamothrix vejdovskyi	60	0.123	0.187	0.005	1.1	90	0.220
68	Pristina foreli	13	0.252	0.430	0.010	1.5	90	1.224
69	Pristina osborni	46	0.118	0.276	0.010	1.5	90	0.193
70	Procladius sp	226	0.432	2.065	0	30.4	90	0.837
71	Prostoma rubrum	116	0.137	0.253	0.005	1.5	90	0.269
72	Pseudocloeon sp	16	0.048	0.066	0.010	0.25	90	0.173
73	Quistadrilus multisetosu	75	0.238	0.271	0.005	1.4	90	0.624
74	Slavina appendiculata	36	0.324	0.829	0.005	4.7	90	1.017
75	Specaria josinae	29	0.433	0.877	0.010	4.7	90	0.920
76	Sphaerium nitidum	17	0.083	0.113	0.005	0.43	90	0.262
77	Sphaerium striatinum	65	0.107	0.193	0.005	1.0	90	0.350
78	Spirosperma ferox	121	0.168	0.244	0.005	1.8	90	0.354
79	Stenonema sp	55	0.066	0.131	0.005	0.91	90	0.178
80	Stictochironomus sp	19	1.716	6.947	0.005	30.4	90	0.410
81	Stylaria lacustris	54	0.251	0.508	0.005	3.25	90	0.385
82	Stylodrilus heringianus	93	0.096	0.196	0.005	1.7	90	0.226
83	Tanytarsus sp	98	0.117	0.183	0.005	1.5	90	0.231
84	Thienemannimyia sp	63	0.104	0.248	0.005	1.5	90	0.344
85	Tubifex sp	36	0.268	0.375	0.050	1.7	90	0.900
86	Turbellaria	100	0.193	0.532	0.010	4.7	90	0.260
87	Uncinais uncinata	20	0.050	0.068	0.005	0.22	90	0.179
88	Valvata sincera	82	0.345	0.667	0.005	4.7	90	0.901
89	Valvata tricarinata	68	0.770	3.692	0.005	30.4	90	1.320
90	Vejdovskyella intermedia	58	0.087	0.123	0.005	0.72	90	0.202
91	Elliptio complanata	12	0.108	0.145	0.005	0.56	90	0.422
92	Sphaerium simile	20	0.050	0.028	0.005	0.1	90	0.089
93	Chironomus plumosus	82	0.169	0.188	0.001	0.8	90	0.435
94	Cricotopus bicinctus	5	0.214	0.193	0.010	0.45	90	.
95	Ephemera sp	3	0.025	0.030	0.005	0.06	90	.
96	Helobdella stagnalis	26	1.520	5.919	0.005	30.4	90	1.690
97	Hexagenia limbata	23	0.202	0.241	0.005	1.1	90	0.416
98	Hexagenia sp	5	0.244	0.178	0.010	0.49	90	.
99	Tanypus sp	0						
100	Tubifex tubifex	60	0.212	0.283	0	1.4	90	0.713

Table 9: **NICKEL** - Species Screening Level Concentrations (µg/g).

Spp. No.	Species	N=	Mean	Std. Dev.	Minimum	Maximum	%	Conc.
1	Ablabesmyia sp	36	23.71	25.52	1.25	110	90	73.3
2	Aelosoma sp	14	16.64	20.65	5.3	81	90	61.0
3	Amnicola limosa	83	15.09	11.66	1.0	81	90	26.6
4	Asellus sp	62	23.52	16.22	3.3	85	90	41.1
5	Aulodrilus limnobius	35	16.08	9.72	3.6	56	90	25.2
6	Aulodrilus pigueti	31	17.47	16.21	3.6	96	90	32.6
7	Aulodrilus pleuriseta	24	17.43	13.18	0.005	56	90	38.5
8	Bithynia tentaculata	23	16.23	12.61	0.5	56	90	31.6
9	Branchiura sowerbyi	14	41.58	28.14	6.2	95	90	92.5
10	Caenis sp	30	15.45	8.22	5.0	41	90	25.9
11	Ceraclea sp	61	12.23	6.63	2.3	33	90	23.8
12	Chaetogaster diaphanus	32	11.97	10.95	1.25	61	90	22.5
13	Cheumatopsyche sp	86	13.35	10.39	2.3	81	90	27.3
14	Chironomus sp	87	18.48	10.31	0.5	50.2	90	34.2
15	Cladopelma sp	22	20.17	21.31	1.5	96	90	52.6
16	Cladotanytarsus sp	47	16.71	16.80	1.25	95	90	34.2
17	Coelotanypus sp	17	22.62	10.94	4.61	41	90	37.8
18	Cricotopus sp	58	58.09	172.89	0.005	930	90	81.2
19	Cricotopus vierriensis	0						
20	Cryptochironomus sp	122	15.24	10.17	0.005	46	90	29.0
21	Dicrotendipes sp	36	19.66	17.32	2.0	96	90	34.3
22	Eukiefferiella sp	53	10.64	4.50	4.4	30	90	16.2
23	Gammarus fasciatus	203	15.81	12.05	0.005	96	90	29.6
24	Glossiphonia heteroclita	2	24.50	2.12	23.0	26	90	.
25	Glossosoma sp	40	16.01	19.96	4.4	110	90	28.8
26	Glyptotendipes sp	17	18.30	8.94	7.0	37	90	30.6
27	Gyraulus parvus	24	12.48	8.67	1.0	40	90	25.5
28	Helisoma anceps	11	14.03	11.32	0.005	40	90	37.0
29	Heterotrissocladius sp	23	13.11	9.20	4.4	41	90	30.1
30	Hyalella azteca	37	94.54	210.38	3.9	930	90	250.0
31	Hydropsyche sp	45	13.20	12.20	4.4	81	90	23.8
32	Hydroptila sp	38	14.58	15.53	2.4	96	90	27.4
33	Ilyodrilus templetoni	17	20.69	21.65	3.6	96	90	51.2
34	Limnodrilus hoffmeisteri	174	18.64	13.80	0.005	96	90	36.0
35	Limnodrilus sp	64	38.83	21.75	0.5	110	90	73.5
36	Limnodrilus udekemianus	33	18.15	18.81	2.2	96	90	41.2
37	Lumbriculus variegatus	53	15.23	8.74	5.3	43.5	90	27.9
38	Manayunkia speciosa	69	14.48	11.26	2.3	81	90	27.0
39	Microtendipes sp	13	19.13	9.42	0.5	31	90	30.2
40	Mystacides sp	12	22.26	24.39	4.6	96	90	75.3
41	Nais behningi	27	10.97	5.00	4.4	30	90	15.6
42	Nais communis	38	11.05	7.25	1.0	31	90	24.1
43	Nais variabilus	69	14.48	14.37	0.005	96	90	30.0
44	Nanocladius sp	35	14.39	12.69	4.4	81	90	18.4
45	Neureclipsis sp	36	10.85	4.77	5.3	31	90	15.0
46	Oecetis sp	38	14.50	9.54	0.5	46	90	28.1
47	Parachironomus sp	18	13.44	12.21	0.005	41	90	34.7
48	Paralauterborniella sp	16	11.83	6.49	0.005	24	90	24.0
49	Paratendipes sp	24	13.37	11.86	1.0	56	90	26.5
50	Phaenopsectra sp	40	19.66	20.72	6.2	110	90	545
51	Phallodrilus sp	24	9.28	3.45	2.3	15	90	14.5
52	Physella gyrina	83	12.39	6.84	2.3	41	90	23.6

53	Piguetiella michiganensi	45	10.74	14.19	0.005	96	90	15.0
54	Pisidium casertanum	176	16.19	12.70	0.005	91	90	32.3
55	Pisidium compressum	15	17.55	15.18	0.005	56	90	47.0
56	Pisidium conventus	16	11.37	11.21	1	41	90	33.5
57	Pisidium fallax	92	13.73	13.48	1	96	90	26.7
58	Pisidium henslowanum	43	15.63	15.07	0.005	81	90	32.2
59	Pisidium lilljeborgi	24	14.82	14.23	1	56	90	35.7
60	Pisidium nitidum	24	11.14	7.88	1	29	90	25.9
61	Pisidium variabile	23	12.40	13.34	0.005	56	90	33.4
62	Pleurocera acuta	77	12.99	9.83	4.4	81	90	20.2
63	Polypedilum scalaenum	13	3.38	2.62	0.005	9.3	90	7.9
64	Polypedilum sp	120	23.61	35.63	4.26	250	90	56.3
65	Pontoporeia hoyi	54	16.48	13.51	1	61	90	37.0
66	Potamothrix moldaviensis	64	14.47	14.75	0.005	91	90	31.5
67	Potamothrix vejdovskyi	63	12.27	8.29	0.005	43.2	90	24.0
68	Pristina foreli	13	12.90	5.32	5.8	26	90	22.4
69	Pristina osborni	46	10.30	4.76	3.6	31	90	15.3
70	Procladius sp	201	24.11	17.83	0.005	110	90	41.0
71	Prostoma rubrum	116	12.28	9.33	1.25	81	90	18.0
72	Pseudocloeon sp	16	11.88	6.27	6.2	31	90	21.9
73	Quistadrilus multisetosu	61	18.60	10.41	2	41	90	35.8
74	Slavina appendiculata	35	14.58	15.09	2.4	96	90	18.4
75	Specaria josinae	29	18.98	18.53	2.2	96	90	36.0
76	Sphaerium nitidum	25	16.26	12.02	2.2	56	90	31.5
77	Sphaerium striatinum	61	15.71	14.93	1	81	90	34.0
78	Spirosperma ferox	103	15.01	11.12	0.005	81	90	28.2
79	Stenonema sp	55	11.61	5.54	4.6	31	90	18.0
80	Stictochironomus sp	15	10.10	5.93	0.5	26	90	20.0
81	Stylaria lacustris	54	21.52	22.34	0.005	95	90	57.5
82	Stylodrilus heringianus	79	13.62	12.49	1	81	90	27.0
83	Tanytarsus sp	92	14.03	10.30	0.005	56	90	29.0
84	Thienemannimyia sp	58	11.31	6.91	0.005	42	90	18.0
85	Tubifex sp	36	42.04	22.06	10	110	90	75.2
86	Turbellaria	100	13.13	10.62	2.3	96	90	23.5
87	Uncinais uncinata	20	9.14	17.37	0.005	81	90	13.7
88	Valvata sincera	69	18.15	14.73	1	96	90	32.0
89	Valvata tricarinata	61	15.73	8.61	0.5	39	90	27.8
90	Vejdovskyella intermedia	57	10.50	12.12	0.005	61	90	18.2
91	Elliptio complanata	0						
92	Sphaerium simile	0						
93	Chironomus plumosus	66	58.43	161.16	0.005	930	90	72.5
94	Cricotopus bicinctus	1	1.00		1	1	90	.
95	Ephemera sp	1	14.00		14	14	90	.
96	Helobdella stagnalis	23	29.44	20.18	10	85	90	71.0
97	Hexagenia limbata	12	17.37	11.57	5.6	44	90	40.4
98	Hexagenia sp	4	12.65	3.68	9.26	15.97	90	.
99	Tanypus sp	0						
100	Tubifex tubifex	50	21.49	15.80	1.25	91	90	38.9

Table 10: **ZINC** - Species Screening Level Concentrations (µg/g).

Spp. No.	Species	N=	Mean	Std. Dev.	Minimum	Maximum	%	Conc.
1	Ablabesmyia sp	37	155.55	183.89	8.70	690	90	554.0
2	Aelosoma sp	14	90.64	70.28	9.00	290	90	220.0
3	Amnicola limosa	106	102.85	105.07	0.01	650	90	280.0
4	Asellus sp	85	166.80	160.08	11.00	977.5	90	388.0
5	Aulodrilus limnobius	26	91.19	63.82	9.00	290	90	182.0
6	Aulodrilus pigueti	32	109.13	49.49	40.00	280	90	175.6
7	Aulodrilus pleuriseta	30	124.83	94.86	0.01	340	90	290.0
8	Bithynia tentaculata	53	143.83	199.49	20.00	1300	90	336.0
9	Branchiura sowerbyi	14	91.79	25.03	61.00	150	90	130.5
10	Caenis sp	34	116.49	140.05	13.00	830	90	221.5
11	Ceraclea sp	64	151.88	252.19	4.00	1200	90	215.0
12	Chaetogaster diaphanus	32	65.68	39.05	8.70	140	90	127.0
13	Cheumatopsyche sp	87	144.47	221.88	4.00	1200	90	222.0
14	Chironomus sp	119	122.97	146.26	6.50	1300	90	220.0
15	Cladopelma sp	22	126.43	175.11	9.50	880	90	199.0
16	Cladotanytarsus sp	48	112.61	163.43	4.00	1100	90	175.0
17	Coelotanypus sp	17	140.19	87.46	20.33	340	90	284.0
18	Cricotopus sp	59	303.47	669.01	0.01	3500	90	920.0
19	Cricotopus vierriensis	0						
20	Cryptochironomus sp	146	113.71	166.12	0.01	1300	90	243.0
21	Dicrotendipes sp	48	118.78	112.12	9.40	550	90	274.0
22	Eukiefferiella sp	53	132.53	219.02	4.00	1200	90	190.0
23	Gammarus fasciatus	244	117.82	153.62	0.01	1200	90	254.0
24	Glossiphonia heteroclita	15	99.10	92.13	6.50	340	90	302.8
25	Glossosoma sp	40	224.15	306.48	4.00	1200	90	816.0
26	Glyptotendipes sp	25	115.48	122.80	10.00	450	90	335.0
27	Gyraulus parvus	33	165.24	232.36	0.01	1100	90	340.0
28	Helisoma anceps	12	108.00	82.29	0.01	300	90	276.0
29	Heterotrissocladius sp	24	91.31	64.61	32.00	290	90	211.2
30	Hyalella azteca	56	308.05	682.52	4.00	3500	90	846.3
31	Hydropsyche sp	50	102.90	118.98	4.00	830	90	159.0
32	Hydroptila sp	38	124.66	168.29	14.00	1100	90	161.0
33	Ilyodrilus templetoni	18	144.89	192.95	20.00	880	90	358.0
34	Limnodrilus hoffmeisteri	220	143.96	193.43	0.01	1500	90	290.0
35	Limnodrilus sp	64	401.45	1363.41	20.00	11000	90	570.0
36	Limnodrilus udekemianus	40	180.79	258.65	10.00	1300	90	516.0
37	Lumbriculus variegatus	54	138.61	210.18	4.00	1200	90	225.6
38	Manayunkia speciosa	69	102.35	82.66	9.00	450	90	240.0
39	Microtendipes sp	14	280.43	332.76	20.00	1300	90	875.0
40	Mystacides sp	15	78.87	30.04	37.00	130	90	124.0
41	Nais behningi	27	164.82	270.19	4.00	1200	90	456.0
42	Nais communis	38	87.87	187.86	0.01	1200	90	112.0
43	Nais variabilus	69	121.66	187.23	0.01	1100	90	220.0
44	Nanocladius sp	35	86.29	51.65	25.00	220	90	158.0
45	Neureclipsis sp	36	108.06	193.16	4.00	1200	90	150.0
46	Oecetis sp	38	172.63	280.69	9.40	1300	90	450.0
47	Parachironomus sp	21	91.38	80.59	0.01	290	90	216.0
48	Paralauterborniella sp	16	129.31	214.33	0.01	920	90	388.0
49	Paratendipes sp	25	109.61	161.08	0.01	830	90	206.0
50	Phaenopsectra sp	41	121.38	144.58	4.00	690	90	355.6
51	Phallodrilus sp	24	92.25	49.74	26.00	220	90	155.0
52	Physella gyrina	103	110.79	180.60	4.00	1200	90	156.0

53	Piguetiella michiganensi	47	97.28	201.10	0.01	1100	90	163.6
54	Pisidium casertanum	195	126.02	184.02	0.01	1300	90	220.0
55	Pisidium compressum	37	74.25	62.36	0.01	290	90	130.0
56	Pisidium conventus	16	74.24	77.44	9.00	290	90	222.4
57	Pisidium fallax	94	126.01	200.57	0.01	1200	90	190.0
58	Pisidium henslowanum	45	85.94	69.69	0.01	290	90	188.2
59	Pisidium lilljeborgi	26	114.67	194.25	0.01	977.5	90	290.0
60	Pisidium nitidum	24	65.15	41.59	0.01	158.55	90	125.0
61	Pisidium variabile	38	70.61	77.45	0.01	320	90	146.0
62	Pleurocera acuta	78	141.15	230.58	4.00	1200	90	211.0
63	Polypedilum scalaenum	13	22.79	19.35	0.01	70	90	57.6
64	Polypedilum sp	123	161.22	243.10	4.00	1200	90	468.0
65	Pontoporeia hoyi	59	91.37	73.27	0.01	290	90	193.4
66	Potamothrix moldaviensis	76	114.16	191.40	0.01	1300	90	254.2
67	Potamothrix vejdovskyi	69	111.93	147.83	0.01	920	90	200.0
68	Pristina foreli	13	90.69	57.27	4.00	220	90	196.0
69	Pristina osborni	46	132.98	226.65	9.00	1200	90	178.0
70	Procladius sp	229	212.50	738.15	0.01	11000	90	420.0
71	Prostoma rubrum	116	126.52	194.96	4.00	1200	90	213.0
72	Pseudocloeon sp	16	269.19	393.88	4.00	1200	90	1130.0
73	Quistadrilus multisetosu	74	167.96	226.29	9.40	1500	90	370.0
74	Slavina appendiculata	36	85.61	47.55	14.00	220	90	156.0
75	Specaria josinae	29	138.45	156.22	20.00	880	90	280.0
76	Sphaerium nitidum	26	96.28	72.80	15.00	290	90	207.7
77	Sphaerium striatinum	66	127.11	198.86	0.01	1100	90	299.0
78	Spirosperma ferox	127	89.99	84.16	0.01	780	90	151.7
79	Stenonema sp	55	150.53	251.25	4.00	1200	90	214.0
80	Stictochironomus sp	19	90.40	107.11	9.40	420	90	340.0
81	Stylaria lacustris	54	119.38	142.38	0.01	977.5	90	199.0
82	Stylodrllus heringianus	93	117.47	200.10	4.00	1200	90	162.4
83	Tanytarsus sp	99	74.72	50.25	0.01	290	90	140.0
84	Thienemannimyia sp	63	149.34	247.40	0.01	1200	90	254.0
85	Tubifex sp	36	229.71	190.33	76.00	690	90	563.0
86	Turbellaria	100	134.79	206.21	4.00	1200	90	206.0
87	Uncinais uncinata	20	42.26	35.39	0.01	130	90	84.9
88	Valvata sincera	86	127.60	164.48	0.01	1100	90	281.6
89	Valvata tricarinata	71	134.11	198.32	9.40	1300	90	334.0
90	Vejdovskyella intermedia	57	63.37	65.17	0.01	300	90	122.0
91	Elliptio complanata	12	74.17	29.92	43.00	150	90	138.0
92	Sphaerium simile	20	51.78	25.01	6.50	110	90	87.2
93	Chironomus plumosus	79	243.69	573.15	0.01	3500	90	340.0
94	Cricotopus bicinctus	5	74.72	41.70	8.60	110	90	.
95	Ephemera sp	3	57.67	62.80	17.00	130	90	.
96	Helobdella stagnalis	27	199.15	158.11	21.00	580	90	426.0
97	Hexagenia limbata	23	121.09	149.93	20.00	580	90	416.0
98	Hexagenia sp	5	48.36	17.61	22.00	65.68	90	.
99	Tanypus sp	0						
100	Tubifex tubifex	64	202.37	284.17	10.00	1500	90	535.0

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APPENDIX II - FIGURES

Calculation of the 5th and 95th Percentiles of the Species Screening Level Concentrations

- Concentrations are expressed on a bulk sediment basis
- Species numbers correspond to those in the tables in Appendix I

Fig 1. SLC Graph For Arsenic.

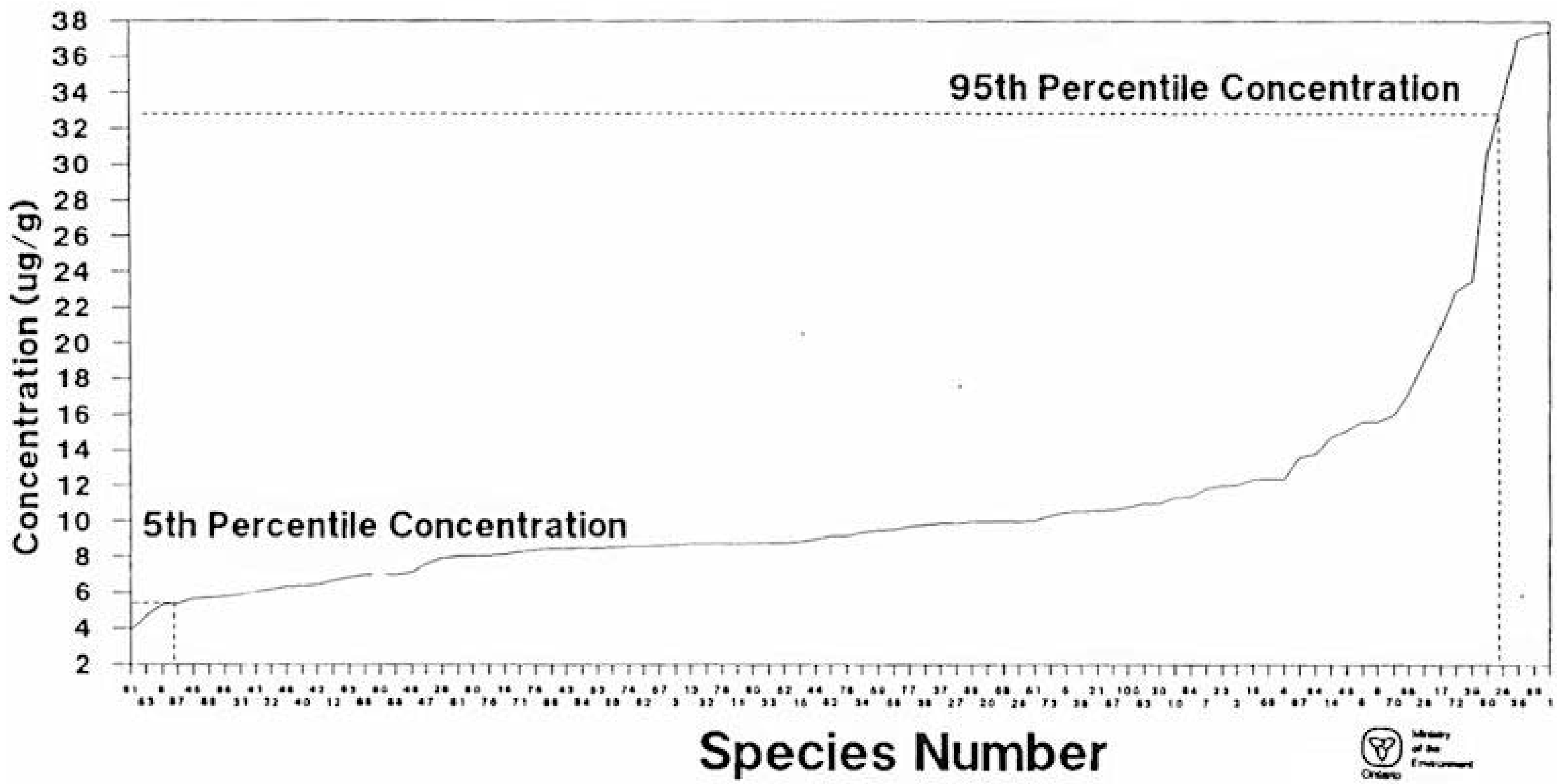

Fig 2. SLC Graph For Cadmium.

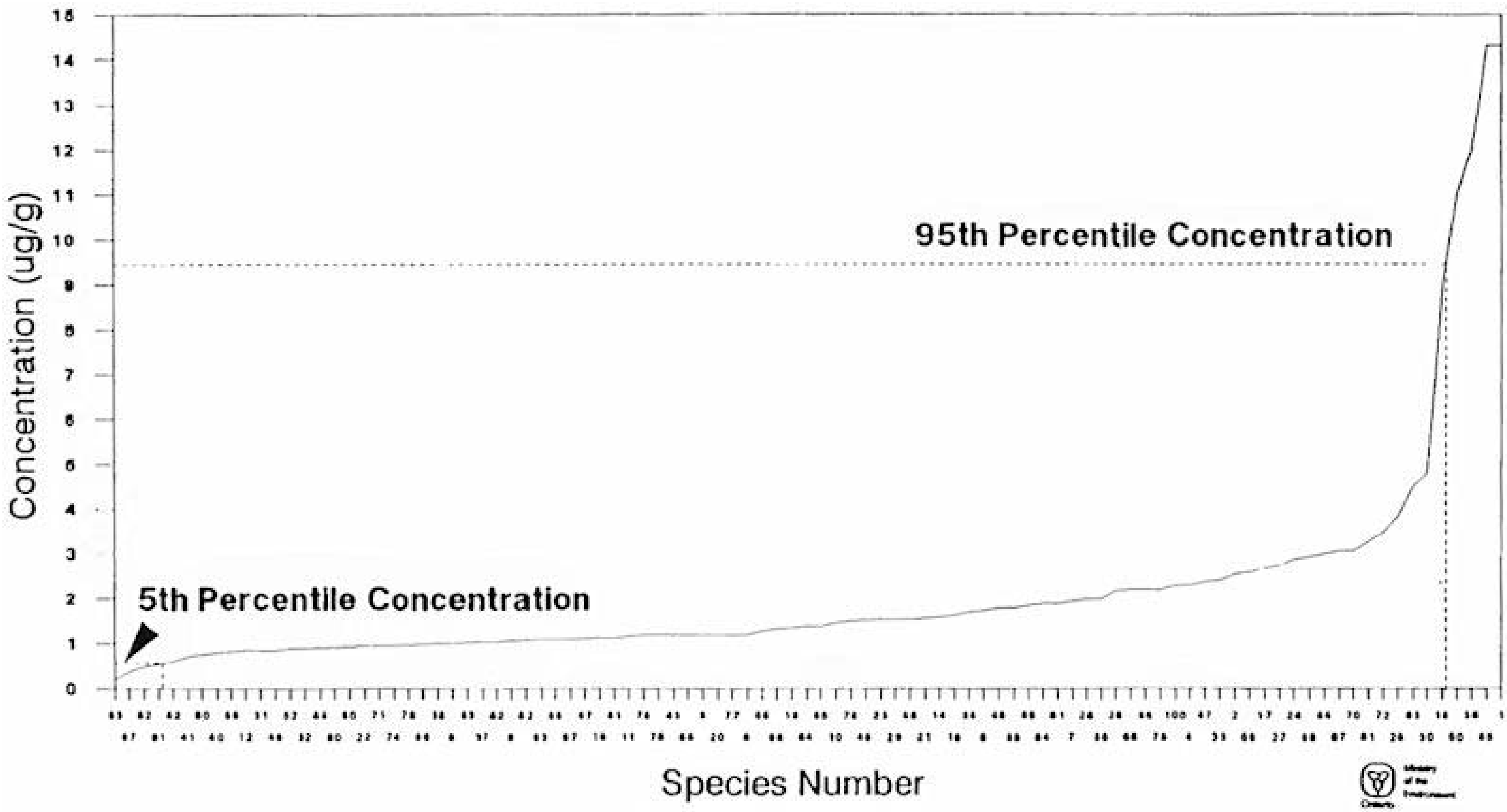

Fig 3. SLC Graph For Chromium.

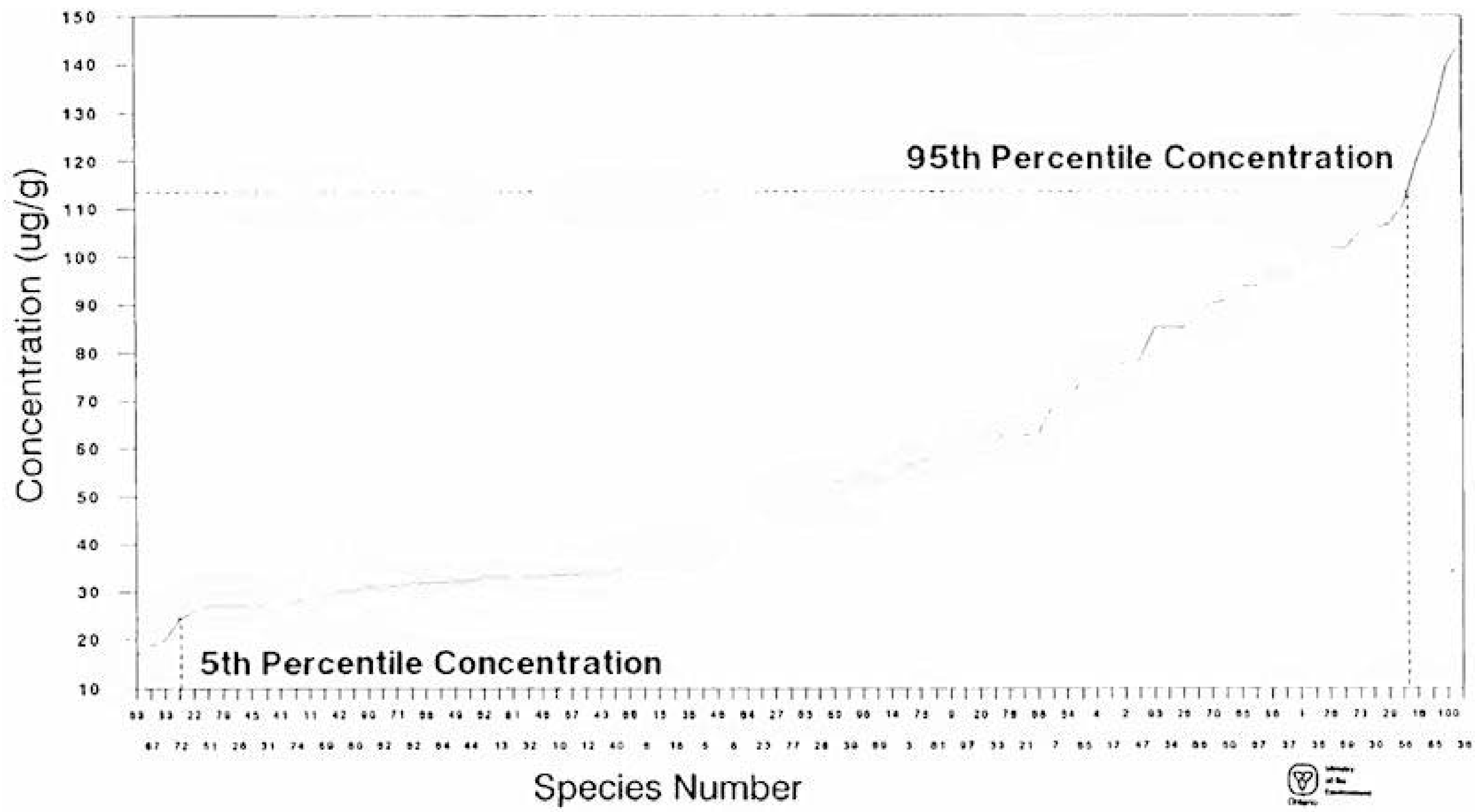

Fig 4. SLC Graph For Copper.

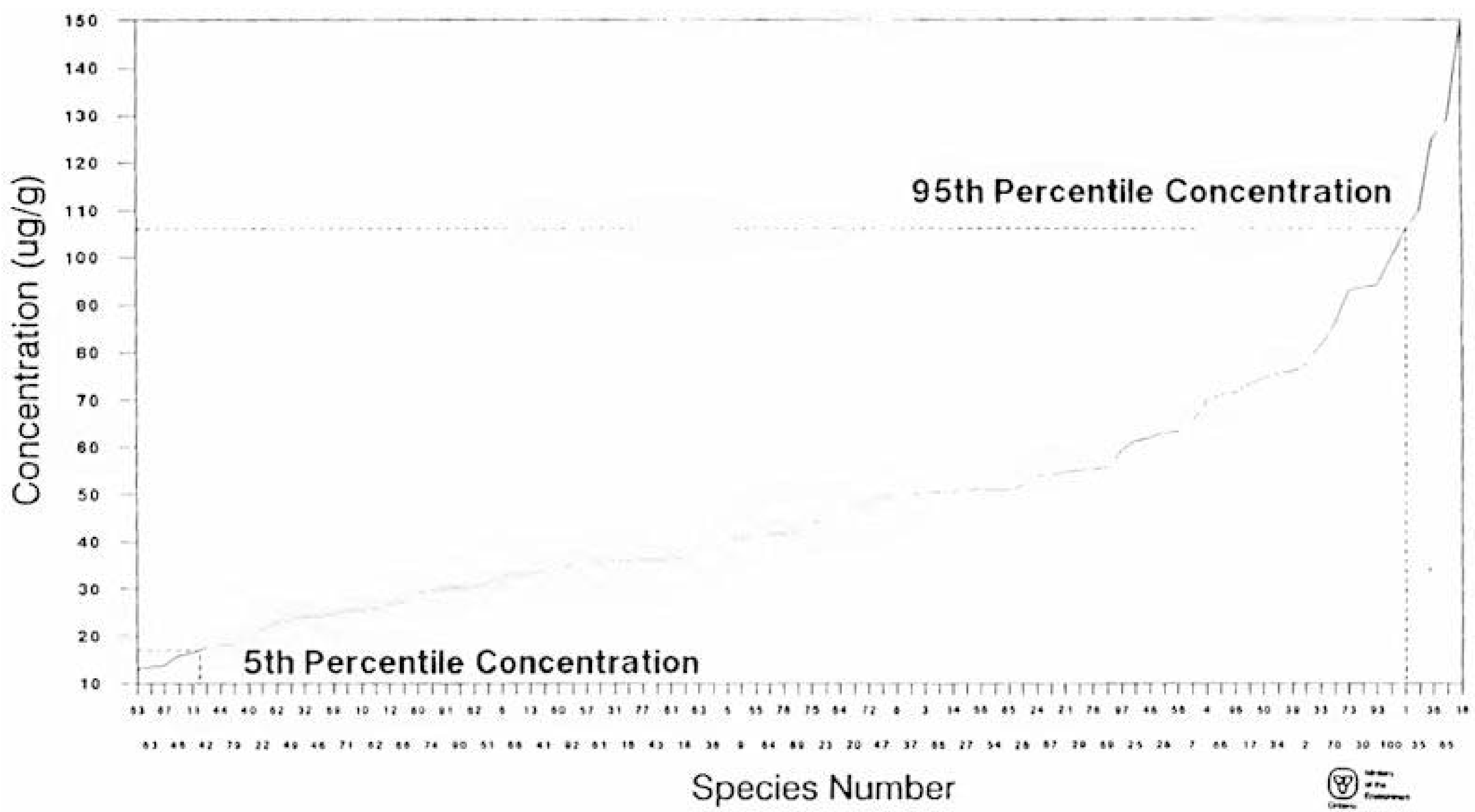

Fig 5. SLC Graph For Iron.

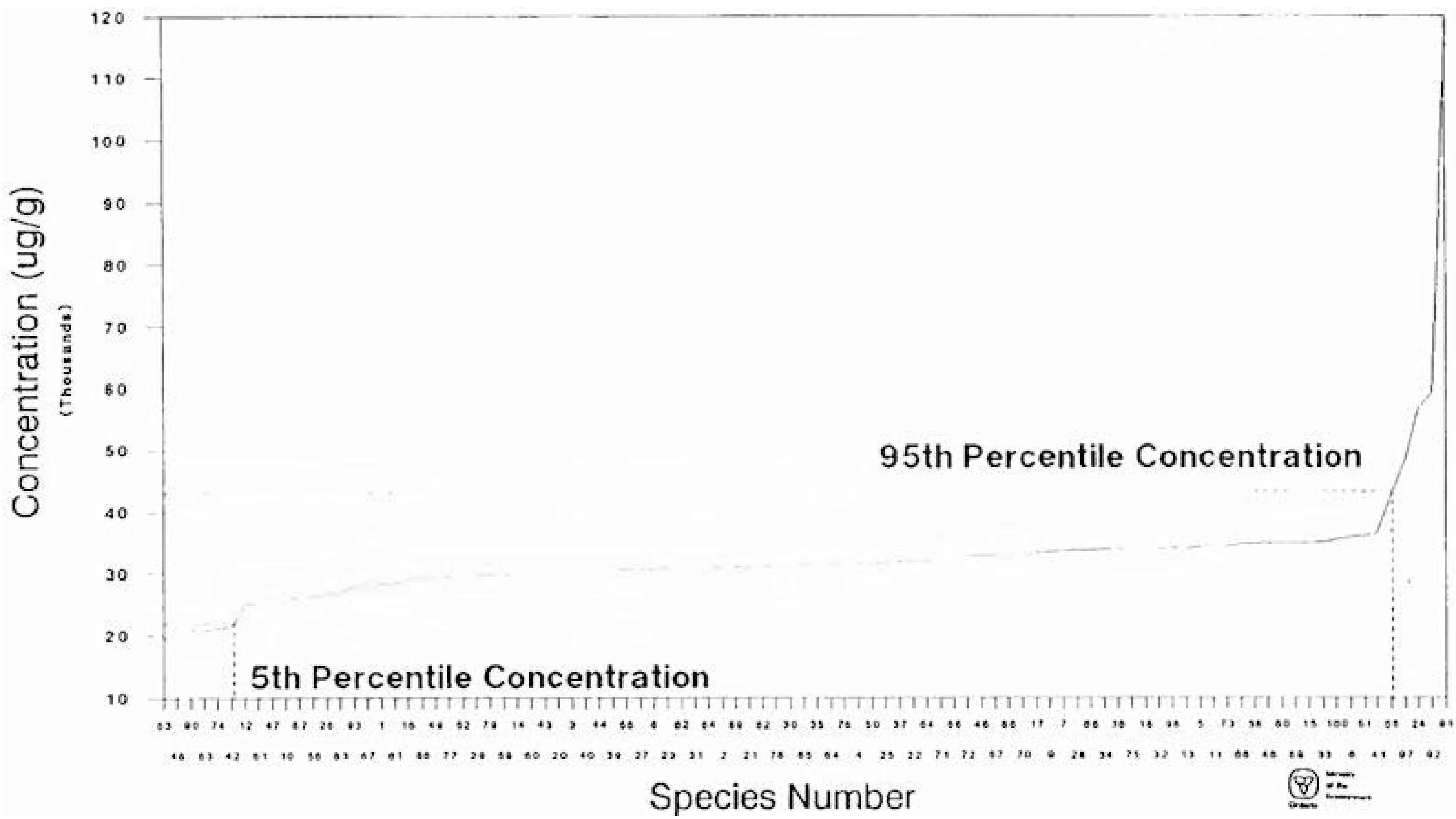

Fig 6. SLC Graph For Lead.

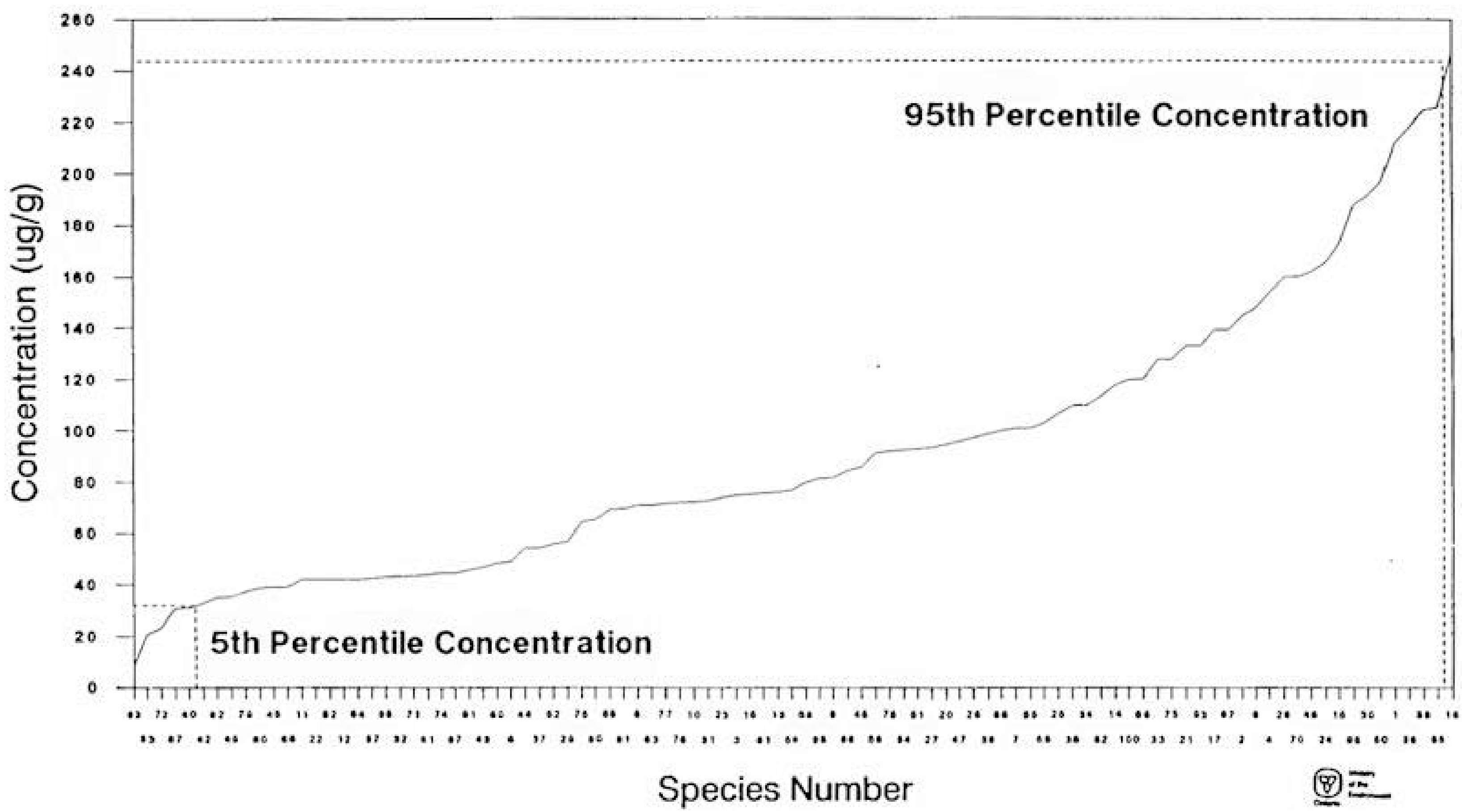

Fig 7. SLC Graph For Manganese.

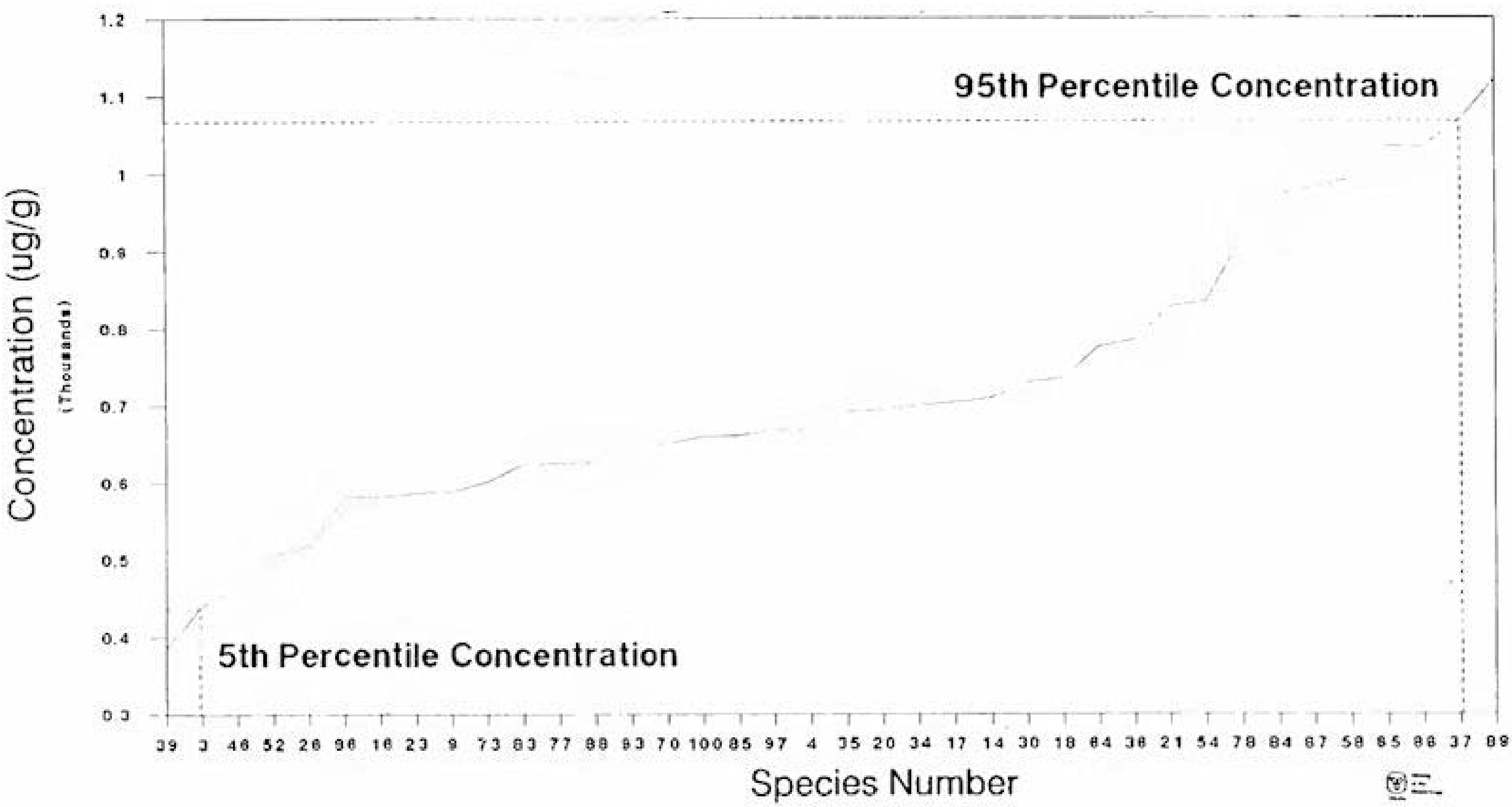

Fig 8. SLC Graph For Mercury.

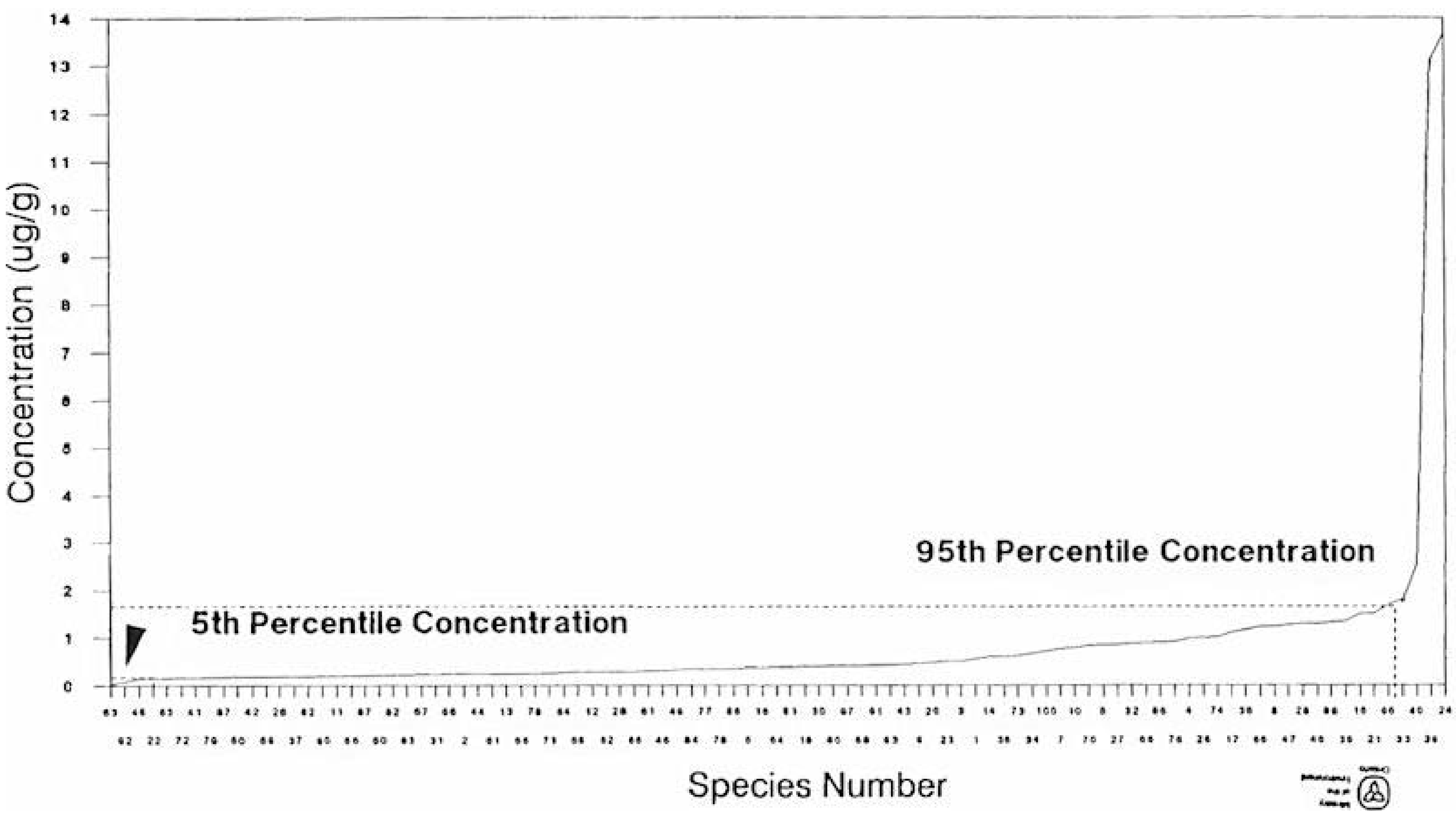

Fig 9. SLC Graph For Nickel.

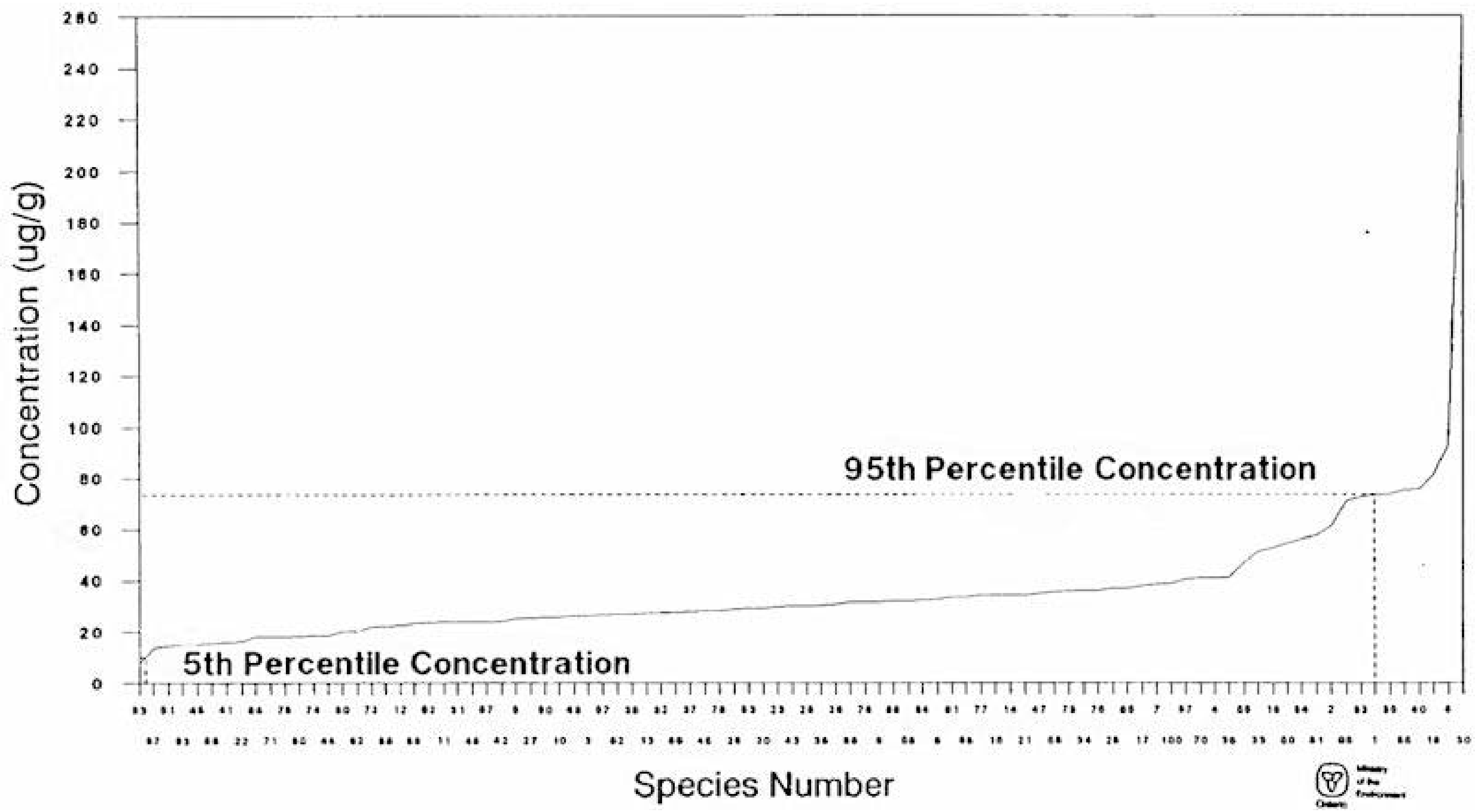

Fig 10. SLC Graph For Zinc.