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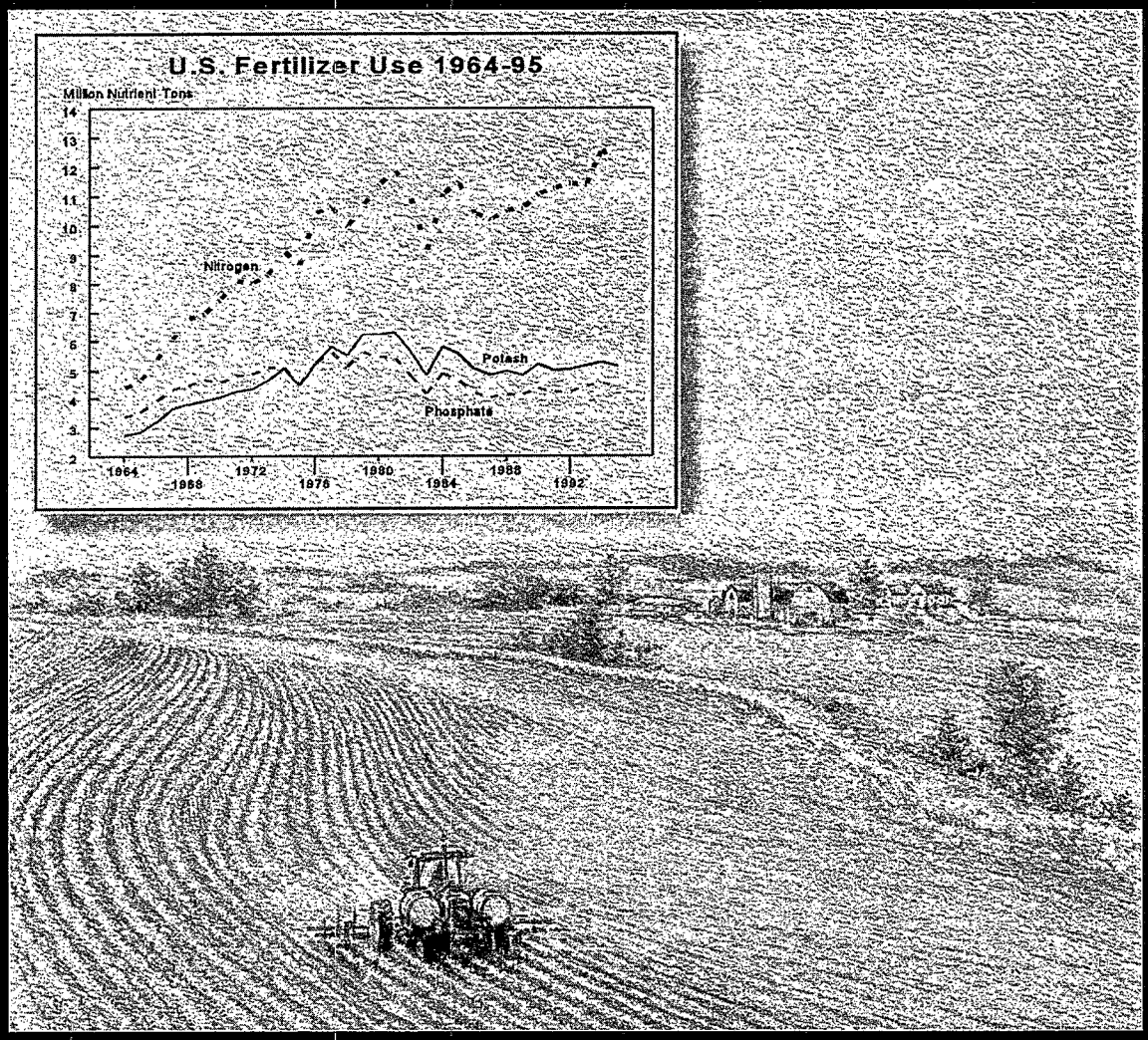
Background Report on Fertilizer Use, Contaminants and Regulations



EXECUTIVE SUMMARY

The Environmental Protection Agency (EPA) is studying the issue of heavy metals and other non-nutritive constituents (also referred to as contaminants) in fertilizers and liming materials (referred to as fertilizers hereafter). The purpose of this report is to provide background information on fertilizer use, consumption patterns, composition and regulations. This information is gathered and presented here for fertilizers from natural mineral sources and those that are derived from industrial by-products. The data for heavy metals in fertilizers compiled here are used to provide estimates of the rates at which these metals may be added to agricultural soils from standard agronomic practices. The additions of heavy metals to agricultural soil are discussed in terms of federal and international regulations.

This report is provided as a source of information. It is not intended as a risk-assessment for contaminants in fertilizer, nor does it address the introduction of these materials into plants, the food chain for humans, and the greater ecosystem. Although some discussion is given here to biosolids (sewage sludge) and its regulations, and other organic fertilizers, such information is limited. The focus of this report is on inorganic fertilizers and their application to agricultural lands. Discussion related to fertilizer usage on public lands, range lands, and residential lawns and gardens is limited for this reason. In addition, some information is presented on the use of recycled industrial by-products as fertilizers; however, an in-depth investigation of these recycling practices was beyond the scope of this study.

More than 54 million tons (110 billion pounds) of commercial fertilizers and liming materials of all kinds were consumed in the United States in the year ending June 30, 1996 (AAPFCO, 1997a). Primary nutrients (N, P, K) accounted for 91% of this total; liming materials accounted for about 4%, and organic fertilizers accounted for 1% of the total. Approximately 5% of the total (2.7 million tons) was due to secondary nutrient fertilizers (calcium, magnesium, sulfur) and micronutrients. States with the highest fertilizer consumption were the agricultural states in the corn belt and California. Florida (1.6 million tons) and Texas (1.6 million tons) consumed the most multiple nutrient fertilizers while Illinois (1.9 million tons of nitrogen (N), 0.8 million tons of phosphate (P_2O_5) and 1.0 million tons of potash (K_2O) fertilizers) consumed the most single-nutrient N, P, and K fertilizers. North Carolina consumed most of the organic fertilizers and liming materials (0.2 million tons organic fertilizer, 0. 9 million tons liming fertilizer), while California consumed most of the secondary and micronutrient fertilizers (1.6 million tons).

The potato crop was the most fertilized (100% of acres receive N, P and K fertilizers) and had one of the highest fertilizer application rates for all primary nutrient fertilizers (average application rates of 195 lbs/acre N, 173 lbs per acre P_2O_5 and 139 lbs/acre K_2O) but represented fewer acres planted (0.8 million acres) than other field crops except tobacco. If consideration were given to the number of acres planted, corn (70 million acres) represented the crop with the highest fertilizer use, though not the highest application rate per acre (average application rates of 133 lbs/acre N, 57 lbs/acre P_2O_5 and 79 lbs/acre K_2O). The fruits and vegetables with the highest fertilizer application rates were watermelon in Arizona (N), bell peppers in California (P_2O_5) and fresh tomatoes in Florida (K_2O). The two states with the highest total consumption of non-farm fertilizer were Florida (0.4 million tons) and California (0.32 million tons). Multiple nutrient, organic and miscellaneous fertilizers were used in higher percentages on non-farm land than

other fertilizers. Non-farm fertilizer use included applications to residential, recreational and public property.

Soils naturally contain trace levels (ppb to ppm) of heavy metals. For example, median concentrations of metals in U.S. soils are 0.2 mg/kg cadmium, 11 mg/kg lead, and 18.2 mg/kg nickel. There are, however, considerable variations in these metal concentrations by geographic region and soil type.

Several studies have measured heavy metals in mineral ores and the resulting fertilizers. Natural rock phosphate ore contains zinc ranging from 0.2 to 576 mg/kg and measurable amounts of cadmium, lead, nickel and copper. These metals can also be found in the NPK fertilizers that are produced from natural ores. For example, the State of Washington Department of Ecology reports the ranges of metal concentrations for a sample of 21 diverse NPK fertilizers with cadmium levels being <0.1-145 mg/kg, lead levels being <0.4-21 mg/kg, and nickel levels being <0.2-195 mg/kg. Measurements of other NPK fertilizers by other authors generally fall within this same range of values. A few studies have also measured arsenic, chromium and mercury in NPK fertilizers.

Organic and biosolid fertilizers may also have measurable concentrations of heavy metals. One study of 6 organic fertilizers (Raven and Loeppert;1997) reported measureable levels for heavy metals such as arsenic, cadmium, chromium, lead and mercury. According to these authors, "Trace metal concentrations generally decreased in the following sample order: rock phosphate > sewage sludge > commercial phosphate fertilizers > organic amendments and liming materials > commercial K_2O fertilizers > commercial N fertilizers". Whether or not fertilizers add significant amounts of metals to soil depends upon several factors including the existing soil metal concentration, the concentration of trace metals in the fertilizer and the fertilizer application rate.

Since some industrial wastes contain substances which can be used, or converted for use, in fertilizers, industrial waste recycling is encouraged in the U.S., if done so in a safe manner. The concern is that the wastes may also contain potentially hazardous constituents that provide no nutritive value to the plant and introduce these constituents into the greater ecosystem. No specific regulations exist requiring fertilizer producers to list non-nutritive constituents on fertilizer labels, so it is difficult to quickly ascertain the levels of heavy metals (and other chemicals) in fertilizers. Chemicals such as radionuclides and persistent organics (e.g., chlorinated dibenzodioxins/furans) are in this category. Several studies have shown that heavy metals are present in the parts per million (mg/kg) range, and occasionally as high as parts per thousand, in fertilizers produced from recycled industrial by-products.

Industrial wastes may be used in the manufacture of fertilizers, provided that such use constitutes legitimate beneficial recycling, and that the concentrations of hazardous constituents in the resulting fertilizers do not exceed the treatment standards specified for the wastes (40 CFR 266.20). No other federal standards apply specifically to fertilizer composition. State regulations require nutrient composition labeling of fertilizers.

Most states regulate fertilizer composition, but generally only for the plant nutrients. State fertilizer laws generally require product registration and/or licensing and efficacy testing to

assure that statements made on the label are correct. Most fertilizer regulations also include general statements about product adulteration and a prohibition against including any product that is harmful to plants, animals, humans or the environment. At this time, only two states (Washington and Texas) have regulations that establish specific limits on heavy metal contaminants, and testing and labeling requirements.

RCRA regulations generally encourage waste minimization and recycling. Examples of hazardous wastes that can be recycled into fertilizer ingredients (usually micronutrient fertilizers) include wood ash, K061wastes (emission control dust/sludge from the primary production of steel in electrical furnaces), brass foundry dusts and tire ash. The Occupational Safety and Health Administration (OSHA) in its hazard communication standard requires employers to include in Material Safety Data Sheets (MSDS) information on any product component present at 1% or greater (0.1% for carcinogens). Thus, if certain metals are present in sufficient quantity in fertilizer products, there exists a mechanism for communicating information on hazardous metal content.

Internationally, the Canadian Fertilizers Act (1993) and Fertilizers Regulations contain specific limits for heavy metals that apply to all fertilizer products. The Canadian Food Inspection Agency originally developed these limits for biosolids applied to land, but these standards now apply to all fertilizers. The Canadian standards are not risk-based, but were instead developed with the objective of "no significant degradation" of soils above background concentrations of metals. Japan regulates industrial waste incinerator ash application to land and has limits for metals and organic chemicals. Additionally, Australia and several European countries limit cadmium in phosphate fertilizers.

The U.S. EPA, states and foreign countries regulate biosolids application to land. The U.S. EPA (40 CFR 503) sets limits for heavy metals in biosolids in the product and on the soil following application. Several states have more stringent metal limits for biosolids application to land. Many foreign countries also have limits for heavy metals in biosolids and for soil. The European Union (EU) has set standards for its member countries, but individual countries may have more stringent regulations. The EU biosolids standards, in units of mg/kg of sludge product, are generally lower than those of the U.S. ceiling concentrations for land applications but are similar to the U.S. monthly average concentrations for application to agricultural land.

This report includes a characterization of the addition of heavy metals to agricultural soils from application of fertilizers which contain heavy metals. The calculations used here are designed to provide an estimate of the yearly incremental additions of metals to soils following diverse types of fertilizer applications. These incremental increases are then used to estimate the years required to double average background levels of metals in soil from yearly applications. These yearly additions of metals to the soil are then compared to the U.S. biosolids annual pollutant loading rates and the Canadian Fertilizers Act limits.

Fertilizer products are compared in this report with respect to the amount of nine heavy metals the product would add to soil, assuming a single application of the product per year. This is termed the yearly soil addition rate of a metal (or "yearly addition of metal X", see Index of Terms). The yearly soil addition rate of a metal is the concentration of that heavy metal in the product per desired nutrient ingredient multiplied by the nutrient application rate, with all

appropriate conversion factors applied. For those fertilizer products with lower nutrient content, a proportionally greater amount of the undesirable heavy metal will be added to the land in achieving a consistent nutrient application rate. Therefore, a fertilizer product may contribute high levels of heavy metals to soil when the heavy metal concentration in the product is high and/or when the desired plant nutrient is at a low level in the product.

For this report, the yearly addition of each metal was calculated for each individual product at three nutrient application rates- an average nutrient application rate, a high rate and at the maximum application rate recorded for this nutrient. An extended appendix of this report (Appendix G) contains the yearly soil addition rate of each metal in each product when applied at these three nutrient application rates. The aggregate of these individual yearly addition rates, then, produced the average soil metal addition rate for a fertilizer product category (e.g., P_2O_5 fertilizers) at the three different nutrient application rates. This aggregate is termed the product average yearly addition of metal X (see Index of Terms). This summary includes discussions of the yearly addition of metals in terms of both the individual product giving the highest yearly soil addition of a specific metal, and in terms of the product average yearly addition rates for metals.

The calculations performed here showed that the product average yearly addition rates of metals to soil would not exceed the U.S. biosolids annual pollutant loading rates for any fertilizer category evaluated. This finding applied to both natural ore-derived fertilizers and industrial by-product derived fertilizers.

The calculations also showed that the product average yearly addition rates of metals to soil rarely exceeded the annualized Canadian Fertilizers Act limits for metals additions. The particular instances when the product average addition rate of metal to soil exceeded the Canadian limits were found in the following combinations of heavy metal and fertilizer categories, and this occurred only at the maximum nutrient application rate:

Arsenic in: liming materials ($CaCO_3$ applied at 15,000 lbs/acre once every 3 years)
iron fertilizers (iron applied at 30 lbs/acre every year)

The Canadian standards for metals additions to soil were exceeded more frequently for **individual** fertilizer products, and were exceeded for metals other than arsenic. A total of 38 cases were identified where a particular heavy metal in an identified individual fertilizer product would exceed Canadian fertilizer standards when applied at the maximum nutrient application rate. These cases included:

Cadmium in: NPK fertilizers applied for P_2O_5 content [10 products of 91evaluated exceeded limits; 10 of 91]
Phosphate fertilizers [1 of 61]
Liming materials [3 of 10]
Zinc fertilizers [3 of 22]

Lead in : NPK fertilizers applied for P_2O_5 content [4 of 91]
Liming materials [2 of 10]
Zinc fertilizers [6 of 63]
Iron fertilizers [1 of 3]

Arsenic in:	NPK fertilizers applied for P_2O_5 content [1 of 84] Liming materials [3 of 10] Iron fertilizers [1 of 3]
Mercury in:	Liming materials [1 of 8]
Nickel in:	Liming materials [1 of 8]
Zinc in:	NPK fertilizers applied for N content [1 of 49]

Of the products listed above, 18 exceeded Canadian standards at the high nutrient application rate, and 8 exceeded the standards at the average nutrient application rate. Data were gathered here on 345 fertilizer products. A total of 1389 combinations of fertilizer product and metal at three application rates (total of 4167 data points) were compared with Canadian standards. (Data on an additional 537 combinations of unregulated heavy metals in products were also gathered). Since some products exceeded standards in more than one metal, the number of individual products exceeding the standards for at least one metal is greater than 2.7% (38 of 1389), but less than 11% (38 of 345).

Figure ES-1 identifies those fertilizer categories where the product average yearly addition rate of a metal is likely to double the average level of that metal in background US soils in 45 or fewer years, when the nutrient is applied at either the average (open box) or maximum (closed box) application rate. Similarly, this figure also identifies those instances where at least one individual product within a category exists that may double the average background level in 45 or fewer years, when the nutrient is applied at either the average (open circle) or maximum (closed circle) application rate. These scenarios assume yearly applications, with exception of lime, which is applied once every three years. For example, the product average application rate of cadmium (Cd) from either NPK-P fertilizers (NPK fertilzers applied for P_2O_5 content) or from P_2O_5 fertilizers will double the average background Cd soil level in 45 or fewer years when either the average or maximum nutrient (P_2O_5) application rate is used every year. In addition, there were individual NPK-N, NPK-P and P_2O_5 products identified that would double background soil Cd levels in 45 or fewer years if applied each year. There were no potash (K_2O), gypsum, manganese (Mn), or boron (B) fertilizer products identified that would double the indicated soil metals levels in 45 or fewer years. In contrast, liming materials were identified that might double the soil levels of all nine metals with consistent use (application once every three years) within a 45 year time frame.

In the process of preparing this report, and performing the above mentioned calculations, it was necessary to make a number of assumptions and simplifications to arrive at the contaminant levels in the soil following fertilizer application.

The simplifying assumptions that were made, and implications thereof, include:

- Metal additions to the soil were based on application of a single fertilizer type, and a single crop per year. In fact, many different fertilizers and liming materials may be

Products That Double Average U.S. Soil Background Level of Indicated Metal in 45 or Fewer Years

Fertilizer Products	Cd	Pb	As	Cr	Hg	Ni	V	Cu	Zn
Primary Nutrients									
NPK-N	■○●	○●						○●	●
NPK-P	❑■○●	○●	●					●	●
P_2O_5	❑■○●							●	
K_2O									
Secondary Nutrients									
Gypsum									
Sulfur	■○●								
Soil pH Adjustment									
Lime	■○●	■○●	■○●	●	■○●	●	●	■○●	■○●
Sulfur	○●								
Micronutrients									
Zn	■○●	■○●							
Fe	■○●	❑■○●	■○●						
Mn									
B									

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❑ Product average yearly addition rate of metal to soil with nutrient applied at average application rate

■ Product average yearly addition rate of metal to soil with nutrient applied at maximum application rate

○ Individual fertilizer product giving highest addition rate of metal to soil with nutrient applied at average application rate

● Individual fertilizer product giving highest addition rate of metal to soil with nutrient applied at maximum application rate

applied to a field in a growing season. The concomitant addition of heavy metals from all sources was not assessed here.

- To simplify calculations, soil type and chemical nature, plant uptake, leaching and erosion and other removal mechanisms were not considered in these calculations. All input of heavy metals was assumed to remain with the soil, and is therefore presumed to be an overestimate of soil metals levels over a long time period.

- Calculations of heavy metal additions to soil from fertilizers were based on all available data. The representativeness of this data set with respect to all fertilizers is not known. There has been as yet no systematic investigation of all fertilizer types, or an investigation of the percentage of recycled industrial waste products with substantial levels of heavy metals in the fertilizer market.

- Fertilizer application rates for agricultural crops were the only ones considered here. No attempt was made to capture the metals additions to residential and public lands, because of a lack of information on application rates. Preliminary data on heavy metals in home garden fertilizers suggest that significant amounts of metals may be added to home gardens from use of some of these products.

- In only a few instances was the origin (e.g., natural ore or industrial by-product) of the fertilizer product known. Although it may be instructive to compare heavy metal additions to soil from natural ores and products from industrial waste, such an exercise could not be undertaken on the basis of the available data.

While the following list is not inclusive, some of the data gaps that may require further study include:

- Nationally-representative micronutrient application rates. Aggregate average application rates for micronutrients and liming materials by state, treated acres and crop type have not been assembled, as has been done for N, P and K fertilizer.

- Regional variability in concomitant use of NPK, micronutrient and liming materials on the same field. Statewide use data for each fertilizer type are available, but the overlap in application by crop has not been compiled. Some areas of the U.S. may receive higher input of heavy metals from fertilizers due to the combination of crop type and existing soil conditions.

- Contribution of fertilizer products derived from industrial wastes to total fertilizer market. While sources of most industrial waste-derived fertilizers are fairly well known, the market share of these products in the total fertilizer market is not known.

- Statistically valid, nationally representative metal contaminant levels of all fertilizer types. While researchers have measured contaminant levels in fertilizers, these studies tend to represent either a single product type and/or products found in a specific state.

- Levels of other contaminants such as radionuclides and persistent organic chemicals in fertilizers and liming materials. Compared with the data on heavy metals in fertilizers, relatively little information exists on the levels of organic pollutants in fertilizers. Such organics could include dioxins, PCBs, pesticides and PAHs.

- The environmental fate of chemical additions to soil. This issue has been studied primarily for cadmium and lead, and most often under controlled laboratory or field conditions. All potential contaminants, soil types and crops have not been addressed. In addition, the fate of metals added to the soil as a result of fertilizer addition to non-agricultural land (e.g., range land and residential land) has not been adequately studied.

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Cement Kiln Dust (CKD) - A by-product from the manufacturing of cement. Contains 4% to 12.8% of potash (K_2O) and averages 30% Ca. Used primarily as a liming material. High content of calcium oxide produces equilibrium pH in suspension of about 12. (Source: Fertilizer Dictionary, Farm Chemicals Handbook).

Contaminant- A constituent or component of a fertilizer that is not part of the guaranteed analysis and/or 1) is not a macronutrient (primary or secondary), 2) is not a micronutrient, 3) is not required for plant nutrition (e.g., Cd, Pb, As, Hg, radionuclides, dioxins), and 4) may be essential for some plants (and humans) at low levels or in one oxidation state but toxic at higher levels or in a different oxidation state (e.g., Cr, Ni, V, Cu, Zn). Contaminant constituents are present naturally in inorganic fertilizer ores and in industrial by-products reprocessed for fertilizers.

Diammonium Phosphate (DAP) - A type of NPK fertilizer. The fertilizer grade of DAP $(NH_4)_2HPO_4$ is made from wet-process phosphoric acid and ammonia and has a grade of 18-46-0. DAP has an economic advantage over monoammonium phosphate (MAP) because the same amount of acid reacts with twice as much ammonia. Substantial quantities of crystalline DAP are produced as by-products from the iron and steel industry (Source: Fertilizer Dictionary, Farm Chemicals Handbook).

Fertilizer - A substance that contains one or more recognized plant nutrients that is specially designed to be used for its plant nutrient content and is claimed to promote plant growth. A fertilizer material is a fertilizer which either:

A. Contains important quantities of no more than one of the primary plant nutrients: nitrogen (N), phosphorus (P), and potassium (K), or

B. Has 85% or more of its plant nutrient content present in the form of a single chemical compound, or

C. Is derived from a plant or animal residue or by-product or natural material deposit which has been processed in such a way that its content of plant nutrients has not been materially changed except by purification and concentration (Source: Fertilizer Dictionary, Farm Chemicals Handbook).

Filler - A substance added to fertilizer materials to provide bulk, prevent caking, or serve some purpose other than providing essential plant nutrients. (Source-Fertilizer Dictionary, Farm Chemicals Handbook '97)

Guaranteed Analysis - The minimum percentage of plant nutrients claimed in a fertilizer that is found on the fertilizer label (Source: Fertilizer Dictionary, Farm Chemicals Handbook).

Gypsum - A product consisting chiefly of calcium sulfate with combined water ($CaSO_4 \cdot 2H_2O$) and is incapable of neutralizing soil acidity. Occurs in large deposits of soft crystalline rock and as sand. A granulated form has been developed for application to soil (for growing peanuts and

other crops) as a calcium source or sulfur source either by itself or in a blend of other fertilizers. In irrigated agriculture it is used to increase permeability of soils (Source: Fertilizer Dictionary, Farm Chemicals Handbook).

Heavy Metals - Certain metals, such as arsenic, cadmium, lead, mercury, and nickel, may be present in varying concentrations in naturally occurring ores or in industrial by-products which contain plant nutrients and are processed for fertilizers (Source: Fertilizer Dictionary, Farm Chemicals Handbook).

Industrial By-Product - Waste materials from various industrial processes which contain plant nutrients. These products may be converted into fertilizer materials, depending upon their physical condition and on their content of possibly undesirable contaminants. Some by-products are hazardous waste, others are not. (Source: Fertilizer Dictionary, Farm Chemicals Handbook).

Inorganic Fertilizer - A fertilizer material which does not have carbon as the essential component of its basic chemical structure (Source: Fertilizer Dictionary, Farm Chemicals Handbook).

K_2O- Potash or potassium oxide. Not used as a fertilizer *per se*, but the chemical term used as the basic measure of potassium (K) content in diverse potassium fertilizers such as potassium chloride, potassium sulfate, potassium nitrate and potassium thiosulfate.

K061 Waste - Emission control dust/sludge from the primary production of steel in electric furnaces (Source: Fertilizer Dictionary, Farm Chemicals Handbook).

Liming Materials - A product whose calcium and magnesium compounds are capable of neutralizing soil acidity (Source: Fertilizer Dictionary, Farm Chemicals Handbook).

Macronutrients - Nutrients that plants require for growth in relatively large amounts. Includes both primary and secondary nutrients. Primary nutrients are nitrogen, phosphorus, and potassium. Secondary nutrients are calcium, magnesium, and sulfur (Source: Fertilizer Dictionary, Farm Chemicals Handbook).

Micronutrients - Nutrients essential for normal growth of plants that are required relatively small amounts. Micronutrients include boron, chlorine, cobalt, copper, iron, manganese, molybdenum, sodium and zinc. (Source: Fertilizer Dictionary, Farm Chemicals Handbook).

Monoammonium Phosphate (MAP) - An important NPK fertilizer ($NH_4H_2PO_4$) whose production and use has increased steadily over the past several years. Granular product, made with wet-process acid, has a grade of about 10-53-0. Some by-product MAP made with furnace acid has a grade of 12-61-0 and is used mainly in production of liquid fertilizers. Nongranular (powder) MAP is used in formulations for granular NP and NPK fertilizers, which it can react with additional ammonia and aid granulation (Source: Fertilizer Dictionary, Farm Chemicals Handbook).

Muriate of Potash (MP) - A potash salt containing 48% to 62% soluble potash (K_2O) , chiefly as chloride. Also known as commercial potassium chloride (Source: Fertilizer Dictionary, Farm Chemicals Handbook).

N- Nitrogen, essential element for plant growth. Not used as a fertilizer *per se*, but the chemical term used as the basic measure of nitrogen content in diverse fertilizers such as nitrates, ammonium salts, liquid ammonium, urea, and natural organics.

Organic Fertilizer - A material that contains carbon and one or more elements besides hydrogen and oxygen that are required for plant growth (Source: Fertilizer Dictionary, Farm Chemicals Handbook).

P_2O_5- Phosphorus oxide. Not used as a fertilizer *per se*, but the chemical term used as the basic measure of phosphorus (P) content in diverse phosphate fertilizers such as calcium phosphates, ammonium phosphates, polyphosphates and superphosphates.

Phosphogypsum - Calcium sulfate ($CaSO_4 \cdot 2H_2O$) that is the dried by-product from the manufacturing of phosphoric acid, see gypsum. (Source: Fertilizer Dictionary, Farm Chemicals Handbook).

ppb- parts per billion. Unit of concentration equal to ng/g or ug/kg.

ppm- parts per million. Unit of concentration equal to ug/g or mg/kg.

Product Average Yearly Addition: Also product average yearly addition of metal X (e.g., Cd); product average yearly soil addition rate of metal X. The average amount of metal X that will be added to agricultural soil from all products of a specific fertilizer category. The product average yearly addition is obtained by calculation: the sum of the yearly addition rates of metal X in product type Y (e.g., P_2O_5 fertilizers) at nutrient application rate Z (e.g., average nutrient application rate), divided by the number of products of that category evaluated. Product average yearly addition is determined for three different nutrient application rates- average, high and maximum.

Soil Amendments - Any substance that is added to soil (other than the substances used primarily as fertilizer) that is thought to improve the physical characteristics of the soil, such as porosity to water and air. Soil amendments do not include commerical fertilizers, agricultuural liming materials, unmanipulated animal manures, unmanipulated vegetable manures, pesticides, and other materials exempted by regulation but can contain important fertilizer elements (Source: Fertilizer Dictionary, Farm Chemicals Handbook).

Yearly Addition: Also yearly addition of metal X (e.g., Cd); yearly soil addition rate of metal X. The amount of metal X that is added to agricultural soil from the application of a specific fertilizer product. Assumes one application of the product fertilizer in the year. The yearly addition value is obtained by calculation as follows: the concentration of that specific heavy metal in the fertiizer product per desired nutrient ingredient, multiplied by the nutrient application rate, with all appropriate conversion factors applied. Yearly addition is calculated with three different nutrient application rates- average, high and maximum.

BACKGROUND REPORT ON FERTILIZER USE, CONTAMINANTS AND REGULATIONS

1.0 INTRODUCTION

The Environmental Protection Agency (EPA) is studying the issue of heavy metals and other non-nutritive constituents (also referred to as contaminants) in fertilizers and liming materials. The purpose of this report is to provide background information on fertilizer use, consumption patterns, composition and regulations. This information is gathered and presented here for fertilizers from natural mineral sources and those that are derived from industrial by-products. The data for heavy metals in fertilizers compiled here are used to provide estimate of the rates at which these metals may be added to agricultural soils from standard agronomic practices. The addition of heavy metals to agricultural soil are discussed in terms of federal and international regulations.

Some industrial by-products contain chemicals which provide plant nutrients. The recycling of these materials conserves resources and minimizes waste, but at the same time may result in fertilizer products that contain chemicals unnecessary for plant growth and development. Examples of such chemicals are heavy metals such as lead and cadmium, radionuclides chemicals and persistent organics such as chlorinated dioxins. Concern has been raised that potentially hazardous constituents of recycled wastes, as well as naturally occurring heavy metals in ores used for fertilizers, might be taken up by plants and ingested by humans or animals in quantities that could be harmful to health. Additional concerns about use of fertilizer products include risks to farmers and their families, damage to soil fertility, and dispersion into groundwater and air.

States regulate label statements made about the plant nutrients (macronutrients: nitrogen, phosphate, potash; secondary nutrients and micronutrients) in fertilizers, but, in general, do not regulate other constituents that may be present as a result of the preparation of these products. Existing EPA Resource Conservation and Recovery Act (RCRA) regulations allow with certain restrictions the recycling of industrial wastes in the interest of minimizing waste that would ultimately end up in landfills or require additional treatment. EPA and the U.S. Department of Agriculture (USDA) also encourage the recycling of agricultural and municipal wastes. These wastes may contain heavy metals (e.g. arsenic, lead and cadmium) and persistent organic compounds (e.g. dioxins and furans) in addition to the beneficial chemicals which are being recycled into plant nutrient products. Biosolids (sewage sludge) are regulated in the U.S. when these products are applied to the land (EPA Part 503 Rule). EPA Part 266.20, "Recyclable Materials Used in a Manner Constituting Disposal," requires that fertilizers containing recycled hazardous materials meet specific treatment standards.

This report is a compilation of existing information on inorganic fertilizers and liming agents. The use and content of other types of materials used in agriculture, such as manures and other biosolid materials, was not addressed in this study.

Section 2 of this report provides an overview of the use of fertilizer in the United States, including including total consumption rates for various fertilizer types by state, for agricultural and non-agricultural use, and for specific crop types. This section also presents a brief profile of the U.S. fertilizer industry, and a discussion of the types of recycled industrial wastes and secondary materials that can be used in fertilizer manufacture.

Section 3 provides information on classification of fertilizers, and presents data on concentrations of heavy metals and other contaminants by fertilizer type, as well as data from a number of studies on soil metal concentrations.

Section 4 is a summary discussion of regulations and guidelines for fertilizers that have been developed in the United States and other countries. This section also outlines regulations for biosolids that are applied to land.

Section 5 combines data on the application rates for different fertilizer types with the data on contaminant levels, to estimate the amounts of metals that may be added to soils from fertilizer usage. These data are compared with regulatory standards and benchmarks, and to background soil concentrations of metals.

1.1 PEER REVIEW PROCESS

This report was reviewed independently by members of a peer review panel. The panel consisted of a diverse group of researchers and policy professionals in government, industry, and environmental advocacy who, together, had considerable knowledge on all subject areas addressed in this report. The members of this panel and their affiliations were:

Darlene H. Blair, Canadian Food Inspection Agency
Sally Brown, US Department of Agriculture- Agricultural Research Service
Stan Daberkow, US Department of Agriculture
Jacqueline Savitz, Environmental Working Group
James Skillen, The Fertilizer Institute
Steven Wong, California Department of Food and Agriculture.

The peer reviewers were invited to provide both general comments and specific suggestions concerning the report.

The majority of the peer reviewer comments can be divided into five main subject areas. These subject areas include:

- purpose of the report,
- definition of terms,
- use of benchmark standards for comparison of products,
- potential fertilizer problems beyond heavy metals in agricultural products, and
- technical issues related to clarity of discussion of calculation methods, and the role of lime and gypsum in the fertilizer industry.

The purpose of the report was not well understood by the reviewers, so that several reviewers requested analyses, data collection, evaluation of EPA's next steps, and/or assessment of EPA's policy position. These requests covered areas that far exceeded the scope and intended purpose of the report. As a result of such reviewer comments, the executive summary and the introduction were modified significantly to emphasize that this report is an information source, and contains a compilation of available data on fertilizer composition, application rates, and applicable regulations, and provides a calculated estimate of the possible soil metal accumulations that may occur over time with repeated applications of fertilizer products. The report was not designed as an exposure assessment or risk assessment, either ecological or human. EPA's next steps and policy position were not addressed as this would go beyond the scope and intent of this report, and would logically be communicated to the public at a later time.

Terms that were used in the peer reviewed version of the report (e.g., contaminant, hazardous waste) were viewed as significantly ambiguous to several reviewers so as to require clarification and/or modification. Several reviewers suggested that a glossary of terms be added at the beginning of the document, and this suggestion was implemented. The glossary covers standard fertilizer terms and their abbreviations (e.g., DAP, diammonium phosphate), as well as terms which may connote different things to different groups if not explicitly defined (e.g., industrial by-product). A consistent set of terms was then applied to the entire document, and these terms were chosen as "neutral" in their connotations. For example, the term "heavy metal contaminant" was replaced with "heavy metal constituent" because heavy metals such as zinc and copper can be used as a nutrient in some circumstances and viewed as an undesirable component in other instances. In addition, because of negative connotations to the word "hazardous waste", especially as applied to materials that are legitimately reprocessed as fertilizer materials or feedstocks, this term was replaced with "industrial by-product" in the report.

Several reviewers questioned the appropriateness of the benchmark standards that were employed in the evaluation of diverse fertilizer products. In particular, reviewers questioned the use of heavy metals limits set in the Canadian Fertilizers Act and Regulations, and the calculation of years required to double soil metal background levels with repeated yearly additions of a given product. As documented in the report, the Canadian standards were not established through a formal risk assessment, but were instead determined from the best estimates of leading scientists in various fields as levels associated with no adverse effect to plants, animals or land over the long term. These limits are being adopted by states and AAPFCO at this time, in lieu of formal risk assessments, so that they constitute a useful and consistent point of reference for comparisons. The report also characterizes fertilizer products with respect to the length of time required for their consistent applications to double the average background US soil metals levels. Although the doubling of soil metal levels may not be associated with any known risk, these calculations help to put products, application rates and fertilizer constituent levels in the perspective of a measurable change to soils.

Due to the concern that recycled industrial by-products may have hazardous constituents other than the heavy metals, the report was expanded to include discussions of other undesirable components of fertilizers. In this section, attention was given specifically to dioxins/furans and radionuclides. Some peripheral comments also noted the potential for pesticides, PAHs, and PCBs to be present in industrial wastes, but organic constituents were not a primary focus of this

report. Similarly, questions were raised about fertilizers other than those applied in production agriculture, specifically those used in the home-and-garden arena. Because data were readily available from several sources on concentrations of heavy metals in home-and-garden fertilizers, these data were included in the report. However, because application rates for these products are so varied among consumers, no attempt was made to estimate soil additions of metals from these products.

Several comments made by reviewers suggested that there was some confusion about what constituted an average fertilizer product. For this reason, there is a definition of average product in the text, an expanded discussion of the calculation method, and examples that show the manner in which both the percentage of the active nutrient ingredient and the individual product heavy metal concentrations contribute to the soil addition rate. As a result of these comments, text in both the executive summary and Section 5 has been augmented by figures which provide a rapid perspective on product types that may require additional scrutiny due to exceedances of Canadian standards or relatively short time of use before soil background metals levels are potentially doubled. These figures provide an excellent perspective for final conclusions of the report.

EPA has established a public record for the peer review of this report under administrative record AR-208 , "Background Report on Fertilizer Use". The record is available in the TSCA Nonconfidential Information Center, which is open from noon to 4 PM Eastern time Monday through Friday, except legal holidays. The TSCA Nonconfidential information Center is located in Room NE-B607, Northeast Mall, 401 M Street SW, Washington, DC.

2.0 FERTILIZER USE AND INDUSTRY CHARACTERIZATION

This section provides an introduction to the fertilizer industry in the United States. Fertilizers are defined in the first subsection. Fertilizer consumption in the U.S. is described in the second subsection. That subsection includes information on tons of fertilizers consumed by types of fertilizer for individual states and regions of the country. Fertilizer use on agricultural crops is provided, both amount consumed and application rates. In addition, fertilizer consumption is broken down into that used for agriculture and other uses in the third and fourth subsections. The final subsection provides an overview of the fertilizer industry describing the market structure, production volumes and size distribution of producing firms.

This section addresses the questions:

- What constitutes a fertilizer and a liming material?
- How much fertilizer is used in the U.S.?
- How much of various kinds of fertilizers and micronutrients are used in the U.S.?
- How do the states and regions of the country differ in fertilizer use?
- What crops use the most of specific fertilizer types?
- What is known about non-farm fertilizer use?
- How is fertilizer made?
- What is known about the fertilizer industry in terms of production, revenue and employment?

2.1. DEFINITION OF FERTILIZER AND LIMING MATERIAL

Fertilizer is defined as "any substance containing one or more recognized plant nutrient(s) which is used for its plant nutrient content and which is designed for use or claimed to have value in promoting plant growth" (Association of American Plant Food Control Officials - AAPFCO, 1997b). A **fertilizer material** is a fertilizer which either

(a) "Contains important quantities of no more than one of the primary plant nutrients: nitrogen (N), phosphorus (P) and potassium (K), or
(b) Has 85% or more of its plant nutrient content present in the form of a single chemical compound, or
(c) Is derived from a plant or animal residue or by-product or natural material deposit which has been processed in such a way that its content of plant nutrients has not been materially changed except by purification and concentration." (AAPFCO)

Fertilizers may be composed of multiple fertilizer materials. In addition, fertilizers may contain additives which "alter transformation in the soil, maintain good physical condition, reduce corrosiveness and serve some purpose other than providing plant nutrients" (Meister, R.T., 1997) and micronutrients. Primary nutrients are defined by the AAPFCO as nitrogen (N), available phosphate (P_2O_5) and soluble potash (K_2O). The AAPFCO defines secondary and micronutrients as "those other than the primary nutrients that are essential for the normal growth of plants and that may need to be added to the growth medium. Secondary plant nutrients shall include calcium, magnesium and sulfur; micro plant nutrients shall include boron, chlorine, cobalt, copper, iron, manganese, molybdenum, sodium and zinc." Calcium (liming materials and

gypsum), magnesium (from dolomite limestone) and sulfur (in the form of inorganic sulfates and sulfur in organic matter) are used to aid in fruit and leaf development and leaf color. More detailed descriptions of the composition of fertilizers are provided in Section 3.

A **liming material** is defined as "a product whose calcium and magnesium compounds are capable of neutralizing soil acidity" (AAPFCO, 1997b).

2.2. FERTILIZER CONSUMPTION IN THE U.S.

Both the AAPFCO and USDA collect information on fertilizer use in the United States. The Economic Research Service (ERS) and National Agricultural Statistics Service (NASS) of USDA and State Statistical Offices (SSO's) collect information on chemical use in agriculture, including information on crops treated, acreage and costs. The AAPFCO, an organization of officials, examiners, and researchers in North America charged with regulating fertilizer materials and enforcing laws applied thereto, collects information on commercial fertilizers consumed in North America, Hawaii, and Puerto Rico. Information provided in this chapter on fertilizer use has been abstracted from both sources and several ancillary sources. The AAPFCO uses the term "consumption" for their fertilizer statistics. Consumption, for the AAPFCO, means data submitted by fertilizer control offices on sales or shipments for farm and non-farm use. The USDA data record fertilizer application to agricultural land, which is a more specific definition of use. Because there are no data on fertilizer stockpiling by the consumer, use and consumption are used interchangeably in this report.

The AAPFCO reports that more than 54 million tons (110 billion lbs) of commercial fertilizers of all kinds were consumed in the United States in the year ending June 30, 1996. Primary nutrients (N, P, K) accounted for 91% of this total; liming materials accounted for about 4%, and organic fertilizers accounted for 1% of the total. Approximately 5% of the total (2.7 million tons) was due to secondary nutrients and micronutrients. Table 2-1 summarizes the U.S. tonnage use of the different fertilizer types. The zinc and iron micronutrient fertilizers, which have come under scrutiny lately as industrial waste by-products with heavy metal content, comprise about 0.1% of the total tonnage of fertilizers consumed.

Table 2-2 summarizes the use of fertilizers in different regions of the United States. The largest single category of fertilizers consumed in 1996 was the nitrogen materials (23 million tons) and the smallest category is natural organic materials (0.57 million tons), which includes compost, manure and sewage sludge. The West North Central region (13 million tons) and the New England Region (0.4 million tons) are the areas consuming the most and least fertilizer in the continental United States, respectively. These consumption values are totals and are not adjusted for the amount of agricultural land in each region. The AAPFCO statistics presented in Table 2-2 differ slightly from those presented in Commercial Fertilizers 1996 (AAPFCO and the Fertilizer Institute (TFI), 1997) because this table was prepared from electronic files obtained from the AAPFCO. Because of the inclusion of liming materials in these tables and some minor differences in the definition of multiple nutrient fertilizers and "other" fertilizer groupings, these fertilizer consumption values differ slightly from those presented in Commercial Fertilizers 1996.

Table 2-1. Total Fertilizer (Tons) Consumed in the United States in 1996[a]

Fertilizer Type	Tons	% of Total
Nitrogen	23,412,475	38
Multiple Nutrient	19,049,707	31
Phosphate	7,204,054	12
Potash	5,988,338	10
Secondary/Micronutrient	2,743,287	4.5
[gypsum	~50%][b]	[2.3]
[other	~25%][b]	[1.1]
[zinc	~1.5%][b]	[0.07]
[iron	~1%][b]	[0.05]
Lime	2,219,922	3.6
Organic	571,575	0.9

a) Source: AAPFCO Electronic Database; see expanded form in Table 2-2 see footnote a, Table 2-2.

b) Selected data; percentage of the secondary/micronutrient total due to indicated type.

Appendix A contains fertilizer consumption for individual states and Puerto Rico, grouped into the regions of the country shown in Table 2-2 (pp. 8-14). These data are abstracted from AAPFCO data files for the year ending June 30, 1996. There are nine states with total fertilizer consumption over 2 million tons. These states are, in order of increasing fertilizer consumption: Florida, Minnesota, Ohio, Nebraska, North Carolina, Texas, Iowa, Illinois and California. Table 2-3 below shows the fertilizer consumption (tons) of the top two states by fertilizer category. Texas and Florida consume the most multiple nutrient fertilizers, while Illinois consumes the most single nutrient nitrogen, phosphate and potash fertilizers. North Carolina consumes the most organic fertilizers and liming materials, while California consumes the most secondary nutrient and micronutrient fertilizers.

Table 2-3. Top States Consuming Fertilizers by Fertilizer Type, 1996[a]

Fertilizer Type[b]	Top State and Tons Consumed	Second Top State and Tons Consumed
Multiple Nutrient	TX - 1,622,103	FL - 1,562,946
Nitrogen	IL - 1,920,268	IA - 1,819,846
Phosphate	IL - 832,904	IA - 647,541
Potash	IL - 979,455	IA - 699,879
Organic	NC - 194,265	CA - 78,781
Secondary Nutrient and Micronutrients	CA - 1,596,796	NC - 145,651
Liming Materials	NC - 947,126	CA - 621,915

a) See Appendix A for more details

b) Source: AAPFCO Database, 1997

Table 2-2. Total Fertilizer (Tons) Consumed in the United States and Regions in 1996

Description	New England	Middle Atlantic	South Atlantic	East North Central	West North Central	East South Central	West South Central	Mountain	Pacific	Alaska Hawaii Puerto Rico	United States and Puerto Rico
MULTIPLE NUTRIENT FERTILIZERS											
N-P-K	238,837	906,139	3,497,228	1,341,258	613,608	737,119	1,595,897	59,972	1,336,439	114,217	10,440,715
N-P	17,756	180,851	259,164	1,636,291	2,773,728	444,812	755,069	628,283	452,600	6,912	7,155,466
N-K	7,326	44,111	526,711	56,458	16,323	41,300	119,429	4,495	35,408	1,572	853,133
P-K	1,982	27,157	145,734	149,290	6,260	45,620	222,927	22	1,386	13	600,392
TOTAL	265,902	1,158,258	4,428,838	3,183,297	3,409,920	1,268,851	2,693,322	692,773	1,825,832	122,714	19,049,707
NITROGEN FERTILIZERS											
Ammonium Nitrate	3,347	21,810	182,906	78,787	442,273	504,232	379,706	308,154	177,368	147	2,098,730
Ammonium Nitrate Solution	0	1	3,714	203	0	228	34	50	70,064	0	74,294
Ammonium Nitrate-limestone Mixtures	2	5	397	0	0	0	0	0	0	0	404
Ammonium Nitrate-sulfate	0	1,167	12,697	4,404	39	890	2,227	7,592	2,490	0	31,505
Ammonium Polysulfide	0	1	3,622	335	115	420	51	10,137	25,047	0	39,728
Ammonium Sulfate	1,258	45,536	101,076	108,605	102,906	28,612	155,272	138,843	350,869	17,021	1,049,999
Ammonium Sulfate Solution	0	507	672	141,415	19,765	0	231	22	318	0	162,930
Ammoniumsulfate-nitrate	0	802	1,260	22,446	1,287	210	7,001	1,709	1,005	0	35,720
Ammoniumsulfate-urea	0	25	469	114	0	0	2,183	0	0	0	2,790
Ammonium Thiosulfate	5	3,239	1,415	15,055	98,942	7,992	21,867	28,426	60,101	0	237,042
Anhydrous Ammonia	2	16,535	22,453	1,020,310	2,713,026	96,978	405,354	290,472	265,361	0	4,830,490
Aqua Ammonia	0	424	600	12,047	3,386	273	0	8,871	349,061	0	374,662
Calcium Ammonium Nitrate	9	77	354	1,231	854	32	454	982	176,673	0	180,665
Calcium Cyanamide	0	0	3	0	0	0	0	0	248	0	252
Calcium Nitrate	1,052	3,486	20,076	47,795	1,742	769	495	3,634	112,688	0	191,737
Calcium Nitrate-urea	0	27	1,495	311	612	0	1,934	87	0	0	4,465

Table 2-2. (Continued)

Description	New England	Middle Atlantic	South Atlantic	East North Central	West North Central	East South Central	West South Central	Mountain	Pacific	Alaska Hawaii Puerto Rico	United States and Puerto Rico
Ferrous Ammonium Sulfate	17	78	242	155	66	1,664	0	43	1,805	0	4,070
Magnesium Nitrate	0	0	3	0	0	0	0	0	0	0	3
Nitric Acid	23	9	991	1,346	747	1	170	212	0	0	3,500
Nitrogen Solution 28%	762	40,384	22,849	2,137,611	1,604,399	103,271	323,376	26,268	18,442	0	4,277,361
Nitrogen Solution 30%	1	220,452	772,531	5,367	8,670	16,629	45,082	423	16	0	1,069,172
Nitrogen Solution 32%	3,108	32,407	38,814	228,594	1,072,964	252,530	862,560	443,132	793,919	18,236	3,746,263
Nitrogen Solution<28%	101	42,211	232,379	139,808	21,593	17,511	31,077	53,999	17,920	0	556,600
Nitrogen Solution>32%	0	210	1,960	857	6,432	918	6,187	23	967	0	17,555
Sodium Nitrate	340	409	18,948	1,443	42	5,339	3,268	95	1,718	0	31,602
Sulfur Coated Urea	6	429	246	1,473	1,104	56	465	426	1,989	8	6,202
Urea	13,437	95,224	83,617	514,168	1,403,713	295,787	852,280	377,587	266,480	9,713	3,912,007
Urea Solution	0	0	301	0	1,277	281	0	63	8,437	0	10,359
Urea-formaldehyde	1,857	12,218	12,929	8,553	4,463	3,240	15,504	88	4,260	1	63,114
Zinc Ammonium Sulfate Solution	0	0	319	2	5,691	546	0	72	0	0	6,631
Zinc Manganese Ammonium Sulfate	0	3	75	0	15	0	0	0	0	0	92
Other	3,389	10,448	68,387	76,305	31,253	68,180	83,512	17,618	33,441	1	392,534
TOTAL	28,715	548,128	1,607,798	4,568,739	7,547,376	1,406,587	3,200,289	1,719,029	2,740,687	45,127	23,412,475
PHOSPHATE FERTILIZERS											
Ammonium Metaphosphate	0	0	0	0	0	0	0	0	8,284	0	8,284
Ammonium Phosphate	1	911	4	38	17,228	98	296	238	468	3,215	22,498
Ammonium Phosphate Nitrate	0	0	1	1	1,238	5	15	0	2,512	0	3,772
Ammonium Phosphate Sulfate	0	121	24	494	3,388	0	7,827	76,593	98,945	0	187,391
Ammonium Polyphosphate	61	446	6	132	52,123	57	0	0	3,706	0	56,533

Table 2-2. (Continued)

Description	New England	Middle Atlantic	South Atlantic	East North Central	West North Central	East South Central	West South Central	Mountain	Pacific	Alaska Hawaii Puerto Rico	United States and Puerto Rico
Basic Lime Phosphate	37	0	0	0	0	0	0	0	0	0	37
Basic Slag	0	0	2,988	0	0	2,143	0	0	0	0	5,131
Bonemeal, Raw	76	59	40	35	0	0	2	1	82	0	294
Bonemeal, Steamed	214	155	178	136	26	12	2	17	374	0	1,113
Bone, Precipitated	0	0	0	0	2	0	5	284	0	0	292
Calcium Metaphosphate	0	0	115	0	253	1,825	25	0	0	0	2,218
Colloidal Phosphate (Soft Phosphate)	4	45	499	196	142	128	28	0	6	0	1,047
Diammonium Phosphate	5,886	45,610	112,709	1,128,423	1,617,708	403,834	213,220	129,627	36,480	615	3,694,109
Limestone, Phosphatic	0	0	45	0	22	0	0	0	0	0	68
Liquid Ammonium Polyphosphate	1,965	23,525	89,524	277,089	486,662	19,340	137,368	64,905	122,073	3,081	1,225,533
Magnesium Phosphate	0	41	43	40	990	48	149	25	3	0	1,340
Mono Ammonium Phosphate	2,538	39,846	4,256	153,501	528,150	8,077	47,462	350,713	165,720	1	1,300,264
Nitric Phosphate	0	0	0	0	0	0	0	0	2,394	0	2,394
Phosphate Rock	10	6	24	632	335	31	150	1,416	2,869	11	5,483
Phosphoric Acid	0	2,319	3,203	577	4,802	1	291	9,933	15,155	0	36,280
Precipitated Phosphate	0	0	23	0	0	0	0	1,187	0	6	1,216
Super Phosphate, Enriched	8	42	86	35	89	28	3	56	556	0	902
Super Phosphate, Normal	146	1,201	2,667	12,666	8,978	520	4	3,785	473	159	30,599
Super Phosphate, Triple	697	17,110	28,658	198,374	91,090	50,095	25,240	19,932	11,950	432	443,577
Super Phosphoric Acid	0	0	2,219	2	10,430	0	893	18,323	12,577	0	44,444
Other	151	3,466	17,579	92,606	3,732	1,613	4,635	2,583	2,868	0	129,235
TOTAL	11,794	134,904	264,890	1,864,977	2,827,389	487,856	437,613	679,617	487,496	7,519	7,204,054
POTASH FERTILIZERS											
Lime-potash Mixtures	46	5,568	220	1,587	30	88	1	543	0	0	8,084

Table 2-2. (Continued)

Description	New England	Middle Atlantic	South Atlantic	East North Central	West North Central	East South Central	West South Central	Mountain	Pacific	Alaska Hawaii Puerto Rico	United States and Puerto Rico
Manure Salts	0	0	504	464	1,179	0	18	1,530	0	0	3,694
Muriate of Potash 60%(Pot. Chloride)	8,063	120,740	192,919	1,787,204	1,488,714	504,059	140,414	104,454	149,085	592	4,496,243
Muriate of Potash 62%	720	13,243	12,943	676,455	196,174	23,565	4,094	6,009	10,990	0	944,192
Potash Suspensions	62	2,752	179	0	0	183	0	0	7,091	0	10,267
Potassium Carbonate	28	77	295	153	292	0	77	442	25	0	1,389
Potassium Nitrate	362	10,126	26,616	2,100	200	2,853	1,176	2,740	23,528	179	69,880
Potassium Sulfate	224	2,743	17,695	10,152	1,857	42,255	5,811	4,708	55,555	1,173	142,173
Potassium-magnesium Sulfate	1,488	3,796	17,017	19,574	39,898	9,336	7,874	5,813	30,301	0	135,098
Potassium-meta Phosphate	4	173	0	0	0	0	0	0	0	0	177
Potassium-sodium Nitrate	1	141	18,418	37	23	224	0	1	0	0	18,845
Other	778	14,242	37,071	26,676	11,338	10,887	10,518	19,325	11,098	16,328	158,260
TOTAL	11,777	173,602	323,878	2,524,402	1,739,704	593,448	169,983	145,598	287,672	18,272	5,988,338
ORGANIC FERTILIZERS											
Blood, Dried	37	20	196	124	172	3	1	1	1,770	0	2,324
Castor Pomace	0	0	8	1	0	0	0	0	0	0	9
Cocoa Shell Meal	0	0	11	0	0	0	0	0	0	0	11
Compost	14,509	15,195	20,863	3,974	492	0	0	8,793	948	0	64,774
Cottonseed Meal	6	0	40	0	0	27	0	0	72	0	144
Fish Scrap	48	0	18	12	0	989	0	0	377	0	1,443
Guano	0	0	0	0	0	0	0	0	6	0	6
Manure	820	13,060	57,307	4,947	2,293	6,830	4,891	8,653	17,470	0	116,271
Peat	0	93	8,461	26,690	0	2,338	0	395	0	0	37,977
Sewage Sludge, Activated	1,241	6,618	10,760	0	523	241	0	97	0	0	19,480
Sewage Sludge, Digested	0	0	0	0	0	0	0	0	2	0	2

Table 2-2. (Continued)

Description	New England	Middle Atlantic	South Atlantic	East North Central	West North Central	East South Central	West South Central	Mountain	Pacific	Alaska Hawaii Puerto Rico	United States and Puerto Rico
Sewage Sludge, Heat Dried	0	127	0	2,472	8	0	0	12,510	0	0	15,116
Sewage Sludge, Other	86	4,038	259	0	0	0	44	0	77,169	0	81,595
Soybean Meal	0	0	0	1	0	0	0	0	0	0	1
Tankage, Animal	0	0	0	37	0	0	0	202	0	0	239
Tankage, Process	0	0	83	281	61	154	0	0	371	0	949
Other	28	7,837	187,427	10,597	2,869	9,763	102	1,055	11,544	11	231,234
TOTAL	16,775	46,988	285,434	49,135	6,418	20,343	5,038	31,706	109,728	11	571,575
SECONDARY AND MICRONUTRIENT FERTILIZERS											
Aluminum Sulfate	421	37	16	1	0	441	3	6	138	0	1,063
Borax	123	800	1,895	1,462	2,339	3,690	11,617	72	4,279	0	26,276
Calcium Chelate	4	82	227	9,026	47	0	0	1	0	3,751	13,138
Calcium Chloride	0	393	38	1,331	4,988	9	0	0	0	0	6,759
Calcium Sulfate (Hydrous)	0	0	13	1,804	190	0	0	0	179	0	2,186
Cobalt Sulfate	0	0	0	0	0	0	0	0	2	0	2
Copper Chelate	0	2	58	49	74	0	0	2	25	0	211
Copper Compound	0	0	7	0	0	0	0	0	582	0	589
Copper Oxide, Black	0	0	0	36	53	0	0	0	0	0	89
Copper Sulfate	2	440	217	42	240	6	0	367	89	0	1,403
Epsom Salt(magnesium Sulfate)	10	57	874	72	1	16	1	82	1,265	219	2,596
Ferric Oxide	0	0	2	0	1,482	255	0	0	1	0	1,740
Ferric Sulfate	0	51	0	0	37	0	0	516	4,073	0	4,677
Ferrous Sulfate	6	22	1,745	0	421	25	0	1,421	1,159	0	4,799
Gypsum (Calcium Sulfate)	488	1,835	334,400	20,838	8,576	1,160	44	37,569	1,205,581	0	1,610,491
Iron Chelate	51	187	629	286	636	45	9	368	162	0	2,372
Iron Compound	7	61	216	5	32	16	0	27	7,020	0	7,383
Lime Sulfur Solution	0	0	0	0	0	0	0	716	3	0	719

Table 2-2. (Continued)

Description	New England	Middle Atlantic	South Atlantic	East North Central	West North Central	East South Central	West South Central	Mountain	Pacific	Alaska Hawaii Puerto Rico	United States and Puerto Rico
Magnesia (Magnesium Oxide)	11	339	266	56	196	74	1	0	0	247	1,190
Magnesium Chelate	0	11	23	0	7	7	12	416	35	0	509
Manganese Agstone	0	0	0	1	19	0	0	0	0	0	20
Manganese Chelate	0	23	119	1	82	10	0	1	105	0	342
Manganese Oxide	4	11	39	3	54	21	0	4	71	0	206
Manganese Slag	0	0	160	0	0	0	0	0	0	0	160
Manganese Sulfate	9	191	3,376	75	387	15	0	73	293	0	4,419
Manganese Oxide	0	0	0	73	3	3	0	0	0	2	81
Potting Soil	0	373	28,530	0	0	2	0	44	0	0	28,950
Sodium Molybdate	0	0	0	9	1	200	0	0	23	0	234
Soil Additive	0	2	1	0	0	0	0	2	0	0	4
Soil Amendment	20,035	72	5,036	0	60	0	3	339	316	0	25,861
Soil Conditioner	0	7,135	415	11,601	1,202	0	0	10,817	0	0	31,171
Sulfur	79	1,090	2,273	4,959	14,323	4,100	630	26,254	66,638	137	120,484
Sulfuric Acid	0	0	0	0	1,248	2	0	15,015	118,100	0	134,365
Zinc Chelate	2	95	83	3	2,955	61	646	4,989	790	0	9,623
Zinc Oxide	0	367	120	673	4,849	359	63	243	1,482	0	8,158
Zinc Oxysulfate	0	72	22	331	39	114	0	0	35	0	612
Zinc Sulfate	20	298	34	206	12,645	186	141	1,526	3,499	15	18,569
Zinc Sulfate Solution	0	0	0	0	1,883	0	144	17	0	0	2,044
Other	48	1,112	117,038	30,415	21,327	12,206	139,236	15,947	332,384	81	669,793
TOTAL	21,319	15,156	497,872	83,357	80,395	23,024	152,549	116,835	1,748,327	4,451	2,743,287
LIMING MATERIALS											
Calcitic Lime (75% Neutral)	13,558	0	25,124	437	0	0	2,953	0	0	8,696	50,768
Calcium Hydroxide (Hydrate)	24	0	231	5	2	41	0	0	1,964	0	2,267
Calcium Oxide (Burnt)	0	0	186	0	0	0	0	0	0	96	282

Table 2-2. (Continued)

Description	New England	Middle Atlantic	South Atlantic	East North Central	West North Central	East South Central	West South Central	Mountain	Pacific	Alaska Hawaii Puerto Rico	United States and Puerto Rico
Dolomitic & Calcitic Blend (Pelletized)	0	0	890	1,114	0	148	0	0	0	0	2,152
Dolomitic Lime (75% Neutral)	11,877	10	111,863	2	0	1,319	174	1	0	0	125,247
Lime Suspensions	0	228	0	0	0	0	0	0	0	0	228
Non-lime Filler (Water, Sand, Etc.)	0	92	7	1,097	0	0	0	0	0	0	1,196
Standard Calcite	8,988	9,469	973,331	0	5,259	22,226	0	564	160,751	180	1,180,768
Standard Dolomite	7,306	34	36,224	0	0	56	27	0	34,432	0	78,079
Other	10,270	9,872	35,824	20,145	65	1,828	115	37	700,781	0	778,936
TOTAL	52,022	19,704	1,183,681	22,800	5,327	25,618	3,268	602	897,928	8,972	2,219,922
TOTAL ALL FERTILIZERS											
GRAND TOTAL[b]	380,487	1,931,326	8,209,554	10,696,555	12,905,624	3,380,801	6,249,756	2,729,707	7,537,010	199,975	54,220,796

a) Notes: Data in this table were compiled from the electronic database provided by the AAPFCO and may differ slightly from those published in Commercial Fertilizers 1996 by the AAPFCO and TFI.

Regions are:
East North Central - IN, IL, MI, OH, WI
East South Central - KY, AL, MS, TN
West North Central - KS, IA, MN, MO, NB, ND, SD
West South Central - LA, AR, OK, TX
New England - CN, ME, MA, NH, NY, RI, VT
Middle Atlantic - DE, MD, NJ, PA, WV
South Atlantic - FL, GA, NC, SC, VA
Mountain - AZ, CO, ID, MT, NM, NV, UT, WY
Pacific - AK, CA, HI, OR, WA

The term "Other" in this table refers to unspecified fertilizer types. For example, Other under Nitrogen Fertilizers refers to nitrogen-containing fertilizer products not previously specified in the listed nitrogen fertilizers.

b) Grand totals are less than sum of the category totals, because some multinutrient fertilizers are also included in other fertilizer categories.

2.3. AGRICULTURAL FERTILIZER USE

The USDA ERS-NASS data presented in this section come from the most recent surveys of field, fruit and vegetable crops. These surveys, the sampling methodology, coverage and data collection are described in the USDA, ERS Agricultural Resources and Environmental Indicators, 1996-1997 Appendix: Agricultural Resource Surveys and Data (1997).

Fruit and vegetable data were abstracted from the Chemical Use Surveys that were initially funded under the 1989 President's Food Safety Initiative. These surveys are conducted by NASS "using personal enumeration of a stratified systematic sample of growers who produce at least one acre of the targeted crops." The information collected on fertilizer use, acreage planted and application rates are survey data for the major crop producing states and do not represent the totality of farms in the U.S. raising these crops. Surveys are conducted in odd numbered years for fruit (latest available survey performed in 1995, reported in 1996) and even numbered years for vegetable crops (latest available survey performed in 1994, reported in 1995; the 1996 survey did not collect fertilizer data).

The latest field crop usage data, covering 70 to 90% of the total U.S. crop, are from the Agricultural Resources Management Survey (ARMS) of 1996 which combines the former Cropping Practices Surveys with the Farm Costs and Returns Survey. This survey has three phases. Phase II, conducted in the autumn, collects data on agricultural production practices, resource and input use and production. In this survey, "a multi-frame, stratified sampling procedure is used. Results are weighted and aggregated to develop state, regional and national estimates." The ARMS collects additional information on a selected field crop in certain years. For example, in 1996 the ARMS collected data on tobacco.

2.3.1 Field Crops

The USDA, ERS, NASS (1997) collected data on selected field crops in the major states with approximately eighty percent of the U.S. acreage for these crops. Table 2-4 shows the number of acres planted, the total amount of N, P (P_2O_5) and K (K_2O) fertilizers applied and N, P and K application rates for these field crops (note that in this section on fertilizer use, P refers to phosphate fertilizers, not phosphorus, and K refers to potash, not potassium). Potatoes have the highest average application rates for nitrogen fertilizers (195 lbs/acre) and phosphate fertilizers (173 lbs/acre), while application rates of potash are highest on tobacco (203 lbs/acre). Potatoes and tobacco, however, each have fewer than 1 million acres planted. More acres are planted with corn (approximately 70 million acres) than any other crop in the U.S., and the application rates are 133 lbs/acre N, 57 lbs/acre P_2O_5 and 79 lbs/acre K_2O. Thus, in terms of total applied fertilizer, acreage in corn, in the aggregate, receives the most fertilizer.

Information on lime, sulfur, manure and micronutrient use is available only from previous USDA surveys. The USDA, ERS, Cropping Practices Survey field crop data for crop year 1994 and 1995 (USDA, AREI, May, 1996) report some information on these fertilizers and soil amendments. Table 2-5 shows the number of field crop acres receiving nutrients and application rates for sulfur and lime for 1994 and 1995. Almost 60 percent of the potato acreage receives sulfur and micronutrient fertilizers, and this is a much greater percentage than any of the other field crops. Application rate for sulfur on potatoes is also much higher than other field crops (82

lbs/acre for potatoes compared to 11-13 lbs/acre for other field crops). Six percent of potato acreage receives lime, and while this is higher than other crops, it is only slightly higher. Fourteen percent of the corn acreage in 1995 received manure treatments. All other crops had fewer acres treated with manure.

Table 2-4. Fertilizer Use on Field Crops in 1996, Totals for All States[a]

Crop	Acres Planted (thousands of acres)	Total Applied (million lbs/year) (Percent of Acres Treated)			Application Rate Per Crop Year (lbs/acre) Average and Range[b]		
		N	P_2O_5	K_2O	N	P_2O_5	K_2O
Corn	70,250	9,089.0 (98%)	3,416.7 (85%)	4,076.1 (73%)	133 79-170	57 34-87	79 22-116
Upland Cotton	11,915	917.7 (77%)	316.0 (55%)	373.1 (43%)	100 74-175	48 38-83	73 21-106
Fall Potatoes	797	154.0 (99%)	134.4 (97%)	98.9 (90%)	195 84-285	173 78-198	139 105-204
Soybeans	50,050	184.3 (15%)	605.4 (25%)	1,151.5 (27%)	24 12-40	49 42-56	85 17-102
Flue-cured Tobacco	415	36.4 (99%)	38.0 (99%)	83.6 (99%)	88 80-108	93 67-116	203 172-284
Winter Wheat	28,520	1,494.8 (86%)	438.2 (51%)	53.0 (6%)	61 41-115	30 20-53	29 17-40
Durum Wheat	3,000	168.6 (93%)	50.9 (73%)	4.9 (8%)	60 na[c]	23 na	21 na
Other Spring Wheat	16,350	983.4 (89%)	399.1 (79%)	83.4 (24%)	67 50-91	31 23-37	21 9-28

a) Source: USDA, ERS, NASS, 1997
b) Averages are state weighted averages. Ranges are the minimum and maximum reported for all states reporting
c) Only one state reported data for this crop, no range can be calculated

Appendix B (Table B-1) presents corn, cotton, potato, soybean, tobacco, and wheat data for primary plant nutrient use (N, P_2O_5 and K_2O), fertilizer (total N, P_2O_5 and K_2O) and fertilizer application rates from the most recent USDA survey. The Agricultural Resources Management Survey was conducted in the fall of 1996 (USDA, NASS, ERS, September, 1997). In 1996, the survey covered the major field crop producing states with data from 63 percent (potatoes) to 88 percent (corn) of all U.S. acreage for these field crops. Corn is the field crop with the most acres planted (70 million) and the most nitrogen (9 billion pounds), phosphate (3 billion pounds) and potash (4 billion pounds) fertilizers consumed. Ninety-nine percent of the tobacco crop (0.4 million acres) and greater than ninety percent of the potato crop (0.8 million acres) is fertilized with N, P_2O_5 and K_2O fertilizers. Less than 30% of the soybean crop (50 million acres) receives application of these primary nutrients.

2.3.2 Fruits and Vegetables

In addition to field crops, the USDA, ERS, NASS collects information on fertilizer usage on fruit and vegetable crops (USDA, ERS, NASS, 1997b and USDA, ERS, NASS, 1996). Appendix B, Tables B-2 and B-3 present information on acres planted, total N, P, and K applied and the application rates per crop year for fruits (1995) and vegetables (1994) in selected states.

Table 2-5. Percent of Acres Receiving Various Nutrients and Application Rates, Selected Field Crops in Major Producing States[a]

	Percent of Acres Receiving Nutrients				Application Rates	
Year	Manure	Sulfur	Lime	Micro-nutrients	Sulfur (lbs/acre)	Lime (tons/acre)
Corn for Grain (10 States, 55,850,000 acres)[b]						
1994	16	10	5	11	12	1.7
1995	14	NA[c]	NA	NA	NA[c]	NA
Cotton (6 States, 11, 650,000 acres)						
1994	3	20	4	20	13	1.1
1995	3	NA	NA	NA	NA	NA
Fall Potatoes (11 States, 1,147,000 acres)						
1994	2	58	6	59	82	0.9
1995	2	NA	NA	NA	NA	NA
Soybeans, Northern (7 States, 41,700,000 acres)						
1994	8	2	4	3	13	1.8
1995	5	NA	NA	NA	NA	NA
Soybeans, Southern (7 States, 10,140,000 acres)						
1994 (AR only)	2	1	4	2	NA	1.3
1995	2	NA	NA	NA	NA	NA
All Wheat (15 States, 52,965,000 acres)						
1994	3	10	1	2	11	1.7
1995	3	NA	NA	NA	NA	NA

a) Source: USDA, ERS Cropping Practices Survey Data. Application rates not available for manure and micronutrients. Information on secondary and micronutrients was not collected in the 1996 survey.
b) Acreage reported is for 1995, Source: USDA, AREI Report Number 2, May, 1996.
c) NA = Not Available.

It should be noted that the application rates presented in these tables are per crop year and may represent multiple applications at lower rates.

There is considerable information in the fruit and vegetable tables in Appendix B. These data are summarized in Tables 2-6 and 2-7. These tables show the acres planted, the total pounds of N, P_2O_5 and K_2O fertilizers applied and the application rates per crop year for vegetable and fruit crops. When more than one state was included in the USDA surveys for a specific crop, the total acreage and pounds of fertilizer applied are presented. Average and ranges of fertilizer application rates are shown for the producing states. In some cases only a single producing state was included in the survey, and the values shown in the table are for only that state.

Table 2-6. Fertilizer Use on Vegetable Crops for Crop Year 1994[a]

			Total Applied (1000 lbs/year)			Application Rate Per Crop Year (lbs/acre) Average and Range[b]		
Crop	State or Total[c]	Acres Planted	N	P_2O_5	K_2O	N	P_2O_5	K_2O
Asparagus	Total	80,650	7,226	1,191	3,504	100 64-136	57 44-101	110 50-145
Beans, Lima (fresh)	GA	6,500	654	364	565	101	56	87
Beans, Lima (processing)	Total[d]	33,500	1,704	959	834	68	61	71
Beans, Snap (fresh)	Total	71,300	5,471	4,954	6,498	85 39-101	88 47-104	115 46-132
Beans, Snap (processing)	Total	173,400	10,695	10,192	10,354	64 35-154	64 40-128	68 51-101
Broccoli	Total	110,900	21,772	9,087	4,345	206 92-247	109 88-159	62 8-131
Cabbage (fresh)	Total	69,900	11,658	6,910	9,724	167 117-258	106 86-149	163 18-272
Cabbage (processing)	Total	5,600	733	525	1,145	126 106-146	94 93-96	198 173-224
Carrots	Total	100,700	18,347	14,954	8,983	182 24-234	166 31-200	110 17-340
Cauliflower	Total	53,850	11,474	5,239	2,382	230 101-315	121 85-236	69 25-159
Celery	Total	35,900	9,119	7,037	9,055	240 134-317	195 126-228	292 207-417
Corn, Sweet (fresh)	Total	163,900	22,557	11,899	20,528	125 95-274	81 40-129	137 66-216
Corn, Sweet (processing)	Total	503,400	69,084	28,476	35,912	135 86-227	63 47-134	85 77-98
Cucumbers (fresh)	Total	51,400	6,025	3,950	5,985	115 81-139	89 47-137	115 28-156
Cucumbers (processing)	Total	82,600	7,866	4,809	7,472	94 61-155	60 40-147	100 55-123
Eggplant	Total	3,500	442	346	456	133 121-153	130 124-137	140 120-168
Lettuce, Head	Total	191,000	45,953	27,196	5,898	262 93-357	190 84-252	77 73-124
Lettuce, Other	Total	60,120	9,459	5,706	2,325	194 75-335	134 34-237	71 71-75
Cantaloupe	Total	97,700	9,781	5,870	2,341	104 80-170	93 79-103	41 9-124

Table 2-6. (Continued)

			Total Applied (1000 lbs/year)			Application Rate Per Crop Year (lbs/acre) Average and Range[b]		
Honeydew Melon	Total	25,700	2,184	2,101	444	83 59-206	96 68-192	58 41-119
Watermelon	Total	166,000	19,347	13,676	15,806	120 61-414	94 51-163	119 46-182
Onions, Dry	Total	127,800	24,798	16,721	11,479	186 107-269	137 73-217	139 16-266
Peas, Green (processing)	Total	280,800	6,920	10,225	13,555	30 24-42	55 40-108	73 40-110
Peppers, Bell	Total	61,000	14,440	9,098	13,961	239 95-320	189 69-405	263 50-393
Spinach (fresh)	Total	10,700	1,344	801	558	149 116-159	97 90-114	79 24-126
Spinach (processing)	TX	8,600	882	834	127	103	97	30
Strawberries	Total	45,800	6,548	3,891	95	153 43-199	95 49-144	116 30-156
Tomatoes (fresh)	Total	103,900	24,584	14,632	31,030	264 83-311	174 64-201	408 65-534
Tomatoes (processing)	Total	322,600	51,561	30,905	7,941	163 91-164	103 103-110	49 40-289

a) Source: USDA, NASS, ERS, 1997, See Appendix B for detailed tables of fertilizer use for vegetable-producing states. Note that no fertilizer data were collected in 1996. The fertilizer data are from the 1994 crop year.

b) Average application rates and ranges are provided if more than one producing state was included in the survey.

c) If more than one state was included in the survey, vegetable totals for all states are presented. If only one state producing the vegetable was included in the survey the state is shown in this column.

d) Data not provided for individual states.

Table 2-7. Fertilizer Use on Fruit Crops for Crop Year 1995[a]

			Total Applied (1000 lbs/year)			Application Rate Per Crop Year (lbs/acre) Average and Range[b]		
Crop	State or Total[c]	Acres Planted	N	P_2O_5	K_2O	N	P_2O_5	K_2O
Oranges	Total	753,800	122,017	15,576	101,430	164 119-179	43 42-46	177 61-182
Grapefruit	Total	145,700	18,123	5,822	18,502	128 102-132	56 54-81	146 55-147
Lemons	CA	45,700	5,492	202	314	128	41	26
Limes	FL	1,900	262	71	281	149	61	160
Tangelos	FL	12,400	2,095	551	2,106	170	65	172
Tangerines	Total	28,600	4,492	584	3,951	159 88-191	34 33-38	185 44-197
Temples	FL	6,800	1,067	132	1,110	157	40	172
Apples	Total	340,300	16,329	4,314	8,146	62 35-75	34 28-60	54 24-75
Apricots	CA	19,800	1,213	604	574	92	101	96
Avocados	Total	73,000	8,707	2,125	2,731	124 120-171	71 68-71	74 55-185
Blueberries	Total	29,750	2,004	790	1,314	72 54-138	42 29-69	55 43-66
Blackberries	OR	4,900	409	361	353	86	78	76
Raspberries	Total	11,100	941	1,141	1,111	87 82-91	106 89-121	103 80-123
Cherries, Sweet	Total	45,000	3,116	531	990	82 73-97	35 31-42	61 34-85
Cherries, Tart	Total	37,100	2,362	343	1,368	74 26-84	40 17-55	74 23-90
Dates	CA	5,500	409	113	NA[d]	99	92	NA
Figs	CA	15,000	783	137	225	81	46	55
Grapes	Total	740,600	41,684	11,570	32,165	67 27-117	55 32-89	107 43-151
Kiwifruit	CA	6,600	427	41	128	77	57	102
Nectarines	CA	32,400	3,398	892	1,550	114	54	92
Olives	CA	33,700	1,884	83	124	72	44	51
Peaches	Total	131,800	9,797	2,013	5,969	84 29-109	38 27-50	76 31-124

a) Source: USDA, NASS, ERS, 1996, See Appendix B for detailed tables of fertilizer use for fruit-producing states.

b) Average application rates and ranges are provided if more than one producing state was included in the survey

c) If more than one state was included in the survey, fruit totals for all states are presented. If only one state producing the fruit was included in the survey the state is shown in this column.

d) NA = insufficient reports to publish data for usage

Fruit and vegetable crops with the highest average application rates (lbs/acre) per crop year are fresh tomatoes (N: 264 lbs/acre and K_2O: 408 lbs/acre) and celery (P_2O_5: 195 lbs/acre). Most acreage is planted with processing sweet corn, tomatoes and green peas. State-specific data are presented in Appendix B. Crops with the highest application rates for nitrogen fertilizers are watermelon, head lettuce and other lettuce in Arizona. Crops with the highest application rates for phosphate fertilizers are processing cucumbers in North Carolina, bell peppers in California and head lettuce in Arizona. Crops with the highest application rate of potash fertilizers are fresh tomatoes, celery and bell peppers in Florida.

2.4. NON-AGRICULTURAL FERTILIZER USE

In addition to the fertilizer consumption by state and fertilizer type, the AAPFCO database (AAPFCO, 1997a) contains estimates of the farm and non-farm consumption data. Table 2-8 summarizes these data for the states, and Appendix C contains the farm and non-farm consumption (tons) for each of the individual fertilizer types. Several states have no recorded non-farm consumption, therefore no non-farm percentages were reported (i.e. the farm use was coded as 1 and non-farm use was coded as 2, and there were no 2s). Farm and non-farm use data were not reported for the states of Arkansas, Iowa, Kentucky, Ohio and Texas (i.e., the field for the variable "use" was blank). Non-farm uses include application around residences, golf courses, other recreational fields, cemeteries and public property.

Over 2,650,000 tons of fertilizer was used on non-agricultural land according to those states reporting data to the AAPFCO. This represents approximately 6% of the total fertilizer use defined as farm and non-farm. The states with the highest non-farm consumption of fertilizers are Florida (393,012 tons) and California (320,367 tons). The states with greater than 30% non-farm fertilizer use are New Jersey (124,661 tons), Nevada (12,408 tons) and Vermont (11,904 tons).

The types of fertilizers used on farm and non-farm land differ. Table 2-9 shows the farm and non-farm consumption of various fertilizer types for the states with the highest consumption in terms of non-farm percent or total tons, as described in the previous paragraph. Detailed information for all states is provided in Appendix C. Multiple nutrient, and organic fertilizers are used in higher percentages on non-farm land than other fertilizers, particularly the single nutrient N, P_2O_5 and K_2O fertilizers.

2.5 U.S. FERTILIZER INDUSTRY PROFILE

Information in this section has been abstracted from an EPA report (The U.S. Fertilizer Industry: A Profile, U.S. EPA, Economics, Exposure and Technology Division, OPPT, November, 1997). Details of the production process, industry definition, domestic production, imports and exports, firms in the fertilizer industry and market structure may be found in that report.

Nitrogen fertilizers are derived from synthetic ammonia that is produced from natural gas. Approximately one-third of nitrogen fertilizer is applied as anhydrous ammonia (soil injection).

Table 2-8. Comparison of Fertilizer Consumption by Farm and Non-Farm Use in 1996[a]

State	Farm (tons)	Non-farm (tons)	% Non-farm
NJ	206,895	124,661	37.60
VT	24,252	11,904	32.92
NV	28,130	12,408	30.61
MD	330,382	109,242	24.85
FL	1,730,243	393,012	18.51
WV	39,117	8,885	18.51
NY	342,631	73,735	17.71
UT	97,331	19,868	16.95
VA	745,966	129,208	14.76
PA	487,229	82,103	14.42
WA	1,061,442	143,746	11.93
MI	1,140,332	124,526	9.85
ME	140,869	13,526	8.76
SC	605,744	43,284	6.67
TN	837,492	54,736	6.13
CA	5,209,585	320,367	5.79
MS	827,853	47,792	5.46
DE	121,175	5,271	4.17
OK	774,463	29,165	3.63
LA	857,526	27,563	3.11
WI	1,217,874	38,609	3.07
IN	1,935,735	57,049	2.86
AZ	352,987	10,342	2.85
MO	1,658,295	43,428	2.55
IL	3,886,719	77,319	1.95
WY	252,150	3,942	1.54
NC[b]	1,816,998	28,386	1.54
OR	791,874	9,995	1.25
NM	154,604	1,024	0.66
CO	362,185	2,106	0.58
MA	104,137	538	0.51
PR	73,115	144	0.20
NH	25,286	25	0.10
NB	2,272,742	428	0.02
AL	649,449	71	0.01
KS	1,674,326	11	0.00
MN	2,138,683	NA[c]	NA
ND	1,109,024	NA	NA
SD	536,982	NA	NA
RI	17,718	NA	NA
GA	1,741,097	NA	NA

Table 2-8. (Continued)

State	Farm (tons)	Non-farm (tons)	% Non-farm
ID	881,219	NA	NA
MT	551,412	NA	NA
AK	8,447	NA	NA
HI	118,269	NA	NA
CT	42,232	NA	NA
TOTAL[d]	39,982,216	2,048,419	NA

a) Source: AAPFCO Database, 1997
b) NC also had other use categories; these have been omitted from the table
c) Not available
d) Totals by use may not be accurate since some states did not report data by use

Table 2-9. Consumption (tons) of Specific Fertilizer Types on Farm and Non-Farm Land for Selected States[a]

Fertilizer Type	Use	FL	CA	NJ	VT	NV
Multiple Nutrient	farm	1,241,508	1,162,687	155,081	15,787	6,747
	non-farm	321,437	316,847	115,523	8,399	6,031
	% non-farm	20.6	21.4	42.7	34.7	47.2
N	farm	168,105	1,706,091	40,361	5,228	13,982
	non-farm	27,661	0	3,793	3,015	5,687
	% non-farm	14.1	0.0	8.6	36.6	28.9
P_2O_5	farm	28,455	223,074	3,367	1,976	5,238
	non-farm	13,647	0	1,345	11	1,135
	% non-farm	32.4	0.0	28.5	0.6	17.8
K_2O	farm	37,349	130,149	5,385	3,079	535
	non-farm	3,378	0	1,038	17	46
	% non-farm	8.3	0.0	16.2	0.5	7.9
Organic	farm	4,487	78,781	31	10	2
	non-farm	11,208	0	16,160	73	226
	% non-farm	71.4	0.0	99.8	88.0	99.1
Secondary and micronutrient	farm	74,735	1,593,276	5,570	54	6,423
	non-farm	16,573	3,520	2,811	413	488
	% non-farm	18.2	0.2	33.5	88.4	7.1
Liming	farm	195,305	621,915	99	0	0
	non-farm	21,054	0	286	29	0
	% non-farm	9.7	0.0	74.3	100.0	no uses

a) Source: AAPFCO database, see text for information on how states were selected. Appendix C contains data for all states

Approximately two-thirds of nitrogen fertilizers are ammonium salts and other nitrogen-containing chemicals (see Table 2-1). Phosphate fertilizers are made by treating phosphate rock with sulfuric acid to produce phosphoric acid. Approximately two-thirds of applied phosphorus is in the form of mono- and diammonium phosphate. Phosphate rock deposits are found primarily in Florida, North Carolina and Idaho, and the U.S. is a net exporter of phosphatic fertilizer. Potash (K_2O) is derived from marine deposits and brines. Most potash fertilizer (approximately 95%) is in the form of potassium chloride. Potassium sulfate and potassium nitrate are also used on certain crops. The U.S. imports most of its potash from Canada.

The U.S. Census of Manufactures classifies fertilizer industries in the following Standard Industrial Classification Codes (SIC):

2873 Nitrogenous fertilizer materials, this SIC includes
Establishments that only produce nitrogen fertilizer materials
Establishments that both manufacture nutrients and prepare fertilizer mixtures

2874 Phosphatic fertilizer materials, this SIC includes
Establishments that only produce phosphate fertilizer materials
Establishments that both manufacture nutrients and prepare fertilizer mixtures

2875 Fertilizer mixing only, this SIC includes
Establishments that only mix raw materials

In addition, producers of other fertilizer materials, such as potassium chloride, will be found in SIC 2819 - Industrial Inorganic Chemicals, not elsewhere classified. Because many fertilizer producers (particularly micronutrient fertilizer producers) are included with the production of inorganic chemicals for all purposes, it is difficult to specifically define industries producing fertilizers. The real value of shipments in 1995 (in 1992 dollars) for SICs 2873, 2874 and 2874 are $3,435.3 million, $3,882.9 million and $2,336.8 million, respectively. Total employment for these three SICs were 7,300, 8,600, and 8,400 in 1995.

The total number of companies in the three fertilizer SICs are shown in Table 2-10. There are 10 companies in SIC 2873 with sales over $1 billion and 28 companies with sales <$10 million. Two companies in SIC 2874 have sales over $1 billion and 12 companies have sales <$10 million. Only one company in SIC 2875 has sales over $1 billion, but 78 companies have sales <$10 million. Therefore, there are few large firms in these SICs. These companies are also small in terms of number of employees. Figures are provided in the EPA report. The report indicates that there are 77 of 114 companies in SIC 2873 employing fewer than 1000 persons. There are 36 companies in SIC 2874 and 148 companies in SIC 2875 considered small businesses based on the standards of the Small Business Administration (those employing fewer than 500 persons).

Manufacturers, formulators, distributors/dealers and brokers of the micronutrients boron, copper, iron, manganese, molybdenum and zinc generally deal with one or more of these chemicals. The EPA report (Table 3-2) lists 74 companies that fit the category of micronutrient manufacturers, formulator etc.

Table 2-10. Number of Companies in Fertilizer Production and Mixing

Industry	Number of Companies Reported by the Census of Manufactures 1992	Number of Companies Reported by Information Access Company 1997
SIC 2873 - Nitrogenous Fertilizers	103	114
SIC 2874 - Phosphatic Fertilizers	54	50
SIC 2875 - Fertilizers, Mixing only	313	165

Cement kiln dust may be used as a liming material because of the high calcium oxide content. The U.S. EPA report to Congress for Cement Kiln Dust, Volume II: Methods and Findings, December, 1993 reports that 122,000 tons of cement kiln dust are used as a soil amendment, and 57,849 tons are used as liming materials.

Most nitrogenous fertilizer is produced in the south central U.S., and most phosphorus fertilizer is produced from phosphate rock deposits in the southeastern U.S. As described previously, most potash comes from Canada. Plants that mix fertilizer are dispersed throughout the country. Most of these plants are small, serving local (within approximately 30 miles of the plant) and regional markets. These plants bulk blend products custom made for the local markets based on crops and soil conditions. Micronutrients, pesticides and even seeds are sometimes added to custom blends. Many of the firms have soil testing laboratories to assist the farmers in determining the optimum fertilizer blend.

In the last two decades, fertilizer production has increased fifty percent. Greater than 10 percent of the volume is exported. Most of the companies, particularly fertilizer mixing companies, are small.

2.6 RECYCLED MATERIALS IN FERTILIZER MANUFACTURE

A number of industrial wastes and by-product materials are used in the manufacture of inorganic fertilizers. Such recycling practices are most common in the manufacture of micronutrient fertilizers, particularly zinc fertilizers. The following recyclable materials can be used as feedstocks to make zinc micronutrient fertilizers:

- Electric arc furnace dust (dust collected from emission control devices in steel manufacturing), otherwise known as K061 (its RCRA waste code)
- Brass foundry dusts (also from emission control devices)
- Tire ash (typically, ash from burning of tires for energy recovery)
- Galvanizing fines

K061 is regulated as a listed hazardous waste under RCRA, and can contain significant amounts of non-nutritive metals such as lead and cadmium. Brass foundry dusts often exhibit a hazardous characteristic when tested according to the Toxicity Characteristic Leaching Procedure (TCLP), usually because of lead and cadmium. Tire ash is also typically a characteristic hazardous waste due to cadmium concentrations. Galvanizing wastes typically do not exhibit a hazardous waste characteristic. It should be noted that non-waste feedstocks that are also used to make zinc fertilizers, such as refined ores from lead mining, can often have concentrations of non-nutritive metals comparable to those in waste feedstock materials. As presented in Chapter 3 of this report, levels of metal contaminants in zinc fertilizer products vary substantially, and depend largely on how the raw materials are processed, rather than on which type of feedstock is used.

Another type of hazardous waste–demetallized photographic fluids–is used to make multinutrient fertilizer products (http://www.itronics.com)

Further discussion of how RCRA regulates recycling of hazardous wastes and hazardous secondary materials to manufacture fertilizers is presented in Chapter 4 of this report.

Examples of industrial secondary materials that are not currently regulated by RCRA as hazardous wastes and that can be recycled to manufacture fertilizers include:

- Cement kiln dust (CKD), which is used primarily as a lime substitute to adjust soil pH
- Mining waste; at least one iron fertilizer product is made from mine tailings (www.ironite.com)
- Gypsum (a source of calcium, sulfur and boron) from coal-burning electric power generation facilities
- Ash from wood-burning power generation facilities
- Pulp and paper sludges, which are generally used as soil amendments

3.0 COMPOSITION OF FERTILIZERS AND SOILS

Phosphate fertilizers are known to contain varying levels of heavy metals such as cadmium, lead, nickel and chromium (Mortvedt, 1987; Charter et al., 1993). These metals originate in the phosphate rock (Mortvedt and Giordano, 1977; Kpomblekou-A and Tabatabai, 1994); much of the cadmium, and other metals, remains with the phosphate during processing (Wakefield, 1980). Phosphate fertilizers, though, are by no means the only fertilizer product with measurable levels of heavy metals. Studies have documented the presence of heavy metals in zinc micronutrient fertilizers (Mortvedt, 1985), in biosolids (Matthews, 1996) applied to agricultural lands, and organic fertilizers such as manure and compost (Raven and Loeppert, 1997; Arora et al., 1975). Because these heavy metals may enter the human food chain either directly (via uptake into the grain, fruit or vegetable) or indirectly (via ingestion by foraging animals), studies have been conducted recently to compare the soil background levels of these metals with levels in fertilizer materials (Mermut et al., 1996) and to assess plant uptake and distribution of these metals (Mortvedt, et al., 1981; Mortvedt and Giordano, 1977; Chaney, 1983; Gavi et al, 1997).

This section addresses the following questions:

- What are the concentrations of heavy metals in U.S. soil and soil in other parts of the world?
- What is the macronutrient composition of different fertilizers?
- What are the heavy metal concentrations in fertilizers and liming materials?
- What other potentially hazardous constituents may be present in fertilizers and liming materials?

3.1 HEAVY METALS IN SOILS

Because heavy metals are naturally present in soil, it is instructive to begin the assessment of fertilizer metals addition to soil with an evaluation of the background levels of these metals in soil. Over the last twenty years, a number of studies have been carried out to assess the levels of metals in soils. Because those studies were carried out for scientific reasons other than assessment of effects of heavy metals addition from fertilizers, the site selection criteria for samples and statistical treatment of the data are not generally comparable across studies. However, these studies, *in toto*, may provide some insight into potentially "typical" values for metals in soils.

Table 3-1 provides an overview of sixteen different studies of metals in soils in which samples were collected from reasonably large (several hundred square miles) geographic areas so that minor site-to-site variations may be negligible. As listed in Table 3-1, the studies in which the number of samples substantially exceeds the number of sites indicates that one or more subsurface soil samples (indicated as "sub") were collected in addition to the surface soil sample (indicated as "surf"). The abbreviated results of several studies (No. 3 and 16) were listed in another study (Holmgren et al., 1993) for comparison purposes, and for those, complete site/sampling descriptions are not available. The notation "nd" indicates that information such as the number of sites has not been determined. Sampling locations included agricultural lands

Table 3-1. Compilation of Studies for Soil Metal Concentrations

Site Descriptions for Soil Metal Concentration Studies					
Region	First Author (Year)	Samples	Sites	Soil type	Depth
1. USA	Holmgren (1993)	3045	3045	ag/no ss[a]	surface[b]
2. USA	Shacklette (1984)	1318	1318	natural[c]	sub-20cm[d]
3. USA	Sposito (1984)[e]	nd[f]	nd	nd	nd
4. Minnesota	Pierce (1982)	159	53	natural	surf/sub[g]
5. Florida	Ma (1997)	94	40	natural	surf/sub
6. Ohio	Logan (1983)	239	239	ag/no ss	surface
7. Ontario	Frank (1976)	296	296	ag	surface
8. Saskatchewan	Mermut (1996)	26	13	ag	surf/sub
9. Canada	McKeague (1980)	173	53	natural	surf/sub
10. England	McGrath (1986)	2276	2776	no sources[h]	surface
11. Wales	Davies (1985)	1308	654	all	surf/sub
12. Eastern Europe[h]	Kabata-Pendias (1992)[i]	nd[i]	nd[i]	natural	surface
13. Netherlands	Edelman (1986)	28	28	natural	surface
14 India	Kuhad (1989)	36	9	ag	surf/sub
15 China	Chen (1991)	12,400	4095	no sources[h]	surf/sub
16 World	Ure (1982)[e]	nd	nd	nd	nd

a) Agricultural land with no sewage sludge application.
b) In this study, primary collection was for surface soils; subsurface soil concentrations were also reported when surface soil Cd was ≥ 1.0 ppm.
c) Background soil –no agriculture, industry, or residential contributions.
d) Subsurface soil samples collected at a depth of 20 cm.
e) Study results reviewed in Holmgren, et al. (1993)
f) Not determined from available reference.
g) Surface and subsurface soil samples collected.
h) All lands except those directly impacted by an anthropogenic source.
i) Compilation of data from 47 different studies.

(ag) and agricultural lands to which sewage sludge had not been applied (ag/no ss). True background soil samples (natural) were collected in pristine, undisturbed environments. The English and Chinese study stated that soils were collected in all regions except those directly impacted by an adjacent industrial source (McGrath et al., 1986; Chen et al., 1991).

The generation of geometric means for soil metals concentrations is the preferable statistical treatment of comprehensive studies because of the logarithmic distribution of metal concentrations commonly observed in soils. For those studies where both geometric and arithmetic means were available, both statistics are included in Table 3-2 of average concentrations for cadmium (Cd), lead (Pb), arsenic (As), chromium (Cr), mercury (Hg), nickel (Ni), vanadium (V), copper (Cu) and zinc (Zn). As indicated by "nd" (not determined), various studies did not include measurement of all metals.

In general, for Studies 1 and 2 in the USA (Holmgren et al., 1993; Shacklette and Boerngen,1984), metals concentrations for the agricultural lands without sewage sludge addition (Study 1) are comparable to those from the natural lands (Study 2). These values for the USA agricultural lands contrast somewhat with both the Ontario and Saskatchewan agricultural land studies (Studies 7 and 8) (Frank et al., 1976; Mermut et al., 1996)) where soil cadmium, and possibly lead and zinc, were elevated relative to U.S. background levels, possibly due to anthropogenic additions (e.g., fertilizer, urban atmospheric deposition). While anthropogenic input to soil metals levels is suggested by the authors for comparisons of the surface and subsurface soil samples in the Saskachewan study, the climatology of the region (limited rainfall relative to southern USA regions) and the mineralogy of the area may also help to explain differences in soil metal content between the U.S. and Canadian plains. In support of anthropogenic input, cadmium, lead and zinc in low clay content soils (clay soils having higher metals levels naturally) show that these metals are at statistically higher levels in surface soil relative to subsurface soil. Fertilizer addition to these Canadian soils has occurred for 30-40 years.

The ranges of metal concentrations for the surface soils are listed in Table 3-3 for reference only. As anticipated, both extremely high and low values were found in most studies, and in that regard, the range of concentrations in US "background" soils often exceeds that found in the Canadian studies. In the U.S., metals are generally found at higher levels in the West relative to the East and in the North relative to the South. Of note in the study conducted in Poland and western USSR, ranges of soil metals concentrations were given for both background soils and then also for soils from industrial regions, urban gardens, vineyards and fertilized agricultural regions. On the basis of these results, the governments have outlined broad land regions based on soil metals concentrations and then made recommendations on the types of agricultural practices appropriate for these lands.

3.2 NITROGEN, PHOSPHATE AND POTASH COMPOSITION OF NPK FERTILIZERS

Due to the diversity of NPK fertilizers, several authors have segregated and analyzed these fertilizers by class. Specific types or classes of NPK that have been analyzed include MAP (monoammonium phosphate), DAP (diammonium phosphate), TSP (triple super phosphate), MP

Table 3-2. Average Concentrations of Selected Metals in Soils around the World

Mean Surface Soil Concentrations of Metals in Surface Soils, ppm (ug/g or mg/kg)										
Region	Avg.	Cd	Pb	As	Cr	Hg	Ni	V	Cu	Zn
1. USA	geometric	0.18	11	nd[a]	nd	nd	17	nd	18	43
	arithmetic	0.27	12	nd	nd	nd	24	nd	30	57
	median	0.20	11	nd	nd	nd	18	nd	19	53
2. USA	geometric	nd	16	5.2	37	0.058	13	58	17	48
	arithmetic	nd	19	7.2	54	0.09	19	80	25	60
3. USA	"typical"[a]	0.35	50	nd	nd	nd	30	nd	50	15
4. Minnesota	arithmetic	0.39	nd	nd	39	nd	18	nd	23	60
5. Florida[b]	geometric	0.21	4.1	1.1	3.9	0.0042	6.5	nd	3.7	12
	arithmetic	0.22	5.4	2.4	5.1	0.0067	6.7	nd	4.7	12
6. Ohio	arithmetic	0.2	19	nd	12	nd	18	nd	19	75
7. Ontario	"mean"[a]	0.56	46	12	22	0.11	16	nd	25	54
8. Saskatchewan	arithmetic	0.58	16	6.6	59	nd	30	90	37	87
9. Canada[b]	arithmetic	≤0.3	20	nd	43	0.059	20	nd	22	74
10. England	geometric	0.9	48	nd	nd	nd	21	nd	18	85
11. Wales	geometric	0.5	73	nd	nd	nd	16	nd	16	79
12. Eastern Europe	nl[c]	0.4	26	nd	nd	nd	nd	nd	16	45
Poland	nl	0.4	18	nd	23	nd	10	nd	8	49
13. Netherlands	range[d]	nd	nd	nd	nd	nd	nd	nd	nd	nd
14. India	"mean"	0.8	15	nd	nd	nd	30	nd	57	26
15. China	geometric	0.07	24	9.2	54	0.040	23	77	20	67
	arithmetic	0.10	27	11	61	0.065	27	82	23	74
16. World	geometric	0.62	34	nd	nd	nd	26	nd	60	29

a) Author designation for type of data presented.
b) Data given as average of surface and subsurface concentrations.
c) Not listed.
d) Data given only as ranges, see Table 3-3.

Table 3-3. Concentration Ranges for Selected Metals in Soils around the World

	Range of Surface Soil Concentrations of Metals Measured, ppm (ug/g or mg/kg)								
Region	Cd	Pb	As	Cr	Hg	Ni	V	Cu	Zn
1. USA	<0.01-2.0	<1-135	nd[a]	nd	nd	0.7-269	nd	<0.6-495	<3-264
2. USA	nd	<10-700	<0.1-97	1-2000	<0.01-4.6	<5-700	<7-500	<1-700	<5-2900
3. USA	nl[b]	nl	nl	nl	nl	nl	nl	nl	nl
4. Minnesota[c]	0.06-0.74	nd	nd	14-111	nd	7-66	nd	16-50	28-97
5. Florida	0.07-0.39	0.42-24	0.01-6.1	0.43-23	0.0005-0.043	4.5-9.6	nd	0.01-16	6.7-18
6. Ohio	0.03-2.9	9-39	nd	4-23	nd	9-38	nd	11-37	47-138
7. Ontario	0.10-8.1	1.5-888	1.1-92	10-46	0.01-1.14	1.3-119	nd	2.1-144	4.6-162
8. Saskatchewan	0.2-0.8	9-20	2.9-12	22-97	nd	13-59	32-180	19-68	41-137
9. Canada[c]	≤0.3	5-50	nd	10-100	0.005-0.1	5-50	nd	5-50	10-200
10. England	0.1-114	3-16,400	nl	0.6-615	nl	0.7-240	nl	0.5-520	5-2125
11. Wales[d]	0.1-1.5	13-211	nl	nl	nl	4-38	nl	5-36	22-159
12. Eastern Europe	0.08-2.7	5-85	nd	12-1085	nd	1-104	nd	1-110	4-360
industrial[e]	2-270	72-3044	nd	nd	nd	nd	nd	24-2015	400-5567
urban garden[f]	0.4-5	17-165	nd	nd	nd	nd	nd	12-240	nd
vineyard[g]	nd	nd	nd	nd	nd	nd	nd	50-83	nd
ag/fert[h]	0.4-107	nd	nd	nd	nd	nd	nd	80-1600	nd
12. Poland	0.1-6.4	5-286	nd	4-68	nd	1-68	nd	1-31	3-762

Table 3-3. (Continued)

Range of Surface Soil Concentrations of Metals Measured, ppm (ug/g or mg/kg)									
Region	Cd	Pb	As	Cr	Hg	Ni	V	Cu	Zn
13. Netherlands	nd	nd	1.4-21	11-117	nd	nd	4-126	nd	6-153
14. India	0.5-1.3	10-23	nd	nd	nd	20-45	nd	25-170	15-96
Austria[i]	nd	nd	nd	1.4-38	nd	nd	nd	nd	7-220
Belgium[i]	nd	nd	0.4-25	20-200	nd	nd	25-300	nd	25-150
Sweden[i]	nd	nd	nd	0.9-57	nd	nd	nd	nd	4-310
15. China	nl	nl	nl	nl	nl	nl	nl	nl	nl
16. World	nl	nl	nl	nl	nl	nl	nl	nl	nl

a) Metal not determined in the study
b) Not listed – concentration ranges not given.
c) Range given for surface and subsurface soils together
d) 10th to 95th percentile concentrations reported
e) Concentrations in industrial soils of Eastern Europe
f) Concentrations in urban gardens of Eastern Europe
g) Concentrations in vineyards of Eastern Europe
h) Concentrations in fertilized agricultural lands of Eastern Europe
i) Limited comparison data provided in Kuhad et al., 1989

(potash or potassium), single nutrient fertilizers and multiple nutrient fertilizers. A complete listing of the various types of NPK fertilizers and their macronutient content (i.e., N, P_2O_5, and K_2O) is given in Table 3-4 for reference.

3.3 HEAVY METALS IN FERTILIZERS AND LIMING MATERIALS

Macro- and micronutrient fertilizers and liming materials may contribute heavy metals to surface agricultural lands. Some of the raw materials that provide this input include rock phosphates (for NPK and NPKS fertilizers), high zinc-content recycled industrial waste (for zinc micronutrient fertilizers) and municipal sewage sludge (for organic fertilizers). In general, on a mass concentration basis (mg/kg), the NPK fertilizers are by comparison with the zinc micronutrient fertilizers, lower in metals content.

Concentrations of nine selected metals (cadmium, lead, arsenic, chromium, mercury, nickel, vanadium, copper and zinc) in world-wide rock phosphates are listed in Table 3-5. Sources of rock phosphates in the USA include North Carolina (NC), Florida (FL) and Idaho (ID). Specific analyses of rock phosphates from the U.S. are listed at the end of Table 3-5. No analytical results were specifically attributed to analyses of Idaho rock phosphates.

Table 3-6 shows the results for analyses of diverse NPK fertilizers. It is especially instructive to separate the analyses of MAP, DAP and TSP as the concentrations of metals (with possible exception of Ni) appear to increase with this sequence of products. (Again, "nd" in these tables indicates that the analyte was not determined. If analyzed and not detected, the analyte is listed as being less than the method detection limit if available.) Cadmium levels less than 10-50 ppm appear consistently throughout these analyses; however, some fertilizer samples, such as those commercially-available in California, have concentrations greater than 150 ppm. Tests of rock phosphates for heavy metal content have indicated that the quality of the ores has been declining over the last two decades (Charter et al., 1993). The heavy metals content of ore may increase with depth of the mine, so that some older mines may produce materials with increasing cadmium levels.

For comparison, the concentrations of metals in various types of organic fertilizers are listed in Table 3-7. The organic fertilizers include composts, bone meal, manures and municipal sewage sludge (sew sl). The levels of Cd, Pb, Ni, V and Cu in these fertilizers are roughly equivalent to levels found in NPK fertilizers; however, Zn levels are often higher. Variability beyond that indicated here is anticipated in the sewage sludges because of the varying nature of the incoming waste streams.

The concentrations of metals in various secondary nutrient and micronutrient fertilizers, primarily Zn fertilizers, are listed in Table 3-8. As indicated earlier, on a mass concentration basis, these fertilizers have higher Cd, Pb, Ni and Cu levels than those found in NPK fertilizers.

Table 3-4. Average Nitrogen, Phosphorus (as P_2O_5) and Potassium (as K_2O) Composition of NPK Fertilizers for 1996 (Percent)[a]

Description	N	P_2O_5	K_2O
MULTIPLE NUTRIENT FERTILIZERS			
N-P-K	14.5	11.5	13.9
N-P	16.0	27.4	0.0
N-K	17.1	0.0	19.3
P-K	0.0	16.0	29.9
NITROGEN FERTILIZERS			
Ammonium Nitrate	33.6	0.0	0.0
Ammonium Nitrate Solution	20.2	0.0	0.0
Ammonium Nitrate-limestone Mixtures	22.0	0.0	0.0
Ammonium Nitrate-sulfate	29.9	0.0	0.0
Ammonium Polysulfide	20.0	0.0	0.0
Ammonium Sulfate	20.9	0.0	0.0
Ammonium Sulfate Solution	6.3	0.0	0.0
Ammonium Sulfate-nitrate	26.0	0.0	0.0
Ammonium Sulfate-urea	33.3	0.0	0.0
Ammonium Thiosulfate	12.0	0.0	0.0
Anhydrous Ammonia	82.0	0.0	0.0
Aqua Ammonia	18.9	0.0	0.0
Calcium Ammonium Nitrate	17.0	0.0	0.0
Calcium Cyanamide	21.0	0.0	0.0
Calcium Nitrate	15.5	0.0	0.0
Calcium Nitrate-urea	33.4	0.0	0.0
Ferrous Ammonium Sulfate	7.1	0.0	0.0
Magnesium Nitrate	7.0	0.0	0.0
Nitric Acid	15.0	0.0	0.0
Nitrogen Solution 28%	28.1	0.0	0.0
Nitrogen Solution 30%	30.0	0.0	0.0

Table 3-4. (Continued)

Description	N	P_2O_5	K_2O
NITROGEN FERTILIZERS			
Nitrogen Solution 32%	32.0	0.0	0.0
Nitrogen Solution <28%	16.5	0.0	0.0
Nitrogen Solution >32%	36.2	0.0	0.0
Sodium Nitrate	16.2	0.0	0.0
Sulfur Coated Urea	36.1	0.0	0.0
Urea	45.9	0.0	0.0
Urea Solution	20.1	0.0	0.0
Urea-formaldehyde	36.2	0.0	0.0
Zinc Ammonium Sulfate Solution	11.1	0.0	0.0
Zinc Manganese Ammonium Sulfate	9.0	0.0	0.0
PHOSPHATE FERTILIZERS			
Ammonium Metaphosphate	12.0	51.0	0.0
Ammonium Phosphate	11.2	46.9	0.0
Ammonium Phosphate Nitrate	27.0	14.3	0.0
Ammonium Phosphate Sulfate	16.0	20.0	0.0
Ammonium Polyphosphate	15.0	60.0	0.0
Basic Lime Phosphate	0.0	6.0	0.0
Basic Slag	0.0	9.2	0.0
Bone Meal, Raw	4.0	16.4	0.0
Bone Meal, Steamed	1.8	16.4	0.0
Bone, Precipitated	0.0	36.6	0.0
Calcium Metaphosphate	0.0	60.0	0.0
Colloidal Phosphate (Soft Phosphate)	0.0	2.0	0.0
Diammonium Phosphate	18.0	46.0	0.0
Limestone, Phosphatic	0.0	13.1	0.0

Table 3-4. (Continued)

Description	N	P_2O_5	K_2O
PHOSPHATE FERTILIZERS			
Liquid Ammonium Polyphosphate	10.1	33.8	0.0
Magnesium Phosphate	0.0	17.8	0.0
Monoammonium Phosphate	10.9	51.8	0.0
Nitric Phosphate	14.0	10.0	0.0
Phosphate Rock	0.0	3.0	0.0
Phosphoric Acid	0.0	53.3	0.0
Precipitated Phosphate	0.0	34.4	0.0
Superphosphate, Enriched	0.0	27.0	0.0
Superphosphate, Normal	0.0	20.7	0.0
Superphosphate, Triple	0.0	45.7	0.0
Superphosphoric Acid	0.0	70.1	0.0
POTASH FERTILIZERS			
Lime-potash Mixtures	0.0	0.0	9.8
Manure Salts	0.0	0.0	21.5
Muriate of Potash 60% (Pot. Chloride)	0.0	0.0	60.1
Muriate of Potash 62%	0.0	0.0	62.1
Potash Suspensions	0.0	0.0	20.0
Potassium Carbonate	0.0	0.0	61.3
Potassium Nitrate	13.6	0.0	43.3
Potassium Sulfate	0.0	0.0	51.3
Potassium-magnesium Sulfate	0.0	0.0	22.6
Potassium-metaphosphate	0.0	55.0	37.0
Potassium-sodium Nitrate	14.5	0.0	14.2

Table 3-4. (Continued)

Description	N	P_2O_5	K_2O
ORGANIC FERTILIZERS			
Blood, Dried	11.7	0.3	0.0
Castor Pomace	5.0	1.0	1.0
Cocoa Shell Meal	2.0	1.0	2.0
Compost	2.3	1.8	1.6
Cottonseed Meal	6.0	2.0	1.0
Fish Scrap	6.0	6.0	6.0
Guano	12.0	11.0	2.0
Manure	1.9	1.0	1.0
Peat	2.0	0.0	0.0
Sewage Sludge, Activated	6.0	2.0	1.2
Sewage Sludge, Digested	10.0	2.0	0.0
Sewage Sludge, Heat Dried	6.2	2.0	1.3
Sewage Sludge, Other	6.0	2.0	0.9
Soybean Meal	6.0	1.0	2.0
Tankage, Animal	8.0	5.0	6.0
Tankage, Process	8.6	0.2	0.0

a) Source: AAFPCO Database, 1997

Table 3-5. Concentrations of Selected Metals in Rock Phosphates

Concentrations of Metals in Rock Phosphates, ppm (ug/g or mg/kg)										
		Cd	Pb	As	Cr	Hg	Ni	V	Cu	Zn
1. Kpomblekou-A and Tabatabai (1994)[a]: Africa, Peru, USA (3)[b]										
n=12[c]	mean	19	18	nd[d]	78	nd	15	nd	15	204
	median	10	14	nd	46	nd	10	nd	8	124
	range	5-47	7-43	nd	18-331	nd	1-61	nd	6-41	54-576
2. Kongshaug et al. (1992): Africa, Middle East, Russia, USA (1)										
n=6	mean	18	11	8.5	97	0.04	27	116	nd	nd
	median	11	7	11	109	0.05	33	100	nd	nd
	range	0.1-60	3-35	1-15	1-225	0.01-0.06	2-37	3-300	nd	nd
3. Hamamo et al. (1995): USA(1) and others of unnamed origin										
n=4	mean	nd	nd	14	nd	nd	nd	41	nd	nd
	median	nd	nd	17	nd	nd	nd	30	nd	nd
	range	nd	nd	6.5-19	nd	nd	nd	17-92	nd	nd
4. Raven and Loeppert (1997): Africa and USA(1)										
n=2	Africa[e]	1.3	29	21	33	<0.4	50	69	nd	79
	USA[e]	49	4.6	17	140	<0.4	17	23	9.6	382
5. Washington Dept of Ecology (1997): unnamed origin										
n=1	conc	36	<20	<30	136	<0.005	18	29	11	385
6. Arora, et al., (1975): unnamed origin										
n=1	conc	nd	962	nd	184	nd	nd	nd	32	187
7. California Department of Food and Agriculture (1997): unnamed origin										
n=4	mean	33	7.6	7.4	nd	nd	125	nd	39	nl

Table 3-5. (Continued)

Concentrations of Metals in Rock Phosphates, ppm (ug/g or mg/kg)										
		Cd	Pb	As	Cr	Hg	Ni	V	Cu	Zn
	median	0.5	7.5	7.5	nd	nd	(n=1)	nd	35	nd
	range	0.0-130	2.5-13	1.4-13	nd	nd	–[f]	nd	5.5-80	nd
8. USA Rock Phosphates - Analyses for individual samples										
Study 1[g]	NC	42	9	16[h]	137	nd	12	nd	8	332
Study 1	North FL	10	9	7[h]	47	nd	6	nd	5	91
Study 1	FL	11	11	7[h]	45	nd	6	nd	6	108
Study 2	USA	11	12	12	109	0.05	37	82	nd	nd
Study 3	FL	nd	nd	6.5	nd	nd	nd	92	nd	nd

a) Reference for the study data
b) Site of origin of the rock phosphates analyzed/reported (number of identified USA samples)
c) Total number of samples analyzed/reported
d) nd = not determined
e) Too few samples to determine mean and range; sample results listed separately by site of origin of the rock phosphate
f) Nickel analyzed in only one sample; range not available
g) Data from study number indicated earlier in Table 3-5
h) Analyses for As reported separately in Charter et al., 1995

Table 3-6. Concentrations of Selected Metals in NPK Fertilizers

Concentrations of Metals in NPK Fertilizers, ppm (ug/g or mg/kg)										
		Cd	Pb	As	Cr	Hg	Ni	V	Cu	Zn
1. Charter, et al. (1993): commercially-available in Iowa										
MAP[a]	mean	7.1	9.1	nd[b]	57	nd	17	nd	<1.5	75
n=23	median	7.0	<9	nd	56	nd	17	nd	<1.5	73
	range	6.4-8.3	<9-12	nd	51-73	nd	15-20	nd	<1.5-1.6	60-91
DAP[c]	mean	10	9.8	nd	71	nd	19	nd	1.6	170
n=25	median	6.7	<9	nd	48	nd	14	nd	<1.5	86
	range	5.4-94	<9-12	nd	45-616	nd	13-127	nd	<1.5-3.2	71-2193
TSP[d]	mean	15	11	nd	133	nd	17	nd	3.5	159
n=24	median	8.1	12	nd	74	nd	16	nd	2.9	97
	range	6.8-47	<9-16	nd	63-548	nd	14-40	nd	1.6-13	75-696
MP[e]	mean	1.6	9.1	nd	nd	nd	2.9	nd	1.6	1.5
n=25	median	1.6	<9	nd	nd	nd	2.8	nd	<1.5	1.3
	range	1.3-1.9	<9-12	nd	nd	nd	<2.8-4.4	nd	<1.5-2.6	1.1-2.6
2. Washington, Dept of Ecology (1997): diverse formulations										
n=21	mean	14	2.7	<3.8	141	0.03	20	81	7.7	177
	median	0.15	1.0	<1.5	2.2	<0.003	0.5	0.5	0.5	17
	range	<0.1-145	<0.4-21	<0.6-<16	<0.1-896	<0.005-0.403	<0.2-195	<0.2-721	<0.1-81	<0.4-1480
3. Arora, et al. (1975): diverse formulations										
single[f]	mean	nd	200	nd	74	nd	nd	nd	11	96
n=7	median	nd	118	nd	8.5	nd	nd	nd	2.8	11
	range	nd	42-488	nd	3-393	nd	nd	nd	0.6-49	4-418
multi[g]	mean	nd	283	nd	80	nd	nd	nd	12	88
n=13	median	nd	285	nd	81	nd	nd	nd	13	89
	range	nd	150-443	nd	50-116	nd	nd	nd	5.4-18	38-164
4. Raven and Loeppert (1997): diverse formulations										

Table 3-6. Continued

Concentrations of Metals in NPK Fertilizers, ppm (ug/g or mg/kg)										
		Cd	Pb	As	Cr	Hg	Ni	V	Cu	Zn
n=14	mean	4.1	2.7	6.0	51	<0.4	9.7	80	5.4	80
	median	0.15	1.1	0.4	17	<0.4	0.6	4.9	1.4	9.5
	range	<0.2-36	<0.2-48	<0.4-16	<1-196	<0.4	<0.2-48	<0.2-237	<0.6-42	4.6-386
5. International Mineral Corporation (1997): diverse formulations										
P_2O_5[h]	conc	6.8	4.1	<0.1	81	<0.1	13	180	1.3	74
NPK[i]	mean	5.3	1.6	<0.1	70	<0.1	11	210	4.6	60
n=3	median	5.4	1.0	<0.1	71	<0.1	11	200	0.5	58
	range	5-6	0.9-3	<0.1	64-75	<0.1	10-12	180-250	0.4-1.3	57-65
K_2O[j]	mean	<0.1	0.30	<0.1	0.08	<0.1	0.51	1.0	0.3	0.9
n=10	median	<0.1	0.13	<0.1	<0.1	<0.1	0.10	1.0	0.3	0.8
	range	<0.1	<0.1-1.0	<0.1	<0.1-0.2	<0.1	<0.1-2.6	<0.1-1.8	<0.1-1.1	0.2-2.1
6. Mermut et al. (1996) Saskatchewan: diverse formulations										
n=11	mean	3.0	1.5	2.7	33	nd	23	44	2.8	37
	median	3.4	1.5	3.0	35	nd	13	46	3.0	41
	range	<0.1-6.3	0.04-3.5	<1-5.8	0.4-83	nd	0.5-81	<0.1-114	0.1-7.3	0.3-83
7. Hamamo et al. (1995): diverse formulations										
n=5	mean	nd	nd	10	nd	nd	nd	131	nd	nd
	median	nd	nd	7.5	nd	nd	nd	162	nd	nd
	range	nd	nd	6.5-13	nd	nd	nd	49-203	nd	nd
8. Mortvedt and Osborn (1982): phosphate fertilizers										
n=5	mean	124	15	nd	nd	nd	114	nd	40	1153
	median	131	15	nd	nd	nd	125	nd	35	1315
	range	48-188	13-18	nd	nd	nd	53-135	nd	5-98	540-1550
9. Mortvedt, Mays, Osborn (1981): diammonium phosphate fertilizers										
n=3	mean	76	6	nd	nd	nd	95	nd	9	850
	median	74	6	nd	nd	nd	120	nd	8	1260

Table 3-6. Continued

Concentrations of Metals in NPK Fertilizers, ppm (ug/g or mg/kg)										
		Cd	Pb	As	Cr	Hg	Ni	V	Cu	Zn
	range	2-153	4-8	nd	nd	nd	10-156	nd	1-18	1-1290
10. Mortvedt and Giordano; diammonium and liquid phosphate fertilizers										
DAP/ID RP[k]		50	4.4	nd	485	nd	64	1600	2.7	715
DAP/NC RP[l]		30	4.7	nd	195	nd	38	90	1.0	285
Liq/ID RP[m]		44	9.0	nd	344	nd	8.0	1150	1.1	673
Liq/NC RP[n]		17	5.2	nd	175	nd	35	52	1.4	500
11. California Department of Food and Agriculture (1997): diverse formulations										
N[o]	n=1	0.0	0.0	0.0	nd	nd	nd	nd	4.0	nd
P_2O_5	mean	89	8.9	11	nd	nd	41[p]	nd	107	nd
n=32	median	132	1.0	13	nd	nd	11	nd	52	nd
	range	0-163	0-200	0-21	nd	nd	9.8-132	nd	1-1170	nd
NPK	mean	37	532	13	134	0.85	34[q]	nd	nd	nd
n=41	median	19	4.0	8.0	n=1	n=1	26	nd	53	nd
	range	0-200	0-5425	0.15-155	134	0.85	19-58	nd	0-1400	nd

a) Analyses of 23 monoammonium phosphate samples
b) Not determined
c) Analyses of 25 diammonium phosphate samples
d) Analyses of 24 triple super phosphate samples
e) Analyses of 25 muriate of potash samples
f) Analyses of single nutrient fertilizers formulations (4 N fertilizers, 2 P_2O_5 fertilizers, 1 K_2O fertilizer)
g) Analyses of multi-nutrient (NPK and NPKS) formulations
h) Analyses of phosphate (P205) fertilizers
i) Analyses of multi-nutrient (NPK) fertilizers
j) Analyses of potash (K_2O) fertilizers
k) DAP produced from an Idaho rock phosphate
l) DAP produced from a North Carolina phosphate
m) Liquid fertilizer produced from an Idaho rock phosphate
n) Liquid fertilizer produced from a North Carolina rock phosphate
o) Analyses of nitrogen (N) fertilizers
p) n=4
q) n=3

Table 3-7. Concentrations of Selected Metals in Organic/Biosolids Fertilizers

		Concentrations of Metals in Organic Fertilizers, ppm (ug/g or mg/kg)								
		Cd	Pb	As	Cr	Hg	Ni	V	Cu	Zn
1. Raven and Loeppert (1997)										
organic[a]	mean	0.5	4.1	4.4	7.4	<0.4	6.9	12	13	178
n=4	median	0.5	4.0	5.2	(n=2)[b]	<0.4	8.7	15	(n=2)[b]	(n=2)[b]
	range	0.3-0.7	0.7-7.5	2.5-6.8	<0.9-14	<0.4	3.2-9.6	0.4-18	9.4-18	164-192
sew sl[c]	Austinite	3.3	87	9.4	106	1.5	37	35	300	563
	Milorganite	7.2	130	nd	2940	1.1	31	19	nd[d]	450
2. Arora, et al. (1975)										
organic[e]	mean	nd	125	nd	12	nd	nd	nd	6.7	75
n=4	median	nd	123	nd	12	nd	nd	nd	6.9	50
	range	nd	90-168	nd	10-14	nd	nd	nd	2.8-13	15-199
3. Metrogro Corp (1997)										
sew sl[c]	compost	6.0	64	3.8	52	2.8	32	nd	386	598
	cake	6.0	77	1.9	77	2.3	32	nd	508	697
4. California Department of Food and Agriculture (1997)										
n=14[f]	mean	2.8	31	2.1	42	4.0	38[g]	nd	113	nd
	median	1.0	19	1.7	(n=2)[b]	(n=2)[b]	40	nd	100	nd
	range	0.0-15	2.5-110	0.0-10	0.75-83	0.0-8.0	32-43	nd	4.5-330	nd

a) Includes corn leaves, manure and compost
b) Sample size (n=2) too small to calculate median_
c) Sewage sludge (n=2); sample concentrations listed separately
d) Not determined
e) Includes fresh and rotted manure
f) Includes humus, compost, sewage sludge, tankage, hoof and horn meal

Table 3-8. Concentrations of Selected Metals in Zinc, Secondary Nutrient and Micronutrient Fertilizers

Concentrations of Metals in Zinc, Secondary Nutrient and Micronutrient Fertilizers, ppm (ug/g or mg/kg)										
		Cd	Pb	As	Cr	Hg	Ni	V	Cu	Zn
1. Mortvedt (1985)										
Zn[a]	mean	777	12,650	nd[b]	nd	nd	1070	nd	nd	380,000
n=9	median	590	1,900	nd	nd	nd	92	nd	nd	351,000
	range	4-2165	50-52E3[c]	nd	nd	nd	10-8,950	nd	nd	(92-890) E3[d]
2. Amrani, et al. (1997)										
Zn	mean	114	4276	nd	nd	nd	nd	nd	nd	500,000
n=6	median	61	293	nd	nd	nd	nd	nd	nd	660,000
	range	43-435	90-23E3	nd	nd	nd	nd	nd	nd	(7-1,000) E3
K061[e]	conc	359	19,170	nd	nd	nd	nd	nd	nd	10,000
3. CoZinCo Co. (1997): various products from diverse manufacturers, analyzed by CoZinCo										
Zn	mean	nd	9,700	nd	nd	nd	nd	nd	nd	256,000
n=41	median	nd	10,050	nd	nd	nd	nd	nd	nd	245,000
	range	nd	10-29E3	nd	nd	nd	nd	nd	nd	(95-430) E3
4. Washington Department of Ecology (1997)										
Granular Zinc		275	11,300	<34	580	3.36	83	41	1680	178,000
Granular Zinc		52	1400	<35	68	nd	62	<1	672	203,000
Micronutrient Mix		<1.7	<11	<17	3.1	0.028	21	<1	19,400	60,300
Micronutrient Mix		55	3590	83	457	0.226	4	33	39,900	94,300
High Mag Gro[f]		<0.6	15	<6	2	0.023	10	0.9	13	66
Manganese Sulfate		<3	<100	<30	10	0.005	50	<3	21	61
Boronat[f]		<1.5	<11	1040	<2.6	0.17	<5	17	8	6

Table 3-8. (Continued)

Concentrations of Metals in Zinc, Secondary Nutrient and Micronutrient Fertilizers, ppm (ug/g or mg/kg)										
		Cd	Pb	As	Cr	Hg	Ni	V	Cu	Zn
5. California Department of Food and Agriculture (1997)										
Zn	mean	149	4054	30	105	nd	nd	nd	491	nd
n=24	median	23	18	0.5	n=1 [g]	nd	nd	nd	10	nd
	range	0-495	0-26,500	0-280	–[h]	nd	nd	nd	0-2,550	nd
S[i]	mean	0.43	2.5	5.8	nd	nd	nd	nd	29	nd
n=7	median	0.0	0.0	1.0	nd	nd	nd	nd	14	nd
	range	0-3.0	0-8.7	0.1-19	nd	nd	nd	nd	0-109	nd
Fe[j]	mean	71	3787	1544	nd	nd	nd	nd	1238	nd
n=9	median	21	2625	118	nd	nd	nd	nd	292	nd
	range	0-334	0-18,750	0.3-4950	nd	nd	nd	nd	5.7-3190	nd
Zn-Fe-Mn blends	average	248	15,400	48	nd	nd	nd	nd	2485	nd
n=2	range	95-400	13,400-17,400	24-71	nd	nd	nd	nd	1970-3000	nd

a) Zinc micronutrient fertilizer; 18% Zn fertilizer = 180,000 ppm Zn; 36% Zn fertilizer = 360,000 ppm Zn
b) Not determined
c) E3 denotes multiplication by 1000, and applies to second number only; 50-52E3 = 50 - 52,000
d) E3 denotes multiplication by 1000, and applies to both numbers; (92-890)E3 = 92,000 - 890,000
e) Electric arc furnace dust
f) Product name
g) One sample analyzed for Cr; no median value
h) One sample analyzed for Cr; no range
i) Sulfur micronutrient fertilizer
j) Iron micronutrient fertilizer

The concentrations of metals in diverse commercially-available fertilizers from two studies (reported by Latimer and the Texas Agricultural Experiment Station,1997a and 1997b) are listed in Table 3-9. The levels of Pb in several products suggest that these products may be derived from recycled industrial waste, although no designation was given to these fertilizer formulations.

The concentrations of selected metals in liming agents are shown in Table 3-10. With possible exception of the kiln dust lime, the mass concentrations reported here appear similar to levels reported for other organic and inorganic fertilizers.

The concentrations of metals in the various gypsum and phosphogypsum samples are listed in Table 3-11. Approximately 5 tons of phosphogypsum are produced as a by-product in the production of 1 ton of phosphoric acid fertilizer. On a worldwide scale, of the residual phosphogypsum produced, 14% is reprocessed, 28% is discharged to water and 58% is stored in stacks (Carmichael, (1988) in Rutherford, et al., 1994). Some of this material is used as a soil amendment, especially for clay soils. Its greater agricultural use, though, is found in its ability to supply secondary nutrients Ca and S.

3.4 RADIOACTIVE COMPOUNDS IN FERTILIZERS

Phosphate and phosphogypsum fertilizers applied to agricultural lands contain trace radioactive nuclides which originate with the rock phosphates. Radionuclides, including uranium (U), radium (Ra) and thorium (Th), and their decay products can remain in these fertilizer products. Uranium in rock phosphate ranges from 3-400 mg/kg in deposits around the world (Mortvedt, 1992). During processing, much of the U, up to 67% of the initial concentration, and Th will remain with the phosphate fertilizer, while Ra will be contained primarily in the phosphogypsum by-product (Rutherford et al., 1995). The U content of triple superphosphate will be greater than that of phosphoric acid because the phosphoric acid, initially obtained from the rock phosphate is concentrated and reacted with additional rock phosphate, resulting in an U concentration approximately 3 times greater than in the phosphoric acid (Erdem et al., 1996).

The concentrations of radionuclides 238U, 226Ra and 232Th in Bq/kg and mg/kg (as available) from various studies are summarized in Table 3-12. As shown there, 238U concentration in rock phosphates around the world varies considerably, 90-4800 Bq/kg; a similar range is found for 226Ra, 40-5022 Bq/kg. The 232Th concentrations are lower, 16-622 Bq/kg. The rock phosphate from Tunisia, with 238U content of 4400 Bq/kg, 226Ra content of 5022 Bq/kg and 232Th content of 622 Bq/kg, when processed into superphosphate had concentrations of 3740, 3394 and 420 Bq/kg for U, Ra and Th respectively, and when processed into triple

Table 3-9. **Concentrations of Selected Metals in Commercially-Available Agricultural Fertilizers That Have No Product Classification Given**

		Concentrations of Metals in Unnamed Fertilizers, ppm (ug/g or mg/kg)								
		Cd	Pb	As	Cr	Hg	Ni	V	Cu	Zn
1. Texas Agricultural Experiment Station (1997a)										
n=67	mean	7.4	93	nd	nd	nd	21	nd	nd	nd
	median	<1	<5	nd	nd	nd	3.3	nd	nd	nd
	range	<1-79	<5-2940	nd	nd	nd	<2.5-127	nd	nd	nd
2. Texas Agricultural Experiment Station (1997b)										
n=16	mean	nd	756	nd	nd	nd	nd	nd	nd	nd
	median	nd	0.63	nd	nd	nd	nd	nd	nd	nd
	range	nd	<0.1-11,700	nd	nd	nd	nd	nd	nd	nd

Table 3-10. Concentrations of Selected Metals in Liming Materials

		Concentrations of Metals in Liming Agents, ppm (ug/g or mg/kg)								
		Cd	Pb	As	Cr	Hg	Ni	V	Cu	Zn
1. Raven and Loeppert (1997)										
Calcite		0.7	1.1	<2	nd	<0.4	1.4	3.0	2.3	nd
Dolomite		<0.2	0.7	1.2	32	<0.4	33	15	nd[a]	8.0
2. Washington Department of Ecology (1997)										
Dical lime[b]		<3	<20	<30	<5	0.0063	<10	<2	<10	7.7
Kiln dust lime[b]		3.6	150	37	73	0.041	18	49	158	1770
Wood ash		<1.5	125	48	34	0.414	23	41	116	424
Limestone		<3	<2	<30	<5	0.0075	<10	<2	<10	16
Cal pril lime[b]		<3	<20	<30	<5	0.006	<10	<2	<10	21
Dolomite		<1.5	49	<15	<2.5	0.022	<5	1	3	224
3. California Department of Food and Agriculture (1997)										
coal/wood ash	mean	1.0	81	7.6	nd	nd	16	nd	119	nd
	median	0.0	16	3.0	nd	nd	(n=1)[c]	nd	75	nd
n=13	range	0-4.0	1-380	1.2-41	nd	nd	--[d]	nd	15-515	nd
Limestone #1		6.5	46	1.1	nd	nd	nd	nd	38	nd
Limestone #2		8.1	53	5.1	nd	nd	nd	nd	46	nd

a) Not determined
b) Product name
c) Single sample analyzed for Ni; no median value
d) Single sample analyzed for Ni; no range

Table 3-11. Concentrations of Selected Metals in Gypsum and Phosphogypsum

		Concentrations of Metals in Gypsum and Phosphogypsum, ppm (ug/g or mg/kg)								
		Cd	Pb	As	Cr	Hg	Ni	V	Cu	Zn
1. May and Sweeney (1982); phosphogypsum slag from phosphoric acid production; Florida										
n=110	mean	7	1	42	nd[a]	nd	2	19	8	9
		n=1[b]	n=6	n=37	nd	nd	n=57	n=110	n=106	n=50
2. Washington Department of Ecology (1997); gypsum										
gypsum		<1.7	11	<17	<2.8	0.011	<6	2.8	7.2	54
3. California Department of Food and Agriculture (1997)										
gypsum	mean	0.83	2.5	3.1	nd	nd	nd	45	29	nd
n=3	median	0.0	0.0	3.0	nd	nd	nd	43	25	nd
	range	0-2.5	1.5-3.0	3-3.4	nd	nd	nd	41-50	21-42	nd

a) Not determined
b) Metal detected in 1 of 110 samples and less than detection limit in 109 of 110 samples

Table 3-12. Concentrations of Radionuclides in Fertilizers and Rock Phosphates

Product[a]	Source[b]	Conc, Bq/kg			Conc, mg/kg		
		238U	226Ra	232Th	U	Ra	Th
Earth Crust							
Scholten[c]	world	25	nld	25	nl	nl	nl
Rutherford	USA	nl	30-40	30-40	nl	nl	nl
Rock Phosphates							
Mortvedt	world	nl	nl	nl	59	18	8
	USA	nl	nl	nl	50-200	nl	nl
	FL/USA	800	800	325	nl	nl	nl
Hamamo	nl	nl	nl	nl	8-139	nl	nl
Erdem	MidEast	nl	nl	nl	34	nl	nl
Scholten	SC/USA	4800	4800	78	nl	nl	nl
	FL/USA	1500	1600	16	nl	nl	nl
	Morocoo	1700	1700	30	nl	nl	nl
	Kola	90	40	90	nl	nl	nl
	China	150	150	25	nl	nl	nl
Makwabe	Tanzania	4400	5022	622	481	nl	183
NPK Fertilizers							
Mortvedt	Finland	3800	1100	nl	nl	nl	nl
Ioannides	Africa	nl	16-4584	nl	nl	nl	nl
Phosphoric Acid (28% P_2O_5)							
Erdem	MidEast	nl	nl	nl	24.5	nl	nl
Superphosphate							
Hamamo	nl	nl	nl	nl	184-195	nl	nl
Makwabe	Tanzania	3740	3394	420	325	nl	119
Triple Superphosphate							
Hamamo		nl	nl	nl	184-195	nl	nl
Erdem	MidEast	nl	nl	nl	77.6	nl	nl
Makwabe	Tanzania	6940	3116	660	362	nl	135
Phosphogypsum							
Rutherford	FL/USA	nl	610	7	nl	nl	nl
Rutherford	Togo	nl	850-1120	30-39	3	nl	nl
Erdem	MidEast	nl	1250 max	nl	nl	nl	nl
Makwabe	Tanzania	nl	3219	nl	nl	nl	nl

a) Product analyzed
b) Source of product
c) First author of study cited

superphosphate had concentrations of 6940, 3116 and 362 Bq/kg for U, Ra and Th , respectively. The residual phosphosgypsum had 226 Ra content of 3219 Bq/kg (Makwabe and Holm, 1993).

Phosphogypsum concentrations of 226Ra are variable, as reported in these studies. Concentration of 226Ra ranged from 610 Bq/kg in a Florida-rock phosphate derived phosphogypsum to 3219 Bq/kg in the phosphogypsum derived from the Tansanian rock phosphate.

3.5 PERSISTENT ORGANIC CHEMICALS IN FERTILIZERS AND LIMING MATERIALS

The presence of chlorinated dibenzodioxins and chlorinated dibenzofurans (CDD/CDF) and polychlorinated biphenyls (PCB) in fertilizer materials (other than biosolids) has been investigated for cement kiln dust (CKD) used as a liming material. These data have been incorporated into the U.S. EPA Dioxin Reassessment document (U.S. EPA, Office of Research and Development, 1994).

Tetra- through octa CDD and CDF were detected in the "gross CKD" (that being the initial particulate material collected as an emission product by the air pollution control device from kiln operation) of 10 of 11 kilns sampled, where 6 of the kilns burned hazardous waste concurrently with a fossil fuel. These same CDD and CDF were also detected in the "net CKD" (that being the particulate material collected by the air pollution control device following recycling of gross CKD back through the kiln system; net CKD is used for land disposal) of 8 of the 11 kilns samples. Analyses for 7 PCB congeners was also conducted, but these were not detected in the CKD samples.

The CDD and CDF content of gross CKD was 0.008-247 ng TEQ (toxic equivalency units)/kg; the CDD and CDF content of net CKD was 0.045-195 ng TEQ/kg. The mean CDD/CDF content of net CKD for hazardous waste-burning kilns was higher than that for the kilns which burned only fossil fuel, 35 ng TEQ/kg versus 0.03 ng TEQ/kg, respectively. One kiln sample had a CDD/CDF concentration that was two orders of magnitude greater than that of the other kilns; if this one result were eliminated as atypical, then the mean CDD/CDF concentration in net CKD for hazardous waste-burning kilns would be 2.9 ng TEQ/kg, as opposed to 35 ng TEQ/kg. (Note: for consistency with concentration units used earlier for metals in fertilizer products, 2.9 ng/kg= 2.9×10^{-6} mg/kg and 35 ng/kg= 35×10^{-6} mg/kg.).

The TEQ for dioxins in other fertilizer and liming materials has been measured recently by the State of Washington, Department of Ecology. These data are shown in Table 3-13. As listed there, these products are derived from industrial wastes such as CKD, K061 waste, and tire ash. The total dioxin toxic equivalency (TEQ) concentration, as defined in footnote b of Table 3-13, ranges from approximately 0.5-350 ng/kg in actual fertilizer materials, and as high as 815 ng/kg in the raw material KO61 used to produce the corresponding zinc fertilizer.

3.6 HEAVY METALS IN HOME GARDENING PRODUCTS

The results of recent analyses for heavy metals in home gardening products are listed in Table 3-14. The concentrations of metals in the individual products are listed. The mean and median concentrations, and range of concentrations for product categories, are listed when more

than three products were analyzed. Levels of these metals, on a mass concentration basis, are similar to those found in agricultural products.

Table 3-13. Concentrations of Dioxins in Fertilizer and Liming Materials Derived from Industrial By-Products

Material Sampled	Total Dioxin TEQ Concentration (ng/kg) [a,b]
Liming Material - Cement Kiln Dust Sample #1	0.67
Liming Material - Cement Kiln Dust Sample #2	0.95
Liming Material - Wood Ash (Hog Fuel Boiler)	35.4
Liquid Zinc Fertilizer	0.59
Liquid Zinc Fertilizer (Duplicate)	1.31
Steel Foundry Dust (K061) (Raw Material)	815
Granular Zinc Fertilizer from K061	342
Granular Zinc Fertilizer from K061 (Duplicate)	322
Tire Ash (Raw Material)	1.62
Granular Zinc Fertilizer from Tire Ash	5.60

a) In calculating the TEQ, concentrations of forms (congeners) that were not detected were assumed to equal 0.

b) TEQ Concentration: There are 17 forms of dioxins considered to be toxic, but not all are equally toxic. The most toxic dioxin is called 2,3,7,8-TCDD, and other similar dioxins have been assigned toxicity values relative to it. These relative toxicity values are called toxicity equivalency factors (TEFs). 2,3,7,8-TCDD is assigned a TEF of 1, and the others are assigned values less than 1. Total concentrations of dioxins in the environment are reached by factoring in the TEF of each form of dioxin before adding them together. The resulting concentration is referred to as TEQ (toxic equivalent).

Source: http://www.wa.gov/ecology/pie/fert.html

Table 3-14. Concentrations of Selected Metals in Home Fertilizer Products

Fertilizer	Product	Concentration of Metals in Home Fertilizer Products (µg/g or mg/kg)								
		Cd	Pb	As	Cr	Hg	Ni	V	Cu	Zn
NPK	Ace Hardware Tomato & Vegetable Food	1.81	5.3	2.9	nd	0.484	11	nd	nd	368
	Jobe's Fertilizer Spikes	2.57	2.0	6.4	nd	0.013	17	nd	nd	39
	Miracid	0.01	0.6	nd	nd	0.06	nd	nd	nd	1,010
	Miracle-Gro	0.02	0.1	nd	nd	nd	nd	nd	nd	688
	Nu Life Spring Feed	0.11	5.0	1.2	nd	0.282	15	nd	nd	388
	Peters Professional	0.01	0.1	1.3	nd	0.1	<1	nd	nd	528
	S&H Organic Fertilizer	0.98	5.4	4.6	nd	0.031	12	nd	nd	62
	Schultz Bloom-Plus	0.01	<0.02	3.4	nd	<0.02	<1	nd	nd	544
	Scotts Vegetable Food	2.49	3.3	5.9	nd	0.006	10	nd	nd	6
	Walt's Rainy Pacific Northwest Blend	1.11	0.4	12.1	nd	0.066	2	nd	nd	57
	Webfoot SuperPhosphate	56.50	2.4	6.0	nd	0.031	113	nd	nd	694
	Whitney Farms Super Phosphate	4.62	7.9	13.7	nd	0.051	29	nd	nd	70
Mean		5.85	2.7	5.8	nd	0.103	21	nd	nd	371
Median		1.05	2.2	5.3	nd	0.051	12	nd	nd	378
Range		0.01-56.50	<0.02-7.9	1.2-13.7	nd	0.006-0.484	<1-113	nd	nd	6-1,010
Iron	Black Leaf Granular	1.10	14.3	0.9	nd	0.0026	6	nd	nd	24,940
	Hoffman Iron Sulfate	4.80	426.1	18.7	nd	0.307	333	nd	nd	83,135
	Ironite	32.37	3,290.0	4,512.7	nd	16.9	18	nd	nd	10,182
	Nu Life Iron Sulfate	0.06	0.6	nd	nd	nd	368	nd	nd	177
Mean		9.58	932.8	1510.8	nd	5.74	181	nd	nd	29,609
Median		2.95	220.2	18.7	nd	0.307	176	nd	nd	17,561
Range		0.06-32.37	0.6-3,290.0	0.9-4,512.7	nd	0.0026-16.9	6-368	nd	nd	177-83,135
Multi--nutrient Mix	Nu Life Trace Elements	86.82	2,491.0	29.2	nd	2,491.0	515	nd	nd	68,150
Other	Lilly Miller Ultralime	0.29	3.0	3.1	nd	0.009	5	nd	nd	18
	Nu Life Rid Moss	0.28	4.4	2.4	nd	0.119	33	nd	nd	175

Source: Seattle Times (1998): http://www.seattletimes.com/news/health-science/html98/fchar_051798.html

4.0 FERTILIZER REGULATIONS, STANDARDS, GUIDELINES AND BENCHMARKS

This section describes the regulation of fertilizers and soil amendments and the constituents of these products. Since there is no federal fertilizer law, the state laws regulating fertilizer composition and efficacy are described first. Federal rules which may be of some relevance for regulating the use of industrial by-products in fertilizers are discussed in the second sub-section. The third sub-section describes international fertilizer regulations. The fourth sub-section describes federal and international standards for the land application of sewage sludge and include limits for metals in sludge and soil following sludge application.

This section addresses the questions:

- Who regulates fertilizer composition and application?
- What are the state regulations regarding fertilizer composition?
- Although there are no specific Federal laws regarding fertilizer composition or efficacy, what Federal regulations may be applied to some aspect of fertilizer use and soil contamination?
- What international laws exist governing fertilizer application and soil contamination?
- What are the regulations for application of biosolids (sewage sludge) to land?

4.1. STATE REGULATIONS

State regulations for fertilizers are generally developed and administered by state agriculture departments. Such regulations primarily address efficacy claims and composition statements of the active ingredients displayed on fertilizer labels. Most states have fertilizer regulations similar to that of the AAPFCO model Uniform State Fertilizer Bill reproduced in Appendix D. Section 4 of that bill requires registration and/or licensing of each brand and grade of fertilizer by the person whose name appears on the label before the product may be distributed. The application for registration includes the brand and grade and a guaranteed analysis. Section 3 of the bill defines guaranteed analysis as:

"the minimum percentage of plant nutrients claimed in the following order and form:

(1) Total Nitrogen (N) ____%
Available Phosphate (P_2O_5) ____%
Soluble Potash (K_2O) ____%

(2) For unacidulated mineral phosphatic material and basic slag, bone, tankage or other organic phosphatic materials, the total Phosphate and/or degree of fineness may also be guaranteed.

(3) Guarantees for plant nutrients other than nitrogen, phosphorus and potassium may be permitted or required by regulation by the _____. The guarantees for such other nutrients shall be expressed in the form of the element. The source (oxides, salts, chelates, etc.) of such other nutrients may be required to be stated on the application for registration and may be included on the label. Other beneficial substances or compounds, determinable by laboratory methods, also may be guaranteed by

permission of the _____ and with the advice of the Director of the Agricultural Experiment Station. When any plant nutrients or other substances or compounds are guaranteed, they shall be subject to inspection and analysis in accord with the methods and regulations prescribed by the _____."

Thus, any claims that are made concerning chemicals necessary or conducive to plant growth must be substantiated. If a chemical included in the analysis is not listed on the label, no analysis is required, except (Section 12, Adulteration):

"No person shall distribute an adulterated fertilizer product. A fertilizer shall be deemed to be adulterated:

(a) If it contains any deleterious or harmful substance in sufficient amount to render it injurious to beneficial plant life, animals, humans, aquatic life, soil or water when applied in accordance with directions for use on the label, or if adequate warning statements or directions for use which may be necessary to protect plant life, animals, humans, aquatic life, soil or water are not shown on the label."

Consistent with the AAPFCO model fertilizer bill, most states currently have a general prohibition on distribution of "adulterated" fertilizer products. AAPFCO and the states have only recently begun to develop specific guidelines on what might constitute adulterated products. In 1998 AAPFCO amended its Uniform State Fertilizer Bill to provide further interpretation of what constitutes adulturation of fertilizers. Under AAPFCO's Policy Statement #25 entitled "Metals in Fertilizer Materials", fertilizer materials are to be considered adulterated if they contain metals in amounts greater than the levels established by the Canadian Standards, and that biosolids are adulterated when they exceed the levels of metals permitted by the U.S. EPA §503 regulations. Under Policy Statement #26, products that meet the guidelines for metals may include the following statement on the label: "When applied as directed, this product meets the guidelines for metals adopted by the Association of the American Plant food Control Officials." AAPFCO is also currently developing additional labeling recommendations that would indicate the ingredients contained in fertilizer products.

State-specific fertilizer initiatives (as of February 1999) include the following

- In 1998 the State of Washington became the first state to enact legislation to comprehensively regulate contaminants in fertilizers. Washington's Safe Fertilizer Act mandates a set of new regulatory requirements for contaminant testing, registration and labeling, and contaminant standards. The Act specified that until national risk-based standards are developed, Washington would adopt the Canadian fertilizer standards on an interim basis. The Act also allows adjustments to the Canadian standards based on application rates that are consistent with agricultural practices in the State of Washington. Further studies of heavy metals and dioxins in fertilizers and soils in Washington, and new research on plant biouptake of metals (being conducted by Washington State University), were also mandated by the Act.

- The State of Texas also enacted in 1988 new regulations governing fertilizer contaminants analogous to those of Washington, though based on the EPA §503 standards for sewage sludge rather than the Canadian standards.

- The State of California (CDFA and CalEPA), has prepared a risk assessment characterizing acceptable lead, cadmium and arsenic levels in fertilizer materials, based on California soils and agricultural practices ("Development of Risk-Based Concentratoins for Arsenic, Cadmium, and Lead in Inorganic Commercial Fertilizers", March 1998, Foster Wheeler Environmental Corporation). California does not yet have comprehensive fertilizer regulations in place, although legislative proposals are under development.

- In Pennsylvania, for fertilizers made from industrial waste products, the Department of Agriculture requires testing data from manufacturers and approval of the registration by the Department of Environmental Protection.

4.2. FEDERAL REGULATIONS

There are no specific Federal laws regulating the composition or efficacy of fertilizers. There are regulations concerning the production, use and disposal of hazardous materials, drinking and surface water contamination and air pollution that are indirectly relevant to the use of hazardous materials in fertilizers and the application of fertilizers to land. In addition, the Hazardous Waste Regulation, 40 CFR Part 503, Standards for the Use or Disposal of Sewage Sludge, provides limits for the concentration of metals in sludge that is applied to land and to the chemical loadings on the land following application. This standard is described in detail in Section 4.4. Other U.S. regulations which are applicable, in part, to the use of industrial by-products in hazardous wastes are discussed below.

4.2.1 OSHA

The Occupational Safety and Health Administration (OSHA) Hazard Communication Standard (29 CFR 1910.1200) applies to chemical manufacturers and importers of "hazardous chemicals" which includes agricultural operations. This standard provides for a comprehensive program of hazard communication including warning workers about chemical hazards via labels, material safety data sheets (MSDSs), other warning mechanisms and employee training. The standard does not apply to family members working on farms, only employees.

One provision of this regulation is that chemicals in concentrations of 1% or more (0.1% for carcinogens) must be listed on the MSDSs for products used in the workplace. Manufacturers and importers must provide MSDSs for their products. Specifically:

(1) 1910.1200 (b)(1)

This section requires chemical manufacturers or importers to assess the hazards of chemicals which they produce or import, and all employers to provide information to their employees about the hazardous chemicals to which they are exposed by

means of a hazard communication program, labels and other forms of warning, material safety data sheets, and information and training.

(2) 1910.1200 (d) (1)

If a mixture has not been tested as a whole to determine whether the mixture is a health hazard, the mixture shall be assumed to present the same health hazards as do the components which comprise one percent (by weight or volume) or greater of the mixture, except that the mixture shall be assumed to present a carcinogenic hazard if it contains a component in concentrations of 0.1 percent or greater which is considered to be a carcinogen under paragraph (d)(4) of this section;

The requirement for MSDSs does not apply, however, for chemicals subject to labeling requirements of specific acts such as the Federal Insecticide, Fungicide and Rodenticide Act (FIFRA), the Toxic Substance Control Act (TSCA), the Federal Food, Drug, and Cosmetic Act (FFDCA), and consumer products regulated under the Consumer Product Safety Act (CPSA) and the Federal Hazardous Substances Act (FHSA). Also, this section of the OSHA regulations do not apply to any hazardous waste as defined by the Solid Waste Disposal Act (SWDA), as amended by the Resource Conservation and Recovery Act (RCRA) and any hazardous substance defined by the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) when the product is the focus of remedial or removal action being conducted in accordance with EPA Regulations.

OSHA regulates hundreds of air contaminants, including heavy metals and persistent organic chemicals in 29 CFR 1910.1000, but agricultural operations are exempt. Agricultural operations are not exempt, however, from the cadmium regulations (29 CFR 1910.1027) limiting airborne exposure to cadmium during a work shift to 5 $\mu g/m^3$. In addition, the standard regulating the storage and handling of anhydrous ammonia (29 CFR 1910.111 (a) and (b)) applies to agricultural operations.

4.2.2 EPA Regulations for Hazardous Waste Derived Fertilizers

One of the primary objectives of the RCRA program is to encourage legitimate recycling of hazardous wastes, while maintaining appropriate regulatory controls to ensure that such practices are protective of human health and the environment. In the case of fertilizers, current RCRA requirements address two major environmental concerns: (a) how hazardous waste secondary materials are managed prior to recycling, and (b) controls on contaminants in the fertilizer products made from such materials. RCRA generally does not regulate the actual units or processes that are used in recycling. The following is a summary of the current regulatory framework for hazardous waste derived fertilizers:

- RCRA regulations currently require that (with one exception) fertilizers made from recycled hazardous wastes have to meet the applicable "land disposal restrictions" treatment standards (these "LDR" treatment standards have been developed by EPA for essentially all hazardous wastes that are land disposed). These standards are generally technology-based, and are expressed as concentrations in leachate when tested according to the Toxicity Characteristic Leaching Procedure (TCLP). This

leaching procedure was originally developed by EPA to simulate how contaminants leach from wastes in municipal solid waste landfills.

- The current regulations provide one exemption from having to meet the LDR treatment standards--fertilizers made from electric arc furnace dust (RCRA waste code K061) are not required to meet any specific contaminant standards.

- Management of hazardous secondary materials prior to recycling for fertilizers is subject to the "use constituting disposal" (UCD) provision of RCRA (40 CFR 266.20). This provision in essence requires that hazardous waste secondary materials must be managed as hazardous wastes prior to being recycled. Thus, for example, shipments of such materials are subject to manifest requirements, and storage of the materials (e.g., by the fertilizer manufacturer) will generally require a RCRA permit.

- Certain types of wastes are specifically exempted in the RCRA statute (the so-called Bevill exemption) from being regulated as hazardous waste, unless EPA establishes through rulemaking that such wastes should be regulated as hazardous wastes. Thus, fertilizers made from such exempt wastes (which include mining wastes, and gypsum from coal-fired power plants) are not subject to RCRA standards, even if the wastes (or the fertilizer) were to exhibit a hazardous waste characteristic.

4.2.3 Military Munitions Rule: Hazardous Waste Identification and Management; Explosives Emergencies; Manifest Exemption for Transport of Hazardous Waste on Right-of-Ways on Contiguous Properties; Final Rule

The Military Munitions Rule (FR, February 12, 1997) discusses the recycling of propellant or explosive as fertilizer. If processed in a manner rendering it suitable for land application, this is a permissible under RCRA. "Under 40 CFR 266.20(b) commercial fertilizers that are produced for the general public's use that contain recyclable materials are not presently subject to regulation provided they meet the treatment standard under 40 CFR Part 268, subpart D, for each recyclable material that they contain." (page 6629). Chemical agents or munitions exhibiting a hazardous waste characteristic, or already listed as a hazardous waste (40 CFR Part 261), are subject to all applicable regulatory requirements of RCRA Subtitle C.

Currently, recycling of munitions into fertilizers has been demonstrated in the laboratory on a bench-scale, and in limited pilot-scale validation and demonstration tests. A mobile unit will be available for military tests by mid-1999, and a larger stationary production facility is planned (http://www.arctech.com).

4.2.4 Metal Containing Pesticides

Metals can be added to soil from the application of pesticides. There are a number of pesticide products containing cadmium, arsenic, copper, mercury and other metals. Many of these products are, however, no longer registered by EPA. Table 4-1 shows the metal-containing pesticide products that are banned, have restricted use, have been canceled in the Special Review Process or have tolerances on food crops.

EPA Office of Pesticide Programs (OPP) publishes a list of pesticides banned and severely restricted in the U.S. (http://www.epa.gov/oppfead1/piclist.html). Table 4-1 shows pesticides containing metals that have been banned from use or have severely restricted use in the United States as of August 1, 1997. Pesticides may be banned either by EPA canceling the registrations or by the registrant (i.e. the manufacturer) voluntarily canceling the registration. The last remaining use of cadmium chloride was voluntarily canceled in 1990 during the special review of cadmium products. All uses were canceled in 1991 (56 FR 14522, April 10, 1991). All registrations of inorganic arsenicals have been canceled except for a few select uses (arsenic trioxide insecticide and mole/gopher control). Copper acetoarsenite and copper arsenate uses were canceled in 1977 (42 FR 18422, April 7, 1977). Uses of mercury as an antifouling agent in paint were canceled in 1990 for indoor paint (55 FR 26754, June 29, 1990) and in 1991 for outdoor paint (56 FR 105, May 31, 1991).

Table 4-1. Regulatory Status of Metal-Containing Pesticides [a]

Pesticide Product	Status	Comments
aluminum phosphide	registration supported, restricted use	See 40 CFR 152.170 (53 FR 15986, May 4, 1988)
arsenic acid	severely restricted	Wood preservative products only
arsenic trioxide	severely restricted	Insecticide and mole/gopher control
cadmium compounds	banned	Voluntary cancellation as a result of the Special Review Process
calcium arsenate	banned	Voluntary cancellation
chromic acid	restricted use	wood preservative products
copper acetoarsenite	banned	Voluntary cancellation as a result of the special review process
copper arsenate	banned	Voluntary cancellation as a result of the Special Review Process
cupric oxide	registration canceled	
cuprous oxide	restricted use	Wood preservative and anti-fouling paint
lead arsenate	banned	Voluntary cancellation as a result of the Special Review Process
magnesium phosphide	restricted use	magnaphos tablets and bags
mercuric chloride	banned	Voluntary cancellation as a result of the Special Review Process
mercurous chloride	banned	Voluntary cancellation as a result of the Special Review Process
phenarsazine chloride	banned	Voluntary cancellation as a result of the Special Review Process
phenylmercury acetate	banned	Voluntary cancellation as a result of the Special Review
phenylmercuric oleate	banned	Voluntary cancellation
sodium arsenate	severely restricted use	Brush on wood preservative products

Table 4-1. (Continued)

Pesticide Product	Status	Comments
sodium arsenite	banned	
tributyltin	severely restricted use, review in progress	anti-fouling paints
triphenyl tin hydroxide	restricted use, review in progress	fungicide
zinc phosphide	registration supported, restricted use	rodent bait

[a]Sources: Banned/restricted pesticides (http://www.epa.gov/oppfead1/piclist.html); Special Reviews (http://www.epa.gov/oppsrrd1/Rainbow/93Rainbow/Chapt-2.txt.html);

Table 4-2 contains a list of metal-containing pesticides for which there is at least one tolerance set on food crops (i.e. these pesticides have some agricultural use). There are also a number of pesticides which are exempt from tolerances on raw agricultural commodities assuming the products are applied in accordance with good agricultural practices. These chemicals are too numerous to mention but consist of many pesticides that contain plant micronutrients. For example, many copper, magnesium and zinc salts and boric acid are listed in 40 CRF Subpart D Section 180.1001 - 1164 as exempt from tolerances.

Table 4-2 Pesticides With Tolerances on Raw Agricultural Commodities[a]

Pesticide Product	Status	Comments
aluminum phosphide	40 CFR 185.200	Residues not to exceed 0.01 parts per million (ppm) on vegetables, 0.1 ppm on other crops
aluminum tris (O-ethylphosphonate)	40 CFR 180.176	For example, 3 ppm on tomatoes and 0.5 ppm on citrus
basic copper carbonate	40 CFR 185.136	Tolerance of 3 ppm in pears
basic zinc sulfate	40 CFR 180.244	Tolerance of 30 ppm on peaches
coordination product of zinc ion and maneb	40 CFR 180.176	tolerances set on commodities such as apples and cranberries
magnesium phosphide	40 CFR 180.375	For example, tolerance of 0.1 ppm on wheat and 0.01 ppm on tomatoes
methanearsonic acid	40 CFR 180.289	Tolerances of 0.7 ppm in or on cottonseed and 0.35 ppm in or on citrus fruit
triphenyl tin hydroxide	40 CFR 180.236	For example, 0.05 ppm on pecans, peanuts and potatoes
zinc phosphide	40 CFR 180.284	Tolerance of 0.01 ppm on grapes and sugar cane

[a]Sources: Tolerances: 40 CFR Subpart D, Sections 180.101 to 180.482; Tolerance exemptions: 40 CFR Subpart D, Sections 180.1001 to 180.1164.

Although most of the highly toxic pesticide products (i.e. those containing mercury, cadmium and arsenic) have been banned, there are still pesticide products which have the potential for adding metals to soils and plants. Many of these pesticides contain metals which are also considered plant micronutrients.

4.2.5 Radon in Phosphogypsum

The National Emission Standards for Hazardous Air Pollutants (NESHAP) for radon regulates radon emissions from phosphogypsum stacks (40 CFR Part 61, Subpart R). The regulation allows phosphogypsum to be removed from phosphogypsum stacks for agricultural purposes if the radium-266 concentration is determined annually and does not exceed 10 picocuries per gram (pCi/g). EPA analyzed the potential risks associated with long-term use of phosphogypsum in agriculture to set this limit. The Fertilizer Institute filed a petition on August 3, 1992 to reconsider this revised rule. The changes that EPA is considering do not, however, affect the concentration limit of 10 pCi/g.

4.3. INTERNATIONAL FERTILIZER REGULATIONS

International fertilizer regulations differ in their content and in enforcement. The regulations for Canada and Japan contain requirements limiting concentrations of heavy metals and, in the case of Japan, organic chemicals in fertilizers. Regulations for the European Union (EU) are also discussed because these directives must be followed by all EU countries.

4.3.1 Canadian Fertilizers Act and Regulations

The Canadian Fertilizers Act R.S., c. F-9, s.l (1993) and Fertilizers Regulations contain metal limits used by the Canadian Food Inspection Agency to regulate all fertilizers and soil supplements sold in Canada. Although these limits were not based on quantitative risk assessments, the Trade Memorandum T-4-93, August, 1996 from the Food Production and Inspection Branch states that these limits:

> "..were developed to help ensure that fertilizers and supplements continue to pose only a minimum risk of adverse effects due to metal contamination... The AAFC metal standards are based on generic principles and are generally applicable to fertilizers or supplements applied to land or in crop protection."

Although the metal limits were originally written for the land application of biosolids, these limits now apply to all fertilizer products. Metal limits were developed by the Ontario Ministry of Agriculture and Food in 1978. These limits were revised and adopted by Agriculture Canada for application to biosolids and similar products in 1980. Table 4-3 shows the limits for metals in fertilizer and soils following application of fertilizers as stated in Trade Memorandum T-4-93 (August, 1996). Agriculture and Agri-Food Canada is considering limits for two additional metals, chromium (210 kg/ha) and copper (150 kg/ha). These limits have not yet been implemented.

The Canadian government enforces metals regulations for fertilizers by requiring all micronutrient fertilizers, fertilizer/pesticide mixes, and most supplements to be registered

through the Canadian Food Inspection Agency (CFIA). For a product to become registered, the manufacturer must submit metal analyses of its product, and the levels must be below the Canadian limits. Non-registered fertilizer products are subject to marketplace monitoring, in which products are randomly selected by the CFIA for metal analyses. If the CFIA finds a product on the market that exceeds the Canadian limits on metals, it has the powers of detention and seizure of the product. More information about Canada's Fertilizers Regulations can be found on the internet at http://www.dfia-acia.agr.ca/english/actsregs/fert/fertrege.html.

The Canadian limits shown in Table 4-3 require some additional explanation. The Maximum Acceptable Cumulative Metal Additions to Soil (kg/ha) pertain to additions over a long term. For the purposes of this calculation, "long term" is taken to mean 45 years. In comparisons made in Section 5 of this report, these values were divided by 45 to more closely approximate annual limits. The Maximum Acceptable Metal Concentrations (mg/kg dry weight) in the fertilizer product were originally developed for biosolids and are based on the assumption that (Agriculture and Agri-Food Canada, Food Production and Inspection Branch, Trade Memorandum T-4-93, August, 1996):

> "A cumulative total application to soil of 200 dry tonnes per hectare of a product that contains 50% moisture and a total N guarantee of 2.5% (i.e. 5% nitrogen on a dry weight basis). Such a product, applied annually at a rate of 220 kg N/ha (or 4,400 kg dry product/ha) would reach the standards for maximum acceptable cumulative metal additions to soil within 45 years"

Table 4-3. Canadian Maximum Acceptable Cumulative Metal Additions to Soil and Maximum Acceptable Metal Concentrations in Products

Metal	Annualized Max. Acceptable Cumulative Metal Addition to Soil (kg/ha)[a]	Maximum Acceptable Metal Concentrations (mg/kg dry weight)[b]
Arsenic	15	75
Cadmium	4	20
Cobalt	30	150
Mercury	1	5
Molybdenum	4	20
Nickel	36	180
Lead	100	500
Selenium	2.8	14
Zinc	370	1850

a) The values in this column pertain to total cumulative additions to soil over the long term (i.e., 45 years)
b) See text for explanation of the derivation of these limits.

In addition:

> "Acceptable metal concentrations increase as the rate of application decreases relative to 4400 kg dry product/ha (e.g. if the rate of application is 2200 kg dry product/ha, this is half 4400 kg therefore the metal concentrations can be double the [maximum acceptable metal concentrations (mg/kg dry weight)]. Or, when products are applied on the basis of their nitrogen content, acceptable metal concentrations increase proportionally with total %N **on a dry weight** basis"

Additional explanation for estimating the maximum acceptable metal concentrations (mg/kg dry weight) may be found in the Trade Memorandum T-4-93.

Trade Memorandum T-4-112 (April 1994), Information Required for the Assessment of By-Products and Other "Waste" Materials Sold as Fertilizers or Supplements, provides for pre-market assessment of specific end-use product types (e.g., micronutrient fertilizers, supplements, soil amendments, wetting agents, and microbial innoculants) and other products if there is a cause for concern. This assessment addresses issues of safety, labelling and efficacy. It requires identification and description of the product and its constituents, identification of the industrial process from which the product is derived, the benefits of the product, rates and methods of application, and documented analyses for heavy metals, dioxins and furans.

The selection of specific product types for assessment is reviewed in an information source for the inspection's staff, entitled "Regulation of Recycled Material and By-Products Under the Fertilizers Act". This information source was drawn up as a guide, and was not intended to be inclusive of all potential recycled by-products, nor representative of current or actual practices. As listed in that source, examples of industrial by-products, and the chemicals these products may contain, are:

1. Baghouse/flue dust (heavy metals including, iron, zinc, manganese and molybdenum),
2. Cement kiln dust (potassium, calcium, sulphur, iron, magnesium, aluminum, and PAHs),
3. Coal fly ash (aluminum, silicon, iron, calcium, potassium, sodium, arsenic molybdenum, selenium and PAHs),
4. Galvanizing fluid (zinc, iron and other heavy metals),
5. Gypsum (calcium sulfate and traces of dioxins, furans and boric acid),
6. Bauxite mine tailings (aluminum, dicalcium silicate),
7. Newsprint (heavy metals, PAHs),
8. Phosphogypsum (gypsum, fluoride),
9. Pulp and paper sludge (a variety of organic and inorganic substances),
10. Smelter slag (heavy metals, magnesium, calcium),
11. Waste lime (calcium, magnesium, cyanides and sulfites).

4.3.2 Japan

Japan regulates incinerator ash from both industrial and municipal waste treatment incinerators. Sludge ash is used for soil improvements. The standards for organic and inorganic

chemicals in incinerator ash are shown in Appendix E, International and National Limits for Pollutants in Biosolids, because these limits apply to the leaching of chemicals from incinerator ash produced from burning sewage sludge. These values are from the Prime Minister's Office Ordinance for Establishing Evaluation Standards Regarding Industrial Wastes, including Metals (1995).

4.3.3 European Union

The European Union Directive, Council Directive On the Approximation of the Laws of the Member States Relating To Fertilizers (76/116/EEC) sets forth the regulations regarding "straight and compound" fertilizers. The directive is similar to the AAPFCO model document in that it describes only the fertilizer content and package markings. Member states may adapt this regulation. Fertilizer marketed as "EEC fertilizer" is subject to official control measures to assure compliance with the declared nutrient content. Subsequent directives have added fertilizer types to the Annex I (N, P and K) and Annex II (Secondary nutrient Fertilizers) of this directive and tolerances for specific components to Annex III. For example, Urea-ammonium sulphate, 0.5% was added to all three Annexes in a Commission Directive of May 10, 1996 (96/28/EC).

The EU Council Directive of 12 June, 1986 (86/278/EEC) describes the use of sewage sludge in agriculture. The limits for metals are described in the following section and in Appendix E, Table E-1 International Contaminant Concentration Limits for Biosolid Application to Land

The Council Directive of 12 December, 1991 (91/689/EEC) replaces the previous Council Directive of 20 March, 1978 (78/319/EEC) on disposal of dangerous waste. This directive defines waste, requires that discharges be identified and recorded, transportation and storage be inspected and controlled and that establishments responsible for disposal and recovery of wastes on behalf of third parties be identified to the Commission. Annex I of this directive identifies categories of hazardous waste. Annex II lists the chemical constituents of wastes and Annex III identifies the properties of wastes which render them hazardous. In simplified form, this regulation is similar to those of U.S. EPA.

The reuse of materials is encouraged in a non-obligatory council directive of 18 March, 1991. Member states are encouraged to become self-sufficient in waste disposal, and the Council discusses the desirability of adopting specific rules on recovered waste. Article 4 states:

> "Member States shall take the necessary measures to ensure that waste is recovered or disposed of without endangering human health and without using processes or methods which could harm the environment."

Annex IIB lists operations which may lead to recovery and describes the R10 recovery method:

> "Spreading on land resulting in benefit to agriculture or ecological improvement, including composting and other biological transformation processes..."

This directive does not, however, provide any guidance on limits of contaminants in the environment.

4.3.4 Cadmium in Fertilizers

Rock phosphates contain cadmium as a trace element (See Table 3-5). Because of the concern about the toxicity of this element and the need for application of phosphate fertilizers, a number of countries have standards and guidelines limiting the cadmium content of fertilizers and soil. Table 4-4 presents a number of these limits for countries around the world. Most of the limits are stated as a weight of cadmium per weight of phosphorus or phosphate in the fertilizer. In some cases, the cadmium limits are for the total fertilizer weight. Belgium has the lowest limit for all fertilizers, 2.5 mg/kg dry weight, and the Netherlands has the lowest limit for compost and "very clean" compost, 1.25 mg/kg and 0.7 mg/kg, respectively. Cadmium limits in biosolids applied to land are discussed in the next section.

4.4. BIOSOLIDS APPLICATION TO LAND

4.4.1 EPA 40 CFR Part 503 Standards for the Use or Disposal of Sewage Sludge

The U.S. EPA regulates use and disposal of biosolids via 40 CFR Part 503, "Standards for the Use or Disposal of Sewage Sludge." In this regulation, EPA sets limits for certain metals in biosolids when applied to agricultural land. These limits are summarized in Table 4-5. Concentrations limits for nine inorganic (metal) pollutants in the sewage sludge and for the soil following application of the sewage sludge are included in the regulation. In addition, in May 1993, EPA prepared a list of 31 potential pollutant candidates to be included in the regulation. These pollutants were selected based upon the frequency of detection in the 1988 National Sewage Sludge Survey. Based on screening risk assessments, EPA is scheduled to propose (by March 1999) comprehensive numerical standards and appropriate management practices for biosolids. These will apply to all use and disposal practices, including land application, surface disposal, and incineration, and will encompass limits for dioxins/furans and coplanar PCBs. A final rule is anticipated by 2001.

Many individual states include several limits for other metals. Appendix E presents limits for metals in biosolids for Pennsylvania and the New England states. Many of these limits are the same or lower than those in the Section 503 rule. All the states listed have limits for chromium (which was deleted from Part 503 rule based on a court decision). Connecticut has additional limits for chromium (VI) and barium.

4.4.2 International Biosolids Regulations

Inorganic and organic concentration limits in sludge and soils following land application are presented in Appendix E. These values have been abstracted from *A Global Atlas of Wastewater Sludge and Biosolids Use and Disposal* (1996) for 15 countries and the European Union. Canadian regulations for biosolids application to land are the same as for any fertilizer (see Table 4-2). All these countries regulate metals (cadmium, chromium, copper, lead, mercury, nickel and zinc) in biosolids and most regulate arsenic. It is difficult to determine which country has the most conservative limits because they vary by metal; however, the Netherlands and the Scandinavian countries generally have the lowest limits.

Table 4-4. International Regulations on Cadmium in Fertilizer[a] and Soil[b]

Country	Year	Value	Units	Type	Comments
Australia	1995	350	mg/kg phosphorus	voluntary maximum	Fertilizer Industry Federation of Australia
	2000	300	mg/kg phosphorus	voluntary maximum	Fertilizer Industry Federation of Australia
	NA[c]	250	mg/kg phosphorus	voluntary maximum	Fertilizer used for horticulture
	NA	10	mg/kg	voluntary maximum	Fertilizers and soil amendments with < 2% phosphorus
	NA	80	mg/kg	voluntary maximum	Trace element supplements
Austria	NA	275	mg/kg phosphorus	limit	Fertilizer
Belgium	NA	2.5	mg/kg dry weight	maximum	Fertilizer
	NA	200	mg/kg phosphorus	voluntary limit	Fertilizer
	NA	1-3	mg/kg dry weight	maximum	Soil
	NA	150	g/hectare/year	maximum	Soil supply
Canada	1993	20	mg/kg	maximum	Fertilizer, sewage sludge and compost
	1993	4	kg/hectare	maximum acceptable cumulative addition	Soil
Denmark	1998	110	mg/kg phosphorus	threshold limit	Statutory order for phosphate fertilizers No. 233
Finland	NA	50	mg/kg phosphorus	maximum	Agricultural and garden fertilizers
Germany	NA	90	g/tonne[d] P_2O_5	voluntary maximum	At least 89% of products should not exceed 70 g Cd/ton P_2O_5 and 63% should not exceed 40 g Cd/ton P_2O_5
	NA	200	mg/kg phosphorus	voluntary maximum	Fertilizer
Japan	1991	≤ 0.01	mg/liter solution of analysis	limit	soil, Basic Environmental Law
	NA	343	mg/kg phosphorus	limit	Fertilizer
	1991	≤ 1	ppm	limit	Agricultural soil

Table 4-4. (Continued)

Country	Year	Value	Units	Type	Comments
Netherlands	1987	35	mg/kg phosphorus	limit	Proposed for fertilizer
	1995	1.25	mg/kg	maximum	For compost
	1995	0.7	mg/kg	maximum	For "very clean" compost
Norway	1995	100	mg/kg phosphorus	limit	For fertilizer
Sweden	1992	100	g Cd/tonne phosphorus	limit	For fertilizer
Switzerland	NA	50	g Cd/tonne phosphorus	maximum	For fertilizer
United Kingdom	NA	none			
European Union	1986	0.15	mg/kg dry weight of soil/year	mandatory cumulative maximum limit	Soil loading

[a] For information on cadmium levels in sewage sludge see Appendix E, Table E-1
[b] Sources: OECD Proceedings, Sources of Cadmium in the Environment, Paris, France, 1996, J.J Mortvedt, Fertilizer Research 43: 55-61, 1996 and J.J. Mortvedt and J.D. Beaton, Phosphorus in the Global Environment. Scope, 1995.
[c] NA = Year of initiation of standard or limit is not available
[d] A tonne equals 1000 kg, therefore, g/tonne = mg/kg

Table 4-5. EPA CFR 40 Part 503 Inorganic Pollutants in Sewage Sludge[a]

Pollutant	Ceiling Concentration mg/kg product for Land Application	Cumulative Loading Rate (kg/ha) for Agricultural Land Application	Monthly Average Concentration (mg/kg product) for Agricultural Land Application	Annual Pollutant Loading Rate for Land Application (kg/ha/365 days)
Arsenic	75	41	41	2.0
Cadmium	85	39	39	1.9
Copper	4300	1500	1500	75
Lead	840	300	300	15
Mercury	57	17	17	0.85
Molybdenum	75			
Nickel	420	420	420	21
Selenium	100	100	100	5.0
Zinc	7500	2800	2800	140

a) The ceiling concentrations and monthly average concentrations are limits for pollutants in the sewage sludge product, not the soil

Some countries also regulate other inorganic chemicals (e.g. molybdenum, boron, selenium) as well as some organic chemicals. For example, Australia sets limits for pesticides in sludge and soil, China regulates mineral oil and Austria regulates persistent organics. Japan applies the same standards for industrial waste to biosolids waste because biosolid sludge is incinerated and these incinerators are considered industrial plants and must meet the environmental regulations for industry. Japan has limits for many organic and inorganic compounds as the extractable solution in the waste.

4.5 SUMMARY OF REGULATIONS

Canada specifically regulates nine metals in all fertilizers. Certain European countries and Australia regulate cadmium in phosphate fertilizers. Japan regulates metals and some organic chemicals in incinerator ash that is applied to agricultural land. The U.S. regulates fertilizers that are made from hazardous waste by setting limits for certain metals in those wastes before the waste or product containing the waste can be applied to the land.

States regulate fertilizers, generally through the state agriculture departments. Most states have fertilizer regulations similar to the AAPFCO Uniform State Fertilizer Bill shown in Appendix D. These bills generally regulate plant nutrient and efficacy claims made on the product labels. States (and AAPFCO) have recently begun to also adopt specific standards for contaminants in fertilizers.

There are international, national and state regulations for the application of sewage sludge (biosolids) to land. These laws and regulations have specific limits for toxic metals in sludge and frequently include limits for metals in the soil following application of biosolids.

5.0 CHARACTERIZATION OF ADDITION OF METALS TO SOILS AS A RESULT OF FERTILIZER APPLICATION - COMPARISON TO REGULATORY LIMITS

This section combines information from Section 2 on fertilizer consumption, Section 3 on metals in fertilizers and soils and Section 4 on regulations for metals in fertilizers and soils. First, we describe the assumptions necessary for the calculation of metal additions to soil following fertilizer application. Next, application rates for N, P and K fertilizers and micronutrients are combined with information on metal concentrations in these products to determine potential soil additions of metals resulting from fertilizer use. Then we compare these values for metals in fertilizers and soils to the available regulatory limits. The fourth part of this section describes questions that have arisen and data gaps identified in the characterization of soil contamination following application of fertilizers which contain non-nutritive heavy metals.

Note that at this time, only the changes in soil concentrations from metal additions are considered. This report does not attempt to evaluate the impacts of these soil additions on human health or the environment.

This section addresses the following questions:

- What do we know about trace-metal contamination of fertilizers and the resulting application to soils?
- Based on simplifying assumptions, what concentrations of metals in soil might be expected following fertilizer application?
- How do these levels compare to national and international standards and guidelines?
- Based on typical fertilizer application rates, how long will it take to double soil background contaminant levels?
- What additional information is necessary to thoroughly characterize the extent of soil contamination following fertilizer application?

5.1 ASSUMPTIONS FOR THE CALCULATION OF METAL SOIL LOADINGS RESULTING FROM FERTILIZER APPLICATION

A number of assumptions must be made to calculate the annual addition of metals to soil (mg/kg or kg/hectare = kg/ha) following fertilizer application. Data from Section 3 listing metal contaminants in various fertilizers have been combined with typical application rates for fertilizer products. The basic equation for the calculation of metal addition to soil (mg/kg) is:

$$\frac{mg\ X}{kg\ soil} = \frac{mg\ X}{kg\ product} \times \frac{1\ kg\ product}{(\%\ Y/100)\ kg\ a.i.} \times AR\ \left(\frac{kg\ a.i.}{ha}\right) \times \frac{ha}{2{,}000{,}000\ kg\ soil} \qquad (1)$$

where: X = metal contaminant
Y = fertilizer nutrient (e.g., zinc, nitrogen, P_2O_5, K_2O)
AR = application rate (kg/ha)
a.i. = active fertilizer ingredient (e.g. nitrogen, N)

The value 2,000,0000 kg soil/ha is calculated based upon an assumed soil density of 1.33 g/cm^3 using the following equation:

$$1{,}995{,}000\ \frac{kg\ soil}{ha} = \frac{100\ m \times 100\ m \times 0.15\ m}{ha} \times \frac{1.33\ (g/cm^3)}{0.01\ (m/cm)^3} \times \frac{kg}{1000g}$$
$$= \sim 2{,}000{,}000\ \frac{kg\ soil}{ha} \qquad (2)$$

This assumes that the soil density is 1.33 g/cm^3 (US EPA Office of Wastewater Management, 1995; Foth, 1990; Manrique and Jones, 1991; US EPA, 1997a) and that the soil plow depth is 15 cm (0.15 m) (Rothbaum et al., 1986). (Note that the soil density, or bulk soil density, is the mass of oven dry soil per volume sampled, and thus includes both the soil particles and the interstitial air.) A hectare is 10,000 m^2. The yearly addition of contaminant X to the soil (kg X/ha) is calculated:

$$\frac{kg\ X}{ha} = \frac{mg\ X}{kg\ fertilizer\ product} \times \frac{1\ kg\ product}{(\%\ Y/100)\ kg\ a.i.} \times AR\ \left(\frac{kg\ a.i.}{ha}\right) \times \frac{kg}{1{,}000{,}000\ mg} \qquad (3)$$

Some limits for metals in soils are reported on a mg/kg basis. To convert from kg/ha to mg/kg, multiply the value of the contaminant in kg/ha by 0.5:

$$\frac{mg\ X}{kg\ soil} = \frac{kg\ X}{ha} \times \frac{ha}{2{,}000{,}000\ kg\ soil} \times \frac{1{,}000{,}000\ mg\ X}{1\ kg\ X} = 0.5\ \frac{kg\ X}{ha} \qquad (4)$$

The applications to soil are calculated per crop year; that is, application rates used in the tables may result from multiple applications of a single product in a single growing season. But we have not considered applications of several fertilizer types during a crop year since that information is not available at this time.

5.2 SOIL CONCENTRATIONS OF METALS FOLLOWING APPLICATION OF N, P AND K FERTILIZERS AND MICRONUTRIENT FERTILIZERS

Although there are considerable data on concentrations of metals in fertilizer products, the data are neither comprehensive nor representative of all fertilizer types. For example, analyses of metals in 141 different NPK , 61 phosphate and 63 zinc fertilizer samples were available for these comparisons. In contrast, analyses of only 2 or 3 boron, iron, magnesium, and manganese fertilizers were available. In addition, the 141 NPK samples (and all other fertilizer samples, as well) were typically not characterized with respect to all 9 metals compared in this report. The most frequently analyzed/reported metals included Cd, Pb, As, and Zn. Data on Hg concentrations in fertilizer products are somewhat limited by analytical method detection limits (i.e., samples were analyzed, and concentrations were reported as less than a detection limit that is substantially higher than concentrations at which Hg was detected in other samples). The application rates are chosen to cover a range of potential values.

The application rates for N, P, and K fertilizers, micronutrient fertilizers, lime and gypsum used for calculations here are summarized in Table 5-1 (N, P, and K) and Table 5-2 (micronutrient, lime and gypsum). The N, P, and K fertilizer application rates are taken from the USDA/NASS database and reflect rates applied to six field crops (1996 crop year), the eight vegetables with more than 100,000 planted acres in one type (cucumbers not included because neither fresh nor processed type alone exceeded 100,000 planted acres) (1994 crop year) and the six fruits with more than 100,000 planted acres (1995 crop year). The six field crops include corn, cotton, potatoes, soybeans, tobacco and wheat; the eight vegetable crops include snap beans, broccoli, carrots, corn, lettuce, onions, peas and tomatoes; the six fruit crops include watermelons (listed in the USDA/NASS database under vegetables), oranges, grapefruit, apples, grapes and peaches. (Note: These 20 crops were selected for subsequent calculations in this report because they account for a large majority of the crop acreage planted in the U.S. each year.) The USDA/NASS database lists fertilizer application rates separately for the three types of wheat (winter, durum and spring). For this report a single, aggregate application rate for wheat was developed, and used, which consisted of the acreage-weighted rate for the three types of wheat. In a similar manner, single acreage-weighted rates were also developed for snap beans (fresh and processed), corn (fresh and processed), and tomatoes (fresh and processed). The N, P (P_2O_5), and K (K_2O) fertilizer application rates for these crops (6 field, 8 vegetables, 6 fruit) are summarized in Appendix Table F-1. Six different global application rates were considered initially for N, P, and K application rates, and these rates are listed at the top of Table 5-1. The three selected application rates for all subsequent calculations are listed at the bottom of Table 5-1. The 6 application rates considered initially included: the maximum rate cited for these crops (max of range); the 19th highest average application rate for the 20 crops selected (95th percentile), the 16th highest average application rate for the 20 crops selected (80th percentile), the average of the top 10 average application rates (avg top 10); the average of all average application rates (avg avg); and the average of all average application rates weighted by the number of acres planted in that crop (avg acre weighted). (Note: The 19th and 16th highest average application rates are unbiased non-parametric statistical estimates of the 95th and 80th percentile average application rates, respectively; see Dudewicz, 1976.)

Table 5-1. NPK Fertilizer Application Rates (lbs/acre) Used in Calculation of Metal Addition to Soil for Field Crops, Vegetables and Fruits[a]

Parameter	N	P	K
max of range	414	252	534
95th pctile	206	173	177
80th pctile	186	120	139
avg (top 10)	178	122	138
avg (avg)	124	84	103
avg (acre weighted)	84	49	69
The following rates were used in subsequent calculations			
avg	124	84	103
high	206	173	177
maximum	414	252	534

a) Source: USDA, ERS, NASS database; see text for more details.

As shown at the bottom of Table 5-1, the average of all average application rates was selected to represent an "average" application rate; the 19th highest average application rate for the 20 crops (95th percentile) was selected to represent a "high" application rate; and the maximum rate cited for these crops (max of range) was selected to represent a "maximum" application rate. The maximum application rates were used on watermelon, lettuce and tomato crops, for N, P, and K respectively. The 95th percentile application rate (high) was the rate applied to broccoli, potatoes, and oranges for N, P, and K respectively.

The Food and Agriculture Organization of the United Nations (FAO) has published world-wide application rates for several additional crops such as peanuts, barley, oats, rye, sunflower, sugar beets, sugar cane, and pasture lane (FAO, 1996). These application rates are based on estimates by experts in the field as opposed to recorded measurements documented in the USDA/NASS database. However, they could be used to supplement the survey data from USDA/NASS that is used in this report. Based on the U.S. data from the FAO, the average application rates are 34 lb/A for nitrogen fertilizers, 18.7 lb/A for P_2O_5 fertilizers, and 44.4 lb/A for K_2O fertilizers for peanuts, barley, oats, rye, sunflower, sugar beets, sugar cane, and pasture land. Pasture had the lowest application rates for all three fertilizers at 4.5, 1.8, and 1.78 lb/A for nitrogen, P_2O_5, and K_2O fertilizers respectively. The high application rates are 93 lb/A for sugar beets, 44 lb/A for peanuts, and 220 lb/A for sugar cane for nitrogen, P_2O_5 and K_2O fertilizers respectively. Although the data from the FAO were not used in these calculations of application rates in Table 5-1, the application rates from the FAO fall within the ranges of the application rates that were used.

The average, high and maximum secondary nutrient, micronutrient, lime and gypsum application rates are listed in Table 5-2. These rates were derived from interviews with experts in the area, including leading scientists with the agricultural extension services at 7 states, and from

Table 5-2. Secondary Nutrient, Micronutrient and Lime Application Rates (lbs/acre) Used in Calculation of Metal Addition to Soil for Field Crops, Vegetables and Fruits[a]

Fertilizer Type	Average[b]	High[c]	Maximum[d]
Zinc	5	10	20
Sulfur (nutrient)	20	40	60
Sulfur (pH)	800	2,000	2,500
Boron	2	3	4
Manganese	4	10	18
Magnesium	25	100	180
Iron	10	20	30
Lime ($CaCO_3$)	4,000	8,000	15,000
Gypsum	2,000	4,000	8,000

a) Source: Ag Extension Service interviews and Internet site-provided information from Ag Extension Services; see text for more details.
b) Average rate from Ag Extension Service data (see Appendix F, Table 1)
c) High is rate determined from Extension Service data (see Appendix F, Table 1)
d) Maximum is highest rate quoted in Extension Service data (see Appendix F, Table 1)

information published by agricultural extension services on the Internet for 8 states. Agricultural extension agency scientists and leading professionals were contacted in CA, OR, WA, AL, OH, NY and NB. Data were obtained from Internet sites for extension services in the following states: NB, MN, GA, AL, FL, IL, MO and TX. The data obtained from these interviews and searches are listed in Appendix Table F-2. Due to the more limited nature of these data compared with the extensive USDA/NASS database, the average and high application rates were selected as best estimates from these searches; the maximum application rate was the highest rate quoted or listed by any agricultural extension service.

The yearly average additions of metals to soil (kg/ha) were calculated for each fertilizer product using Equation [1]. These calculations are tabulated in Appendix G of this report for:

P_2O_5 fertilizers: Tables G-1(a-e),
NPK fertilizers applied for P_2O_5 content: Tables G-2(a-e),
NPK fertilizers applied for N content: Tables G-3a-e),
Potash (K_2O) fertilizers: Tables G-4(a-e),
Zinc (Zn) fertilizers: Tables G-5(a-d),
Manganese (Mn) fertilizers: Tables G-6(a-e),
Boron (B) fertilizers: Tables G-7(a-e),
Iron (Fe) fertilizers: Tables G-8(a-e),
Sulfur (S) fertilizers applied for nutrient content: Tables G-9(a-e),
Sulfur fertilizers (S) applied for pH adjustment: Tables G-10(a-0e),
Liming Materials: Tables G-11(a-e),
Gypsum: Tables G-12(a-e), and
Micronutrient mixes: Tables G-13(a-e).

Important Note:

For these calculations, each product-specific metal X level (mg X/kg of product) and the product-specific concentration of active ingredient (e.g. 20% zinc fertilizer = 0.2 kg a.i./kg product) were combined with the three global application rates for average, high and maximum application of active ingredient (Equation [3]), to obtain an average, high and maximum yearly addition of each metal for that specific product. At the conclusion of each table is listed the average yearly metal addition from all products, as (or if) applied at the average, high and maximum application rate. In addition, in Appendix G the product which produces the highest yearly addition of the specific metal being characterized is shaded for visual identification.

As indicated in Equation [3], the yearly addition of metal to soil is determined by both the level of the metal in the product and the level of the desired nutrient. A fertilizer product can contribute high levels of heavy metals to soil when the heavy metal concentration in the product is high and/or when the desired plant nutrient is at a low level in the product. For example, one lime product had $CaCO_3$ content of only 7.6%. Although the Cd concentration in this product was comparable to levels in other lime products, the calculated addition of Cd to soil was high, due to the low nutrient content. For this report, soil metal addition rates for each product were calculated, and then the average soil metal addition rate from all products of a fertilizer category was calculated. The **average** product of each fertilizer category is defined here as that product which would give the average soil addition rate of a given metal.

The fertilizer products that were analyzed in this way are those reported in Section 3, Tables 3-6 though 3-11, with some exceptions. Exceptions include those products for which the active ingredient percentage was not identified (e.g., Table 3-9 samples), the single magnesium fertilizer sample identified (Table 3-8), and the organic and/or biosolids fertilizers (Table 3-7).

Inasmuch as this report was designed to evaluate only the inorganic fertilizers, the organic fertilizers and/or soil amendments (sewage sludge, humus, compost, tankage, etc.) were not carried through this set of calculations. Those NPK fertilizers that were clearly identified as being "biosolids-based" were also eliminated from these calculations. In addition, soil amendments, potting soils, and "soil conditioners" were not carried through this set of calculations, this due in part because application rates were not fully characterized.

Tables 5-3a through 5-8a provide the summary of the average metals soil additions (kg/ha soil) that may result from average, high and maximum application rates of inorganic fertilizers, gypsum and lime. Tables 5-3b through 5-8b provide the summary of the average, high and maximum soil metal contaminant levels resulting from the individual products in each fertilizer category which give rise to the highest calculated soil loadings with the global average, high and maximum product-specific application rates.

Application of zinc fertilizers (Table 5-3a) at the maximum application rate results in soil additions of less than 0.1 kg/hectare of all metals except for lead (0.884 kg/hectare). Phosphate products (Table 5-3a) at the maximum application rate also result in metal addition to the soil of less than <0.1 kg/hectare for all metals except chromium (0.1 kg/hectare), vanadium (0.173 kg/ha) and zinc (0.150 kg/hectare). NPK fertilizers applied for N content (Table 5-4a) and applied at the maximum rate contribute 0.10 kg/ha/year of lead to the soil (Table 5-4a). Boron and K_20 fertilizers (Tables 5-5a and 5-6a) contribute extremely low levels of contaminants, generally <0.001 kg/ha/year at the maximum application rate, with exception of 0.023 kg/ha/year of arsenic from boron fertilizers. Iron fertilizers contribute almost 0.5 kg/ha/year of arsenic and 1.6 kg/ha/year of lead to the soil when applied at the maximum rate (Table 5-5a). The manganese fertilizers (Table 5-6a) contribute very low levels of contaminants, with the highest level contributed by the zinc in the manganese fertilizers at 0.004 kg/ha/year at the maximum application rate. Adding sulfur to the soil as a nutrient adds 0.18 kg/ha of zinc to the soil; adding sulfur for pH adjustment adds 0.11 kg/ha of copper to the soil each year (Table 5-7a) at the maximum application rate. Average additions of zinc and vanadium (0.48 and 0.30 kg/ha, respectively) are the highest metals additions from gypsum applications (Table 5-8a). Zinc, lead and copper (at 6.6, 0.69 and 0.63 kg/a, respectively) are the metals added in highest quantities with liming agents (Table 5-8a).

The data from Tables 5-3(a/b) to 5-8(a/b) are represented graphically in Figures 5-1 to 5-9. As shown in Figure 5-1, the data for Cd additions to soil from the different fertilizer types are compared, and those individual products which are known to be derived from industrial waste products are so indicated.

The number of metals analyzed in each fertilizer product varied from as few as one or two, to the entire suite of nine metals. In Tables 5-3a through 5-8a, the number of samples in which a Cd concentration was measured is given in the header information of that table. In general, Cd was the one metal analyzed most frequently. However, because some of the metals

were analyzed far less frequently than Cd, the number of samples, by fertilizer type, which provided concentration data for each metal have been tabulated (see Table 5-9).
As shown there, the data for several of the metals in several fertilizer types is limited, and this may significantly affect the accuracy of conclusions drawn about the soil additions of these metals.

This table provides a listing of the number of products in each fertilizer category for which metals data were available, and the number of those products which exceeded the annualized Canadian Fertilizers Regulations limits when applied at the nutrient application rates chosen here. Note that in each fertilizer category, metals concentrations were not available for all products. For example, for the P_2O_5 fertilizers, Cd levels were listed for 61 products, Pb levels were given for 58 products, As levels were given for 64 products, and so on. Several of the metals evaluated here, e.g., Cr, V, and Cu, do not have limits imposed by the Canadian regulations, and for these metals an accounting of exceedances was not necessary. The exceedances in Table 5-9 are listed separately in Table 5-10 by the number of products that exceed the Canadian standards at the average, high and maximum nutrient application rates evaluated here. For example, in the P_2O_5 products, the one product that exceeded the Canadian standards did so only at the maximum application rate. In the NPK products applied for P_2O_5 content (NPK-P), 5 products exceeded the Canadian standards at the high application rate, and 10 products exceeded the standard at the maximum application rate. One lime product exceeded standards for 5 of the metals at the average application rate; one NPK-P product exceeded Pb standards at the average application rate; and one iron product exceeded As standards at the average application rate.

Table 5-3a. Averaged Yearly Addition of Metals to Soil from All Products Applied at Average, High and Maximum Nutrient Application Rates: Zinc and Phosphate Fertilizers[a]

	Zinc Fertilizers at application rate (n=22)[b]			Phosphate (P_2O_5) Fertilizers at application rate (n=61)			U.S. 40 CFR Part 503 - Biosolids	Canadian Fertilizer Act
	average	high	maximum	average	high	maximum	kg/ha[c]	kg/ha[d]
Yearly Addition in kg/ha								
Cd	0.007	0.014	0.029	0.011	0.022	0.033	1.9	0.089
Pb	0.221	0.442	0.884	0.003	0.007	0.009	15	2.222
As	<0.001	0.001	0.002	0.002	0.005	0.007	2.0	0.333
Cr	0.011	0.021	0.042	0.034	0.070	0.102	nl[e]	nl
Hg	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.85	0.022
Ni	0.010	0.019	0.039	0.006	0.012	0.018	21	0.800
V	0.001	0.001	0.003	0.052	0.107	0.155	nl	nl
Cu	0.023	0.046	0.091	0.020	0.042	0.061	75	nl
Zn	NA[f]	NA	NA	0.050	0.103	0.150	140	8.222

a) Source: See Appendices G-5(a-d) for Zn fertilizers and G-1(a-e) for P_2O_5 fertilizers
b) Number of samples providing Cd values for calculation; number of samples providing other metals are listed in Table 5-9.
c) U.S. limits in kg/ha are annual pollutant loading rates
d) Canadian limits in kg/ha are long term cumulative additions; the numbers in the table were divided by 45 to be comparable to the U.S. annual pollutant loading rates
e) nl = no limits currently set
f) Not applicable: Zinc fertilizers are applied specifically to add zinc to the soil and/or crop.

Table 5-4a. Averaged Yearly Addition of Metals to Soil from All Products Applied at Average, High and Maximum Nutrient Application Rates: NPK for N Content and NPK for P Content Fertilizers[a]

	Applied for P Content NPK Fertilizers at application rate (n=91)[b]			Applied for N Content NPK Fertilizers at application rate (n=50)			U.S. 40 CFR Part 503 - Biosolids	Canadian Fertilizer Act
	average	high	maximum	average	high	maximum	kg/ha[c]	kg/ha[d]
Yearly Addition in kg/ha								
Cd	0.008	0.017	0.025	0.006	0.009	0.018	1.9	0.089
Pb	0.087	0.179	0.261	0.031	0.051	0.103	15	2.222
As	0.004	0.008	0.012	0.008	0.013	0.027	2	0.333
Cr	0.019	0.039	0.057	0.081	0.134	0.270	nl[e]	nl
Hg	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.85	0.022
Ni	0.006	0.013	0.019	0.018	0.030	0.061	21	0.8
V	0.042	0.087	0.127	0.106	0.176	0.354	nl	nl
Cu	0.013	0.028	0.040	0.064	0.107	0.215	75	nl
Zn	0.054	0.112	0.163	0.308	0.513	1.030	140	8.222

a) Source: See Appendices G-2 (a-e) for NPK-P and G-3(a-e) for NPK-N.
b) Number of samples providing Cd values for calculation; number of samples providing other metals are listed in Table 5-9
c) U.S. limits in kg/ha are annual pollutant loading rates
d) Canadian limits in kg/ha are long term cumulative additions so values were divided by 45 to approximate annual limits
e) nl = no limits currently set

Table 5-5a. Averaged Yearly Addition of Metals to Soil from All Products Applied at Average, High and Maximum Nutrient Application Rates: Boron and Iron Fertilizers[a]

	Boron Fertilizers at application rate (n=2)[b]			Iron Fertilizers at application rate (n=3)			U.S. 40 CFR Part 503 - Biosolids	Canadian Fertilizer Act
	average	high	maximum	average	high	maximum	kg/ha[c]	kg/ha[d]
Yearly Addition in kg/ha								
Cd	<0.001	<0.001	<0.001	0.009	0.018	0.027	1.9	0.089
Pb	<0.001	<0.001	<0.001	0.549	1.098	1.647	15	2.222
As	0.012	0.017	0.023	0.155	0.310	0.465[e]	2.0	0.333
Cr	<0.001	<0.001	<0.001	nt[f]	nt	nt	nl[g]	nl
Hg	<0.001	<0.001	<0.001	nt	nt	nt	0.85	0.022
Ni	<0.001	<0.001	<0.001	nt	nt	nt	21	0.800
V	<0.001	0.001	0.001	nt	nt	nt	nl	nl
Cu	<0.001	<0.001	<0.001	0.051	0.102	0.153	75	nl
Zn	<0.001	0.001	0.001	nt	nt	nt	140	8.222

a) Source: See Appendix G-7(a-e) for Boron and G-8(a-e) for Iron
b) Number of samples providing Cd values for calculation; number of samples providing other metals are listed in Table 5-9
c) U.S. limits in kg/ha are annual pollutant loading rates
d) Canadian limits in kg/ha are long term cumulative additions so values were divided by 45 to approximate annual limits
e) Shading indicates that value exceeds Canadian standard
f) nt = analyte not tested in fertilizers
g) nl = no limits currently set

Table 5-6a. Averaged Yearly Addition of Metals to Soil from All Products Applied at Average, High and Maximum Nutrient Application Rates: Potash and Manganese Fertilizers[a]

	K_2O Fertilizers at Application Rate (n=42)[b]			Manganese Fertilizers at Application Rate (n=2)			U.S. 40 CFR Part 503 - Biosolids	Canadian Fertilizer Act
	average	high	maximum	average	high	maximum	kg/ha[c]	kg/ha[d]
Yearly Addition in kg/ha								
Cd	<0.001	<0.001	0.001	<0.001	<0.001	<0.001	1.9	0.089
Pb	0.001	0.001	0.003	<0.001	0.001	0.002	15	2.222
As	<0.001	<0.001	<0.001	<0.001	<0.001	0.001	2.0	0.333
Cr	<0.001	0.001	0.001	<0.001	<0.001	0.001	nl[e]	nl
Hg	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.85	0.022
Ni	<0.001	<0.001	0.002	0.001	0.002	0.003	21	0.800
V	<0.001	0.001	0.002	<0.001	<0.001	<0.001	nl	nl
Cu	<0.001	<0.001	0.001	<0.001	<0.001	0.001	75	nl
Zn	<0.001	0.001	0.002	0.001	0.002	0.004	140	8.222

a) Source: See Appendices G-4(a-e) for Potash and G-6(a-e) and Manganese
b) Number of samples providing Cd values for calculation; number of samples providing other metals are listed in Table 5-9.
c) U.S. limits in kg/ha are annual pollutant loading rates
d) Canadian limits in kg/ha are long term cumulative additions so values were divided by 45 to approximate annual limits.
e) nl = no limits currently set

Table 5-7a. Averaged Yearly Addition of Metals to Soil from All Products Applied at Average, High and Maximum Nutrient Application Rates: Sulfur (Nutrient) and Sulfur (pH Adjustment) Fertilizers[a]

	Sulfur (nutrient) at application rate (n = 9)[b]			Sulfur (pH adjustment) at application rate (n = 5)			U.S. 40 CFR Part 503 - Biosolids	Canadian Fertilizer Act
	average	high	maximum	average	high	maximum	kg/ha[c]	kg/ha[d]
Yearly Addition in kg/ha								
Cd	0.003	0.005	0.008	<0.001	<0.001	<0.001	1.9	0.089
Pb	<0.001	0.001	0.001	0.002	0.006	0.007	15	2.222
As	<0.001	<0.001	0.001	0.007	0.017	0.022	2.0	0.333
Cr	0.009	0.017	0.026	nt[e]	nt	nt	nl[f]	nl
Hg	<0.001	<0.001	<0.001	nt	nt	nt	0.85	0.022
Ni	0.008	0.016	0.023	nt	nt	nt	21	0.800
V	0.016	0.032	0.048	nt	nt	nt	nl	nl
Cu	0.001	0.002	0.002	0.036	0.090	0.113	75	nl
Zn	0.060	0.120	0.181	nt	nt	nt	140	8.222

a) Source: See Appendices G-9(a-e) sulfur (nutrient) and G-10(a-e) for sulfur (pH adjustment)
b) Number of samples providing Cd values for calculation; number of samples providing other metals are listed in Table 5-9.
c) U.S. limits in kg/ha are annual pollutant loading rates
d) Canadian limits in kg/ha are long term cumulative additions so values were divided by 45 to approximate annual limits.
e) nt = analyte not tested in fertilizers; NPKS and sulfur used for S-nutrient addition; only sulfur products used for pH adjustment
f) nl = no limits currently set

Table 5-8a. Averaged Yearly Addition Addition of Metals to Soil from All Products Applied at Average, High and Maximum Nutrient Application Rates: Gypsum and Liming Materials[a]

	Gypsum at Application Rate (n=4)[b]			Lime at Application Rate (n=10)[b]			U.S. 40 CFR Part 503 - Biosolids	Canadian Fertilizer Act
	average	high	maximum	average	high	maximum	kg/ha[c]	kg/ha[d]
Yearly Addition in kg/ha				(for year in which addded)[e]				
Cd	0.002	0.004	0.007	0.017	0.034	0.064	1.9	0.089
Pb	0.010	0.021	0.041	0.902	1.804	3.383[f]	15	2.222
As	0.010	0.020	0.040	0.344	0.689	1.292	2.0	0.333
Cr	0.003	0.006	0.013	0.371	0.742	1.391	nl[g]	nl
Hg	<0.001	<0.001	<0.001	0.003	0.007	0.013	0.85	0.022
Ni	0.007	0.013	0.027	0.200	0.400	0.750	21	0.800
V	0.076	0.152	0.303	0.348	0.696	1.305	nl	nl
Cu	0.053	0.106	0.212	0.910	1.819	3.411	75	nl
Zn	0.121	0.241	0.482	4.456	8.911	16.708	140	8.222
Yearly Addition in kg/ha				(average over 3 years)[h]				
Cd				0.006	0.011	0.021	1.9	0.089
Pb				0.300	0.601	1.127	15	2.222
As				0.115	0.230	0.431	2.0	0.333
Cr				0.124	0.247	0.464	nl	nl
Hg				0.001	0.002	0.004	0.85	0.022
Ni				0.067	0.133	0.250	21	0.800
V				0.116	0.232	0.435	nl	nl
Cu				0.303	0.606	1.137	75	nl
Zn				1.485	2.970	5.569	140	8.222

a) Source: See Appendices G-11(a-e) for lime and G-12(a-e) for gypsum
b) Number of samples providing Cd values for calculation; number of samples providing other metals are listed in Table 5-9
c) U.S. limits in kg/ha are annual pollutant loading rates
d) Canadian limits in kg/ha are long term cumulative additions, so values were divided by 45 to approximate annual limits
e) Additions of metals for lime addition based on year in which application is made. Lime typically added only once every three years
f) Shading indicates value exceeds Canadian standard
g) nl = no limits currently set
h) Values listed in this portion of the table are the metals additions averaged over 3 years

Table 5-3b. Highest Yearly Addition of Metals to Soil from an Individual Product, Applied at Average, High and Maximum Nutrient Application Rates: Zinc and Phosphate Fertilizers[a]

	Zinc Fertilizers at application rate			Phosphate (P_2O_5) Fertilizers at application rate			U.S. 40 CFR Part 503 - Biosolids	Canadian Fertilizer Act
	average	high	maximum	average	high	maximum	kg/ha[b]	kg/ha[c]
Yearly Addition in kg/ha								
Cd	0.036	0.071	0.143[d]	0.038	0.078	0.113	1.9	0.089
Pb	0.856	1.713	3.426	0.094	0.194	0.282	15	2.222
As	0.001	0.003	0.006	0.006	0.013	0.018	2.0	0.333
Cr	0.018	0.036	0.072	0.124	0.256	0.372	nl[e]	nl
Hg	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.85	0.022
Ni	0.086	0.172	0.344	0.032	0.065	0.095	21	0.800
V	0.001	0.003	0.005	0.151	0.311	0.452	nl	nl
Cu	0.064	0.128	0.255	0.550	1.135	1.650	75	nl
Zn	NA[f]	NA	NA	0.324	0.668	0.971	140	8.222

a) Source: See Appendices G-5(a-d) for zinc fertilizers and G-1(a-e) for P_2O_5 fertilizers
b) U.S. limits in kg/ha are annual pollutant loading rates
c) Canadian limits in kg/ha are long term cumulative additions); the numbers in the table were divided by 45 to be comparable to the U.S. annual pollutant loading rates
d) Shading indicates value exceeds Canadian standard
e) nl = no limits currently set
f) Not applicable: Zinc fertilizers are applied specifically to add zinc to the soil and/or crop.

Table 5-4b. Highest Yearly Addition of Metals to Soil from an Individual Product, Applied at Average, High and Maximum Nutrient Application Rates: NPK for N Content and NPK for P content Fertilizers[a]

	Applied for P Content: NPK Fertilizers at application rate			Applied for N Content: NPK Fertilizers at application rate			U.S. 40 CFR Part 503 - Biosolids	Canadian Fertilizer Act
	average	high	maximum	average	high	maximum	kg/ha[b]	kg/ha[c]
Yearly Addition in kg/ha								
Cd	0.074	0.154[d]	0.223	0.022	0.036	0.074	1.9	0.089
Pb	2.820	5.820	8.460	0.652	1.083	2.176	15	2.222
As	0.112	0.231	0.336	0.049	0.081	0.162	2	0.333
Cr	0.126	0.260	0.378	0.312	0.519	1.042	nl[e]	nl
Hg	<0.001	<0.001	<0.001	<0.001	<0.001	0.001	0.85	0.022
Ni	0.092	0.189	0.275	0.119	0.198	0.398	21	0.8
V	0.186	0.384	0.558	0.639	1.063	2.134	nl	nl
Cu	0.353	0.728	1.058	1.080	1.795	3.606	75	nl
Zn	0.696	1.436	2.087	6.860	11.401	22.901	140	8.222

a) Source: See Appendices G-2 (a-e) for NPK-P and G-3(a-e) NPK-N.
b) U.S. limits in kg/ha are annual pollutant loading rates
c) Canadian limits in kg/ha are long term cumulative additions so values were divided by 45 to approximate annual limits.
d) Shading indicates value exceeds Canadian standard.
e) nl = no limits currently set

Table 5-5b. Highest Yearly Addition of Metals to Soil from an Individual Product, Applied at Average, High and Maximum Nutrient Application Rates: Boron and Iron Fertilizers[a]

	Boron Fertilizers at application rate			Iron Fertilizers at application rate			U.S. 40 CFR Part 503 - Biosolids	Canadian Fertilizer Act
	average	high	maximum	average	high	maximum	kg/ha[b]	kg/ha[c]
Yearly Addition in kg/ha								
Cd	<0.001	<0.001	<0.001	0.025	0.050	0.075	1.9	0.089
Pb	<0.001	<0.001	<0.001	1.400	2.800[d]	4.200	15	2.222
As	0.023	0.035	0.047	0.462	0.924	1.386	2.0	0.333
Cr	<0.001	<0.001	<0.001	nt[e]	nt	nt	nl[f]	nl
Hg	<0.001	<0.001	<0.001	nt	nt	nt	0.85	0.022
Ni	<0.001	<0.001	<0.001	nt	nt	nt	21	0.800
V	<0.001	0.001	0.001	nt	nt	nt	nl	nl
Cu	<0.001	<0.001	<0.001	0.131	0.261	0.392	75	nl
Zn	<0.001	0.001	0.001	nt	nt	nt	140	8.222

a) Source: See Appendix G-7(a-e) for boron and G-8(a-e) for iron
b) U.S. limits in kg/ha are annual pollutant loading rates
c) Canadian limits in kg/ha are long term cumulative additions so values were divided by 45 to approximate annual limits
d) Shading indicates value exceeds Canadian standard
e) nt = analyte not tested in fertilizers
f) Standards are not specified in these units

Table 5-6b. Highest Yearly Addition of Metals to Soil from an Individual Product, Applied at Average, High and Maximum Nutrient Application Rates: Potash and Manganese Fertilizers[a]

	K_2O Fertilizers at Application Rate			Manganese Fertilizers at Application			U.S. 40 CFR Part 503 - Biosolids	Canadian Fertilizer Act
	average	high	maximum	average	high	maximum	kg/ha[b]	kg/ha[c]
Yearly Addition in kg/ha								
Cd	<0.001	0.001	0.002	<0.001	<0.001	<0.001	1.9	0.089
Pb	0.002	0.004	.012	0.001	0.002	0.003	15	2.222
As	<0.001	0.001	0.002	<0.001	0.001	0.001	2.0	0.333
Cr	0.001	0 .002	0 .007	<0.001	<0.001	0.001	nl[d]	nl
Hg	<0.001	<0.001	0.001	<0.001	<0.001	<0.001	0.85	0.022
Ni	0.001	0.002	0.004	0.001	0.002	0.003	21	0.800
V	0.005	0.008	0.024	<0.001	<0.001	<0.001	nl	nl
Cu	0.002	0.004	0.013	<0.001	0.001	0.001	75	nl
Zn	0.004	0.008	0.023	0.001	0.002	0.004	140	8.222

a) Source: See Appendices G-4(a-e) for K_2O and G-6(a-e) for manganese
b) U.S. limits in kg/ha are annual pollutant loading rates
c) Canadian limits in kg/ha are long term cumulative additions so values were divided by 45 to approximate annual limits.
d) nl = no limits currently set

Table 5-7b. Highest Yearly Maximum Addition of Metals to Soil from an Individual Product, Applied at Average, High and Maximum Nutrient Application Rates: Sulfur (Nutrient) and Sulfur (pH Adjustment) Fertilizers[a]

	Sulfur (nutrient) at application rate			Sulfur (pH adjustment) at application rate			U.S. 40 CFR Part 503 - Biosolids	Canadian Fertilizer Act
	average	high	maximum	average	high	maximum	kg/ha[b]	kg/ha[c]
Yearly Addition in kg/ha								
Cd	0.023	0.046	0.070	<0.001	<0.001	<0.001	1.9	0.089
Pb	0.001	0.003	0.004	0.008	0.019	0.024	15	2.222
As	0.001	0.001	0.002	0.017	0.043	0.053	2.0	0.333
Cr	0.034	0.068	0.103	nt[d]	nt	nt	nl[e]	nl
Hg	<0.001	<0.001	<0.001	nt	nt	nt	0.85	0.022
Ni	0.031	0.062	0.094	nt	nt	nt	21	0.800
V	0.063	0.127	0.190	nt	nt	nt	nl	nl
Cu	0.003	0.005	0.008	0.098	0.244	0.305	75	nl
Zn	0.237	0.474	0.710	nt	nt	nt	140	8.222

a) Source: See Appendices G-9(a-e) for sulfur (nutrient) and G-10(a-e) for sulfur (pH adjustment)
b) U.S. limits in kg/ha are annual pollutant loading rates
c) Canadian limits in kg/ha are long term cumulative additions so values were divided by 45 to approximate annual limits.
d) nt = analyte not tested in fertilizers
e) nl = no limits currently set

Table 5-8b. Highest Yearly Addition of Metals to Soil from an Individual Product, Applied at Average, High and Maximum Nutrient Application Rates: Gypsum and Liming Materials[a]

	Gypsum at Application Rate			Lime at Application Rate			U.S. 40 CFR Part 503 - Biosolids	Canadian Fertilizer Act
	average	high	maximum	average	high	maximum	kg/ha[b]	kg/ha[c]
Yearly Addition in kg/ha				(for year in which added)[d]				
Cd	0.006	0.011	0.022	0.044	0.088	0.165	1.9	0.089
Pb	0.025	0.049	0.099	7.368	14.737	27.632	15	2.222
As	0.019	0.038	0.076	2.829	5.659	10.611	2.0	0.333
Cr	0.003	0.006	0.013	2.004	4.008	7.515	nl[f]	nl
Hg	<0.001	<0.001	<0.001	0.024	0.049	0.092	0.85	0.022
Ni	0.007	0.013	0.027	1.356	2.712	5.085	21	0.800
V	0.112	0.224	0.448	2.417	4.834	9.064	nl	nl
Cu	0.094	0.188	0.376	6.838	13.676	25.643	75	nl
Zn	0.121	0.241	0.482	24.994	49.987	93.726	140	8.222
				(average over 3 years)[g]				
Cd				0.015	0.029	0.055	1.9	0.089
Pb				2.456	4.912	9.211	15	2.222
As				0.943	1.886	3.537	2.0	0.333
Cr				0.668	1.336	2.505	nL	nl
Hg				0.008	0.016	0.031	0.85	0.022
Ni				0.452	0.904	1.695	21	0.800
V				0.806	1.611	3.021	nl	nl
Cu				2.279	4.559	8.548	75	nl
Zn				8.331	16.662	31.242	140	8.222

a) Source: See Appendices G-11(a-e) for gypsum and G-12(a-e) for liming materials
b) U.S. limits in kg/ha are annual pollutant loading rates
c) Canadian limits in kg/ha are long term cumulative additions so values were divided by 45 to approximate annual limits.
d) Lime is usually applied only once every 3 years. Values listed in this portion of the table are the metals additions added in the year of application.
e) Shading indicates value exceeds Canadian standard
f) nl = no limits currently set
g) Lime is usually applied only once every 3 years. Values listed in this portion of the table are the metals additions averaged over 3 years.

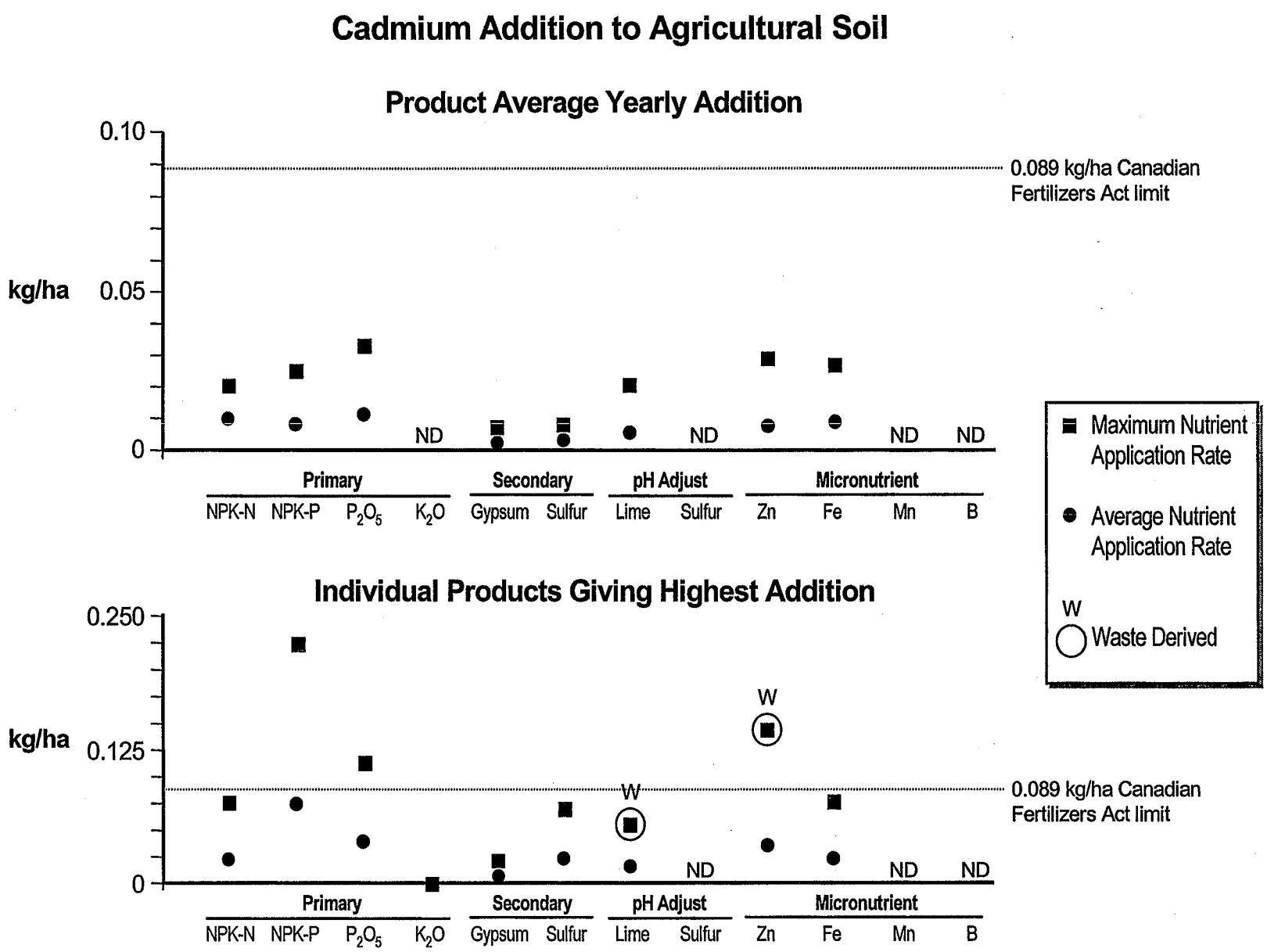

Figure 5-1. Cadmium Addition to Agricultural Soil from Twelve Fertilizer Types

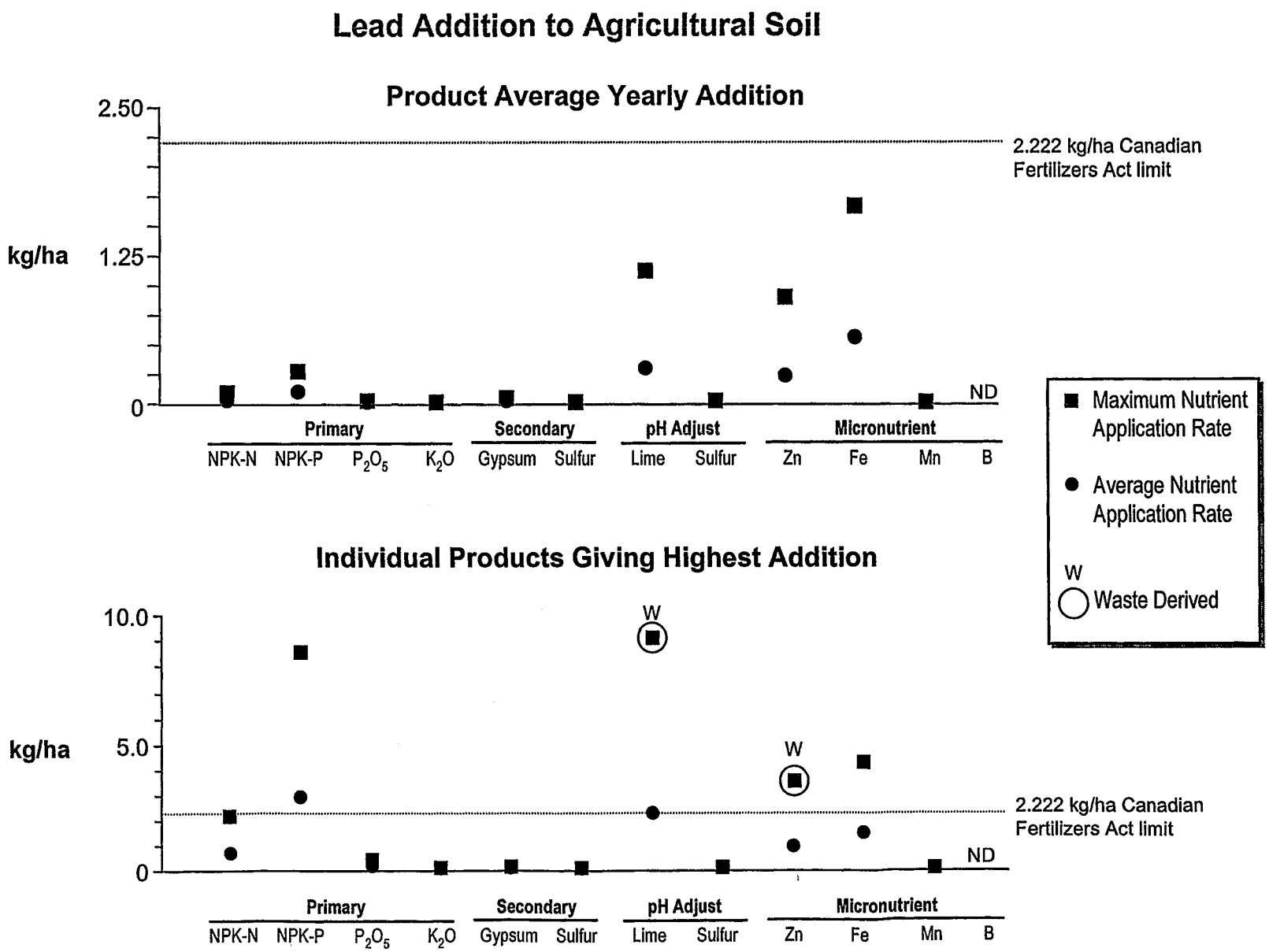

Figure 5-2. Lead Addition to Agricultural Soil from Twelve Fertilizer Types

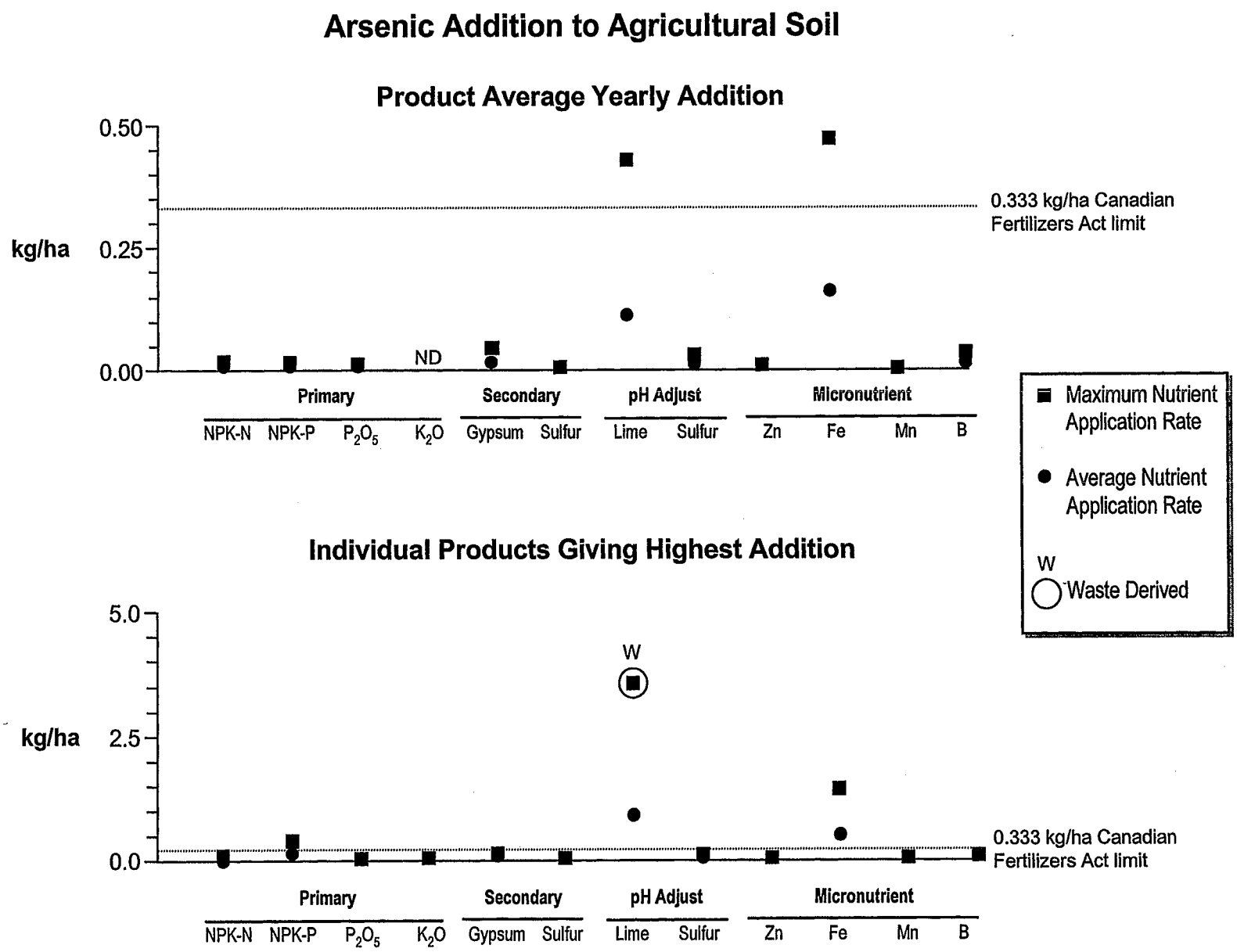

Figure 5-3. Arsenic Addition to Agricultural Soil from Twelve Fertilizer Types

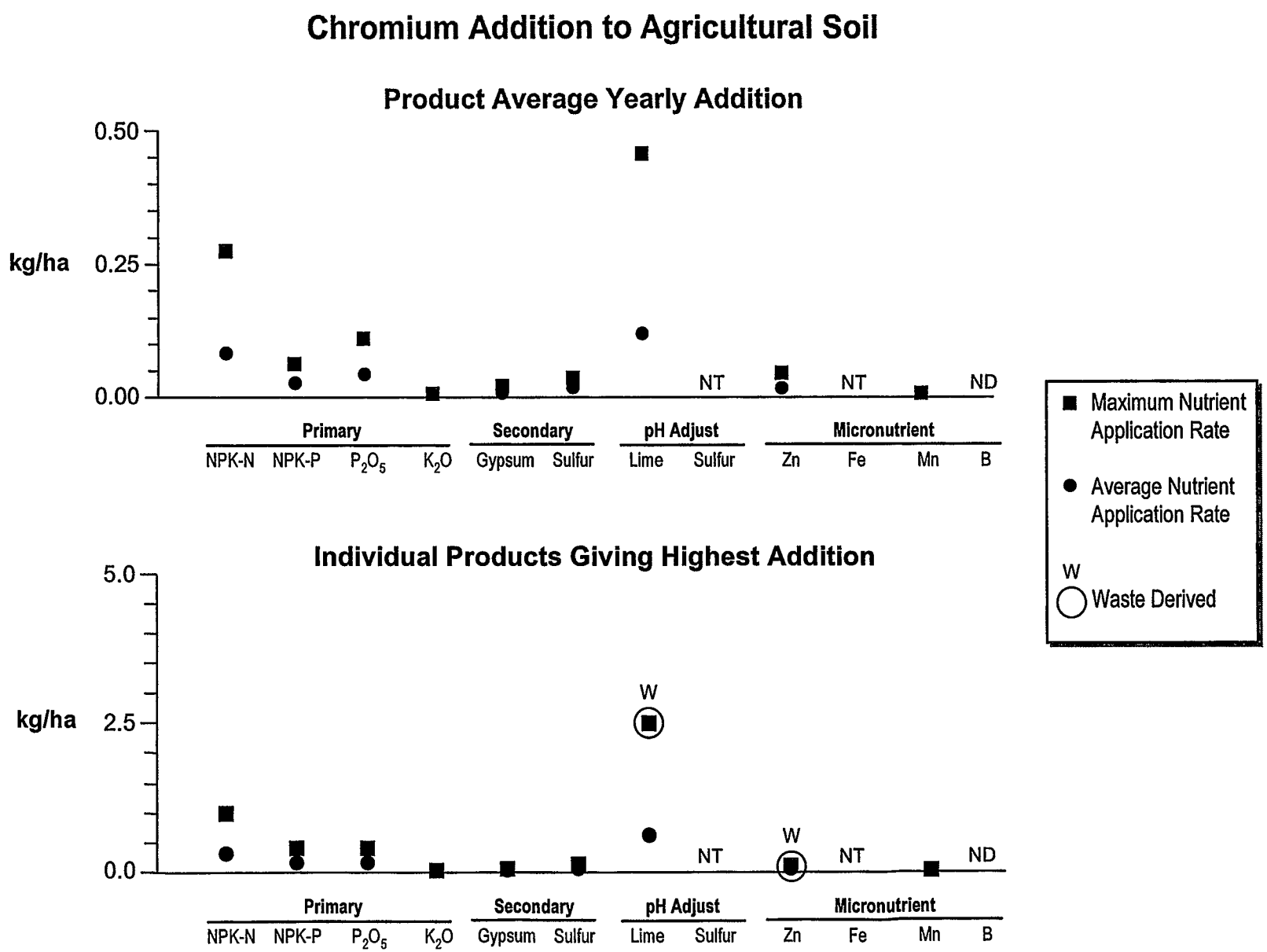

Figure 5-4. Chromium Addition to Agricultural Soil from Twelve Fertilizer Types

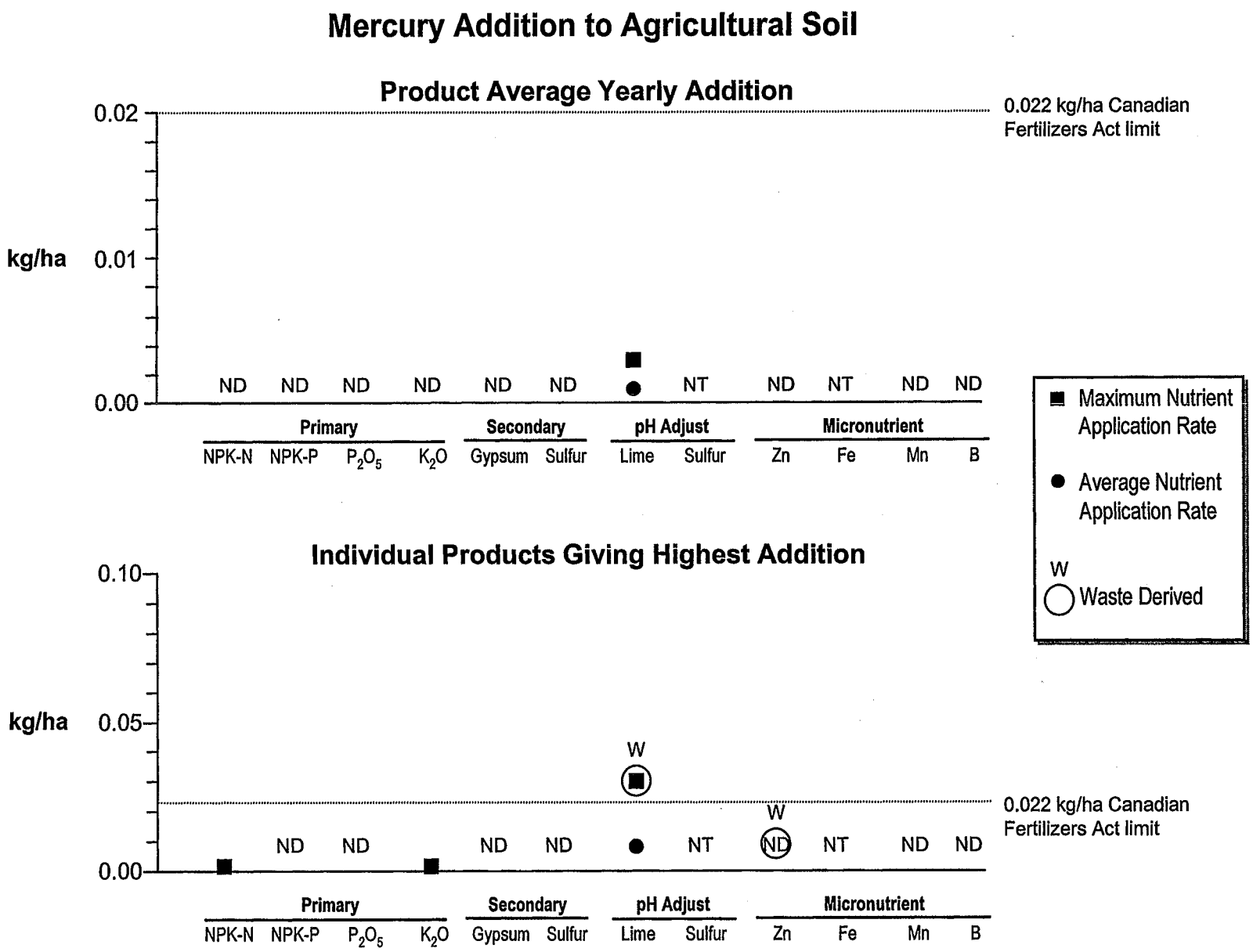

Figure 5-5. Mercury Addition to Agricultural Soil from Twelve Fertilizer Types

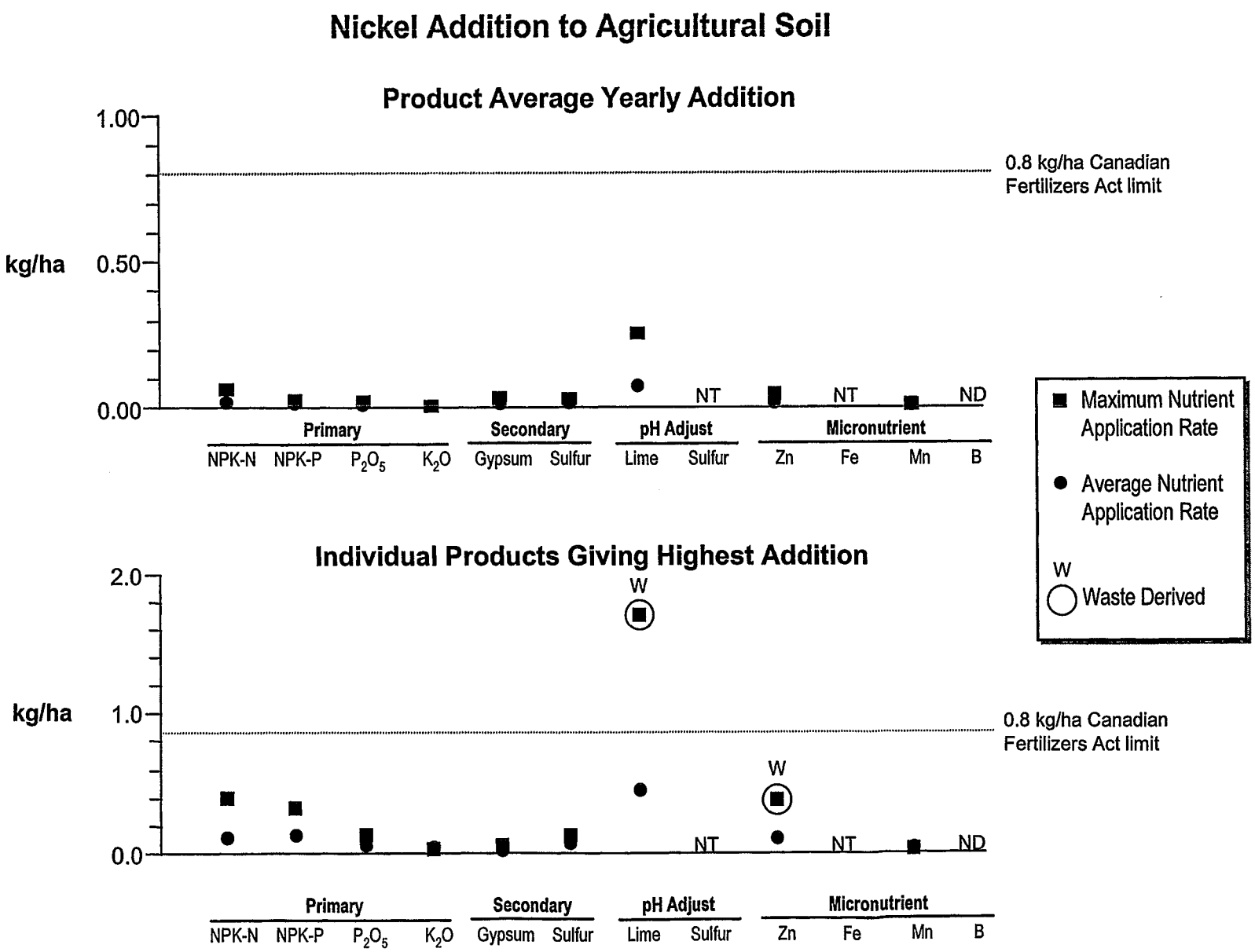

Figure 5-6. Nickel Addition to Agricultural Soil from Twelve Fertilizer Types

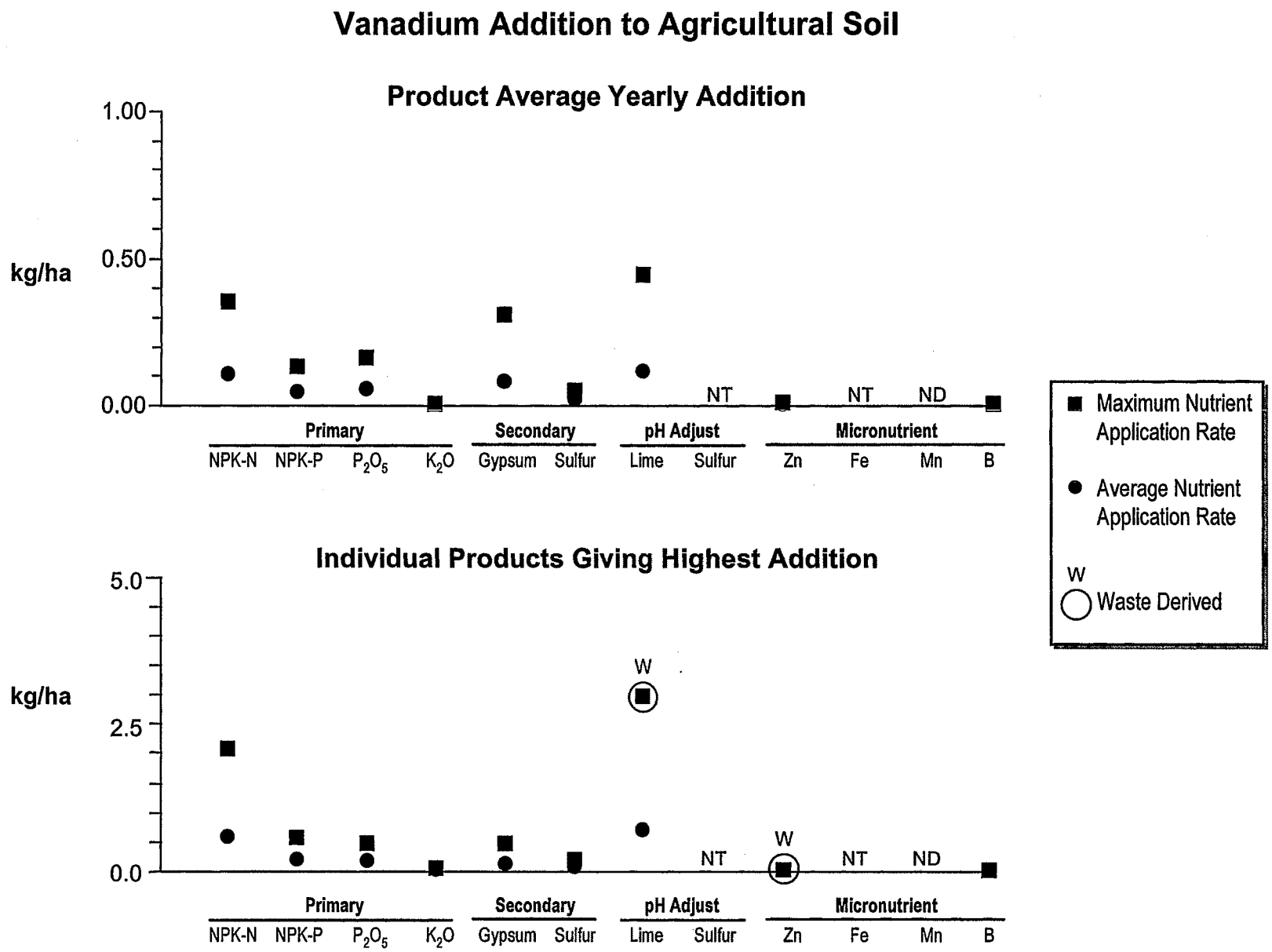

Figure 5-7. Vanadium Addition to Agricultural Soil from Twelve Fertilizer Types

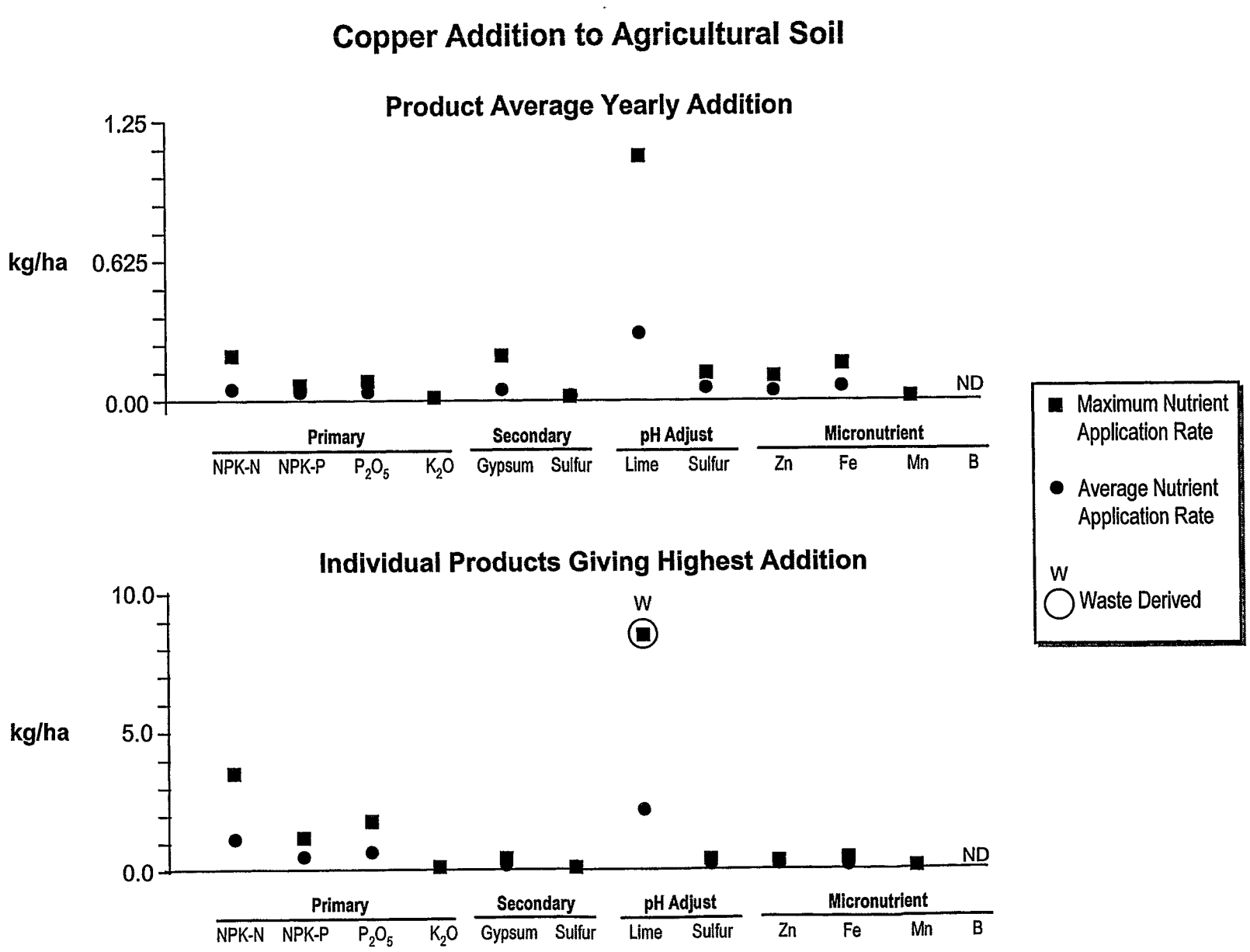

Figure 5-8. Copper Addition to Agricultural Soil from Twelve Fertilizer Types

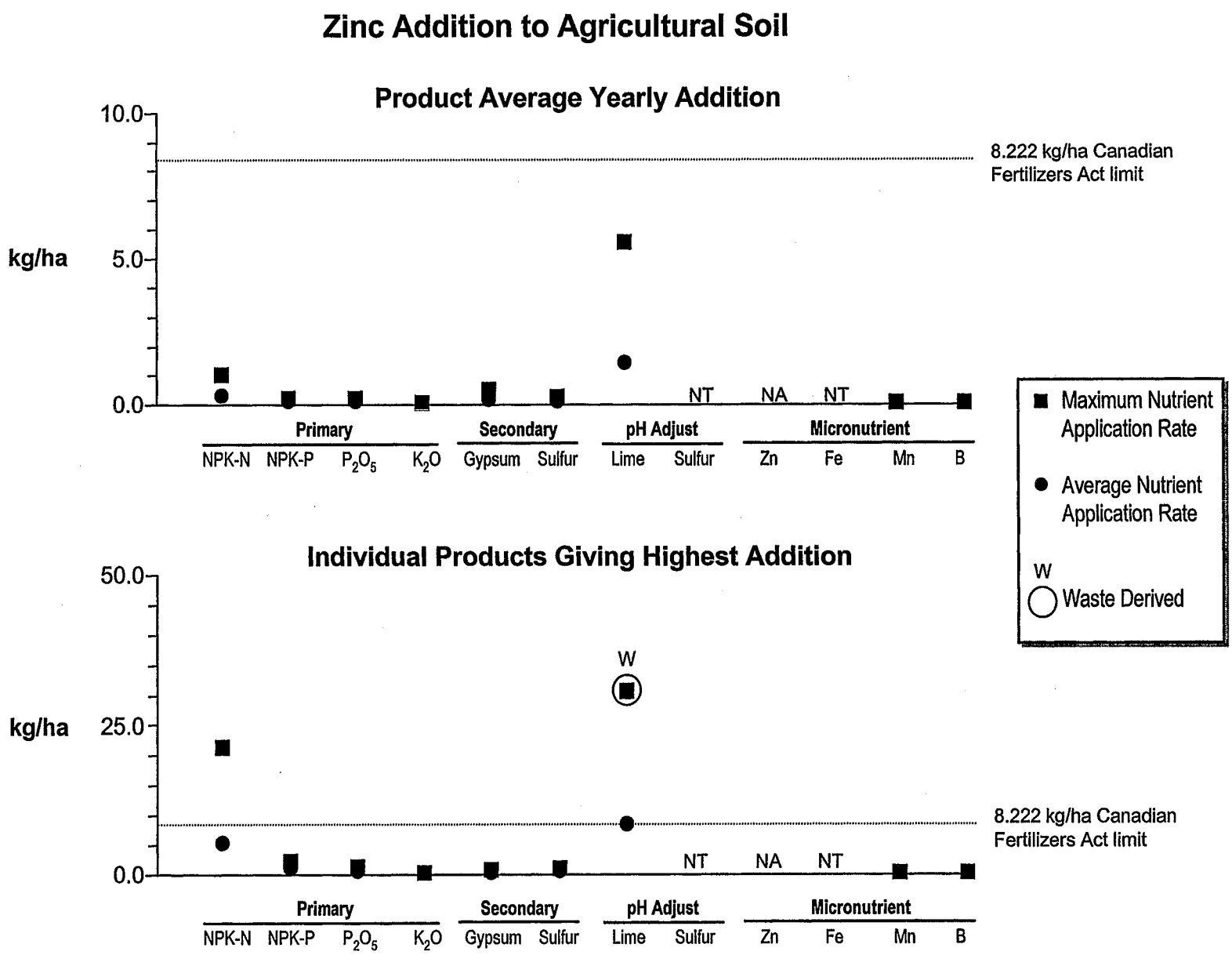

Figure 5-9. Zinc Addition to Agricultural Soil from Twelve Fertilizer Types

Table 5-9. Number of Fertilizer Products Included in Calculation of Average Yearly Additions of Metals to Soil Number of Products[a] (Number of Products That Exceed Canadian Standard)[b]

Fertilizer	Cd	Pb	As	Cr	Hg	Ni	V	Cu	Zn
P_2O_5	61(1)	58(0)	64(0)	27[c]	4(0)	33(0)	8[c]	58[c]	28(0)
NPK-N	50(0)	50(1)	50(0)	40	43(0)	43(0)	43	49	39(0)
NPK-P	91(10)	91(4)	84(1)	60	14(0)	70(0)	14	89	67(0)
K_2O	42(0)	42(0)	17(0)	15	16(0)	41(0)	16	42	39(0)
Zn	22(3)	63(6)	6(0)	2	1(0)	11(0)	2	6	NA
Mn	2(0)	2(0)	2(0)	1	1(0)	1(0)	1	2	1(0)
Fe	3(0)	3(1)	3(1)	0	0(-)[d]	0(-)	0	3	0(-)
Sulfur-Nutrient	9(0)	9(0)	9(0)	4	4(0)	4(0)	4	9	4(0)
Sulfur-pH	5(0)	5(0)	5(0)	0	0(-)	0(-)	0	5	0(-)
Boron	2(0)	2(0)	2(0)	1	1(0)	1(0)	1	2	1(0)
Lime[e]	10(3)	10(2)	10(3)	7	8(1)	8(1)	8	9	7(2)
Gypsum	4(0)	4(0)	4(0)	1	1(0)	1(0)	4	4	1(0)

a) Number of products analyzed for individual yearly addition and average for fertilizer type yearly addition of metals to soil.
b) Number of individual products that exceed annualized Canadian Fertilizers Act limits at either the average, high, or maximum product application rate.
c) Metal for which there is no Canadian Fertilizers Act limit.
d) No products identified in literature with specific concentration given for this metal.
e) Exceedances are based on the year in which applied. See footnotes regarding lime applications in Table G11(a-e).

Table 5-10. Number of Products That Exceed the Canadian Fertilizers Regulation Standards at the Average, High and Maximum Nutrient Application Rates of the Product

Fertilizer	Cd	Pb	As	Hg	Ni	Zn
P_2O_5	0-0-1[a] (n=61)	NE[b]	NE	NE	NE	NE
NPK-N	NE	NE	NE	NE	NE	0-1-1 (n=49)
NPK-P	0-5-10 (n=91)	1-3-4 (n=91)	0-0-1 (n=84)	NE	NE	NE
K_2O	NE	NE	NE	NE	NE	NE
Zinc	0-0-3 (n=22)	0-0-6 (n=63)	NE	NE	NE	NA[c]
Manganese	NE	NE	NE	NE	NE	NE
Iron	NE	0-0-1 (n=3)	1-1-1 (n=3)	NP[d]	NP	NP
Sulfur-nutrient	NE	NE	NE	NE	NE	NE
Sulfur-pH	NE	NE	NE	NP	NP	NP
Boron	NE	NE	NG	NE	NE	NE
Lime[e]	0-0-3 (n=10)	1-1-2[e] (n=10)	1-3-3 (n=10)	1-1-1 (n=8)	1-1-1 (n=8)	2-2-2 (n=7)
Gypsum	NE	NE	NE	NE	NE	NE

a) 0-0-1: Number of products that exceed the Canadian Fertilizer standard at the average - high - maximum application rate of the product type.
b) NE: No exceedances of the Canadian Fertilizer standard at any application rate for the product type.
c) NA: Not applicable (Zinc in zinc products).
d) NP: No products in which this element measured.
e) Exceedances are based on the year in which lime is applied. See Footnotes regarding lime applications in Tables G-11(a-e).

5.3 ADDITIONAL DATA PROVIDED ON BLENDED PRODUCTS

The inventory of heavy metals additions to soil from NPK fertilizers applied for N content (NPK-N) was largely supplied by the Pennsylvania Department of Agriculture (PDA). The PDA measured concentrations of heavy metals in 125 diverse fertilizers during the first half of 1998. The 125 products tested were selected to represent a cross-section of fertilizer products distributed in Pennsylvania; 32 were solid NPK formulations for the agricultural market, 20 were solid NPK formulations with micronutrients for the agricultural market, 35 were specialty fertilizers for the residential market, 25 were NPK liquid fertilizers, and 20 were primary ingredients. The concentrations of heavy metals in these samples are listed in Appendix H, Tables H-1 through H-5.

These PDA products differed from the products obtained from other surveys, and only selected products were readily amenable to inclusion in the calculations of Appendix G of this report. The 32 solid NPK fertilizer blends were included in the NPK-N (NPK fertilizers applied for N content) portion of Appendix G for determination of an average addition of metals from this class of fertilizers. The NPK blends with micronutrients were not used in the NPK category because the added micronutrients were not specified and their concentrations may have governed the application rates. The specialty fertilizers were not used in Appendix G, as these were listed as products for the residential market; many were listed as being either biosolids-based, organic (e.g., made from fish meal), or blended with micronutrients. The fertilizers listed as "Ag liquid" had the notation that they were applied to land at much lower application rates than solid fertilizers. Because of that caveat, and the fact that no typical application rates were available, these fertilizers were not included in Appendix G of this report. Appendix H of this report, though, does include a listing of metals concentrations in these sample fertilizers, and may be used for reference with the data presented elsewhere in the report.

The data provided by PDA provides important insight into the manner in which fertilizers are now being blended on a custom basis for each farm, soil and crop type. With the proliferation of rapid soil nutrient testing procedures, and computerized calculations of nutrient need vs available nutrient, it is clear that blending of products on a case-by-case basis provides the optimal fertilizer for each application. This customization, though, means that from a survey perspective, it may be very difficult to ascertain the broad range of formulations and application rates that are being used across the country.

In general, the range of metals concentrations in the fertilizers that are found in these PDA samples are similar to the range identified from other studies. The solid NPK ferilizers blended with micronutrients tend to have higher levels of copper, lead, mercury and zinc than that found in the straight NPK blends. Inasmuch as the micronutrient fertilizers tend to have higher metals levels than the NPK fertilizers, it is apparent that the higher levels of heavy metals in the NPK/micronutrient blends are probably due to the added micronutrients. The specialty fertilizers for the residential market, in some cases, also had higher than average levels of copper, lead, mercury and zinc. Presumably, these fertilizers either are biosolids-based or contain micronutrients.

The NPK blends were compared for the metal addition rates that would result from application of the product according to either the N content, the P_2O_5 content, or the K_2O content.

The data for individual products are listed in Appendix H, Tables H-6 through H-10. The summary statistics for these comparisons are listed in Appendix H Table H-11. The summary statistics include the mean, median and range of soil metals additions for the NPK products, when applied for either N, P or K content at the average, high or maximum application rate. As shown there, application rates used according to N content result in the highest soil loadings of the heavy metals, relative to the P_2O_5 and K_2O application rates. The average of all the NPK products, applied at the highest N application rate, is, in all cases, lower than the Canadian Fertilizer Acts limits for annualized additions for cadmium, lead, arsenic, copper, zinc and mercury.

5.4 COMPARISON OF METAL CONCENTRATIONS IN SOIL TO NATIONAL AND INTERNATIONAL STANDARDS

The Canadian Fertilizers Act, described in Section 4.3.1, and the 40 CRF Part 503 Biosolids Standards (Section 4.4.1) may be used for comparison to the values presented in section 5.2 for metal addition to land from fertilizer application. Although the biosolids regulation may not be appropriate because we have not considered metal availability, soil type, and soil and organic matter content, these values provide a guideline for the comparisons. The Canadian Fertilizers Regulations specifies limits in terms of the maximum acceptable cumulative metal addition to soil (kg/ha) and the maximum acceptable metal concentrations in fertilizer products (mg/kg dry weight). Since the Canadian regulations for the maximum acceptable cumulative additions to the soil are long-term standards (45 years), these contaminant limits have been divided by 45 for comparison to the calculated values and to the U.S. biosolids annual pollutant loading rates in Tables 5-3a to 5-8a. The biosolids rule presents the annual pollutant loading rate for land (kg/ha/year) and the ceiling concentration for land application (mg/kg product). The soil values can be used for comparison to the concentrations calculated in Section 5.2 (kg/ha). We have assumed that the application rates are for a yearly basis (i.e., may combine multiple applications of a single product), but we have not considered simultaneous application of several fertilizer types.

The U.S. biosolids annual pollutant loading rate for land application (kg/ha/year) range from 0.85 for mercury to 140 for zinc. Comparison of these values to those in Tables 5-3a to 5-8a show that even based on the worst case assumptions, additions of metals to soil for the averaged fertilizers presented in Appendix G are generally two orders of magnitude lower than is specified in the biosolids regulation. When compared to the Canadian limits (divided by 45 to approximate annualized pollutant loading rates), only two fertilizer averages exceed the limits: arsenic from iron fertilizers and arsenic from liming materials exceed the limit when these products are applied at the maximum application rate. Based upon the maximum application rate and the contaminant levels from the individual products in each fertilizer category which give rise to the calculated highest soil loadings for each metal (Tables 5-3b to 5-8b), six fertilizer products exceed the Canadian Fertilizer Act limits for at least one metal: cadmium and lead in zinc fertilizers, cadmium in phosphate fertilizers, cadmium, arsenic, and lead in NPK fertilizers applied for P content, zinc in NPK fertilizers applied for N content, lead and arsenic in iron fertilizers, and lead, arsenic, mercury, nickel and zinc in liming materials.

5.5 COMPARISON OF FERTILIZER AGRONOMIC PRACTICES WITH BACKGROUND SOIL METAL CONCENTRATIONS

The calculated yearly additions of metals to soils (mg/kg of soil) due to each fertilizer class (Tables 5-3 to 5-8, a and b) were combined with the average (geometric mean) background soil metals levels to estimate the number of years of continuous applications that would be required for the doubling of background soil metals concentrations (Mortvedt, 1987). There is not necessarily any human health or environmental consequence from a doubling of the soil metal background level. Potential human and environmental effects depend upon many factors that are not considered in this report. The calculation of the number of years to double soil contaminants is, however, a method for comparing increases of contaminant levels in soils resulting from application of different types of fertilizers at different application rates. The number of years to double the background level is obtained by dividing the background soil level by the yearly soil addition rate. This approach assumes that there is no plant uptake of the metals (or that metals taken up are returned to the soil when stems, leaves, roots, etc, are returned to the field), that metals are not lost from the top 15 cm of soil via runoff, wind-borne resuspension, and/or percolation and leaching into lower depths of the soil, and that wet and dry atmospheric deposition of metals do not increase soil background levels. The latter assumption neglects recent work (e.g., Johnston and Jones, 1992), which concludes that atmospheric deposition of cadmium has been a significant source to soil, leading to an increase in some areas of 30-50% in the top 23 cm of soil over the last 100 years.

The results of years to double soil background presented in Tables 5-11a and 5-11b are based on the assumption that the fertilizers contain average contaminant concentrations and are applied either at the average (Table 5-11a) or the maximum nutrient application rate (Table 5-11b). Tables 5-12a and 5-12b use the single highest product metal addition rate with either the average (Table 5-12a) or the maximum (Table 5-12b) nutrient application rate.

Those fertilizer applications where soil background levels are doubled in 45 or fewer years have been shaded for visual identification. The choice of 45 years has no particular environmental or human health consequence, but was chosen because of the manner in which the Canadian Fertilizers Regulation limits are defined. The years to double soil metals levels from lime applications was calculated on the basis of the liming being done only once every 3 years. All other nutrients were calculated on the basis of a yearly addition.

Cadmium is the metal most likely to double in soil levels in less than 45 years, followed by lead, arsenic and copper. Several scenarios evaluated here indicate that mercury and zinc soil levels may double in less than 45 years with the application of lime products. Mercury additions, though, may be lost due to volatilization. Application of liming materials is most likely to cause soil metal concentrations to double in less than 45 years, and several of the products likely to cause this rise in soil metals are recycled industrial wastes.

Background soil metals levels are doubled in less than 10 years when the single product which gives the highest yearly addition to soil is applied at the average nutrient application rate for the following combinations of metal and fertilizer product: Cd from zinc, P_2O_5 and NPK-P fertilizers; Pb from NPK-P fertilizers and liming materials; and Zn from liming materials. Background soil metals levels are doubled in less than 10 years when the single product which

Table 5-11a. Years to Double Soil Metals Levels using Fertilizer Metal Addition Rates from Product Average Applied at the Nutrient Average Yearly Application Rate (footnote a)

Fertilizer Type	Cd	Pb	As	Cr	Hg	Ni	V	Cu	Zn
Years to Double Soil Level (years)									
Zinc	51	100	20,800	6,727	232	3,400	116,000	1,565	NA[b]
P_2O_5	33[c]	7,333	5,200	2,176	232	5,667	2,231	1,800	1,720
NPK (for N)	60	710	1,300	914	232	1,889	1,094	563	279
Potash	720	22,000	20,800	148,000	232	68,000	232,000	72,000	172,000
Boron	720	44,000	867	148,000	232	68,000	232,000	72,000	172,000
Iron	40	40	67	NC[d]	NC	NC	NC	706	NC
NPK (for P)	45	253	2,600	3,895	232	5,667	2,762	2,769	1,593
Manganese	720	44,000	20,800	148,000	232	34,000	232,000	72,000	86,000
Sulfur (as nutrient)	120	44,000	20,800	8,222	232	4,250	7,250	36,000	1,433
Sulfur (for pH)	720	11,000	1,486	NC	NC	NC	NC	1,000	NC
Gypsum	180	2,200	1,040	24,667	232	4,857	1,526	679	711
Liming Materials[e]	60	73	90	597	116	507	1,000	119	58

a) Sources: Tables 5-3a through 5-8a for yearly metal addition rates (kg/ha); Table 3-2 for soil metal concentration (mg/kg) Study 1 geometric means for Cd, Pb, Ni, Cu, Zn and Study 2 geometric means for As, Cr, Hg; equation 5-4 for conversion of kg/ha addition to mg/kg of soil concentration (kg of metal)/ha addition mg/(kg of soil) concentration

b) NA = Not applicable; zinc fertilizers are applied specifically to add zinc to the soil and/or crop

c) Shaded boxes indicate 45 or fewer years to double

d) NC = not calculated; no samples in this category

e) Based on lime application once every 3 years.

Table 5-11b. Years to Double Soil Metals Levels using Fertilizer Metal Addition Rates from Product Average Applied at the Nutrient Maximum Yearly Application Rate (footnote a)

Fertilizer Type	Cd	Pb	As	Cr	Hg	Ni	V	Cu	Zn
Years to Double Soil Level (years)									
Zinc	12[b]	25	5,200	1,762	232	872	38,667	396	NA[c]
P_2O_5	11	2,444	1,486	725	232	1,889	748	590	573
NPK (for N)	20	214	385	274	232	557	328	167	83
Potash	360	7,333	20,800	37,000	232	17,000	58,000	36,000	43,000
Boron	720	44,000	452	148,000	232	68,000	116,000	72,000	86,000
Iron	13	13	22	NC[d]	NC	NC	NC	235	NC
NPK (for P)	14	84	867	1,298	232	1,789	913	900	528
Manganese	720	11,000	10,400	74,000	232	11,333	232,000	36,000	21,500
Sulfur (as nutrient)	45	22,000	10,400	2,846	232	1,478	2,417	18,000	475
Sulfur (for pH)	720	3,143	473	NC	NC	NC	NC	319	NC
Gypsum	51	537	260	5,692	232	1,259	383	170	178
Liming Materials[e]	17	20	24	159	29	136	267	32	15

a) Sources: Tables 5-3a through 5-8a for yearly metal addition rates (kg/ha); Table 3-2 for soil metal concentration (mg/kg) Study 1 geometric means for Cd, Pb, Ni, Cu, Zn and Study 2 geometric means for As, Cr, Hg; equation 5-4 for conversion of kg/ha addition to mg/kg of soil concentration (kg of metal)/ha addition mg/(kg of soil) concentration

b) NA = Not applicable; zinc fertilizers are applied specifically to add zinc to the soil and/or crop

c) Shaded boxes indicate 45 or fewer years to double

d) NC = not calculated; no samples analyzed in this category

e) Based on lime application once every 3 years.

Table 5-12a. Years to Double Soil Metals Levels using Fertilizer Metal Addition Rates from Single Highest Product Applied at the Nutrient Average Yearly Application Rate (footnotes a, b)

Fertilizer Type	Cd	Pb	As	Cr	Hg	Ni	V	Cu	Zn
Years to Double Soil Level (years)									
Zinc	10[c]	26	10,400	4,111	232	395	116,000	563	NA[d]
P_2O_5	9	234	1,733	597	232	1,063	768	65	265
NPK (for N)	16	34	217	237	232	283	181	33	13
Potash	720	11,000	20,800	74,000	232	34,000	23,200	18,000	21,500
Boron	720	44,000	452	148,000	232	68,000	232,000	72,000	172,000
Iron	14	16	23	NC[e]	NC	NC	NC	275	NC
NPK (for P)	5	8	93	587	232	370	624	102	124
Manganese	720	22,000	20,800	148,000	232	34,000	232,000	72,000	86,000
Sulfur (as nutrient)	16	22,000	10,400	2,176	232	1,097	1,841	12,000	363
Sulfur (for pH)	720	2,750	612	NC	NC	NC	NC	367	NC
Gypsum	60	880	547	24,667	232	4,857	1,036	383	711
Liming Materials[f]	24	9	11	111	15	75	144	16	10

a) Sources: Tables 5-3b through 5-8b for yearly metal addition rates (kg/ha); Table 3-2 for soil metal concentration (mg/kg) Study 1 geometric means for Cd, Pb, Ni, Cu, Zn and Study 2 geometric means for As, Cr, Hg; equation 5-4 for conversion of kg/ha addition to mg/kg of soil concentration (kg of metal)/ha addition mg/(kg of soil) concentration

b) Note that some values in this table are the same as those in Table 5-11a. In some cases the concentration of a specific fertilizer type is based on a single sample so the average value and the maximum value are the same or all values were reported as below the limit of detection and this value was replaced with one-half the limit of detection.

c) Shaded boxes indicate 45 or fewer years to double

d) NA = Not applicable; zinc fertilizers are applied specifically to add zinc to the soil and/or crop

e) NC = not calculated; no samples analyzed in this category

f) Based on lime application once every 3 years.

Table 5-12b. Years to Double Soil Metals Levels using Fertilizer Metal Addition Rates from Single Highest Product Applied at the Nutrient Maximum Yearly Application Rate (footnotes a, b)

Fertilizer Type	Cd	Pb	As	Cr	Hg	Ni	V	Cu	Zn
Years to Double Soil Level (years)									
Zinc	3[c]	6	1,733	1,028	232	99	23,200	141	NA[d]
P_2O_5	3	78	578	199	232	358	257	22	89
NPK (for N)	5	10	64	71	116	85	54	10	4
Potash	180	1,833	5,200	10,571	116	8,500	4,833	2,769	3,739
Boron	720	44,000	221	148,000	232	68,000	116,000	72,000	86,000
Iron	5	5	8	NC[e]	NC	NC	NC	92	NC
NPK (for P)	2	3	31	196	232	124	208	34	41
Manganese	720	7,333	10,400	74,000	232	11,333	232,000	36,000	21,500
Sulfur (as nutrient)	5	5,500	5,200	718	232	362	611	4,500	121
Sulfur (for pH)	720	917	196	NC	NC	NC	NC	118	NC
Gypsum	16	222	137	5,692	232	1,259	259	96	178
Liming Materials[f]	7	2	3	30	4	20	38	4	3

a) Sources: Tables 5-3b through 5-8b for yearly metal addition rates (kg/ha); Table 3-2 for soil metal concentration (mg/kg) Study 1 geometric means for Cd, Pb, Ni, Cu, Zn and Study 2 geometric means for As, Cr, Hg; equation 5-4 for conversion of kg/ha addition to mg/kg of soil concentration (kg of metal)/ha addition mg/(kg of soil) concentration

b) Note that some values in this table are the same as those in Table 5-11b. In some cases the concentration of a specific fertilizer type is based on a single sample so the average value and the maximum value are the same or all values were reported as below the limit of detection and this value was replaced with one-half the limit of detection.

c) Shaded boxes indicate 45 or fewer years to double

d) NA = Not applicable; zinc fertilizers are applied specifically to add zinc to the soil and/or crop

e) NC = not calculated; no samples analyzed in this category

f) Based on lime application once every 3 years.

gives the highest yearly addition to soil is applied at the maximum nutrient application rate for the following combinations of metal and fertilizer product: Cd from zinc, P_2O_5, NPK-N, NPK-P, iron, sulfur (as nutrient), and lime products; Pb from zinc, NPK-N, NPK-P, iron, and lime products; As from iron and lime products; Hg from lime products; Cu from NPK-N and lime products; and Zn from NPK-N and lime products.

The estimates for doubling of the Hg background are limited to a great degree by the sensitivity of analytical methods used. Wherever analyses were carried out but Hg was not detected, one half the detection limit was used as the estimate of the Hg level. This approach may overestimate the levels of Hg in the fertilizer products. This approach may then result in an underestimate of the number of years required to double soil Hg levels.

5.6 ASSUMPTIONS, DATA GAPS AND QUESTIONS FOR FURTHER INVESTIGATION

In the process of performing the calculations on metal additions to soil following fertilizer application and comparing these values to appropriate standards and regulations, a number of assumptions had to be made.

Simplifying assumptions used for the calculations presented in Section 5.3 were:

- Fertilizer application rates chosen for the calculations in this report are for agricultural crops only. Fertilizer application rates for non-agricultural land (e.g., residential and public land), have only a limited amount of information. The variety of ornamentals, turf and garden vegetables requiring fertilizers and the variety of soil types makes it difficult to obtain specific data such as that available from the USDA for agricultural crops. Preliminary data on heavy metals in home garden fertilizers suggest that significant amounts of metals may be added to home gardens from use of some of these products.

- Metal additions to the soil were based on application of a single fertilizer type, and a single crop per year. In fact, many different fertilizers and liming materials may be applied to a field in a growing season. The concomitant addition of heavy metals from all sources was not assessed here.

- Calculations of heavy metal additions to soil from fertilizers were based on all available data. The representativeness of this data set with respect to all fertilizers is not known. There has not yet been a systematic investigation of all fertilizer types, or an investigation of the percentage of recycled industrial waste products with substantial levels of heavy metals in the fertilizer market.

- In only a few instances was the origin (e.g., natural ore or industrial by product) of the fertilizer product known. Although it may be instructive to compare heavy metal additions to soil from natural ores and products from industrial waste, such an exercise could not be undertaken on the basis of the available data.

- To simplify calculations, soil type and chemical nature, plant uptake, leaching and erosion were not considered in these calculations. All input of heavy metals was

assumed to remain with the soil, and this may result in an overestimate of soil metals levels over a long time period.

The following list presents some areas where data are lacking, and questions remain for further investigation.

- Nationally-representative micronutrient application rates. Aggregate average application rates for micronutrients and liming materials by state, treated acres and crop type have not been assembled, as has been done for N, P and K fertilizer.

- Regional variability in concomitant use of NPK, micronutrient and liming materials on the same field. Statewide use data for each fertilizer type are available, but the overlap in application by crop has not been compiled. Some areas of the U.S. may receive higher input of heavy metals from fertilizers due to the combination of crop type and existing soil conditions.

- Contribution of fertilizer products derived from industrial wastes to total fertilizer market. While sources of industrial waste-derived fertilizers are fairly well known, the market share of these products in the total fertilizer market is not known.

- Nationally representative metal contaminant levels of all fertilizer types. Only a few studies exist that have measured contaminant levels in fertilizers, and these studies tend to represent either a single product type and/or products found in a specific state.

- Levels of other contaminants such as radionuclides and persistent organic chemicals in fertilizers and liming materials. Compared with the data on heavy metals in fertilizers, relatively little information exists on the levels of organic pollutants in fertilizers. Organics include dioxins, PCBs, pesticides and PAHs.

- The environmental fate of chemical additions to soil. This issue has been studied primarily for cadmium and lead, and most often under controlled laboratory or field conditions. All potential contaminants, soil types and crops have not been addressed. In addition, the fate of metals added to the soil as a result of fertilizer addition to non-agricultural land (e.g., range land and residential land) has not been adequately studied.

5.7 SUMMARY

Calculations of the additions of metals to soils from different fertilizer applications has been carried out here, but the interpretation of the data remains limited, due in part to the fact that few regulations exist that can be used for comparisons. It is unclear whether the U.S. biosolids standards are appropriate for comparison to inorganic fertilizer types because of differences in metal availability to the plant, organic matter content and plant uptake between biosolids fertilizers and inorganic fertilizers. The Canadian limits for metal additions to the soil are annualized long term (45 year) average values. The extent to which current data can be extrapolated to a 45 year trend is not known. Assuming an annual addition of a constant amount of the same type of fertilizer to the soil may not be realistic. Nonetheless, this report identifies

several fertilizer types that exceed the annualized pollutant loading rates allowable in Canada, and, identifies a few product types that approach the U.S. biosolids limits when applied at maximum nutrient application rates.

Fertilizer products are compared in this report with respect to the amount of nine heavy metals the product would add to soil, assuming a single application of the product per year. This is termed the yearly soil addition rate of a metal (or "yearly addition of metal X", see Index of Terms). The yearly soil addition rate of a metal is the concentration of that heavy metal in the product per desired nutrient ingredient multiplied by the nutrient application rate, with all appropriate conversion factors applied. For those fertilizer products with lower nutrient content, a proportionally greater amount of the undesirable heavy metal will be added to the land in achieving a consistent nutrient application rate. Therefore, a fertilizer product may contribute high levels of heavy metals to soil when the heavy metal concentration in the product is high and/or when the desired plant nutrient is at a low level in the product.

For this report, the yearly addition of each metal was calculated for each individual product at three nutrient application rates- an average nutrient application rate, a high rate and at the maximum application rate recorded for this nutrient. An extended appendix of this report (Appendix G) contains the yearly soil addition rate of each metal in each product when applied at these three nutrient application rates. The aggregate of these individual yearly addition rates, then, produced the average soil metal addition rate for a fertilizer product category (e.g., P_2O_5 fertilizers) at the three different nutrient application rates. This aggregate is termed the product average yearly addition of metal X (see Index of Terms). This summary includes discussions of the yearly addition of metals in terms of both the individual product giving the highest yearly soil addition of a specific metal, and in terms of the product average yearly addition rates for metals.

The calculations performed here showed that the product average yearly addition rates of metals to soil would not exceed the U.S. biosolids annual pollutant loading rates for any fertilizer category evaluated. This finding applied to both natural ore-derived fertilizers and industrial by-product derived fertilizers.

The calculations also showed that the product average yearly addition rates of metals to soil rarely exceeded the annualized Canadian Fertilizers Act limits for metals additions. The particular instances when the product average addition rate of metal to soil exceeded the Canadian limits were found in the following combinations of heavy metal and fertilizer categories, and this occurred only at the maximum nutrient application rate:

Arsenic in: liming materials ($CaCO_3$ applied at 15,000 lbs/acre once every 3 years)
iron fertilizers (iron applied at 30 lbs/acre every year)

The Canadian standards are exceeded more frequently for **individual** fertilizer products, and are exceeded for metals other than arsenic. A total of 38 cases were identified where a particular heavy metal in an identified individual fertilizer product would exceed Canadian fertilizer standards when applied at the maximum nutrient application rate. These cases include:

Cadmium in: NPK fertilizers applied for P_2O_5 content [10 products of 91evaluated exceeded limits; 10 of 91]

	Phosphate fertilizers [1 of 61] Liming materials [3 of 10] Zinc fertilizers [3 of 22]
Lead in :	NPK fertilizers applied for P_2O_5 content [4 of 91] Liming materials [2 of 10] Zinc fertilizers [6 of 63] Iron fertilizers [1 of 3]
Arsenic in:	NPK fertilizers applied for P_2O_5 content [1 of 84] Liming materials [3 of 10] Iron fertilizers [1 of 3]
Mercury in:	Liming materials [1 of 8]
Nickel in:	Liming materials [1 of 8]
Zinc in:	NPK fertilizers applied for N content [1 of 49]

Of the products listed above, 18 exceeded Canadian standards at the high nutrient application rate, and 8 exceeded the standards at the average nutrient application rate. Data were gathered here on 345 fertilizer products; 1389 combinations of fertilizer product and metal at three application rates (total of 4167 data points) were compared with Canadian standards. (Data on an additional 537 combinations of unregulated heavy metals in products were also gathered). Since some products exceeded standards in more than one metal, the number of individual products exceeding the standards for at least one metal is greater than 2.7% (38 of 1389), but less than 11% (38 of 345).

Figure 5-10 identifies those fertilizer categories where the product average yearly addition rate of a metal is likely to double the average level of that metal in background US soils in 45 or fewer years, when the nutrient is applied at either the average (open box) or maximum (closed box) application rate. Similarly, this figure also identifies those instances where at least one individual product within a category exists that may double the average background level in 45 or fewer years, when the nutrient is applied at either the average (open circle) or maximum (closed circle) application rate. These scenarios assume yearly applications, with exception of lime, which is applied once every three years. For example, the product average application rate of cadmium (Cd) from either NPK-P fertilizers (NPK fertilzers applied for P_2O_5 content) or from P_2O_5 fertilizers will double the average background Cd soil level in 45 or fewer years when either the average or maximum nutrient (P_2O_5) application rate is used every year. In addition, there were individual NPK-N, NPK-P and P_2O_5 products identified that would double background soil Cd levels in 45 or fewer years if applied each year. There were no potash (K_2O), gypsum, manganese (Mn), or boron (B) fertilizer products identified that would double the indicated soil metals levels in 45 or fewer years. In contrast, liming materials were identified that might double the soil levels of all nine metals with consistent use (application once every three years) within a 45 year time frame.

Fertilizer Products	Cd	Pb	As	Cr	Hg	Ni	V	Cu	Zn
Primary Nutrients									
NPK-N	■○●	○●						○●	●
NPK-P	❑■○●	○●	●					●	●
P_2O_5	❑■○●							●	
K_2O									
Secondary Nutrients									
Gypsum									
Sulfur	■○●								
Soil pH Adjustment									
Lime	■○●	■○●	■○●	●	■○●	●	●	■○●	■○●
Sulfur	○●								
Micronutrients									
Zn	■○●	■○●							
Fe	■○●	❑■○●	■○●						
Mn									
B									

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❑ Product average yearly addition rate of metal to soil with nutrient applied at
■ Product average yearly addition rate of metal to soil with nutrient applied at
○ Individual fertilizer product giving highest addition rate of metal to soil with nutrient applied at
● Individual fertilizer product giving highest addition rate of metal to soil with nutrient applied at

Figure 5-11. Products That Double Average U.S. Soil Background Level of Indicated Metal in 45 or Fewer Years

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APPENDIX A
FERTILIZER CONSUMPTION IN THE U.S.

Appendix A. Fertilizer Consumption in the U.S.

The tables in Appendix A have been abstracted from electronic files created by the Association of American Plant Food Control Officials (AAPFCO). The data in these tables are for the year ending June 30, 1996. Slight differences in reported values between the tables in this report and Commercial Fertilizers 1996 (AAPFCO and TFI) are due to the inclusion of liming materials and some minor differences in the definition of multiple nutrient fertilizers and "other" fertilizer groupings. Tables A-1 through A-5 contain the tons of different types of fertilizers and micronutrients consumed for each state and Puerto Rico. The tables are organized with the states grouped into geographic regions of the country. These tables are:

A-1. East North Central (IN, IL, MI, OH, WI) and
East South Central (KY, AL, MS, TN)

A-2. West North Central (KS, IA, MN, MO, NB, ND, SD) and
West South Central (LA, AR, OK, TX)

A-3. New England (CN, ME, MA, NH, NY, RI, VT) and
Middle Atlantic (DE, MD, NJ, PA, WV)

A-4. South Atlantic (FL, GA, NC, SC, VA)

A-5. Mountain (AZ, CO, ID, MT, NM, NV, UT, WY),
Pacific (AK, CA, HI, OR, WA) and Puerto Rico

The total U.S. fertilizer consumption, by fertilizer type is presented in Table 2-1.

Table A-1. Fertilizer Consumption (Tons) by State - East North Central and East South Central Regions

Description	IN	IL	MI	OH	WI	KY	AL	MS	TN
MULTIPLE NUTRIENT FERTILIZERS									
N-P-K	382,542	198,220	370,204	214,942	175,351	147,369	233,519	205,200	151,031
N-P	259,966	707,763	109,463	376,472	182,628	177,311	46,223	57,380	163,898
N-K	14,618	4,840	28,419	2,519	6,062	3,015	21,162	13,921	3,202
P-K	94,532	12,264	9,321	26,930	6,243	6,953	13,324	24,009	1,333
TOTAL	751,658	923,087	517,407	620,862	370,284	334,649	314,229	300,510	319,464
NITROGEN FERTILIZERS									
Ammonium Nitrate	7,388	32,850	7,900	3,993	26,657	110,319	122,191	103,202	168,520
Ammonium Nitrate Solution	203	0	0	0	0	0	0	228	0
Ammonium Nitrate-limestone Mixtures	0	0	0	0	0	0	0	0	0
Ammonium Nitrate-sulfate	4,138	0	262	0	3	258	44	574	14
Ammonium Polysulfide	335	0	0	0	0	0	0	420	0
Ammonium Sulfate	12,180	20,606	15,093	27,297	33,429	446	12,848	11,988	3,331
Ammonium Sulfate Solution	5,885	135,422	107	0	0	0	0	0	0
Ammonium Sulfate-nitrate	9,802	48	9,107	3,488	0	55	118	29	9
Ammonium Sulfate-urea	114	0	0	0	0	0	0	0	0
Ammonium Thiosulfate	779	11,549	252	1,138	1,337	49	331	7,610	2
Anhydrous Ammonia	194,582	609,003	61,777	101,303	53,647	61,525	1,513	18,906	15,035
Aqua Ammonia	9,699	0	0	0	2,348	0	0	273	0
Calcium Ammonium Nitrate	147	1,003	75	0	5	1	6	25	0
Calcium Cyanamide	0	0	0	0	0	0	0	0	0
Calcium Nitrate	233	43,791	3,438	141	191	171	90	221	286
Calcium Nitrate-urea	311	0	0	0	0	0	0	0	0
Ferrous Ammonium Sulfate	103	25	25	2	0	1,638	0	12	14
Magnesium Nitrate	0	0	0	0	0	0	0	0	0
Nitric Acid	1,346	0	0	0	0	0	0	0	1
Nitrogen Solution 28%	381,514	721,753	212,610	649,226	172,508	65,305	11,008	22,821	4,136

Table A-1. (Continued)

Description	IN	IL	MI	OH	WI	KY	AL	MS	TN
Nitrogen Solution 30%	1,528	977	0	2,856	7	14,479	620	947	582
Nitrogen Solution 32%	27,235	155,188	4,517	22,108	19,546	28,779	37,726	140,241	45,784
Nitrogen Solution <28%	46,384	68,688	9,741	11,505	3,490	231	14,501	1,333	1,446
Nitrogen Solution >32%	156	305	0	0	396	89	129	14	686
Sodium Nitrate	1,130	44	93	52	124	515	629	1,563	2,632
Sulfur Coated Urea	689	0	702	78	4	3	8	41	4
Urea	71,864	109,168	84,740	128,658	119,738	104,979	20,380	95,679	74,749
Urea Solution	0	0	0	0	0	0	0	281	0
Urea-formaldehyde	719	5,339	1,565	616	314	16	3,020	153	52
Zinc Ammonium Sulfate Solution	0	0	0	0	2	0	0	247	299
Zinc Manganese Ammonium Sulfate	0	0	0	0	0	0	0	0	0
Other	13,879	4,508	35,424	22,148	345	7,079	43,796	9,877	7,428
TOTAL	792,344	1,920,268	447,429	974,608	434,091	395,936	268,956	416,684	325,010
PHOSPHATE FERTILIZERS									
Ammonium Metaphosphate	0	0	0	0	0	0	0	0	0
Ammonium Phosphate	30	0	9	0	0	30	0	68	0
Ammonium Phosphate Nitrate	1	0	0	0	0	0	5	0	0
Ammonium Phosphate Sulfate	406	0	0	87	0	0	0	0	0
Ammonium Polyphosphate	132	0	0	0	0	0	7	50	0
Basic Lime Phosphate	0	0	0	0	0	0	0	0	0
Basic Slag	0	0	0	0	0	0	0	1,851	292
Bone Meal, Raw	0	0	0	0	35	0	0	0	0
Bone Meal, Steamed	2	6	1	3	125	4	2	0	6
Bone, Precipitated	0	0	0	0	0	0	0	0	0
Calcium Metaphosphate	0	0	0	0	0	112	2	0	1,711
Colloidal Phosphate (Soft Phosphate)	88	0	22	86	0	22	17	22	67

Table A-1. (Continued)

Description	IN	IL	MI	OH	WI	KY	AL	MS	TN
Diammonium Phosphate	111,288	575,531	38,217	248,811	154,576	162,455	35,350	45,924	160,104
Limestone, Phosphatic	0	0	0	0	0	0	0	0	0
Liquid Ammonium Polyphosphate	104,347	34,352	36,686	85,822	15,883	5,850	2,611	8,578	2,300
Magnesium Phosphate	0	0	0	35	5	25	4	10	9
Monoammonium Phosphate	12,155	81,713	17,852	32,747	9,033	6,362	720	541	454
Nitric Phosphate	0	0	0	0	0	0	0	0	0
Phosphate Rock	0	62	123	3	445	0	31	0	0
Phosphoric Acid	126	449	2	0	0	0	0	0	0
Precipitated Phosphate	0	0	0	0	0	0	0	0	0
Superphosphate, Enriched	5	0	24	0	5	0	28	0	0
Superphosphate, Normal	14	0	13	0	12,639	13	501	0	7
Superphosphate, Triple	40,368	49,033	4,738	92,925	11,310	19,981	6,913	14,581	8,621
Superphosphoric Acid	0	0	0	2	0	0	0	0	0
Other	310	91,759	227	4	307	155	812	140	506
TOTAL	269,274	832,904	97,913	460,524	204,363	195,011	47,003	71,765	174,077
POTASH FERTILIZERS									
Lime-potash Mixtures	1,537	0	50	0	0	0	88	0	0
Manure Salts	464	0	0	0	0	0	0	0	0
Muriate of Potash 60% (Pot. Chloride)	335,046	877,049	161,547	412,906	655	157,955	43,942	116,361	185,802
Muriate of Potash 62%	38,184	95,057	76,437	94,428	372,350	3,761	2,188	15,499	2,116
Potash Suspensions	0	0	0	0	0	0	131	52	0
Potassium Carbonate	15	0	138	0	0	0	0	0	0
Potassium Nitrate	409	2	1,569	119	1	8	1,963	628	253
Potassium Sulfate	1,967	600	2,840	1,879	2,866	35,121	539	1,063	5,533
Potassium-magnesium Sulfate	2,739	903	3,029	1,834	11,069	5,618	815	2,085	817
Potassium-metaphosphate	0	0	0	0	0	0	0	0	0
Potassium-sodium Nitrate	0	0	37	0	0	0	0	0	224

Table A-1. (Continued)

Description	IN	IL	MI	OH	WI	KY	AL	MS	TN
Other	11,680	5,843	4,357	1,933	2,864	137	4,943	2,388	3,419
TOTAL	392,040	979,455	250,003	513,099	389,805	202,600	54,610	138,074	198,164
ORGANIC FERTILIZERS									
Blood, Dried	3	0	0	0	121	0	3	0	0
Castor Pomace	1	0	0	0	0	0	0	0	0
Cocoa Shell Meal	0	0	0	0	0	0	0	0	0
Compost	0	0	3,961	0	13	0	0	0	0
Cottonseed Meal	0	0	0	0	0	0	0	0	27
Fish Scrap	0	0	0	0	12	0	0	0	989
Guano	0	0	0	0	0	0	0	0	0
Manure	401	0	698	0	3,848	0	1,398	3,885	1,546
Peat	1,083	0	25,607	0	0	0	0	0	2,338
Sewage Sludge, Activated	0	0	0	0	0	0	43	0	198
Sewage Sludge, Digested	0	0	0	0	0	0	0	0	0
Sewage Sludge, Heat Dried	0	0	0	0	2,472	0	0	0	0
Sewage Sludge, Other	0	0	0	0	0	0	0	0	0
Soybean Meal	0	0	0	0	1	0	0	0	0
Tankage, Animal	0	0	0	0	37	0	0	0	0
Tankage, Process	0	0	0	0	281	0	0	0	154
Other	1,368	0	7,793	0	1,437	0	3	44	9,715
TOTAL	2,856	0	38,058	0	8,221	0	1,446	3,930	14,966
SECONDARY AND MICRONUTRIENT FERTILIZERS									
Aluminum Sulfate	0	0	1	0	0	0	27	384	30
Borax	71	0	281	0	1,110	0	104	1,454	2,132
Calcium Chelate	0	0	0	0	9,026	0	0	0	0
Calcium Chloride	0	0	0	0	1,331	0	1	0	8
Calcium Sulfate (Hydrous)	0	0	0	0	1,804	0	0	0	0

Table A-1. (Continued)

Description	IN	IL	MI	OH	WI	KY	AL	MS	TN
Cobalt Sulfate	0	0	0	0	0	0	0	0	0
Copper Chelate	0	0	0	0	49	0	0	0	0
Copper Compound	0	0	0	0	0	0	0	0	0
Copper Oxide, Black	0	0	0	0	36	0	0	0	0
Copper Sulfate	1	0	41	0	0	0	0	0	6
Epsom Salt (Magnesium Sulfate)	0	0	72	0	0	0	0	0	16
Ferric Oxide	0	0	0	0	0	0	255	0	0
Ferric Sulfate	0	0	0	0	0	0	0	0	0
Ferrous Sulfate	0	0	0	0	0	0	0	0	25
Gypsum (Calcium Sulfate)	4,445	0	13,002	0	3,391	0	241	32	888
Iron Chelate	3	0	44	0	238	0	8	17	20
Iron Compound	0	0	3	0	2	0	0	16	0
Lime Sulfur Solution	0	0	0	0	0	0	0	0	0
Magnesia (Magnesium Oxide)	31	0	15	0	10	0	0	0	74
Magnesium Chelate	0	0	0	0	0	0	0	7	0
Manganese Agstone	1	0	0	0	0	0	0	0	0
Manganese Chelate	1	0	0	0	0	0	0	8	2
Manganese Oxide	1	0	2	0	0	0	0	0	21
Manganese Slag	0	0	0	0	0	0	0	0	0
Manganese Sulfate	36	0	39	0	0	0	15	0	1
Manganous Oxide	0	0	0	0	73	0	0	0	3
Potting Soil	0	0	0	0	0	0	0	2	0
Sodium Molybdate	0	0	0	0	9	0	0	200	0
Soil Additive	0	0	0	0	0	0	0	0	0
Soil Amendment	0	0	0	0	0	0	0	0	0
Soil Conditioner	0	0	11,601	0	0	0	0	0	0
Sulfur	569	0	664	0	3,726	0	731	1,469	1,899

Table A-1. (Continued)

Description	IN	IL	MI	OH	WI	KY	AL	MS	TN
Sulfuric Acid	0	0	0	0	0	0	0	0	2
Zinc Chelate	0	0	3	0	0	0	0	0	61
Zinc Oxide	0	0	3	0	669	0	0	173	186
Zinc Oxysulfate	0	0	331	0	0	0	0	0	114
Zinc Sulfate	4	0	202	0	0	0	4	8	174
Zinc Sulfate Solution	0	0	0	0	0	0	0	0	0
Other	2,238	0	7,307	19,816	1,054	9,922	1,526	504	255
TOTAL	7,400	0	33,612	19,816	22,528	9,922	2,912	4,273	5,918
LIMING MATERIALS									
Calcitic Lime (75% Neutral)	0	0	437	0	0	0	0	0	0
Calcium Hydroxide (Hydrate)	0	0	5	0	0	0	0	0	41
Calcium Oxide (Burnt)	0	0	0	0	0	0	0	0	0
Dolomitic & Calcitic Blend (Pelletized)	0	0	1,114	0	0	0	0	0	148
Dolomitic Lime (75% Neutral)	0	0	2	0	0	0	1,319	0	0
Lime Suspensions	0	0	0	0	0	0	0	0	0
Non-lime Filler (Water, Sand, Etc.)	0	0	0	0	1,097	0	0	0	0
Standard Calcite	0	0	0	0	0	0	23	0	22,203
Standard Dolomite	0	0	0	0	0	0	27	0	29
Other	4,501	0	3,513	0	12,131	0	1,094	84	649
TOTAL	4,501	0	5,071	0	13,228	0	2,464	84	23,070
ALL FERTILIZERS									
TOTAL	1,989,785	3,964,109	1,264,857	2,221,321	1,256,483	963,407	649,521	875,645	892,228

Table A-2. Fertilizer Consumption (Tons) by State - West North Central and West South Central Regions

Description	KS	IA	MN	MO	NB	ND	SD	LA	AR	OK	TX
MULTIPLE NUTRIENT FERTILIZERS											
N-P-K	38,136	264,907	71,022	94,778	137,487	40	7,237	262,361	273,832	45,461	1,014,243
N-P	398,776	640,695	529,868	286,572	369,018	332,312	216,487	38,024	31,335	166,284	519,427
N-K	2,790	2,048	1,976	2,869	6,613	0	29	20,116	15,709	1,952	81,653
P-K	187	1,077	2,531	2,257	129	0	79	66,725	149,077	344	6,781
TOTAL	439,890	908,727	605,397	386,476	513,247	332,352	223,832	387,225	469,953	214,041	1,622,103
NITROGEN FERTILIZERS											
Ammonium Nitrate	76,603	31,697	9,122	277,326	33,246	11,433	2,846	69,206	80,626	73,201	156,672
Ammonium Nitrate Solution	0	0	0	0	0	0	0	0	0	34	0
Ammonium Nitrate-limestone Mixtures	0	0	0	0	0	0	0	0	0	0	0
Ammonium Nitrate-sulfate	4	18	0	2	15	0	0	2,036	1	173	18
Ammonium Polysulfide	26	0	0	0	0	79	11	0	0	51	0
Ammonium Sulfate	2,158	10,760	42,323	16,629	23,619	3,869	3,548	11,064	26,959	7,526	109,722
Ammonium Sulfate Solution	8	19,748	0	9	0	0	0	0	0	3	229
Ammonium Sulfate-nitrate	0	285	428	54	502	0	18	39	0	26	6,936
Ammonium Sulfate-urea	0	0	0	0	0	0	0	2,183	0	0	0
Ammonium Thiosulfate	17,192	7,479	3,978	5,848	63,426	373	646	1,136	0	3,896	16,835
Anhydrous Ammonia	503,336	705,100	348,293	128,273	605,998	394,352	27,673	8,366	1,656	134,320	261,011
Aqua Ammonia	3,194	0	122	0	71	0	0	0	0	0	0
Calcium Ammonium Nitrate	0	49	756	6	42	0	1	0	0	0	454
Calcium Cyanamide	0	0	0	0	0	0	0	0	0	0	0
Calcium Nitrate	543	213	83	698	8	197	0	2	0	147	345
Calcium Nitrate-urea	0	0	282	0	330	0	0	0	0	1,934	0
Ferrous Ammonium Sulfate	0	34	0	33	0	0	0	0	0	0	0
Magnesium Nitrate	0	0	0	0	0	0	0	0	0	0	0
Nitric Acid	9	0	0	0	735	4	0	25	0	145	0
Nitrogen Solution 28%	258,746	559,704	149,524	66,969	436,765	28,677	104,015	4,751	13,362	149,326	155,937
Nitrogen Solution 30%	84	4,224	13	4,349	0	0	0	32,606	76	141	12,258

Table A-2. (Continued)

Description	KS	IA	MN	MO	NB	ND	SD	LA	AR	OK	TX
Nitrogen Solution 32%	165,782	276,540	15,556	207,117	399,386	10	8,573	212,327	148,356	44,859	457,018
Nitrogen Solution <28%	5,157	8,841	1,379	1,649	3,813	54	701	4,995	0	629	25,452
Nitrogen Solution >32%	6,200	232	0	0	0	0	0	266	0	0	5,921
Sodium Nitrate	1	0	2	39	0	0	0	851	2,384	5	28
Sulfur Coated Urea	184	0	162	2	710	47	0	196	0	36	233
Urea	101,051	185,463	472,342	161,127	68,397	286,992	128,341	73,389	408,305	121,045	249,541
Urea Solution	0	0	1,277	0	0	0	0	0	0	0	0
Urea-formaldehyde	101	67	663	420	2,900	312	0	9,017	1,891	420	4,177
Zinc Ammonium Sulfate Solution	158	0	0	0	5,518	0	16	0	0	0	0
Zinc Manganese Ammonium Sulfate	0	0	0	0	0	0	15	0	0	0	0
Other	7,889	9,393	1,313	1,980	4,896	0	5,781	14,387	35,336	327	33,462
TOTAL	1,148,425	1,819,846	1,047,618	872,531	1,650,375	726,398	282,183	446,844	718,953	538,244	1,496,248
PHOSPHATE FERTILIZERS											
Ammonium Metaphosphate	0	0	0	0	0	0	0	0	0	0	0
Ammonium Phosphate	0	0	250	0	16,978	0	0	0	0	0	296
Ammonium Phosphate Nitrate	244	0	0	5	989	0	0	0	0	0	15
Ammonium Phosphate Sulfate	67	0	1,172	140	1,990	0	19	0	0	56	7,771
Ammonium Polyphosphate	0	0	0	0	52,123	0	0	0	0	0	0
Basic Lime Phosphate	0	0	0	0	0	0	0	0	0	0	0
Basic Slag	0	0	0	0	0	0	0	0	0	0	0
Bone Meal, Raw	0	0	0	0	0	0	0	0	0	2	0
Bone Meal, Steamed	7	0	0	18	0	0	0	2	0	0	0
Bone, Precipitated	0	0	0	2	0	0	0	5	0	0	0
Calcium Metaphosphate	0	0	253	0	0	0	0	0	0	25	0
Colloidal Phosphate (Soft Phosphate)	0	0	2	116	24	0	0	25	0	4	0
Diammonium Phosphate	163,170	424,465	402,007	233,123	57,197	205,055	132,690	18,293	22,102	127,577	45,248

Table A-2. (Continued)

Description	KS	IA	MN	MO	NB	ND	SD	LA	AR	OK	TX
Limestone, Phosphatic	5	0	0	18	0	0	0	0	0	0	0
Liquid Ammonium Polyphosphate	148,294	59,626	55,563	15,156	150,353	13,352	44,318	12,231	3,608	22,050	99,478
Magnesium Phosphate	0	0	0	22	968	0	0	0	0	0	149
Monoammonium Phosphate	84,557	138,492	61,202	33,082	75,877	113,905	21,036	150	145	11,671	35,497
Nitric Phosphate	0	0	0	0	0	0	0	0	0	0	0
Phosphate Rock	0	149	0	3	130	53	0	0	0	0	150
Phosphoric Acid	198	172	0	3,329	176	739	189	80	0	9	201
Precipitated Phosphate	0	0	0	0	0	0	0	0	0	0	0
Superphosphate, Enriched	0	0	1	88	0	0	0	0	0	0	3
Superphosphate, Normal	248	0	0	26	8,664	40	0	2	1	0	1
Superphosphate, Triple	1,859	21,714	13,748	42,629	3,505	3,576	4,059	4,321	17,979	2,053	888
Superphosphoric Acid	1,690	2,880	2,589	-157	3,428	0	0	0	0	0	893
Other	2,274	44	0	983	431	0	0	185	3,842	572	36
TOTAL	402,612	647,541	536,787	328,584	372,835	336,720	202,310	35,294	47,677	164,018	190,625
POTASH FERTILIZERS											
Lime-potash Mixtures	0	0	7	23	0	0	0	0	0	1	0
Manure Salts	866	0	313	0	0	0	0	0	0	18	0
Muriate of Potash 60% (Pot. Chloride)	54,092	614,535	444,579	280,795	30,407	40,439	23,868	33,920	44,645	43,257	18,591
Muriate of Potash 62%	12,362	79,579	0	93,263	6,897	2,283	1,790	1,192	0	381	2,521
Potash Suspensions	0	0	0	0	0	0	0	0	0	0	0
Potassium Carbonate	27	207	0	0	58	0	0	40	0	0	37
Potassium Nitrate	35	0	88	75	0	0	2	15	305	2	854
Potassium Sulfate	119	285	766	529	28	125	6	3,126	92	72	2,521
Potassium-magnesium Sulfate	4,503	379	6,983	3,817	23,926	114	176	190	472	1,352	5,860
Potassium-metaphosphate	0	0	0	0	0	0	0	0	0	0	0
Potassium-sodium Nitrate	0	0	0	0	0	0	23	0	0	0	0
Other	1,710	4,894	1,621	590	2,227	153	142	3,403	2,417	64	4,634
TOTAL	73,713	699,879	454,357	379,092	63,543	43,114	26,007	41,887	47,932	45,146	35,018

Table A-2. (Continued)

Description	KS	IA	MN	MO	NB	ND	SD	LA	AR	OK	TX
ORGANIC FERTILIZERS											
Blood, Dried	81	0	0	0	0	0	91	1	0	0	0
Castor Pomace	0	0	0	0	0	0	0	0	0	0	0
Cocoa Shell Meal	0	0	0	0	0	0	0	0	0	0	0
Compost	0	0	0	0	492	0	0	0	0	0	0
Cottonseed Meal	0	0	0	0	0	0	0	0	0	0	0
Fish Scrap	0	0	0	0	0	0	0	0	0	0	0
Guano	0	0	0	0	0	0	0	0	0	0	0
Manure	1,006	0	0	0	1,287	0	0	83	1,577	3,231	0
Peat	0	0	0	0	0	0	0	0	0	0	0
Sewage Sludge, Activated	302	0	0	0	182	40	0	0	0	0	0
Sewage Sludge, Digested	0	0	0	0	0	0	0	0	0	0	0
Sewage Sludge, Heat Dried	8	0	0	0	0	0	0	0	0	0	0
Sewage Sludge, Other	0	0	0	0	0	0	0	0	0	44	0
Soybean Meal	0	0	0	0	0	0	0	0	0	0	0
Tankage, Animal	0	0	0	0	0	0	0	0	0	0	0
Tankage, Process	0	0	0	0	0	61	0	0	0	0	0
Other	2,562	0	0	0	0	308	0	102	0	0	0
TOTAL	3,959	0	0	0	1,960	408	91	186	1,577	3,275	0
SECONDARY AND MICRONUTRIENT FERTILIZERS											
Aluminum Sulfate	0	0	0	0	0	0	0	3	0	0	0
Borax	148	190	210	1,474	302	6	10	118	11,499	0	0
Calcium Chelate	5	0	0	0	42	0	0	0	0	0	0
Calcium Chloride	390	3,164	4	0	1,427	0	4	0	0	0	0
Calcium Sulfate (Hydrous)	0	0	0	0	190	0	0	0	0	0	0
Cobalt Sulfate	0	0	0	0	0	0	0	0	0	0	0
Copper Chelate	6	0	13	0	55	0	0	0	0	0	0
Copper Compound	0	0	0	0	0	0	0	0	0	0	0
Copper Oxide, Black	0	18	0	34	1	0	0	0	0	0	0
Copper Sulfate	5	0	173	0	56	5	1	0	0	0	0

Table A-2. (Continued)

Description	KS	IA	MN	MO	NB	ND	SD	LA	AR	OK	TX
Epsom Salt (Magnesium Sulfate)	0	0	0	0	1	0	0	1	0	0	0
Ferric Oxide	0	0	0	1,480	0	0	2	0	0	0	0
Ferric Sulfate	1	25	7	0	4	0	0	0	0	0	0
Ferrous Sulfate	15	0	4	0	397	1	3	0	0	0	0
Gypsum (Calcium Sulfate)	27	4,781	1,553	1,243	905	67	0	44	0	0	0
Iron Chelate	45	0	17	0	565	9	0	4	0	5	0
Iron Compound	32	0	0	0	0	0	0	0	0	0	0
Lime Sulfur Solution	0	0	0	0	0	0	0	0	0	0	0
Magnesia (Magnesium Oxide)	1	3	10	131	51	0	0	1	0	0	0
Magnesium Chelate	5	0	2	0	0	0	0	12	0	0	0
Manganese Agstone	0	19	0	0	0	0	0	0	0	0	0
Manganese Chelate	17	0	25	0	39	0	0	0	0	0	0
Manganese Oxide	0	0	0	54	0	0	0	0	0	0	0
Manganese Slag	0	0	0	0	0	0	0	0	0	0	0
Manganese Sulfate	1	0	68	0	315	3	0	0	0	0	0
Manganous Oxide	0	0	0	0	3	0	0	0	0	0	0
Potting Soil	0	0	0	0	0	0	0	0	0	0	0
Sodium Molybdate	0	0	1	0	0	0	0	0	0	0	0
Soil Additive	0	0	0	0	0	0	0	0	0	0	0
Soil Amendment	0	0	0	0	0	60	0	3	0	0	0
Soil Conditioner	0	0	5	0	1,197	0	0	0	0	0	0
Sulfur	826	4,989	1,307	1,940	4,307	591	363	169	359	102	0
Sulfuric Acid	0	0	190	0	1,058	0	0	0	0	0	0
Zinc Chelate	1,223	0	245	0	1,399	19	69	87	488	71	0
Zinc Oxide	296	1,252	131	1,199	1,892	80	0	63	0	0	0
Zinc Oxysulfate	3	0	9	0	27	0	0	0	0	0	0
Zinc Sulfate	244	0	2,008	0	8,890	1,430	74	99	0	42	0
Zinc Sulfate Solution	0	0	0	0	1,883	0	0	0	0	144	0
Other	910	3,853	8,824	7,504	4	111	120	676	27,430	3,057	108,073

Table A-2. (Continued)

Description	KS	IA	MN	MO	NB	ND	SD	LA	AR	OK	TX
TOTAL	4,200	18,295	14,806	15,059	25,009	2,382	645	1,280	39,775	3,421	108,073
LIMING MATERIALS											
Calcitic Lime (75% Neutral)	0	0	0	0	0	0	0	2,953	0	0	0
Calcium Hydroxide (Hydrate)	0	0	0	0	0	2	0	0	0	0	0
Calcium Oxide (Burnt)	0	0	0	0	0	0	0	0	0	0	0
Dolomitic & Calcitic Blend (Pelletized)	0	0	0	0	0	0	0	0	0	0	0
Dolomitic Lime (75% Neutral)	0	0	0	0	0	0	0	174	0	0	0
Lime Suspensions	0	0	0	0	0	0	0	0	0	0	0
Non-lime Filler (Water, Sand, Etc.)	0	0	0	0	0	0	0	0	0	0	0
Standard Calcite	8	0	0	1,581	3,670	0	0	0	0	0	0
Standard Dolomite	0	0	0	0	0	0	0	27	0	0	0
Other	65	0	0	0	0	0	0	0	0	115	0
TOTAL	73	0	0	1,581	3,670	2	0	3,154	0	115	0
ALL FERTILIZERS											
TOTAL	1,674,338	3,471,704	2,138,683	1,701,723	2,273,170	1,109,024	536,982	885,089	1,298,129	803,628	3,262,910

Table A-3. Fertilizer Consumption (Tons) by State - New England and Middle Atlantic Regions

Description	DE	CN	ME	MD	MA	NJ	NH	NY	RI	PA	VT	WV
MULTIPLE NUTRIENT FERTILIZERS												
N-P-K	34,844	34,218	73,202	125,085	87,020	254,804	18,459	201,816	9,755	261,834	16,184	27,757
N-P	7,035	947	5,634	88,410	2,931	7,043	506	39,230	1,112	34,837	6,625	4,296
N-K	4,771	1,538	587	10,491	3,164	7,052	1,078	7,914	110	13,731	849	151
P-K	867	866	21	2,092	500	1,704	47	4,427	21	17,657	528	410
TOTAL	47,517	37,569	79,443	226,078	93,615	270,603	20,090	253,387	10,998	328,058	24,186	32,614
NITROGEN FERTILIZERS												
Ammonium Nitrate	1,827	58	2,993	3,362	139	1,190	46	6,324	42	8,401	69	706
Ammonium Nitrate Solution	0	0	0	0	0	0	0	1	0	0	0	0
Ammonium Nitrate-limestone Mixtures	0	0	1	0	0	0	1	5	0	0	0	0
Ammonium Nitrate-sulfate	0	0	0	29	0	1,062	0	11	0	18	0	48
Ammonium Polysulfide	0	0	0	0	0	0	0	0	0	1	0	0
Ammonium Sulfate	7,733	87	720	12,652	221	1,365	70	9,713	14	13,819	145	255
Ammonium Sulfate Solution	75	0	0	330	0	0	0	5	0	97	0	0
Ammonium Sulfate-nitrate	49	0	0	360	0	0	0	0	0	393	0	0
Ammonium Sulfate-urea	0	0	0	0	0	0	0	25	0	0	0	0
Ammonium Thiosulfate	3	1	0	584	0	32	1	425	3	2,194	0	1
Anhydrous Ammonia	30	0	0	10,057	2	30	0	2,837	0	2,855	0	727
Aqua Ammonia	0	0	0	323	0	0	0	0	0	0	0	101
Calcium Ammonium Nitrate	0	0	0	5	0	8	9	64	0	0	0	0
Calcium Cyanamide	0	0	0	0	0	0	0	0	0	0	0	0
Calcium Nitrate	17	180	239	441	263	862	188	1,447	132	695	50	23
Calcium Nitrate-urea	2	0	0	0	0	0	0	25	0	0	0	0
Ferrous Ammonium Sulfate	1	0	0	33	11	14	6	28	0	0	0	2

Table A-3. (Continued)

Description	DE	CN	ME	MD	MA	NJ	NH	NY	RI	PA	VT	WV
Magnesium Nitrate	0	0	0	0	0	0	0	0	0	0	0	0
Nitric Acid	0	0	0	2	23	0	0	6	0	0	0	2
Nitrogen Solution 28%	1,569	41	691	538	29	24,790	1	731	0	11,944	0	813
Nitrogen Solution 30%	37,587	0	0	93,283	1	1,227	0	13,587	0	71,508	0	3,260
Nitrogen Solution 32%	1,128	176	502	206	598	2	167	24,345	1	6,726	1,664	0
Nitrogen Solution <28%	11,211	5	86	15,470	4	3,867	5	1,337	1	10,314	0	13
Nitrogen Solution >32%	0	0	0	0	0	0	0	165	0	45	0	0
Sodium Nitrate	11	3	4	95	6	210	2	66	1	9	325	17
Sulfur Coated Urea	4	1	0	14	1	16	0	298	0	97	4	0
Urea	573	1,806	4,156	8,980	2,400	4,457	1,445	28,796	361	49,761	3,269	2,657
Urea Solution	0	0	0	0	0	0	0	0	0	0	0	0
Urea-formaldehyde	10	353	0	344	1,463	3,254	38	574	0	7,947	3	89
Zinc Ammonium Sulfate Solution	0	0	0	0	0	0	0	0	0	0	0	0
Zinc Manganese Ammonium Sulfate	0	0	0	0	0	0	0	3	0	0	0	0
Other	320	103	7	2,334	519	1,768	19	1,713	26	4,282	2,715	31
TOTAL	62,150	2,816	9,398	149,442	5,679	44,154	1,998	92,530	581	191,106	8,243	8,746
PHOSPHATE FERTILIZERS												
Ammonium Metaphosphate	0	0	0	0	0	0	0	0	0	0	0	0
Ammonium Phosphate	0	0	0	891	1	0	0	20	0	0	0	0
Ammonium Phosphate Nitrate	0	0	0	0	0	0	0	0	0	0	0	0
Ammonium Phosphate Sulfate	74	0	0	0	0	0	0	48	0	0	0	0
Ammonium Polyphosphate	0	0	0	0	5	0	0	194	0	252	56	0
Basic Lime Phosphate	0	0	0	0	37	0	0	0	0	0	0	0

Table A-3. (Continued)

Description	DE	CN	ME	MD	MA	NJ	NH	NY	RI	PA	VT	WV
Basic Slag	0	0	0	0	0	0	0	0	0	0	0	0
Bone Meal, Raw	0	0	3	0	72	13	0	1	0	45	0	0
Bone Meal, Steamed	5	48	8	1	141	3	15	142	1	4	1	0
Bone, Precipitated	0	0	0	0	0	0	0	0	0	0	0	0
Calcium Metaphosphate	0	0	0	0	0	0	0	0	0	0	0	0
Colloidal Phosphate (Soft Phosphate)	0	0	0	0	4	0	0	0	0	45	0	0
Diammonium Phosphate	1,924	5	3,261	18,624	1,842	1,462	297	7,562	0	12,043	481	3,997
Limestone, Phosphatic	0	0	0	0	0	0	0	0	0	0	0	0
Liquid Ammonium Polyphosphate	3,348	0	1,677	4,075	41	1,119	73	9,523	6	5,255	168	206
Magnesium Phosphate	0	0	0	0	0	0	0	40	0	1	0	0
Monoammonium Phosphate	769	455	112	7,130	616	164	68	19,439	120	12,337	1,167	8
Nitric Phosphate	0	0	0	0	0	0	0	0	0	0	0	0
Phosphate Rock	0	0	3	2	0	0	0	4	0	0	7	0
Phosphoric Acid	1,322	0	0	420	0	0	0	0	0	577	0	0
Precipitated Phosphate	0	0	0	0	0	0	0	0	0	0	0	0
Superphosphate, Enriched	5	0	0	0	8	0	0	23	0	14	0	0
Superphosphate, Normal	53	12	3	11	95	1,014	31	27	2	95	2	1
Superphosphate, Triple	87	83	70	8,222	365	281	45	1,202	37	5,878	97	1,441
Superphosphoric Acid	0	0	0	0	0	0	0	0	0	0	0	0
Other	113	23	5	1,683	76	656	24	130	16	849	7	35
TOTAL	7,699	628	5,142	41,059	3,303	4,711	553	38,355	182	37,393	1,987	5,687
POTASH FERTILIZERS												
Lime-potash Mixtures	0	0	0	0	36	0	0	5,568	0	0	10	0
Manure Salts	0	0	0	0	0	0	0	0	0	0	0	0

Table A-3. (Continued)

Description	DE	CN	ME	MD	MA	NJ	NH	NY	RI	PA	VT	WV
Muriate of Potash 60% (Pot. Chloride)	12,042	874	1,797	33,031	1,141	2,800	1,432	43,166	182	25,375	2,636	4,325
Muriate of Potash 62%	427	8	0	2,294	712	47	0	2,095	0	8,345	0	35
Potash Suspensions	0	13	0	0	20	0	24	303	5	2,449	0	0
Potassium Carbonate	0	0	0	250	28	48	0	-246	0	25	0	0
Potassium Nitrate	3	42	0	1,396	289	141	31	96	0	8,490	0	0
Potassium Sulfate	9	26	2	302	79	210	18	370	4	1,721	95	131
Potassium-magnesium Sulfate	137	36	266	1,047	873	168	34	1,959	4	478	274	6
Potassium-metaphosphate	0	0	0	0	1	173	3	0	0	0	0	0
Potassium-sodium Nitrate	0	0	0	0	1	32	0	109	0	0	0	0
Other	1,580	74	35	713	444	2,804	130	8,355	14	720	81	69
TOTAL	14,199	1,074	2,100	39,033	3,625	6,423	1,672	61,776	209	47,605	3,097	4,566
ORGANIC FERTILIZERS												
Blood, Dried	3	7	3	0	23	2	4	6	0	9	0	0
Castor Pomace	0	0	0	0	0	0	0	0	0	0	0	0
Cocoa Shell Meal	0	0	0	0	0	0	0	0	0	0	0	0
Compost	170	0	0	0	14,435	7,841	64	1,413	0	481	10	5,289
Cottonseed Meal	0	0	1	0	4	0	0	0	0	0	0	0
Fish Scrap	0	0	0	0	48	0	0	0	0	0	0	0
Guano	0	0	0	0	0	0	0	0	0	0	0	0
Manure	386	28	18	4,731	676	4,041	45	1,084	0	1,205	53	1,612
Peat	0	0	0	73	0	20	0	0	0	0	0	0
Sewage Sludge, Activated	0	458	124	0	613	279	46	5,028	0	1,311	0	0
Sewage Sludge, Digested	0	0	0	0	0	0	0	0	0	0	0	0

Table A-3. (Continued)

Description	DE	CN	ME	MD	MA	NJ	NH	NY	RI	PA	VT	WV
Sewage Sludge, Heat Dried	127	0	0	0	0	0	0	0	0	0	0	0
Sewage Sludge, Other	33	0	0	0	0	4,004	86	1	0	0	0	0
Soybean Meal	0	0	0	0	0	0	0	0	0	0	0	0
Tankage, Animal	0	0	0	0	0	0	0	0	0	0	0	0
Tankage, Process	0	0	0	0	0	0	0	0	0	0	0	0
Other	353	0	0	1,099	8	3	0	1,369	0	5,013	20	0
TOTAL	1,072	494	147	5,903	15,806	16,190	245	8,902	0	8,019	84	6,902
SECONDARY AND MICRONUTRIENT FERTILIZERS												
Aluminum Sulfate	22	4	0	1	12	2	1	8	3	5	400	0
Borax	27	2	74	153	1	40	14	443	2	113	30	24
Calcium Chelate	1	0	0	0	4	6	0	74	0	1	0	0
Calcium Chloride	0	0	0	0	0	8	0	2	0	384	0	0
Calcium Sulfate (Hydrous)	0	0	0	0	0	0	0	0	0	0	0	0
Cobalt Sulfate	0	0	0	0	0	0	0	0	0	0	0	0
Copper Chelate	0	0	0	0	0	0	0	2	0	0	0	0
Copper Compound	0	0	0	0	0	0	0	0	0	0	0	0
Copper Oxide, Black	0	0	0	0	0	0	0	0	0	0	0	0
Copper Sulfate	0	0	1	2	0	1	0	56	0	381	0	0
Epsom Salt (Magnesium Sulfate)	0	0	1	1	3	33	6	11	0	13	0	0
Ferric Oxide	0	0	0	0	0	0	0	0	0	0	0	0
Ferric Sulfate	0	0	0	0	0	0	0	0	0	51	0	0
Ferrous Sulfate	1	0	0	0	6	0	0	6	0	14	0	0
Gypsum (Calcium Sulfate)	47	129	23	328	267	647	46	104	1	709	22	0
Iron Chelate	0	24	0	19	19	36	6	96	1	32	1	4
Iron Compound	0	2	0	10	4	6	0	45	1	0	0	0

Table A-3. (Continued)

Description	DE	CN	ME	MD	MA	NJ	NH	NY	RI	PA	VT	WV
Lime Sulfur Solution	0	0	0	0	0	0	0	0	0	0	0	0
Magnesia (Magnesium Oxide)	0	0	11	3	0	0	0	131	0	203	0	2
Magnesium Chelate	0	0	0	0	0	0	0	11	0	0	0	0
Manganese Agstone	0	0	0	0	0	0	0	0	0	0	0	0
Manganese Chelate	0	0	0	17	0	0	0	5	0	1	0	0
Manganese Oxide	7	0	0	3	4	0	0	1	0	0	0	0
Manganese Slag	0	0	0	0	0	0	0	0	0	0	0	0
Manganese Sulfate	63	0	1	26	4	6	4	90	0	6	0	0
Manganous Oxide	0	0	0	0	0	0	0	0	0	0	0	0
Potting Soil	14	0	0	0	0	360	0	0	0	0	0	0
Sodium Molybdate	0	0	0	0	0	0	0	0	0	0	0	0
Soil Additive	0	0	0	0	0	2	0	0	0	0	0	0
Soil Amendment	3	0	20,035	0	0	2	0	67	0	0	0	0
Soil Conditioner	0	0	0	0	0	7,135	0	0	0	0	0	0
Sulfur	5	2	61	43	9	23	3	364	0	645	4	9
Sulfuric Acid	0	0	0	0	0	0	0	0	0	0	0	0
Zinc Chelate	5	0	0	30	1	0	0	55	0	4	0	0
Zinc Oxide	0	0	0	0	0	0	0	331	0	36	0	0
Zinc Oxysulfate	0	0	0	15	0	0	0	49	0	8	0	0
Zinc Sulfate	37	0	7	61	0	12	0	165	3	23	9	0
Zinc Sulfate Solution	0	0	0	0	0	0	0	0	0	0	0	0
Other	245	15	0	70	31	64	2	300	0	431	0	2
TOTAL	478	178	20,215	780	367	8,381	81	2,415	12	3,061	467	42
LIMING MATERIALS												
Calcitic Lime (75% Neutral)	0	0	13,094	0	70	0	394	0	0	0	0	0
Calcium Hydroxide (Hydrate)	0	0	7	0	0	0	0	0	17	0	0	0

Table A-3. (Continued)

Description	DE	CN	ME	MD	MA	NJ	NH	NY	RI	PA	VT	WV
Calcium Oxide (Burnt)	0	0	0	0	0	0	0	0	0	0	0	0
Dolomitic & Calcitic Blend (Pelletized)	0	0	0	0	0	0	0	0	0	0	0	0
Dolomitic Lime (75% Neutral)	0	510	11,294	0	2	10	0	0	71	0	0	0
Lime Suspensions	0	0	0	228	0	0	0	0	0	0	0	0
Non-lime Filler (Water, Sand, Etc.)	0	0	0	0	0	0	0	92	0	0	0	0
Standard Calcite	0	0	8,713	7,947	0	0	10	940	265	24	0	557
Standard Dolomite	0	0	353	0	984	0	442	34	5,498	0	29	0
Other	169	0	9,694	6,074	9	375	554	2,753	12	500	0	0
TOTAL	169	510	43,154	14,249	1,065	385	1,401	3,820	5,863	524	29	557
ALL FERTILIZERS												
TOTAL	126,446	42,232	154,395	439,624	104,675	331,556	25,311	416,366	17,718	569,331	36,156	48,002

Table A-4. Fertilizer Consumption (Tons) by State - South Atlantic Region

Description	FL	GA	NC	SC	VA
MULTIPLE NUTRIENT FERTILIZERS					
N-P-K	1,073,365	989,848	792,236	299,311	342,468
N-P	49,685	55,376	71,605	15,851	66,647
N-K	379,121	0	83,792	42,200	21,598
P-K	60,775	0	19,698	60,513	4,749
TOTAL	1,562,946	1,045,224	967,331	417,875	435,462
NITROGEN FERTILIZERS					
Ammonium Nitrate	33,591	81,043	38,198	17,564	12,511
Ammonium Nitrate Solution	3,294	0	0	382	38
Ammonium Nitrate-limestone Mixtures	5	0	392	0	0
Ammonium Nitrate-sulfate	6	0	11,793	54	844
Ammonium Polysulfide	1	0	2,916	606	98
Ammonium Sulfate	29,702	8,088	35,160	3,290	24,836
Ammonium Sulfate Solution	210	0	1	31	429
Ammonium Sulfate-nitrate	1,073	0	107	7	73
Ammonium Sulfate-urea	0	0	0	456	13
Ammonium Thiosulfate	843	0	253	65	253
Anhydrous Ammonia	5,535	8,734	5,187	2,215	782
Aqua Ammonia	27	0	308	0	265
Calcium Ammonium Nitrate	24	0	85	212	33
Calcium Cyanamide	0	0	1	2	0
Calcium Nitrate	10,914	0	6,997	1,342	822
Calcium Nitrate-urea	10	0	1,046	439	0
Ferrous Ammonium Sulfate	33	0	122	0	88
Magnesium Nitrate	3	0	0	0	0
Nitric Acid	0	0	1	16	974
Nitrogen Solution 28%	18,613	0	1,038	2,465	732
Nitrogen Solution 30%	290	332,803	290,404	66,162	82,872
Nitrogen Solution 32%	12,992	0	23,779	1,145	898
Nitrogen Solution <28%	26,999	0	86,347	73,959	45,074
Nitrogen Solution >32%	358	0	72	1,177	353
Sodium Nitrate	912	0	14,178	2,218	1,640
Sulfur Coated Urea	51	0	3	146	46
Urea	16,715	23,762	15,785	4,304	23,051
Urea Solution	159	0	0	143	0
Urea-formaldehyde	7,645	0	1,497	3,020	767
Zinc Ammonium Sulfate Solution	0	0	85	105	129
Zinc Manganese Ammonium Sulfate	5	0	7	0	63

Table A-4. (Continued)

Description	FL	GA	NC	SC	VA
Other	25,758	27,930	5,317	7,966	1,416
TOTAL	195,767	482,360	541,078	189,492	199,101
PHOSPHATE FERTILIZERS					
Ammonium Metaphosphate	0	0	0	0	0
Ammonium Phosphate	2	0	0	0	2
Ammonium Phosphate Nitrate	1	0	0	0	0
Ammonium Phosphate Sulfate	0	0	0	16	8
Ammonium Polyphosphate	6	0	0	0	0
Basic Lime Phosphate	0	0	0	0	0
Basic Slag	2,869	0	119	0	0
Bone Meal, Raw	0	0	24	16	0
Bone Meal, Steamed	37	0	2	0	138
Bone, Precipitated	0	0	0	0	0
Calcium Metaphosphate	13	0	14	0	88
Colloidal Phosphate (Soft Phosphate)	393	0	56	1	50
Diammonium Phosphate	13,674	13,123	34,613	2,757	48,541
Limestone, Phosphatic	45	0	0	0	0
Liquid Ammonium Polyphosphate	8,055	42,253	22,673	9,882	6,661
Magnesium Phosphate	25	0	12	5	0
Monoammonium Phosphate	84	0	2,227	28	1,917
Nitric Phosphate	0	0	0	0	0
Phosphate Rock	0	0	0	0	24
Phosphoric Acid	2,945	0	156	1	100
Precipitated Phosphate	0	0	23	0	0
Super Phosphate, Enriched	25	0	16	26	19
Super Phosphate, Normal	1,737	0	158	561	211
Super Phosphate, Triple	4,260	5,171	10,850	2,313	6,064
Super Phosphoric Acid	2,219	0	0	0	0
Other	5,710	11,371	34	81	383
TOTAL	42,102	71,918	70,978	15,688	64,205
POTASH FERTILIZERS					
Lime-potash Mixtures	30	0	96	1	93
Manure Salts	1	0	478	1	24
Muriate of Potash 60% (Pot. Chloride)	10,570	29,836	77,488	11,619	63,405
Muriate of Potash 62%	738	0	5,121	2,914	4,170
Potash Suspensions	179	0	0	0	0
Potassium Carbonate	2	0	288	4	0
Potassium Nitrate	4,142	0	17,085	5,361	28

Table A-4. (Continued)

Description	FL	GA	NC	SC	VA
Potassium Sulfate	9,313	0	4,883	2,626	873
Potassium-magnesium Sulfate	3,402	6,325	5,779	921	591
Potassium-metaphosphate	0	0	0	0	0
Potassium-sodium Nitrate	946	0	15,713	325	1,434
Other	11,405	12,594	3,605	4,813	4,655
TOTAL	40,727	48,755	130,537	28,586	75,273
ORGANIC FERTILIZERS					
Blood, Dried	5	0	125	0	66
Castor Pomace	0	0	8	0	0
Cocoa Shell Meal	0	0	11	0	0
Compost	3	0	12	1,586	19,263
Cottonseed Meal	1	0	39	0	0
Fish Scrap	0	0	18	0	0
Guano	0	0	0	0	0
Manure	4,010	0	42,046	3,573	7,679
Peat	0	0	8,399	0	62
Sewage Sludge, Activated	10,682	0	23	56	0
Sewage Sludge, Digested	0	0	0	0	0
Sewage Sludge, Heat Dried	0	0	0	0	0
Sewage Sludge, Other	0	0	6	0	253
Soybean Meal	0	0	0	0	0
Tankage, Animal	0	0	0	0	0
Tankage, Process	0	0	83	0	0
Other	996	29,314	143,494	1,397	12,226
TOTAL	15,695	29,314	194,265	6,612	39,548
SECONDARY AND MICRONUTRIENT FERTILIZERS					
Aluminum Sulfate	4	0	4	0	9
Borax	84	0	1,268	75	467
Calcium Chelate	222	0	3	0	2
Calcium Chloride	8	0	2	5	24
Calcium Sulfate (Hydrous)	13	0	0	0	0
Cobalt Sulfate	0	0	0	0	0
Copper Chelate	0	0	58	0	0
Copper Compound	4	0	0	3	0
Copper Oxide, Black	0	0	0	0	0
Copper Sulfate	175	0	35	4	3
Epsom Salt (Magnesium Sulfate)	859	0	2	8	5
Ferric Oxide	1	0	0	0	0

Table A-4. (Continued)

Description	FL	GA	NC	SC	VA
Ferric Sulfate	0	0	0	0	0
Ferrous Sulfate	1,723	0	22	0	0
Gypsum (Calcium Sulfate)	22,357	79,514	130,820	9,506	92,203
Iron Chelate	553	0	69	0	7
Iron Compound	172	0	0	38	5
Lime Sulfur Solution	0	0	0	0	0
Magnesia (Magnesium Oxide)	160	0	46	47	13
Magnesium Chelate	21	0	0	0	3
Manganese Agstone	0	0	0	0	0
Manganese Chelate	38	0	80	0	1
Manganese Oxide	13	0	24	-1	3
Manganese Slag	72	0	0	88	0
Manganese Sulfate	3,238	0	129	8	1
Manganous Oxide	0	0	0	0	0
Potting Soil	0	0	0	0	28,530
Sodium Molybdate	0	0	0	0	0
Soil Additive	1	0	0	0	0
Soil Amendment	0	0	0	0	5,036
Soil Conditioner	356	0	1	0	58
Sulfur	807	0	656	226	584
Sulfuric Acid	0	0	0	0	0
Zinc Chelate	15	0	27	0	41
Zinc Oxide	118	0	0	3	0
Zinc Oxysulfate	0	0	11	8	3
Zinc Sulfate	3	0	3	1	27
Zinc Sulfate Solution	0	0	0	0	0
Other	60,293	39,388	12,392	4,448	518
TOTAL	91,308	118,902	145,651	14,468	127,543
LIMING MATERIALS					
Calcitic Lime (75% Neutral)	25,124	0	0	0	0
Calcium Hydroxide (Hydrate)	231	0	0	0	0
Calcium Oxide (Burnt)	186	0	0	0	0
Dolomitic & Calcitic Blend (Pelletized)	775	0	0	0	115
Dolomitic Lime (75% Neutral)	111,666	0	0	0	197
Lime Suspensions	0	0	0	0	0
Non-lime Filler (Water, Sand, Etc.)	7	0	0	0	0
Standard Calcite	22,288	0	947,126	0	3,917
Standard Dolomite	36,218	0	0	0	6

Table A-4. (Continued)

Description	FL	GA	NC	SC	VA
Other	19,864	0	0	0	15,960
TOTAL	216,359	0	947,126	0	20,196
ALL FERTILIZERS					
TOTAL	2,123,256	1,741,097	2,821,000	649,028	875,174

Table A-5. Fertilizer Consumption (Tons) by State - Mountain and Pacific Region and Puerto Rico

	AZ	AK	CA	CO	HI	ID	MT	NV	NM	OR	Puerto Rico	UT	WA	WY
MULTIPLE NUTRIENT FERTILIZERS														
N-P-K	0	2,379	1,248,781	23,218	45,031	0	4,383	5,679	6,651	20,353	66,807	13,565	67,305	6,476
N-P	59,497	585	206,474	74,704	6,297	213,955	166,831	6,912	36,594	101,923	30	16,551	144,203	53,239
N-K	1,853	0	24,219	891	0	0	238	170	460	5,553	1,572	152	5,636	732
P-K	0	0	60	0	0	0	0	18	0	315	13	0	1,011	5
TOTAL	61,351	2,964	1,479,534	98,813	51,328	213,955	171,452	12,778	43,704	128,144	68,422	30,268	218,155	60,452
NITROGEN FERTILIZERS														
Ammonium Nitrate	2,416	15	92,968	53,971	0	126,896	56,557	1,700	1,827	32,335	132	36,433	52,065	28,354
Ammonium Nitrate Solution	0	0	67,364	0	0	0	0	50	0	2,700	0	0	0	0
Ammonium Nitrate-limestone Mixtures	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ammonium Nitrate-sulfate	0	0	0	0	0	6,508	0	0	48	26	0	0	2,464	1,036
Ammonium Polysulfide	7,155	0	9,125	0	0	900	0	301	989	3,489	0	792	12,433	0
Ammonium Sulfate	8,994	123	205,878	3,830	15,285	82,425	18,146	3,674	7,054	86,629	1,613	11,532	58,361	3,188
Ammonium Sulfate Solution	0	0	0	0	0	0	0	0	16	314	0	7	4	0
Ammonium Sulfate-nitrate	0	0	0	0	0	0	0	0	1,707	847	0	0	158	1
Ammonium Sulfate-urea	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ammonium Thiosulfate	0	0	8,977	7,853	0	13,972	1,660	326	2,347	11,596	0	480	39,528	1,788
Anhydrous Ammonia	18,877	0	154,673	50,381	0	44,552	75,716	559	13,750	32,545	0	1,799	78,143	84,839
Aqua Ammonia	1,408	0	204,931	200	0	6,672	426	0	6	9,179	0	0	134,951	158
Calcium Ammonium Nitrate	0	0	173,949	176	0	0	0	326	377	649	0	5	2,076	98
Calcium Cyanamide	0	0	0	0	0	0	0	0	0	0	0	0	248	0
Calcium Nitrate	1,309	0	95,323	626	0	0	0	18	1,136	3,889	0	0	13,476	545
Calcium Nitrate-urea	0	0	0	0	0	0	0	0	0	0	0	0	0	87
Ferrous Ammonium Sulfate	0	0	0	0	0	0	0	0	43	0	0	0	1,805	0

Table A-5. (Continued)

	AZ	AK	CA	CO	HI	ID	MT	NV	NM	OR	Puerto Rico	UT	WA	WY
Magnesium Nitrate	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Nitric Acid	0	0	0	188	0	0	0	0	20	0	0	4	0	0
Nitrogen Solution 28%	0	0	7,168	6,053	0	0	15,076	0	4,529	4,678	0	32	6,595	578
Nitrogen Solution 30%	0	0	0	252	0	0	0	0	106	0	0	0	16	65
Nitrogen Solution 32%	138,961	0	586,101	63,869	18,236	136,491	7,895	4,105	31,050	70,144	0	10,666	137,675	50,096
Nitrogen Solution <28%	41,408	0	975	9,458	0	2,002	0	376	401	403	0	244	16,542	110
Nitrogen Solution >32%	0	0	0	0	0	0	0	0	23	0	0	0	967	0
Sodium Nitrate	0	0	1,694	0	0	0	0	7	20	0	0	68	24	0
Sulfur Coated Urea	0	0	1,741	11	0	0	0	0	237	248	8	178	0	0
Urea	27,443	5,125	86,788	27,931	2,480	123,923	168,648	520	13,106	111,569	2,108	4,963	68,123	11,055
Urea Solution	0	0	8,437	0	0	0	0	63	0	0	0	0	0	0
Urea-formaldehyde	0	0	0	2	0	0	0	11	0	3,860	1	75	399	0
Zinc Ammonium Sulfate Solution	0	0	0	4	0	0	0	0	0	0	0	4	0	64
Zinc Manganese Ammonium Sulfate	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other	0	0	0	6,678	0	0	0	7,635	1,802	9,484	1	1,126	23,958	376
TOTAL	247,971	5,263	1,706,091	231,483	36,000	544,340	344,124	19,670	80,595	384,584	3,864	68,407	650,012	182,439
PHOSPHATE FERTILIZERS														
Ammonium Metaphosphate	0	0	0	0	0	0	0	0	0	0	0	0	8,284	0
Ammonium Phosphate	37	0	0	0	3,215	201	0	0	0	116	0	0	353	0
Ammonium Phosphate Nitrate	0	0	0	0	0	0	0	0	0	1	0	0	2,511	0
Ammonium Phosphate Sulfate	9,497	0	35,053	78	0	39,813	17,674	1,949	542	34,233	0	2,427	29,659	4,612
Ammonium Polyphosphate	0	0	0	0	0	0	0	0	0	0	0	0	3,706	0
Basic Lime Phosphate	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table A-5. (Continued)

	AZ	AK	CA	CO	HI	ID	MT	NV	NM	OR	Puerto Rico	UT	WA	WY
Basic Slag	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Bone Meal, Raw	0	0	0	0	0	0	0	1	0	0	0	0	82	0
Bone Meal, Steamed	0	0	0	0	0	0	0	17	0	0	0	0	374	0
Bone, Precipitated	0	0	0	0	0	0	0	0	0	0	0	0	0	284
Calcium Metaphosphate	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Colloidal Phosphate (Soft Phosphate)	0	0	0	0	0	0	0	0	0	0	0	0	6	0
Diammonium Phosphate	1,737	585	18,104	3,998	0	49,045	47,927	58	3,120	7,963	30	1,363	10,414	22,378
Limestone, Phosphatic	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Liquid Ammonium Polyphosphate	19,153	0	74,203	11,328	3,081	10,277	3,211	644	17,212	8,361	0	1,508	39,510	1,572
Magnesium Phosphate	0	0	0	0	0	0	0	0	25	0	0	0	3	0
Monoammonium Phosphate	29,073	0	78,651	59,301	0	114,618	98,019	3,096	11,526	44,192	1	10,519	42,876	24,561
Nitric Phosphate	0	0	0	0	0	0	0	0	0	0	0	0	2,394	0
Phosphate Rock	0	0	0	232	11	0	0	0	0	2,804	0	1,185	65	0
Phosphoric Acid	3,737	0	10,668	451	0	5,626	0	24	0	1,440	0	32	3,047	64
Precipitated Phosphate	0	0	0	0	0	0	0	0	0	0	6	0	0	1,187
Superphosphate, Enriched	0	0	0	0	0	0	0	0	0	194	0	56	362	0
Superphosphate, Normal	0	4	468	0	155	3,785	0	0	0	0	0	0	5	0
Superphosphate, Triple	731	4	4,363	946	172	3,759	1,059	414	1,082	2,336	255	10,524	5,250	1,414
Superphosphoric Acid	0	0	1,533	0	0	13,069	0	0	635	10,582	0	0	462	4,619
Other	0	0	31	2,013	0	88	0	170	98	59	0	214	2,778	0
TOTAL	63,966	593	223,074	78,345	6,635	240,282	167,891	6,373	34,241	112,279	291	27,828	152,142	60,692
POTASH FERTILIZERS														
Lime-potash Mixtures	0	0	0	0	0	237	0	0	307	0	0	0	0	0
Manure Salts	0	0	0	0	0	0	0	0	1,530	0	0	0	0	0

Table A-5. (Continued)

	AZ	AK	CA	CO	HI	ID	MT	NV	NM	OR	Puerto Rico	UT	WA	WY
Muriate of Potash 60% (Pot. Chloride)	3,776	30	52,170	3,418	494	44,162	31,808	227	14,671	32,666	68	3,569	64,250	2,823
Muriate of Potash 62%	0	0	0	5,221	0	494	0	0	13	10,917	0	211	73	70
Potash Suspensions	0	0	0	0	0	0	0	0	0	2,647	0	0	4,444	0
Potassium Carbonate	0	0	0	0	0	0	0	0	442	21	0	0	4	0
Potassium Nitrate	1,853	0	23,208	871	0	0	0	16	0	244	179	0	76	0
Potassium Sulfate	407	2	41,748	685	845	2,138	0	49	464	3,883	326	920	9,924	44
Potassium-magnesium Sulfate	95	0	12,705	322	0	0	0	0	5,241	7,666	0	0	9,930	156
Potassium-metaphosphate	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Potassium-sodium Nitrate	0	0	0	0	0	0	0	0	0	0	0	1	0	0
Other	0	0	319	1,396	16,328	17,395	0	289	66	533	0	212	10,245	1
TOTAL	6,131	32	130,149	11,913	17,667	64,426	31,808	581	22,732	58,576	573	4,913	98,947	3,095
ORGANIC FERTILIZERS														
Blood, Dried	0	0	1,612	0	0	0	0	0	0	0	0	0	158	0
Castor Pomace	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cocoa Shell Meal	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Compost	0	0	0	2,381	0	0	4,284	0	0	0	0	0	948	2,128
Cottonseed Meal	0	0	0	0	0	0	0	0	0	0	0	0	72	0
Fish Scrap	0	0	0	0	0	0	0	0	0	0	0	0	377	0
Guano	0	0	0	0	0	0	0	0	0	0	0	0	6	0
Manure	0	0	0	7,399	0	0	99	217	0	0	0	673	17,470	265
Peat	0	0	0	0	0	0	0	0	0	0	0	0	0	395
Sewage Sludge, Activated	0	0	0	0	0	0	0	0	0	0	0	97	0	0
Sewage Sludge, Digested	0	0	0	0	0	0	0	0	0	0	0	0	2	0
Sewage Sludge, Heat Dried	0	0	0	12,506	0	0	0	4	0	0	0	0	0	0

Table A-5. (Continued)

	AZ	AK	CA	CO	HI	ID	MT	NV	NM	OR	Puerto Rico	UT	WA	WY
Sewage Sludge, Other	0	0	77,169	0	0	0	0	0	0	0	0	0	0	0
Soybean Meal	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tankage, Animal	0	0	0	0	0	0	0	0	0	0	0	0	0	202
Tankage, Process	0	0	0	0	0	0	0	0	0	0	0	0	371	0
Other	0	0	0	1,046	0	0	0	7	0	0	11	2	11,544	0
TOTAL	0	0	78,781	23,333	0	0	4,383	228	0	0	11	772	30,947	2,990
SECONDARY AND MICRONUTRIENT FERTILIZERS														
Aluminum Sulfate	0	0	0	0	0	0	6	0	0	2	0	0	136	0
Borax	0	0	0	25	0	0	0	15	0	788	0	21	3,491	10
Calcium Chelate	0	0	0	0	3,751	0	0	0	0	0	0	1	0	0
Calcium Chloride	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Calcium Sulfate (Hydrous)	0	0	0	0	0	0	0	0	0	0	0	0	179	0
Cobalt Sulfate	0	0	0	0	0	0	0	0	0	0	0	0	2	0
Copper Chelate	0	0	0	0	0	0	0	1	0	0	0	0	25	0
Copper Compound	0	0	342	0	0	0	0	0	0	240	0	0	0	0
Copper Oxide, Black	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Copper Sulfate	0	0	0	18	0	343	0	0	0	0	0	1	89	5
Epsom Salt (Magnesium Sulfate)	0	0	0	0	0	0	0	0	0	14	219	0	1,250	82
Ferric Oxide	0	0	0	0	0	0	0	0	0	0	0	0	1	0
Ferric Sulfate	492	0	0	0	0	0	0	22	0	0	0	2	4,073	0
Ferrous Sulfate	0	0	0	971	0	0	0	47	0	0	0	3	1,159	400
Gypsum (Calcium Sulfate)	26,043	0	1,170,333	1,493	0	3,703	261	5,831	0	12,736	0	238	22,513	0
Iron Chelate	0	0	0	18	0	310	0	1	0	7	0	37	155	0
Iron Compound	0	0	4,736	0	0	0	0	5	0	2,284	0	22	0	0
Lime Sulfur Solution	716	0	0	0	0	0	0	0	0	0	0	0	3	0
Magnesia (Magnesium Oxide)	0	0	0	0	240	0	0	0	0	0	7	0	0	0

Table A-5. (Continued)

	AZ	AK	CA	CO	HI	ID	MT	NV	NM	OR	Puerto Rico	UT	WA	WY
Magnesium Chelate	0	0	0	0	0	415	0	0	0	0	0	0	35	0
Manganese Agstone	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Manganese Chelate	0	0	0	0	0	0	0	0	0	0	0	1	105	0
Manganese Oxide	0	0	0	4	0	0	0	0	0	59	0	0	12	0
Manganese Slag	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Manganese Sulfate	0	0	0	19	0	0	0	2	0	0	0	15	293	37
Manganous Oxide	0	0	0	0	2	0	0	0	0	0	0	0	0	0
Potting Soil	0	0	0	0	0	0	0	0	0	0	0	44	0	0
Sodium Molybdate	0	0	0	0	0	0	0	0	0	0	0	0	23	0
Soil Additive	0	0	0	2	0	0	0	0	0	0	0	0	0	0
Soil Amendment	0	0	0	339	0	0	0	0	0	316	0	0	0	0
Soil Conditioner	0	0	0	10,817	0	0	0	0	0	0	0	0	0	0
Sulfur	2,168	0	57,043	2,786	137	17,672	788	852	8	2,440	0	694	7,155	1,287
Sulfuric Acid	13,814	0	117,877	1,177	0	0	0	24	0	223	0	0	0	0
Zinc Chelate	0	0	0	121	0	4,859	0	2	0	0	0	5	790	1
Zinc Oxide	0	0	0	0	0	0	0	0	0	1,066	0	132	417	111
Zinc Oxysulfate	0	0	0	0	0	0	0	0	0	0	0	0	35	0
Zinc Sulfate	0	0	0	818	15	31	0	26	0	0	0	96	3,499	555
Zinc Sulfate Solution	0	0	0	0	0	0	0	0	0	0	0	0	0	17
Other	2,028	0	246,465	72	0	4,799	1,865	82	6,782	497	81	285	85,422	32
TOTAL	45,261	0	1,596,796	18,682	4,144	32,134	2,920	6,911	6,790	20,671	307	1,599	130,861	2,538

Table A-5. (Continued)

	AZ	AK	CA	CO	HI	ID	MT	NV	NM	OR	Puerto Rico	UT	WA	WY
LIMING MATERIALS														
Calcitic Lime (75% Neutral)	0	0	0	0	8,696	0	0	0	0	0	0	0	0	0
Calcium Hydroxide (Hydrate)	0	0	0	0	0	0	0	0	0	171	0	0	1,793	0
Calcium Oxide (Burnt)	0	0	0	0	96	0	0	0	0	0	0	0	0	0
Dolomitic & Calcitic Blend (Pelletized)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Dolomitic Lime (75% Neutral)	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Lime Suspensions	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non-lime Filler (Water, Sand, Etc.)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Standard Calcite	0	180	0	516	0	0	48	0	0	147,919	0	0	12,832	0
Standard Dolomite	0	0	0	0	0	0	0	0	0	20,473	0	0	13,959	0
Other	0	0	621,915	0	0	37	0	0	0	24,161	0	0	54,705	0
TOTAL	0	180	621,915	516	8,792	37	48	0	0	192,724	0	0	83,289	1
ALL FERTILIZERS														
TOTAL	363,329	8,447	5,529,952	364,291	118,269	881,219	551,412	40,538	155,629	801,869	73,259	117,199	1,205,189	256,092

APPENDIX B
CROP-SPECIFIC FERTILIZER USE IN THE UNITED STATES

Appendix B. Crop-Specific Fertilizer Use in the United States

The USDA ERS-NASS data presented in this appendix come from the most recent surveys of field, fruit and vegetable crops. These surveys, the sampling methodology, coverage and data collection are described in Agricultural Resources and Environmental Indicators (AREI) Production Management Appendix (1997).

Fruit and vegetable data were abstracted from the Chemical Use Surveys that were initially funded under the 1989 President's Food Safety Initiative. These surveys are conducted by NASS "using personal enumeration of a stratified systematic sample of growers who produce at least one acre of the targeted crops." The information collected on fertilizer use, acreage planted, and application rates are survey data for the major crop producing states and do not represent the totality of farms in the U.S. raising these crops. Surveys are conducted odd years for fruit (latest available survey performed in 1995, representing the crop year 1995, and reported in 1996) and even years for vegetable crops (latest available survey is for the crop year, 1994 reported in 1995).

The latest field crop usage data, covering 70 to 90% of the total U.S. crop, are from the Agricultural Resources Management Survey (ARMS) of 1996 which combines the former Cropping Practices Surveys with the Farm Costs and Returns Survey. This survey has three phases. Phase II, conducted in the autumn, for the preceeding crop year, collects data on agricultural production practices, resource and input use, and production. In this survey, "a multi-frame, stratified sampling procedure is used. Results are weighted and aggregated to develop state, regional and national estimates." Note that there are some crops (strawberries, cantaloupe, honeydew melon and watermelon) in the vegetable survey that are commonly considered fruits.

Detailed descriptions of the survey procedures are presented in the following documents available on the internet from http://mann77.mannlib.cornell.edu.:

1. Agricultural Chemical Usage, 1995 Fruits Summary, USDA, NASS, ERS, July 1996, Ag Ch 1 (96)
2. Agricultural Chemical Usage, Vegetables, 1996 Summary, USDA, NASS, ERS, July, 1997, Ag Ch 1 (97)
3. Agricultural Chemical Usage, 1996 Field Crops Summary, USDA, NASS, ERS, September, 1997, Ag Ch 1 (97)

Table B-1. Fertilizer Use on Field Crops for the 1996 Crop Year[a]

			Total Applied (million lbs/year)			Application Rate per Crop Year (lbs/acre)		
Crop	State	Acres Planted (1,000 acres)	N	P	K	N	P	K
Corn	IL	11,000	1,823.9	737.5	1,056.0	166	85	116
	IN	5,600	774.7	346.1	542.4	138	64	110
	IA	12,700	1,631.7	627.7	786.1	132	60	76
	KS	2,500	416.5	79.5	26.1	170	38	36
	KY	1,300	186.9	87.2	94.1	146	78	82
	MI	2,650	307.9	112.7	226.5	116	47	101
	MN	7,500	784.4	375.6	420.9	108	53	65
	MO	2,750	398.5	132.7	163.5	149	55	69
	NE	8,500	1,174.0	227.6	75.0	140	34	22
	NC	1,000	113.1	53.6	88.7	114	59	100
	OH	2,900	425.4	245.8	244.0	147	87	98
	PA	1,450	112.2	67.0	43.6	79	58	40
	SC	400	46.0	21.8	42.3	115	57	106
	SD	4,000	312.3	105.7	31.8	89	34	20
	TX	2,100	284.5	61.6	25.4	137	37	28
	WI	3,900	297.0	134.6	209.7	81	39	61
	Total	70,250	9,089.0	3,416.7	4,076.1	133	57	79
Upland Cotton	AZ	315	45.8	6.6	1.6	148	49	44
	AR	1,000	94.0	25.2	49.3	97	38	70
	CA	1,000	168.1	30.6	9.5	175	83	58
	GA	1,350	139.3	76.7	139.1	104	57	106
	LA	890	60.1	25.7	39.5	74	45	67
	MS	1,120	110.4	14.0	63.4	100	47	100
	TN	540	47.8	32.0	47.1	89	60	88
	TX	5,700	252.2	105.2	23.6	80	39	21
	Total	11,915	917.7	316.0	373.1	100	48	73

Table B-1. (Continued)

			Total Applied (million lbs/year)			Application Rate per Crop Year (lbs/acre)		
Crop	State	Acres Planted (1,000 acres)	N	P	K	N	P	K
Fall Potatoes	ID	410	84.4	80.6	40.7	206	198	116
	ME	78	13.0	13.4	13.6	167	174	175
	WA	163	44.3	39.4	30.2	285	195	204
	RR[b]	146	12.3	11.0	14.4	84	78	105
	Total	797	154.0	134.4	98.9	195	173	139
Soybeans	AR	3,550	8.2	76.4	90.5	26	48	60
	IL	9,900	32.4	128.3	329.6	22	56	99
	IN	5,400	37.9	79.1	240.7	31	45	102
	IA	9,500	19.5	55.2	99.3	26	49	76
	LA	1,100	0.7	17.1	26.0	14	43	70
	MN	5,950	9.2	38.4	42.9	15	47	69
	MS	1,800	2.5	14.0	19.4	13	42	62
	MO	4,100	20.5	54.9	81.3	21	54	71
	NE	3,050	10.2	64.4	5.3	12	42	17
	OH	4,500	30.4	50.1	164.8	34	46	102
	TN	1,200	12.8	27.5	51.5	40	53	82
	Total	50,050	184.3	605.4	1,151.3	24	49	85
Flue-cured Tobacco	GA	46	5.0	5.2	13.0	108	114	284
	NC	280	24.0	25.3	54.7	86	91	197
	SC	51	4.1	3.3	8.8	80	67	172
	VA	38	3.3	4.2	7.1	90	116	193
	Total	415	36.4	38.0	83.6	88	93	203
Winter Wheat	CO	2,200	70.2	18.0	NA[c]	41	21	NA
	ID	860	96.2	22.1	5.0	115	53	40
	KS	8,800	461.6	162.3	NA	56	28	NA

Table B-1. (Continued)

			Total Applied (million lbs/year)			Application Rate per Crop Year (lbs/acre)		
Crop	State	Acres Planted (1,000 acres)	N	P	K	N	P	K
	MT	1,980	84.7	46.9	4.3	53	30	17
	NE	2,100	78.6	34.8	NA	43	32	NA
	OK	4,900	199.2	70.8	26.1	54	32	49
	OR	850	65.0	2.5	1.1	77	30	28
	SD	1,580	60.8	29.2	NA	49	28	NA
	TX	2,900	183.6	39.4	NA	81	44	NA
	WA	2,350	194.9	12.2	5.4	83	20	24
	Total	28,520	1,494.8	438.2	53.0	61	30	29
Durum Wheat	ND	3,000	168.6	50.9	4.9	60	23	21
Other Spring Wheat	MN	2,550	227.0	82.1	33.8	91	37	28
	MT	4,200	173.5	89.6	3.6	50	27	9
	ND	9,600	582.9	227.4	46.0	68	30	20
	Total	16,350	983.4	399.1	83.4	67	31	21

a) Source: USDA, ERS, September, 1997
b) RR = Red River Valley includes the counties of Clay, Clearwater, Kittson, Mahnomen, Marshall, Norman, Pennington, Polk, Red Lake, Roseau and Wilkin in Minnesota and Cass, Grand Forks, Pembina, Richland, Steele, Traill and Walsh in North Dakota
c) NA = Insufficient reports to publish data

Table B-2. Fertilizer Use on Vegetable Crops[a] for the 1994 Crop Year

		Acres Planted	Total Applied (1000 lbs/year)			Application Rate Per Crop Year (lbs/acre)		
Crop	State		N	P	K	N	P	K
Asparagus	CA	34,500	3,091	380	522	136	66	51
	IL	750	36	48	9	64	85	88
	MI	19,500	1,290	110	2,505	68	44	134
	NJ	900	72	85	123	85	101	145
	WA	25,000	2,737	568	344	128	52	50
	Total	80,650	7,226	1,191	3,504	100	57	110
Beans, Lima (fresh)	GA	6,500	654	364	565	101	56	87
Beans, Lima (processing)	6 States	33,500	1,704	959	834	68	61	71
Beans, Snap (fresh)	CA	7,500	636	387	173	101	104	106
	FL	26,900	2,288	2,439	3,173	86	99	120
	GA	18,000	1,623	1,006	1,946	100	66	132
	MI	2,200	76	118	147	39	64	72
	NJ	4,200	214	274	286	53	68	70
	NY	5,200	199	237	234	40	47	46
	NC	7,300	435	493	540	61	69	79
	Total	71,300	5,471	4,954	6,498	85	88	115
Beans, Snap (processing)	CA	ND[b]	ND	ND	ND	154	96	73
	IL	15,800	1,081	567	1,073	72	52	101
	MI	23,000	1,072	839	1,179	47	40	67
	NJ	ND	ND	ND	ND	77	40	51
	NY	18,000	624	1,348	1,159	35	75	65
	NC	ND	ND	ND	ND	47	102	88
	OR	23,200	2,016	2,838	1,475	88	128	71
	WA	ND	ND	ND	ND	86	49	NE[b]
	WI	84,800	4,983	3,964	5,096	59	48	63
	Total	173,400	10,695	10,192	10,354	64	64	68
Broccoli	AZ	9,400	2,322	1,827	11	247	199	8
	CA	94,500	18,593	6,556	3,970	203	88	61
	OR	3,200	613	505	348	193	159	131
	TX	3,800	244	191	16	92	88	14
	Total	110,900	21,772	9,087	4,345	206	109	62

a) Source: USDA, NASS, ERS Agricultural Chemical Usage Vegetables 1996.
b) ND = USDA did not publish data to avoid disclosure.
c) NE = Absence of data is not explained in the USDA report.

Table B-2. (Continued)

		Acres Planted	Total Applied (1000 lbs/year)			Application Rate Per Crop Year (lbs/acre)		
Crop	State		N	P	K	N	P	K
Cabbage (fresh)	CA	10,500	1,567	874	406	162	97	70
	FL	9,300	2,395	874	2,527	258	94	272
	GA	11,000	2,274	1,246	2,202	207	119	200
	MI	2,200	303	206	357	138	101	164
	NJ	2,300	377	271	342	168	121	152
	NY	12,300	1,425	1,314	2,111	117	110	173
	NC	5,400	814	797	991	152	149	186
	TX	11,900	1,425	803	110	120	86	18
	WI	5,000	1,078	526	677	218	106	137
	Total	69,900	11,658	6,910	9,724	167	106	163
Cabbage (processing)	NY	2,100	223	201	363	106	96	173
	WI	3,500	509	325	782	146	93	224
	Total	5,600	733	525	1,145	126	94	198
Carrots	AZ	2,200	NA[a]	NA	NA	NA	NA	NA
	CA	58,500	13,664	11,298	3,000	234	200	68
	FL	7,600	178	229	562	24	31	77
	MI	8,000	1,114	761	1,766	141	97	223
	NY	1,400	107	106	162	80	95	145
	OR	1,400	146	158	127	112	116	96
	TX	9,000	867	247	54	102	55	17
	WA	8,200	1,631	1,020	1,853	200	128	235
	WI	4,400	324	601	1,413	90	148	340
	Total	100,700	18,347	14,954	8,983	182	166	110
Cauliflower	AZ	5,700	1,795	1,344	NA	315	236	
	CA	41,500	8,661	3,243	1,799	219	85	57
	MI	800	102	60	127	127	92	159
	NY	1,600	159	158	172	101	101	111
	OR	3,300	631	392	279	192	129	94
	TX	950	127	43	5	234	96	25
	Total	53,850	11,474	5,239	2,382	230	121	69
Celery	CA	24,500	7,749	5,559	5,033	317	228	207
	FL	7,200	962	1,149	3,003	134	160	417
	MI	2,800	408	330	1,019	151	126	377
	TX	1,400	NA	NA	NA	NA	NA	NA
	Total	35,900	9,119	7,037	9,055	240	195	292

a) NA = Insufficient reports to publish data.

Table B-2. (Continued)

		Acres Planted	Total Applied (1000 lbs/year)			Application Rate Per Crop Year (lbs/acre)		
Crop	State		N	P	K	N	P	K
Corn, Sweet (fresh)	CA	21,600	4,632	2,385	950	219	129	68
	FL	42,900	3,634	3,257	9,273	95	78	216
	GA	19,500	5,055	933	3,467	268	50	186
	IL	8,700	903	452	604	106	68	89
	MI	13,500	1,217	705	1,226	97	65	102
	NJ	9,500	1,352	916	880	146	102	98
	NY	25,500	2,557	1,921	2,431	101	76	96
	NC	6,000	615	375	646	105	68	112
	OR	2,300	470	221	146	208	100	66
	TX	3,500	931	264	229	274	83	85
	WA	2,900	416	163	136	145	71	83
	WI	8,000	774	308	540	98	40	72
	Total	163,900	22,557	11,899	20,528	125	81	137
Corn, Sweet (processing)	IL	36,700	5,033	1,842	3,100	139	60	93
	MI	7,100	1,120	269	441	158	47	77
	MN	143,000	16,087	5,882	7,566	113	48	68
	NY	32,500	2,706	1,986	2,190	86	68	85
	OR	48,600	9,750	6,214	4,226	202	134	94
	WA	74,700	16,583	4,599	4,731	227	68	98
	WI	160,800	17,804	7,684	13,657	112	49	89
	Total	503,400	69,084	28,476	35,912	135	63	85
Cucumbers (fresh)	CA	5,000	399	296	200	81	61	56
	FL	13,300	1,529	1,035	1,533	115	137	119
	GA	13,000	1,788	1,108	2,018	139	89	156
	MI	5,800	722	385	838	125	69	145
	NJ	2,400	302	198	236	127	84	100
	NY	3,300	318	304	305	97	93	94
	NC	6,000	725	540	811	121	91	136
	TX	2,600	242	84	45	99	47	28
	Total	51,400	6,025	3,950	5,985	115	89	115

Table B-2. (Continued)

Crop	State	Acres Planted	Total Applied (1000 lbs/year)			Application Rate Per Crop Year (lbs/acre)		
			N	P	K	N	P	K
Cucumbers (processing)	CA	5,000	772	266	248	155	56	55
	FL	2,100	206	82	241	98	40	115
	GA	ND[a]	ND	ND	ND	61	55	63
	MI	24,500	1,786	1,143	2,511	73	48	109
	NC	25,500	2,356	1,064	2,475	93	47	102
	OR	ND	ND	ND	ND	87	115	83
	TX	13,900	1,555	1,330	822	112	101	67
	WA	ND	ND	ND	ND	107	147	123
	WI	6,200	679	334	721	110	54	116
	Total	82,600	7,866	4,809	7,472	94	60	100
Eggplant	FL	2,500	301	219	301	121	124	120
	NJ	1,000	141	127	156	153	137	168
	Total	3,500	442	346	456	133	130	140
Lettuce, Head	AZ	52,100	18,562	12,668		357	252	
	CA	128,500	27,014	14,251	5,487	210	147	73
	FL	7,400	NA[b]	NA	NA			
	NJ	1,900	276	187	277	146	99	146
	NY	1,100	101	90	134	93	84	124
	Total	191,000	45,953	27,196	5,898	262	190	77
Lettuce, Other	AZ	7,700	2,582	1,813		335	237	
	CA	51,000	6,772	3,846	2,220	163	107	71
	FL	1,420	105	48	105	75	34	75
	Total	60,120	9,459	5,706	2,325	194	134	71
Cantaloupe	AZ	14,400	2,440	1,413	82	170	103	9
	CA	59,300	5,279	2,528	574	90	86	47
	GA	9,000	918	688	1,097	104	79	124
	MI	1,100	105	85	115	97	85	111
	TX	13,900	1,039	1,157	472	80	93	42
	Total	97,700	9,781	5,870	2,341	104	93	41
Honeydew Melon	AZ	2,600	534	182	NA	206	93	NA
	CA	18,100	1,068	986	247	59	68	119
	TX	5,000	583	933	196	120	192	NA
	Total	25,700	2,184	2,101	444	83	96	68

a) ND = USDA did not publish data to avoid disclosure.
b) NA = Insufficient reports to publish data.

Table B-2. (Continued)

Crop	State	Acres Planted	Total Applied (1000 lbs/year)			Application Rate Per Crop Year (lbs/acre)		
			N	P	K	N	P	K
Watermelon	AZ	6,800	2,774	678	NA[a]	414	123	NA
	CA	16,700	2,863	1,910	862	175	163	96
	FL	40,000	5,731	4,330	7,209	145	123	182
	GA	37,000	3,930	3,142	4,941	108	87	136
	NC	9,500	910	465	1,093	98	51	119
	TX	56,000	138	3,150	1,701	61	65	46
	Total	166,000	19,347	13,676	15,806	120	94	119
Onions, Dry	AZ	1,700	458	288	2	269	188	16
	CA	38,200	9,172	5,452	1,085	247	163	95
	GA	11,000	2,087	2,201	2,665	204	217	266
	MI	7,400	1,051	1,060	1,502	143	145	221
	NY	13,200	1,494	1,652	2,228	113	128	175
	OR	19,800	5,292	2,709	1,520	268	147	98
	TX	22,100	2,301	1,466	509	107	73	32
	WA	12,400	2,691	1,671	603	218	142	157
	WI	2,000	251	222	365	126	111	183
	Total	127,800	24,798	16,721	11,479	186	137	139
Peas, Green (processing)	IL	13,400	393	584	1,170	36	54	102
	MN	84,900	1,413	2,163	3,175	25	40	58
	NY	10,200	423	754	849	42	75	87
	OR	37,100	856	586	362	24	52	40
	WA	61,800	1,270	3,696	3,334	32	108	110
	WI	73,400	2,565	2,442	4,665	39	41	72
	Total	280,800	6,920	10,225	13,555	30	55	73
Peppers, Bell	CA	19,000	5,451	4,419	2,618	320	405	286
	FL	22,100	6,274	2,707	8,675	284	139	393
	MI	2,700	257	182	283	95	73	105
	NJ	5,400	1,002	801	963	190	152	183
	NC	7,000	871	472	1,246	125	69	178
	TX	4,800	585	518	176	122	124	50
	Total	61,000	14,440	9,098	13,961	239	189	263

a) NA = Insufficient reports to publish data.

Table B-2. (Continued)

		Acres Planted	Total Applied (1000 lbs/year)			Application Rate Per Crop Year (lbs/acre)		
Crop	**State**		N	P	K	N	P	K
Spinach (fresh)	CA	5,800	704	323	237	159	92	75
	NJ	2,300	349	202	282	155	90	126
	TX	2,600	290	276	39	116	114	24
	Total	10,700	1,344	801	558	149	97	79
Spinach (processing)	TX	8,600	882	834	127	103	97	30
Strawberries	CA	23,300	4,621	2,063	2,380	199	94	112
	FL	5,800	676	286	890	117	58	156
	MI	2,100	203	125	190	100	67	95
	NJ	500	31	19	190	68	49	52
	NY	2,600	133	74	21	85	62	65
	NC	2,500	340	255	78	142	111	119
	OR	6,300	416	822	275	72	144	113
	WA	1,400	55	183	607	43	144	132
	WI	1,300	75	65	146	62	71	101
	Total	45,800	6,548	3,891	95	153	95	116
Tomatoes (fresh)	CA	36,500	6,906	3,530	2,346	193	120	91
	FL	47,900	14,902	9,114	25,572	311	201	534
	GA	4,000	1,140	429	1,304	286	109	327
	MI	2,800	229	155	341	83	64	124
	NJ	4,800	452	532	599	103	121	136
	NY	2,700	469	436	468	183	172	185
	NC	1,700	189	202	214	113	122	128
	TX	3,500	296	234	186	95	78	65
	Total	103,900	24,584	14,632	31,030	264	174	408
Tomatoes (processing)	CA	318,000	51,149	30,449	6,662	164	103	40
	MI	4,600	412	456	1,280	91	110	289
	Total	322,600	51,561	30,905	7,941	163	103	49

Table B-3. Fertilizer Use on Fruit Crops for Crop Year 1995[a]

		Acres Planted	Total Applied (1000 lbs/year)			Application Rate Per Crop Year (lbs/acre)		
Crop	State		N	P	K	N	P	K
Oranges	CA	191,000	21,731	834	1,321	119	46	61
	FL	562,800	100,286	14,733	100,109	179	42	182
	Total	753,800	122,017	15,576	101,430	164	43	177
Grapefruit	CA	18,400	1,670	283	152	102	81	55
	FL	127,300	16,456	5,539	18,350	132	54	147
	Total	145,700	18,123	5,822	18,502	128	56	146
Lemons	CA	45,700	5,492	202	314	128	41	26
Limes	FL	1,900	262	71	281	149	61	160
Tangelos	FL	12,400	2,095	551	2,106	170	65	172
Tangerines	CA	8,500	716	80	72	88	38	44
	FL	20,100	3,776	504	3,879	191	33	197
	Total	28,600	4,492	584	3,951	159	34	185
Temples	FL	6,800	1,067	132	1,110	157	40	172
Apples	CA	35,000	1,518	334	396	76	55	60
	GA	2,400	79	46	46	42	55	55
	MI	54,000	2,359	850	2,072	54	43	69
	NJ	4,100	95	60	123	36	28	45
	NY	57,500	2,539	475	3,163	53	32	69
	OR	8,600	426	80	62	75	31	24
	PA	22,000	521	332	363	35	31	35
	SC	3,700	176	141	227	51	60	75
	WA	153,000	8,616	1,996	1,649	71	30	35
	Total	340,300	16,329	4,314	8,146	62	34	54
Apricots	CA	19,800	1,213	604	574	92	101	96
Avocados	CA	67,200	7,753	1,810	1,699	120	71	55
	FL	5,800	954	315	1,032	171	68	185
	Total	73,000	8,707	2,125	2,731	124	71	74
Blueberries	GA	3,800	182	119	143	54	36	43
	MI	16,300	1,098	193	600	72	29	51
	NJ	7,700	481	369	477	66	51	66
	OR	1,950	243	109	94	138	69	61
	Total	29,750	2,004	790	1,314	72	42	55

a) Source USDA, ERS, NASS Agricultural Chemical Usage 1995 Fruits Summary.

Table B-3. (Continued)

		Acres Planted	Total Applied (1000 lbs/year)			Application Rate Per Crop Year (lbs/acre)		
Crop	State		N	P	K	N	P	K
Blackberries	OR	4,900	409	361	353	86	78	76
Raspberries	OR	5,200	419	447	406	82	89	80
	WA	5,900	522	694	705	91	121	123
	Total	11,100	941	1,141	1,111	87	106	103
Cherries, Sweet	CA	12,500	653	148	406	73	36	85
	MI	7,300	500	124	321	76	42	73
	OR	10,400	696	62	65	73	34	39
	WA	14,800	1,267	197	198	97	31	34
	Total	45,000	3,116	531	990	82	35	61
Cherries, Tart	MI	30,000	1,969	309	1,060	76	41	72
	NY	4,000	255	9	285	73	40	90
	OR	1,600	111	16	16	84	55	56
	PA	1,500	27	9	7	26	17	23
	Total	37,100	2,362	343	1,368	74	40	74
Dates	CA	5,500	409	113	NA[a]	99	92	
Figs	CA	15,000	783	137	225	81	46	55
Grapes	CA	645,200	34,529	10,276	26,199	64	56	104
	MI	11,800	1,091	219	1,393	97	58	149
	NY	33,000	3,003	272	1,899	100	89	151
	OR	5,600	34	18	23	27	32	43
	PA	11,000	1,261	110	1,226	117	57	157
	WA	34,000	1,766	675	1,425	70	46	80
	Total	740,600	41,684	11,570	32,165	67	55	107
Kiwifruit	CA	6,600	427	41	128	77	57	102
Nectarines	CA	32,400	3,398	892	1,550	114	54	92
Olives	CA	33,700	1,884	83	124	72	44	51
Peaches	CA	60,600	5,396	542	1,040	104	32	52
	GA	21,000	1,395	298	1,332	67	31	66
	MI	5,500	311	36	162	60	36	59
	NJ	10,800	570	210	507	56	43	63
	NY	1,600	69	4	87	55	27	87
	PA	6,800	157	63	80	29	30	34
	SC	23,000	1,674	836	2,742	74	50	124
	WA	2,500	225	24	19	109	32	31
	Total	131,800	9,797	2,013	5,969	84	38	76

a) NA = Insufficient reports to publish data.

Table B-3. (Continued)

		Acres Planted	Total Applied (1000 lbs/year)			Application Rate Per Crop Year		
Crop	State		N	P	K	N	P	K
Pears	CA	23,900	3,135	280	618	134	54	102
	NY	2,500	60	8	113	39	25	76
	OR	17,000	1,491	290	244	108	42	38
	WA	24,200	1,766	264	152	86	32	28
	Total	67,600	6,452	842	1,127	109	41	58
Plums	CA	42,000	3,008	243	536	95	28	56
Prunes	CA	78,800	8,396	989	5,110	122	59	149

APPENDIX C
FERTILIZER CONSUMPTION BY USE

Appendix C. Fertilizer Consumption by Use

The AAPFCO data set, described in Appendix A, contains a variable for farm versus non-farm use. The tables in this Appendix present fertilizer consumption by state and region for farm and non-farm use. Non-farm use includes application to residential and recreational properties. Note that there are five states for which the variable "use" was left blank. These states (Arkansas, Iowa, Kentucky, Ohio and Texas) have been excluded from the following tables. The use codes are 1 = farm and 2 = non-farm. For several states the non-farm code (2) was not used. NA is inserted in the Appendix tables for non-farm use for these states although it is unclear whether there was no non-farm use or the the two uses could not be separated out based on data collected by the individual states.

The following tables are included in this appendix:

Table C-1. Fertilizer Consumption by Use, East North Central States, 1996 (tons)

These states are: IN, IL, MI, WI

Table C-2. Fertilizer Consumption by Use, East South Central States, 1996 (tons)

These states are: AL, MS, TN

Table C-3. Fertilizer Consumption by Use, West North Central States, 1996 (tons)

These states are: KS, MN, MO, NB, ND, SD

Table C-4. Fertilizer Consumption by Use, West South Central States, 1996 (tons)

These states are: LA, OK

Table C-5. Fertilizer Consumption by Use, New England States, 1996 (tons)

These states are: CT, ME, MA, NH, RI, VT

Table C-6. Fertilizer Consumption by Use, Middle Atlantic States, 1996 (tons)

These states are: DE, MD, NJ, NY, PA, WV

Table C-7. Fertilizer Consumption by Use, South Atlantic States, 1996 (tons)

Thee states are: FL, GA, NC, SC, VA

Table C-8. Fertilizer Consumption by Use, Mountain States, 1996 (tons)

These states are: AZ, CO, ID, MT, NM, NV, UT, WY

Table C-9. Fertilizer Consumption by Use, Pacific States (and Puerto Rico), 1996 (tons)

These states are: AK, CA, HI, OR, WA and Puerto Rico

Table C-1. Fertilizer Consumption by Use, East North Central States, 1996 (tons)

Description	Indiana		Illinois		Michigan		Wisconsin	
	Farm	Nonfarm	Farm	Nonfarm	Farm	Nonfarm	Farm	Nonfarm
MULTIPLE NUTRIENT FERTILIZERS								
N-P-K	340,148	42,394	133,642	64,578	281,054	89,150	140,902	34,449
N-P	258,925	1,041	706,214	1,549	107,444	2,019	182,607	21
N-K	10,085	4,534	2,385	2,455	25,446	2,973	3,139	2,923
P-K	94,371	161	12,203	60	9,311	11	6,126	116
TOTAL	703,529	48,129	854,444	68,642	423,254	94,152	332,774	37,510
NITROGEN FERTILIZERS								
Ammonium Nitrate	7,351	37	32,817	33	7,843	58	26,642	14
Ammonium Nitrate Solution	203	NA	NA	NA	NA	NA	NA	NA
Ammonium Nitrate-limestone Mixtures	NA	NA	NA	NA	NA	NA	NA	NA
Ammonium Nitrate-sulfate	4,138	NA	NA	NA	242	20	3	NA
Ammonium Polysulfide	335	NA	NA	NA	NA	NA	NA	NA
Ammonium Sulfate	12,128	52	20,534	72	14,984	109	33,422	7
Ammonium Sulfate Solution	5,885	NA	135,421	1	107	NA	NA	NA
Ammonium Sulfate-nitrate	9,802	NA	48	NA	9,107	NA	NA	NA
Ammonium Sulfate-urea	114	NA	NA	NA	NA	NA	NA	NA
Ammonium Thiosulfate	658	121	11,533	16	249	3	1,337	NA
Anhydrous Ammonia	193,582	999	609,003	NA	61,777	NA	53,647	NA
Aqua Ammonia	9,699	NA	NA	NA	NA	NA	2,348	NA
Calcium Ammonium Nitrate	147	NA	1,003	NA	75	NA	5	NA
Calcium Cyanamide	NA	NA	NA	NA	NA	NA	NA	NA
Calcium Nitrate	233	NA	43,777	15	3,406	32	191	NA
Calcium Nitrate-urea	311	NA	NA	NA	NA	NA	NA	NA
Ferrous Ammonium Sulfate	101	2	NA	25	22	3	NA	NA
Magnesium Nitrate	NA	NA	NA	NA	NA	NA	NA	NA
Nitric Acid	1,330	16	NA	NA	NA	NA	NA	NA

Table C-1. (Continued)

Description	Indiana		Illinois		Michigan		Wisconsin	
	Farm	Nonfarm	Farm	Nonfarm	Farm	Nonfarm	Farm	Nonfarm
Nitrogen Solution 28%	381,031	484	721,731	22	212,610	NA	172,502	7
Nitrogen Solution 30%	1,528	NA	967	11	NA	NA	7	NA
Nitrogen Solution 32%	26,795	440	155,188	NA	4,517	NA	19,543	3
Nitrogen Solution <28%	43,752	2,632	68,529	160	9,552	189	3,465	25
Nitrogen Solution >32%	149	7	305	NA	NA	NA	396	NA
Sodium Nitrate	1,129	1	40	4	89	4	119	5
Sulfur Coated Urea	689	NA	NA	NA	701	NA	4	NA
Urea	70,196	1,669	107,515	1,653	84,342	398	119,480	258
Urea Solution	NA	NA	NA	NA	NA	NA	NA	NA
Urea-formaldehyde	700	19	500	4,839	1,345	220	59	256
Zinc Ammonium Sulfate Solution	NA	NA	NA	NA	NA	NA	2	NA
Zinc Manganese Ammonium Sulfate	NA	NA	NA	NA	NA	NA	NA	NA
Other	13,158	721	3,811	697	35,247	177	16	328
TOTAL	785,144	7,200	1,912,720	7,548	446,215	1,214	433,188	903
PHOSPHATE FERTILIZERS								
Ammonium Metaphosphate	NA	NA	NA	NA	NA	NA	NA	NA
Ammonium Phosphate	30	NA	NA	NA	9	NA	NA	NA
Ammonium Phosphate Nitrate	1	NA	NA	NA	NA	NA	NA	NA
Ammonium Phosphate Sulfate	406	NA	NA	NA	NA	NA	NA	NA
Ammonium Polyphosphate	132	NA	NA	NA	NA	NA	NA	NA
Basic Lime Phosphate	NA	NA	NA	NA	NA	NA	NA	NA
Basic Slag	NA	NA	NA	NA	NA	NA	NA	NA
Bone Meal, Raw	NA	NA	NA	NA	NA	NA	35	NA
Bone Meal, Steamed	NA	2	NA	6	1	NA	125	NA
Bone, Precipitated	NA	NA	NA	NA	NA	NA	NA	NA
Calcium Metaphosphate	NA	NA	NA	NA	NA	NA	NA	NA

Table C-1. (Continued)

Description	Indiana		Illinois		Michigan		Wisconsin	
	Farm	Nonfarm	Farm	Nonfarm	Farm	Nonfarm	Farm	Nonfarm
Colloidal Phosphate (Soft Phosphate)	88	NA	NA	NA	22	NA	NA	NA
Diammonium Phosphate	111,262	26	575,347	184	38,184	32	154,576	NA
Limestone, Phosphatic	NA	NA	NA	NA	NA	NA	NA	NA
Liquid Ammonium Polyphosphate	104,273	74	34,351	NA	36,686	NA	15,883	NA
Magnesium Phosphate	NA	NA	NA	NA	NA	NA	NA	5
Monoammonium Phosphate	12,155	NA	81,693	20	17,840	12	9,031	2
Nitric Phosphate	NA	NA	NA	NA	NA	NA	NA	NA
Phosphate Rock	NA	NA	62	NA	121	1	445	NA
Phosphoric Acid	126	NA	449	NA	NA	2	NA	NA
Precipitated Phosphate	NA	NA	NA	NA	NA	NA	NA	NA
Superphosphate, Enriched	5	NA	NA	NA	24	NA	4	1
Superphosphate, Normal	14	NA	NA	NA	NA	13	12,639	NA
Superphosphate, Triple	40,324	44	48,990	43	4,623	115	11,310	NA
Superphosphoric Acid	NA	NA	NA	NA	NA	NA	NA	NA
Other	260	49	91,685	74	42	185	270	37
TOTAL	269,078	195	832,576	327	97,552	360	204,318	46
POTASH FERTILIZERS								
Lime-potash Mixtures	1,528	9	NA	NA	50	NA	NA	NA
Manure Salts	436	28	NA	NA	NA	NA	NA	NA
Muriate of Potash 60% (Pot. Chloride)	334,986	60	876,895	154	161,490	57	655	NA
Muriate of Potash 62%	37,944	239	94,988	68	75,907	529	372,336	14
Potash Suspensions	NA	NA	NA	NA	NA	NA	NA	NA
Potassium Carbonate	15	NA	NA	NA	138	NA	NA	NA
Potassium Nitrate	399	10	2	NA	1,218	351	NA	1
Potassium Sulfate	1,911	56	540	59	2,825	14	2,863	3

Table C-1. (Continued)

Description	Indiana		Illinois		Michigan		Wisconsin	
	Farm	Nonfarm	Farm	Nonfarm	Farm	Nonfarm	Farm	Nonfarm
Potassium-magnesium Sulfate	2,739	NA	893	10	2,992	37	11,064	5
Potassium-metaphosphate	NA	NA	NA	NA	NA	NA	NA	NA
Potassium-sodium Nitrate	NA	NA	NA	NA	37	NA	NA	NA
Other	11,586	93	5,052	791	4,194	163	2,754	110
TOTAL	391,544	496	978,371	1,083	248,852	1,151	389,671	134
ORGANIC FERTILIZERS								
Blood, Dried	NA	3	NA	NA	NA	NA	121	NA
Castor Pomace	NA	1	NA	NA	NA	NA	NA	NA
Cocoa Shell Meal	NA	NA	NA	NA	NA	NA	NA	NA
Compost	NA	NA	NA	NA	NA	3,961	13	NA
Cottonseed Meal	NA	NA	NA	NA	NA	NA	NA	NA
Fish Scrap	NA	NA	NA	NA	NA	NA	12	NA
Guano	NA	NA	NA	NA	NA	NA	NA	NA
Manure	370	31	NA	NA	NA	698	3,848	NA
Peat	NA	1,083	NA	NA	2,552	23,055	NA	NA
Sewage Sludge, Activated	NA	NA	NA	NA	NA	NA	NA	NA
Sewage Sludge, Digested	NA	NA	NA	NA	NA	NA	NA	NA
Sewage Sludge, Heat Dried	NA	NA	NA	NA	NA	NA	2,472	NA
Sewage Sludge, Other	NA	NA	NA	NA	NA	NA	NA	NA
Soybean Meal	NA	NA	NA	NA	NA	NA	1	NA
Tankage, Animal	NA	NA	NA	NA	NA	NA	37	NA
Tankage, Process	NA	NA	NA	NA	NA	NA	281	NA
Other	205	1,163	NA	NA	NA	7,793	1,437	NA
TOTAL	575	2,281	NA	NA	2,552	35,507	8,221	NA
SECONDARY AND MICRONUTRIENT FERTILIZERS								
Aluminum Sulfate	NA	NA	NA	NA	NA	1	NA	NA
Borax	71	NA	NA	NA	273	8	1,110	NA
Calcium Chelate	NA	NA	NA	NA	NA	NA	9,026	NA
Calcium Chloride	NA	NA	NA	NA	NA	NA	1,331	NA
Calcium Sulfate (Hydrous)	NA	NA	NA	NA	NA	NA	1,804	NA
Cobalt Sulfate	NA	NA	NA	NA	NA	NA	NA	NA
Copper Chelate	NA	NA	NA	NA	NA	NA	49	NA

Table C-1. (Continued)

Description	Indiana		Illinois		Michigan		Wisconsin	
	Farm	Nonfarm	Farm	Nonfarm	Farm	Nonfarm	Farm	Nonfarm
Copper Compound	NA	NA	NA	NA	NA	NA	NA	NA
Copper Oxide, Black	NA	NA	NA	NA	NA	NA	36	NA
Copper Sulfate	1	NA	NA	NA	39	2	NA	NA
Epsom Salt (Magnesium Sulfate)	NA	NA	NA	NA	62	9	NA	NA
Ferric Oxide	NA	NA	NA	NA	NA	NA	NA	NA
Ferric Sulfate	NA	NA	NA	NA	NA	NA	NA	NA
Ferrous Sulfate	NA	NA	NA	NA	NA	NA	NA	NA
Gypsum (Calcium Sulfate)	4,445	NA	NA	NA	4,863	8,140	3,391	NA
Iron Chelate	NA	3	NA	NA	NA	44	238	NA
Iron Compound	NA	NA	NA	NA	NA	3	2	NA
Lime Sulfur Solution	NA	NA	NA	NA	NA	NA	NA	NA
Magnesia (Magnesium Oxide)	31	NA	NA	NA	15	NA	10	NA
Magnesium Chelate	NA	NA	NA	NA	NA	NA	NA	NA
Manganese Agstone	1	NA	NA	NA	NA	NA	NA	NA
Manganese Chelate	1	NA	NA	NA	NA	NA	NA	NA
Manganese Oxide	1	NA	NA	NA	2	NA	NA	NA
Manganese Slag	NA	NA	NA	NA	NA	NA	NA	NA
Manganese Sulfate	36	NA	NA	NA	39	NA	NA	NA
Manganous Oxide	NA	NA	NA	NA	NA	NA	73	NA
Potting Soil	NA	NA	NA	NA	NA	NA	NA	NA
Sodium Molybdate	NA	NA	NA	NA	NA	NA	9	NA
Soil Additive	NA	NA	NA	NA	NA	NA	NA	NA
Soil Amendment	NA	NA	NA	NA	NA	NA	NA	NA
Soil Conditioner	NA	NA	NA	NA	NA	11,601	NA	NA
Sulfur	569	NA	NA	NA	653	11	3,705	21
Sulfuric Acid	NA	NA	NA	NA	NA	NA	NA	NA
Zinc Chelate	NA	NA	NA	NA	3	NA	NA	NA
Zinc Oxide	NA	NA	NA	NA	3	NA	669	NA
Zinc Oxysulfate	NA	NA	NA	NA	331	NA	NA	NA

Table C-1. (Continued)

Description	Indiana		Illinois		Michigan		Wisconsin	
	Farm	Nonfarm	Farm	Nonfarm	Farm	Nonfarm	Farm	Nonfarm
Zinc Sulfate	4	NA	NA	NA	197	5	NA	NA
Zinc Sulfate Solution	NA	NA	NA	NA	NA	NA	NA	NA
Other	2,238	NA	NA	NA	7,105	202	1,054	NA
TOTAL	7,397	3	NA	NA	13,586	20,027	22,507	21
LIMING MATERIALS								
Calcitic Lime (75% Neutral)	NA	NA	NA	NA	437	NA	NA	NA
Calcium Hydroxide (Hydrate)	NA	NA	NA	NA	NA	5	NA	NA
Calcium Oxide (Burnt)	NA	NA	NA	NA	NA	NA	NA	NA
Dolomitic & Calcitic Blend (Pelletized)	NA	NA	NA	NA	997	117	NA	NA
Dolomitic Lime (75% Neutral)	NA	NA	NA	NA	2	NA	NA	NA
Lime Suspensions	NA	NA	NA	NA	NA	NA	NA	NA
Non-lime Filler (Water, Sand, Etc.)	NA	NA	NA	NA	NA	NA	1,097	NA
Standard Calcite	NA	NA	NA	NA	NA	NA	NA	NA
Standard Dolomite	NA	NA	NA	NA	NA	NA	NA	NA
Other	4,501	NA	NA	NA	3,411	102	12,131	NA
TOTAL	4,501	NA	NA	NA	4,847	223	13,228	NA
ALL FERTILIZERS								
TOTAL	1,932,735	57,049	3,886,719	77,391	1,140,332	124,526	1,217,874	38,609

1. Data for Ohio was not divided into farm and non-farm use.

NA = it is unclear from the database whether there was no non-farm use recorded or on-farm use was zero.

Table C-2. Fertilizer Consumption by Use, Alabama, East South Central States of Mississippi and Tennessee, 1996 (tons)

Description	Alabama		Mississippi		Tennessee	
	Farm	Nonfarm	Farm	Nonfarm	Farm	Nonfarm
MULTIPLE NUTRIENT FERTILIZERS						
N-P-K	233,473	45	181,634	23,566	113,802	37,230
N-P	46,223	NA	52,073	5,308	163,058	840
N-K	21,162	NA	13,336	584	2,256	946
P-K	13,324	NA	23,564	445	1,314	19
TOTAL	314,182	45	270,606	29,903	280,430	39,034
NITROGEN FERTILIZERS						
Ammonium Nitrate	122,191	NA	101,199	2,003	165,627	2,893
Ammonium Nitrate Solution	NA	NA	228	NA	NA	NA
Ammonium Nitrate-limestone Mixtures	NA	NA	NA	NA	NA	NA
Ammonium Nitrate-sulfate	44	NA	574	NA	14	NA
Ammonium Polysulfide	NA	NA	420	NA	NA	NA
Ammonium Sulfate	12,848	NA	11,752	236	2,957	374
Ammonium Sulfate Solution	NA	NA	NA	NA	NA	NA
Ammonium Sulfate-nitrate	118	NA	29	NA	9	NA
Ammonium Sulfate-urea	NA	NA	NA	NA	NA	NA
Ammonium Thio Sulfate	331	NA	7,347	263	2	NA
Anhydrous Ammonia	1,513	NA	18,906	NA	15,035	NA
Aqua Ammonia	NA	NA	273	NA	NA	NA
Calcium Ammonium Nitrate	6	NA	25	NA	NA	NA
Calcium Cyanamide	NA	NA	NA	NA	NA	NA
Calcium Nitrate	90	NA	44	178	282	4
Calcium Nitrate-urea	NA	NA	NA	NA	NA	NA
Ferrous Ammonium Sulfate	NA	NA	12	NA	14	NA
Magnesium Nitrate	NA	NA	NA	NA	NA	NA
Nitricacid	NA	NA	NA	NA	1	NA
Nitrogen Solution 28%	10,983	26	22,584	237	4,085	52
Nitrogen Solution 30%	620	NA	947	NA	582	NA
Nitrogen Solution 32%	37,726	NA	140,067	174	45,505	279
Nitrogen Solution<28%	14,501	NA	1,329	4	1,419	27
Nitrogen Solution>32%	129	NA	14	NA	422	265
Sodium Nitrate	629	NA	1,561	2	2,630	2
Sulfur Coated Urea	8	NA	41	NA	4	NA
Urea	20,380	NA	89,587	6,092	74,047	701
Urea Solution	NA	NA	281	NA	NA	NA
Urea-formaldehyde	3,020	NA	99	55	25	27
Zinc Ammonium Sulfate Solution	NA	NA	247	NA	299	NA

Table C-2. (Continued)

Description	Alabama		Mississippi		Tennessee	
	Farm	Nonfarm	Farm	Nonfarm	Farm	Nonfarm
Zinc Manganese Ammonium Sulfate	NA	NA	NA	NA	NA	NA
Other	43,796	NA	9,826	51	7,265	163
TOTAL	268,931	26	407,389	9,295	320,223	4,787
PHOSPHATE FERTILIZERS						
Ammonium Metaphosphate	NA	NA	NA	NA	NA	NA
Ammonium Phosphate	NA	NA	68	NA	NA	NA
Ammonium Phosphate Nitrate	5	NA	NA	NA	NA	NA
Ammonium Phosphate Sulfate	NA	NA	NA	NA	NA	NA
Ammonium Polyphosphate	7	NA	50	NA	NA	NA
Basic Limephosphate	NA	NA	NA	NA	NA	NA
Basic Slag	NA	NA	1,851	NA	177	115
Bone Meal Raw	NA	NA	NA	NA	NA	NA
Bone Meal Steamed	2	NA	NA	NA	NA	6
Bone Precipitated	NA	NA	NA	NA	NA	NA
Calcium Metaphosphate	2	NA	NA	NA	1,711	NA
Colloidal Phosphate (Softphosphate)	17	NA	22	NA	67	NA
Diammonium Phosphate	35,350	NA	40,745	5,179	159,458	646
Limestone Phosphatic	NA	NA	NA	NA	NA	NA
Liquid Ammonium Polyphosphate	2,611	NA	8,578	NA	2,193	107
Magnesium Phosphate	4	NA	NA	10	NA	9
Monoammonium Phosphate	720	NA	541	NA	448	7
Nitric Phosphate	NA	NA	NA	NA	NA	NA
Phosphate Rock	31	NA	NA	NA	NA	NA
Phosphoric Acid	NA	NA	NA	NA	NA	NA
Precipitated Phosphate	NA	NA	NA	NA	NA	NA
Super Phosphate Enriched	28	NA	NA	NA	NA	NA
Super Phosphate Normal	501	NA	NA	NA	4	3
Super Phosphate Triple	6,913	NA	13,900	681	8,617	4
Super Phosphoric Acid	NA	NA	NA	NA	NA	NA
Other	812	NA	59	81	240	266
TOTAL	47,003	NA	65,814	5,951	172,915	1,162
POTASH FERTILIZERS						
Lime-potash Mixtures	88	NA	NA	NA	NA	NA
Manure Salts	NA	NA	NA	NA	NA	NA
Muriate of Potash 60% (Pot.chloride)	43,942	NA	108,907	7,453	184,406	1,395
Muriate of Potash 62%	2,188	NA	15,292	207	2,111	5
Potash Suspensions	131	NA	52	NA	NA	NA

Table C-2. (Continued)

Description	Alabama		Mississippi		Tennessee	
	Farm	Nonfarm	Farm	Nonfarm	Farm	Nonfarm
Potassium Carbonate	NA	NA	NA	NA	NA	NA
Potassium Nitrate	1,963	NA	600	28	253	NA
Potassium Sulfate	539	NA	1,056	7	5,533	NA
Potassium-magnesium Sulfate	815	NA	2,066	19	816	1
Potassium-meta Phosphate	NA	NA	NA	NA	NA	NA
Potassium-sodium Nitrate	NA	NA	NA	NA	224	NA
Other	4,943	NA	2,386	2	3,285	134
TOTAL	54,610	NA	130,359	7,716	196,628	1,536
ORGANIC FERTILIZERS						
Blood Dried	3	NA	NA	NA	NA	NA
Castor Pomace	NA	NA	NA	NA	NA	NA
Cocoa Shell Meal	NA	NA	NA	NA	NA	NA
Compost	NA	NA	NA	NA	NA	NA
Cottonseed Meal	NA	NA	NA	NA	27	NA
Fish Scrap	NA	NA	NA	NA	122	866
Guano	NA	NA	NA	NA	NA	NA
Manure	1,398	NA	NA	3,885	29	1,518
Peat	NA	NA	NA	NA	NA	2,338
Sewage Sludge Activated	43	NA	NA	NA	NA	198
Sewage Sludge Digested	NA	NA	NA	NA	NA	NA
Sewage Sludge Heat Dried	NA	NA	NA	NA	NA	NA
Sewage Sludge Other	NA	NA	NA	NA	NA	NA
Soybean Meal	NA	NA	NA	NA	NA	NA
Tankage Animal	NA	NA	NA	NA	NA	NA
Tankage Process	NA	NA	NA	NA	154	NA
Other	3	NA	NA	44	1,074	8,641
TOTAL	1,446	NA	NA	3,930	1,406	13,561
SECONDARY AND MICRONUTRIENT FERTILIZERS						
Aluminum Sulfate	27	NA	384	NA	27	4
Borax	104	NA	1,440	14	2,088	44
Calcium Chelate	NA	NA	NA	NA	NA	NA
Calcium Chloride	1	NA	NA	NA	8	NA
Calcium Sulfate (Hydrous)	NA	NA	NA	NA	NA	NA
Cobalt Sulfate	NA	NA	NA	NA	NA	NA
Copper Chelate	NA	NA	NA	NA	NA	NA
Copper Compound	NA	NA	NA	NA	NA	NA
Copper Oxide Black	NA	NA	NA	NA	NA	NA

Table C-2. (Continued)

Description	Alabama		Mississippi		Tennessee	
	Farm	Nonfarm	Farm	Nonfarm	Farm	Nonfarm
Copper Sulfate	NA	NA	NA	NA	6	NA
Epsom Salt (Magnesium Sulfate)	NA	NA	NA	NA	16	NA
Ferric Oxide	255	NA	NA	NA	NA	NA
Ferric Sulfate	NA	NA	NA	NA	NA	NA
Ferrous Sulfate	NA	NA	NA	NA	23	2
Gypsum (Calcium Sulfate)	241	NA	22	10	767	121
Iron Chelate	8	NA	17	NA	2	18
Iron Compound	NA	NA	16	NA	NA	NA
Lime Sulfur Solution	NA	NA	NA	NA	NA	NA
Magnesia (Magnesium Oxide)	NA	NA	NA	NA	74	NA
Magnesium Chelate	NA	NA	7	NA	NA	NA
Manganese Agstone	NA	NA	NA	NA	NA	NA
Manganese Chelate	NA	NA	8	NA	2	NA
Manganese Oxide	NA	NA	NA	NA	21	NA
Manganese Slag	NA	NA	NA	NA	NA	NA
Manganese Sulfate	15	NA	NA	NA	1	NA
Manganous Oxide	NA	NA	NA	NA	3	NA
Potting Soil	NA	NA	2	NA	NA	NA
Sodium Molybdate	NA	NA	200	NA	NA	NA
Soil Additive	NA	NA	NA	NA	NA	NA
Soil Amendment	NA	NA	NA	NA	NA	NA
Soil Conditioner	NA	NA	NA	NA	NA	NA
Sulfur	731	NA	1,468	1	1,894	5
Sulfuric Acid	NA	NA	NA	NA	2	NA
Zinc Chelate	NA	NA	NA	NA	61	NA
Zinc Oxide	NA	NA	173	NA	186	NA
Zinc Oxysulfate	NA	NA	NA	NA	114	NA
Zinc Sulfate	4	NA	8	NA	174	NA
Zinc Sulfate Solution	NA	NA	NA	NA	NA	NA
Other	1,526	NA	439	65	194	61
TOTAL	2,912	NA	4,183	90	5,662	255

Table C-2. (Continued)

Description	Alabama		Mississippi		Tennessee	
	Farm	Nonfarm	Farm	Nonfarm	Farm	Nonfarm
LIMING MATERIALS						
Calciticlime (75%neutral)	NA	NA	NA	NA	NA	NA
Calcium Hydroxide (Hydrate)	NA	NA	NA	NA	41	NA
Calcium Oxide (Burnt)	NA	NA	NA	NA	NA	NA
Dolomitic & Calcitic Blend (Pelletized)	NA	NA	NA	NA	147	1
Dolomitic Lime (75% Neutral)	1,319	NA	NA	NA	NA	NA
Lime Suspensions	NA	NA	NA	NA	NA	NA
Non-lime Filler (Water, Sand, Etc.)	NA	NA	NA	NA	NA	NA
Standard Calcite	23	NA	NA	NA	22,164	39
Standard Dolomite	27	NA	NA	NA	NA	29
Other	1,094	NA	84	NA	632	17
TOTAL	2,464	NA	84	NA	22,984	86
ALL FERTILIZERS						
TOTAL	649,449	71	827,853	47,792	837,492	54,736

1. Data for Kentucky was not divided into farm and non-farm use.

NA = it is unclear from the database whether there was no non-farm use recorded or on-farm use was zero.

Table C-3. Fertilizer Consumption by Use, West North Central States, 1996 (tons)

Description	Kansas		Minnesota		Missouri		Nebraska		North Dakota		South Dakota
	Farm	Nonfarm	Farm	Nonfarm	Farm	Nonfarm	Farm	Nonfarm	Farm	Nonfarm	Farm
MULTIPLE NUTRIENT FERTILIZERS											
N-P-K	38,126	10	71,022	NA	63,276	31,502	137,462	25	40	NA	7,237
N-P	398,776	NA	529,868	NA	285,925	647	369,018	NA	332,312	NA	216,487
N-K	2,790	NA	1,976	NA	1,872	997	6,613	NA	NA	NA	29
P-K	187	NA	2,531	NA	1,900	357	129	NA	NA	NA	79
TOTAL	439,879	10	605,397	NA	352,973	33,503	513,222	25	332,352	NA	223,832
NITROGEN FERTILIZERS											
Ammonium Nitrate	76,603	NA	9,122	NA	277,277	49	33,246	NA	11,433	NA	2,846
Ammonium Nitrate Solution	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Ammonium Nitrate-limestone Mixtures	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Ammonium Nitrate-sulfate	4	NA	NA	NA	2	NA	15	NA	NA	NA	NA
Ammonium Polysulfide	26	NA	NA	NA	NA	NA	NA	NA	79	NA	11
Ammonium Sulfate	2,158	NA	42,323	NA	16,472	157	23,619	NA	3,869	NA	3,548
Ammonium Sulfate Solution	8	NA	NA	NA	9	NA	NA	NA	NA	NA	NA
Ammonium Sulfate-nitrate	NA	NA	428	NA	50	4	502	NA	NA	NA	18
Ammonium Sulfate-urea	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Ammonium Thiosulfate	17,192	NA	3,978	NA	5,848	NA	63,426	NA	373	NA	646
Anhydrous Ammonia	503,336	NA	348,293	NA	128,273	NA	605,595	403	394,352	NA	27,673
Aqua Ammonia	3,194	NA	122	NA	NA	NA	71	NA	NA	NA	NA
Calcium Ammonium Nitrate	NA	NA	756	NA	6	NA	42	NA	NA	NA	1
Calcium Cyanamide	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Calcium Nitrate	543	NA	83	NA	641	56	8	NA	197	NA	NA
Calcium Nitrate-urea	NA	NA	282	NA	NA	NA	330	NA	NA	NA	NA
Ferrous Ammonium Sulfate	NA	NA	NA	NA	NA	33	NA	NA	NA	NA	NA

Table C-3. (Continued)

Description	Kansas		Minnesota		Missouri		Nebraska		North Dakota		South Dakota
	Farm	Nonfarm	Farm	Nonfarm	Farm	Nonfarm	Farm	Nonfarm	Farm	Nonfarm	Farm
Magnesium Nitrate	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Nitric Acid	9	NA	NA	NA	NA	NA	735	NA	4	NA	NA
Nitrogen Solution 28%	258,746	NA	149,524	NA	66,893	76	436,765	NA	28,677	NA	104,015
Nitrogen Solution 30%	84	NA	13	NA	4,349	NA	NA	NA	NA	NA	NA
Nitrogen Solution 32%	165,782	NA	15,556	NA	207,117	NA	399,386	NA	10	NA	8,573
Nitrogen Solution <28%	5,157	NA	1,379	NA	1,649	NA	3,813	NA	54	NA	701
Nitrogen Solution >32%	6,200	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Sodium Nitrate	1	NA	2	NA	38	1	NA	NA	NA	NA	NA
Sulfur Coated Urea	184	NA	162	NA	NA	2	710	NA	47	NA	NA
Urea	101,051	NA	472,342	NA	160,563	565	68,397	NA	286,992	NA	128,341
Urea Solution	NA	NA	1,277	NA	NA	NA	NA	NA	NA	NA	NA
Urea-formaldehyde	101	NA	663	NA	237	183	2,900	NA	312	NA	NA
Zinc Ammonium Sulfate Solution	158	NA	NA	NA	NA	NA	5,518	NA	NA	NA	16
Zinc Manganese Ammonium Sulfate	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	15
Other	7,889	NA	1,313	NA	1,486	495	4,896	NA	NA	NA	5,781
TOTAL	1,148,425	NA	1,047,618	NA	870,911	1,620	1,649,972	403	726,398	NA	282,183
PHOSPHATE FERTILIZERS											
Ammonium Metaphosphate	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Ammonium Phosphate	NA	NA	250	NA	NA	NA	16,978	NA	NA	NA	NA
Ammonium Phosphate Nitrate	244	NA	NA	NA	5	NA	989	NA	NA	NA	NA
Ammonium Phosphate Sulfate	67	NA	1,172	NA	140	NA	1,990	NA	NA	NA	19
Ammonium Polyphosphate	NA	NA	NA	NA	NA	NA	52,123	NA	NA	NA	NA
Basic Lime Phosphate	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Basic Slag	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Bone Meal, Raw	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Table C-3. (Continued)

Description	Kansas		Minnesota		Missouri		Nebraska		North Dakota		South Dakota
	Farm	Nonfarm	Farm	Nonfarm	Farm	Nonfarm	Farm	Nonfarm	Farm	Nonfarm	Farm
Bone Meal, Steamed	7	NA	NA	NA	18	1	NA	NA	NA	NA	NA
Bone, Precipitated	NA	NA	NA	NA	NA	2	NA	NA	NA	NA	NA
Calcium Metaphosphate	NA	NA	253	NA	NA	NA	NA	NA	NA	NA	NA
Colloidal Phosphate (Soft Phosphate)	NA	NA	2	NA	93	23	24	NA	NA	NA	NA
Diammonium Phosphate	163,170	NA	402,007	NA	233,104	19	57,197	NA	205,055	NA	132,690
Limestone, Phosphatic	5	NA	NA	NA	18	NA	NA	NA	NA	NA	NA
Liquid Ammonium Polyphosphate	148,294	NA	55,563	NA	15,156	NA	150,353	NA	13,352	NA	44,318
Magnesium Phosphate	NA	NA	NA	NA	22	NA	968	NA	NA	NA	NA
Monoammonium Phosphate	84,557	NA	61,202	NA	33,075	6	75,877	NA	113,905	NA	21,036
Nitric Phosphate	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Phosphate Rock	NA	NA	NA	NA	NA	3	130	NA	53	NA	NA
Phosphoric Acid	198	NA	NA	NA	3,329	NA	176	NA	739	NA	189
Precipitated Phosphate	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Superphosphate, Enriched	NA	NA	1	NA	88	NA	NA	NA	NA	NA	NA
Superphosphate, Normal	248	NA	NA	NA	26	NA	8,664	NA	40	NA	NA
Superphosphate, Triple	1,859	NA	13,748	NA	42,520	110	3,505	NA	3,576	NA	4,059
Superphosphoric Acid	1,690	NA	2,589	NA	-157	NA	3,428	NA	NA	NA	NA
Other	2,274	NA	NA	NA	855	127	431	NA	NA	NA	NA
TOTAL	402,612	NA	536,787	NA	328,292	292	372,835	NA	336,720	NA	202,310
POTASH FERTILIZERS											
Lime-potash Mixtures	NA	NA	7	NA	NA	23	NA	NA	NA	NA	NA
Manure Salts	866	NA	313	NA	NA	NA	NA	NA	NA	NA	NA
Muriate of Potash 60% (Pot. Chloride)	54,092	NA	444,579	NA	280,669	126	30,407	NA	40,439	NA	23,868
Muriate of Potash 62%	12,362	NA	NA	NA	93,152	110	6,897	NA	2,283	NA	1,790
Potash Suspensions	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Table C-3. (Continued)

Description	Kansas		Minnesota		Missouri		Nebraska		North Dakota		South Dakota
	Farm	Nonfarm	Farm	Nonfarm	Farm	Nonfarm	Farm	Nonfarm	Farm	Nonfarm	Farm
Potassium Carbonate	27	NA	NA	NA	NA	NA	58	NA	NA	NA	NA
Potassium Nitrate	35	NA	88	NA	71	4	NA	NA	NA	NA	2
Potassium Sulfate	119	NA	766	NA	480	49	28	NA	125	NA	6
Potassium-magnesium Sulfate	4,503	NA	6,983	NA	3,811	6	23,926	NA	114	NA	176
Potassium-metaphosphate	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Potassium-sodium Nitrate	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	23
Other	1,710	NA	1,621	NA	537	53	2,227	NA	153	NA	142
TOTAL	73,713	NA	454,357	NA	378,720	372	63,543	NA	43,114	NA	26,007
ORGANIC FERTILIZERS											
Blood, Dried	81	NA	NA	NA	NA	NA	NA	NA	NA	NA	91
Castor Pomace	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Cocoa Shell Meal	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Compost	NA	NA	NA	NA	NA	NA	492	NA	NA	NA	NA
Cottonseed Meal	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Fish Scrap	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Guano	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Manure	1,006	NA	NA	NA	NA	NA	1,287	NA	NA	NA	NA
Peat	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Sewage Sludge, Activated	302	NA	NA	NA	NA	NA	182	NA	40	NA	NA
Sewage Sludge, Digested	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Sewage Sludge, Heat Dried	8	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Sewage Sludge, Other	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Soybean Meal	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Tankage, Animal	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Tankage, Process	NA	NA	NA	NA	NA	NA	NA	NA	61	NA	NA
Other	2,562	NA	NA	NA	NA	NA	NA	NA	308	NA	NA

Table C-3. (Continued)

Description	Kansas		Minnesota		Missouri		Nebraska		North Dakota		South Dakota
	Farm	Nonfarm	Farm	Nonfarm	Farm	Nonfarm	Farm	Nonfarm	Farm	Nonfarm	Farm
TOTAL	3,959	NA	NA	NA	NA	NA	1,960	NA	408	NA	91
SECONDARY AND MICRONUTRIENT FERTILIZERS											
Aluminum Sulfate	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Borax	148	NA	210	NA	1,474	NA	302	NA	6	NA	10
Calcium Chelate	5	NA	NA	NA	NA	NA	42	NA	NA	NA	NA
Calcium Chloride	390	NA	4	NA	NA	NA	1,427	NA	NA	NA	4
Calcium Sulfate (Hydrous)	NA	NA	NA	NA	NA	NA	190	NA	NA	NA	NA
Cobalt Sulfate	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Copper Chelate	6	NA	13	NA	NA	NA	55	NA	NA	NA	NA
Copper Compound	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Copper Oxide, Black	NA	NA	NA	NA	34	NA	1	NA	NA	NA	NA
Copper Sulfate	5	NA	173	NA	NA	NA	56	NA	5	NA	1
Epsom Salt (Magnesium Sulfate)	NA	NA	NA	NA	NA	NA	1	NA	NA	NA	NA
Ferric Oxide	NA	NA	NA	NA	1,463	17	NA	NA	NA	NA	2
Ferric Sulfate	1	NA	7	NA	NA	NA	4	NA	NA	NA	NA
Ferrous Sulfate	15	NA	4	NA	NA	NA	397	NA	1	NA	3
Gypsum (Calcium Sulfate)	27	NA	1,553	NA	1,158	86	905	NA	67	NA	NA
Iron Chelate	45	NA	17	NA	NA	NA	565	NA	9	NA	NA
Iron Compound	32	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Lime Sulfur Solution	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Magnesia (Magnesium Oxide)	NA	1	10	NA	120	11	51	NA	NA	NA	NA
Magnesium Chelate	5	NA	2	NA	NA	NA	NA	NA	NA	NA	NA
Manganese Agstone	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Manganese Chelate	17	NA	25	NA	NA	NA	39	NA	NA	NA	NA
Manganese Oxide	NA	NA	NA	NA	39	15	NA	NA	NA	NA	NA
Manganese Slag	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Table C-3. (Continued)

Description	Kansas		Minnesota		Missouri		Nebraska		North Dakota		South Dakota
	Farm	Nonfarm	Farm	Nonfarm	Farm	Nonfarm	Farm	Nonfarm	Farm	Nonfarm	Farm
Manganese Sulfate	1	NA	68	NA	NA	NA	315	NA	3	NA	NA
Manganous Oxide	NA	NA	NA	NA	NA	NA	3	NA	NA	NA	NA
Potting Soil	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Sodium Molybdate	NA	NA	1	NA	NA	NA	NA	NA	NA	NA	NA
Soil Additive	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Soil Amendment	NA	NA	NA	NA	NA	NA	NA	NA	60	NA	NA
Soil Conditioner	NA	NA	5	NA	NA	NA	1,197	NA	NA	NA	NA
Sulfur	826	NA	1,307	NA	1,931	9	4,307	NA	591	NA	363
Sulfuric Acid	NA	NA	190	NA	NA	NA	1,058	NA	NA	NA	NA
Zinc Chelate	1,223	NA	245	NA	NA	NA	1,399	NA	19	NA	69
Zinc Oxide	296	NA	131	NA	1,199	NA	1,892	NA	80	NA	NA
Zinc Oxysulfate	3	NA	9	NA	NA	NA	27	NA	NA	NA	NA
Zinc Sulfate	244	NA	2,008	NA	NA	NA	8,890	NA	1,430	NA	74
Zinc Sulfate Solution	NA	NA	NA	NA	NA	NA	1,883	NA	NA	NA	NA
Other	910	NA	8,824	NA	323	7,181	4	NA	111	NA	120
TOTAL	4,199	1	14,806	NA	7,741	7,318	25,009	NA	2,382	NA	645
LIMING MATERIALS											
Calcitic Lime (75% Neutral)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Calcium Hydroxide (Hydrate)	NA	NA	NA	NA	NA	NA	NA	NA	2	NA	NA
Calcium Oxide (Burnt)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Dolomitic & Calcitic Blend (Pelletized)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Dolomitic Lime (75% Neutral)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Lime Suspensions	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Non-lime Filler (Water, Sand, Etc.)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Standard Calcite	8	NA	NA	NA	1,228	353	3,670	NA	NA	NA	NA

Table C-3. (Continued)

Description	Kansas		Minnesota		Missouri		Nebraska		North Dakota		South Dakota
	Farm	Nonfarm	Farm	Nonfarm	Farm	Nonfarm	Farm	Nonfarm	Farm	Nonfarm	Farm
Standard Dolomite	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Other	65	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
TOTAL	73	NA	NA	NA	1,228	353	3,670	NA	2	NA	NA
ALL FERTILIZERS											
TOTAL	1,674,326	11	2,138,683	NA	1,658,295	43,428	2,272,742	428	1,109,024	NA	536,982

NA = it is unclear from the database whether there was no non-farm use recorded or on-farm use was zero.

Table C-4. Fertilizer Consumption by Use, West South Central States of Oklahoma and Louisiana, 1996 (tons)

Description	Louisiana		Oklahoma	
	Farm	Nonfarm	Farm	Nonfarm
MULTIPLE NUTRIENT FERTILIZERS				
N-P-K	245,831	16,530	23,164	22,297
N-P	30,545	7,479	165,937	347
N-K	19,733	382	1,333	619
P-K	66,686	38	204	140
TOTAL	362,796	24,429	190,638	23,403
NITROGEN FERTILIZERS				
Ammonium Nitrate	67,390	1,817	71,385	1,816
Ammonium Nitrate Solution	NA	NA	25	9
Ammonium Nitrate-limestone Mixtures	NA	NA	NA	NA
Ammonium Nitrate-sulfate	2,036	NA	172	1
Ammonium Polysulfide	NA	NA	26	25
Ammonium Sulfate	11,035	29	6,871	655
Ammonium Sulfate Solution	NA	NA	3	NA
Ammonium Sulfate-nitrate	39	NA	26	NA
Ammonium Sulfate-urea	2,171	12	NA	NA
Ammonium Thiosulfate	1,132	4	3,895	1
Anhydrous Ammonia	8,207	160	134,320	NA
Aqua Ammonia	NA	NA	NA	NA
Calcium Ammonium Nitrate	NA	NA	NA	NA
Calcium Cyanamide	NA	NA	NA	NA
Calcium Nitrate	1	2	136	11
Calcium Nitrate-urea	NA	NA	1,920	13
Ferrous Ammonium Sulfate	NA	NA	NA	NA
Magnesium Nitrate	NA	NA	NA	NA
Nitric Acid	22	3	145	NA
Nitrogen Solution 28%	4,751	NA	149,326	NA
Nitrogen Solution 30%	32,606	NA	141	NA
Nitrogen Solution 32%	212,002	325	44,859	NA
Nitrogen Solution <28%	4,979	16	629	NA
Nitrogen Solution >32%	266	NA	NA	NA

Table C-4. (Continued)

Description	Louisiana		Oklahoma	
	Farm	Nonfarm	Farm	Nonfarm
Sodium Nitrate	838	13	NA	5
Sulfur Coated Urea	196	NA	7	29
Urea	73,134	256	119,786	1,259
Urea Solution	NA	NA	NA	NA
Urea-formaldehyde	9,005	12	402	17
Zinc Ammonium Sulfate Solution	NA	NA	NA	NA
Zinc Manganese Ammonium Sulfate	NA	NA	NA	NA
Other	14,201	186	274	54
TOTAL	444,010	2,834	534,348	3,896
PHOSPHATE FERTILIZERS				
Ammonium Metaphosphate	NA	NA	NA	NA
Ammonium Phosphate	NA	NA	NA	NA
Ammonium Phosphate Nitrate	NA	NA	NA	NA
Ammonium Phosphate Sulfate	NA	NA	52	3
Ammonium Polyphosphate	NA	NA	NA	NA
Basic Lime Phosphate	NA	NA	NA	NA
Basic Slag	NA	NA	NA	NA
Bone Meal, Raw	NA	NA	NA	2
Bone Meal, Steamed	NA	2	NA	NA
Bone, Precipitated	5	NA	NA	NA
Calcium Metaphosphate	NA	NA	25	NA
Colloidal Phosphate (Soft Phosphate)	25	NA	NA	4
Diammonium Phosphate	10,859	7,434	127,336	240
Limestone, Phosphatic	NA	NA	NA	NA
Liquid Ammonium Polyphosphate	12,230	2	22,050	NA
Magnesium Phosphate	NA	NA	NA	NA
Monoammonium Phosphate	148	2	11,671	NA
Nitric Phosphate	NA	NA	NA	NA
Phosphate Rock	NA	NA	NA	NA
Phosphoric Acid	80	NA	9	NA
Precipitated Phosphate	NA	NA	NA	NA

Table C-4. (Continued)

Description	Louisiana		Oklahoma	
	Farm	Nonfarm	Farm	Nonfarm
Superphosphate, Enriched	NA	NA	NA	NA
Superphosphate, Normal	NA	2	NA	NA
Superphosphate, Triple	4,312	9	2,006	47
Superphosphoric Acid	NA	NA	NA	NA
Other	5	180	529	43
TOTAL	27,664	7,630	163,678	339
POTASH FERTILIZERS				
Lime-potash Mixtures	NA	NA	1	NA
Manure Salts	NA	NA	18	NA
Muriate of Potash 60% (Pot. Chloride)	33,863	58	43,164	93
Muriate of Potash 62%	1,189	3	339	41
Potash Suspensions	NA	NA	NA	NA
Potassium Carbonate	40	NA	NA	NA
Potassium Nitrate	15	NA	NA	2
Potassium Sulfate	3,126	NA	63	9
Potassium-magnesium Sulfate	190	NA	1,351	1
Potassium-metaphosphate	NA	NA	NA	NA
Potassium-sodium Nitrate	NA	NA	NA	NA
Other	3,376	27	51	13
TOTAL	41,799	88	44,987	159
ORGANIC FERTILIZERS				
Blood, Dried	NA	1	NA	NA
Castor Pomace	NA	NA	NA	NA
Cocoa Shell Meal	NA	NA	NA	NA
Compost	NA	NA	NA	NA
Cottonseed Meal	NA	NA	NA	NA
Fish Scrap	NA	NA	NA	NA
Guano	NA	NA	NA	NA
Manure	NA	83	NA	3,231
Peat	NA	NA	NA	NA
Sewage Sludge, Activated	NA	NA	NA	NA
Sewage Sludge, Digested	NA	NA	NA	NA

Table C-4. (Continued)

Description	Louisiana		Oklahoma	
	Farm	Nonfarm	Farm	Nonfarm
Sewage Sludge, Heat Dried	NA	NA	NA	NA
Sewage Sludge, Other	NA	NA	NA	44
Soybean Meal	NA	NA	NA	NA
Tankage, Animal	NA	NA	NA	NA
Tankage, Process	NA	NA	NA	NA
Other	102	NA	NA	NA
TOTAL	102	84	NA	3,275
SECONDARY AND MICRONUTRIENT FERTILIZERS				
Aluminum Sulfate	NA	3	NA	NA
Borax	118	NA	NA	NA
Calcium Chelate	NA	NA	NA	NA
Calcium Chloride	NA	NA	NA	NA
Calcium Sulfate (Hydrous)	NA	NA	NA	NA
Cobalt Sulfate	NA	NA	NA	NA
Copper Chelate	NA	NA	NA	NA
Copper Compound	NA	NA	NA	NA
Copper Oxide, Black	NA	NA	NA	NA
Copper Sulfate	NA	NA	NA	NA
Epsom Salt (Magnesium Sulfate)	1	NA	NA	NA
Ferric Oxide	NA	NA	NA	NA
Ferric Sulfate	NA	NA	NA	NA
Ferrous Sulfate	NA	NA	NA	NA
Gypsum (Calcium Sulfate)	44	NA	NA	NA
Iron Chelate	NA	4	NA	5
Iron Compound	NA	NA	NA	NA
Lime Sulfur Solution	NA	NA	NA	NA
Magnesia (Magnesium Oxide)	1	NA	NA	NA
Magnesium Chelate	12	NA	NA	NA
Manganese Agstone	NA	NA	NA	NA
Manganese Chelate	NA	NA	NA	NA
Manganese Oxide	NA	NA	NA	NA
Manganese Slag	NA	NA	NA	NA

Table C-4. (Continued)

Description	Louisiana		Oklahoma	
	Farm	Nonfarm	Farm	Nonfarm
Manganese Sulfate	NA	NA	NA	NA
Manganous Oxide	NA	NA	NA	NA
Potting Soil	NA	NA	NA	NA
Sodium Molybdate	NA	NA	NA	NA
Soil Additive	NA	NA	NA	NA
Soil Amendment	3	NA	NA	NA
Soil Conditioner	NA	NA	NA	NA
Sulfur	159	10	100	2
Sulfuric Acid	NA	NA	NA	NA
Zinc Chelate	87	NA	64	7
Zinc Oxide	63	NA	NA	NA
Zinc Oxysulfate	NA	NA	NA	NA
Zinc Sulfate	98	NA	42	NA
Zinc Sulfate Solution	NA	NA	144	NA
Other	673	3	1,458	1,599
TOTAL	1,259	21	1,808	1,613
LIMING MATERIALS				
Calcitic Lime (75% Neutral)	2,953	NA	NA	NA
Calcium Hydroxide (Hydrate)	NA	NA	NA	NA
Calcium Oxide (Burnt)	NA	NA	NA	NA
Dolomitic & Calcitic Blend (Pelletized)	NA	NA	NA	NA
Dolomitic Lime (75% Neutral)	174	NA	NA	NA
Lime Suspensions	NA	NA	NA	NA
Non-lime Filler (Water, Sand, Etc.)	NA	NA	NA	NA
Standard Calcite	NA	NA	NA	NA
Standard Dolomite	27	NA	NA	NA
Other	NA	NA	113	2
TOTAL	3,154	NA	113	2

Table C-4. (Continued)

Description	Louisiana		Oklahoma	
	Farm	Nonfarm	Farm	Nonfarm
ALL FERTILIZERS				
TOTAL	857,526	27,563	774,463	29,165

1. Data for Arkansas and Texas was not divided into farm versus non-farm use.

NA = it is unclear from the database whether there was no non-farm use recorded or on-farm use was zero.

Table C-5. Fertilizer Consumption by Use, New England States, 1996 (tons)

Description	Connecticut	Maine		Massachusettes		New Hampshire		Rhode Island	Vermont	
	Farm	Farm	Nonfarm	Farm	Nonfarm	Farm	Nonfarm	Farm	Farm	Nonarm
MULTIPLE NUTRIENT FERTILIZERS										
N-P-K	34,218	64,146	9,056	86,482	538	18,447	12	9,755	12,525	3,659
N-P	947	5,633	1	2,931	NA	506	NA	1,112	1,924	4,701
N-K	1,538	488	99	3,164	NA	1,078	NA	110	820	29
P-K	866	2	18	500	NA	47	NA	21	518	10
TOTAL	37,569	70,269	9,175	93,077	538	20,078	12	10,998	15,787	8,399
NITROGEN FERTILIZERS										
Ammonium Nitrate	58	2,988	4	139	NA	46	NA	42	69	NA
Ammonium Nitrate Solution	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Ammonium Nitrate-limestone Mixtures	NA	NA	1	NA	NA	1	NA	NA	NA	NA
Ammonium Nitrate-sulfate	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Ammonium Polysulfide	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Ammonium Sulfate	87	700	20	221	NA	70	NA	14	141	4
Ammonium Sulfate Solution	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Ammonium Sulfate-nitrate	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Ammonium Sulfate-urea	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Ammonium Thiosulfate	1	NA	NA	NA	NA	1	NA	3	NA	NA
Anhydrous Ammonia	NA	NA	NA	2	NA	NA	NA	NA	NA	NA
Aqua Ammonia	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Calcium Ammonium Nitrate	NA	NA	NA	NA	NA	9	NA	NA	NA	NA
Calcium Cyanamide	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Calcium Nitrate	180	238	1	263	NA	188	NA	132	50	NA

Table C-5. (Continued)

Description	Connecticut	Maine		Massachusettes		New Hampshire		Rhode Island	Vermont	
	Farm	Farm	Nonfarm	Farm	Nonfarm	Farm	Nonfarm	Farm	Farm	Nonarm
Calcium Nitrate-urea	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Ferrous Ammonium Sulfate	NA	NA	NA	11	NA	6	NA	NA	NA	NA
Magnesium Nitrate	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Nitric Acid	NA	NA	NA	23	NA	NA	NA	NA	NA	NA
Nitrogen Solution 28%	41	632	58	29	NA	1	NA	NA	NA	NA
Nitrogen Solution 30%	NA	NA	NA	1	NA	NA	NA	NA	NA	NA
Nitrogen Solution 32%	176	502	NA	598	NA	167	NA	1	1,664	NA
Nitrogen Solution <28%	5	NA	86	4	NA	5	NA	1	NA	NA
Nitrogen Solution >32%	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Sodium Nitrate	3	NA	4	6	NA	2	NA	1	27	298
Sulfur Coated Urea	1	NA	NA	1	NA	NA	NA	NA	4	NA
Urea	1,806	2,917	1,239	2,400	NA	1,445	NA	361	3,262	7
Urea Solution	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Urea-formaldehyde	353	NA	NA	1,463	NA	38	NA	NA	2	1
Zinc Ammonium Sulfate Solution	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Zinc Manganese Ammonium Sulfate	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Other	103	5	2	519	NA	19	NA	26	10	2,704
TOTAL	2,816	7,982	1,416	5,679	NA	1,998	NA	581	5,228	3,015
PHOSPHATE FERTILIZERS										
Ammonium Metaphosphate	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Ammonium Phosphate	NA	NA	NA	1	NA	NA	NA	NA	NA	NA
Ammonium Phosphate Nitrate	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Ammonium Phosphate Sulfate	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Table C-5. (Continued)

Description	Connecticut	Maine		Massachusettes		New Hampshire		Rhode Island	Vermont	
	Farm	Farm	Nonfarm	Farm	Nonfarm	Farm	Nonfarm	Farm	Farm	Nonarm
Ammonium Polyphosphate	NA	NA	NA	5	NA	NA	NA	NA	56	NA
Basic Lime Phosphate	NA	NA	NA	37	NA	NA	NA	NA	NA	NA
Basic Slag	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Bone Meal, Raw	NA	3	NA	72	NA	NA	NA	NA	NA	NA
Bone Meal, Steamed	48	8	NA	141	NA	15	NA	1	NA	1
Bone, Precipitated	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Calcium Metaphosphate	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Colloidal Phosphate (Soft Phosphate)	NA	NA	NA	4	NA	NA	NA	NA	NA	NA
Diammonium Phosphate	5	3,261	NA	1,842	NA	297	NA	NA	481	NA
Limestone, Phosphatic	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Liquid Ammonium Polyphosphate	NA	1,677	NA	41	NA	73	NA	6	168	NA
Magnesium Phosphate	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Monoammonium Phosphate	455	112	NA	616	NA	68	NA	120	1,167	NA
Nitric Phosphate	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Phosphate Rock	NA	3	NA	NA	NA	NA	NA	NA	NA	7
Phosphoric Acid	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Precipitated Phosphate	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Superphosphate, Enriched	NA	NA	NA	8	NA	NA	NA	NA	NA	NA
Superphosphate, Normal	12	NA	3	95	NA	18	13	2	2	NA
Superphosphate, Triple	83	62	8	365	NA	45	NA	37	97	NA
Superphosphoric Acid	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Other	23	NA	5	76	NA	24	NA	16	4	3
TOTAL	628	5,125	16	3,303	NA	540	13	182	1,976	11

Table C-5. (Continued)

Description	Connecticut	Maine		Massachusettes		New Hampshire		Rhode Island	Vermont	
	Farm	Farm	Nonfarm	Farm	Nonfarm	Farm	Nonfarm	Farm	Farm	Nonarm
POTASH FERTILIZERS										
Lime-potash Mixtures	NA	NA	NA	36	NA	NA	NA	NA	10	NA
Manure Salts	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Muriate of Potash 60% (Pot. Chloride)	874	1,775	23	1,141	NA	1,432	NA	182	2,633	3
Muriate of Potash 62%	8	NA	NA	712	NA	NA	NA	NA	NA	NA
Potash Suspensions	13	NA	NA	20	NA	24	NA	5	NA	NA
Potassium Carbonate	NA	NA	NA	28	NA	NA	NA	NA	NA	NA
Potassium Nitrate	42	NA	NA	289	NA	31	NA	NA	NA	NA
Potassium Sulfate	26	2	NA	79	NA	18	NA	4	91	4
Potassium-magnesium Sulfate	36	245	21	873	NA	34	NA	4	267	7
Potassium-metaphosphate	NA	NA	NA	1	NA	3	NA	NA	NA	NA
Potassium-sodium Nitrate	NA	NA	NA	1	NA	NA	NA	NA	NA	NA
Other	74	6	29	444	NA	130	NA	14	78	3
TOTAL	1,074	2,028	73	3,625	NA	1,672	NA	209	3,079	17
ORGANIC FERTILIZERS										
Blood, Dried	7	3	NA	23	NA	4	NA	NA	NA	NA
Castor Pomace	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Cocoa Shell Meal	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Compost	NA	NA	NA	14,435	NA	64	NA	NA	10	NA
Cottonseed Meal	NA	1	NA	4	NA	NA	NA	NA	NA	NA
Fish Scrap	NA	NA	NA	48	NA	NA	NA	NA	NA	NA
Guano	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Manure	28	6	11	676	NA	45	NA	NA	NA	53
Peat	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Table C-5. (Continued)

Description	Connecticut	Maine		Massachusettes		New Hampshire		Rhode Island	Vermont	
	Farm	Farm	Nonfarm	Farm	Nonfarm	Farm	Nonfarm	Farm	Farm	Nonarm
Sewage Sludge, Activated	458	NA	124	613	NA	46	NA	NA	NA	NA
Sewage Sludge, Digested	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Sewage Sludge, Heat Dried	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Sewage Sludge, Other	NA	NA	NA	NA	NA	86	NA	NA	NA	NA
Soybean Meal	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Tankage, Animal	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Tankage, Process	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Other	NA	NA	NA	8	NA	NA	NA	NA	NA	20
TOTAL	494	11	136	15,806	NA	245	NA	NA	10	73
SECONDARY AND MICRONUTRIENT FERTILIZERS										
Aluminum Sulfate	4	NA	NA	12	NA	1	NA	3	NA	400
Borax	2	73	1	1	NA	14	NA	2	30	NA
Calcium Chelate	NA	NA	NA	4	NA	NA	NA	NA	NA	NA
Calcium Chloride	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Calcium Sulfate (Hydrous)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Cobalt Sulfate	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Copper Chelate	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Copper Compound	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Copper Oxide, Black	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Copper Sulfate	NA	1	NA	NA	NA	NA	NA	NA	NA	NA
Epsom Salt (Magnesium Sulfate)	NA	1	NA	3	NA	6	NA	NA	NA	NA
Ferric Oxide	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Ferric Sulfate	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Ferrous Sulfate	NA	NA	NA	6	NA	NA	NA	NA	NA	NA

Table C-5. (Continued)

Description	Connecticut	Maine		Massachusettes		New Hampshire		Rhode Island	Vermont	
	Farm	Farm	Nonfarm	Farm	Nonfarm	Farm	Nonfarm	Farm	Farm	Nonarm
Gypsum (Calcium Sulfate)	129	19	3	267	NA	46	NA	1	10	12
Iron Chelate	24	NA	NA	19	NA	6	NA	1	NA	1
Iron Compound	2	NA	NA	4	NA	NA	NA	1	NA	NA
Lime Sulfur Solution	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Magnesia (Magnesium Oxide)	NA	11	NA	NA	NA	NA	NA	NA	NA	NA
Magnesium Chelate	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Manganese Agstone	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Manganese Chelate	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Manganese Oxide	NA	NA	NA	4	NA	NA	NA	NA	NA	NA
Manganese Slag	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Manganese Sulfate	NA	1	NA	4	NA	4	NA	NA	NA	NA
Manganous Oxide	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Potting Soil	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Sodium Molybdate	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Soil Additive	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Soil Amendment	NA	20,035	NA	NA	NA	NA	NA	NA	NA	NA
Soil Conditioner	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Sulfur	2	61	NA	9	NA	3	NA	NA	4	NA
Sulfuric Acid	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Zinc Chelate	NA	NA	NA	1	NA	NA	NA	NA	NA	NA
Zinc Oxide	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Zinc Oxysulfate	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Zinc Sulfate	NA	7	NA	NA	NA	NA	NA	3	9	NA
Zinc Sulfate Solution	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Other	15	NA	NA	31	NA	2	NA	NA	NA	NA

Table C-5. (Continued)

Description	Connecticut	Maine		Massachusettes		New Hampshire		Rhode Island	Vermont	
	Farm	Farm	Nonfarm	Farm	Nonfarm	Farm	Nonfarm	Farm	Farm	Nonarm
TOTAL	178	20,210	5	367	NA	81	NA	12	54	413
LIMING MATERIALS										
Calcitic Lime (75% Neutral)	NA	11,253	1,841	70	NA	394	NA	NA	NA	NA
Calcium Hydroxide (Hydrate)	NA	NA	7	NA	NA	NA	NA	17	NA	NA
Calcium Oxide (Burnt)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Dolomitic & Calcitic Blend (Pelletized)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Dolomitic Lime (75% Neutral)	510	10,936	358	2	NA	NA	NA	71	NA	NA
Lime Suspensions	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Non-lime Filler (Water, Sand, Etc.)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Standard Calcite	NA	8,713	NA	NA	NA	10	NA	265	NA	NA
Standard Dolomite	NA	NA	353	984	NA	442	NA	5,498	NA	29
Other	NA	9,410	284	9	NA	554	NA	12	NA	NA
TOTAL	510	40,312	2,843	1,065	NA	1,401	NA	5,863	NA	29
ALL FERTILIZERS										
TOTAL	42,232	140,869	13,526	104,137	538	25,286	25	17,718	24,252	11,904

NA = it is unclear from the database whether there was no non-farm use recorded or on-farm use was zero.

Table C-6. Fertilizer Consumption by Use, Middle Atlantic States, 1996 (tons)

Description	Delaware		Maryland		New Jersey		New York		Pennsylvania		West Virginia	
	Farm	Nonfarm	Farm	Nonfarm	Farm	Nonfarm	Farm	Nonfarm	Farm	Nonfarm	Farm	Nonfarm
MULTIPLE NUTRIENT FERTILIZERS												
N-P-K	31,133	3,711	82,347	42,738	145,535	109,268	137,783	64,033	190,246	71,588	19,605	8,152
N-P	6,888	148	53,063	35,347	2,960	4,084	37,364	1,866	32,949	1,888	4,100	195
N-K	4,304	467	9,539	952	4,926	2,126	6,408	1,507	12,098	1,632	52	99
P-K	867	NA	2,038	54	1,659	45	4,220	207	17,485	172	410	NA
TOTAL	43,191	4,325	146,987	79,091	155,081	115,523	185,775	67,612	252,779	75,280	24,168	8,447
NITROGEN FERTILIZERS												
Ammonium Nitrate	1,788	39	2,946	416	1,013	177	6,173	152	8,257	143	676	30
Ammonium Nitrate Solution	NA	NA	NA	NA	NA	NA	1	NA	NA	NA	NA	NA
Ammonium Nitrate-limestone Mixtures	NA	NA	NA	NA	NA	NA	5	NA	NA	NA	NA	NA
Ammonium Nitrate-sulfate	NA	NA	29	NA	1,061	1	11	NA	18	NA	48	NA
Ammonium Polysulfide	NA	NA	NA	NA	NA	NA	NA	NA	1	NA	NA	NA
Ammonium Sulfate	7,687	47	12,475	176	1,209	156	9,490	223	13,051	768	255	NA
Ammonium Sulfate Solution	75	NA	325	5	NA	NA	3	2	93	4	NA	NA
Ammonium Sulfate-nitrate	49	NA	360	NA	NA	NA	NA	NA	391	2	NA	NA
Ammonium Sulfate-urea	NA	NA	NA	NA	NA	NA	25	NA	NA	NA	NA	NA
Ammonium Thiosulfate	3	NA	584	NA	32	NA	423	2	2,194	NA	NA	1
Anhydrous Ammonia	30	NA	2,311	7,746	30	NA	2,666	172	2,855	NA	568	159
Aqua Ammonia	NA	NA	298	25	NA	NA	NA	NA	NA	NA	101	NA

Table C-6. (Continued)

Description	Delaware		Maryland		New Jersey		New York		Pennsylvania		West Virginia	
	Farm	Nonfarm	Farm	Nonfarm	Farm	Nonfarm	Farm	Nonfarm	Farm	Nonfarm	Farm	Nonfarm
Calcium Ammonium Nitrate	NA	NA	5	NA	8	NA	14	50	NA	NA	NA	NA
Calcium Cyanamide	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Calcium Nitrate	17	NA	352	89	601	261	1,346	101	427	268	23	NA
Calcium Nitrate-urea	2	NA	NA	NA	NA	NA	25	NA	NA	NA	NA	NA
Ferrous Ammonium Sulfate	1	NA	33	NA	14	NA	28	NA	NA	NA	2	NA
Magnesium Nitrate	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Nitric Acid	NA	NA	2	NA	NA	NA	6	NA	NA	NA	NA	2
Nitrogen Solution 28%	1,569	NA	536	2	23,963	827	612	119	11,335	609	813	NA
Nitrogen Solution 30%	37,586	1	80,379	12,904	1,205	22	13,438	149	70,479	1,029	3,260	NA
Nitrogen Solution 32%	1,128	NA	206	NA	NA	2	24,339	6	6,726	NA	NA	NA
Nitrogen Solution <28%	11,197	14	15,016	454	3,844	23	1,267	70	10,228	87	13	NA
Nitrogen Solution >32%	NA	NA	NA	NA	NA	NA	165	NA	35	10	NA	NA
Sodium Nitrate	11	NA	91	4	150	60	56	11	2	7	16	1
Sulfur Coated Urea	NA	4	NA	14	6	10	198	100	97	NA	NA	NA
Urea	448	125	8,216	764	3,640	817	28,253	543	49,294	467	2,650	7
Urea Solution	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Urea-formaldehyde	NA	10	174	170	2,657	597	341	233	7,006	942	70	19
Zinc Ammonium Sulfate Solution	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Zinc Manganese Ammonium Sulfate	NA	NA	NA	NA	NA	NA	NA	3	NA	NA	NA	NA
Other	297	23	1,745	589	928	840	1,302	412	2,984	1,299	9	22

Table C-6. (Continued)

Description	Delaware		Maryland		New Jersey		New York		Pennsylvania		West Virginia	
	Farm	Nonfarm	Farm	Nonfarm	Farm	Nonfarm	Farm	Nonfarm	Farm	Nonfarm	Farm	Nonfarm
TOTAL	61,886	264	126,083	23,359	40,361	3,793	90,184	2,346	185,472	5,634	8,505	240
PHOSPHATE FERTILIZERS												
Ammonium Metaphosphate	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Ammonium Phosphate	NA	NA	594	297	NA	NA	20	NA	NA	NA	NA	NA
Ammonium Phosphate Nitrate	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Ammonium Phosphate Sulfate	74	NA	NA	NA	NA	NA	48	NA	NA	NA	NA	NA
Ammonium Polyphosphate	NA	NA	NA	NA	NA	NA	194	NA	252	NA	NA	NA
Basic Lime Phosphate	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Basic Slag	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Bone Meal, Raw	NA	NA	NA	NA	NA	13	NA	1	44	1	NA	NA
Bone Meal, Steamed	NA	5	NA	1	1	2	1	142	4	NA	NA	NA
Bone, Precipitated	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Calcium Metaphosphate	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Colloidal Phosphate (Soft Phosphate)	NA	NA	NA	NA	NA	NA	NA	NA	45	NA	NA	NA
Diammonium Phosphate	1,860	64	17,407	1,217	1,342	120	7,398	165	12,038	5	3,881	116
Limestone, Phosphatic	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Liquid Ammonium Polyphosphate	3,348	NA	3,995	80	1,119	NA	8,994	529	5,065	189	197	9
Magnesium Phosphate	NA	NA	NA	NA	NA	NA	NA	40	NA	1	NA	NA

Table C-6. (Continued)

Description	Delaware		Maryland		New Jersey		New York		Pennsylvania		West Virginia	
	Farm	Nonfarm	Farm	Nonfarm	Farm	Nonfarm	Farm	Nonfarm	Farm	Nonfarm	Farm	Nonfarm
Monoammonium Phosphate	690	79	6,678	453	163	1	18,643	796	12,313	24	3	5
Nitric Phosphate	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Phosphate Rock	NA	NA	2	NA	NA	NA	1	3	NA	NA	NA	NA
Phosphoric Acid	1,322	NA	386	34	NA	NA	NA	NA	577	NA	NA	NA
Precipitated Phosphate	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Superphosphate, Enriched	5	NA	NA	NA	NA	NA	23	NA	NA	14	NA	NA
Superphosphate, Normal	51	2	3	8	4	1,010	NA	27	91	4	1	NA
Superphosphate, Triple	23	64	7,370	852	166	115	1,120	82	5,828	50	1,441	NA
Superphosphoric Acid	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Other	111	2	386	1,296	572	84	NA	130	649	200	NA	35
TOTAL	7,484	215	36,821	4,238	3,367	1,345	36,440	1,915	36,905	488	5,522	166
POTASH FERTILIZERS												
Lime-potash Mixtures	NA	NA	NA	NA	NA	NA	5,565	3	NA	NA	NA	NA
Manure Salts	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Muriate of Potash 60% (Pot. Chloride)	12,005	37	30,368	2,663	2,237	563	42,640	527	25,241	134	4,325	NA
Muriate of Potash 62%	415	12	1,686	608	9	38	1,747	348	8,294	51	29	6
Potash Suspensions	NA	NA	NA	NA	NA	NA	90	213	2,449	NA	NA	NA
Potassium Carbonate	NA	NA	250	NA	48	NA	(246)	NA	25	NA	NA	NA
Potassium Nitrate	3	NA	1,393	2	138	3	84	12	8,482	9	NA	NA
Potassium Sulfate	1	8	287	16	85	125	329	41	1,532	190	130	1

Table C-6. (Continued)

Description	Delaware		Maryland		New Jersey		New York		Pennsylvania		West Virginia	
	Farm	Nonfarm	Farm	Nonfarm	Farm	Nonfarm	Farm	Nonfarm	Farm	Nonfarm	Farm	Nonfarm
Potassium-magnesium Sulfate	137	NA	1,041	6	106	62	1,931	28	451	27	NA	6
Potassium-metaphosphate	NA	NA	NA	NA	173	NA	NA	NA	NA	NA	NA	NA
Potassium-sodium Nitrate	NA	NA	NA	NA	32	NA	109	NA	NA	NA	NA	NA
Other	1,538	42	554	160	2,557	247	8,187	168	548	172	7	62
TOTAL	14,099	99	35,579	3,455	5,385	1,038	60,437	1,339	47,022	582	4,491	75
ORGANIC FERTILIZERS												
Blood, Dried	NA	3	NA	NA	NA	2	NA	6	9	NA	NA	NA
Castor Pomace	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Cocoa Shell Meal	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Compost	NA	170	NA	NA	NA	7,841	NA	1,413	NA	481	1,990	3,300
Cottonseed Meal	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Fish Scrap	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Guano	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Manure	NA	386	NA	4,731	NA	4,041	NA	1,084	16	1,190	NA	1,612
Peat	NA	NA	NA	73	7	13	NA	NA	NA	NA	NA	NA
Sewage Sludge, Activated	NA	NA	NA	NA	NA	279	3,743	1,285	652	659	NA	NA
Sewage Sludge, Digested	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Sewage Sludge, Heat Dried	NA	127	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Sewage Sludge, Other	29	4	NA	NA	24	3,980	1	NA	NA	NA	NA	NA
Soybean Meal	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Tankage, Animal	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Table C-6. (Continued)

Description	Delaware		Maryland		New Jersey		New York		Pennsylvania		West Virginia	
	Farm	Nonfarm	Farm	Nonfarm	Farm	Nonfarm	Farm	Nonfarm	Farm	Nonfarm	Farm	Nonfarm
Tankage, Process	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Other	NA	353	NA	1,099	NA	3	374	995	5,013	NA	NA	NA
TOTAL	29	1,043	NA	5,903	31	16,160	4,118	4,784	5,689	2,330	1,990	4,912
SECONDARY AND MICRONUTRIENT FERTILIZERS												
Aluminum Sulfate	22	NA	NA	1	1	NA	3	5	5	NA	NA	NA
Borax	27	NA	153	NA	24	16	231	212	113	NA	24	NA
Calcium Chelate	1	NA	NA	NA	NA	6	NA	74	1	NA	NA	NA
Calcium Chloride	NA	NA	NA	NA	8	NA	2	NA	384	NA	NA	NA
Calcium Sulfate (Hydrous)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Cobalt Sulfate	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Copper Chelate	NA	NA	NA	NA	NA	NA	2	NA	NA	NA	NA	NA
Copper Compound	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Copper Oxide, Black	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Copper Sulfate	NA	NA	2	NA	1	NA	14	42	381	NA	NA	NA
Epsom Salt (Magnesium Sulfate)	NA	NA	1	NA	7	26	9	2	13	NA	NA	NA
Ferric Oxide	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Ferric Sulfate	NA	NA	NA	NA	NA	NA	NA	NA	51	NA	NA	NA
Ferrous Sulfate	NA	1	NA	NA	NA	NA	4	2	12	2	NA	NA
Gypsum (Calcium Sulfate)	47	NA	328	NA	558	88	1	103	408	301	NA	NA
Iron Chelate	NA	NA	NA	19	2	34	40	55	29	3	NA	4
Iron Compound	NA	NA	1	9	NA	6	16	29	NA	NA	NA	NA
Lime Sulfur Solution	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Magnesia (Magnesium Oxide)	NA	NA	3	NA	NA	NA	26	106	180	23	2	NA

Table C-6. (Continued)

Description	Delaware		Maryland		New Jersey		New York		Pennsylvania		West Virginia	
	Farm	Nonfarm	Farm	Nonfarm	Farm	Nonfarm	Farm	Nonfarm	Farm	Nonfarm	Farm	Nonfarm
Magnesium Chelate	NA	NA	NA	NA	NA	NA	11	NA	NA	NA	NA	NA
Manganese Agstone	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Manganese Chelate	NA	NA	17	NA	NA	NA	5	NA	1	NA	NA	NA
Manganese Oxide	7	NA	3	NA	NA	NA	1	NA	NA	NA	NA	NA
Manganese Slag	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Manganese Sulfate	63	NA	26	NA	5	1	90	NA	6	NA	NA	NA
Manganous Oxide	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Potting Soil	NA	14	NA	NA	NA	360	NA	NA	NA	NA	NA	NA
Sodium Molybdate	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Soil Additive	NA	NA	NA	NA	NA	2	NA	NA	NA	NA	NA	NA
Soil Amendment	NA	3	NA	NA	NA	2	NA	67	NA	NA	NA	NA
Soil Conditioner	NA	NA	NA	NA	4,920	2,215	NA	NA	NA	NA	NA	NA
Sulfur	NA	5	42	1	13	10	171	193	645	1	7	2
Sulfuric Acid	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Zinc Chelate	5	NA	30	NA	NA	NA	55	NA	4	NA	NA	NA
Zinc Oxide	NA	NA	NA	NA	NA	NA	6	325	36	NA	NA	NA
Zinc Oxysulfate	NA	NA	15	NA	NA	NA	7	41	8	NA	NA	NA
Zinc Sulfate	37	NA	61	NA	1	11	156	9	23	NA	NA	NA
Zinc Sulfate Solution	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Other	240	5	49	22	30	34	272	28	413	18	1	1
TOTAL	449	29	730	50	5,570	2,811	1,122	1,293	2,713	347	34	7
LIMING MATERIALS												
Calcitic Lime (75% Neutral)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Calcium Hydroxide (Hydrate)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Table C-6. (Continued)

Description	Delaware		Maryland		New Jersey		New York		Pennsylvania		West Virginia	
	Farm	Nonfarm	Farm	Nonfarm	Farm	Nonfarm	Farm	Nonfarm	Farm	Nonfarm	Farm	Nonfarm
Calcium Oxide (Burnt)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Dolomitic & Calcitic Blend (Pelletized)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Dolomitic Lime (75% Neutral)	NA	NA	NA	NA	10	NA	NA	NA	NA	NA	NA	NA
Lime Suspensions	NA	NA	228	NA	NA	NA	NA	NA	NA	NA	NA	NA
Non-lime Filler (Water, Sand, Etc.)	NA	NA	NA	NA	NA	NA	92	NA	NA	NA	NA	NA
Standard Calcite	NA	NA	7,947	NA	NA	NA	933	7	24	NA	478	80
Standard Dolomite	NA	NA	NA	NA	NA	NA	11	23	NA	NA	NA	NA
Other	40	130	6,074	NA	89	286	2,753	NA	500	NA	NA	NA
TOTAL	40	130	14,249	NA	99	286	3,790	30	524	NA	478	80
ALL FERTILIZERS												
TOTAL	121,175	5,271	330,382	109,242	206,895	124,661	342,631	73,735	487,229	82,103	39,117	8,885

NA = it is unclear from the database whether there was no non-farm use recorded or on-farm use was zero.

Table C-7 Fertilizer Consumption by Use, South Atlantic States, 1996 (tons)

Description	Florida		Georgia	North Carolina[1]		South Carolina		Virginia	
	Farm	Nonfarm	Farm	Farm	Nonfarm	Farm	Nonfarm	Farm	Nonarm
MULTIPLE NUTRIENT FERTILIZERS									
N-P-K	802,855	270,510	989,848	687,330	18,704	267,331	31,980	268,843	73,625
N-P	29,646	20,039	55,376	69,238	1,148	14,900	951	60,991	5,656
N-K	348,543	30,579	NA	79,179	908	39,109	3,091	19,996	1,603
P-K	60,465	310	NA	19,407	44	60,412	101	4,744	5
TOTAL	1,241,508	321,437	1,045,224	855,153	20,805	381,751	36,124	354,574	80,888
NITROGEN FERTILIZERS									
Ammonium Nitrate	32,473	1,117	81,043	36,935	296	16,486	1,078	12,289	222
Ammonium Nitrate Solution	3,294	NA	NA	NA	NA	382	NA	38	NA
Ammonium Nitrate-limestone Mixtures	5	NA	NA	392	NA	NA	NA	NA	NA
Ammonium Nitrate-sulfate	4	2	NA	11,166	18	54	NA	844	NA
Ammonium Polysulfide	NA	1	NA	2,765	NA	581	25	98	NA
Ammonium Sulfate	25,597	4,105	8,088	34,540	210	2,708	582	24,800	37
Ammonium Sulfate Solution	209	1	NA	1	NA	31	NA	423	6
Ammonium Sulfate-nitrate	1,073	NA	NA	107	NA	4	3	73	NA
Ammonium Sulfate-urea	NA	NA	NA	NA	NA	455	1	9	4
Ammonium Thiosulfate	564	279	NA	253	NA	65	NA	253	NA
Anhydrous Ammonia	3,561	1,974	8,734	5,155	NA	2,215	NA	703	79
Aqua Ammonia	27	NA	NA	308	NA	NA	NA	265	NA
Calcium Ammonium Nitrate	24	NA	NA	85	NA	212	NA	33	NA
Calcium Cyanamide	NA	NA	NA	1	NA	2	NA	NA	NA
Calcium Nitrate	10,740	174	NA	6,805	1	1,292	50	811	12
Calcium Nitrate-urea	10	NA	NA	1,046	NA	439	NA	NA	NA

Table C-7. (Continued)

Description	Florida		Georgia	North Carolina[1]		South Carolina		Virginia	
	Farm	Nonfarm	Farm	Farm	Nonfarm	Farm	Nonfarm	Farm	Nonarm
Ferrous Ammonium Sulfate	32	1	NA	122	NA	NA	NA	88	NA
Magnesium Nitrate	3	NA	NA	NA	NA	NA	NA	NA	NA
Nitric Acid	NA	NA	NA	1	NA	1	15	962	12
Nitrogen Solution 28%	15,967	2,646	NA	1,016	1	2,440	25	686	46
Nitrogen Solution 30%	249	41	332,803	281,692	1,410	66,162	NA	82,872	NA
Nitrogen Solution 32%	12,175	817	NA	21,855	1,924	1,105	40	898	1
Nitrogen Solution <28%	25,344	1,655	NA	85,596	73	73,857	103	45,055	19
Nitrogen Solution >32%	358	NA	NA	70	NA	1,177	NA	353	NA
Sodium Nitrate	885	28	NA	13,966	11	2,197	21	1,619	21
Sulfur Coated Urea	50	1	NA	NA	3	138	8	46	NA
Urea	10,010	6,705	23,762	14,837	42	3,049	1,255	21,987	1,064
Urea Solution	159	NA	NA	NA	NA	115	28	NA	NA
Urea-formaldehyde	3,833	3,812	NA	1,409	6	2,733	287	722	45
Zinc Ammonium Sulfate Solution	NA	NA	NA	85	NA	105	NA	129	NA
Zinc Manganese Ammonium Sulfate	1	3	NA	7	NA	NA	NA	63	NA
Other	21,459	4,299	27,930	4,365	82	7,651	316	1,207	208
TOTAL	168,105	27,661	482,360	524,580	4,077	185,656	3,835	197,327	1,774
PHOSPHATE FERTILIZERS									
Ammonium Metaphosphate	NA	NA	NA	NA	NA	NA	NA	NA	NA
Ammonium Phosphate	1	1	NA	NA	NA	NA	NA	2	NA
Ammonium Phosphate Nitrate	1	NA	NA	NA	NA	NA	NA	NA	NA
Ammonium Phosphate Sulfate	NA	NA	NA	NA	NA	16	NA	8	NA
Ammonium Polyphosphate	6	NA	NA	NA	NA	NA	NA	NA	NA
Basic Lime Phosphate	NA	NA	NA	NA	NA	NA	NA	NA	NA
Basic Slag	2,869	NA	NA	119	NA	NA	NA	NA	NA

Table C-7. (Continued)

Description	Florida		Georgia	North Carolina[1]		South Carolina		Virginia	
	Farm	Nonfarm	Farm	Farm	Nonfarm	Farm	Nonfarm	Farm	Nonarm
Bone Meal, Raw	NA	NA	NA	24	NA	1	15	NA	NA
Bone Meal, Steamed	4	33	NA	2	NA	NA	NA	94	44
Bone, Precipitated	NA	NA	NA	NA	NA	NA	NA	NA	NA
Calcium Metaphosphate	13	NA	NA	14	NA	NA	NA	88	NA
Colloidal Phosphate (Soft Phosphate)	391	2	NA	34	NA	NA	1	47	3
Diammonium Phosphate	2,817	10,858	13,123	33,191	1,069	2,179	578	48,160	381
Limestone, Phosphatic	45	NA	NA	NA	NA	NA	NA	NA	NA
Liquid Ammonium Polyphosphate	7,902	153	42,253	22,532	2	9,755	127	6,190	471
Magnesium Phosphate	16	9	NA	12	NA	5	NA	NA	NA
Monoammonium Phosphate	45	39	NA	2,225	NA	27	1	1,916	1
Nitric Phosphate	NA	NA	NA	NA	NA	NA	NA	NA	NA
Phosphate Rock	NA	NA	NA	NA	NA	NA	NA	24	NA
Phosphoric Acid	2,940	5	NA	156	NA	1	NA	100	NA
Precipitated Phosphate	NA	NA	NA	23	NA	NA	NA	NA	NA
Superphosphate, Enriched	25	NA	NA	16	NA	23	3	19	NA
Superphosphate, Normal	1,673	64	NA	133	NA	561	NA	199	12
Superphosphate, Triple	2,513	1,747	5,171	10,757	15	1,587	726	6,041	23
Superphosphoric Acid	2,219	NA	NA	NA	NA	NA	NA	NA	NA
Other	4,974	736	11,371	22	NA	11	71	68	315
TOTAL	28,455	13,647	71,918	69,261	1,087	14,167	1,522	62,955	1,250
POTASH FERTILIZERS									
Lime-potash Mixtures	NA	30	NA	96	NA	1	NA	93	NA
Manure Salts	1	NA	NA	464	13	NA	1	21	3
Muriate of Potash 60% (Pot. Chloride)	10,218	352	29,836	73,330	3,258	11,366	253	63,401	4
Muriate of Potash 62%	530	208	NA	5,086	6	2,771	143	4,067	103

Table C-7. (Continued)

Description	Florida		Georgia	North Carolina[1]		South Carolina		Virginia	
	Farm	Nonfarm	Farm	Farm	Nonfarm	Farm	Nonfarm	Farm	Nonarm
Potash Suspensions	179	NA	NA	NA	NA	NA	NA	NA	NA
Potassium Carbonate	NA	2	NA	276	NA	4	NA	NA	NA
Potassium Nitrate	3,765	377	NA	16,073	10	5,295	66	14	13
Potassium Sulfate	9,062	251	NA	4,799	4	2,577	49	871	2
Potassium-magnesium Sulfate	2,466	936	6,325	5,759	6	893	28	577	14
Potassium-metaphosphate	NA	NA	NA	NA	NA	NA	NA	NA	NA
Potassium-sodium Nitrate	917	29	NA	15,253	16	325	NA	1,434	NA
Other	10,210	1,195	12,594	3,539	47	4,560	252	4,489	166
TOTAL	37,349	3,378	48,755	124,677	3,360	27,793	792	74,968	306
ORGANIC FERTILIZERS									
Blood, Dried	NA	5	NA	111	9	NA	NA	66	NA
Castor Pomace	NA	NA	NA	8	NA	NA	NA	NA	NA
Cocoa Shell Meal	NA	NA	NA	11	NA	NA	NA	NA	NA
Compost	NA	3	NA	12	NA	NA	1,586	NA	19,263
Cottonseed Meal	1	NA	NA	39	NA	NA	NA	NA	NA
Fish Scrap	NA	NA	NA	12	6	NA	NA	NA	NA
Guano	NA	NA	NA	NA	NA	NA	NA	NA	NA
Manure	1,167	2,843	NA	6,288	966	74	3,499	621	7,057
Peat	NA	NA	NA	1,958	NA	NA	NA	50	12
Sewage Sludge, Activated	3,076	7,606	NA	NA	12	NA	56	NA	NA
Sewage Sludge, Digested	NA	NA	NA	NA	NA	NA	NA	NA	NA
Sewage Sludge, Heat Dried	NA	NA	NA	NA	NA	NA	NA	NA	NA
Sewage Sludge, Other	NA	NA	NA	6	NA	NA	NA	NA	253
Soybean Meal	NA	NA	NA	NA	NA	NA	NA	NA	NA
Tankage, Animal	NA	NA	NA	NA	NA	NA	NA	NA	NA
Tankage, Process	NA	NA	NA	83	NA	NA	NA	NA	NA

Table C-7. (Continued)

Description	Florida		Georgia	North Carolina[1]		South Carolina		Virginia	
	Farm	Nonfarm	Farm	Farm	Nonfarm	Farm	Nonfarm	Farm	Nonarm
Other	244	751	29,314	93,204	531	55	1,343	119	12,107
TOTAL	4,487	11,208	29,314	101,733	1,524	129	6,483	856	38,692
SECONDARY AND MICRONUTRIENT FERTILIZERS									
Aluminum Sulfate	4	NA	NA	3	NA	NA	NA	NA	9
Borax	25	60	NA	978	NA	71	4	467	NA
Calcium Chelate	211	11	NA	3	NA	NA	NA	2	NA
Calcium Chloride	8	NA	NA	2	NA	4	2	24	NA
Calcium Sulfate (Hydrous)	13	NA	NA	NA	NA	NA	NA	NA	NA
Cobalt Sulfate	NA	NA	NA	NA	NA	NA	NA	NA	NA
Copper Chelate	NA	NA	NA	34	NA	NA	NA	NA	NA
Copper Compound	4	NA	NA	NA	NA	3	NA	NA	NA
Copper Oxide, Black	NA	NA	NA	NA	NA	NA	NA	NA	NA
Copper Sulfate	168	7	NA	35	NA	4	NA	3	NA
Epsom Salt (Magnesium Sulfate)	626	233	NA	2	NA	8	NA	4	1
Ferric Oxide	NA	1	NA	NA	NA	NA	NA	NA	NA
Ferric Sulfate	NA	NA	NA	NA	NA	NA	NA	NA	NA
Ferrous Sulfate	951	771	NA	NA	NA	NA	NA	NA	NA
Gypsum (Calcium Sulfate)	21,375	982	79,514	30,114	NA	9,168	338	92,136	67
Iron Chelate	148	405	NA	44	NA	NA	NA	NA	7
Iron Compound	6	166	NA	NA	NA	17	22	NA	5
Lime Sulfur Solution	NA	NA	NA	NA	NA	NA	NA	NA	NA
Magnesia (Magnesium Oxide)	159	NA	NA	32	NA	47	NA	13	NA
Magnesium Chelate	19	1	NA	NA	NA	NA	NA	3	NA
Manganese Agstone	NA	NA	NA	NA	NA	NA	NA	NA	NA
Manganese Chelate	37	1	NA	80	NA	NA	NA	1	NA
Manganese Oxide	13	NA	NA	NA	NA	(1)	NA	3	NA

Table C-7. (Continued)

Description	Florida		Georgia	North Carolina[1]		South Carolina		Virginia	
	Farm	Nonfarm	Farm	Farm	Nonfarm	Farm	Nonfarm	Farm	Nonarm
Manganese Slag	NA	72	NA	NA	NA	88	NA	NA	NA
Manganese Sulfate	2,801	437	NA	119	NA	8	NA	1	NA
Manganous Oxide	NA	NA	NA	NA	NA	NA	NA	NA	NA
Potting Soil	NA	NA	NA	NA	NA	NA	NA	NA	28,521
Sodium Molybdate	NA	NA	NA	NA	NA	NA	NA	NA	NA
Soil Additive	1	NA	NA	NA	NA	NA	NA	NA	NA
Soil Amendment	NA	NA	NA	NA	NA	NA	NA	NA	5,036
Soil Conditioner	10	346	NA	1	NA	NA	NA	NA	58
Sulfur	717	89	NA	409	2	199	27	583	1
Sulfuric Acid	NA	NA	NA	NA	NA	NA	NA	NA	NA
Zinc Chelate	15	NA	NA	27	NA	NA	NA	41	NA
Zinc Oxide	84	34	NA	NA	NA	3	NA	NA	NA
Zinc Oxysulfate	NA	NA	NA	11	NA	8	NA	3	NA
Zinc Sulfate	2	NA	NA	3	NA	1	NA	27	NA
Zinc Sulfate Solution	NA	NA	NA	NA	NA	NA	NA	NA	NA
Other	47,338	12,956	39,388	9,268	68	4,298	149	492	26
TOTAL	74,735	16,573	118,902	41,164	71	13,926	542	93,813	33,731

Table C-7. (Continued)

Description	Florida		Georgia	North Carolina[1]		South Carolina		Virginia	
	Farm	Nonfarm	Farm	Farm	Nonfarm	Farm	Nonfarm	Farm	Nonarm
LIMING MATERIALS									
Calcitic Lime (75% Neutral)	24,064	1,060	NA	NA	NA	NA	NA	NA	NA
Calcium Hydroxide (Hydrate)	191	40	NA	NA	NA	NA	NA	NA	NA
Calcium Oxide (Burnt)	186	NA	NA	NA	NA	NA	NA	NA	NA
Dolomitic & Calcitic Blend (Pelletized)	342	433	NA	NA	NA	NA	NA	46	70
Dolomitic Lime (75% Neutral)	98,197	13,469	NA	NA	NA	NA	NA	197	NA
Lime Suspensions	NA	NA	NA	NA	NA	NA	NA	NA	NA
Non-lime Filler (Water, Sand, Etc.)	NA	7	NA	NA	NA	NA	NA	NA	NA
Standard Calcite	18,641	3,647	NA	222,411	NA	NA	NA	3,917	NA
Standard Dolomite	33,848	2,370	NA	NA	NA	NA	NA	NA	NA
Other	19,835	28	NA	NA	NA	NA	NA	15,804	156
TOTAL	195,305	21,054	NA	222,411	NA	NA	NA	19,964	232
ALL FERTILIZERS									
TOTAL	1,730,243	393,012	1,741,097	1,816,998	28,386	605,744	43,284	745,966	129,208

[1] North Carolina has other use codes which were not included in this table.

NA = it is unclear from the database whether there was no non-farm use recorded or on-farm use was zero.

Table C-8. Fertilizer Consumption by Use, Mountain States, 1996 (tons)

Description	Arizona		Colorado		Idaho		Montana	New Mexico		Nevada		Utah		Wyoming	
	Farm	Nonfarm	Farm	Nonfarm	Farm	Nonfarm	Farm	Farm	Nonfarm	Farm	Nonfarm	Farm	Nonfarm	Farm	Nonfarm
MULTIPLE NUTRIENT FERTILIZERS															
N-P-K	NA	NA	21,532	1,687	NA	NA	4,383	6,270	381	1,848	3,831	1,013	12,552	3,565	2,911
N-P	58,528	969	74,704	NA	213,955	NA	166,831	36,393	200	4,887	2,025	14,196	2,356	52,801	437
N-K	1,810	43	891	NA	NA	NA	238	460	NA	12	158	13	139	729	3
P-K	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	17	NA	NA	NA	5
TOTAL	60,338	1,012	97,126	1,687	213,955	NA	171,452	43,123	581	6,747	6,031	15,221	15,047	57,096	3,356
NITROGEN FERTILIZERS															
Ammonium Nitrate	2,157	259	53,971	NA	126,896	NA	56,557	1,827	NA	1,141	558	35,825	608	28,342	12
Ammonium Nitrate Solution	NA	NA	NA	NA	NA	NA	NA	NA	NA	24	26	NA	NA	NA	NA
Ammonium Nitrate-limestone Mixtures	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Ammonium Nitrate-sulfate	NA	NA	NA	NA	6,508	NA	NA	48	NA	NA	NA	NA	NA	1,036	NA
Ammonium Polysulfide	7,155	NA	NA	NA	900	NA	NA	965	24	301	NA	792	NA	NA	NA
Ammonium Sulfate	5,780	3,215	3,830	NA	82,425	NA	18,146	7,050	4	3,448	226	10,386	1,146	3,096	92
Ammonium Sulfate Solution	NA	NA	NA	NA	NA	NA	NA	16	NA	NA	NA	NA	6	NA	NA
Ammonium Sulfate-nitrate	NA	NA	NA	NA	NA	NA	NA	1,707	NA	NA	NA	NA	NA	1	NA
Ammonium Sulfate-urea	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Ammonium Thiosulfate	NA	NA	7,853	NA	13,972	NA	1,660	2,346	1	326	NA	477	3	1,788	NA
Anhydrous Ammonia	17,944	933	50,381	NA	44,552	NA	75,716	13,603	147	559	NA	1,799	NA	84,839	NA
Aqua Ammonia	1,344	64	200	NA	6,672	NA	426	6	NA	NA	NA	NA	NA	158	NA

Table C-8. (Continued)

Description	Arizona		Colorado		Idaho		Montana	New Mexico		Nevada		Utah		Wyoming	
	Farm	Nonfarm	Farm	Nonfarm	Farm	Nonfarm	Farm	Farm	Nonfarm	Farm	Nonfarm	Farm	Nonfarm	Farm	Nonfarm
Calcium Ammonium Nitrate	NA	NA	176	NA	NA	NA	NA	377	NA	326	NA	NA	5	98	NA
Calcium Cyanamide	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Calcium Nitrate	1,175	134	626	NA	NA	NA	NA	1,136	NA	NA	18	NA	NA	545	NA
Calcium Nitrate-urea	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	87	NA
Ferrous Ammonium Sulfate	NA	NA	NA	NA	NA	NA	NA	43	NA	NA	NA	NA	NA	NA	NA
Magnesium Nitrate	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Nitric Acid	NA	NA	188	NA	NA	NA	NA	20	NA	NA	NA	NA	4	NA	NA
Nitrogen Solution 28%	NA	NA	6,053	NA	NA	NA	15,076	4,529	NA	NA	NA	32	NA	578	NA
Nitrogen Solution 30%	NA	NA	252	NA	NA	NA	NA	106	NA	NA	NA	NA	NA	65	NA
Nitrogen Solution 32%	137,907	1,054	63,869	NA	136,491	NA	7,895	30,953	97	4,022	83	10,665	1	50,020	77
Nitrogen Solution <28%	41,286	122	9,458	NA	2,002	NA	NA	401	NA	311	65	221	23	108	2
Nitrogen Solution >32%	NA	NA	NA	NA	NA	NA	NA	23	NA	NA	NA	NA	NA	NA	NA
Sodium Nitrate	NA	NA	NA	NA	NA	NA	NA	20	NA	7	NA	67	1	NA	NA
Sulfur Coated Urea	NA	NA	11	NA	NA	NA	NA	237	NA	NA	NA	46	132	NA	NA
Urea	27,030	413	27,931	NA	123,923	NA	168,648	13,029	77	387	132	4,085	878	10,772	283
Urea Solution	NA	NA	NA	NA	NA	NA	NA	NA	NA	63	NA	NA	NA	NA	NA
Urea-formaldehyde	NA	NA	2	NA	NA	NA	NA	NA	NA	10	1	18	57	NA	NA
Zinc Ammonium Sulfate Solution	NA	NA	4	NA	NA	NA	NA	NA	NA	NA	NA	4	NA	64	NA
Zinc Manganese Ammonium Sulfate	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Table C-8. (Continued)

Description	Arizona		Colorado		Idaho		Montana	New Mexico		Nevada		Utah		Wyoming	
	Farm	Nonfarm	Farm	Nonfarm	Farm	Nonfarm	Farm	Farm	Nonfarm	Farm	Nonfarm	Farm	Nonfarm	Farm	Nonfarm
Other	NA	NA	6,678	NA	NA	NA	NA	1,802	NA	3,057	4,578	294	832	376	NA
TOTAL	241,778	6,193	231,483	NA	544,340	NA	344,124	80,245	350	13,982	5,687	64,711	3,696	181,973	465
PHOSPHATE FERTILIZERS															
Ammonium Metaphosphate	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Ammonium Phosphate	35	2	NA	NA	201	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Ammonium Phosphate Nitrate	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Ammonium Phosphate Sulfate	8,999	499	78	NA	39,813	NA	17,674	542	NA	1,241	708	2,426	1	4,612	NA
Ammonium Polyphosphate	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Basic Lime Phosphate	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Basic Slag	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Bone Meal, Raw	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	1	NA	NA	NA	NA
Bone Meal, Steamed	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	17	NA	NA	NA	NA
Bone, Precipitated	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	284	NA
Calcium Metaphosphate	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Colloidal Phosphate (Soft Phosphate)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Diammonium Phosphate	1,735	2	3,998	NA	49,045	NA	47,927	3,120	NA	58	NA	1,363	NA	22,378	NA
Limestone, Phosphatic	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Liquid Ammonium Polyphosphate	18,959	195	11,328	NA	10,277	NA	3,211	17,212	NA	555	88	1,508	NA	1,572	NA
Magnesium Phosphate	NA	NA	NA	NA	NA	NA	NA	25	NA	NA	NA	NA	NA	NA	NA

Table C-8. (Continued)

Description	Arizona		Colorado		Idaho		Montana	New Mexico		Nevada		Utah		Wyoming	
	Farm	Nonfarm	Farm	Nonfarm	Farm	Nonfarm	Farm	Farm	Nonfarm	Farm	Nonfarm	Farm	Nonfarm	Farm	Nonfarm
Monoammonium Phosphate	28,801	272	59,301	NA	114,618	NA	98,019	11,328	198	2,939	157	8,657	1,862	24,131	431
Nitric Phosphate	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Phosphate Rock	NA	NA	232	NA	NA	NA	NA	NA	NA	NA	NA	721	464	NA	NA
Phosphoric Acid	3,737	NA	451	NA	5,626	NA	NA	NA	NA	24	NA	32	NA	64	NA
Precipitated Phosphate	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	1,187	NA
Superphosphate, Enriched	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	56	NA	NA	NA
Superphosphate, Normal	NA	NA	NA	NA	3,785	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Superphosphate, Triple	682	49	946	NA	3,759	NA	1,059	1,082	NA	350	65	10,522	2	1,385	30
Superphosphoric Acid	NA	NA	NA	NA	13,069	NA	NA	635	NA	NA	NA	NA	NA	4,619	NA
Other	NA	NA	2,013	NA	88	NA	NA	98	NA	70	100	41	173	NA	NA
TOTAL	62,947	1,018	78,345	NA	240,282	NA	167,891	34,043	198	5,238	1,135	25,326	2,502	60,231	461
POTASH FERTILIZERS															
Lime-potash Mixtures	NA	NA	NA	NA	237	NA	NA	307	NA	NA	NA	NA	NA	NA	NA
Manure Salts	NA	NA	NA	NA	NA	NA	NA	1,530	NA	NA	NA	NA	NA	NA	NA
Muriate of Potash 60% (Pot. Chloride)	3,157	619	3,418	NA	44,162	NA	31,808	14,671	NA	227	NA	3,568	1	2,736	87
Muriate of Potash 62%	NA	NA	5,221	NA	494	NA	NA	13	NA	NA	NA	211	NA	70	NA
Potash Suspensions	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Potassium Carbonate	NA	NA	NA	NA	NA	NA	NA	442	NA	NA	NA	NA	NA	NA	NA
Potassium Nitrate	1,810	43	871	NA	NA	NA	NA	NA	NA	3	12	NA	NA	NA	NA
Potassium Sulfate	351	57	685	NA	2,138	NA	NA	464	NA	35	14	874	45	44	NA

Table C-8. (Continued)

Description	Arizona		Colorado		Idaho		Montana	New Mexico		Nevada		Utah		Wyoming	
	Farm	Nonfarm	Farm	Nonfarm	Farm	Nonfarm	Farm	Farm	Nonfarm	Farm	Nonfarm	Farm	Nonfarm	Farm	Nonfarm
Potassium-magnesium Sulfate	94	1	322	NA	NA	NA	NA	5,241	NA	NA	NA	NA	NA	156	NA
Potassium-metaphosphate	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Potassium-sodium Nitrate	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	1	NA	NA
Other	NA	NA	1,396	NA	17,395	NA	NA	66	NA	270	19	205	7	1	NA
TOTAL	5,412	720	11,913	NA	64,426	NA	31,808	22,732	NA	535	46	4,859	54	3,008	87
ORGANIC FERTILIZERS															
Blood, Dried	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Castor Pomace	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Cocoa Shell Meal	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Compost	NA	NA	2,381	NA	NA	NA	4,284	NA	NA	NA	NA	NA	NA	2,128	NA
Cottonseed Meal	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Fish Scrap	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Guano	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Manure	NA	NA	5,712	1,687	NA	NA	99	NA	NA	NA	217	NA	673	265	NA
Peat	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	395	NA
Sewage Sludge, Activated	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	97	NA	NA
Sewage Sludge, Digested	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Sewage Sludge, Heat Dried	NA	NA	12,506	NA	NA	NA	NA	NA	NA	NA	4	NA	NA	NA	NA
Sewage Sludge, Other	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Soybean Meal	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Tankage, Animal	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	202	NA
Tankage, Process	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Table C-8. (Continued)

Description	Arizona		Colorado		Idaho		Montana	New Mexico		Nevada		Utah		Wyoming	
	Farm	Nonfarm	Farm	Nonfarm	Farm	Nonfarm	Farm	Farm	Nonfarm	Farm	Nonfarm	Farm	Nonfarm	Farm	Nonfarm
Other	NA	NA	1,046	NA	NA	NA	NA	NA	NA	2	5	2	NA	NA	NA
TOTAL	NA	NA	21,646	1,687	NA	NA	4,383	NA	NA	2	226	2	770	2,990	NA
SECONDARY AND MICRONUTRIENT FERTILIZERS															
Aluminum Sulfate	NA	NA	NA	NA	NA	NA	6	NA	NA	NA	NA	NA	NA	NA	NA
Borax	NA	NA	25	NA	NA	NA	NA	NA	NA	15	NA	21	NA	10	NA
Calcium Chelate	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	1	NA	NA	NA
Calcium Chloride	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Calcium Sulfate (Hydrous)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Cobalt Sulfate	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Copper Chelate	NA	NA	NA	NA	NA	NA	NA	NA	NA	1	NA	NA	NA	NA	NA
Copper Compound	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Copper Oxide, Black	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Copper Sulfate	NA	NA	18	NA	343	NA	NA	NA	NA	NA	NA	1	NA	5	NA
Epsom Salt (Magnesium Sulfate)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	82	NA
Ferric Oxide	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Ferric Sulfate	310	182	NA	NA	NA	NA	NA	NA	NA	22	NA	2	NA	NA	NA
Ferrous Sulfate	NA	NA	971	NA	NA	NA	NA	NA	NA	1	46	NA	3	396	4
Gypsum (Calcium Sulfate)	24,519	1,524	1,493	NA	3,703	NA	261	NA	NA	5,657	174	133	105	NA	NA
Iron Chelate	NA	NA	18	NA	310	NA	NA	NA	NA	1	NA	17	20	NA	NA
Iron Compound	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	5	20	2	NA	NA
Lime Sulfur Solution	716	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Magnesia (Magnesium Oxide)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Table C-8. (Continued)

Description	Arizona		Colorado		Idaho		Montana	New Mexico		Nevada		Utah		Wyoming	
	Farm	Nonfarm	Farm	Nonfarm	Farm	Nonfarm	Farm	Farm	Nonfarm	Farm	Nonfarm	Farm	Nonfarm	Farm	Nonfarm
Magnesium Chelate	NA	NA	NA	NA	415	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Manganese Agstone	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Manganese Chelate	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	1	NA	NA	NA
Manganese Oxide	NA	NA	4	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Manganese Slag	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Manganese Sulfate	NA	NA	19	NA	NA	NA	NA	NA	NA	2	NA	15	NA	37	NA
Manganous Oxide	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Potting Soil	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	44	NA	NA	NA
Sodium Molybdate	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Soil Additive	NA	NA	2	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Soil Amendment	NA	NA	339	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Soil Conditioner	NA	NA	10,398	419	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Sulfur	2,075	93	2,786	NA	17,672	NA	788	8	NA	656	196	406	288	1,287	NA
Sulfuric Acid	13,351	463	1,177	NA	NA	NA	NA	NA	NA	24	NA	NA	NA	NA	NA
Zinc Chelate	NA	NA	121	NA	4,859	NA	NA	NA	NA	2	NA	5	NA	1	NA
Zinc Oxide	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	132	NA	111	NA
Zinc Oxysulfate	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Zinc Sulfate	NA	NA	818	NA	31	NA	NA	NA	NA	25	1	96	NA	555	NA
Zinc Sulfate Solution	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	17	NA
Other	1,879	149	72	NA	4,799	NA	1,865	6,689	93	16	66	269	16	32	NA
TOTAL	42,851	2,411	18,263	419	32,134	NA	2,920	6,697	93	6,423	488	1,165	434	2,534	4
LIMING MATERIALS															
Calcitic Lime (75% Neutral)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Table C-8. (Continued)

Description	Arizona		Colorado		Idaho		Montana	New Mexico		Nevada		Utah		Wyoming	
	Farm	Nonfarm	Farm	Nonfarm	Farm	Nonfarm	Farm	Farm	Nonfarm	Farm	Nonfarm	Farm	Nonfarm	Farm	Nonfarm
Calcium Hydroxide (Hydrate)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Calcium Oxide (Burnt)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Dolomitic & Calcitic Blend (Pelletized)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Dolomitic Lime (75% Neutral)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	1	NA
Lime Suspensions	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Non-lime Filler (Water, Sand, Etc.)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Standard Calcite	NA	NA	516	NA	NA	NA	48	NA	NA	NA	NA	NA	NA	NA	NA
Standard Dolomite	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Other	NA	NA	NA	NA	37	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
TOTAL	NA	NA	516	NA	37	NA	48	NA	NA	NA	NA	NA	NA	1	NA
ALL FRTILIZERS															
TOTAL	352,987	10,342	362,185	2,106	881,219	NA	551,412	154,604	1,024	28,130	12,408	97,331	19,868	252,150	3,942

NA = it is unclear from the database whether there was no non-farm use recorded or on-farm use was zero.

Table C-9. Fertilizer Consumption by Use, Pacific States (and Puerto Rico), 1996 (tons)

Description	Alaska	California		Hawaii	Oregon		Washington		Puerto Rico	
	Farm	Farm	Nonfarm	Farm	Farm	Nonfarm	Farm	Nonfarm	Farm	Nonfarm
MULTIPLE NUTRIENT FERTILIZERS										
N-P-K	2,379	931,934	316,847	45,031	17,966	2,387	22,331	44,974	66,668	139
N-P	585	206,474	NA	6,297	101,918	5	136,658	7,544	30	NA
N-K	NA	24,219	NA	NA	5,395	158	4,551	1,085	1,572	NA
P-K	NA	60	NA	NA	315	NA	520	492	9	4
TOTAL	2,964	1,162,687	316,847	51,328	125,594	2,550	164,060	54,095	68,279	143
NITROGEN FERTILIZERS										
Ammonium Nitrate	15	92,968	NA	NA	32,335	NA	51,332	734	132	NA
Ammonium Nitrate Solution	NA	67,364	NA	NA	2,700	NA	NA	NA	NA	NA
Ammonium Nitrate-limestone Mixtures	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Ammonium Nitrate-sulfate	NA	NA	NA	NA	26	NA	1,171	1,293	NA	NA
Ammonium Polysulfide	NA	9,125	NA	NA	3,489	NA	12,433	NA	NA	NA
Ammonium Sulfate	123	205,878	NA	15,285	86,534	96	57,966	396	1,613	NA
Ammonium Sulfate Solution	NA	NA	NA	NA	314	NA	NA	4	NA	NA
Ammonium Sulfate-nitrate	NA	NA	NA	NA	847	NA	99	59	NA	NA

Table C-9. (Continued)

Description	Alaska	California		Hawaii	Oregon		Washington		Puerto Rico	
	Farm	Farm	Nonfarm	Farm	Farm	Nonfarm	Farm	Nonfarm	Farm	Nonfarm
Ammonium Sulfate-urea	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Ammonium Thiosulfate	NA	8,977	NA	NA	11,596	NA	39,528	NA	NA	NA
Anhydrous Ammonia	NA	154,673	NA	NA	32,545	NA	78,047	95	NA	NA
Aqua Ammonia	NA	204,931	NA	NA	9,179	NA	134,951	NA	NA	NA
Calcium Ammonium Nitrate	NA	173,949	NA	NA	649	NA	2,076	NA	NA	NA
Calcium Cyanamide	NA	NA	NA	NA	NA	NA	248	NA	NA	NA
Calcium Nitrate	NA	95,323	NA	NA	3,889	NA	13,474	2	NA	NA
Calcium Nitrate-urea	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Ferrous Ammonium Sulfate	NA	NA	NA	NA	NA	NA	500	1,305	NA	NA
Magnesium Nitrate	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Nitric Acid	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Nitrogen Solution 28%	NA	7,168	NA	NA	4,678	NA	5,873	723	NA	NA
Nitrogen Solution 30%	NA	NA	NA	NA	NA	NA	16	NA	NA	NA
Nitrogen Solution 32%	NA	586,101	NA	18,236	70,144	NA	137,638	37	NA	NA
Nitrogen Solution <28%	NA	975	NA	NA	403	NA	13,104	3,437	NA	NA

Table C-9. (Continued)

Description	Alaska	California		Hawaii	Oregon		Washington		Puerto Rico	
	Farm	Farm	Nonfarm	Farm	Farm	Nonfarm	Farm	Nonfarm	Farm	Nonfarm
Nitrogen Solution >32%	NA	NA	NA	NA	NA	NA	NA	967	NA	NA
Sodium Nitrate	NA	1,694	NA	NA	NA	NA	24	NA	NA	NA
Sulfur Coated Urea	NA	1,741	NA	NA	248	NA	NA	NA	8	NA
Urea	5,125	86,788	NA	2,480	111,569	NA	68,121	1	2,108	NA
Urea Solution	NA	8,437	NA	NA	NA	NA	NA	NA	NA	NA
Urea-formaldehyde	NA	NA	NA	NA	3,730	130	374	25	1	NA
Zinc Ammonium Sulfate Solution	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Zinc Manganese Ammonium Sulfate	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Other	NA	NA	NA	NA	9,362	122	22,181	1,777	NA	1
TOTAL	5,263	1,706,091	NA	36,000	384,237	348	639,157	10,854	3,863	1
PHOSPHATE FERTILIZERS										
Ammonium Metaphosphate	NA	NA	NA	NA	NA	NA	8,284	NA	NA	NA
Ammonium Phosphate	NA	NA	NA	3,215	116	NA	353	NA	NA	NA
Ammonium Phosphate Nitrate	NA	NA	NA	NA	1	NA	2,511	NA	NA	NA
Ammonium Phosphate Sulfate	NA	35,053	NA	NA	34,228	5	29,578	82	NA	NA
Ammonium Polyphosphate	NA	NA	NA	NA	NA	NA	3,706	NA	NA	NA

Table C-9. (Continued)

Description	Alaska	California		Hawaii	Oregon		Washington		Puerto Rico	
	Farm	Farm	Nonfarm	Farm	Farm	Nonfarm	Farm	Nonfarm	Farm	Nonfarm
Basic Lime Phosphate	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Basic Slag	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Bone Meal, Raw	NA	NA	NA	NA	NA	NA	82	NA	NA	NA
Bone Meal, Steamed	NA	NA	NA	NA	NA	NA	374	NA	NA	NA
Bone, Precipitated	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Calcium Metaphosphate	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Colloidal Phosphate (Soft Phosphate)	NA	NA	NA	NA	NA	NA	6	NA	NA	NA
Diammonium Phosphate	585	18,104	NA	NA	7,963	NA	10,413	1	30	NA
Limestone, Phosphatic	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Liquid Ammonium Polyphosphate	NA	74,203	NA	3,081	8,361	NA	39,510	NA	NA	NA
Magnesium Phosphate	NA	NA	NA	NA	NA	NA	NA	3	NA	NA
Monoammonium Phosphate	NA	78,651	NA	NA	44,192	NA	39,186	3,690	1	NA
Nitric Phosphate	NA	NA	NA	NA	NA	NA	2,394	NA	NA	NA
Phosphate Rock	NA	NA	NA	11	2,804	NA	65	NA	NA	NA
Phosphoric Acid	NA	10,668	NA	NA	1,440	NA	3,047	NA	NA	NA
Precipitated Phosphate	NA	NA	NA	NA	NA	NA	NA	NA	6	NA

Table C-9. (Continued)

Description	Alaska	California		Hawaii	Oregon		Washington		Puerto Rico	
	Farm	Farm	Nonfarm	Farm	Farm	Nonfarm	Farm	Nonfarm	Farm	Nonfarm
Superphosphate, Enriched	NA	NA	NA	NA	194	NA	7	356	NA	NA
Superphosphate, Normal	4	468	NA	155	NA	NA	5	NA	NA	NA
Superphosphate, Triple	4	4,363	NA	172	2,336	NA	5,250	NA	255	NA
Superphosphoric Acid	NA	1,533	NA	NA	10,582	NA	462	NA	NA	NA
Other	NA	31	NA	NA	59	NA	2,345	433	NA	NA
TOTAL	593	223,074	NA	6,635	112,274	5	147,578	4,565	291	NA
POTASH FERTILIZERS										
Lime-potash Mixtures	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Manure Salts	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Muriate of Potash 6NA% (Pot. Chloride)	30	52,170	NA	494	32,666	NA	64,228	22	68	NA
Muriate of Potash 62%	NA	NA	NA	NA	10,917	NA	73	NA	NA	NA
Potash Suspensions	NA	NA	NA	NA	2,647	NA	4,444	NA	NA	NA
Potassium Carbonate	NA	NA	NA	NA	21	NA	4	NA	NA	NA
Potassium Nitrate	NA	23,208	NA	NA	244	NA	76	NA	179	NA
Potassium Sulfate	2	41,748	NA	845	3,883	NA	8,913	1,012	326	NA
Potassium-magnesium Sulfate	NA	12,705	NA	NA	7,666	NA	9,766	164	NA	NA

Table C-9. (Continued)

Description	Alaska	California		Hawaii	Oregon		Washington		Puerto Rico	
	Farm	Farm	Nonfarm	Farm	Farm	Nonfarm	Farm	Nonfarm	Farm	Nonfarm
Potassium-metaphosphate	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Potassium-sodium Nitrate	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Other	NA	319	NA	16,328	533	NA	9,974	271	NA	NA
TOTAL	32	130,149	NA	17,667	58,576	NA	97,478	1,469	573	NA
ORGANIC FERTILIZERS										
Blood, Dried	NA	1,612	NA	NA	NA	NA	158	NA	NA	NA
Castor Pomace	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Cocoa Shell Meal	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Compost	NA	NA	NA	NA	NA	NA	948	NA	NA	NA
Cottonseed Meal	NA	NA	NA	NA	NA	NA	72	NA	NA	NA
Fish Scrap	NA	NA	NA	NA	NA	NA	377	NA	NA	NA
Guano	NA	NA	NA	NA	NA	NA	6	NA	NA	NA
Manure	NA	NA	NA	NA	NA	NA	17,470	NA	NA	NA
Peat	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Sewage Sludge, Activated	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Sewage Sludge, Digested	NA	NA	NA	NA	NA	NA	2	NA	NA	NA
Sewage Sludge, Heat Dried	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Sewage Sludge, Other	NA	77,169	NA	NA	NA	NA	NA	NA	NA	NA
Soybean Meal	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Table C-9. (Continued)

Description	Alaska	California		Hawaii	Oregon		Washington		Puerto Rico	
	Farm	Farm	Nonfarm	Farm	Farm	Nonfarm	Farm	Nonfarm	Farm	Nonfarm
Tankage, Animal	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Tankage, Process	NA	NA	NA	NA	NA	NA	371	NA	NA	NA
Other	NA	NA	NA	NA	NA	NA	11,544	NA	11	NA
TOTAL	NA	78,781	NA	NA	NA	NA	30,947	NA	11	NA
SECONDARY AND MICRONUTRIENT FERTILIZERS										
Aluminum Sulfate	NA	NA	NA	NA	2	NA	136	NA	NA	NA
Borax	NA	NA	NA	NA	788	NA	3,491	NA	NA	NA
Calcium Chelate	NA	NA	NA	3,751	NA	NA	NA	NA	NA	NA
Calcium Chloride	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Calcium Sulfate (Hydrous)	NA	NA	NA	NA	NA	NA	179	NA	NA	NA
Cobalt Sulfate	NA	NA	NA	NA	NA	NA	2	NA	NA	NA
Copper Chelate	NA	NA	NA	NA	NA	NA	25	NA	NA	NA
Copper Compound	NA	342	NA	NA	240	NA	NA	NA	NA	NA
Copper Oxide, Black	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Copper Sulfate	NA	NA	NA	NA	NA	NA	89	NA	NA	NA
Epsom Salt (Magnesium Sulfate)	NA	NA	NA	NA	14	NA	1,250	NA	219	NA
Ferric Oxide	NA	NA	NA	NA	NA	NA	1	NA	NA	NA
Ferric Sulfate	NA	NA	NA	NA	NA	NA	4,073	NA	NA	NA
Ferrous Sulfate	NA	NA	NA	NA	NA	NA	1,159	NA	NA	NA

Table C-9. (Continued)

Description	Alaska	California		Hawaii	Oregon		Washington		Puerto Rico	
	Farm	Farm	Nonfarm	Farm	Farm	Nonfarm	Farm	Nonfarm	Farm	Nonfarm
Gypsum (Calcium Sulfate)	NA	1,170,333	NA	NA	12,275	460	22,513	NA	NA	NA
Iron Chelate	NA	NA	NA	NA	7	NA	155	NA	NA	NA
Iron Compound	NA	4,736	NA	NA	2,277	7	NA	NA	NA	NA
Lime Sulfur Solution	NA	NA	NA	NA	NA	NA	3	NA	NA	NA
Magnesia (Magnesium Oxide)	NA	NA	NA	240	NA	NA	NA	NA	7	NA
Magnesium Chelate	NA	NA	NA	NA	NA	NA	35	NA	NA	NA
Manganese Agstone	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Manganese Chelate	NA	NA	NA	NA	NA	NA	105	NA	NA	NA
Manganese Oxide	NA	NA	NA	NA	59	NA	12	NA	NA	NA
Manganese Slag	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Manganese Sulfate	NA	NA	NA	NA	NA	NA	293	NA	NA	NA
Manganous Oxide	NA	NA	NA	2	NA	NA	NA	NA	NA	NA
Potting Soil	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Sodium Molybdate	NA	NA	NA	NA	NA	NA	23	NA	NA	NA
Soil Additive	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Soil Amendment	NA	NA	NA	NA	301	15	NA	NA	NA	NA
Soil Conditioner	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Sulfur	NA	57,043	NA	137	2,439	1	7,155	NA	NA	NA

Table C-9. (Continued)

Description	Alaska	California		Hawaii	Oregon		Washington		Puerto Rico	
	Farm	Farm	Nonfarm	Farm	Farm	Nonfarm	Farm	Nonfarm	Farm	Nonfarm
Sulfuric Acid	NA	117,877	NA	NA	223	NA	NA	NA	NA	NA
Zinc Chelate	NA	NA	NA	NA	NA	NA	790	NA	NA	NA
Zinc Oxide	NA	NA	NA	NA	1,066	NA	417	NA	NA	NA
Zinc Oxysulfate	NA	NA	NA	NA	NA	NA	35	NA	NA	NA
Zinc Sulfate	NA	NA	NA	15	NA	NA	3,499	NA	NA	NA
Zinc Sulfate Solution	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Other	NA	242,945	3,520	NA	473	24	8,886	76,536	81	NA
TOTAL	NA	1,593,276	3,520	4,144	20,163	507	54,325	76,536	307	NA
LIMING MATERIALS										
Calcitic Lime (75% Neutral)	NA	NA	NA	8,696	NA	NA	NA	NA	NA	NA
Calcium Hydroxide (Hydrate)	NA	NA	NA	NA	164	7	1,793	NA	NA	NA
Calcium Oxide (Burnt)	NA	NA	NA	96	NA	NA	NA	NA	NA	NA
Dolomitic & Calcitic Blend (Pelletized)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Dolomitic Lime (75% Neutral)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Lime Suspensions	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Non-lime Filler (Water, Sand, Etc.)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Standard Calcite	180	NA	NA	NA	147,021	898	12,832	NA	NA	NA

Table C-9. (Continued)

Description	Alaska	California		Hawaii	Oregon		Washington		Puerto Rico	
	Farm	Farm	Nonfarm	Farm	Farm	Nonfarm	Farm	Nonfarm	Farm	Nonfarm
Standard Dolomite	NA	NA	NA	NA	15,334	5,139	13,959	NA	NA	NA
Other	NA	621,915	NA	NA	23,615	547	54,705	NA	NA	NA
TOTAL	180	621,915	NA	8,792	186,134	6,590	83,289	NA	NA	NA
ALL FERTILIZERS										
TOTAL	8,447	5,209,585	320,367	118,269	791,874	9,995	1,061,442	143,746	73,115	144

NA = it is unclear from the database whether there was no non-farm use recorded or on-farm use was zero.

APPENDIX D
AAPFCO UNIFORM FERTILIZER BILL

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OFFICIALLY ADOPTED DOCUMENTS

Note - Although these documents have not been passed into law in all states, the subject matter covered herein does represent the official policy of this Association. NOTE: Tentative actions are in BOLD ITALICS, new wording is enclosed in brackets and underlined [__], and deleted material is denoted with strike throughs,------

UNIFORM STATE FERTILIZER BILL
(Official 1982)

AN ACT to regulate the sale[,] ~~and~~ [storage,] distribution[, use and application] of fertilizers in the State of _____. BE IT ENACTED by the legislature of the State of _____. (Tentative 1996)

Section 1. Title

This Act shall be known as the "_____ Fertilizer Law of 19__".

Section 2. Enforcing Official

This Act shall be administered by the _____ of the State of _____, hereinafter referred to as the "_____".

Section 3. Definitions of Words and Terms

When used in this Act:

(a) The term "fertilizer" means any substance containing one or more recognized plant nutrient(s) which is used for its plant nutrient content and which is designed for use or claimed to have value in promoting plant growth, except unmanipulated animal and vegetable manures, marl, lime, limestone, wood ashes and other products exempted by regulation by the _____.

(1) The term "Fertilizer material" means a fertilizer which either:

A. Contains important quantities of no more than one of the primary plant nutrients: nitrogen (N), phosphate (P_2O_5) and potash (K_2O), or (Official 1994)

B. Has 85 percent or more of its plant nutrient content present in the form of a single chemical compound, or

C. Is derived from a plant or animal residue or by-product or natural material deposit which has been processed in such a way that its content of plant nutrients has not been materially changed except by purification and concentration.

(2) The term "mixed fertilizer" means a fertilizer containing any combination or mixture of fertilizer materials.

(3) The term "specialty fertilizer" means a fertilizer distributed for non-farm use.

(4) The term "bulk fertilizer" means a fertilizer distributed in a non-packaged form.

(b) The term "brand" means a term, design, or trademark used in connection with one or several grades of fertilizer.

(c) Guaranteed Analysis:

Until the _____ prescribes the alternative form of "Guaranteed Analysis" in accordance with the provisions of subparagraph (2) hereof, the term "Guaranteed Analysis" shall mean the minimum percentage of plant nutrients claimed in the following order and form:

(1) Total Nitrogen (N) _____ %
Available Phosphate (P_2O_5) _____ %
Soluble Potash (K_2O) _____ %
(Official 1994)

(2) For unacidulated mineral phosphatic material and basic slag, bone, tankage and other organic phosphatic materials, the Total Phosphate and/or degree of fineness may also be guaranteed. (Official 1994)

(3) Guarantees for plant nutrients other than nitrogen, phosphorus and potassium may be permitted or required by regulation by the _____. The guarantees for such other nutrients shall be expressed in the form of the element. The source (oxides, salts, chelates, etc.) of such other nutrients may be required to be stated on the application for registration and may be included on the label. Other beneficial substances or compounds, determinable by laboratory methods, also may be guaranteed by permission of the _____ and with the advice of the Director of the Agricultural Experiment Station. When any plant nutrients or other substances or compounds are guaranteed, they shall be subject to inspection and analysis in accord with the methods and regulations prescribed by the _____. (Official 1994)

Secretary's Note: *Section 3.(c)(2) (Off. Pub. No. 47) deleted. (Official 1994.)*

(d) The term "grade" means the percentage of total nitrogen, available phosphate, and soluble potash stated in whole numbers in the same terms, order, and percentages as in the guaranteed analysis. Provided, however, That specialty fertilizers may be guaranteed in fractional units of less than one percent of total nitrogen, available phosphate, and soluble potash: Provided, further, That fertilizer materials, bone meal, manures, and similar materials may be guaranteed in fractional units. (Official 1994)

(e) The term "official sample" means any sample of fertilizer taken by the _____ or his agent and designated as "official" by the _____.

(f) The term "ton" means a net weight of two thousand pounds avoirdupois.

(g) The term "primary nutrient" means total nitrogen, available phosphate, and soluble potash. (Official 1994)

(h) The term "percent" or "percentage" means the percentage by weight.

(i) The term "person" means individual, partnership, association, firm and corporation.

(j) The term "distribute" means to import, consign, manufacture, produce, compound, mix, or blend fertilizer, or to offer for sale, sell, barter or otherwise supply fertilizer in this state.

(k) The term "distributor" means any person who distributes.

(l) The term "registrant" means the person who registers fertilizer under the provisions of this Act.

(m) The term "licensee" means the person who receives a license to distribute a fertilizer under the provisions of this Act.

(n) The term "label" means the display of all written, printed, or graphic matter, upon the immediate container, or a statement accompanying a fertilizer.

(o) The term "labeling" means all written, printed, or graphic matter, upon or accompanying any fertilizer, or advertisements, brochures, posters, television and radio announcements used in promoting the sale of such fertilizer.

(p) The term "investigational allowance" means an allowance for variations inherent in the taking, preparation and analysis of an official sample of fertilizer.

(q) The term "deficiency" means the amount of nutrient found by analysis less than that guaranteed which may result from a lack of nutrient ingredients or from lack of uniformity. (Official 1985)

Section 4. Option A - Registration

(a) Each brand and grade of fertilizer shall be registered in the name of that person whose name appears upon the label before being distributed in this state. The application for registration shall be submitted to the _____ on a form furnished by the _____ and shall be accompanied by a fee of $_____ per each grade of each brand except those fertilizers sold in packages of 10 pounds or less shall be registered at a fee of $_____ per each grade of each brand. Upon approval by the _____ a copy of the registration shall be furnished to the applicant. All registrations expire on _____ each year. The application shall include the following information:

(1) The brand and grade;

(2) The guaranteed analysis;

(3) The name and address of the registrant;

(4) Net weight. (Official 1988)

(b) A distributor shall not be required to register any fertilizer which is already registered under this Act by another person, providing the label does not differ in any respect.

(c) A distributor shall not be required to register each grade of fertilizer formulated according to specifications which are furnished by a consumer prior to mixing, but shall be required to register his firm in a manner and at a fee as prescribed in regulations by the _____ and to label such fertilizer as provided in Section 5(b).

Section 4. Option B - Registration and Licensing

(a) No person whose name appears upon the label of a fertilizer shall distribute that fertilizer, except specialty fertilizers, to a non-licensee until a license to distribute has been obtained by that person from the _____ upon payment of a $_____ fee. All licenses expire on the _____ day of _____ each year.

(b) An application for license shall include:

(1) The name and address of licensee.

(2) The name and address of each distribution point in the state. The name and address shown on the license shall be shown on all labels, pertinent invoices, and storage facilities for fertilizer distributed by the licensee in this state.

(c) The licensee shall inform the _____ in writing of additional distribution points established during the period of the license.

(d) No person shall distribute in this state a specialty fertilizer until it is registered with the _____ by the distributor whose name appears on the label. An application for each brand and product name of each grade of specialty fertilizer shall be made on a form furnished by the _____ and shall be accompanied by a fee of $_____ per each grade of each brand, except those fertilizers sold in packages of 10 pounds or less shall be registered at a fee of $_____ per each grade of each brand. Labels for each brand and product name of each grade shall accompany the application. Upon the approval of an application by the _____, a copy of the registration shall be furnished the applicant. All registrations expire on the _____ day of _____ each year.

(e) An application for registration shall include the following:

(1) The brand and grade;

(2) The guaranteed analysis;

(3) Name and address of the registrant;

(4) Net weight. (Official 1988)

Section 4. Option C - Licensing

(a) No person whose name appears upon the label of a fertilizer shall distribute that fertilizer to a non-licensee until a license to distribute has been obtained by that person from the _____ upon payment of a $_____ fee. All licenses expire on the _____ day of each year.

(b) An application for license shall include:

(1) The name and address of licensee.

(2) The name and address of each distribution point in the state.

The name and address shown on the license shall be shown on all labels, pertinent invoices, and storage facilities for fertilizers distributed by the licensee in this state.

(c) The licensee shall inform the _____ in writing of additional distribution points established during the period of the license.

Section 5. Labels

(a) Any fertilizer distributed in this state in containers shall have placed on or affixed to the container a label setting forth in clearly legible and conspicuous form the following information:

(1) Net weight;

(2) Brand and grade: Provided, That the grade shall not be required when no primary nutrients are claimed;

(3) Guaranteed analysis;

(4) Name and address of the registrant/licensee.

In case of bulk shipments, this information in written or printed form shall accompany delivery and be supplied to the purchaser at time of delivery.

(b) A fertilizer formulated according to specifications which are furnished by/for a consumer prior to mixing shall be labeled to show the net weight, the guaranteed analysis, and the name and address of the distributor or registrant/licensee.

Section 6. Inspection Fees

(a) There shall be paid to the _____ for all fertilizers distributed in this state to non-registrants/non-licensees an inspection fee at the rate of _____ cents per ton; Provided, That sales or exchanges between importers, manufacturers, distributors or registrants/licensees are hereby exempted.

(b) Every registrant/licensee who distributes fertilizer in the state shall file with the _____ a (monthly, quarterly, or semi-annual) statement for the reporting period setting forth the number of net tons of each fertilizer so distributed in this state during such period. The report shall be due on or before thirty days following the close of the filing period and upon such statement shall pay the inspection fee at the rate stated in paragraph (a) of this section. If the tonnage report is not filed and the payment of inspection fees is not made within 30 days after the end of the specified filing period, a collection fee, amounting to 10 percent (minimum $10) of the amount due, shall be assessed against the registrant/licensee and added to the amount due.

(c) When more than one person is involved in the distribution of a fertilizer, the last person who has the fertilizer registered (is licensed) and who distributed to a non-registrant/licensee dealer, or consumer is responsible for reporting the tonnage and paying the inspection fee, unless the report and payment is made by a prior distributor of the fertilizer.

(d) On individual packages of fertilizer containing 10 pounds or less there shall be paid, in lieu of the inspection fee of _____ cents per ton and in lieu of $_____ per brand and grade, an annual registration and inspection fee of $_____ for each grade of each brand sold or distributed. Where a person distributes fertilizer in packages of 10 pounds or less and in packages over 10 pounds, the annual fee shall apply only to that portion distributed in packages of 10 pounds or less.

(e) Fees so collected shall be used for the payment of the costs of inspection, sampling and analysis, and other expenses necessary for the administration of this Act.

Section 7. Tonnage Reports

(a) The person distributing or selling fertilizer to a non- registrant/non-licensee shall furnish the _____ a report showing the county of the consignee, the amounts (tons) of each grade of fertilizer, and the form in which the fertilizer was distributed (bags, bulk, liquid, etc.). This information shall be reported by one of the following methods:

(1) Submitting a summary report approved by the _____ on or before the _____ day of each month covering shipments made during the preceding month; or

(2) Submitting a copy of the invoice within _____ business days after shipment.

(b) No information furnished the _____ under this section shall be disclosed in such a way as to divulge the operation of any person.

Section 8. Inspection, Sampling, Analysis

(a) It shall be the duty of the _____, who may act through his authorized agent, to sample, inspect, make analyses of, and test fertilizers distributed within this state and inspect the storage of bulk fertilizer at any time and place and to such an extent he may deem necessary to determine whether such fertilizers are in compliance with the provisions of this Act. The _____, individually or through his agent, is authorized to enter upon any public or private premises or carriers during regular business hours in order to have access to fertilizer subject to provisions of this Act and the regulations pertaining thereto, and to the records relating to their distribution and storage. (Official 1990)

(b) The methods of sampling and analysis shall be those adopted by the AOAC International. In cases not covered by such methods, or in cases where methods are available in which improved applicability has been demonstrated, the _____ may adopt such appropriate methods from other sources.

(c) The _____, in determining for administrative purposes whether any fertilizer is deficient in plant food, shall be guided solely by the Official sample as defined in paragraph (e) of Section 3, and obtained and analyzed as provided for in paragraph (b) of this section.

(d) The results of official analysis of fertilizers and portions of official samples shall be distributed by the _____ as provided by regulation. Official samples establishing a penalty for nutrient deficiency shall be retained for a minimum of 90 days from issuance of a deficiency report.

Section 9. Plant Food Deficiency

(a) Penalty for nitrogen, available phosphate, and soluble potash -- If the analysis shall show that a fertilizer is deficient (1) in one or more of its

guaranteed primary plant nutrients beyond the investigational allowances and compensations as established by regulation, or (2) if the overall index value of the fertilizer is below the level established by regulation, a penalty payment of _____ times the value of such deficiency or deficiencies shall be assessed. When a fertilizer is subject to a penalty payment under both (1) and (2), the larger penalty payment shall apply. (Official 1994)

(b) Penalty payment for other deficiencies -- Deficiencies beyond the investigational allowances as established by regulation in any other constituent(s) covered under Section 3 paragraph (c)(1) B and C of this Act, which the registrant/licensee is required to or may guarantee, shall be evaluated and penalty payments prescribed by the _____.

(c) All penalty payments assessed under this section shall be paid by the registrant/licensee to the consumer of the lot of fertilizer represented by the sample analyzed within three months after the date of notice from the _____ to the registrant/licensee, receipts taken therefore and promptly forwarded to the _____. If said consumer cannot be found, the amount of the penalty payments shall be paid to the _____ who shall deposit the same in the appropriate state fund allocated to fertilizer control service. If upon satisfactory evidence a person is shown to have altered the content of a fertilizer shipped to him by a registrant/licensee, or to have mixed or commingled fertilizer from two or more suppliers such that the result of either alteration changes the analysis of the fertilizer as originally guaranteed, then that person shall become responsible for obtaining a registration/license and shall be held liable for all penalty payments and be subject to other provisions of this Act, including seizure, condemnation and stop sale.

(d) A deficiency in an official sample of mixed fertilizer resulting from non-uniformity is not distinguishable from a deficiency due to actual plant nutrient shortage and is properly subject to official action. (Official 1985)

(e) Nothing contained in this section shall prevent any person from appealing to a court of competent jurisdiction praying for judgment as to the justification of such penalty payments.

Section 10. Commercial Value

For the purpose of determining the commercial value to be applied under the provisions of Section 9 the _____ shall determine and publish annually the values per unit of nitrogen, available phosphate, and soluble potash in fertilizers in this state. The value so determined and published shall be used in determining and assessing penalty payments. (Official 1994)

Section 11. Misbranding

No person shall distribute misbranded fertilizer. A fertilizer shall be deemed to be misbranded:

(a) If its labeling is false or misleading in any particular.

(b) If it is distributed under the name of another fertilizer product.

(c) If it is not labeled as required in Section 5 of this Act and in accordance with regulations prescribed under this Act.

(d) If it purports to be or is represented as a fertilizer, or is represented as containing a plant nutrient or fertilizer unless such plant nutrient or fertilizer conforms to the definition of identity, if any, prescribed by regulation of the _____; in adopting such regulations the _____ shall give due regard to commonly accepted definitions and official fertilizer terms such as those issued by the Association of American Plant Food Control Officials.

Section 12. Adulteration

No person shall distribute an adulterated fertilizer product. A fertilizer shall be deemed to be adulterated:

(a) If it contains any deleterious or harmful ~~ingredient~~[substance] in sufficient amount to render it injurious to beneficial plant [life, animals, humans, aquatic] life[, soil or water] when applied in accordance with directions for use on the label, or if adequate warning statements or directions for use which may be necessary to protect plant [life, animals, humans, aquatic] life[, soil or water] are not shown upon the label.

(b) If its composition falls below or differs from that which it is purported to possess by its labeling.

(c) If it contains unwanted crop seed or weed seed.

(Tentative 1996)

Section 13. Publications

The _____ shall publish at least annually and in such forms as he may deem proper: (a) Information concerning the distribution of fertilizers, (b) Results of analyses based on official samples of fertilizer distributed within the state as compared with analyses guaranteed under Section 4 and Section 5.

[Section 14. Storage, Use and Application

Bulk fertilizers must be stored in a manner that minimizes the release of fertilizers and protects the environment. Fertilizer use and application may be set forth in regulations to protect the environment.] (Tentative 1996)

Section [15~~14~~.] Rules and Regulations

The _____ is authorized to prescribe and, after a public hearing following due public notice, to enforce such rules and regulations relating to investigational allowances, definitions, records, ~~and the~~ distribution[,] storage[, use and application] of fertilizers as may be necessary to carry into effect the full intent and meaning of this Act[, including protection of the environment] . (Tentative 1996)

Section [16~~15~~.] Short Weight(Tentative 1996)

If any fertilizer in the possession of the consumer is found by the _____ to be short in weight, the registrant/licensee of said fertilizer shall within thirty days after official notice from the _____ submit to the consumer a penalty payment of _____ times the value of the actual shortage.

Section [17~~16~~.] Cancellation of Registration/License (Tentative 1996)

The _____ is authorized and empowered to cancel the registration (license of any person) of any brand of fertilizer or to refuse to register any brand of fertilizer (issue a license) as herein provided, upon satisfactory evidence that the registrant/licensee has used fraudulent or deceptive practices in the evasion or attempted evasion of the provisions of this Act or any regulations promulgated thereunder: Provided, That no license or registration shall be revoked or refused until the person (registrant/licensee) shall have been given the opportunity to appear for a hearing by the _____.

Section [18~~17~~.] "Stop Sale" Orders (Tentative 1996)

The _____ may issue and enforce a written or printed "stop sale, use, or removal" order to the owner or custodian of any lot of fertilizer and to hold at a designated place when the _____ finds said fertilizer is being offered or exposed for sale in violation of any of the provisions of this Act until the law has been complied with and said fertilizer is released in writing by the _____, or said violation has been otherwise legally disposed of by written authority. The _____ shall release the fertilizer so withdrawn when the requirements of the provisions of this Act have been complied with and all costs and expenses incurred in connection with the withdrawal have been paid.

Section [19~~18~~.] Seizure, Condemnation and Sale (Tentative 1996)

Any lot of fertilizer not in compliance with the provisions of this Act shall be subject to seizure on complaint of the _____ to a court of competent jurisdiction in the area in which said fertilizer is located. In the event the court finds the said fertilizer to be in violation of this Act and orders the condemnation of said fertilizer it shall be disposed of in any manner consistent with the quality of the fertilizer and the laws of the state: Provided, That in no instance shall the disposition of said fertilizer be ordered by the court without first giving the claimant an opportunity to apply to the court for release of said fertilizer or for permission to process or relabel said fertilizer to bring it into compliance with this Act.

Section [20~~19~~.] Violations (Tentative 1996)

(a) If it shall appear from the examination of any fertilizer that any of the provisions of this Act or the rules or regulations issued thereunder have been violated, the _____ shall cause notice of the violations to be given to the registrant/licensee or distributor from whom said sample was taken; any person so notified shall be given opportunity to be heard under such regulations as may be prescribed by the _____. If it appears after such

hearing, either in the presence or absence of the person so notified, that any of the provisions of this Act or rules and regulations issued thereunder have been violated, the _____ may certify the facts to the proper prosecuting attorney. (Official 1989)

(b) Any person convicted of violating any provision of this Act or the rules and regulations issued thereunder shall be punished in the discretion of the court.

(c) Nothing in this Act shall be construed as requiring the _____ or his representative to report for prosecution or for the institution of seizure proceedings as a result of minor violations of the Act when he believes that the public interests will be best served by a suitable notice of warning in writing.

(d) It shall be the duty of each _____ attorney to whom any violation is reported to cause appropriate proceedings to be instituted and prosecuted in a court of competent jurisdiction without delay.

(e) The _____ is hereby authorized to apply for and the court to grant a temporary or permanent injunction restraining any person from violating or continuing to violate any of the provisions of this Act or any rule or regulation promulgated under this Act notwithstanding the existence of other remedies at law. Said injunction to be issued without bond.

Section [21~~20~~.] Cooperation with Other Entities (Tentative 1996)

The _____ may cooperate with and enter into agreement with governmental agencies of this State, other States, and agencies of the Federal Government in order to carry out the purpose and provisions of this Act. (Official 1991)

Section [22~~21~~.] Exchanges Between Manufacturers (Tentative 1996)

Nothing in this Act shall be construed to restrict or avoid sales or exchanges of fertilizers to each other by importers, manufacturers, or manipulators who mix fertilizer materials for sale, or as preventing the free and unrestricted shipments of fertilizer to manufacturers or manipulators who have registered their brands (are licensed) as required by provisions of this Act.

Section [23~~22~~.] Constitutionality (Tentative 1996)

If any clause, sentence, paragraph or part of this Act shall for any reason be judged invalid by any court of competent jurisdiction, such judgment shall not affect, impair, or invalidate the remainder thereof but shall be confined in its operation to the clause, sentence, paragraph, or part thereof directly involved in the controversy in which such judgment shall have been rendered.

Section [24~~23~~.] Repeal (Tentative 1996)

All laws and parts of laws in conflict with or inconsistent with the provisions of this Act are hereby repealed.

Section [25~~24~~.] ***Effective Date (Tentative 1996)***

This Act shall take effect and be in force from and after the first day of _____.

FERTILIZER
RULES AND REGULATIONS

Under the Uniform State Fertilizer Bill by the _____ of the State of _____ Pursuant to due publication and notice of opportunity for a public hearing, the _____ has adopted the following regulations.

1. Plant Nutrients in Addition to Nitrogen, Phosphate and Potash.

Other plant nutrients when mentioned in any form or manner shall be registered and shall be guaranteed. Guarantees shall be made on the elemental basis. Sources of the elements guaranteed and proof of availability shall be provided the _____ upon request. Except guarantees for those water soluble nutrients labeled for ready to use foliar fertilizers, ready to use specialty liquid fertilizers, hydroponic or continuous liquid feed programs and guarantees for potting soils, the minimum percentages which will be accepted for registration are as follows: (Official 1996)

Element	%
Calcium (Ca)	1.0000
Magnesium (Mg)	0.5000
Sulfur (S)	1.0000
Boron (B)	0.0200
Chlorine (Cl)	0.1000
Cobalt (Co)	0.0005
Copper (Cu)	0.0500
Iron (Fe)	0.1000
Manganese (Mn)	0.0500
Molybdenum (Mo)	0.0005
Sodium (Na)	0.1000
Zinc (Zn)	0.0500

Guarantees or claims for the above listed plant nutrients are the only ones which will be accepted. Proposed labels and directions for the use of the fertilizer shall be furnished with the application for registration upon request. Any of the above listed elements which are guaranteed shall appear in the order listed immediately following guarantees for the primary nutrients of nitrogen, phosphate and potash. (Official 1994)

Secretary's Note - Paragraphs 3 and 4 (Off. Publication No. 38) were deleted - Official 1985.

A warning or caution statement may be required for any product which contains (name of micro-nutrient) in water soluble form when there is evidence that (name of micro-nutrient) in excess of _____% may be harmful to certain crops or where there are unusual environmental conditions. (Official 1984)

Examples of Warning or Caution Statements:

1. Directions: Apply this fertilizer at a maximum rate of (number of pounds) per acre for (name of crop).

   CAUTION: Do not use on other crops. The (name of micro-nutrient) may cause injury to them.

2. CAUTION: Apply this fertilizer at a maximum rate of (number of pounds) per acre for (name of crop). Do not use on other crops; the (name of micro-nutrient) may cause serious injury to them.

3. WARNING: This fertilizer carries added (name of micro-nutrient) and is intended for use only on (name of crop). Its use on any other crops or under conditions other than those recommended may result in serious injury to the crops.

4. CAUTION: This fertilizer is to be used only on soil which responds to (name of micro-nutrient). Crops high in (name of micro-nutrient) are toxic to grazing animals (ruminants). (Official 1991)

Secretary's Note - Example Warning and Caution statements for boron and molybdenum (page 36 Off. Pub. No. 43) were deleted and above generic statements substituted. (Official 1991)

2. Fertilizer Labels.

   The following information, in the format presented, is the minimum required for all fertilizer labels. For packaged products, this information shall either (1) appear on the front or back of the package, (2) occupy at least the upper-third of a side of the package, or (3) be printed on a tag and attached to the package. This information shall be in a readable and conspicuous form. For bulk products, this same information in written or printed form shall accompany delivery and be supplied to the purchaser at time of delivery.

   (a) Net weight

   (b) Brand

   (c) Grade (Provided that the grade shall not be required when no primary nutrients are claimed.)

(d) Guaranteed Analysis*

Total Nitrogen (N)** ..... _____%
_____% Ammoniacal Nitrogen
_____% Nitrate Nitrogen
_____% Water Insoluble Nitrogen
_____% Urea Nitrogen
_____% (Other recognized and determinable forms of N)
Available Phosphate(P_2O_5)..... _____%
Soluble Potash (K_2O)..... _____%
(Other nutrients, elemental basis)*** ..... _____%
(Official 1993)

(e) Sources of nutrients, when shown on the label, shall be listed below the completed guaranteed analysis statement.

(f) Name and address of registrant or licensee.

* Zero (0) guarantees should not be made and shall not appear in statement except in nutrient guarantee breakdowns. (Official 1993)

** *If chemical forms of N are claimed or required, the form shall be shown ~~and the percentages of the individual forms shall add up to the Total Nitrogen percentage~~. No implied order of the forms of nitrogen is intended. (Tentativel 1996)*

*** As prescribed by regulation No. 1.
(Official 1986)

3. Slowly Released Plant Nutrients.

(a) No fertilizer label shall bear a statement that connotes or implies that certain plant nutrients contained in a fertilizer are released slowly over a period of time, unless the slow release components are identified and guaranteed at a level of at least 15% of the total guarantee for that nutrient(s). (Official 1991)

(b) Types of products with slow release properties recognized are (1) water insoluble, such as natural organics, ureaform materials, urea-formaldehyde products, isobutylidene diurea, oxamide, etc., (2) coated slow release, such as sulfur coated urea and other encapsulated soluble fertilizers, (3) occluded slow release, where fertilizers or fertilizer materials are mixed with waxes, resins, or other inert materials and formed into particles and (4) products containing water soluble nitrogen such as ureaform materials, urea-formaldehyde products, methylenediurea (MDU), dimethylenetriurea (DMTU), dicyanodiamide (DCD), etc. The terms, "water insoluble", "coated slow release", "slow release", "controlled release", "slowly available water soluble", and "occluded slow release" are accepted as descriptive of these products, provided the manufacturer can show a testing program substantiating the claim (testing under guidance of Experiment Station personnel or a recognized reputable researcher acceptable to the _____). A laboratory procedure, acceptable to the _____ for evaluating the

release characteristics of the product(s) must also be provided by the manufacturer. (Official 1991)

Secretary's Note: Rule 3(c) was deleted and Rule 3(d) renamed as they appeared on page 40 and 41 of Off. Pub. No. 47. (Official 1994)

(c) Until more appropriate methods are developed, AOAC International Method 970.04 (15th Edition) is to be used to confirm the coated slow release and occluded slow release nutrients and others whose slow release characteristics depend on particle size. AOAC International Method 945.01 (15th Edition) shall be used to determine the water insoluble nitrogen of organic materials. (Official 1994)

4. Definitions.

Except as the _____ designates otherwise in specific cases, the names and definitions for commercial fertilizers shall be those adopted by the Association of American Plant Food Control Officials.

5. Percentages.

The term of "percentage" by symbol or word, when used on a fertilizer label shall represent only the amount of individual plant nutrients in relation to the total product by weight.

6. Investigational Allowances.

(a) A commercial fertilizer shall be deemed deficient if the analysis of any nutrient is below the guarantee by an amount exceeding the values in the following schedule, or if the overall index value of the fertilizer is below 98%. *Note: For these investigational allowances to be applicable, the recommended AOAC International procedures for obtaining samples, preparation and analysis must be used. These are described in Official Methods of Analysis of the Association of Official Analytical Chemists, 13th Edition, 1980, and in succeeding issues of the Journal of the Association of Official Analytical Chemists. In evaluating replicate data, Table 19, page 935, Journal of the Association of Official Analytical Chemists, Volume 49, No. 5, October, 1966, should be followed.*

Guaranteed percent	Nitrogen percent	Available Phosphate percent	Potash percent
04 or less	0.49	0.67	0.41
05	0.51	0.67	0.43
06	0.52	0.67	0.47
07	0.54	0.68	0.53
08	0.55	0.68	0.60
09	0.57	0.68	0.65
10	0.58	0.69	0.70
12	0.61	0.69	0.79
14	0.63	0.70	0.87

16	0.67	0.70	0.94
18	0.70	0.71	1.01
20	0.73	0.72	1.08
22	0.75	0.72	1.15
24	0.78	0.73	1.21
26	0.81	0.73	1.27
28	0.83	0.74	1.33
30	0.86	0.75	1.39
32 or more	0.88	0.76	1.44

(Official 1993)

For guarantees not listed, calculate the appropriate value by interpolation.

The overall index value is calculated by comparing the commercial value guaranteed with the commercial value found. Unit values of the nutrients used shall be those referred to in Section 10 of the Act.

Overall index value - Example of calculation for a 10-10-10 grade found to contain 10.1% Total Nitrogen (N), 10.2% Available Phosphate (P_2O_5) and 10.1% Soluble Potash (K_2O). Nutrient unit values are assumed to be $3 per unit N, $2 per unit P_2O_5, and $1 per unit K_2O. (Official 1993)

10.0 units N	x3 =	30.0
10.0 units P_2O_5	x2 =	20.0
10.0 units K_2O	x1 =	10.0
Commercial Value Guaranteed	=	60.0
10.1 units N	x3 =	30.3
10.2 units P_2O_5	x2 =	20.4
10.1 units K_2O	x1 =	10.1
Commercial Value Found	=	60.8

Overall Index Value = 100(60.8/60.00) = 101.3%

(b) Secondary and minor elements shall be deemed deficient if any element is below the guarantee by an amount exceeding the values in the following schedule:

Element		Investigational Allowance
Calcium	)	0.2 unit + 5% of guarantee
Magnesium	)	0.2 unit + 5% of guarantee
Sulfur	)	0.2 unit + 5% of guarantee
Boron	)	0.003 unit + 15% of guarantee
Cobalt	)	0.0001 unit + 30% of guarantee
Chlorine	)	0.005 unit + 10% of guarantee
Copper	)	0.005 unit + 10% of guarantee

Iron	)	0.005 unit + 10% of guarantee
Manganese	)	0.005 unit + 10% of guarantee
Molybdenum	)	0.0001 unit + 30% of guarantee
Sodium	)	0.005 unit + 10% of guarantee
Zinc	)	0.005 unit + 10% of guarantee

The maximum allowance when calculated in accordance to the above shall be 1 unit (1%).

7. Sampling.

Sampling equipment and procedures shall be those adopted by the AOAC International wherever applicable.

8. Breakdown of Plant Food Elements Within the Guaranteed Analysis.

When a plant nutrient guarantee is broken down into the component forms, the percentage for each component shall be shown before the name of the form.

EXAMPLES:

Total Nitrogen (N)..... _____%
_____% Ammoniacal Nitrogen
_____% Nitrate Nitrogen
Magnesium (Mg)..... _____%
_____% Water Soluble Magnesium (Mg)
Sulfur (S) ..... _____%
_____% Free Sulfur (S)
_____% Combined Sulfur (S)
Iron (Fe)..... _____%
_____% Chelated Iron (Fe)
Manganese (Mn)..... _____%
_____% Water Soluble Manganese (Mn)

(Official 1992)

9. Organic Nitrogen

If an amount of nitrogen is designated as organic then the water insoluble nitrogen or the slow release nitrogen guarantee must not be less than 60% of the nitrogen so designated. Coated urea shall not be included in meeting the 60% requirement. (Official 1994)

UNIFORM FERTILIZER REGISTRATION APPLICATION

APPLICATION FOR REGISTRATION OF COMMERCIAL FERTILIZERS IN _____

Mail to: _____ (name and address of enforcement agency)

Application is hereby made for the registration of _____ brands and grades of commercial fertilizer at $_____ per brand and grade for the period ending _____, 19 ___.
Make check payable to _____

REGISTERED BY _____

STREET _____ CITY _____ STATE _____ ZIP CODE _____

NET WEIGHT OF PACKAGES: _____

DATE _____, 19 ___ SIGNED BY _____ TITLE _____

CERTIFICATE OF REGISTRATION

This certifies that the following brands and grades of commercial fertilizer have been approved for sale in _____ beginning with the date of registration and ending _____, 19 ___.

DATE _____, 19 ___ AMOUNT _____ BY _____

BRAND NAME AND GRADE OF FERTILIZER OR FERTILIZER MATERIAL	Nitrogen	Avail. Phos.	Potash	Ca	Mg	S	B	Cl	Co	Cu	Fe	Mn	Mo	Na	Zn	Registration Number

Note: See other side for minimum guarantees for secondary and micro-nutrients.

REVERSE SIDE

SECONDARY AND MICRO-NUTRIENTS: When claims for such nutrients are made, the minimum percentages which will be accepted for registration are as follows:

Calcium (Ca)	1.00	Copper (Cu)	0.05
Magnesium (Mg)	0.50	Iron (Fe)	0.10
Sulfur (S)	1.00	Manganese (Mn)	0.05
Boron (B)	0.02	Molybdenum (Mo)	0.0005
Chlorine (Cl)	0.10	Sodium (Na)	0.10
Cobalt (Co)	0.0005	Zinc (Zn)	0.05

UNIFORM COMMERCIAL FERTILIZER LICENSE APPLICATION

APPLICATION FOR COMMERCIAL FERTILIZER LICENSE

STATE OF _____ DATE: _____ 19 __

Control Agency

Address

FOR CONTROL OFFICIAL'S USE

Application is hereby made and fee of $ _____ enclosed for a license to manufacture and/or distribute commercial fertilizer at the following location for the period _____, 19 ___ through _____, 19 ___.

Applicant's Business Name	*Plant Name, If Different*
P.O. Box *Number & Street*	*P.O. Box* *Number & Street*
City *State* *Zip Code*	*City* *State* *Zip Code*

Person in Charge and Title *Area Code* *Telephone Number*

Type of Operation: Manufacturer; Distributor; Other _____
Describe Kind

Materials Produced: ☐ Dry Blends; ☐ Ammoniation; ☐ Liquid Hot Mix;
☐ Liquid Cold Mix; ☐ Anhydrous Ammonia; ☐ Solutions;
☐ Suspensions; ☐ Secdy. or Micronutrients; ☐ Other _____
Desc.

_____
Signature

Submit in duplicate. Make check payable to: (Name of agency authorized to receive funds)

COMMERCIAL FERTILIZER LICENSE

This license entitles the above named applicant to manufacture and/or distribute commercial fertilizer at the above location in the State of _____ for the period _____, 19 ___ through _____, 19 ___. Such license shall remain in effect unless suspended or revoked by the _____ for cause.

LICENSE NUMBER: _____ DATE _____, 19 ___.

_____
Signature Control Official

_____
Title

APPENDIX E

INTERNATIONAL AND NATIONAL LIMITS FOR POLLUTANTS IN BIOSOLIDS

Appendix E. International and National Limits for Pollutants in Biosolids

These tables were abstracted from *A Global Atlas of Wastewater Sludge and Biosolids Use and Disposal*, Peter Matthews (ed.), International Association on Water Quality, Scientific and Technical Report No. 4, London England, 1996.

Table E-1. International Contaminant Concentration Limits for Biosolid Application to Land

Australia (New South Wales)				
	Contaminant Acceptance Thresholds		Max. Allowable	
	Thresholds (mg/kg)		Soil Conc (mg/kg dw)	
Contaminant	Grade A*	Grade C*	Ag land*	Non-ag land*
Arsenic	20	20	20	20
Cadmium	3	20	1	5
Chromium	100	500	100	250
Copper	150	420	100	375
Lead	1	15	15	150
Mercury	60	270	1	4
Nickel	60	270	60	125
Selenium	5	50	5	8
Zinc	200	2500	200	700
DDT/DDD/DDE	0.50	1.00	0.50	0.50
Aldrin	0.02	0.50	0.02	0.02
Dieldrin	0.02	0.50	0.02	0.02
Chlordane	0.02	0.50	0.02	0.02
Heptachlor	0.02	0.50	0.02	0.02
HCB	0.02	0.50	0.02	0.02
Lindane	0.02	0.50	0.02	0.02
BHC	0.02	0.50	0.02	0.02
PCBs	0.30	1.00	0.30	0.30

* Grade A has unrestricted use, Grade C is the lowest grade that can be used in agriculture

Table E-1. (Continued)

Austria (Lower A., 1994)		
Inorganic	Max. Allowable Contaminants in Sludge (mg/kg dw)	
	Class II - Lower A*	Tyrol*
Arsenic		20
Cadmium	2	10
Chromium	50	500
Copper	200	500
Cobalt	10	2000
Lead	100	500
Mercury	2	10
Molybdenum	--	100
Nickel	25	100
Zinc	1000	2000
Organic		
PCB	0.2	0.2
PCDD/F	0.0001	0.0001
AOX	500	500
* Most conservative class and States were chosen for this example. Tyrol was chosen because it is the only state with limits for arsenic		
Belgium		
Contaminant	Limits for Sludge Deposits on Soils (mg/kg DM)**	Max levels for Sludge Deposits on Soils (mg/kg DM)
Cadmium	1	12
Chromium	100	500
Copper	50	750
Lead	50	600
Mercury	1	10
Nickel	30	100
Zinc	150	2500
** Depends on soil type, most conservative (sandy) chosen for this table		

Table E-1. (Continued)

China (Tianjin)			
Inorganic	**Max permissible (mg/kg)***	**Typical Sludge (mg/kg)****	**Typical Soil (mg/kg)**
Aluminum		432	na
Arsenic	75	18.75	15.16
Boron	150	na	
Cadmium	5	5.1	0.17
Chromium(III)	600	528	73.12
Copper	250	514	27.5
Lead	300		16.7
Mercury	5	8.6	0.047
Nickel	100		27.62
Zinc	500	1294	61.8
Organic			
Mineral Oil	3000		
* more conservative value used for soil with pH<6.5 for all elements except Nickel ** max value of range shown			
Taiwan			
Contaminant	**Guidelines for Contaminated Soils (mg/kg)*** **	**Mean Background in Rural Soil (mg/kg)**	
Arsenic	14	4.54	
Cadmium	2.5	1.74	
Chromium	101	43.2	
Copper	89	20.3	
Lead	58	32.6	
Mercury	0.55	0.13	
Nickel	63	43.2	
Zinc	163	180	
*** Proposed monitoring values			

Table E-1. (Continued)

Denmark			
Contaminant	Limit Values (mg/kg DS)	Average Sludge Used in Agriculture (mg/kg)	
Cadmium	0.8	1.5	
Calcium		40	
Chromium	100	30	
Copper	1000	280	
Lead	120	73	
Mercury	0.8	1.3	
Nickel	30	23	
Zinc	4000	810	
Nitrogen		40	
Phosphorus		25	
European Union			
Contaminant	Permitted Loads 86/275/EC (mg/kg)*	Soil Boundary Values 86/278/EC (mg/kg)	Sludge Boundary Values (mg/kg) 86/278/EC
Cadmium	0.15	1-3	20-40
Chromium	4	100-150	1000-1500
Copper	12	50-140	1000-1750
Lead	15	50-300	750-1200
Mercury	0.1	1-1.5	16-25
Nickel	3	30-75	300-400
Zinc	30	150-300	2500-4000
* mean value over a period of 10 years			

Table E-1. (Continued)

France			
Contaminant	Limits for Sludge Use (mg/kg dw)	Average Sludge (mg/kg dw)*	Average Soil (mg/kg dw)*
Cadmium	2	4.5	0.3-0.5
Chromium	150	116	<30
Copper	100	409	<30
Lead	100	28.8	<30
Mercury	1	1.05	<1
Nickel	50	74.7	<50
Selenium	10	5.2	<0.3
Zinc	300	1479	<80
* City of Besancon			
Italy			
Contaminant	Limit Values for Sludge Used in Agriculture (mg/kg DM)		
Cadmium	20		
Copper	1000		
Lead	750		
Mercury	10		
Nickel	300		
Zinc	2500		
Salmonella	<1000	(MPN/g SS)	

Table E-1. (Continued)

Japan	
Contaminant	Industrial Wastes* Max allowable in extracted solution (mg/liter)
1,1,1-Trichloroethane	3
1,1,2-Trichloroethane	0.06
1,2-Dichloroethane	0.04
1,2-Dichloroethylene	0.4
1,2-Dichloropropene	0.02
Alkyl Mercury Cpds	ND
Arsenic and Cpds	0.3
Benzene	0.1
Cadmium and Cpds	0.3
Carbon Tetrachloride	0.02
Chrome (VI)	1.5
Cyanide cpds	1
Dichloromethane	0.2
Lead and Cpds	0.3
Mercury and Cpds	0.005
Organic Phosphorus	1
PCB	0.003
Selenium and Cpds	0.3
Simazine	0.03
Tetrachloroethylene	0.1
Thiobendcarb	0.2
Thiuram	0.06
Triichloroethylene	0.3

* Note that these values apply to industrial wastes

Table E-1. (Continued)

Netherlands		
Contaminant	Limits for Sewage Sludge on Land (mg/kg DM)	
Arsenic	15	
Cadmium	1.25	
Chromium	75	
Copper	75	
Lead	100	
Mercury	0.75	
Nickel	30	
Zinc	300	
Norway		
Contaminant	Max content on soil when sludge is used in agriculture (mg/kg DS)	Max content in soil before sludge is used in agriculture (mg/kg DS)
Cadmium	4	1
Chromium	125	100
Copper	1000	50
Lead	100	50
Mercury	5	1
Nickel	80	30
Zinc	1500	150

Table E-1. (Continued)

Slovakia		
Contaminant	Max Permissible Conc in Raw Material (mg/kg)	Max Permissible Conc in Compost (mg/kg)*
Arsenic	50	10
Cadmium	13	2
Chromium	1000	100
Copper	1200	100
Lead	500	100
Mercury	10	1
Molybdenum	25	5
Nickel	200	50
Zinc	3000	300
* Compost class I		

South Africa		
Contaminant	Max Permissible in Soil (mg/kg)	Sludge Limts for Agricultural Use (mg/kg)
Arsenic	2	15
Boron	10	80
Cadmium	2	
Chromium	80	1750
Cobalt	20	100
Copper	100	
Fluoride	50	400
Lead	56	400
Mercury	0.5	
Molybdenum	2.3	25
Nickel	15	
Selenium	2	15
Zinc	185	

Table E-1. (Continued)

Sweden		
Contaminant	Max Permissible Concentrations in Sewage Sludge on Ag Land (mg/kg)*	No Use of Sludge on Ag Land if Soil Exceeds Value (mg/kg DS)
Cadmium	2	0.4
Chromium	100	30
Copper	600	40
Lead	100	40
Mercury	2.5	0.3
Nickel	50	30
Zinc	800	75
* Limits as of January 1, 1998		
Switzerland		
Contaminant	Limits for Sludge Used in Agriculture (mg/kg DS)	
Cadmium	5	
Chromium	500	
Cobalt	60	
Copper	600	
Lead	500	
Mercury	5	
Molybdenum	20	
Nickel	80	
Zinc	2000	
AOX	500	

Table E-1. (Continued)

United Kingdom			
	Max Permissible Concentration		
Contaminant	In Soil After Application of Sludge (mg/kg DS)*	Typical Value for Sludge (mg/kg)	Typical Value for Soil (mg/kg)
Arsenic	50	3	10
Cadmium	3		
Chromium	400	50	15
Copper	80		
Fluorine	500	100	60
Lead	300		
Mercury	1		
Molybdenum	4	1	15
Nickel	50		
Selenium	3	0.3	0.2
Zinc	200		
* Values for soil 5.0<pH<5.5			

Table E-2. State Contaminant Concentration Limits for Biosolid Application to Land

Maximum Allowable Concentrations, Micronutrient Concentrations for Land Application (mg/kg dw)							
Contaminant	**NH**	**VT**	**MA**	**NY**	**RI**	**ME**	**CN**
Arsenic	75	75	75	75	75	75	5
Cadmium	85	25	25	25	25	10	34
Chromium	3000	1000	1000	1000	3000	1000	1200
Copper	4300	1000	1000	1000	4300	1000	1500
Lead	840	1000	1000	1000	840	700	300
Mercury	57	10	10	10	57	10	17
Molybdenum	75	75	10	75	75	75	15
Nickel	420	200	200	200	420	200	420
Selenium	100	100	100	100	100	100	36
Zinc	7500	2500	2500	2500	7500	2000	2800
Chromium (VI)							150
Barium							4700
Micronutrient Concentrations for Product Distribution and Marketing, Max Allowable (mg/kg dw)							
Contaminant	**NH**	**VT**	**MA**	**NY**	**RI**	**ME**	**CN**
Arsenic	41	41	41	41	41	41	5
Cadmium	39	25	14	10	39	10	34
Chromium	1200	1000	1000	100	1200	1000	1200
Copper	1500	1000	1000	1000	1500	1000	1500
Lead	300	1000	300	250	300	700	300
Mercury	17	10	10	10	17	10	17
Molybdenum	18	18	10	18	75	18	18
Nickel	420	200	200	200	420	200	420
Selenium	36	36	36	36	36	36	36
Zinc	2800	2500	2500	2500	2800	2000	2800
Chromium (VI)							150
Barium							4700

Table E-2. (Continued)

Pennsylvania			
Contaminant	Biosolids Analysis Philadelphia (mg/kg)	Max Allowable For Land Application (mg/kg)	National Biosolids Survey (mg/kg)
Arsenic	15	50	9.93
Cadmium	6	56	6.95
Chromium	178	2000	119
Copper	668	2866	741
Lead	191	560	134
Mercury	3	38	5.2
Molybdenum	12	75	9.2
Nickel	52	420	42
Selenium	6	66	5
Zinc	1372	5000	1201

APPENDIX F
NPK, MICRONUTRIENT, LIME AND GYPSUM FERTILIZER APPLICATION RATES FROM USDA/NASS DATABASES U.S. AGRICULTURAL EXTENSION SERVICE INTERVIEWS AND INTERNET PUBLICATIONS

Table F-1. Average and Maximum N, P, and K Application Rates for High Acreage Crops[a]

Field Crops		Average and Maximum N, P (P_2O_5), and K (K_2O) Application Rates for High-Acreage Crops, lb/A		
		N average; (max)	P_2O_5 average; (max)	K_2O average; (max)
Corn		133 (170)	57 (87)	79 (116)
Cotton		100 (175)	48 (83)	73 (106)
Potatoes		195 (285)	173 (198)	139 (204)
Soybeans		24 (40)	49 (56)	85 (102)
Tobacco		88 (108)	93 (116)	203 (284)
Wheat	winter (60%)[b]	61 (115)	30 (53)	29 (40)
	durum (6%)	60 (NA)[c]	23 (NA)	21 (NA)
	spring (34%)	67 (91)	31 (37)	21 (28)
Wheat, aggregate[d]		63 (NC)[e]	30 (NC)	26 (NC)
Vegetables				
Broccoli		206 (247)	109 (159)	62 (131)
Carrots		182 (234)	166 (200)	110 (340)
Head lettuce		262 (357)	190 (252)	77 (124)
Onion		186 (269)	137 (217)	139 (266)
Green peas		30 (42)	55 (108)	73 (110)
Snap beans	fresh (29%)	85 (101)	88 (104)	115 (132)
	processed (71%)	64 (154)	64 (128)	68 (101)
Snap beans, aggregate		70 (NC)	71 (NC)	82 (NC)
Corn	fresh (25%)	125 (274)	81 (129)	137 (216)
	processed (75%)	135 (227)	63 (134)	85 (98)
Corn, aggregate		133 (NC)	68 (NC)	98 (NC)
Tomatoes	fresh (24%)	264 (311)	174 (201)	408 (534)
	processed (76%)	163 (164)	103 (110)	49 (289)
Tomatoes, aggregate		187 (NC)	120 (NC)	135 (NC)
Fruit				
Watermelon		120 (414)	94 (163)	119 (182)
Oranges		164 (179)	43 (46)	177 (182)
Grapefruit		128 (132)	56 (81)	146 (147)

Table F-1. (Continued)

	Average and Maximum N, P (P_2O_5), and K (K_2O) Application Rates for High-Acreage Crops, lb/A		
Field Crops	**N** average; (max)	**P_2O_5** average; (max)	**K_2O** average; (max)
Apples	62 (75)	34 (60)	54 (75)
Grapes	67 (117)	55 (89)	107 (151)
Peaches	84 (109)	38 (50)	76 (124)

a) Source: USDA/NASS databases; USDA/NASS/ERS, 1997 for field crops; USDA/NASS/ERS, 1997 for vegetables; USDA/NASS/ERS, 1996 for fruits
b) Percent of total acreage planted in that variant of crop
c) NA = data not available from USDA/NASS
d) Acreage-weighted application rate for total crop
e) NC = not calculated as such a value is not needed

Table F-2. Fertilizer Application Rates

Micronutrient	Application Rate per Crop Year	State	Crop	Application Method	Comment	Citation
Zinc	5 lbs/A	GA	Onions	nl[a]		Internet[b]
	5 lbs/A	GA	Peppers	nl		Internet
	5 lbs/A	GA	Eggplant	nl		Internet
	5-10 lbs/A	MN	Fruit/Vegetables	Broadcast		Internet[c]
	1-2 lbs/A	MN	Fruit/Vegetables (corn, edible beans)	Row Applied Starter		Internet
	1-2 lbs/A	NE	Dry Beans	Row		Internet[d]
	5-10 lbs/A	NE	Dry Beans	Broadcast		Internet
	5-10 lbs/A	NE	Soybeans	nl		Internet
	3-5 lbs/A	AL	Sorghum	nl		Internet[e]
	3-4 lbs/A	OR	Pole Beans	Banded		OSU Extension Bulletin/Herschell Pendell
	10 lbs/A	OR	Pole Beans	Broadcast		OSU Extension Bulletin/Herschell Pendell
	15 lbs/A	OR	Apples, prunes, cherries, pears	Foliar Spray		OSU Extension Bulletin/Herschell Pendell
	3-4 lbs/A	OR	Onions, potatoes	Banded		OSU Extension Bulletin/Herschell Pendell
	10 lbs/A	OR	Onions, potatoes	Broadcast		OSU Extension Bulletin/Herschell Pendell
	5-10 lbs/A	WA	nl	nl	"normal" rate	WSU-Bob Stevens
	20 lbs/A	WA	nl	nl	"if really deficient"	WSU-Bob Stevens
	10-20 lbs/A	WA, OR	Dryland potatoes	nl	Central OR and WA	WSU-Bob Stevens
	10 lbs/A	CA	nl	nl	Peat, muck, high organic, but not continuously	Bill Liebhardt-UC Davis

Table F-2. (Continued)

Micronutrient	Application Rate per Crop Year	State	Crop	Application Method	Comment	Citation
	1-5 lbs/A	CA	nl	nl	Over the long range	Bill Liebhardt-UC Davis
	2-10 lbs/A		nl	nl		CoZinCo
	3.6-13 lbs/ A	Ontario, Canada	nl	nl	4-14 kg/ha	Internet[f]
	20 lbs/A	CA	Almonds, grapes, trees, cherries	Foliar	If deficient	CALTECH- Bob Dixon
	18 lbs/A	WA	nl	nl		WA-Dept. of Ecology
	1.9 lbs/A	WA	nl	nl	Sample H4756[g]	WA-Dept. of Ecology
	0.5-2 lbs/A	WA	nl	nl	Sample H4772	WA-Dept. of Ecology
Sulfur	40-60 lbs/A	GA	Onions (seed bed)	nl		Internet[b]
	35-55 lbs/A	GA	Onions (mature crop)	nl		Internet
	≥10 lbs/A	GA	Peppers	nl		Internet
	≥10 lbs/A	GA	Eggplant	nl		Internet
	10-15 lbs/A	MN	nl	Row/side Application		Internet[c]
	20-30 lbs/A	MN	nl	Broadcast		Internet

Table F-2. (Continued)

Micronutrient	Application Rate per Crop Year	State	Crop	Application Method	Comment	Citation
	25 lbs/A	MN	Alfalfa, barley, corn, oats, wheat, rye	nl		Internet[c]
	5-10 lbs/A	NE	Corn	Row Application		Internet[d]
	10-20 lbs/A	NE	nl	Broadcast		Internet
	30-40 lbs/A	NE	Irrigated alfalfa	nl		Internet
	10-20 lbs/A	AL	Oats	nl		Internet[e]
	10 lbs/A	AL	Cotton; most crops	nl		Internet
	40 lbs/A	WA	Alfalfa, potatoes, corn	nl		WSU-Bob Stevens
	10-25 lbs/A	CA	nl	nl	Sandy soils	CALTECH-Bob Dixon
	20-40 lbs/A	WA	nl	nl	Sample H4766 Gypsum	CALTECH-Bob Dixon
	5.6-9.8 lbs/A	WA	nl	nl	Sample H2532	CALTECH-Bob Dixon
	5-39 lbs/A	WA	nl	nl	Sample H2547 thiosol	CALTECH-Bob Dixon
	8-40 lbs/A	WA	nl	nl	Sample H1231 nitrosol	CALTECH-Bob Dixon
	170-800 lbs/A	MN	nl	nl	Sandy soil pH 7-4.5	Internet[c]
	500-2500 lbs/A	MN	nl	nl	Loam soil pH 7-4.5	Internet
	1000 lbs/A	WA	nl	nl	Once	WSU-Bob Stevens

Table F-2. (Continued)

Micronutrient	Application Rate per Crop Year	State	Crop	Application Method	Comment	Citation
	1500 lbs/A	WA	nl	nl	Over several years	WSU-Bob Stevens
	4 tons gypsum/A (1-2 ton sulfur/application)		nl	nl		WSU-Bob Stevens
	200/300-1000/2000 lbs/A		nl	nl	CA-sandy soils	CALTECH-Bob Dixon
Boron	1 lb/A	MO	Cotton	Side-dress		Internet[h]
	2 lb/A	MO	nl	nl	After liming	Internet
	1 lb/A	MO	Alfalfa	nl		Internet
	1 lb/A	GA	Onions	nl		Internet[b]
	1 lb/A	GA	Peppers	nl		Internet
	1 lb/A	GA	Eggplant	nl		Internet
	1-4 lbs/A	MN	Fruits/ Vegetables	nl		Internet[c]
	1-1.5 lbs/A	MN	Corn	nl		Internet
	0.1-0.3 lbs/A	MN	Alfalfa	Foliar Spray		Internet
	1 lb/A	NE	Soybeans	nl		Internet[d]
	0.3 lbs/A	AL	Cotton	Foliar Spray		Internet[e]
	2-3 lbs/A	WA	nl	nl		WSU-Bob Stevens
	<1 lbs/A	CA	Almonds, grapes	Foliar spray		CALTECH-Bob Dixon

Table F-2. (Continued)

Micronutrient	Application Rate per Crop Year	State	Crop	Application Method	Comment	Citation
	2-4 lbs/A	CA	nl	applied to soil		CALTECH-Bob Dixon
	3 lbs/A	WA	nl	nl	Sample H0753	WSU-Dept. of Ecology
Gypsum	100-1500 lbs/A		nl	nl	pH - over a few years	WSU-Bob Stevens
	8000 lbs/A		nl	nl	Soil amendment-2000-4000 lbs/A at a time	WSU-Bob Stevens
	2000 lb/A minimum	CA	nl	nl	Soil structure	CALTECH-Bob Dixon
	4000-8000 lbs/A average	CA	nl	nl		CALTECH-Bob Dixon
Manganese (Mn)	4-15 lbs/A	MN	Vegetables	nl		Internet[c]
	8 lbs/A	MN	Onions	nl		Internet
	0.2-15 lbs/A	MN	General	nl		Internet
	8.9-17.7 lbs/A	WA	nl	nl	Sample H4753	WSU-Bob Stevens
	0.3-1 lbs/A	WA	nl	nl	Sample H4772	WSU-Bob Stevens
	1.1 lbs/A	WA	nl	nl	Sample H4756	WSU-Bob Stevens
	25 lbs/A	GA	Onions	nl		Internet[b]
	25 lbs/A	GA	Peppers	nl		Internet
	25 lbs/A	GA	Eggplant	nl		Internet

Table F-2. (Continued)

Micronutrient	Application Rate per Crop Year	State	Crop	Application Method	Comment	Citation
	10-20 lbs/A	MN	Fruit/Vegetables (corn)	Row-application		Internet [c]
	50-100 lbs/A	MN	Fruit/Vegetables (corn)	Broadcast		Internet
	6.3-63 lbs/A	WA	nl	nl	Sample H2530	WSU-Bob Stevens
	50-180 lbs/A	WA	nl	nl	Sample H4768	WSU-Bob Stevens
	226-453 lbs/A	WA	nl	nl	Sample H2550	WSU-Bob Stevens
Iron	0.1-0.15 lbs/A	MN	Fruit/Vegetables	Foliar Spray		Internet[c]
	10-30 lbs/A	NE	Corn	nl		Internet[d]
Lime $CaCO_3$	2500 lbs/A	MO	nl	nl	Lime stabilized biosolids 900 lbs/A Ca	Internet[h]
	2000 lbs/A	MO	nl	nl	Limestone	Internet
	2000 lbs/A	GA	Peppers	nl	Lime	Internet[b]
	4000-15000 lbs/A	MN	nl	nl	Lime	Internet[c]
	2000 lbs/A	AL	nl	nl	Ornamentals	Internet[e]
	4000-6000 lbs/A	OR	nl	nl		OSU-Hershel Pendell
	500-1000 lbs/A		nl	nl	$CaCO_3$ equiv. Low	WSU-Bob Stevens
	2000-4000 lbs/A		nl	nl	$CaCO_3$ equiv. High	WSU-Bob Stevens

Table F-2. (Continued)

Micronutrient	Application Rate per Crop Year	State	Crop	Application Method	Comment	Citation
	8000 lbs/A gypsum		nl	nl	1-2 ton/ applicaton	WSU-Bob Stevens
	2000-16000 lbs/A	CA	nl	nl	Min.-Max.	CALTECH-Bob Dixon
	6000-8000 lbs/A	CA	nl	nl	Average	CALTECH-Bob Dixon
	2000 lbs/A gypsum		nl	nl	Minimum	CALTECH-Bob Dixon
	4000-8000 lbs/A gypsum		nl	nl	Typical	CALTECH-Bob Dixon
	1000 lbs/A	MN	Potatoes			Internet[c]
	660-1320 lbs/A		nl	nl	Sample H2529 dical lime	WSU-Dept. Of Ecology
	3400-6800 lbs/A		nl	nl	Once every 3 years; sample H4763 Kiln dust lime	WSU-Dept. Of Ecology
	1133-2267 lbs/A		nl	nl	per crop year	WSU-Dept. Of Ecology
	2736-5776 lbs/A		nl	nl	Once every 3 years; sample H4775; wood ash	WSU-Dept. Of Ecology

Table F-2. (Continued)

Micronutrient	Application Rate per Crop Year	State	Crop	Application Method	Comment	Citation
	912-1925 lbs/A		nl	nl	Per crop year	WSU-Dept. of Ecology
	1920-3840 lbs/A		nl	nl	Sample H4759; ground limestone	WSU-Dept. of Ecology

a) nl=not listed
b) University of Georgia College of Agriculture & Environmental Sciences/Cooperative Extension
www.ces.uga.edu/pubcd/b1027-w.html#Lime and Fertilizer
c) University of Minnesota Extension Service
www.mes.umn.edu/Documents/D/C/DC6572.html
d) University of Nebraska-Lincoln/Institute of Agriculture and Natrural Resources/Cooperative Extension
www.ianr.un/.edu/PUBS/fieldcrops/g174.htm
e) Alabama A&M and Auburn Universities/Alabama Cooperative Extension System
www.acenet.auburn.edu/department/grain/ANR469.htm
f) University of Guelph Soil Testing Laboratory
ozone.crle.uoguelph.ca/manure
g) University of Washington Department of Ecology; Data from Sample H4756
h) University of Missouri-Columbia; Department of Agronomy
muextension.missouri.edu/xplor/agguides

APPENDIX G
YEARLY ADDITIONS OF METALS TO SOILS FROM FERTILIZERS, MICRONUTRIENTS AND SOIL AMENDMENTS

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Table G7a. Yearly Cd and Pb Additions to Soil (kg/ha) from Boron Fertilizers
Table G7b. Yearly As and Cr Additions to Soil (kg/ha) from Boron Fertilizers
Table G7c. Yearly Hg and Ni Additions to Soil (kg/ha) from Boron Fertilizers
Table G7d. Yearly V and Cu Additions to Soil (kg/ha) from Boron Fertilizers

Table G7e. Yearly Zn Additions to Soil (kg/ha) from Boron Fertilizers

Table G8a. Yearly Cd and Pb Additions to Soil (kg/ha) from Iron Fertilizers
Table G8b. Yearly As and Cr Additions to Soil (kg/ha) from Iron Fertilizers
Table G8c. Yearly Hg and Ni Additions to Soil (kg/ha) from Iron Fertilizers
Table G8d. Yearly V and Cu Additions to Soil (kg/ha) from Iron Fertilizers
Table G8e. Yearly Zn Additions to Soil (kg/ha) from Iron Fertilizers

Table G9a. Yearly Cd and Pb Additions to Soil (kg/ha) from S (as nutrient) Fertilizers
Table G9b. Yearly As and Cr Additions to Soil (kg/ha) from S (as nutrient) Fertilizers
Table G9c. Yearly Hg and Ni Additions to Soil (kg/ha) from S (as nutrient) Fertilizers
Table G9d. Yearly V and Cu Additions to Soil (kg/ha) from S (as nutrient) Fertilizers
Table G9e. Yearly Zn Additions to Soil (kg/ha) from S (as nutrient) Fertilizers

Table G10a. Yearly Cd and Pb Additions to Soil (kg/ha) from S (as pH adjustment)
Table G10b. Yearly As and Cr Additions to Soil (kg/ha) from S (as pH adjustment)
Table G10c. Yearly Hg and Ni Additions to Soil (kg/ha) from S (as pH adjustment)
Table G10d. Yearly V and Cu Additions to Soil (kg/ha) from S (as pH adjustment)
Table G10e. Yearly Zn Additions to Soil (kg/ha) from S (as pH adjustment)

Table G11a. Yearly Cd and Pb Additions to Soil (kg/ha) from Liming Materials
Table G11b. Yearly As and Cr Additions to Soil (kg/ha) from Liming Materials
Table G11c. Yearly Hg and Ni Additions to Soil (kg/ha) from Liming Materials
Table G11d. Yearly V and Cu Additions to Soil (kg/ha) from Liming Materials
Table G11e. Yearly Zn Additions to Soil (kg/ha) from Liming Materials

Table G12a. Yearly Cd and Pb Additions to Soil (kg/ha) from Gypsum Products
Table G12b. Yearly As and Cr Additions to Soil (kg/ha) from Gypsum Products
Table G12c. Yearly Hg and Ni Additions to Soil (kg/ha) from Gypsum Products
Table G12d. Yearly V and Cu Additions to Soil (kg/ha) from Gypsum Products
Table G12e. Yearly Zn Additions to Soil (kg/ha) from Gypsum Products

Table G13a. Yearly Cd and Pb Additions to Soil (kg/ha) from Micronutrient Mixes
Table G13b. Yearly As and Cr Additions to Soil (kg/ha) from Micronutrient Mixes
Table G13c. Yearly Hg and Ni Additions to Soil (kg/ha) from Micronutrient Mixes
Table G13d. Yearly V and Cu Additions to Soil (kg/ha) from Micronutrient Mixes
Table G13e. Yearly Zn Additions to Soil (kg/ha) from Micronutrient Mixes

Table G-1a. Yearly Cd and Pb Additions to Soil (kg/ha) from P_2O_5 Fertilizers

Source[a]	ID[b]	Percent P_2O_5	Cd mg/kg	Pb mg/kg	Yearly Cd addition in kg/ha at 84 lb P_2O_5/A 94 kg/ha	173 lb P_2O_5/A 194 kg/ha	252 lb P_2O_5/A 282 kg/ha	Yearly Pb addition in kg/ha at 84 lb P_2O_5/A 94 kg/ha	173 lb P_2O_5/A 194 kg/ha	252 lb P_2O_5/A 282 kg/ha
CDFA	24837	53	1	2	0.000	0.000	0.001	0.000	0.001	0.001
	24836	53	69.5	2.5	0.012	0.025	0.037	0.000	0.001	0.001
	24355	53	140	1	0.025	0.051	0.074	0.000	0.000	0.001
	24728	53	130	1	0.023	0.048	0.069	0.000	0.000	0.001
	24278	53	150	0	0.027	0.055	0.080	0.000	0.000	0.000
	23058	53	154	0	0.027	0.056	0.082	0.000	0.000	0.000
	23189	53	140	0	0.025	0.051	0.074	0.000	0.000	0.000
	22811	53	133	2	0.024	0.049	0.071	0.000	0.001	0.001
	22816	53	130	1	0.023	0.048	0.069	0.000	0.000	0.001
	22818	53	140	2	0.025	0.051	0.074	0.000	0.001	0.001
	21786	53	151	0	0.027	0.055	0.080	0.000	0.000	0.000
	21741	53	140	0	0.025	0.051	0.074	0.000	0.000	0.000
	26286	53	139	1	0.025	0.051	0.074	0.000	0.000	0.001
	25864	53	150	0	0.027	0.055	0.080	0.000	0.000	0.000
	25731	53	135.5	0	0.024	0.050	0.072	0.000	0.000	0.000
	25699	53	41	0	0.007	0.015	0.022	0.000	0.000	0.000
	25167	53	140	1	0.025	0.051	0.074	0.000	0.000	0.001
	26736	53	162.5	0	0.029	0.059	0.086	0.000	0.000	0.000
	20704	53	0	1	0.000	0.000	0.000	0.000	0.000	0.001
	20968	53	149	NR[c]	0.026	0.055	0.079	NC[d]	NC	NC
	20969	53	145	NR	0.026	0.053	0.077	NC	NC	NC
	20970	53	150	NR	0.027	0.055	0.080	NC	NC	NC
	25108	45	0	0	0.000	0.000	0.000	0.000	0.000	0.000
	23226	45	120	4	0.025	0.052	0.075	0.001	0.002	0.003
Wash St	H4770	45	119	10.5	0.025	0.051	0.075	0.002	0.005	0.007
Raven	TSP#1[e]	45	5	11.1	0.001	0.002	0.003	0.002	0.005	0.007
	TSP#2	45	6.2	13.2	0.001	0.003	0.004	0.003	0.006	0.008
Charter	TSP-1	45	7.8	12	0.002	0.003	0.005	0.003	0.005	0.008
	TSP-2	45	9.1	16	0.002	0.004	0.006	0.003	0.007	0.010
	TSP-3	45	6.8	12	0.001	0.003	0.004	0.003	0.005	0.008

Note: Footnotes may be found at the end of this table

Table G-1a. (Continued)

Source[a]	ID[b]	Percent P_2O_5	Cd mg/kg	Pb mg/kg	Yearly Cd addition in kg/ha at 84 lb P_2O_5/A 94 kg/ha	173 lb P_2O_5/A 194 kg/ha	252 lb P_2O_5/A 282 kg/ha	Yearly Pb addition in kg/ha at 84 lb P_2O_5/A 94 kg/ha	173 lb P_2O_5/A 194 kg/ha	252 lb P_2O_5/A 282 kg/ha
Charter	TSP-4	45	8.7	16	0.002	0.004	0.005	0.003	0.007	0.010
	TSP-5	45	8.1	15	0.002	0.003	0.005	0.003	0.006	0.009
	TSP-6	45	47	4.5	0.010	0.020	0.029	0.001	0.002	0.003
	TSP-7	45	7.5	12	0.002	0.003	0.005	0.003	0.005	0.008
	TSP-8	45	6.8	16	0.001	0.003	0.004	0.003	0.007	0.010
	TSP-9	45	39	4.5	0.008	0.017	0.024	0.001	0.002	0.003
	TSP-10	45	7.8	12	0.002	0.003	0.005	0.003	0.005	0.008
	TSP-11	45	8.1	4.5	0.002	0.003	0.005	0.001	0.002	0.003
	TSP-12	45	7.8	16	0.002	0.003	0.005	0.003	0.007	0.010
	TSP-13	45	8.1	12	0.002	0.003	0.005	0.003	0.005	0.008
	TSP-14	45	8.1	12	0.002	0.003	0.005	0.003	0.005	0.008
	TSP-15	45	11	12	0.002	0.005	0.007	0.003	0.005	0.008
	TSP-16	45	8.8	12	0.002	0.004	0.006	0.003	0.005	0.008
	TSP-17	45	7.2	12	0.002	0.003	0.005	0.003	0.005	0.008
	TSP-18	45	30	12	0.006	0.013	0.019	0.003	0.005	0.008
	TSP-19	45	40	12	0.008	0.017	0.025	0.003	0.005	0.008
	TSP-20	45	8.5	12	0.002	0.004	0.005	0.003	0.005	0.008
	TSP-21	45	36	4.5	0.008	0.016	0.023	0.001	0.002	0.003
	TSP-22	45	7.7	15	0.002	0.003	0.005	0.003	0.006	0.009
	TSP-23	45	8.1	16	0.002	0.003	0.005	0.003	0.007	0.010
	TSP-24	45	26	4.5	0.005	0.011	0.016	0.001	0.002	0.003
M&O	TSP	45	180	18	0.038[f]	0.078	**0.113**[g]	0.004	0.008	0.011
CDFA	25972	20	32	200	0.015	0.031	0.045	0.094	0.194	0.282
	25658	20	7	2	0.003	0.007	0.010	0.001	0.002	0.003
	24682	20	3	14	0.001	0.003	0.004	0.007	0.014	0.020
	22899	15	1	1	0.001	0.001	0.002	0.001	0.001	0.002
	20705	15	2	5	0.001	0.003	0.004	0.003	0.006	0.009
	21244	23	0	4.7	0.000	0.000	0.000	0.002	0.004	0.006
	20986	33.5	0	9.5	0.000	0.000	0.000	0.003	0.006	0.008
	20987	33.5	0	2.2	0.000	0.000	0.000	0.001	0.001	0.002
Wash St	H2549	68	0.15	2	0.000	0.000	0.000	0.000	0.001	0.001
Average		45.3	57.9	10.1	0.011	0.022	0.033	0.003	0.007	0.009

a) Sources:
CDFA: California Department of Food and Agriculture (1997)
Wash St: Washington State Department of Ecology (1997)
Raven: Raven and Loeppert (1997)
Charter: Charter et al. (1993)
M&O: Mortvedt and Osborn (1982)
b) Sample identification used by author
c) NR = not reported
d) NC = not calculated
e) TSP=Triple superphosphate
f) Shading indicates highest yearly addition values of this metal from phosphate products
g) Bold indicates a yearly addition that exceeds the Canadian Fertilizers Act limits for this metal

Table G-1b. Yearly As and Cr Additions to Soil (kg/ha) from P_2O_5 Fertilizers

Source[a]	ID Number[b]	Percent P_2O_5	As mg/kg	Cr mg/kg	Yearly As addition in kg/ha at 84 lb P_2O_5/A 94 kg/ha	173 lb P_2O_5/A 194 kg/ha	252 lb P_2O_5/A 282 kg/ha	Yearly Cr addition in kg/ha at 84 lb P_2O_5/A 94 kg/ha	173 lb P_2O_5/A 194 kg/ha	252 lb P_2O_5/A 282 kg/ha
CDFA	24837	53	7	NR[c]	0.001	0.003	0.004	NC[d]	NC	NC
	24836	53	12	NR	0.002	0.004	0.006	NC	NC	NC
	24355	53	14.5	NR	0.003	0.005	0.008	NC	NC	NC
	24728	53	13.5	NR	0.002	0.005	0.007	NC	NC	NC
	24278	53	12.3	NR	0.002	0.005	0.007	NC	NC	NC
	23058	53	17	NR	0.003	0.006	0.009	NC	NC	NC
	23189	53	14.5	NR	0.003	0.005	0.008	NC	NC	NC
	22811	53	16	NR	0.003	0.006	0.009	NC	NC	NC
	22816	53	17	NR	0.003	0.006	0.009	NC	NC	NC
	22818	53	17	NR	0.003	0.006	0.009	NC	NC	NC
	21786	53	8	NR	0.001	0.003	0.004	NC	NC	NC
	21741	53	15.5	NR	0.003	0.006	0.008	NC	NC	NC
	26286	53	16	NR	0.003	0.006	0.009	NC	NC	NC
	25864	53	9	NR	0.002	0.003	0.005	NC	NC	NC
	25731	53	20.5	NR	0.004	0.008	0.011	NC	NC	NC
	25699	53	3.5	NR	0.001	0.001	0.002	NC	NC	NC
	25167	53	19	NR	0.003	0.007	0.010	NC	NC	NC
	26736	53	15.5	NR	0.003	0.006	0.008	NC	NC	NC
	20704	53	5.5	NR	0.001	0.002	0.003	NC	NC	NC
	20968	53	13	NR	0.002	0.005	0.007	NC	NC	NC
	20969	53	16.5	NR	0.003	0.006	0.009	NC	NC	NC
	20970	53	15	NR	0.003	0.005	0.008	NC	NC	NC
	25108	45	0.5	NR	0.000	0.000	0.000	NC	NC	NC
	23226	45	14	NR	0.003	0.006	0.009	NC	NC	NC
Wash St	H4770	45	15.5	516	0.003	0.007	0.010	0.108	0.222	0.323
Raven	TSP#1[e]	45	16.2	88.9	0.003	0.007	0.010	0.019	0.038	0.056
	TSP#2	45	15.3	NR	0.003	0.007	0.010	NC	NC	NC
Hamamo	TSP#1	46	12.3	NR	0.003	0.005	0.008	NC	NC	NC
	TSP#5	46	13	NR	0.003	0.005	0.008	NC	NC	NC
	SP#2	21	7.5	NR	0.003	0.007	0.01	NC	NC	NC
	SP#4	21	13	NR	0.003	0.012	0.017	NC	NC	NC
Charter	TSP-1	45	11.1	63	0.002	0.005	0.007	0.013	0.027	0.039
	TSP-2	45	12.9	85	0.003	0.006	0.008	0.018	0.037	0.053
	TSP-3	45	14.7	69	0.003	0.006	0.009	0.014	0.030	0.043

Note: Footnotes may be found at the end of this table

Table G-1b. (Continued)

Source[a]	ID	Percent P_2O_5	As mg/kg	Cr mg/kg	Yearly As addition in kg/ha at 84 lb P_2O_5/A 94 kg/ha	173 lb P_2O_5/A 194 kg/ha	252 lb P_2O_5/A 282 kg/ha	Yearly Cr addition in kg/ha at 84 lb P_2O_5/A 94 kg/ha	173 lb P_2O_5/A 194 kg/ha	252 lb P_2O_5/A 282 kg/ha
Charter	TSP-4	45	9.7	68	0.002	0.004	0.006	0.014	0.029	0.043
	TSP-5	45	9.8	77	0.002	0.004	0.006	0.016	0.033	0.048
	TSP-6	45	2.7	309	0.001	0.001	0.002	0.065	0.133	0.194
	TSP-7	45	13.8	70	0.003	0.006	0.009	0.015	0.030	0.044
	TSP-8	45	13.4	70	0.003	0.006	0.008	0.015	0.030	0.044
	TSP-9	45	8.8	548	0.002	0.004	0.006	0.114	0.236	0.343
	TSP-10	45	10.1	76	0.002	0.004	0.006	0.016	0.033	0.048
	TSP-11	45	9.4	74	0.002	0.004	0.006	0.015	0.032	0.046
	TSP-12	45	13.2	73	0.003	0.006	0.008	0.015	0.031	0.046
	TSP-13	45	13.7	70	0.003	0.006	0.009	0.015	0.030	0.044
	TSP-14	45	9.7	76	0.002	0.004	0.006	0.016	0.033	0.048
	TSP-15	45	18.5	72	0.004	0.008	0.012	0.015	0.031	0.045
	TSP-16	45	9.2	68	0.002	0.004	0.006	0.014	0.029	0.043
	TSP-17	45	15.8	70	0.003	0.007	0.010	0.015	0.030	0.044
	TSP-18	45	4.8	223	0.001	0.002	0.003	0.047	0.096	0.140
	TSP-19	45	2.4	373	0.001	0.001	0.002	0.078	0.161	0.234
	TSP-20	45	10.1	81	0.002	0.004	0.006	0.017	0.035	0.051
	TSP-21	45	3.1	272	0.001	0.001	0.002	0.057	0.117	0.170
	TSP-22	45	10	65	0.002	0.004	0.006	0.014	0.028	0.041
	TSP-23	45	12.4	68	0.003	0.005	0.008	0.014	0.029	0.043
	TSP-24	45	7.1	159	0.001	0.003	0.004	0.033	0.069	0.100
CDFA	25972	20	13	NR	0.006[f]	0.013	0.018	NC	NC	NC
	25658	20	1	NR	0.000	0.001	0.001	NC	NC	NC
	24682	20	12	NR	0.006	0.012	0.017	NC	NC	NC
	22899	15	0.5	NR	0.000	0.001	0.001	NC	NC	NC
	20705	15	2.6	NR	0.002	0.003	0.005	NC	NC	NC
	21244	23	0	NR	0	0	0	NC	NC	NC
	20986	33.5	0	NR	0	0	0	NC	NC	NC
	20987	33.5	0	NR	0	0	0	NC	NC	NC
Wash St	H2549	68	7.8	896	0.001	0.002	0.003	0.124	0.256	0.372
Average		45.3	11.0	173.33	0.002	0.005	0.007	0.034	0.070	0.102

a) Sources:
California Department of Food and Agriculture (1997)
Washington Department of Ecology (1997)
Raven and Loeppert (1997)
Hamamo: Hamamo et al. (1995)
Charter et al. (1993) and Charter et al. (1995) for As
Mortvedt and Osborn (1982)

b) Sample identification used by author

c) NR = not reported

d) NC = not calculated

e) TSP=Triple superphosphate

f) Shading indicates highest yearly addition values of this contaminant from phosphate products

Table G-1c. Yearly Hg and Ni Additions to Soil (kg/ha) from P_2O_5 Fertilizers

Source[a]	ID[b]	Percent P_2O_5	Hg mg/kg	Ni mg/kg	Yearly Hg addition in kg/ha at 84 lb P_2O_5/A 94 kg/ha	173 lb P_2O_5/A 194 kg/ha	252 lb P_2O_5/A 282 kg/ha	Yearly Ni addition in kg/ha at 84 lb P_2O_5/A 94 kg/ha	173 lb P_2O_5/A 194 kg/ha	252 lb P_2O_5/A 282 kg/ha
CDFA	23226	45	NR[c]	132	NC[d]	NC	NC	0.028	0.057	0.083
Wash St	H4770	45	0.003	151	0.000	0.000	0.000	0.032[e]	0.065[e]	0.095[e]
Raven	TSP#1[f]	45	0.2	25.2	0.000[e]	0.000[e]	0.000[e]	0.005	0.011	0.016
	TSP#2	45	0.2	15.6	0.000	0.000	0.000	0.003	0.007	0.010
Charter	TSP-1	45	NR	15	NC	NC	NC	0.003	0.006	0.009
	TSP-2	45	NR	19	NC	NC	NC	0.004	0.008	0.012
	TSP-3	45	NR	17	NC	NC	NC	0.004	0.007	0.011
	TSP-4	45	NR	16	NC	NC	NC	0.003	0.007	0.010
	TSP-5	45	NR	19	NC	NC	NC	0.004	0.008	0.012
	TSP-6	45	NR	16	NC	NC	NC	0.003	0.007	0.010
	TSP-7	45	NR	16	NC	NC	NC	0.003	0.007	0.010
	TSP-8	45	NR	18	NC	NC	NC	0.004	0.008	0.011
	TSP-9	45	NR	40	NC	NC	NC	0.008	0.017	0.025
	TSP-10	45	NR	17	NC	NC	NC	0.004	0.007	0.011
	TSP-11	45	NR	16	NC	NC	NC	0.003	0.007	0.010
	TSP-12	45	NR	17	NC	NC	NC	0.004	0.007	0.011
	TSP-13	45	NR	14	NC	NC	NC	0.003	0.006	0.009
	TSP-14	45	NR	14	NC	NC	NC	0.003	0.006	0.009
	TSP-15	45	NR	16	NC	NC	NC	0.003	0.007	0.010
	TSP-16	45	NR	14	NC	NC	NC	0.003	0.006	0.009
	TSP-17	45	NR	18	NC	NC	NC	0.004	0.008	0.011
	TSP-18	45	NR	17	NC	NC	NC	0.004	0.007	0.011
	TSP-19	45	NR	15	NC	NC	NC	0.003	0.006	0.009
	TSP-20	45	NR	17	NC	NC	NC	0.004	0.007	0.011
	TSP-21	45	NR	18	NC	NC	NC	0.004	0.008	0.011
	TSP-22	45	NR	16	NC	NC	NC	0.003	0.007	0.010
	TSP-23	45	NR	16	NC	NC	NC	0.003	0.007	0.010
	TSP-24	45	NR	15	NC	NC	NC	0.003	0.006	0.009
M&O	TSP	45	NR	135	NC	NC	NC	0.028	0.058	0.085
CDFA	21244	23	NR	10	NC	NC	NC	0.004	0.008	0.012
	20986	33.5	NR	11.6	NC	NC	NC	0.003	0.007	0.010
	20987	33.5	NR	9.8	NC	NC	NC	0.003	0.006	0.008
Wash St	H2549	68	0.003	0.5	0.000	0.000	0.000	0.000	0.000	0.000
Average		44.3	0.10	27.5	0.000	0.000	0.000	0.006	0.012	0.018

a) Sources:
CDFA: California Department of Food and Agriculture (1997)
Wash St: Washington State Department of Ecology (1997)
Raven: Raven and Loeppert (1997)
Charter: Charter et al. (1993)
M&O: Mortvedt and Osborn (1982)

b) Sample identification used by author

c) NR = not reported

d) NC = not calculated

e) Shading indicates highest yearly addition values of this metal from phosphate products

f) TSP=Triple superphosphate

Table G-1d. Yearly V and Cu Additions to Soil (kg/ha) from P_2O_5 Fertilizers

Source[a]	ID[b]	Percent P_2O_5	V mg/kg	Cu mg/kg	Yearly V addition in kg/ha at 84 lb P_2O_5/A 94 kg/ha	173 lb P_2O_5/A 194 kg/ha	252 lb P_2O_5/A 282 kg/ha	Yearly Cu addition in kg/ha at 84 lb P_2O_5/A 94 kg/ha	173 lb P_2O_5/A 194 kg/ha	252 lb P_2O_5/A 282 kg/ha
CDFA	24837	53	NR[c]	3	NC[d]	NC	NC	0.001	0.001	0.002
	24836	53	NR	2	NC	NC	NC	0.000	0.001	0.001
	24355	53	NR	58.5	NC	NC	NC	0.010	0.021	0.031
	24728	53	NR	100	NC	NC	NC	0.018	0.037	0.053
	24278	53	NR	52	NC	NC	NC	0.009	0.019	0.028
	23058	53	NR	51.5	NC	NC	NC	0.009	0.019	0.027
	23189	53	NR	48	NC	NC	NC	0.009	0.018	0.026
	22811	53	NR	57	NC	NC	NC	0.010	0.021	0.030
	22816	53	NR	55	NC	NC	NC	0.010	0.020	0.029
	22818	53	NR	60	NC	NC	NC	0.011	0.022	0.032
	21786	53	NR	27	NC	NC	NC	0.005	0.010	0.014
	21741	53	NR	55	NC	NC	NC	0.010	0.020	0.029
	26286	53	NR	55	NC	NC	NC	0.010	0.020	0.029
	25864	53	NR	11	NC	NC	NC	0.002	0.004	0.006
	25731	53	NR	59	NC	NC	NC	0.010	0.022	0.031
	25699	53	NR	3	NC	NC	NC	0.001	0.001	0.002
	25167	53	NR	55	NC	NC	NC	0.010	0.020	0.029
	26736	53	NR	42.5	NC	NC	NC	0.008	0.016	0.023
	20704	53	NR	2	NC	NC	NC	0.000	0.001	0.001
	20968	53	NR	NR	NC	NC	NC	NC	NC	NC
	20969	53	NR	NR	NC	NC	NC	NC	NC	NC
	20970	53	NR	NR	NC	NC	NC	NC	NC	NC
CDFA	25108	45	NR	6.5	NC	NC	NC	0.001	0.003	0.004
	23226	45	NR	57	NC	NC	NC	0.012	0.025	0.036
Wash St	H4770	45	721	40.2	0.151[e]	0.311[e]	0.452[e]	0.008	0.017	0.025
Raven	TSP#1[f]	45	189	3.2	0.039	0.081	0.118	0.001	0.001	0.002
	TSP#2	45	154	3.5	0.032	0.066	0.097	0.001	0.002	0.002
Hamamo	TSP#1	46	162	NR	0.033	0.068	0.099	NC	NC	NC
	TSP#5	46	203	NR	0.041	0.086	0.124	NC	NC	NC
	SP#2	21	48.7	NR	0.022	0.045	0.065	NC	NC	NC
	SP#4	21	194	NR	0.087	0.179	0.261	NC	NC	NC
Charter	TSP-1	45	NR	3.7	NC	NC	NC	0.001	0.002	0.002
	TSP-2	45	NR	3.2	NC	NC	NC	0.001	0.001	0.002
	TSP-3	45	NR	2.1	NC	NC	NC	0.000	0.001	0.001
	TSP-4	45	NR	5.8	NC	NC	NC	0.001	0.003	0.004

Note: Footnotes may be found at the end of this table

Table G-1d. (Continued)

Source[a]	ID[b]	Percent P_2O_5	V mg/kg	Cu mg/kg	Yearly V addition in kg/ha at 84 lb P_2O_5/A 94 kg/ha	173 lb P_2O_5/A 194 kg/ha	252 lb P_2O_5/A 282 kg/ha	Yearly Cu addition in kg/ha at 84 lb P_2O_5/A 94 kg/ha	173 lb P_2O_5/A 194 kg/ha	252 lb P_2O_5/A 282 kg/ha
Charter	TSP-5	45	NR	2.1	NC	NC	NC	0.000	0.001	0.001
	TSP-6	45	NR	3.7	NC	NC	NC	0.001	0.002	0.002
	TSP-7	45	NR	1.6	NC	NC	NC	0.000	0.001	0.001
	TSP-8	45	NR	1.6	NC	NC	NC	0.000	0.001	0.001
	TSP-9	45	NR	13	NC	NC	NC	0.003	0.006	0.008
	TSP-10	45	NR	2.6	NC	NC	NC	0.001	0.001	0.002
	TSP-11	45	NR	2.6	NC	NC	NC	0.001	0.001	0.002
	TSP-12	45	NR	2.6	NC	NC	NC	0.001	0.001	0.002
	TSP-13	45	NR	2.6	NC	NC	NC	0.001	0.001	0.002
	TSP-14	45	NR	2.1	NC	NC	NC	0.000	0.001	0.001
	TSP-15	45	NR	3.2	NC	NC	NC	0.001	0.001	0.002
	TSP-16	45	NR	5.8	NC	NC	NC	0.001	0.003	0.004
	TSP-17	45	NR	3.7	NC	NC	NC	0.001	0.002	0.002
	TSP-18	45	NR	3.7	NC	NC	NC	0.001	0.002	0.002
	TSP-19	45	NR	3.2	NC	NC	NC	0.001	0.001	0.002
	TSP-20	45	NR	2.6	NC	NC	NC	0.001	0.001	0.002
	TSP-21	45	NR	2.6	NC	NC	NC	0.001	0.001	0.002
	TSP-22	45	NR	2.1	NC	NC	NC	0.000	0.001	0.001
	TSP-23	45	NR	4.2	NC	NC	NC	0.001	0.002	0.003
	TSP-24	45	NR	3.7	NC	NC	NC	0.001	0.002	0.002
M&O	TSP	45	NR	55	NC	NC	NC	0.011	0.024	0.034
CDFA	25972	20	NR	690	NC	NC	NC	0.324	0.669	0.973
	25658	20	NR	1170	NC	NC	NC	0.550[e]	1.135[e]	1.650[e]
	24682	20	NR	33	NC	NC	NC	0.016	0.032	0.047
	22899	15	NR	1	NC	NC	NC	0.001	0.001	0.002
	20705	15	NR	7	NC	NC	NC	0.004	0.009	0.013
	21244	23	NR	53.5	NC	NC	NC	0.022	0.045	0.066
	20986	33.5	NR	31.5	NC	NC	NC	0.009	0.018	0.027
	20987	33.5	NR	250	NC	NC	NC	0.070	0.145	0.210
Wash St	H2549	68	57.2	0.2	0.008	0.016	0.024	0.000	0.000	0.000
Average		45.3	280.3	56.6	0.052	0.107	0.155	0.020	0.042	0.061

a) Sources:
CDFA: California Department of Food and Agriculture (1997)
Wash St: Washington State Department of Ecology (1997)
Raven: Raven and Loeppert (1997)
Hamamo: Hamamo et al. (1995)
Charter: Charter et al. (1993);
M&O: Mortvedt and Osborn (1982)

b) Sample identification used by author

c) NR = not reported

d) NC = not calculated

e) Shading indicates highest yearly addition values of this metal from phosphate products

f) TSP=Triple superphosphate

Table G-1e. Yearly Zn Additions to Soil (kg/ha) from P_2O_5 Fertilizers

Source[a]	ID[b]	Percent P_2O_5 in product	Zn mg/kg	Yearly Zn addition in kg/ha at 84 lb P_2O_5/A 94 kg/ha	173 lb P_2O_5/A 194 kg/ha	252 lb P_2O_5/A 282 kg/ha
Wash St	H4770	45	1260	0.263	0.543	0.790
Raven	TSP#1[c]	45	61.3	0.013	0.026	0.038
	TSP#2	45	NR[d]	NC[e]	NC	NC
Charter	TSP-1	45	77	0.016	0.033	0.048
	TSP-2	45	108	0.023	0.047	0.068
	TSP-3	45	75	0.016	0.032	0.047
	TSP-4	45	80	0.017	0.034	0.050
	TSP-5	45	85	0.018	0.037	0.053
	TSP-6	45	346	0.072	0.149	0.217
	TSP-7	45	82	0.017	0.035	0.051
	TSP-8	45	77	0.016	0.033	0.048
	TSP-9	45	696	0.145	0.300	0.436
	TSP-10	45	82	0.017	0.035	0.051
	TSP-11	45	95	0.020	0.041	0.060
	TSP-12	45	96	0.020	0.041	0.060
	TSP-13	45	100	0.021	0.043	0.063
	TSP-14	45	98	0.020	0.042	0.061
	TSP-15	45	105	0.022	0.045	0.066
	TSP-16	45	92	0.019	0.040	0.058
	TSP-17	45	93	0.019	0.040	0.058
	TSP-18	45	242	0.051	0.104	0.152
	TSP-19	45	313	0.065	0.135	0.196
	TSP-20	45	191	0.040	0.082	0.120
	TSP-21	45	276	0.058	0.119	0.173
	TSP-22	45	100	0.021	0.043	0.063
	TSP-23	45	92	0.019	0.040	0.058
	TSP-24	45	221	0.046	0.095	0.138
M&O	TSP	45	1550	0.324[f]	0.668	0.971
Wash St	H2549	68	31.3	0.004	0.009	0.013
Average		45.8	240.2	0.050	0.103	0.150

a) Sources:
Washington State Department of Ecology (1997)
Raven and Loeppert (1997)
Charter et al. (1993)
Mortvedt and Osborn (1982)
b) Sample identification used by author
c) TSP=Triple superphosphate
d) NR = not reported
e) NC = not calculated
f) Shading indicates highest yearly addition values of this metal from phosphate products

Table G-2a. Yearly Cd and Pb Additions to Soil (kg/ha) from NPK Fertilizers Applied for P_2O_5 Content

Source[a]	ID[b]	Percent N	Percent P	Percent K	Cd mg/kg	Pb mg/kg	Yearly Cd Addition in kg/ha soil at: 84 lb P_2O_5/A 94 kg/ha	173 lb P_2O_5/A 194 kg/ha	252 lb P_2O_5/A 282 kg/ha	Yearly Pb Addition in kg/ha soil at: 84 lb P_2O_5/A 94 kg/ha	173 lb P_2O_5/A 194 kg/ha	252 lb P_2O_5/A 282 kg/ha
Charter	MAP-1[b]	11	52	0	6.4	4.5	0.001	0.002	0.003	0.001	0.002	0.002
	MAP-2	11	52	0	6.7	4.5	0.001	0.002	0.004	0.001	0.002	0.002
	MAP-3	11	52	0	7.3	4.5	0.001	0.003	0.004	0.001	0.002	0.002
	MAP-4	11	52	0	7.4	4.5	0.001	0.003	0.004	0.001	0.002	0.002
	MAP-5	11	52	0	7	4.5	0.001	0.003	0.004	0.001	0.002	0.002
	MAP-6	11	52	0	7	4.5	0.001	0.003	0.004	0.001	0.002	0.002
	MAP-7	11	52	0	6.7	4.5	0.001	0.002	0.004	0.001	0.002	0.002
	MAP-8	11	52	0	7	4.5	0.001	0.003	0.004	0.001	0.002	0.002
	MAP-9	11	52	0	6.7	4.5	0.001	0.002	0.004	0.001	0.002	0.002
	MAP-10	11	52	0	6.7	4.5	0.001	0.002	0.004	0.001	0.002	0.002
	MAP-11	11	52	0	7.1	4.5	0.001	0.003	0.004	0.001	0.002	0.002
	MAP-12	11	52	0	7.7	4.5	0.001	0.003	0.004	0.001	0.002	0.002
	MAP-13	11	52	0	8.3	4.5	0.002	0.003	0.005	0.001	0.002	0.002
	MAP-14	11	52	0	7.4	4.5	0.001	0.003	0.004	0.001	0.002	0.002
	MAP-15	11	52	0	7	12	0.001	0.003	0.004	0.002	0.004	0.007
	MAP-16	11	52	0	6.7	4.5	0.001	0.002	0.004	0.001	0.002	0.002
	MAP-17	11	52	0	7.7	4.5	0.001	0.003	0.004	0.001	0.002	0.002
	MAP-18	11	52	0	7.3	4.5	0.001	0.003	0.004	0.001	0.002	0.002
	MAP-19	11	52	0	7.3	4.5	0.001	0.003	0.004	0.001	0.002	0.002
	MAP-20	11	52	0	6.7	4.5	0.001	0.002	0.004	0.001	0.002	0.002
	MAP-21	11	52	0	6.7	4.5	0.001	0.002	0.004	0.001	0.002	0.002
	MAP-22	11	52	0	7	4.5	0.001	0.003	0.004	0.001	0.002	0.002
	MAP-23	11	52	0	7.7	4.5	0.001	0.003	0.004	0.001	0.002	0.002
	DAP-1[d]	18	46	0	5.4	12	0.001	0.002	0.003	0.002	0.005	0.007
	DAP-2	18	46	0	6.7	4.5	0.001	0.003	0.004	0.001	0.002	0.003
	DAP-3	18	46	0	6.7	12	0.001	0.003	0.004	0.002	0.005	0.007
	DAP-4	18	46	0	8.9	4.5	0.002	0.004	0.005	0.001	0.002	0.003
	DAP-5	18	46	0	94	4.5	0.019	0.040	0.058	0.001	0.002	0.003
	DAP-6	18	46	0	6.4	4.5	0.001	0.003	0.004	0.001	0.002	0.003
	DAP-7	18	46	0	6.4	4.5	0.001	0.003	0.004	0.001	0.002	0.003
	DAP-8	18	46	0	6	4.5	0.001	0.003	0.004	0.001	0.002	0.003
	DAP-9	18	46	0	7.3	4.5	0.001	0.003	0.004	0.001	0.002	0.003
	DAP-10	18	46	0	6	12	0.001	0.003	0.004	0.002	0.005	0.007
	DAP-11	18	46	0	8.6	4.5	0.002	0.004	0.005	0.001	0.002	0.003
	DAP-12	18	46	0	6	4.5	0.001	0.003	0.004	0.001	0.002	0.003
	DAP-13	18	46	0	5.7	4.5	0.001	0.002	0.003	0.001	0.002	0.003
	DAP-14	18	46	0	5.7	4.5	0.001	0.002	0.003	0.001	0.002	0.003
	DAP-15	18	46	0	7	4.5	0.001	0.003	0.004	0.001	0.002	0.003

Note: Footnotes may be found at the end of this table

Table G-2a. (Continued)

Source[a]	ID[b]	Percent N	Percent P	Percent K	Cd mg/kg	Pb mg/kg	Yearly Cd Addition in kg/ha soil at: 84 lb P_2O_5/A 94 kg/ha	173 lb P_2O_5/A 194 kg/ha	252 lb P_2O_5/A 282 kg/ha	Yearly Pb Addition in kg/ha soil at: 84 lb P_2O_5/A 94 kg/ha	173 lb P_2O_5/A 194 kg/ha	252 lb P_2O_5/A 282 kg/ha
Charter	DAP-16	18	46	0	6.3	4.5	0.001	0.003	0.004	0.001	0.002	0.003
	DAP-17	18	46	0	6.7	4.5	0.001	0.003	0.004	0.001	0.002	0.003
	DAP-18	18	46	0	8.6	4.5	0.002	0.004	0.005	0.001	0.002	0.003
	DAP-19	18	46	0	7	4.5	0.001	0.003	0.004	0.001	0.002	0.003
	DAP-20	18	46	0	6.7	4.5	0.001	0.003	0.004	0.001	0.002	0.003
	DAP-21	18	46	0	6.4	12	0.001	0.003	0.004	0.002	0.005	0.007
	DAP-22	18	46	0	7.3	12	0.001	0.003	0.004	0.002	0.005	0.007
	DAP-23	18	46	0	7	12	0.001	0.003	0.004	0.002	0.005	0.007
	DAP-24	18	46	0	6	4.5	0.001	0.003	0.004	0.001	0.002	0.003
	DAP-25	18	46	0	6.4	12	0.001	0.003	0.004	0.002	0.005	0.007
Wash St	H4754	11	52	0	0.15	1	0.000	0.000	0.000	0.000	0.000	0.001
	H4755	18	46	0	6.9	2.5	0.001	0.003	0.004	0.001	0.001	0.002
	H4762	16	15	15	0.75	5	0.000	0.001	0.001	0.003	0.006	0.009
	H2526	11	37	0	0.6	1	0.000	0.000	0.000	0.000	0.001	0.001
	H2574	11	30	0	1.6	1	0.001	0.001	0.002	0.000	0.001	0.001
	H2532	16	20	0	145	4.4	0.068	**0.141**[e]	**0.204**[e]	0.002	0.004	0.006
	H2546	10	34	0	25	1	0.007	0.014	0.021	0.000	0.001	0.001
Raven	MAP-1	11	52	0	0.15	0.1	0.000	0.000	0.000	0.000	0.000	0.000
	MAP-2	11	52	0	4	2.9	0.001	0.001	0.002	0.001	0.001	0.002
	DAP-1	18	46	0	4.6	3.7	0.001	0.002	0.003	0.001	0.002	0.002
	DAP-2	18	46	0	35.5	2.1	0.007	0.015	0.022	0.000	0.001	0.001
IMC	8813182	18	46	0	5	0.88	0.001	0.002	0.003	0.000	0.000	0.001
	8813183	11	52	0	5.4	1	0.001	0.002	0.003	0.000	0.000	0.001
	8813184	11	52	0	5.6	2.9	0.001	0.002	0.003	0.001	0.001	0.002
M&O	DAP(A)	18	46	0	48	13	0.010	0.020	0.029	0.003	0.005	0.008
	DAP(B)	18	46	0	73	13	0.015	0.031	0.045	0.003	0.005	0.008
	DAP(C)	18	46	0	131	15	0.027	0.055	0.080	0.003	0.006	0.009
	DAP(D)	18	46	0	188	15	0.038	0.079	**0.115**	0.003	0.006	0.009
MMO	DAP1	21	53	0	2	4	0.000	0.001	0.001	0.001	0.001	0.002
	DAP2	18	46	0	74	8	0.015	0.031	0.045	0.002	0.003	0.005
	DAP3	18	46	0	153	6	0.031	0.065	**0.094**	0.001	0.003	0.004

Note: Footnotes may be found at the end of this table

Table G-2a. (Continued)

Source[a]	ID[b]	Percent N	Percent P	Percent K	Cd mg/kg	Pb mg/kg	Yearly Cd Addition in kg/ha soil at: 84 lb P_2O_5/A 94 kg/ha	173 lb P_2O_5/A 194 kg/ha	252 lb P_2O_5/A 282 kg/ha	Yearly Pb Addition in kg/ha soil at: 84 lb P_2O_5/A 94 kg/ha	173 lb P_2O_5/A 194 kg/ha	252 lb P_2O_5/A 282 kg/ha
CDFA	24295	10	34	0	28	0	0.008	0.016	0.023	0.000	0.000	0.000
	23730	4	21	25	105	2340	0.047	**0.097**	**0.141**	1.047	2.162	**3.142**
	23845	5	24	24	110	1700	0.043	**0.089**	**0.129**	0.666	1.374	1.998
	23647	4	5	3	0	2	0.000	0.000	0.000	0.004	0.008	0.011
	23622	11	52	0	162.5	4	0.029	0.061	0.088	0.001	0.001	0.002
	23202	11	52	0	0	1.7	0.000	0.000	0.000	0.000	0.001	0.001
	22278	11	52	0	135.5	0	0.024	0.051	0.073	0.000	0.000	0.000
	22396	11	52	0	166	4	0.030	0.062	**0.090**	0.001	0.001	0.002
	22245	19	24	18	0	0	0.000	0.000	0.000	0.000	0.000	0.000
	21842	14.4	23.4	0	81.5	4650	0.033	0.068	**0.098**	1.868	**3.855**	**5.604**
	21884	14.2	13	30	37	23	0.027	0.055	0.080	0.017	0.034	0.050
	21936	6	20	20	60	266	0.028	0.058	0.085	0.125	0.258	0.375
	21946	16	16	16	32.5	0	0.019	0.039	0.057	0.000	0.000	0.000
	21949	15	15	15	9	2	0.006	0.012	0.017	0.001	0.003	0.004
	22023	8.5	40	0	200	5425	0.047	**0.097**	**0.141**	1.275	**2.631**	**3.825**
	22026	20	20	20	0	0	0.000	0.000	0.000	0.000	0.000	0.000
	22244	4	12	8	42	2.5	0.033	0.068	**0.099**	0.002	0.004	0.006
	25338	18	12	12	95	3600	**0.074**[f]	**0.154**	**0.223**	**2.820**	**5.820**	**8.460**
	26520	12	61	0	0	2	0.000	0.000	0.000	0.000	0.001	0.001
	26361	6	12	6	0	0	0.000	0.000	0.000	0.000	0.000	0.000
	26412	18	46	0	5	2	0.001	0.002	0.003	0.000	0.001	0.001
	25861	18	46	0	5	2.5	0.001	0.002	0.003	0.001	0.001	0.002
Average		14.1	42.9	2.33	28.6	202.3	0.008	0.017	0.025	0.087	0.179	0.261

a) Sources:
Charter: Charter et al. (1993)
Wash St: Washington State Department of Ecology 1997)
Raven: Raven and Loeppert (1997)
IMC: International Mineral Company (1997)
M&O: Mortvedt and Osborn (1982)
MMO: Mortvedt, Mays and Osborne (1981)
CDFA: California Department of Food and Agriculture (1997)

b) Sample identification used by author

c) MAP = monoammonium phosphate

d) DAP = diammonium phosphate

e) Bold indicates that the yearly addition exceeds the Canadian Fertilizers Act limits for this metal

f) Shading indicates highest yearly addition values of this metal from NPK products (based on P content)

Table G-2b. Yearly As and Cr Additions to Soil (kg/ha) from NPK Fertilizers Applied for P_2O_5 Content

Source[a]	ID[b]	Percent N	Percent P	Percent K	As mg/kg	Cr mg/kg	Yearly As Addition in kg/ha soil at: 84 lb P_2O_5/A 94 kg/ha	173 lb P_2O_5/A 194 kg/ha	252 lb P_2O_5/A 282 kg/ha	Yearly Cr Addition in kg/ha soil at: 84 lb P_2O_5/A 94 kg/ha	173 lb P_2O_5/A 194 kg/ha	252 lb P_2O_5/A 282 kg/ha
Charter	MAP-1[c]	11	52	0	12.1	54	0.002	0.005	0.007	0.010	0.020	0.029
	MAP-2	11	52	0	14.1	55	0.003	0.005	0.008	0.010	0.021	0.030
	MAP-3	11	52	0	17.1	56	0.003	0.006	0.009	0.010	0.021	0.030
	MAP-4	11	52	0	9.5	55	0.002	0.004	0.005	0.010	0.021	0.030
	MAP-5	11	52	0	12.4	59	0.002	0.005	0.007	0.011	0.022	0.032
	MAP-6	11	52	0	12.4	55	0.002	0.005	0.007	0.010	0.021	0.030
	MAP-7	11	52	0	16	57	0.003	0.006	0.009	0.010	0.021	0.031
	MAP-8	11	52	0	8.1	59	0.001	0.003	0.004	0.011	0.022	0.032
	MAP-9	11	52	0	14.9	73	0.003	0.006	0.008	0.013	0.027	0.040
	MAP-10	11	52	0	14.8	58	0.003	0.006	0.008	0.010	0.022	0.031
	MAP-11	11	52	0	16.1	54	0.003	0.006	0.009	0.010	0.020	0.029
	MAP-12	11	52	0	9.9	55	0.002	0.004	0.005	0.010	0.021	0.030
	MAP-13	11	52	0	11.2	57	0.002	0.004	0.006	0.010	0.021	0.031
	MAP-14	11	52	0	10.8	55	0.002	0.004	0.006	0.010	0.021	0.030
	MAP-15	11	52	0	8.9	62	0.002	0.003	0.005	0.011	0.023	0.034
	MAP-16	11	52	0	14.3	56	0.003	0.005	0.008	0.010	0.021	0.030
	MAP-17	11	52	0	10.7	56	0.002	0.004	0.006	0.010	0.021	0.030
	MAP-18	11	52	0	10.9	56	0.002	0.004	0.006	0.010	0.021	0.030
	MAP-19	11	52	0	17.8	57	0.003	0.007	0.010	0.010	0.021	0.031
	MAP-20	11	52	0	12.9	51	0.002	0.005	0.007	0.009	0.019	0.028
	MAP-21	11	52	0	15.5	54	0.003	0.006	0.008	0.010	0.020	0.029
	MAP-22	11	52	0	11.4	58	0.002	0.004	0.006	0.010	0.022	0.031
	MAP-23	11	52	0	11.2	56	0.002	0.004	0.006	0.010	0.021	0.030

Note: Footnotes may be found at the end of this table

Table G-2b. (Continued)

Source[a]	ID[b]	Percent N	Percent P	Percent K	As mg/kg	Cr mg/kg	Yearly As Addition in kg/ha soil at: 84 lb P_2O_5/A 94 kg/ha	173 lb P_2O_5/A 194 kg/ha	252 lb P_2O_5/A 282 kg/ha	Yearly Cr Addition in kg/ha soil at: 84 lb P_2O_5/A 94 kg/ha	173 lb P_2O_5/A 194 kg/ha	252 lb P_2O_5/A 282 kg/ha
Charter	DAP-1[d]	18	46	0	13.1	53	0.003	0.008	0.008	0.011	0.022	0.032
	DAP-2	18	46	0	15.4	50	0.003	0.006	0.009	0.010	0.021	0.031
	DAP-3	18	46	0	15.6	48	0.003	0.007	0.010	0.010	0.020	0.029
	DAP-4	18	46	0	13.8	48	0.003	0.006	0.008	0.010	0.020	0.029
	DAP-5	18	46	0	6.8	616	0.001	0.003	0.004	0.126	0.260	0.378
	DAP-6	18	46	0	9.9	49	0.002	0.004	0.006	0.010	0.021	0.030
	DAP-7	18	46	0	12.4	48	0.003	0.005	0.008	0.010	0.020	0.029
	DAP-8	18	46	0	12.5	49	0.003	0.005	0.008	0.010	0.021	0.030
	DAP-9	18	46	0	11.1	45	0.002	0.005	0.007	0.009	0.019	0.028
	DAP-10	18	46	0	13.1	45	0.003	0.006	0.008	0.009	0.019	0.028
	DAP-11	18	46	0	11.1	47	0.002	0.005	0.007	0.010	0.020	0.029
	DAP-12	18	46	0	13.3	47	0.003	0.006	0.008	0.010	0.020	0.029
	DAP-13	18	46	0	11.1	46	0.002	0.005	0.007	0.009	0.019	0.028
	DAP-14	18	46	0	13.5	47	0.003	0.006	0.008	0.010	0.020	0.029
	DAP-15	18	46	0	13	50	0.003	0.005	0.008	0.010	0.021	0.031
	DAP-16	18	46	0	10.4	50	0.002	0.004	0.006	0.010	0.021	0.031
	DAP-17	18	46	0	12.8	49	0.003	0.005	0.008	0.010	0.021	0.030
	DAP-18	18	46	0	12.2	48	0.002	0.005	0.007	0.010	0.020	0.029
	DAP-19	18	46	0	11.7	47	0.002	0.005	0.007	0.010	0.020	0.029
	DAP-20	18	46	0	14.2	49	0.003	0.006	0.009	0.010	0.021	0.030
	DAP-21	18	46	0	15/4	47	0.003	0.006	0.009	0.010	0.020	0.029
	DAP-22	18	46	0	10.6	51	0.002	0.004	0.006	0.010	0.022	0.031
	DAP-23	18	46	0	11.2	50	0.002	0.005	0.007	0.010	0.021	0.031
	DAP-24	18	46	0	11.2	47	0.002	0.005	0.007	0.010	0.020	0.029
	DAP-25	18	46	0	11.1	49	0.002	0.005	0.007	0.010	0.021	0.030

Note: Footnotes may be found at the end of this table

Table G-2b. (Continued)

Source[a]	ID[b]	Percent N	Percent P	Percent K	As mg/kg	Cr mg/kg	Yearly As Addition in kg/ha soil at: 84 lb P_2O_5/A 94 kg/ha	173 lb P_2O_5/A 194 kg/ha	252 lb P_2O_5/A 282 kg/ha	Yearly Cr Addition in kg/ha soil at: 84 lb P_2O_5/A 94 kg/ha	173 lb P_2O_5/A 194 kg/ha	252 lb P_2O_5/A 282 kg/ha
Wash St	H4754	11	52	0	6.8	5.8	0.001	0.003	0.004	0.001	0.002	0.003
	H4755	18	46	0	18	92	0.004	0.008	0.011	0.019	0.039	0.056
	H4762	16	15	15	8	4.3	0.005	0.010	0.015	0.003	0.006	0.008
	H2526	11	37	0	1.5	433	0.000	0.001	0.001	0.110	0.227	0.330
	H2574	11	30	0	1.5	379	0.000	0.001	0.001	0.119	0.245	0.356
	H2532	16	20	0	4.2	214	0.002	0.004	0.006	0.101	0.208	0.302
	H2546	10	34	0	4.8	400	0.001	0.003	0.004	0.111	0.228	0.332
Raven	MAP-1	11	52	0	10.9	16.9	0.002	0.004	0.006	0.003	0.006	0.009
	MAP-2	11	52	0	13.7	NR	0.002	0.005	0.007	NC	NC	NC
	DAP-1	18	46	0	9.9	NR	0.002	0.004	0.006	NC	NC	NC
	DAP-2	18	46	0	16.2	196	0.003	0.007	0.010	0.040	0.083	0.120
IMC	8813182	18	46	0	0.05	64	0.000	0.000	0.000	0.013	0.027	0.039
	8813183	11	52	0	0.05	71	0.000	0.000	0.000	0.013	0.026	0.039
	8813184	11	52	0	0.05	75	0.000	0.000	0.000	0.014	0.028	0.041
M&O	DAP(A)	18	46	0	NR[f]	NR	NC[g]	NC	NC	NC	NC	NC
	DAP(B)	18	46	0	NR	NR	NC	NC	NC	NC	NC	NC
	DAP(C)	18	46	0	NR	NR	NC	NC	NC	NC	NC	NC
	DAP(D)	18	46	0	NR	NR	NC	NC	NC	NC	NC	NC
MMO	DAP1	21	53	0	NR	NR	NC	NC	NC	NC	NC	NC
	DAP2	18	46	0	NR	NR	NC	NC	NC	NC	NC	NC
	DAP3	18	46	0	NR	NR	NC	NC	NC	NC	NC	NC

Note: Footnotes may be found at the end of this table

Table G-2b. (Continued)

Source[a]	ID[b]	Percent N	Percent P	Percent K	As mg/kg	Cr mg/kg	Yearly As Addition in kg/ha soil at: 84 lb P_2O_5/A 94 kg/ha	173 lb P_2O_5/A 194 kg/ha	252 lb P_2O_5/A 282 kg/ha	Yearly Cr Addition in kg/ha soil at: 84 lb P_2O_5/A 94 kg/ha	173 lb P_2O_5/A 194 kg/ha	252 lb P_2O_5/A 282 kg/ha
CDFA	24295	10	34	0	10	NR	0.003	0.006	0.008	NC	NC	NC
	23730	4	21	25	11.5	NR	0.005	0.011	0.015	NC	NC	NC
	23845	5	24	24	8.4	NR	0.003	0.007	0.010	NC	NC	NC
	23647	4	5	3	0.6	NR	0.001	0.002	0.003	NC	NC	NC
	23622	11	52	0	15.5	NR	0.003	0.006	0.008	NC	NC	NC
	23202	11	52	0	3.5	NR	0.001	0.001	0.002	NC	NC	NC
	22278	11	52	0	12.5	NR	0.002	0.005	0.007	NC	NC	NC
	22396	11	52	0	16	NR	0.003	0.006	0.009	NC	NC	NC
	22245	19	24	18	5.5	NR	0.002	0.004	0.006	NC	NC	NC
	21842	14.4	23.4	0	32.5	NR	0.013	0.027	0.039	NC	NC	NC
	21884	14.2	13	30	155	NR	0.112	0.231	**0.336**[h]	NC	NC	NC
	21936	6	20	20	45	NR	0.021	0.044	0.063	NC	NC	NC
	21946	16	16	16	2.5	NR	0.001	0.003	0.004	NC	NC	NC
	21949	15	15	15	6	NR	0.004	0.008	0.011	NC	NC	NC
	22023	8.5	40	0	23.5	NR	0.006	0.011	0.017	NC	NC	NC
	22026	20	20	20	4	NR	0.002	0.004	0.006	NC	NC	NC
	22244	4	12	8	3	NR	0.002	0.005	0.007	NC	NC	NC
	25338	18	12	12	11.2	NR	0.009	0.018	0.026	NC	NC	NC
	26520	12	61	0	0.65	NR	0.000	0.000	0.000	NC	NC	NC
	26361	6	12	6	0.4	NR	0.000	0.001	0.001	NC	NC	NC
	26412	18	46	0	8	NR	0.002	0.003	0.005	NC	NC	NC
	25861	18	46	0	8.5	NR	0.002	0.004	0.005	NC	NC	NC
Average		14.1	42.9	2.3	13.3	83.9	0.004	0.008	0.012	0.019	0.039	0.057

a) Sources:
Charter: Charter et al. (1993) and Charter et al. (1995) for As
Wash St: Washington State Department of Ecology (1997)
Rave: Raven and Loeppert (1997)
IMC: International Mineral Company (1997)
M&O: Mortvedt and Osborn (1982)
MMO: Mortvedt, Mays and Osborne (1981)
CDFA: California Department of Food and Agriculture (1997)

b) Sample identification used by author

c) MAP = monoammonium phosphate

d) DAP = diammonium phosphate

e) Shading indicates highest yearly addition values of this metal from NPK products (based on P content)

f) NR = not reported

g) NC = not calculated

h) Bold indicates that the yearly addition exceeds the Canadian Fertilizers Act limits for this contaminant

Table G-2c. Yearly Hg and Ni Additions to Soil (kg/ha) from NPK Fertilizers Applied for P_2O_5 Content

Source[a]	ID[b]	Percent			Hg mg/kg	Ni mg/kg	Yearly Hg Addition in kg/ha soil at:			Yearly Ni Addition in kg/ha soil at:		
							84 lb P_2O_5/A	173 lb P_2O_5/A	252 lb P_2O_5/A	84 lb P_2O_5/A	173 lb P_2O_5/A	252 lb P_2O_5/A
		N	P	K			94 kg/ha	194 kg/ha	282 kg/ha	94 kg/ha	194 kg/ha	282 kg/ha
Charter	MAP-1[c]	11	52	0	NR[d]	15	NC[e]	NC	NC	0.003	0.006	0.008
	MAP-2	11	52	0	NR	17	NC	NC	NC	0.003	0.006	0.009
	MAP-3	11	52	0	NR	20	NC	NC	NC	0.004	0.007	0.011
	MAP-4	11	52	0	NR	18	NC	NC	NC	0.003	0.007	0.010
	MAP-5	11	52	0	NR	17	NC	NC	NC	0.003	0.006	0.009
	MAP-6	11	52	0	NR	16	NC	NC	NC	0.003	0.006	0.009
	MAP-7	11	52	0	NR	16	NC	NC	NC	0.003	0.006	0.009
	MAP-8	11	52	0	NR	15	NC	NC	NC	0.003	0.006	0.008
	MAP-9	11	52	0	NR	18	NC	NC	NC	0.003	0.007	0.010
	MAP-10	11	52	0	NR	17	NC	NC	NC	0.003	0.006	0.009
	MAP-11	11	52	0	NR	15	NC	NC	NC	0.003	0.006	0.008
	MAP-12	11	52	0	NR	18	NC	NC	NC	0.003	0.007	0.010
	MAP-13	11	52	0	NR	17	NC	NC	NC	0.003	0.006	0.009
	MAP-14	11	52	0	NR	16	NC	NC	NC	0.003	0.006	0.009
	MAP-15	11	52	0	NR	19	NC	NC	NC	0.003	0.007	0.010
	MAP-16	11	52	0	NR	17	NC	NC	NC	0.003	0.006	0.009
	MAP-17	11	52	0	NR	16	NC	NC	NC	0.003	0.006	0.009
	MAP-18	11	52	0	NR	19	NC	NC	NC	0.003	0.007	0.010
	MAP-19	11	52	0	NR	20	NC	NC	NC	0.004	0.007	0.011
	MAP-20	11	52	0	NR	15	NC	NC	NC	0.003	0.006	0.008
	MAP-21	11	52	0	NR	19	NC	NC	NC	0.003	0.007	0.010
	MAP-22	11	52	0	NR	17	NC	NC	NC	0.003	0.006	0.009
	MAP-23	11	52	0	NR	17	NC	NC	NC	0.003	0.006	0.009

Note: Footnotes may be found at the end of this table

Table G-2c. (Continued)

Source[a]	ID[b]	Percent N	Percent P	Percent K	Hg mg/kg	Ni mg/kg	Yearly Hg Addition in kg/ha soil at: 84 lb P_2O_5/A 94 kg/ha	173 lb P_2O_5/A 194 kg/ha	252 lb P_2O_5/A 282 kg/ha	Yearly Ni Addition in kg/ha soil at: 84 lb P_2O_5/A 94 kg/ha	173 lb P_2O_5/A 194 kg/ha	252 lb P_2O_5/A 282 kg/ha
Charter	DAP-1[f]	18	46	0	NR	13	NC	NC	NC	0.003	0.005	0.008
	DAP-2	18	46	0	NR	11	NC	NC	NC	0.002	0.005	0.007
	DAP-3	18	46	0	NR	14	NC	NC	NC	0.003	0.006	0.009
	DAP-4	18	46	0	NR	16	NC	NC	NC	0.003	0.007	0.010
	DAP-5	18	46	0	NR	127	NC	NC	NC	0.026	0.054	0.078
	DAP-6	18	46	0	NR	14	NC	NC	NC	0.003	0.006	0.009
	DAP-7	18	46	0	NR	12	NC	NC	NC	0.002	0.005	0.007
	DAP-8	18	46	0	NR	14	NC	NC	NC	0.003	0.006	0.009
	DAP-9	18	46	0	NR	14	NC	NC	NC	0.003	0.006	0.009
	DAP-10	18	46	0	NR	14	NC	NC	NC	0.003	0.006	0.009
	DAP-11	18	46	0	NR	15	NC	NC	NC	0.003	0.006	0.009
	DAP-12	18	46	0	NR	17	NC	NC	NC	0.003	0.007	0.010
	DAP-13	18	46	0	NR	15	NC	NC	NC	0.003	0.006	0.009
	DAP-14	18	46	0	NR	19	NC	NC	NC	0.004	0.008	0.012
	DAP-15	18	46	0	NR	13	NC	NC	NC	0.003	0.005	0.008
	DAP-16	18	46	0	NR	16	NC	NC	NC	0.003	0.007	0.010
	DAP-17	18	46	0	NR	14	NC	NC	NC	0.003	0.006	0.009
	DAP-18	18	46	0	NR	16	NC	NC	NC	0.003	0.007	0.010
	DAP-19	18	46	0	NR	15	NC	NC	NC	0.003	0.006	0.009
	DAP-20	18	46	0	NR	14	NC	NC	NC	0.003	0.006	0.009
	DAP-21	18	46	0	NR	13	NC	NC	NC	0.003	0.005	0.008
	DAP-22	18	46	0	NR	14	NC	NC	NC	0.003	0.006	0.009
	DAP-23	18	46	0	NR	13	NC	NC	NC	0.003	0.005	0.008
	DAP-24	18	46	0	NR	17	NC	NC	NC	0.003	0.007	0.010
	DAP-25	18	46	0	NR	16	NC	NC	NC	0.003	0.007	0.010

Note: Footnotes may be found at the end of this table

Table G-2c. (Continued)

Source[a]	ID[b]	Percent N	Percent P	Percent K	Hg mg/kg	Ni mg/kg	Yearly Hg Addition in kg/ha soil at: 84 lb P_2O_5/A 94 kg/ha	173 lb P_2O_5/A 194 kg/ha	252 lb P_2O_5/A 282 kg/ha	Yearly Ni Addition in kg/ha soil at: 84 lb P_2O_5/A 94 kg/ha	173 lb P_2O_5/A 194 kg/ha	252 lb P_2O_5/A 282 kg/ha
Wash St	H4754	11	52	0	0.0025	19.2	0.000	0.000	0.000	0.003	0.007	0.010
	H4755	18	46	0	0.025	19.1	0.000[g,h]	0.000	0.000	0.004	0.008	0.012
	H4762	16	15	15	0.0025	2.5	0.000	0.000	0.000	0.002	0.003	0.005
	H2526	11	37	0	0.0025	0.5	0.000	0.000	0.000	0.000	0.000	0.000
	H2574	11	30	0	0.0025	13.9	0.000	0.000	0.000	0.004	0.009	0.013
	H2532	16	20	0	0.024	195	0.000	0.000	0.000	0.092	0.189	0.275
	H2546	10	34	0	0.0025	0.5	0.000	0.000	0.000	0.000	0.000	0.000
Raven	MAP-1	11	52	0	0.2	7.4	0.000	0.000	0.000	0.001	0.003	0.004
	MAP-2	11	52	0	0.2	22.2	0.000	0.000	0.000	0.004	0.008	0.012
	DAP-1	18	46	0	0.2	15.5	0.000	0.000	0.000	0.003	0.007	0.010
	DAP-2	18	46	0	0.2	48.3	0.000	0.000	0.000	0.010	0.020	0.030
IMC	8813182	18	46	0	0.05	11	0.000	0.000	0.000	0.002	0.005	0.007
	8813183	11	52	0	0.05	12	0.000	0.000	0.000	0.002	0.004	0.007
	8813184	11	52	0	0.05	10	0.000	0.000	0.000	0.002	0.004	0.005
M&O	DAP(A)	18	46	0	NR	53	NC	NC	NC	0.011	0.022	0.032
	DAP(B)	18	46	0	NR	120	NC	NC	NC	0.025	0.051	0.074
	DAP(C)	18	46	0	NR	125	NC	NC	NC	0.026	0.053	0.077
	DAP(D)	18	46	0	NR	135	NC	NC	NC	0.028	0.057	0.083
MMO	DAP1	21	53	0	NR	10	NC	NC	NC	0.002	0.004	0.005
	DAP2	18	46	0	NR	156	NC	NC	NC	0.032	0.066	0.096
	DAP3	18	46	0	NR	120	NC	NC	NC	0.025	0.051	0.074

Note: Footnotes may be found at the end of this table

Table G-2c. (Continued)

Source	ID[b]	Percent N	Percent P	Percent K	Hg mg/kg	Ni mg/kg	Yearly Hg Addition in kg/ha soil at: 84 lb P_2O_5/A 94 kg/ha	173 lb P_2O_5/A 194 kg/ha	252 lb P_2O_5/A 282 kg/ha	Yearly Ni Addition in kg/ha soil at: 84 lb P_2O_5/A 94 kg/ha	173 lb P_2O_5/A 194 kg/ha	252 lb P_2O_5/A 282 kg/ha
CDFA	24295	10	34	0	NR	NR	NC	NC	NC	NC	NC	NC
	23730	4	21	25	NR	NR	NC	NC	NC	NC	NC	NC
	23845	5	24	24	NR	NR	NC	NC	NC	NC	NC	NC
	23647	4	5	3	NR	NR	NC	NC	NC	NC	NC	NC
	23622	11	52	0	NR	NR	NC	NC	NC	NC	NC	NC
	23202	11	52	0	NR	19	NC	NC	NC	0.003	0.007	0.010
	22278	11	52	0	NR	NR	NC	NC	NC	NC	NC	NC
	22396	11	52	0	NR	NR	NC	NC	NC	NC	NC	NC
	22245	19	24	18	NR	NR	NC	NC	NC	NC	NC	NC
	21842	14.4	23.4	0	NR	NR	NC	NC	NC	NC	NC	NC
	21884	14.2	13	30	NR	NR	NC	NC	NC	NC	NC	NC
	21936	6	20	20	NR	NR	NC	NC	NC	NC	NC	NC
	21946	16	16	16	NR	NR	NC	NC	NC	NC	NC	NC
	21949	15	15	15	NR	NR	NC	NC	NC	NC	NC	NC
	22023	8.5	40	0	NR	NR	NC	NC	NC	NC	NC	NC
	22026	20	20	20	NR	NR	NC	NC	NC	NC	NC	NC
	22244	4	12	8	NR	NR	NC	NC	NC	NC	NC	NC
	25338	18	12	12	NR	NR	NC	NC	NC	NC	NC	NC
	26520	12	61	0	NR	NR	NC	NC	NC	NC	NC	NC
	26361	6	12	6	NR	NR	NC	NC	NC	NC	NC	NC
	26412	18	46	0	NR	NR	NC	NC	NC	NC	NC	NC
	25861	18	46	0	NR	NR	NC	NC	NC	NC	NC	NC
Average		14.1	42.9	2.3	0.07	28.36	0.000	0.000	0.000	0.006	0.013	0.019

a) Sources:
Charter: Charter et al. (1993)
Wash St: Washington State Department of Ecology (1997)
Raven: Raven and Loeppert (1997)
IMC: International Mineral Company (1997)
M&O: Mortvedt and Osborn (1982)
MMO: Mortvedt, Mays and Osborne (1981)
CDFA: California Department of Food and Agriculture (1997)

b) Sample identification used by author

c) MAP = monoammonium phosphate

d) NR = not reported

e) NC = not calculated

f) DAP = diammonium phosphate

g) Shading indicates highest yearly addition values of this metal from NPK products (based on P content)

h) Values chosen for highest yearly addition based on actual detection of Hg in samples; Raven samples are listed as ND, < detection limit of 0.4 and listed here as half the detection limit

Table G-2d. Yearly V and Cu Additions to Soil (kg/ha) from NPK Fertilizers Applied for P_2O_5 Content

Source[a]	ID[b]	Percent N	Percent P	Percent K	V mg/kg	Cu mg/kg	Yearly V Addition in kg/ha soil at: 84 lb P_2O_5/A 94 kg/ha	173 lb P_2O_5/A 194 kg/ha	252 lb P_2O_5/A 282 kg/ha	Yearly Cu Addition in kg/ha soil at: 84 lb P_2O_5/A 94 kg/ha	173 lb P_2O_5/A 194 kg/ha	252 lb P_2O_5/A 282 kg/ha
Charter	MAP-1[c]	11	52	0	NR[d]	0.75	NC[e]	NC	NC	0.000	0.000	0.000
	MAP-2	11	52	0	NR	0.75	NC	NC	NC	0.000	0.000	0.000
	MAP-3	11	52	0	NR	0.75	NC	NC	NC	0.000	0.000	0.000
	MAP-4	11	52	0	NR	0.75	NC	NC	NC	0.000	0.000	0.000
	MAP-5	11	52	0	NR	0.75	NC	NC	NC	0.000	0.000	0.000
	MAP-6	11	52	0	NR	0.75	NC	NC	NC	0.000	0.000	0.000
	MAP-7	11	52	0	NR	0.75	NC	NC	NC	0.000	0.000	0.000
	MAP-8	11	52	0	NR	1.6	NC	NC	NC	0.000	0.001	0.001
	MAP-9	11	52	0	NR	0.75	NC	NC	NC	0.000	0.000	0.000
	MAP-10	11	52	0	NR	0.75	NC	NC	NC	0.000	0.000	0.000
	MAP-11	11	52	0	NR	0.75	NC	NC	NC	0.000	0.000	0.000
	MAP-12	11	52	0	NR	0.75	NC	NC	NC	0.000	0.000	0.000
	MAP-13	11	52	0	NR	0.75	NC	NC	NC	0.000	0.000	0.000
	MAP-14	11	52	0	NR	0.75	NC	NC	NC	0.000	0.000	0.000
	MAP-15	11	52	0	NR	1.6	NC	NC	NC	0.000	0.001	0.001
	MAP-16	11	52	0	NR	0.75	NC	NC	NC	0.000	0.000	0.000
	MAP-17	11	52	0	NR	0.75	NC	NC	NC	0.000	0.000	0.000
	MAP-18	11	52	0	NR	0.75	NC	NC	NC	0.000	0.000	0.000
	MAP-19	11	52	0	NR	0.75	NC	NC	NC	0.000	0.000	0.000
	MAP-20	11	52	0	NR	0.75	NC	NC	NC	0.000	0.000	0.000
	MAP-21	11	52	0	NR	0.75	NC	NC	NC	0.000	0.000	0.000
	MAP-22	11	52	0	NR	0.75	NC	NC	NC	0.000	0.000	0.000
	MAP-23	11	52	0	NR	0.75	NC	NC	NC	0.000	0.000	0.000

Note: Footnotes may be found at the end of the table

Table G-2d. (Continued)

Source[a]	ID[b]	Percent N	Percent P	Percent K	V mg/kg	Cu mg/kg	Yearly V Addition in kg/ha soil at: 84 lb P_2O_5/A 94 kg/ha	173 lb P_2O_5/A 194 kg/ha	252 lb P_2O_5/A 282 kg/ha	Yearly Cu Addition in kg/ha soil at: 84 lb P_2O_5/A 94 kg/ha	173 lb P_2O_5/A 194 kg/ha	252 lb P_2O_5/A 282 kg/ha
Charter	DAP-1[f]	18	46	0	NR	1.6	NC	NC	NC	0.000	0.001	0.001
	DAP-2	18	46	0	NR	0.75	NC	NC	NC	0.000	0.000	0.000
	DAP-3	18	46	0	NR	0.75	NC	NC	NC	0.000	0.000	0.000
	DAP-4	18	46	0	NR	1.6	NC	NC	NC	0.000	0.001	0.001
	DAP-5	18	46	0	NR	0.75	NC	NC	NC	0.000	0.000	0.000
	DAP-6	18	46	0	NR	0.75	NC	NC	NC	0.000	0.000	0.000
	DAP-7	18	46	0	NR	1.6	NC	NC	NC	0.000	0.001	0.001
	DAP-8	18	46	0	NR	0.75	NC	NC	NC	0.000	0.000	0.000
	DAP-9	18	46	0	NR	3.2	NC	NC	NC	0.001	0.001	0.002
	DAP-10	18	46	0	NR	0.75	NC	NC	NC	0.000	0.000	0.000
	DAP-11	18	46	0	NR	1.6	NC	NC	NC	0.000	0.001	0.001
	DAP-12	18	46	0	NR	1.6	NC	NC	NC	0.000	0.001	0.001
	DAP-13	18	46	0	NR	0.75	NC	NC	NC	0.000	0.000	0.000
	DAP-14	18	46	0	NR	1.6	NC	NC	NC	0.000	0.001	0.001
	DAP-15	18	46	0	NR	0.75	NC	NC	NC	0.000	0.000	0.000
	DAP-16	18	46	0	NR	0.75	NC	NC	NC	0.000	0.000	0.000
	DAP-17	18	46	0	NR	0.75	NC	NC	NC	0.000	0.000	0.000
	DAP-18	18	46	0	NR	2.1	NC	NC	NC	0.000	0.001	0.001
	DAP-19	18	46	0	NR	0.75	NC	NC	NC	0.000	0.000	0.000
	DAP-20	18	46	0	NR	0.75	NC	NC	NC	0.000	0.000	0.000
	DAP-21	18	46	0	NR	0.75	NC	NC	NC	0.000	0.000	0.000
	DAP-22	18	46	0	NR	0.75	NC	NC	NC	0.000	0.000	0.000
	DAP-23	18	46	0	NR	0.75	NC	NC	NC	0.000	0.000	0.000
	DAP-24	18	46	0	NR	1.6	NC	NC	NC	0.000	0.001	0.001
	DAP-25	18	46	0	NR	0.75	NC	NC	NC	0.000	0.000	0.000

Note: Footnotes may be found at the end of this table

Table G-2d. (Continued)

Source[a]	ID[b]	Percent N	Percent P	Percent K	V mg/kg	Cu mg/kg	Yearly V Addition in kg/ha soil at: 84 lb P_2O_5/A 94 kg/ha	173 lb P_2O_5/A 194 kg/ha	252 lb P_2O_5/A 282 kg/ha	Yearly Cu Addition in kg/ha soil at: 84 lb P_2O_5/A 94 kg/ha	173 lb P_2O_5/A 194 kg/ha	252 lb P_2O_5/A 282 kg/ha
Wash St	H4754	11	52	0	37.9	3.6	0.007	0.014	0.021	0.001	0.001	0.002
	H4755	18	46	0	174	5.4	0.036	0.073	0.107	0.001	0.002	0.003
	H4762	16	15	15	25.7	80.7	0.016	0.033	0.048	0.051	0.104	0.152
	H2526	11	37	0	31.7	0.5	0.008	0.017	0.024	0.000	0.000	0.000
	H2574	11	30	0	32	5.8	0.010	0.021	0.030	0.002	0.004	0.005
	H2532	16	20	0	396	16	0.186[g]	0.384	0.558	0.008	0.016	0.023
	H2546	10	34	0	228	3.3	0.063	0.130	0.189	0.001	0.002	0.003
Raven	MAP-1	11	52	0	146	13.2	0.026	0.054	0.079	0.002	0.005	0.007
	MAP-2	11	52	0	205	1	0.037	0.076	0.111	0.000	0.000	0.001
	DAP-1	18	46	0	177	1	0.036	0.075	0.109	0.000	0.000	0.001
	DAP-2	18	46	0	237	41.8	0.048	0.100	0.145	0.009	0.018	0.026
IMC	8813182	18	46	0	180	0.45	0.037	0.076	0.110	0.000	0.000	0.000
	8813183	11	52	0	200	0.44	0.036	0.075	0.108	0.000	0.000	0.000
	8813184	11	52	0	250	1.3	0.045	0.093	0.136	0.000	0.000	0.001
M&O	DAP(A)	18	46	0	NR	5	NC	NC	NC	0.001	0.002	0.003
	DAP(B)	18	46	0	NR	8	NC	NC	NC	0.002	0.003	0.005
	DAP(C)	18	46	0	NR	35	NC	NC	NC	0.007	0.015	0.021
	DAP(D)	18	46	0	NR	98	NC	NC	NC	0.020	0.041	0.060
MMO	DAP1	21	53	0	NR	1	NC	NC	NC	0.000	0.000	0.001
	DAP2	18	46	0	NR	8	NC	NC	NC	0.002	0.003	0.005
	DAP3	18	46	0	NR	18	NC	NC	NC	0.004	0.008	0.011

Note: Footnotes may be found at the end of this table

Table G-2d. (Continued)

Source[a]	ID[b]	Percent N	Percent P	Percent K	V mg/kg	Cu mg/kg	Yearly V Addition in kg/ha soil at: 84 lb P_2O_5/A 94 kg/ha	173 lb P_2O_5/A 194 kg/ha	252 lb P_2O_5/A 282 kg/ha	Yearly Cu Addition in kg/ha soil at: 84 lb P_2O_5/A 94 kg/ha	173 lb P_2O_5/A 194 kg/ha	252 lb P_2O_5/A 282 kg/ha
CDFA	24295	10	34	0	NR	0	NC	NC	NC	0.000	0.000	0.000
	23730	4	21	25	NR	245	NC	NC	NC	0.110	0.226	0.329
	23845	5	24	24	NR	190	NC	NC	NC	0.074	0.154	0.223
	23647	4	5	3	NR	52	NC	NC	NC	0.098	0.202	0.293
	23622	11	52	0	NR	65.5	NC	NC	NC	0.012	0.024	0.036
	23202	11	52	0	NR	11.5	NC	NC	NC	0.002	0.004	0.006
	22278	11	52	0	NR	53	NC	NC	NC	0.010	0.020	0.029
	22396	11	52	0	NR	62	NC	NC	NC	0.011	0.023	0.034
	22245	19	24	18	NR	NR	NC	NC	NC	NC	NC	NC
	21842	14.4	23.4	0	NR	310	NC	NC	NC	0.125	0.257	0.374
	21884	14.2	13	30	NR	29.5	NC	NC	NC	0.021	0.044	0.064
	21936	6	20	20	NR	144	NC	NC	NC	0.068	0.140	0.203
	21946	16	16	16	NR	3	NC	NC	NC	0.002	0.004	0.005
	21949	15	15	15	NR	14	NC	NC	NC	0.009	0.018	0.026
	22023	8.5	40	0	NR	700	NC	NC	NC	0.165	0.340	0.494
	22026	20	20	20	NR	NR	NC	NC	NC	NC	NC	NC
	22244	4	12	8	NR	4.5	NC	NC	NC	0.004	0.007	0.011
	25338	18	12	12	NR	450	NC	NC	NC	0.353	0.728	1.058
	26520	12	61	0	NR	2	NC	NC	NC	0.000	0.001	0.001
	26361	6	12	6	NR	12	NC	NC	NC	0.009	0.019	0.028
	26412	18	46	0	NR	9	NC	NC	NC	0.002	0.004	0.006
	25861	18	46	0	NR	9.5	NC	NC	NC	0.002	0.004	0.006
Average		14.1	42.9	2.3	165.7	31.0	0.042	0.087	0.127	0.013	0.028	0.040

a) Sources:
Charter: Charter et al. (1993)
Wash St: Washington State Department of Ecology (1997)
Raven: Raven and Loeppert (1997)
IMC: International Mineral Company (1997)
M&O: Mortvedt and Osborn (1982)
MMO: Mortvedt, Mays and Osborne (1981)
CDFA: California Department of Food and Agriculture (1997)

b) Sample identification used by author

c) MAP = monoammonium phosphate

d) NR = not reported

e) NC = not calculated

f) DAP = diammonium phosphate

g) Shading indicates highest yearly addition values of this metal from NPK products (based on P content)

Table G-2e. Yearly Zn Additions to Soil (kg/ha) from NPK Fertilizers Applied for P_2O_5 Content

Source[a]	ID[b]	Percent N	Percent P	Percent K	Zn mg/kg	Yearly Zn Addition in kg/ha soil at: 84 lb P_2O_5/A 94 kg/ha	173 lb P_2O_5/A 194 kg/ha	252 lb P_2O_5/A 282 kg/ha
Charter	MAP-1[c]	11	52	0	60	0.011	0.022	0.033
	MAP-2	11	52	0	64	0.012	0.024	0.035
	MAP-3	11	52	0	67	0.012	0.025	0.036
	MAP-4	11	52	0	72	0.013	0.027	0.039
	MAP-5	11	52	0	70	0.013	0.026	0.038
	MAP-6	11	52	0	68	0.012	0.025	0.037
	MAP-7	11	52	0	65	0.012	0.024	0.035
	MAP-8	11	52	0	81	0.015	0.030	0.044
	MAP-9	11	52	0	73	0.013	0.027	0.040
	MAP-10	11	52	0	63	0.011	0.024	0.034
	MAP-11	11	52	0	78	0.014	0.029	0.042
	MAP-12	11	52	0	80	0.014	0.030	0.043
	MAP-13	11	52	0	91	0.016	0.034	0.049
	MAP-14	11	52	0	80	0.014	0.030	0.043
	MAP-15	11	52	0	83	0.015	0.031	0.045
	MAP-16	11	52	0	63	0.011	0.024	0.034
	MAP-17	11	52	0	80	0.014	0.030	0.043
	MAP-18	11	52	0	76	0.014	0.028	0.041
	MAP-19	11	52	0	72	0.013	0.027	0.039
	MAP-20	11	52	0	70	0.013	0.026	0.038
	MAP-21	11	52	0	76	0.014	0.028	0.041
	MAP-22	11	52	0	90	0.016	0.034	0.049
	MAP-23	11	52	0	95	0.017	0.035	0.052

Note: Footnotes may be found at the end of this table

Table G-2e. (Continued)

Source[a]	ID[b]	Percent N	Percent P	Percent K	Zn mg/kg	Yearly Zn Addition in kg/ha soil at: 84 lb P_2O_5/A 94 kg/ha	173 lb P_2O_5/A 194 kg/ha	252 lb P_2O_5/A 282 kg/ha
Charter	DAP-1[d]	18	46	0	85	0.017	0.036	0.052
	DAP-2	18	46	0	86	0.018	0.036	0.053
	DAP-3	18	46	0	87	0.018	0.037	0.053
	DAP-4	18	46	0	80	0.016	0.034	0.049
	DAP-5	18	46	0	2193	0.448	0.925	1.344
	DAP-6	18	46	0	84	0.017	0.035	0.051
	DAP-7	18	46	0	59	0.012	0.025	0.036
	DAP-8	18	46	0	86	0.018	0.036	0.053
	DAP-9	18	46	0	97	0.020	0.041	0.059
	DAP-10	18	46	0	86	0.018	0.036	0.053
	DAP-11	18	46	0	96	0.020	0.040	0.059
	DAP-12	18	46	0	88	0.018	0.037	0.054
	DAP-13	18	46	0	86	0.018	0.036	0.053
	DAP-14	18	46	0	86	0.018	0.036	0.053
	DAP-15	18	46	0	91	0.019	0.038	0.056
	DAP-16	18	46	0	93	0.019	0.039	0.057
	DAP-17	18	46	0	89	0.018	0.038	0.055
	DAP-18	18	46	0	91	0.019	0.038	0.056
	DAP-19	18	46	0	85	0.017	0.036	0.052
	DAP-20	18	46	0	97	0.020	0.041	0.059
	DAP-21	18	46	0	96	0.020	0.040	0.059
	DAP-22	18	46	0	71	0.015	0.030	0.044
	DAP-23	18	46	0	72	0.015	0.030	0.044
	DAP-24	18	46	0	98	0.020	0.041	0.060
	DAP-25	18	46	0	72	0.015	0.030	0.044

Note: Footnotes may be found at the end of this table

Table G-2e. (Continued)

Source[a]	ID[b]	Percent N	Percent P	Percent K	Zn mg/kg	Yearly Zn Addition in kg/ha soil at: 84 lb P_2O_5/A 94 kg/ha	173 lb P_2O_5/A 194 kg/ha	252 lb P_2O_5/A 282 kg/ha
Wash St	H4754	11	52	0	54	0.010	0.020	0.029
	H4755	18	46	0	81.6	0.017	0.034	0.050
	H4762	16	15	15	81.6	0.051	0.106	0.153
	H2562	11	37	0	25.3	0.006	0.013	0.019
	H2574	11	30	0	301	0.094	0.195	0.283
	H2532	16	20	0	1480	0.696[e]	1.436	2.087
	H2564	10	34	0	315	0.087	0.180	0.261
Raven	MAP-1	11	52	0	10.3	0.002	0.004	0.006
	MAP-2	11	52	0	NR[f]	NC[g]	NC	NC
	DAP-1	18	46	0	NR	NC	NC	NC
	DAP-2	18	46	0	386	0.079	0.163	0.237
IMC	8813182	18	46	0	57	0.012	0.024	0.035
	8813183	11	52	0	65	0.012	0.024	0.035
	8813184	11	52	0	58	0.010	0.022	0.031
M&O	DAP(A)	18	46	0	540	0.110	0.228	0.331
	DAP(B)	18	46	0	960	0.196	0.405	0.589
	DAP(C)	18	46	0	1315	0.269	0.555	0.806
	DAP(D)	18	46	0	1400	0.286	0.590	0.858
MMO	DAP1	21	53	0	1	0.000	0.000	0.001
	DAP2	18	46	0	1260	0.257	0.531	0.772
	DAP3	18	46	0	1290	0.264	0.544	0.791

Note: Footnotes may be found at the end of this table

Table G-2e. (Continued)

Source[a]	ID[b]	Percent N	Percent P	Percent K	Zn mg/kg	Yearly Zn Addition in kg/ha soil at: 84 lb P_2O_5/A 94 kg/ha	173 lb P_2O_5/A 194 kg/ha	252 lb P_2O_5/A 282 kg/ha
CDFA	24295	10	34	0	NR	NC	NC	NC
	23730	4	21	25	NR	NC	NC	NC
	23845	5	24	24	NR	NC	NC	NC
	23647	4	5	3	NR	NC	NC	NC
	23622	11	52	0	NR	NC	NC	NC
	23202	11	52	0	NR	NC	NC	NC
	22278	11	52	0	NR	NC	NC	NC
	22396	11	52	0	NR	NC	NC	NC
	22245	19	24	18	NR	NC	NC	NC
	21842	14.4	23.4	0	NR	NC	NC	NC
	21884	14.2	13	30	NR	NC	NC	NC
	21936	6	20	20	NR	NC	NC	NC
	21946	16	16	16	NR	NC	NC	NC
	21949	15	15	15	NR	NC	NC	NC
	22023	8.5	40	0	NR	NC	NC	NC
	22026	20	20	20	NR	NC	NC	NC
	22244	4	12	8	NR	NC	NC	NC
	25338	18	12	12	NR	NC	NC	NC
	26520	12	61	0	NR	NC	NC	NC
	26361	6	12	6	NR	NC	NC	NC
	26412	18	46	0	NR	NC	NC	NC
	25861	18	46	0	NR	NC	NC	NC
Average		14.1	42.9	2.3	233.6	0.054	0.112	0.163

a) Sources:
Charter: Charter et al. (1995)
Wash St: Washington State Department of Ecology (1997)
Raven: Raven and Loeppert (1997)
IMC: International Mineral Company (1997)
M&O: Mortvedt and Osborn (1982)
MMO: Mortvedt, Mays and Osborne (1981)
CDFA: California Department of Food and Agriculture (1997)

b) Sample identification used by author

c) MAP = monoammonium phosphate

d) DAP = diammonium phosphate

e) Shading indicates highest yearly addition values of this metal from NPK products (based on P content)

f) NR = not reported

g) NC = not calculated

Table G-3a. Yearly Cd and Pb Additions to Soil (kg/ha) from NPK Fertilizers Applied for N Content

Source[a]	ID Number[b]	Percent			Cd mg/kg	Pb mg/kg	Yearly Cd addition in kg/ha at			Yearly Pb addition in kg/ha at		
							124 lb N/A	206 lb N/A	414 lb N/A	124 lb N/A	206 lb N/A	414 lb N/A
		N	P	K			139 kg/ha	231 kg/ha	464 kg/ha	139 kg/ha	231 kg/ha	464 kg/ha
PDA	B960243	19	19	19	3.5	2.2	0.003	0.004	0.009	0.002	0.003	0.005
	B960244	12	24	24	4.3	4.6	0.005	0.008	0.017	0.005	0.009	0.018
	B960249	7	35	12	4.6	3.9	0.009	0.015	0.030	0.008	0.013	0.026
	B960282	9	44	9	2.3	3.5	0.004	0.006	0.012	0.005	0.009	0.018
	B960325	10	21	15	2.7	11.1	0.004	0.006	0.013	0.015	0.026	0.052
	B960333	8	32	16	3.9	5.3	0.007	0.011	0.023	0.009	0.015	0.031
	B960389	19	19	19	1.6	1.4	0.001	0.002	0.004	0.001	0.002	0.003
	B960412	7	26	26	2.6	2.8	0.005	0.009	0.017	0.006	0.009	0.019
	B960418	19	19	19	2.2	3.8	0.002	0.003	0.005	0.003	0.005	0.009
	B960441	9	34	10	3.3	3.6	0.005	0.008	0.017	0.006	0.009	0.019
	B960442	9	3	10	3.6	3	0.006	0.009	0.019	0.005	0.008	0.015
	B960453	10	20	20	4.3	3	0.006	0.010	0.020	0.004	0.007	0.014
	B960475	9	40	5	14.3	422	0.022[c]	0.037	0.074	0.652	1.083	2.176
	B960510	9	43	10	5.2	1.7	0.008	0.013	0.027	0.003	0.004	0.009
	B960580	10	10	10	1.8	3.6	0.003	0.004	0.008	0.005	0.008	0.017
	B960584	10	20	20	2.6	2.5	0.004	0.006	0.012	0.003	0.006	0.012
	B960599	15	15	15	2.1	2.1	0.002	0.003	0.006	0.002	0.003	0.006
	B960611	19	19	19	24.35	1.1	0.018	0.030	0.059	0.001	0.001	0.003
	B960639	6	2	0	5.7	6.9	0.013	0.022	0.044	0.016	0.027	0.053
	B960708	7	27	11	6.4	153	0.013	0.021	0.042	0.304	0.505	1.014
	B960711	8	24	8	9.5	14	0.017	0.027	0.055	0.024	0.040	0.081
	B960713	10	20	10	2.4	6.7	0.003	0.006	0.011	0.009	0.015	0.031
	B960715	15	15	15	2	1.8	0.002	0.003	0.006	0.002	0.003	0.006
	B980726	19	19	19	4.1	3.7	0.003	0.005	0.010	0.003	0.004	0.009
	B960820	26	9	9	2	2.3	0.001	0.002	0.004	0.001	0.002	0.004
	B960896	10	20	20	3.3	3.6	0.005	0.008	0.015	0.005	0.008	0.017
	B960900	10	20	20	3.1	3.3	0.004	0.007	0.014	0.005	0.008	0.015
	B960909	3	17	40	2.4	2.6	0.011	0.018	0.037	0.012	0.020	0.040
	B960912	3	17	40	4.3	3.9	0.020	0.033	0.067	0.018	0.030	0.060
	B960913	8	41	12	1.5	18	0.003	0.004	0.009	0.031	0.052	0.104
	B961058	8	17	34	1	2.4	0.002	0.003	0.006	0.004	0.007	0.014
	B961321	9	43	10	4.7	6.9	0.007	0.012	0.024	0.011	0.018	0.036
Wash St	H0751	46	0	0	0.15	1	0.000	0.000	0.000	0.000	0.001	0.001
	H0752	20	0	0	0.03	0.2	0.000	0.000	0.000	0.000	0.000	0.000
	H2538	32	0	0	0.03	0.2	0.000	0.000	0.000	0.000	0.000	0.000
	H1233	17	0	0	0.15	1	0.000	0.000	0.000	0.001	0.001	0.003
	H0754	15.5	0	0	0.8	5.5	0.001	0.001	0.002	0.005	0.008	0.016
	H4769	21	0	0	1.2	15	0.001	0.001	0.003	0.010	0.017	0.033
	H4771	34.5	0	0	0.15	1	0.000	0.000	0.000	0.000	0.001	0.001

Table G-3a. Continued

Source[a]	ID Number[b]	Percent N	Percent P	Percent K	Cd mg/kg	Pb mg/kg	Yearly Cd addition in kg/ha at 124 lb N/A 139 kg/ha	Yearly Cd addition in kg/ha at 206 lb N/A 231 kg/ha	Yearly Cd addition in kg/ha at 414 lb N/A 464 kg/ha	Yearly Pb addition in kg/ha at 124 lb N/A 139 kg/ha	Yearly Pb addition in kg/ha at 206 lb N/A 231 kg/ha	Yearly Pb addition in kg/ha at 414 lb N/A 464 kg/ha
Raven	Urea[d]	46	0	0	0.1	0.2	0.000	0.000	0.000	0.000	0.000	0.000
	NH_4NO_3[e]	34	0	0	0.1	0.2	0.000	0.000	0.000	0.000	0.000	0.000
	NH_4SO_4[e]	21	0	0	0.1	0.2	0.000	0.000	0.000	0.000	0.000	0.000
	NH_4SO_4[e]	21	0	0	0.1	0.2	0.000	0.000	0.000	0.000	0.000	0.000
CDFA	25042	20	0	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000
	21575	32	10	10	0	0	0.000	0.000	0.000	0.000	0.000	0.000
	24276	14	3	7	0	2	0.000	0.000	0.000	0.002	0.003	0.007
	23106	7	2	2	0	3	0.000	0.000	0.000	0.006	0.010	0.020
	22080	34	17	0	47	2.5	0.019	0.032	0.064	0.001	0.002	0.003
	22216	9	4	4	12.5	71	0.019	0.032	0.064	0.110	0.182	0.366
	20891	16	4	8	23	255	0.020	0.033	0.067	0.222	0.368	0.740
Average		23.2	2.4	2.5	6.2	69.6	0.006	0.009	0.018	0.031	0.051	0.103

a) Sources:
PDA: Pennsylvania Department of Agriculture (1998)
Wash St: Washington State Deparmtent of Ecology (1997)
Raven: Raven and Loeppert (1997)
CDFA: California Department of Food & Agriculture (1997)

b) Sample identification used by author.
c) Shading indicates highest yearly addition values for this metal from NPK products applied for N content.
d) NPK rating not given, see Table 3-4.
e) NPK rating not given, granular grade used.

Table G-3b. Yearly As and Cr Additions to Soil (kg/ha) from NPK Fertilizers Applied for N Content

Source[a]	ID Number[b]	Percent			As mg/kg	Cr mg/kg	Yearly As addition in kg/ha at			Yearly Cr addition in kg/ha at		
							124 lb N/A	206 lb N/A	414 lb N/A	124 lb N/A	206 lb N/A	414 lb N/A
		N	P	K			139 kg/ha	231 kg/ha	464 kg/ha	139 kg/ha	231 kg/ha	464 kg/ha
PDA	B960243	19	19	19	6.6	45.4	0.005	0.008	0.016	0.033	0.055	0.111
	B960244	12	24	24	9.8	59	0.011	0.019	0.038	0.068	0.114	0.228
	B960249	7	35	12	9.7	66.8	0.019	0.032	0.064	0.133	0.220	0.443
	B960282	9	44	9	13.2	90.7	0.020	0.034	0.068	0.140	0.233	0.468
	B960325	10	21	15	7.2	46.3	0.010	0.017	0.033	0.064	0.107	0.215
	B960333	8	32	16	11.2	68.1	0.019	0.032	0.065	0.118	0.197	0.395
	B960389	19	19	19	5.2	43.5	0.004	0.006	0.013	0.032	0.053	0.106
	B960412	7	26	26	6	51.8	0.012	0.020	0.040	0.103	0.171	0.343
	B960418	19	19	19	7.5	62	0.005	0.009	0.018	0.045	0.075	0.151
	B960441	9	34	10	10.7	67.4	0.017	0.027	0.055	0.104	0.173	0.347
	B960442	9	3	10	9.2	88.8	0.014	0.024	0.047	0.137	0.228	0.458
	B960453	10	20	20	3.6	68.7	0.005	0.008	0.017	0.095	0.159	0.319
	B960475	9	40	5	10	107.9	0.015	0.026	0.052	0.167	0.277	0.556
	B960510	9	43	10	11.2	79.4	0.017	0.029	0.058	0.123	0.204	0.409
	B960580	10	10	10	4.1	51.4	0.006	0.009	0.019	0.071	0.119	0.238
	B960584	10	20	20	6.9	52.8	0.010	0.016	0.032	0.073	0.122	0.245
	B960599	15	15	15	4.9	42.5	0.005	0.008	0.015	0.039	0.065	0.131
	B960611	19	19	19	0	160	0.000	0.000	0.000	0.117	0.195	0.391
	B960639	6	2	0	4.7	40.3	0.011	0.018	0.036	0.093	0.155	0.312
	B960708	7	27	11	9	73.2	0.018	0.030	0.060	0.145	0.242	0.485
	B960711	8	24	8	3.5	60.5	0.006	0.010	0.020	0.105	0.175	0.351
	B960713	10	20	10	5.4	42	0.008	0.012	0.025	0.058	0.097	0.195
	B960715	15	15	15	4.7	28	0.004	0.007	0.015	0.026	0.043	0.087
	B980726	19	19	19	7.8	48.8	0.006	0.009	0.019	0.036	0.059	0.119
	B960820	26	9	9	4.1	34.2	0.002	0.004	0.007	0.018	0.030	0.061
	B960896	10	20	20	7	39	0.010	0.016	0.032	0.054	0.090	0.181
	B960900	10	20	20	7.4	201	0.010	0.017	0.034	0.279	0.464	0.933
	B960909	3	17	40	5.1	34.3	0.024	0.039	0.079	0.159	0.264	0.531
	B960912	3	17	40	10.5	67.4	0.049	0.981	0.162	0.312	0.519	1.042
	B960913	8	41	12	6.2	68.3	0.011	0.018	0.036	0.119	0.197	0.396
	B961058	8	17	34	3.1	30.8	0.005	0.009	0.018	0.054	0.089	0.179
	B961321	9	43	10	10.7	69.8	0.017	0.027	0.055	0.108	0.179	0.360
Wash St	H0751	46	0	0	1.5	2.2	0.000	0.001	0.002	0.001	0.001	0.002
	H0752	20	0	0	0.3	0.05	0.000	0.000	0.001	0.000	0.000	0.000
	H2538	32	0	0	0.3	0.15	0.000	0.000	0.000	0.000	0.000	0.000
	H1233	17	0	0	1.5	2	0.001	0.002	0.004	0.002	0.003	0.005
	H0754	15.5	0	0	8	1.4	0.007	0.012	0.024	0.001	0.002	0.004
	H4769	21	0	0	1.5	0.7	0.001	0.002	0.003	0.000	0.001	0.002
	H4771	34.5	0	0	1.5	0.25	0.001	0.001	0.002	0.000	0.000	0.000

Table G-3b. Continued

Source[a]	ID Number[b]	Percent N	Percent P	Percent K	As mg/kg	Cr mg/kg	Yearly As addition in kg/ha at 124 lb N/A 139 kg/ha	Yearly As addition in kg/ha at 206 lb N/A 231 kg/ha	Yearly As addition in kg/ha at 414 lb N/A 464 kg/ha	Yearly Cr addition in kg/ha at 124 lb N/A 139 kg/ha	Yearly Cr addition in kg/ha at 206 lb N/A 231 kg/ha	Yearly Cr addition in kg/ha at 414 lb N/A 464 kg/ha
Raven	Urea[d]	46	0	0	0.2	NR[e]	0.000	0.000	0.000	NC[f]	NC	NC
	NH_4NO_3[g]	34	0	0	0.2	NR	0.000	0.000	0.000	NC	NC	NC
	NH_4SO_4[g]	21	0	0	0.2	NR	0.000	0.000	0.000	NC	NC	NC
	NH_4SO_4[g]	21	0	0	0.4	2.14	0.000	0.000	0.001	0.001	0.002	0.005
CDFA	25042	20	0	0	0	NR	0.000	0.000	0.000	NC	NC	NC
	21575	32	10	10	0.6	NR	0.000	0.000	0.001	NC	NC	NC
	24276	14	3	7	1.5	NR	0.001	0.002	0.005	NC	NC	NC
	23106	7	2	2	0.15	NR	0.000	0.000	0.001	NC	NC	NC
	22080	34	17	0	4.5	NR	0.002	0.003	0.006	NC	NC	NC
	22216	9	4	4	4.3	NR	0.007	0.011	0.022	NC	NC	NC
	20891	16	4	8	8.4	NR	0.007	0.012	0.024	NC	NC	NC
Average		23.2	2.35	2.5	3.4	1.1	0.008	0.013	0.027	0.081	0.134	0.270

a) Sources:
PDA: Pennsylvania Department of Agriculture (1998)
Wash St: Washington State Deparmtent of Ecology (1997)
Raven: Raven and Loeppert (1997)
CDFA: California Department of Food & Agriculture (1997)

b) Sample identification used by author.
c) Shading indicates highest yearly addition values for this metal from NPK products applied for N content.
d) NPK rating not given, see Table 3-4.
e) NR = not reported.
f) NC = not calculated.
g) NPK rating not given, granular grade used.

Table G-3c. Yearly Hg and Ni Additions to Soil (kg/ha) from NPK Fertilizers Applied for N Content

Source[a]	ID Number[b]	Percent N	Percent P	Percent K	Hg mg/kg	Ni mg/kg	Yearly Hg addition in kg/ha at 124 lb N/A 139 kg/ha	Yearly Hg addition in kg/ha at 206 lb N/A 231 kg/ha	Yearly Hg addition in kg/ha at 414 lb N/A 464 kg/ha	Yearly Ni addition in kg/ha at 124 lb N/A 139 kg/ha	Yearly Ni addition in kg/ha at 206 lb N/A 231 kg/ha	Yearly Ni addition in kg/ha at 414 lb N/A 464 kg/ha
PDA	B960243	19	19	19	0	11.2	0.000	0.000	0.000	0.008	0.014	0.027
	B960244	12	24	24	0	14.7	0.000	0.000	0.000	0.017	0.028	0.057
	B960249	7	35	12	0	20.9	0.000	0.000	0.000	0.042	0.069	0.139
	B960282	9	44	9	0	14.5	0.000	0.000	0.000	0.022	0.037	0.075
	B960325	10	21	15	0.17	13.4	0.000	0.000	0.001	0.019	0.031	0.062
	B960333	8	32	16	0	14.9	0.000	0.000	0.000	0.026	0.043	0.086
	B960389	19	19	19	0	0	0.000	0.000	0.000	0.000	0.000	0.000
	B960412	7	26	26	0	11.5	0.000	0.000	0.000	0.023	0.038	0.076
	B960418	19	19	19	0	9.2	0.000	0.000	0.000	0.007	0.011	0.022
	B960441	9	34	10	0	12.2	0.000	0.000	0.000	0.019	0.031	0.063
	B960442	9	3	10	0	14.5	0.000	0.000	0.000	0.022	0.037	0.075
	B960453	10	20	20	0	18	0.000	0.000	0.000	0.025	0.042	0.084
	B960475	9	40	5	0	29.2	0.000	0.000	0.000	0.045	0.075	0.151
	B960510	9	43	10	0	17.8	0.000	0.000	0.000	0.027	0.046	0.092
	B960580	10	10	10	0	14.6	0.000	0.000	0.000	0.020	0.034	0.068
	B960584	10	20	20	0	15.7	0.000	0.000	0.000	0.022	0.036	0.073
	B960599	15	15	15	0	11.4	0.000	0.000	0.000	0.011	0.018	0.035
	B960611	19	19	19	0	36.9	0.000	0.000	0.000	0.027	0.045	0.090
	B960639	6	2	0	0	11.2	0.000	0.000	0.000	0.026	0.043	0.087
	B960708	7	27	11	0	22.7	0.000	0.000	0.000	0.045	0.075	0.150
	B960711	8	24	8	0	11.9	0.000	0.000	0.000	0.021	0.034	0.069
	B960713	10	20	10	0	10.1	0.000	0.000	0.000	0.014	0.023	0.047
	B960715	15	15	15	0	6.2	0.000	0.000	0.000	0.006	0.010	0.019
	B980726	19	19	19	0	11.5	0.000	0.000	0.000	0.008	0.014	0.028
	B960820	26	9	9	0	8	0.000	0.000	0.000	0.004	0.007	0.014
	B960896	10	20	20	0	8.6	0.000	0.000	0.000	0.012	0.020	0.040
	B960900	10	20	20	0	85.7	0.000	0.000	0.000	0.119[c]	0.198	0.398
	B960909	3	17	40	0	5.7	0.000	0.000	0.000	0.026	0.044	0.088
	B960912	3	17	40	0	12	0.000	0.000	0.000	0.056	0.092	0.186
	B960913	8	41	12	0	14.8	0.000	0.000	0.000	0.026	0.043	0.086
	B961058	8	17	34	0	8.9	0.000	0.000	0.000	0.015	0.026	0.052
	B961321	9	43	10	0	13.3	0.000	0.000	0.000	0.021	0.034	0.069
Wash St	H0751	46	0	0	0	0.5	0.000	0.000	0.000	0.000	0.000	0.001
	H0752	20	0	0	0	0.1	0.000	0.000	0.000	0.000	0.000	0.000
	H2538	32	0	0	0	0.1	0.000	0.000	0.000	0.000	0.000	0.000
	H1233	17	0	0	0	0.5	0.000	0.000	0.000	0.000	0.001	0.001
	H0754	15.5	0	0	0	2.5	0.000	0.000	0.000	0.002	0.004	0.007
	H4769	21	0	0	0.40	0.5	0.000	0.000	0.001	0.000	0.001	0.001
	H4771	34.5	0	0	0	0.5	0.000	0.000	0.000	0.000	0.000	0.001
Raven	Urea[d]	46	0	0	0.2	0.1	0.000	0.000	0.000	0.000	0.000	0.000
	NH_4NO_3[e]	34	0	0[d]	0.2	0.1	0.000	0.000	0.000	0.000	0.000	0.000
	NH_4SO_4[e]	21	0	0[e]	0.2	0.1	0.000	0.000	0.000	0.000	0.000	0.000
	NH_4SO_4[e]	21	0	0[e]	0.2	0.6	0.000	0.000	0.000	0.000	0.001	0.001

Table G-3c. Continued

Source[a]	ID Number[b]	Percent N	Percent P	Percent K	Hg mg/kg	Ni mg/kg	Yearly Hg addition in kg/ha at 124 lb N/A 139 kg/ha	Yearly Hg addition in kg/ha at 206 lb N/A 231 kg/ha	Yearly Hg addition in kg/ha at 414 lb N/A 464 kg/ha	Yearly Ni addition in kg/ha at 124 lb N/A 139 kg/ha	Yearly Ni addition in kg/ha at 206 lb N/A 231 kg/ha	Yearly Ni addition in kg/ha at 414 lb N/A 464 kg/ha
CDFA	25042	20	0	0	NR[f]	NR	NC[g]	NC	NC	NC	NC	NC
	21575	32	10	10	NR	NR	NC	NC	NC	NC	NC	NC
	24276	14	3	7	NR	NR	NC	NC	NC	NC	NC	NC
	23106	7	2	2	NR	NR	NC	NC	NC	NC	NC	NC
	22080	34	17	0	NR	NR	NC	NC	NC	NC	NC	NC
	22216	9	4	4	NR	NR	NC	NC	NC	NC	NC	NC
	20891	16	4	8	NR	NR	NC	NC	NC	NC	NC	NC
Average		23.2	2.4	2.5	0.11	0.51	0.000	0.000	0.000	0.018	0.030	0.061

a) Sources:
PDA: Pennsylvania Department of Agriculture (1998)
Wash St: Washington State Deparmtent of Ecology (1997)
Raven: Raven and Loeppert (1997)
CDFA: California Department of Food & Agriculture (1997)

b) Sample identification used by author.
c) Shading indicates highest yearly addition values for this metal from NPK products applied for N content.
d) NPK rating not given, see Table 3-4.
e) NPK rating not given, granular grade used.
f) NR = not reported.
g) NC = not calculated.

Table G-3d. Yearly V and Cu Additions to Soil (kg/ha) from NPK Fertilizers Applied for N Content

Source[a]	ID Number[b]	Percent N	Percent P	Percent K	V mg/kg	Cu mg/kg	Yearly V addition in kg/ha at 124 lb N/A 139 kg/ha	Yearly V addition in kg/ha at 206 lb N/A 231 kg/ha	Yearly V addition in kg/ha at 414 lb N/A 464 kg/ha	Yearly Cu addition in kg/ha at 124 lb N/A 139 kg/ha	Yearly Cu addition in kg/ha at 206 lb N/A 231 kg/ha	Yearly Cu addition in kg/ha at 414 lb N/A 464 kg/ha
PDA	B960243	19	19	19	85.2	25.6	0.062	0.104	0.208	0.019	0.031	0.063
	B960244	12	24	24	119	49.3	0.138	0.229	0.460	0.057	0.095	0.191
	B960249	7	35	12	116	45	0.230	0.383	0.769	0.089	0.149	0.298
	B960282	9	44	9	163	30.1	0.252	0.418	0.840	0.046	0.077	0.155
	B960325	10	21	15	87.7	10.2	0.122	0.203	0.407	0.014	0.024	0.047
	B960333	8	32	16	126	22.2	0.219	0.364	0.731	0.039	0.064	0.129
	B960389	19	19	19	77.7	0	0.057	0.094	0.190	0.000	0.000	0.000
	B960412	7	26	26	79.4	26.2	0.158	0.262	0.526	0.052	0.086	0.174
	B960418	19	19	19	97.8	13.7	0.072	0.119	0.239	0.010	0.017	0.033
	B960441	9	34	10	121	16.3	0.187	0.311	0.624	0.025	0.042	0.084
	B960442	9	3	10	159	6.6	0.246	0.408	0.820	0.010	0.017	0.034
	B960453	10	20	20	67.1	16.4	0.093	0.155	0.311	0.023	0.038	0.076
	B960475	9	40	5	130	90.5	0.201	0.334	0.670	0.140	0.232	0.467
	B960510	9	43	10	136	7.1	0.210	0.349	0.701	0.011	0.018	0.037
	B960580	10	10	10	68.8	13.6	0.096	0.159	0.319	0.019	0.031	0.063
	B960584	10	20	20	83.4	10.6	0.116	0.193	0.387	0.015	0.024	0.049
	B960599	15	15	15	73.2	7.2	0.068	0.113	0.226	0.007	0.011	0.022
	B960611	19	19	19	47.2	3.9	0.035	0.057	0.115	0.003	0.005	0.010
	B960639	6	2	0	18.6	24.3	0.043	0.072	0.144	0.056	0.094	0.188
	B960708	7	27	11	99.2	544	0.197	0.327	0.658	1.080[c]	1.795	3.606
	B960711	8	24	8	47.3	13.6	0.082	0.137	0.274	0.024	0.039	0.079
	B960713	10	20	10	68.9	32	0.096	0.159	0.320	0.044	0.074	0.148
	B960715	15	15	15	49.2	3.9	0.046	0.076	0.152	0.004	0.006	0.012
	B980726	19	19	19	85.1	7.9	0.062	0.103	0.208	0.006	0.010	0.019
	B960820	26	9	9	61.6	14.4	0.033	0.055	0.110	0.008	0.013	0.026
	B960896	10	20	20	64.5	25.5	0.090	0.149	0.299	0.035	0.059	0.118
	B960900	10	20	20	70.3	12.9	0.098	0.162	0.326	0.018	0.030	0.060
	B960909	3	17	40	64.2	4.9	0.297	0.494	0.993	0.023	0.038	0.076
	B960912	3	17	40	138	7.8	0.639	1.063	2.134	0.036	0.060	0.121
	B960913	8	41	12	18.4	454	0.032	0.053	0.107	0.789	1.311	2.633
	B961058	8	17	34	27.8	5	0.048	0.080	0.161	0.009	0.014	0.029
	B961321	9	43	10	152	60.1	0.235	0.390	0.784	0.093	0.154	0.310
Wash St	H0751	46	0	0	3.12	0.5	0.001	0.002	0.003	0.000	0.000	0.001
	H0752	20	0	0	0.05	0.27	0.000	0.000	0.000	0.000	0.000	0.001
	H2538	32	0	0	0.19	0.14	0.000	0.000	0.000	0.000	0.000	0.000
	H1233	17	0	0	0.1	0.2	0.000	0.000	0.000	0.000	0.000	0.001
	H0754	15.5	0	0	0.5	2.5	0.000	0.001	0.002	0.002	0.004	0.007
	H4769	21	0	0	0.41	0.5	0.000	0.000	0.001	0.000	0.001	0.001
	H4771	34.5	0	0	0.1	0.5	0.000	0.000	0.000	0.000	0.000	0.001

Table G-3d. Continued

Source[a]	ID Number[b]	Percent			V mg/kg	Cu mg/kg	Yearly V addition in kg/ha at			Yearly Cu addition in kg/ha at		
							124 lb N/A	206 lb N/A	414 lb N/A	124 lb N/A	206 lb N/A	414 lb N/A
		N	P	K			139 kg/ha	231 kg/ha	464 kg/ha	139 kg/ha	231 kg/ha	464 kg/ha
Raven	Urea[d]	46	0	0	0.2	0.3	0.000	0.000	0.000	0.000	0.000	0.000
	NH_4NO_3[e]	34	0	0	0.1	0.3	0.000	0.000	0.000	0.000	0.000	0.000
	NH_4SO_4[e]	21	0	0	0.1	0.3	0.000	0.000	0.000	0.000	0.000	0.001
	NH_4SO_4[e]	21	0	0	0.1	0.3	0.000	0.000	0.000	0.000	0.000	0.001
CDFA	25042	20	0	0	NR[f]	4	NC[g]	NC	NC	0.003	0.005	0.009
	21575	32	10	10	NR	10.5	NC	NC	NC	0.005	0.008	0.015
	24276	14	3	7	NR	21	NC	NC	NC	0.021	0.035	0.070
	23106	7	2	2	NR	40.5	NC	NC	NC	0.080	0.134	0.268
	22080	34	17	0	NR	17	NC	NC	NC	0.007	0.012	0.023
	22216	9	4	4	NR	NR	NC	NC	NC	NR	NR	NR
	20891	16	4	8	NR	265	NC	NC	NC	0.230	0.383	0.769
Average		23.9	2.26	2.37	65.3	40.2	0.106	0.176	0.354	0.064	0.107	0.215

a) Sources:
PDA: Pennsylvania Department of Agriculture (1998)
Wash St: Washington State Deparmtent of Ecology (1997)
Raven: Raven and Loeppert (1997)
CDFA: California Department of Food & Agriculture (1997)

b) Sample identification used by author.
c) Shading indicates highest yearly addition values for this metal from NPK products applied for N content.
d) NPK rating not given, see Table 3-4.
e) NPK rating not given, granular grade used.
f) NR = not reported.
g) NC = not calculated.

Table G-3e. Yearly Zn Additions to Soil (kg/ha) from NPK Fertilizers Applied for N Content

Source[a]	ID Number[b]	Percent N	Percent P	Percent K	Zn mg/kg	Yearly Zn addition in kg/ha at 124 lb N/A 139 kg/ha	206 lb N/A 231 kg/ha	414 lb N/A 464 kg/ha
PDA	B960243	19	19	19	36	0.026	0.044	0.088
	B960244	12	24	24	44.5	0.052	0.086	0.172
	B960249	7	35	12	55.1	0.109	0.182	0.365
	B960282	9	44	9	49.8	0.077	0.128	0.257
	B960325	10	21	15	872	1.212	2.014	4.046
	B960333	8	32	16	43.9	0.076	0.127	0.255
	B960389	19	19	19	0	0.000	0.000	0.000
	B960412	7	26	26	37	0.073	0.122	0.245
	B960418	19	19	19	33.1	0.024	0.040	0.081
	B960441	9	34	10	34.6	0.053	0.089	0.178
	B960441	9	3	10	53.1	0.082	0.136	0.274
	B960453	10	20	20	60.9	0.085	0.141	0.283
	B960475	9	40	5	4442	6.860[c]	11.401[d]	22.901
	B960510	9	43	10	66.2	0.102	0.170	0.341
	B960580	10	10	10	803	1.116	1.855	3.726
	B960584	10	20	20	0.48	0.001	0.001	0.002
	B960599	15	15	15	0.55	0.001	0.001	0.002
	B960611	19	19	19	6.93	0.005	0.008	0.017
	B960639	6	2	0	1.1	0.003	0.004	0.009
	B960708	7	27	11	57.8	0.115	0.191	0.383
	B960711	8	24	8	177	0.308	0.511	1.027
	B960713	10	20	10	84.5	0.117	0.195	0.392
	B960715	15	15	15	0.3	0.000	0.000	0.001
	B980726	19	19	19	74.5	0.055	0.091	0.182
	B960820	26	9	9	45.7	0.024	0.041	0.082
	B960896	10	20	20	23.6	0.033	0.055	0.110
	B960900	10	20	20	25.5	0.035	0.059	0.118
	B960909	3	17	40	39.5	0.183	0.304	0.611
	B960912	3	17	40	52.2	0.242	0.402	0.807
	B960913	8	41	12	484	0.841	1.398	2.807
	B961058	8	17	34	18.3	0.032	0.053	0.106
	B961321	9	43	10	44.8	0.069	0.115	0.231
Wash St	H0751	46	0	0	7.7	0.002	0.004	0.008
	H0752	20	0	0	3.90	0.003	0.005	0.009
	H2538	32	0	0	0.5	0.000	0.000	0.001
	H1233	17	0	0	0.2	0.000	0.000	0.001
	H0754	15.5	0	0	1	0.001	0.001	0.003
	H4769	21	0	0	17	0.011	0.019	0.038
	H4771	34.5	0	0	2.5	0.001	0.002	0.003

Table G-3e. Continued

Source[a]	ID Number[b]	Percent			Zn mg/kg	Yearly Zn addition in kg/ha at		
						124 lb N/A	206 lb N/A	414 lb N/A
		N	P	K		139 kg/ha	231 kg/ha	464 kg/ha
Raven	Urea[e]	46	0	0	NR[f]	NC[g]	NC	NC
	NH_4NO_3[h]	34	0	0	NR	NC	NC	NC
	NH_4SO_4[h]	21	0	0	NR	NC	NC	NC
	NH_4SO_4[h]	21	0	0	NR	NC	NC	NC
CDFA	25042	20	0	0	NR[f]	NC[g]	NC	NC
	21575	32	10	10	NR	NC	NC	NC
	24276	14	3	7	NR	NC	NC	NC
	23106	7	2	2	NR	NC	NC	NC
	22080	34	17	0	NR	NC	NC	NC
	22216	9	4	4	NR	NC	NC	NC
	20891	16	4	8	NR	NC	NC	NC
Average		23.2	2.35	2.45	4.9	0.308	0.513	1.030

a) Sources:
PDA: Pennsylvania Department of Agriculture (1998)
Wash St: Washington State Deparmtent of Ecology (1997)
Raven: Raven and Loeppert (1997)
CDFA: California Department of Food & Agriculture (1997)

b) Sample identification used by author.
c) Shading indicates highest yearly addition values for this metal from NPK products applied for N content.
d) Bold indicates yearly addition exceeds the Canadian Fertilizers Act limit for this metal.
e) NPK rating not given, see Table 3-4.
f) NR = not reported.
g) NC = not calculated.
h) NPK rating not given, granular grade used.

Table G-4a. Yearly Cd and Pb Additions to Soil (kg/ha) from Potash (K_2O) Fertilizers

Source[a]	ID[b]	Percent K_2O	Cd mg/kg	Pb mg/kg	Yearly Cd addition in kg/ha at 103 lb K_2O/A 115 kg/ha	Yearly Cd addition in kg/ha at 177 lb K_2O/A 198 kg/ha	Yearly Cd addition in kg/ha at 534 lb K_2O/A 598 kg/ha	Yearly Pb addition in kg/ha at 103 lb K_2O/A 115 kg/ha	Yearly Pb addition in kg/ha at 177 lb K_2O/A 198 kg/ha	Yearly Pb addition in kg/ha at 534 lb K_2O/A 598 kg/ha
Charter	MP1[c]	60	1.6	4.5	0.000	0.001	0.002	0.001	0.001	0.004
	MP2	60	1.6	4.5	0.000	0.001	0.002	0.001	0.001	0.004
	MP3	60	1.3	4.5	0.000	0.000	0.001	0.001	0.001	0.004
	MP4	60	1.6	4.5	0.000	0.001	0.002	0.001	0.001	0.004
	MP5	60	1.6	4.5	0.000	0.001	0.002	0.001	0.001	0.004
	MP6	60	1.6	4.5	0.000	0.001	0.002	0.001	0.001	0.004
	MP7	60	1.6	4.5	0.000	0.001	0.002	0.001	0.001	0.004
	MP8	60	1.6	4.5	0.000	0.001	0.002	0.001	0.001	0.004
	MP9	60	1.3	4.5	0.000	0.000	0.001	0.001	0.001	0.004
	MP10	60	1.6	4.5	0.000	0.001	0.002	0.001	0.001	0.004
	MP11	60	1.6	4.5	0.000	0.001	0.002	0.001	0.001	0.004
	MP12	60	1.3	12	0.000	0.000	0.001	0.002[d]	0.004	0.012
	MP13	60	1.6	4.5	0.000	0.001	0.002	0.001	0.001	0.004
	MP14	60	1.6	4.5	0.000	0.001	0.002	0.001	0.001	0.004
	MP15	60	1.6	4.5	0.000	0.001	0.002	0.001	0.001	0.004
	MP16	60	1.6	4.5	0.000	0.001	0.002	0.001	0.001	0.004
	MP17	60	1.6	4.5	0.000	0.001	0.002	0.001	0.001	0.004
	MP18	60	1.6	4.5	0.000	0.001	0.002	0.001	0.001	0.004
	MP19	60	1.6	4.5	0.000	0.001	0.002	0.001	0.001	0.004
	MP20	60	1.9	4.5	0.000	0.001	0.002	0.001	0.001	0.004
	MP21	60	1.6	4.5	0.000	0.001	0.002	0.001	0.001	0.004
	MP22	60	1.6	4.5	0.000	0.001	0.002	0.001	0.001	0.004
	MP23	60	1.9	4.5	0.000	0.001	0.002	0.001	0.001	0.004
	MP24	60	1.6	4.5	0.000	0.001	0.002	0.001	0.001	0.004
	MP25	60	1.6	4.5	0.000	0.001	0.002	0.001	0.001	0.004
IMC	8813185	22.6[e]	0.05	0.95	0.000	0.000	0.000	0.000	0.001	0.003
	8813186	22.6[e]	0.05	0.58	0.000	0.000	0.000	0.000	0.001	0.002
	8813187	51.3[f]	0.05	0.74	0.000	0.000	0.000	0.000	0.000	0.001
	8813188	51.3[f]	0.05	0.32	0.000	0.000	0.000	0.000	0.000	0.000
	8813189	60[g]	0.05	0.2	0.000	0.000	0.000	0.000	0.000	0.000
	8813190	60[h]	0.05	0.05	0.000	0.000	0.000	0.000	0.000	0.000
	8813191	60[h]	0.05	0.05	0.000	0.000	0.000	0.000	0.000	0.000
	8813192	60[h]	0.05	0.05	0.000	0.000	0.000	0.000	0.000	0.000
	8813193	60[h]	0.05	0.05	0.000	0.000	0.000	0.000	0.000	0.000
	8813194	60[h]	0.05	0.05	0.000	0.000	0.000	0.000	0.000	0.000

Note: Footnotes may be found at the end of this table

Table G-4a. (Continued)

Source[a]	ID[b]	Percent K_2O	Cd mg/kg	Pb mg/kg	Yearly Cd addition in kg/ha at 103 lb K_2O/A 115 kg/ha	177 lb K_2O/A 198 kg/ha	534 lb K_2O/A 598 kg/ha	Yearly Pb addition in kg/ha at 103 lb K_2O/A 115 kg/ha	177 lb K_2O/A 198 kg/ha	534 lb K_2O/A 598 kg/ha
Raven	KCl1	60[h]	0.1	0.2	0.000	0.000	0.000	0.000	0.000	0.000
	KCl2	60[h]	0.1	1	0.000	0.000	0.000	0.000	0.000	0.001
	$KMgSO_4$	22.6[i]	0.1	1.4	0.000	0.000	0.000	0.001	0.001	0.004
	$KMgSO_4$	22.6[i]	0.8	1.1	0.000	0.001	0.002	0.001	0.001	0.003
Wash St	H4767	62	0.15	1	0.000	0.000	0.000	0.000	0.000	0.001
	H4765	46	0.15	1	0.000	0.000	0.000	0.000	0.000	0.001
CDFA	25029	51.3[j]	0	1	0.000	0.000	0.000	0.000	0.000	0.001
Average		55.6	1.0	5.8	0.000	0.000	0.001	0.001	0.001	0.003

a) Sources:
Charter: Charter et al. (1993)
IMC: International Mineral Company (1997)
Raven: Raven and Loeppert (1997)
Wash St: Washington State Department of Ecology (1997)
CDFA: California Department of Food and Agriculture (1997)

b) Sample identification used by author

c) MP=muriate of potash

d) Shading indicates highest yearly addition values of this metal from potash products.

e) Samples listed as "SPM" or "GSPM"- sulfopotassium magnesium or granular SPM; assumed 22.6% K_2O, see Table 3-4.

f) Samples listed as "SSOP" or "GSOP"- standard/granular sulfate of potash; assumed 51.3% K_2O, see Table 3-4.

g) Samples listed as "GMOP"- granular muriate of potash; assumed 60% K_2O per Table 3-4.

h) Samples listed as either "Ind White", "Ag. White", "Std KCl", "Coarse KCl", "Granular KCl", and indicated as all KCl products; assumed 60% K_2O, see Table 3-4.

i Samples listed as "Potassium magnesium sulfate"; assumed 22.6% K_2O.

j) Sample listed as "Potassium sulfate"; assumed 51.3% K_2O.

Table G-4b. Yearly As and Cr Additions to Soil (kg/ha) from Potash (K_2O) Fertilizers

Source[a]	ID[b]	Percent K_2O	As mg/kg	Cr mg/kg	Yearly As addition in kg/ha at 103 lb K_2O/A 115 kg/ha	177 lb K_2O/A 198 kg/ha	534 lb K_2O/A 598 kg/ha	Yearly Cr addition in kg/ha at 103 lb K_2O/A 115 kg/ha	177 lb K_2O/A 198 kg/ha	534 lb K_2O/A 598 kg/ha
Charter	MP1[c]	60	NR[d]	NR	NC[e]	NC	NC	NC	NC	NC
	MP2	60	NR	NR	NC	NC	NC	NC	NC	NC
	MP3	60	NR	NR	NC	NC	NC	NC	NC	NC
	MP4	60	NR	NR	NC	NC	NC	NC	NC	NC
	MP5	60	NR	NR	NC	NC	NC	NC	NC	NC
	MP6	60	NR	NR	NC	NC	NC	NC	NC	NC
	MP7	60	NR	NR	NC	NC	NC	NC	NC	NC
	MP8	60	NR	NR	NC	NC	NC	NC	NC	NC
	MP9	60	NR	NR	NC	NC	NC	NC	NC	NC
	MP10	60	NR	NR	NC	NC	NC	NC	NC	NC
	MP11	60	NR	NR	NC	NC	NC	NC	NC	NC
	MP12	60	NR	NR	NC	NC	NC	NC	NC	NC
	MP13	60	NR	NR	NC	NC	NC	NC	NC	NC
	MP14	60	NR	NR	NC	NC	NC	NC	NC	NC
	MP15	60	NR	NR	NC	NC	NC	NC	NC	NC
	MP16	60	NR	NR	NC	NC	NC	NC	NC	NC
	MP17	60	NR	NR	NC	NC	NC	NC	NC	NC
	MP18	60	NR	NR	NC	NC	NC	NC	NC	NC
	MP19	60	NR	NR	NC	NC	NC	NC	NC	NC
	MP20	60	NR	NR	NC	NC	NC	NC	NC	NC
	MP21	60	NR	NR	NC	NC	NC	NC	NC	NC
	MP22	60	NR	NR	NC	NC	NC	NC	NC	NC
	MP23	60	NR	NR	NC	NC	NC	NC	NC	NC
	MP24	60	NR	NR	NC	NC	NC	NC	NC	NC
	MP25	60	NR	NR	NC	NC	NC	NC	NC	NC
IMC	8813185	22.6[f]	0.05	0.05	0.000	0.000	0.000	0.000	0.000	0.000
	8813186	22.6[f]	0.05	0.05	0.000	0.000	0.000	0.000	0.000	0.000
	8813187	51.3[g]	0.05	0.13	0.000	0.000	0.000	0.000	0.000	0.000
	8813188	51.3[g]	0.05	0.17	0.000	0.000	0.000	0.000	0.000	0.000
	8813189	60[h]	0.05	0.05	0.000	0.000	0.000	0.000	0.000	0.000
	8813190	60[i]	0.05	0.12	0.000	0.000	0.000	0.000	0.000	0.000
	8813191	60[i]	0.05	0.05	0.000	0.000	0.000	0.000	0.000	0.000
	8813192	60[i]	0.05	0.05	0.000	0.000	0.000	0.000	0.000	0.000
	8813193	60[i]	0.05	0.05	0.000	0.000	0.000	0.000	0.000	0.000
	8813194	60[i]	0.05	0.05	0.000	0.000	0.000	0.000	0.000	0.000

Note: Footnotes may be found at the end of this table

Table G-4b. (Continued)

Source[a]	ID[b]	Percent K_2O	As mg/kg	Cr mg/kg	Yearly As addition in kg/ha at 103 lb K_2O/A 115 kg/ha	177 lb K_2O/A 198 kg/ha	534 lb K_2O/A 598 kg/ha	Yearly Cr addition in kg/ha at 103 lb K_2O/A 115 kg/ha	177 lb K_2O/A 198 kg/ha	534 lb K_2O/A 598 kg/ha
Raven	KCl1	60[i]	0.2	0.52	0.000	0.000	0.000	0.000	0.000	0.001
	KCl2	60[i]	0.2	NR	0.000	0.000	0.000	NC	NC	NC
	$KMgSO_4$	22.6[j]	0.3	2.75	0.000	0.000	0.001	0.001	0.002	0.007
	$KMgSO_4$	22.6[j]	0.3	NR	0.000	0.000	0.001	NC	NC	NC
Wash St	H4767	62	1.5	0.25	0.000	0.000	0.001	0.000	0.000	0.000
	H4765	46	1.5	2.5	0.000[k]	0.001	0.002	0.001	0.001	0.003
CDFA	25029	51.3[l]	0.2	NR	0.000	0.000	0.000	NC	NC	NC
Average		55.6	0.3	1.306	0.000	0.000	0.000	0.000	0.001	0.001

a) Sources:
Charter: Charter et al. (1995)
IMC: International Mineral Company (1997)
Raven: Raven and Loeppert (1997)
Wash St: Washington State Department of Ecology (1997)
CDFA: California Department of Food and Agriculture (1997)

b) Sample identification used by author

c) MP=muriate of potash

d) NR = not reported

e) NC = not calculated

f) Samples listed as "SPM" or "GSPM"- sulfopotassium magnesium or granular SPM; assumed 22.6% K_2O, see Table 3-4.

g) Samples listed as "SSOP" or "GSOP"- standard/granular sulfate of potash; assumed 51.3% K_2O, see Table 3-4.

h) Samples listed as "GMOP"- granular muriate of potash; assumed 60% K_2O, see Table 3-4.

i) Samples listed as either "Ind White", "Ag. White", "Std KCl", "Coarse KCl", "Granular KCl", and indicated as all KCl products; assumed 60% K_2O, see Table 3-4.

j) Samples listed as "Potassium magnesium sulfate"; assumed 22.6% K_2O.

k) Shading indicates highest yearly addition values of this metal from potash products

l) Sample listed as "Potassium sulfate"; assumed 51.3% K_2O.

Table G-4c. Yearly Hg and Ni Additions to Soil (kg/ha) from Potash (K_2O) Fertilizers

Source[a]	ID[b]	Percent K_2O	Hg mg/kg	Ni mg/kg	Yearly Hg addition in kg/ha at 103 lb K_2O/A 115 kg/ha	177 lb K_2O/A 198 kg/ha	534 lb K_2O/A 598 kg/ha	Yearly Ni addition in kg/ha at 103 lb K_2O/A 115 kg/ha	177 lb K_2O/A 198 kg/ha	534 lb K_2O/A 598 kg/ha
Charter	MP1[c]	60	NR[d]	1.4	NC[e]	NC	NC	0.000	0.000	0.001
	MP2	60	NR	3.5	NC	NC	NC	0.001	0.001	0.003
	MP3	60	NR	1.4	NC	NC	NC	0.000	0.000	0.001
	MP4	60	NR	3.5	NC	NC	NC	0.001	0.001	0.003
	MP5	60	NR	2.8	NC	NC	NC	0.001	0.001	0.003
	MP6	60	NR	2.8	NC	NC	NC	0.001	0.001	0.003
	MP7	60	NR	1.4	NC	NC	NC	0.000	0.000	0.001
	MP8	60	NR	2.8	NC	NC	NC	0.001	0.001	0.003
	MP9	60	NR	4.4	NC	NC	NC	0.001[f]	0.002	0.004
	MP10	60	NR	2.8	NC	NC	NC	0.001	0.001	0.003
	MP11	60	NR	1.4	NC	NC	NC	0.000	0.000	0.001
	MP12	60	NR	1.4	NC	NC	NC	0.000	0.000	0.001
	MP13	60	NR	1.4	NC	NC	NC	0.000	0.000	0.001
	MP14	60	NR	1.4	NC	NC	NC	0.000	0.000	0.001
	MP15	60	NR	3.5	NC	NC	NC	0.001	0.001	0.003
	MP16	60	NR	1.4	NC	NC	NC	0.000	0.000	0.001
	MP17	60	NR	1.4	NC	NC	NC	0.000	0.000	0.001
	MP18	60	NR	2.8	NC	NC	NC	0.001	0.001	0.003
	MP19	60	NR	1.4	NC	NC	NC	0.000	0.000	0.001
	MP20	60	NR	1.4	NC	NC	NC	0.000	0.000	0.001
	MP21	60	NR	1.4	NC	NC	NC	0.000	0.000	0.001
	MP22	60	NR	1.4	NC	NC	NC	0.000	0.000	0.001
	MP23	60	NR	1.4	NC	NC	NC	0.000	0.000	0.001
	MP24	60	NR	1.4	NC	NC	NC	0.000	0.000	0.001
	MP25	60	NR	1.4	NC	NC	NC	0.000	0.000	0.001
IMC	8813185	22.6[g]	0.05	0.05	0.000	0.000	0.000	0.000	0.000	0.000
	8813186	22.6[g]	0.05	0.05	0.000	0.000	0.000	0.000	0.000	0.000
	8813187	51.3[h]	0.05	2.6	0.000	0.000	0.000	0.001	0.001	0.003
	8813188	51.3[h]	0.05	1	0.000	0.000	0.000	0.000	0.000	0.001
	8813189	60[i]	0.05	0.25	0.000	0.000	0.000	0.000	0.000	0.000
	8813190	60[j]	0.05	0.14	0.000	0.000	0.000	0.000	0.000	0.000
	8813191	60[j]	0.05	0.05	0.000	0.000	0.000	0.000	0.000	0.000
	8813192	60[j]	0.05	0.05	0.000	0.000	0.000	0.000	0.000	0.000
	8813193	60[j]	0.05	0.05	0.000	0.000	0.000	0.000	0.000	0.000
	8813194	60[j]	0.05	0.82	0.000	0.000	0.000	0.000	0.000	0.001

Note: Footnotes may be found at the end of the table

Table G-4c. (Continued)

Source[a]	ID[b]	Percent K_2O	Hg mg/kg	Ni mg/kg	Yearly Hg addition in kg/ha at 103 lb K_2O/A 115 kg/ha	177 lb K_2O/A 198 kg/ha	534 lb K_2O/A 598 kg/ha	Yearly Ni addition in kg/ha at 103 lb K_2O/A 115 kg/ha	177 lb K_2O/A 198 kg/ha	534 lb K_2O/A 598 kg/ha
	KCl1	60[j]	0.2	0.1	0.000	0.000	0.000	0.000	0.000	0.000
	KCl2	60[j]	0.2	0.1	0.000	0.000	0.000	0.000	0.000	0.000
	$KMgSO_4$	22.6[k]	0.2	0.5	0.000	0.000	0.001	0.000	0.000	0.001
Raven	$KMgSO_4$	22.6[k]	0.2	0.3	0.000	0.000	0.001	0.000	0.000	0.001
	H4767	62	0.003	0.5	0.000	0.000	0.000	0.000	0.000	0.000
Wash St	H4765	46	0.003	1.5	0.000	0.000	0.000	0.000	0.001	0.002
CDFA	25029	51.3[l]	NR	NR	NC	NC	NC	NC	NC	NC
Average		55.6	0.1	1.4	0.000	0.000	0.000	0.000	0.000	0.002

a) Sources:
Charter: Charter et al. (1995)
IMC: International Mineral Company (1997)
Raven: Raven and Loeppert (1997)
Wash St: Washington State Department of Ecology (1997)
CDFA: California Department of Food and Agriculture (1997)

b) Sample identification used by author

c) MP=muriate of potash

d) NR = not reported

e) NC = not calculated

f) Shading indicates highest yearly addition values of this metal from potash products.

g) Samples listed as "SPM" or "GSPM"- sulfopotassium magnesium or granular SPM; assumed 22.6% K_2O, see Table 3-4.

h) Samples listed as "SSOP" or "GSOP"- standard/granular sulfate of potash; assumed 51.3% K_2O, see Table 3-4.

i) Samples listed as "GMOP"- granular muriate of potash; assumed 60% K_2O, see Table 3-4.

j) Samples listed as either "Ind White", "Ag. White", "Std KCl", "Coarse KCl", "Granular KCl", and indicated as all KCl products; assumed 60% K_2O, see Table 3-4.

k) Samples listed as "Potassium magnesium sulfate"; assumed 22.6% K_2O.

l) Sample listed as "Potassium sulfate"; assumed 51.3% K_2O.

Table G-4d. Yearly V and Cu Additions to Soil (kg/ha) from Potash (K_2O) Fertilizers

Source[a]	ID[b]	Percent K_2O	V mg/kg	Cu mg/kg	Yearly V addition in kg/ha at 103 lb K_2O/A 115 kg/ha	177 lb K_2O/A 198 kg/ha	534 lb K_2O/A 598 kg/ha	Yearly Cu addition in kg/ha at 103 lb K_2O/A 115 kg/ha	177 lb K_2O/A 198 kg/ha	534 lb K_2O/A 598 kg/ha
Charter	MP1[c]	60	NR[d]	0.75	NC[e]	NC	NC	0.000	0.000	0.001
	MP2	60	NR	0.75	NC	NC	NC	0.000	0.000	0.001
	MP3	60	NR	0.75	NC	NC	NC	0.000	0.000	0.001
	MP4	60	NR	0.75	NC	NC	NC	0.000	0.000	0.001
	MP5	60	NR	2.1	NC	NC	NC	0.000	0.001	0.002
	MP6	60	NR	0.75	NC	NC	NC	0.000	0.000	0.001
	MP7	60	NR	0.75	NC	NC	NC	0.000	0.000	0.001
	MP8	60	NR	0.75	NC	NC	NC	0.000	0.000	0.001
	MP9	60	NR	0.75	NC	NC	NC	0.000	0.000	0.001
	MP10	60	NR	0.75	NC	NC	NC	0.000	0.000	0.001
	MP11	60	NR	0.75	NC	NC	NC	0.000	0.000	0.001
	MP12	60	NR	0.75	NC	NC	NC	0.000	0.000	0.001
	MP13	60	NR	0.75	NC	NC	NC	0.000	0.000	0.001
	MP14	60	NR	0.75	NC	NC	NC	0.000	0.000	0.001
	MP15	60	NR	0.75	NC	NC	NC	0.000	0.000	0.001
	MP16	60	NR	0.75	NC	NC	NC	0.000	0.000	0.001
	MP17	60	NR	0.75	NC	NC	NC	0.000	0.000	0.001
	MP18	60	NR	0.75	NC	NC	NC	0.000	0.000	0.001
	MP19	60	NR	0.75	NC	NC	NC	0.000	0.000	0.001
	MP20	60	NR	0.75	NC	NC	NC	0.000	0.000	0.001
	MP21	60	NR	2.6	NC	NC	NC	0.000	0.001	0.003
	MP22	60	NR	0.75	NC	NC	NC	0.000	0.000	0.001
	MP23	60	NR	0.75	NC	NC	NC	0.000	0.000	0.001
	MP24	60	NR	0.75	NC	NC	NC	0.000	0.000	0.001
	MP25	60	NR	0.75	NC	NC	NC	0.000	0.000	0.001
IMC	8813185	22.6[f]	0.05	0.36	0.000	0.000	0.000	0.000	0.000	0.001
	8813186	22.6[f]	1.1	0.05	0.001	0.001	0.003	0.000	0.000	0.000
	8813187	51.3[g]	0.93	0.19	0.000	0.000	0.001	0.000	0.000	0.000
	8813188	51.3[g]	0.05	0.34	0.000	0.000	0.000	0.000	0.000	0.000
	8813189	60[h]	1.8	1.1	0.000	0.001	0.002	0.000	0.000	0.001
	8813190	60[i]	1.3	0.05	0.000	0.000	0.001	0.000	0.000	0.000
	8813191	60[i]	2	0.3	0.000	0.001	0.002	0.000	0.000	0.000
	8813192	60[i]	0.05	0.05	0.000	0.000	0.000	0.000	0.000	0.000
	8813193	60[i]	0.74	0.33	0.000	0.000	0.001	0.000	0.000	0.000
	8813194	60[h]	1.6	0.05	0.000	0.001	0.002	0.000	0.000	0.000

Note: Footnotes may be found at the end of the table.

Table G-4d. (Continued)

Source[a]	ID[b]	Percent K_2O	V mg/kg	Cu mg/kg	Yearly V addition in kg/ha at 103 lb K_2O/A 115 kg/ha	177 lb K_2O/A 198 kg/ha	534 lb K_2O/A 598 kg/ha	Yearly Cu addition in kg/ha at 103 lb K_2O/A 115 kg/ha	177 lb K_2O/A 198 kg/ha	534 lb K_2O/A 598 kg/ha
Raven	KCl1	60[i]	0.3	3.5	0.000	0.000	0.000	0.001	0.001	0.003
	KCl2	60[i]	0.1	1	0.000	0.000	0.000	0.000	0.000	0.001
	$KMgSO_4$	22.6[j]	0.7	5	0.000	0.001	0.002	0.002[k]	0.004	0.013
	$KMgSO_4$	22.6[j]	9	1.4	0.005	0.008	0.024	0.001	0.001	0.004
Wash St	H4767	62	0.1	0.5	0.000	0.000	0.000	0.000	0.000	0.000
	H4765	46	0.1	0.5	0.000	0.000	0.000	0.000	0.000	0.001
CDFA	25029	51.3[l]	NR	5	NC	NC	NC	0.001	0.002	0.006
Arora	MP	60	NR	3.1	NC	NC	NC	0.001	0.001	0.003
Average		55.6	1.2	1.0	0.000	0.001	0.002	0.000	0.000	0.001

a) Sources:
Charter: Charter et al. (1995)
IMC: International Mineral Company (1997)
Raven: Raven and Loeppert (1997)
Wash St: Washington State Department of Ecology (1997)
CDFA: California Department of Food and Agriculture (1997)

b) Sample identification used by author

c) MP = muriate of potash

d) NR = not reported

e) NC = not calculated

f) Samples listed as "SPM" or "GSPM"- sulfopotassium magnesium or granular SPM; assumed 22.6% K_2O, see Table 3-4.

g) Samples listed as "SSOP" or "GSOP"- standard/granular sulfate of potash; assumed 51.3% K_2O, see Table 3-4.

h) Samples listed as "GMOP"- granular muriate of potash; assumed 60% K_2O, see Table 3-4.

i) Samples listed as either "Ind White", "Ag. White", "Std KCl", "Coarse KCl", "Granular KCl", and indicated as all KCl products; assumed 60% K_2O, see Table 3-4.

j) Samples listed as "Potassium magnesium sulfate"; assumed 22.6% K_2O.

k) Shading indicates highest yearly addition values of this metal from potash products.

l) Sample listed as "Potassium sulfate"; assumed 51.3% K_2O.

Table G-4e. Yearly Zn Additions to Soil (kg/ha) from Potash (K_2O) Fertilizers

Source[a]	ID[b]	Percent K_2O	Zn mg/kg	Yearly Zn addition in kg/ha at 103 lb K_2O/A 115 kg/ha	177 lb K_2O/A 198 kg/ha	534 lb K_2O/A 598 kg/ha
Charter	MP1[c]	60	3	0.001	0.001	0.003
	MP2	60	1.3	0.000	0.000	0.001
	MP3	60	1.1	0.000	0.000	0.001
	MP4	60	1.9	0.000	0.001	0.002
	MP5	60	1.9	0.000	0.001	0.002
	MP6	60	1.6	0.000	0.001	0.002
	MP7	60	1.8	0.000	0.001	0.002
	MP8	60	1.3	0.000	0.000	0.001
	MP9	60	1.3	0.000	0.000	0.001
	MP10	60	1.5	0.000	0.000	0.001
	MP11	60	1.1	0.000	0.000	0.001
	MP12	60	1.3	0.000	0.000	0.001
	MP13	60	1.3	0.000	0.000	0.001
	MP14	60	1.1	0.000	0.000	0.001
	MP15	60	1.3	0.000	0.000	0.001
	MP16	60	1.8	0.000	0.001	0.002
	MP17	60	1.1	0.000	0.000	0.001
	MP18	60	1.3	0.000	0.000	0.001
	MP19	60	1.1	0.000	0.000	0.001
	MP20	60	1.5	0.000	0.000	0.001
	MP21	60	2.6	0.000	0.001	0.003
	MP22	60	1	0.000	0.000	0.001
	MP23	60	1.6	0.000	0.001	0.002
	MP24	60	1.3	0.000	0.000	0.001
	MP25	60	1.3	0.000	0.000	0.001
IMC	8813185	22.6[d]	0.69	0.000	0.001	0.002
	8813186	22.6[d]	0.92	0.000	0.001	0.002
	8813187	51.3[e]	1.3	0.000	0.001	0.002
	8813188	51.3[e]	2.1	0.000	0.001	0.002
	8813189	60[f]	1.1	0.000	0.000	0.001
	8813190	60[g]	0.81	0.000	0.000	0.001
	8813191	60[g]	0.64	0.000	0.000	0.001
	8813192	60[g]	0.39	0.000	0.000	0.000
	8813193	60[g]	0.72	0.000	0.000	0.001
	8813194	60[g]	0.19	0.000	0.000	0.000

Note: Footnotes may be found at the end of the table.

Table G-4e. (Continued)

Source[a]	ID[b]	Percent K_2O	Zn mg/kg	Yearly Zn addition in kg/ha at		
				103 lb K_2O/A	177 lb K_2O/A	534 lb K_2O/A
				115 kg/ha	198 kg/ha	598 kg/ha
Raven	KCl1	60[g]	4.59	0.001	0.002	0.005
	KCl2	60[g]	NR[h]	NC[i]	NC	NC
	$KMgSO_4$	22.6[j]	8.75	0.004[k]	0.008	0.023
	$KMgSO_4$	22.6[j]	NR	NC	NC	NC
Wash St	H4767	62	0.69	0.000	0.000	0.001
	H4765	46	0.73	0.000	0.000	0.001
CDFA	25029	51.3[l]	NR	NC	NC	NC
Average		55.6	1.8	0.000	0.001	0.002

a) Sources:
Charter: Charter et al. (1995)
IMC: International Mineral Company (1997)
Raven: Raven and Loeppert (1997)
Wash St: Washington State Department of Ecology (1997)
CDFA: California Department of Food and Agriculture (1997)
b) Sample identification used by author
c) MP=muriate of potash
d) Samples listed as "SPM" or "GSPM"- sulfopotassium magnesium or granular SPM; assumed 22.6% K_2O, see Table 3-4.
e) Samples listed as "SSOP" or "GSOP"- standard/granular sulfate of potash; assumed 51.3% K_2O, see Table 3-4.
f) Samples listed as "GMOP"- granular muriate of potash; assumed 60% K_2O, see Table 3-4.
g) Samples listed as either "Ind White", "Ag. White", "Std KCl", "Coarse KCl", "Granular KCl", and indicated as all KCl products; assumed 60% K_2O, see Table 3-4.
h) NR = not reported
i) NC = not calculated
j) Samples listed as "Potassium magnesium sulfate"; assumed 22.6% K_2O.
k) Shading indicates highest yearly addition values of this metal from potash products.
l) Sample listed as "Potassium sulfate"; assumed 51.3% K_2O.

Table G-5a. Yearly Cd and Pb Additions to Soil (kg/ha) from Zn Fertilizers

Source[a]	ID[b]	Percent Zn in product	Cd mg/kg	Pb mg/kg	Yearly Cd addition in kg/ha, at 5 lb Zn/A 5.6 kg/ha	10 lb Zn/A 11.2 kg/ha	20 lb Zn/A 22.4 kg/ha	Yearly Pb addition in kg/ha at 5 lb Zn/A 5.6 kg/ha	10 lb Zn/A 11.2 kg/ha	20 lb Zn/A 22.4 kg/ha
Mortvedt	$ZnSO_4$	34	2165	60	0.036[c]	0.071	**0.143[d]**	0.001	0.002	0.004
	ZnOS-1	35.1	590	44000	0.009	0.019	0.038	0.702	1.404	**2.808**
	ZnOS-2	41.5	1970	400	0.027	0.053	**0.106**	0.005	0.011	0.022
	ZnOBP-1	58.3	243	1900	0.002	0.005	0.009	0.018	0.037	0.073
	ZnOBP-2	34	1420	52000	0.023	0.047	**0.094**	0.856	1.713	**3.426**
	ZnOBP-3	27.7	76	2470	0.002	0.003	0.006	0.050	0.100	0.200
	Zn-ZnOBP	89	500	11870	0.003	0.006	0.013	0.075	0.149	0.299
	ZnFeBP1	9.2	4	50	0.000	0.000	0.001	0.003	0.006	0.012
	ZnFePB2	13.3	26	1080	0.001	0.002	0.004	0.045	0.091	0.182
Amrani	$ZnSO_4$	35.5	61	90	0.001	0.002	0.004	0.001	0.003	0.006
	Zn20	20.4	75	158	0.002	0.004	0.008	0.004	0.009	0.017
	Zn27	27.3	43	178	0.001	0.002	0.004	0.004	0.007	0.015
	Zn40	39.9	28	293	0.000	0.001	0.002	0.004	0.008	0.016
	ZnOxS	37.7	43	1866	0.001	0.001	0.003	0.028	0.055	0.111
	ZnOS	17.5	435	23070	0.014	0.028	0.056	0.738	1.476	**2.953**
	K061[e]	15	359	19170	0.013	0.027	0.054	0.716	1.431	**2.863**
Wash St	H1906	18	275	11300	0.009	0.017	0.034	0.352	0.703	1.406
	GrZn	18	52	1400	0.002	0.003	0.006	0.044	0.087	0.174
CoZinco	1	26.75	NR[f]	18700	NC[g]	NC	NC	0.391	0.783	1.566
	2	14.5	NR	20300	NC	NC	NC	0.784	1.568	**3.136**
	3	28.35	NR	1300	NC	NC	NC	0.026	0.051	0.103
	4	18.4	NR	1500	NC	NC	NC	0.046	0.091	0.183
	5	18.9	NR	600	NC	NC	NC	0.018	0.036	0.071
	6	13.8	NR	200	NC	NC	NC	0.008	0.016	0.032
	7	29.2	NR	20700	NC	NC	NC	0.397	0.794	1.588
	8	16.3	NR	10500	NC	NC	NC	0.361	0.721	1.443
	9	16.5	NR	14000	NC	NC	NC	0.475	0.950	1.901
	10	42.8	NR	2300	NC	NC	NC	0.030	0.060	0.120
	11	32	NR	29400	NC	NC	NC	0.515	1.029	2.058
	12	19	NR	15400	NC	NC	NC	0.454	0.908	1.816
	13	21.3	NR	17500	NC	NC	NC	0.460	0.920	1.840
	14	17.1	NR	13000	NC	NC	NC	0.426	0.851	1.703
	15	38.1	NR	0	NC	NC	NC	0.000	0.000	0.000
	16	17.5	NR	9300	NC	NC	NC	0.298	0.595	1.190

Note: Footnotes may be found at the end of this table

Table G-5a. (Continued)

Source[a]	ID[b]	Percent Zn in product	Cd mg/kg	Pb mg/kg	Yearly Cd addition in kg/ha, at			Yearly Pb addition in kg/ha at		
					5 lb Zn/A	10 lb Zn/A	20 lb Zn/A	5 lb Zn/A	10 lb Zn/A	20 lb Zn/A
					5.6 kg/ha	11.2 kg/ha	22.4 kg/ha	5.6 kg/ha	11.2 kg/ha	22.4 kg/ha
CoZinco	17	28.1	NR	23700	NC	NC	NC	0.472	0.945	1.889
	18	38.2	NR	12500	NC	NC	NC	0.183	0.366	0.733
	19	18.2	NR	6700	NC	NC	NC	0.206	0.412	0.825
	20	16.1	NR	15500	NC	NC	NC	0.539	1.078	2.157
	21	24.7	NR	15400	NC	NC	NC	0.349	0.698	1.397
	22	35.3	NR	0	NC	NC	NC	0.000	0.000	0.000
	23	36	NR	0	NC	NC	NC	0.000	0.000	0.000
	24	16.9	NR	2400	NC	NC	NC	0.080	0.159	0.318
	25	36	NR	0	NC	NC	NC	0.000	0.000	0.000
	26	29.6	NR	700	NC	NC	NC	0.013	0.026	0.053
	27	24.6	NR	1000	NC	NC	NC	0.023	0.046	0.091
	28	22.4	NR	19000	NC	NC	NC	0.475	0.950	1.900
	29	19.5	NR	21400	NC	NC	NC	0.615	1.229	**2.458**
	30	24.5	NR	14800	NC	NC	NC	0.338	0.677	1.353
	31	40.5	NR	16100	NC	NC	NC	0.223	0.445	0.890
	32	22.5	NR	16500	NC	NC	NC	0.411	0.821	1.643
	33	23.5	NR	19200	NC	NC	NC	0.458	0.915	1.830
	34	19.5	NR	17200	NC	NC	NC	0.494	0.988	1.976
	35	10.5	NR	30	NC	NC	NC	0.002	0.003	0.006
	36	9.5	NR	1400	NC	NC	NC	0.083	0.165	0.330
	37	32.7	NR	30	NC	NC	NC	0.001	0.001	0.002
	38	41	NR	14800	NC	NC	NC	0.202	0.404	0.809
	39	40.7	NR	3700	NC	NC	NC	0.051	0.102	0.204
	40	32.6	NR	1900	NC	NC	NC	0.033	0.065	0.131
	41	35.6	NR	40	NC	NC	NC	0.001	0.001	0.003
CDFA	26160	12	2	18	0.000	0.000	0.000	0.001	0.002	0.003
	21351	18	370	10700	0.012	0.023	0.046	0.333	0.666	1.332
	22487	10	11.5	13	0.001	0.001	0.003	0.001	0.001	0.003
	22575	7	8	0	0.001	0.001	0.003	0.000	0.000	0.000
Average		26.5	398	9219	0.007	0.014	0.029	0.221	0.442	0.884

a) Sources:
Mortvedt: Mortvedt (1985)
Amrani: Amrani et al. (1997)
Wash St: Washington State Department of Ecology (1997)
CoZinco: CoZinco Sales (1997)
CDFA: California Department of Food and Agriculture (1997)
b) Sample identification used by author
c) Shading indicates highest yearly addition values of this metal from zinc products
d) Bold indicates that the yearly addition exceeds the Canadian Fertilizer Act limits for this contaminant
e) Product specifically identified as recycled K061 waste
f) NR = not reported
g) NC = not calculated

Table G-5b. Yearly As and Cr Additions to Soil (kg/ha) from Zn Fertilizers

Source[a]	ID[b]	Percent Zn in product	As mg/kg	Cr mg/kg	Yearly As addition in kg/ha, at 5 lb Zn/A 5.6 kg/ha	10 lb Zn/A 11.2 kg/ha	20 lb Zn/A 22.4 kg/ha	Yearly Cr addition in kg/ha, at 5 lb Zn/A 5.6 kg/ha	10 lb Zn/A 11.2 kg/ha	20 lb Zn/A 22.4 kg/ha
Wash St	H1906	18	17	580	0.001	0.001	0.002	0.018[c]	0.036	0.072
	GrZn	18	17	97.8	0.001	0.001	0.002	0.003	0.006	0.012
CDFA	26160	12	0.5	NR[d]	0.000	0.000	0.000	NC[e]	NC	NC
	21351	18	45.5	NR	0.001	0.003	0.006	NC	NC	NC
	22487	10	0	NR	0.000	0.000	0.000	NC	NC	NC
	22575	7	0	NR	0.000	0.000	0.000	NC	NC	NC
Average		14	13	338.9	0.000	0.001	0.002	0.011	0.021	0.042

a) Sources:
Wash St: Washington State Department of Ecology (1997)
CDFA: California Department of Food and Agriculture (1997)
b) Sample identification used by author
c) Shading indicates highest yearly addition values of this metal from zinc products
d) NR = not reported
e) NC = not calculated

Table G-5c. Yearly Hg and Ni Additions to Soil (kg/ha) from Zn Fertilizers

Source[a]	ID[b]	Percent Zn in product	Hg mg/kg	Ni mg/kg	Yearly Hg addition in kg/ha, at 5 lb Zn/A 5.6 kg/ha	10 lb Zn/A 11.2 kg/ha	20 lb Zn/A 22.4 kg/ha	Yearly Ni addition in kg/ha, at 5 lb Zn/A 5.6 kg/ha	10 lb Zn/A 11.2 kg/ha	20 lb Zn/A 22.4 kg/ha
Wash St	H1906	18	3.36	83	0.000[c]	0.000	0.000	0.003	0.005	0.010
	GrZn	18	NR[d]	61.6	NC[e]	NC	NC	0.002	0.004	0.008
Mortvedt	$ZnSO_4$	34	NR	92	NC	NC	NC	0.002	0.003	0.006
	ZnOS1	35.1	NR	158	NC	NC	NC	0.003	0.005	0.010
	ZnOS2	41.5	NR	19	NC	NC	NC	0.000	0.001	0.001
	ZnOBP1	58.3	NR	8950	NC	NC	NC	0.086	0.172	0.344
	ZnOBP2	34	NR	250	NC	NC	NC	0.004	0.008	0.016
	ZnOBP3	27.7	NR	24	NC	NC	NC	0.000	0.001	0.002
	ZnZnO	89	NR	10	NC	NC	NC	0.000	0.000	0.000
	ZnFeBP1	9.2	NR	82	NC	NC	NC	0.005	0.010	0.020
	ZnFEBP2	13.3	NR	60	NC	NC	NC	0.003	0.005	0.010
Average		34	3.36	890	0.000	0.000	0.000	0.010	0.019	0.039

a) Sources:
Wash St: Washington State Department of Ecology (1997)
Mortvedt: Mortvedt (1985))
b) Sample identification used by author
c) Shading indicates highest yearly addition values of this metal from zinc products
d) NR = not reported
e) NC = not calculated

Table G-5d. Yearly V and Cu Additions to Soil (kg/ha) from Zn Fertilizers

Source[a]	ID[b]	Percent Zn in product	V mg/kg	Cu mg/kg	Yearly V addition in kg/ha, at 5 lb Zn/A 5.6 kg/ha	10 lb Zn/A 11.2 kg/ha	20 lb Zn/A 22.4 kg/ha	Yearly Cu addition in kg/ha, at 5 lb Zn/A 5.6 kg/ha	10 lb Zn/A 11.2 kg/ha	20 lb Zn/A 22.4 kg/ha
Wash St	H1906	18	41	1680	0.001[c]	0.003	0.005	0.052	0.105	0.209
	GrZn	18	0.5	672	0.000	0.000	0.000	0.021	0.042	0.084
CDFA	26160	12	NR[d]	3	NC[e]	NC	NC	0.000	0.000	0.001
	21351	18	NR	2050	NC	NC	NC	0.064	0.128	0.255
	22487	10	NR	0	NC	NC	NC	0.000	0.000	0.000
	22575	7	NR	0	NC	NC	NC	0.000	0.000	0.000
Average		13.8	20.8	734	0.001	0.001	0.003	0.023	0.046	0.091

a) Sources:
Wash St: Washington State Department of Ecology (1997)
CDFA: California Department of Food and Agriculture (1997)
b) Sample identification used by author
c) Shading indicates highest yearly addition values of this metal from zinc products
d) NR = not reported
e) NC = not calculated

Table G-5e. Yearly Zn Additions to Soil (kg/ha) from Zn Fertilizers

					Not applicable					

Table G-6a. Yearly Cd and Pb Additions to Soil (kg/hg) from Mn Fertilizers

Source[a]	ID[b]	Percent Mn in product	Cd mg/kg	Pb mg/kg	Yearly Cd addition in kg/ha soil at			Yearly Pb addition in kg/ha soil at		
					4 lb Mn/A	10 lb Mn/A	18 lb Mn/A	4 lb Mn/A	10 lb Mn/A	18 lb Mn/A
					4.48 kg/ha	11.2 kg/ha	20.16 kg/ha	4.48 kg/ha	11.2 kg/ha	20.16 kg/ha
Wash St	H4753	29.5	1.5	50	0.000	0.000	0.000	0.001[c]	0.002	0.003
CDFA	21791	24.7[d]	3	5	0.000	0.000	0.000	0.000	0.000	0.000
Average		27.1	2.25	27.5	0.000	0.000	0.000	0.000	0.001	0.002

a) Sources:
Wash St: Washington State Department of Ecology (1997)
CDFA: California Department of Food and Agriculture (1977)
b) Sample identification used by author
c) Shading indicates highest yearly addition values of this metal from manganese products
d) Sample listed as manganese sulfate; assumed 100% product ($MnSO_4 \cdot 4H_2O$) which has 24.7% Mn by weight.

Table G-6b. Yearly As and Cr Additions to Soil (kg/hg) from Mn Fertilizers

Source[a]	ID[b]	Percent Mn in product	As mg/kg	Cr mg/kg	Yearly As addition in kg/ha soil at			Yearly Cr addition in kg/ha soil at		
					4 lb Mn/A	10 lb Mn/A	18 lb Mn/A	4 lb Mn/A	10 lb Mn/A	18 lb Mn/A
					4.48 kg/ha	11.2 kg/ha	20.16 kg/ha	4.48 kg/ha	11.2 kg/ha	20.16 kg/ha
Wash St	H4753	29.5	15	10	0.000[c]	0.001	0.001	0.000	0.000	0.001
CDFA	21791	24.7[d]	0.5	NR[e]	0.000	0.000	0.000	NC[f]	NC	NC
Average		27.1	7.8	10	0.000	0.000	0.001	0.000	0.000	0.001

a) Sources:
Wash St: Washington State Department of Ecology (1997)
CDFA: California Department of Food and Agriculture (1997)
b) Sample identification used by author
c) Shading indicates highest yearly addition values of this metal from manganese products
d) Sample listed as manganese sulfate; assumed 100% product ($MnSO_4 \cdot 4H_2O$) which has 24.7% Mn by weight.
e) NR = not reported
f) NC = not calculated

Table G-6c. Yearly Hg and Ni Additions to Soil (kg/hg) from Mn Fertilizers

Source[a]	ID[b]	Percent Mn in product	Hg mg/kg	Ni mg/kg	Yearly Hg addition in kg/ha soil at			Yearly Ni addition in kg/ha soil at		
					4 lb Mn/A	10 lb Mn/A	18 lb Mn/A	4 lb Mn/A	10 lb Mn/A	18 lb Mn/A
					4.48 kg/ha	11.2 kg/ha	20.16 kg/ha	4.48 kg/ha	11.2 kg/ha	20.16 kg/ha
Wash St	H4753	29.5	0.01	50	0.000[c]	0.000	0.000	0.001	0.002	0.003
CDFA	21791	24.7[d]	NR[e]	NR	NC[f]	NC	NC	NC	NC	NC
Average		27.1	0.01	50	0.000	0.000	0.000	0.001	0.002	0.003

a) Sources:
Wash St: Washington State Department of Ecology (1997)
CDFA: California Department of Food and Agriculture (1997)
b) Sample identification used by author
c) Shading indicates highest yearly addition values of this metal from manganese products
d) Sample listed as manganese sulfate; assumed 100% product ($MnSO_4 \cdot 4H_2O$) which has 24.7% Mn by weight.
e) NR = not reported
f) NC = not calculated

Table G-6d. Yearly V and Cu Additions to Soil (kg/hg) from Mn Fertilizers

Source[a]	ID[b]	Percent Mn in product	V mg/kg	Cu mg/kg	Yearly V addition in kg/ha soil at			Yearly Cu addition in kg/ha soil at		
					4 lb Mn/A	10 lb Mn/A	18 lb Mn/A	4 lb Mn/A	10 lb Mn/A	18 lb Mn/A
					4.48 kg/ha	11.2 kg/ha	20.16 kg/ha	4.48 kg/ha	11.2 kg/ha	20.16 kg/ha
Wash St	H4753	29.5	1.5	21	0.000[c]	0.000	0.000	0.000	0.001	0.001
CDFA	21791	24.7[d]	NR[e]	1.5	NC[f]	NC	NC	0.000	0.000	0.000
Average		27	1.5	11.3	0.000	0.000	0.000	0.000	0.000	0.001

a) Sources:
Wash St: Washington State Department of Ecology (1997)
CDFA: California Department of Food and Agriculture (1997)
b) Sample identification used by author
c) Shading indicates highest yearly addition values of this metal from manganese products
d) Sample listed as manganese sulfate; assumed 100% product ($MnSO_4 \cdot 4H_2O$) which has 24.7% Mn by weight.
e) NR = not reported
f) NC = not calculated

Table G-6e. Yearly Zn Additions to Soil (kg/hg) from Mn Fertilizers

Source[a]	ID[b]	Percent Mn in product	Zn mg/kg	Yearly Zn addition in kg/ha soil at		
				4 lb Mn/A	10 lb Mn/A	18 lb Mn/A
				4.48 kg/ha	11.2 kg/ha	20.16 kg/ha
Wash St	H4753	29.5	60.8	0.001[c]	0.002	0.004
CDFA	21791	24.7[d]	NR[e]	NC[f]	NC	NC
Average		27.1	60.8	0.001	0.002	0.004

a) Sources:
Wash St: Washington State Department of Ecology (1997)
CDFA: California Department of Food and Agriculture (1997)
b) Sample identification used by author
c) Shading indicates highest yearly addition values of this metal from manganese products
d) Sample listed as manganese sulfate; assumed 100% product ($MnSO_4 \cdot 4H_2O$) which has 24.7% Mn by weight.
e) NR = not reported
f) NC = not calculated

Table G-7a. Yearly Cd and Pb Additions to Soil (kg/ha) from Boron Fertilizers

Source[a]	ID[b]	Percent Boron in product	Cd mg/kg	Pb mg/kg	Yearly Cd addition in kg/ha at			Yearly Pb addition in kg/ha at		
					2 lb B/A	3 lb B/A	4 lb B/A	2 lb B/A	3 lb B/A	4 lb B/A
					2.24 kg/ha	3.36 kg/ha	4.48 kg/ha	2.24 kg/ha	3.36 kg/ha	4.48 kg/ha
Wash St	H0753	10	0.75	5.5	0.000[c]	0.000	0.000	0.000	0.000	0.000
CDFA	25030	21	0	0	0.000	0.000	0.000	0.000	0.000	0.000
Average		15.5	0.38	2.75	0.000	0.000	0.000	0.000	0.000	0.000

a) Sources:
Wash St: Washington State Department of Ecology (1997)
CDFA: California Department of Food and Agriculture (1997)
b) Sample identification used by author
c) Shading indicates highest yearly addition values of this metal from boron products

Table G-7b. Yearly As and Cr Additions to Soil (kg/ha) from Boron Fertilizers

Source[a]	ID[b]	Percent Boron in product	As mg/kg	Cr mg/kg	Yearly As addition in kg/ha at			Yearly Cr addition in kg/ha at		
					2 lb B/A	3 lb B/A	4 lb B/A	2 lb B/A	3 lb B/A	4 lb B/A
					2.24 kg/ha	3.36 kg/ha	4.48 kg/ha	2.24 kg/ha	3.36 kg/ha	4.48 kg/ha
Wash St	H0753	10	1040	1.3	0.023[c]	0.035	0.047	0.000	0.000	0.000
CDFA	25030	21	1	NR[d]	0.000	0.000	0.000	NC[e]	NC	NC
Average		15.5	520.5	1.3	0.012	0.017	0.023	0.000	0.000	0.000

a) Sources:
Wash St: Washington State Department of Ecology (1997)
CDFA: California Department of Food and Agriculture (1997)
b) Sample identification used by author
c) Shading indicates highest yearly addition values of this metal from boron products
d) NR = not reported
e) NC = not calculated

Table G-7c. Yearly Hg and Ni Additions to Soil (kg/ha) from Boron Fertilizers

Source[a]	ID[b]	Percent Boron in product	Hg mg/kg	Ni mg/kg	Yearly Hg addition in kg/ha at			Yearly Ni addition in kg/ha at		
					2 lb B/A	3 lb B/A	4 lb B/A	2 lb B/A	3 lb B/A	4 lb B/A
					2.24 kg/ha	3.36 kg/ha	4.48 kg/ha	2.24 kg/ha	3.36 kg/ha	4.48 kg/ha
Wash St	H0753	10	0.17	2.5	0.000[c]	0.000	0.000	0.000	0.000	0.000
CDFA	25030	21	NR[d]	NR	NC[e]	NC	NC	NC	NC	NC
Average		16	0.17	2.5	0.000	0.000	0.000	0.000	0.000	0.000

a) Sources:
Wash St: Washington State Department of Ecology (1997)
CDFA: California Department of Food and Agriculture (1997)
b) Sample identification used by author
c) Shading indicates highest yearly addition values of this metal from boron products
d) NR = not reported
e) NC = not calculated

Table G-7d. Yearly V and Cu Additions to Soil (kg/ha) from Boron Fertilizers

Source[a]	ID[b]	Percent Boron in product	V mg/kg	Cu mg/kg	Yearly V addition in kg/ha at			Yearly Cu addition in kg/ha at		
					2 lb B/A	3 lb B/A	4 lb B/A	2 lb B/A	3 lb B/A	4 lb B/A
					2.24 kg/ha	3.36 kg/ha	4.48 kg/ha	2.24 kg/ha	3.36 kg/ha	4.48 kg/ha
Wash St	H0753	10	16.9	8.1	0.000[c]	0.001	0.001	0.000	0.000	0.000
CDFA	25030	21	NR[d]	0	NC[e]	0	0	0.000	0.000	0.000
Average		16	16.9	4.0	0.000	0.001	0.001	0.000	0.000	0.000

a) Sources:
Wash St: Washington State Department of Ecology (1997)
CDFA: California Department of Food and Agriculture (1997)
b) Sample identification used by author
c) Shading indicates highest yearly addition values of this metal from boron products
d) NR = not reported
e) NC = not calculated

Table G-7e. Yearly Zn Additions to Soil (kg/ha) from Boron Fertilizers

Source[a]	ID[b]	Percent Boron in product	Zn mg/kg	Yearly Zn addition in kg/ha at		
				2 lb B/A	3 lb B/A	4 lb B/A
				2.24 kg/ha	3.36 kg/ha	4.48 kg/ha
Wash St	H0753	10	6	0.000[c]	0.001	0.001
CDFA	25030	21	NR[d]	NC[e]	NC	NC
Average		16	6	0.000	0.001	0.001

a) Sources:
Wash St: Washington State Department of Ecology (1997)
CDFA: California Department of Food and Agriculture (1997)
b) Sample identification used by author
c) Shading indicates highest yearly addition values of this metal from boron products
d) NR = not reported
e) NC = not calculated

Table G-8a. Yearly Cd and Pd Additions to Soil (kg/ha) from Iron Fertilizers

Source[a]	ID[b]	Percent Iron in product	Cd mg/kg	Pd mg/kg	Yearly Cd addition in kg/ha at 10 lb Fe/A 11.2 kg/ha	20 lb Fe/A 22.4 kg/ha	30 lb Fe/A 33.6 kg/ha	Yearly Pd addition in kg/ha at 10 lb Fe/A 11.2 kg/ha	20 lb Fe/A 22.4 kg/ha	30 lb Fe/A 33.6 kg/ha
CDFA	22334	15	333.5	18750	0.025[c]	0.050	0.075	1.400	**2.800**[d]	**4.200**
	25819	12	20.5	2625	0.002	0.004	0.006	0.245	0.490	0.735
	25835	15	0	29	0.000	0.000	0.000	0.002	0.004	0.006
Average		14	118.0	7135	0.009	0.018	0.027	0.549	1.098	1.647

a) Sources:
CDFA: California Department of Food and Agriculture (1997)
b) Sample identification used by author
c) Shading indicates highest yearly addition values for this metal from iron products
d) Bold indicates that the yearly addition exceeds the Canadian Fertilizers Act limits for this metal

Table G-8b. Yearly As and Cr Additions to Soil (kg/ha) from Iron Fertilizers

Source[a]	ID[b]	Percent Iron in product	As mg/kg	Cr mg/kg	Yearly As addition in kg/ha at 10 lb Fe/A 11.2 kg/ha	20 lb Fe/A 22.4 kg/ha	30 lb Fe/A 33.6 kg/ha	Yearly Cr addition in kg/ha at 10 lb Fe/A 11.2 kg/ha	20 lb Fe/A 22.4 kg/ha	30 lb Fe/A 33.6 kg/ha
CDFA	22334	15	34.5	NR[c]	0.003	0.005	0.008	NC[d]	NC	NC
	25819	12	4950	NR	**0.462**[e,f]	**0.924**	**1.386**	NC	NC	NC
	25835	15	2.5	NR	0.000	0.000	0.001	NC	NC	NC
Average		14	1662.3	NR	0.155	0.310	**0.465**	NC	NC	NC

a) Sources:
CDFA: California Department of Food and Agriculture (1997)
b) Sample identification used by author
c) NR = not reported
d) NC = not calculated
e) Shading indicates highest yearly addition values for this metal from iron products
f) Bold indicates that the yearly addition exceeds the Canadian Fertilizers Act limits for this metal

Table G-8c. Yearly Hg and Ni Additions to Soil (kg/ha) from Iron Fertilizers

					No available data					

Table G-8d. Yearly V and Cu Additions to Soil (kg/ha) from Iron Fertilizers

Source[a]	ID[b]	Percent Iron in product	V mg/kg	Cu mg/kg	Yearly V addition in kg/ha at 10 lb Fe/A 11.2 kg/ha	20 lb Fe/A 22.4 kg/ha	30 lb Fe/A 33.6 kg/ha	Yearly Cu addition in kg/ha at 10 lb Fe/A 11.2 kg/ha	20 lb Fe/A 22.4 kg/ha	30 lb Fe/A 33.6 kg/ha
CDFA	22334	15	NR[c]	1750	NC[d]	NC	NC	0.131[e]	0.261	0.392
	25819	12	NR	210	NC	NC	NC	0.020	0.039	0.059
	25835	15	NR	40	NC	NC	NC	0.003	0.006	0.009
Average		14	NC	667	NC	NC	NC	0.051	0.102	0.153

a) Sources:
CDFA: California Department of Food and Agriculture (1997)
b) Sample identification used by author
c) NR = not reported
d) NC = not calculated
e) Shading indicates highest yearly addition values for this metal from iron products

Table G-8e. Yearly Zn Additions to Soil (kg/ha) from Iron Fertilizers

					No available data					

Table G-9a. Yearly Cd and Pb Additions to Soil (kg/ha) from S (as Nutrient) Fertilizers

Source[a]	ID[b]	Percent Sulfur in product	Cd mg/kg	Pb mg/kg	Yearly Cd addition in kg/ha soil at			Yearly Pb addition in kg/ha soil at		
					20lb S/A 22.4 kg/ha	40lb S/A 44.8 kg/ha	60 lb S/A 67.2 kg/ha	20lb S/A 22.4 kg/ha	40lb S/A 44.8 kg/ha	60 lb S/A 67.2 kg/ha
Wash St	H2547	26	0.03	0.2	0.000	0.000	0.000	0.000	0.000	0.000
	H1231	40	0.03	0.2	0.000	0.000	0.000	0.000	0.000	0.000
	H2532	14	145	4.4	0.023[c]	0.046	0.070	0.001	0.001	0.002
	H4769	24	1.2	15	0.000	0.000	0.000	0.001	0.003	0.004
CDFA	26310	100[d]	0	0	0.000	0.000	0.000	0.000	0.000	0.000
	21259	100	0	8.7	0.000	0.000	0.000	0.000	0.000	0.001
	21260	100	0	4	0.000	0.000	0.000	0.000	0.000	0.000
	24884	100	0	0	0.000	0.000	0.000	0.000	0.000	0.000
	24885	100	0	0	0.000	0.000	0.000	0.000	0.000	0.000
Average		67	16	4	0.003	0.005	0.008	0.000	0.001	0.001

a) Sources:
Wash St: Washington State Department of Ecology (1997)
CDFA: California Department of Food and Agriculture (1997)
b) Sample identification used by author
c) Shading indicates highest yearly addition values of this metal from sulfur nutrient products
d) Listed as "sulfur"; assumed 100% sulfur

Table G-9b. Yearly As and Cr Additions to Soil (kg/ha) from S (as Nutrient) Fertilizers

Source[a]	ID[b]	Percent Sulfur in product	As mg/kg	Cr mg/kg	Yearly As addition in kg/ha soil at			Yearly Cr addition in kg/ha soil at		
					20lb S/A 22.4 kg/ha	40lb S/A 44.8 kg/ha	60 lb S/A 67.2 kg/ha	20lb S/A 22.4 kg/ha	40lb S/A 44.8 kg/ha	60 lb S/A 67.2 kg/ha
Wash St	H2547	26	0.3	0.05	0.000	0.000	0.000	0.000	0.000	0.000
	H1231	40	0.3	0.05	0.000	0.000	0.000	0.000	0.000	0.000
	H2532	14	4.2	214	0.001[c]	0.001	0.002	0.034	0.068	0.103
	H4769	24	1.5	0.68	0.000	0.000	0.000	0.000	0.000	0.000
CDFA	26310	100[d]	0.1	NR[e]	0.000	0.000	0.000	NC[f]	NC	NC
	21259	100	2	8.7	0.000	0.000	0.000	NC	NC	NC
	21260	100	0.86	4	0.000	0.000	0.000	NC	NC	NC
	24884	100	17	0	0.000	0.001	0.001	NC	NC	NC
	24885	100	19	0	0.000	0.001	0.001	NC	NC	NC
Average		67	5.0	54	0.000	0.000	0.001	0.009	0.017	0.026

a) Sources:
Wash St: Washington State Department of Ecology (1997)
CDFA: California Department of Food and Agriculture (1997)
b) Sample identification used by author
c) Shading indicates highest yearly addition values of this metal from sulfur nutrient products
d) Listed as "sulfur"; assumed 100% sulfur
e) NR = not reported
f) NC = not calculated

Table G-9c. Yearly Hg and Ni Additions to Soil (kg/ha) from S (as Nutrient) Fertilizers

Source[a]	ID[b]	Percent Sulfur in product	Hg mg/kg	Ni mg/kg	Yearly Hg addition in kg/ha soil at 20lb S/A 22.4 kg/ha	40lb S/A 44.8 kg/ha	60 lb S/A 67.2 kg/ha	Yearly Ni addition in kg/ha soil at 20lb S/A 22.4 kg/ha	40lb S/A 44.8 kg/ha	60 lb S/A 67.2 kg/ha
Wash St	H2547	26	0.01	0.1	0.000	0.000	0.000	0.000	0.000	0.000
	H1231	40	0	0.1	0.000	0.000	0.000	0.000	0.000	0.000
	H2532	14	0.024	195	0.000	0.000	0.000	0.031[c]	0.062	0.094
	H4769	24	0.403	0.5	0.000	0.000	0.000	0.000	0.000	0.000
CDFA	26310	100[d]	NR[e]	NR	NC[f]	NC	NC	NC	NC	NC
	21259	100	NR	NR	NC	NC	NC	NC	NC	NC
	21260	100	NR	NR	NC	NC	NC	NC	NC	NC
	24884	100	NR	NR	NC	NC	NC	NC	NC	NC
	24885	100	NR	NR	NC	NC	NC	NC	NC	NC
Average		67.1	0.11	48.9	0.000	0.000	0.000	0.008	0.016	0.023

a) Sources:
Wash St: Washington State Department of Ecology (1997)
CDFA: California Department of Food and Agriculture (1997)
b) Sample identification used by author
c) Shading indicates highest yearly addition values of this metal from sulfur nutrient products
d) Listed as "sulfur"; assumed 100% sulfur
e) NR = not reported
f) NC = not calculated

Table G-9d. Yearly V and Cu Additions to Soil (kg/ha) from S (as Nutrient) Fertilizers

Source[a]	ID[b]	Percent Sulfur in product	V mg/kg	Cu mg/kg	Yearly V addition in kg/ha soil at 20 lb S/A 22.4 kg/ha	40 lb S/A 44.8 kg/ha	60 lb S/A 67.2 kg/ha	Yearly Cu addition in kg/ha soil at 20 lb S/A 22.4 kg/ha	40 lb S/A 44.8 kg/ha	60 lb S/A 67.2 kg/ha
Wash St	H2547	26	0.055	0.04	0.000	0.000	0.000	0.000	0.000	0.000
	H1231	40	0.046	0.094	0.000	0.000	0.000	0.000	0.000	0.000
	H2532	14	396	16	0.063[c]	0.127	0.190	0.003	0.005	0.008
	H4769	24	0.41	0.5	0.000	0.000	0.000	0.000	0.000	0.000
CDFA	26310	100[d]	NR[e]	2	NC[f]	NC	NC	0.000	0.000	0.000
	21259	100	NR	109	NC	NC	NC	0.002	0.005	0.007
	21260	100	NR	61	NC	NC	NC	0.001	0.003	0.004
	24884	100	NR	16	NC	NC	NC	0.000	0.001	0.001
	24885	100	NR	14	NC	NC	NC	0.000	0.001	0.001
Average		67	99.13	24.29	0.016	0.032	0.048	0.001	0.002	0.002

a) Sources:
Wash St: Washington State Department of Ecology (1997)
CDFA: California Department of Food and Agriculture (1997)
b) Sample identification used by author
c) Shading indicates highest yearly addition values of this metal from sulfur nutrient products
d) Listed as "sulfur"; assumed 100% sulfur
e) NR = not reported
f) NC = not calculated

Table G-9e. Yearly Zn Additions to Soil (kg/ha) from S (as Nutrient) Fertilizers

Source[a]	ID[b]	Percent Sulfur in product	Zn mg/kg	Yearly Zn addition in kg/ha soil at		
				20 lb S/A	40 lb S/A	60 lb S/A
				22.4 kg/ha	44.8 kg/ha	67.2 kg/ha
Wash St	H2547	26	0.21	0.000	0.000	0.000
	H1231	40	42	0.002	0.005	0.007
	H2532	14	1480	0.237[c]	0.474	0.710
	H4769	24	17	0.002	0.003	0.005
Average		26	385	0.060	0.120	0.181

a) Sources:
Wash St: Washington State Department of Ecology (1997)
b) Sample identification used by author
c) Shading indicates highest yearly addition values of this metal from sulfur nutrient products

Table G-10a. Yearly Cd and Pb Additions to Soil (kg/ha) from S (as pH) Fertilizers

Source[a]	ID[b]	Percent Sulfur in product	Cd mg/kg	Pb mg/kg	Yearly Cd addition in kg/ha soil at 800 lb S/A 896 kg/ha	2000 lb S/A 2240 kg/ha	2500 lb S/A 2800 kg/ha	Yearly Pb addition in kg/ha soil at 800 lb S/A 896 kg/ha	2000 lb S/A 2240 kg/ha	2500 lb S/A 2800 kg/ha
CDFA	26310	100[c]	0	0	0.000	0.000	0.000	0.000	0.000	0.000
	21259	100	0	8.7	0.000	0.000	0.000	0.008[d]	0.019	0.024
	21260	100	0	4	0.000	0.000	0.000	0.004	0.009	0.011
	24884	100	0	0	0.000	0.000	0.000	0.000	0.000	0.000
	24885	100	0	0	0.000	0.000	0.000	0.000	0.000	0.000
Average		100	0	2.5	0.000	0.000	0.000	0.002	0.006	0.007

a) Sources:
CDFA: California Department of Food and Agriculture (1997)
b) Sample identification used by author
c) Listed as "sulfur"; assumed 100% sulfur
d) Shading indicates highest yearly addition values of this metal from sulfur pH adjustment products

Table G-10b. Yearly As and Cr Additions to Soil (kg/ha) from S (as pH) Fertilizers

Source[a]	ID[b]	Percent Sulfur in product	As mg/kg	Cr mg/kg	Yearly As addition in kg/ha soil at 800 lb S/A 896 kg/ha	2000 lb S/A 2240 kg/ha	2500 lb S/A 2800 kg/ha	Yearly Cr addition in kg/ha soil at 800 lb S/A 896 kg/ha	2000 lb S/A 2240 kg/ha	2500 lb S/A 2800 kg/ha
CDFA	26310	100[c]	0.1	NR[d]	0.000	0.000	0.000	NC[e]	NC	NC
	21259	100	2	NR	0.002	0.004	0.006	NC	NC	NC
	21260	100	0.86	NR	0.001	0.002	0.002	NC	NC	NC
	24884	100	17	NR	0.015	0.038	0.048	NC	NC	NC
	24885	100	19	NR	0.017[f]	0.043	0.053	NC	NC	NC
Average		100	7.8	NC	0.007	0.017	0.022	NC	NC	NC

a) Sources:
CDFA: California Department of Food and Agriculture (1997)
b) Sample identification used by author
c) Listed as "sulfur"; assumed 100% sulfur
d) NR = not reported
e) NC = not calculated
f) Shading indicates highest yearly addition values of this metal from sulfur pH adjustment products

Table G-10c. Yearly Hg and Ni Additions to Soil (kg/ha) from S (as pH) Fertilizers

Source[a]	ID[b]	Percent Sulfur in product	Hg mg/kg	Ni mg/kg	Yearly Hg addition in kg/ha soil at			Yearly Ni addition in kg/ha soil at		
					800 lb S/A	2000 lb S/A	2500 lb S/A	800 lb S/A	2000 lb S/A	2500 lb S/A
					896 kg/ha	2240 kg/ha	2800 kg/ha	896 kg/ha	2240 kg/ha	2800 kg/ha
CDFA	26310	100[c]	NR[d]	NR	NC[e]	NC	NC	NC	NC	NC
	21259	100	NR	NR	NC	NC	NC	NC	NC	NC
	21260	100	NR	NR	NC	NC	NC	NC	NC	NC
	24884	100	NR	NR	NC	NC	NC	NC	NC	NC
	24885	100	NR	NR	NC	NC	NC	NC	NC	NC
Average		100	NC	NC	NC	NC	NC	NC	NC	NC

a) Sources:
CDFA: California Department of Food and Agriculture (1997)
b) Sample identification used by author
c) Listed as "sulfur"; assumed 100% sulfur
d) NR = not reported
e) NC = not calculated

Table G-10d. Yearly V and Cu Additions to Soil (kg/ha) from S (as pH) Fertilizers

Source[a]	ID[b]	Percent Sulfur in product	V mg/kg	Cu mg/kg	Yearly V addition in kg/ha soil at			Yearly Cu addition in kg/ha soil at		
					800lb S/A	2000lb S/A	2500 lb S/A	800lb S/A	2000lb S/A	2500 lb S/A
					896 kg/ha	2240 kg/ha	2800 kg/ha	896 kg/ha	2240 kg/ha	2800 kg/ha
CDFA	26310	100[c]	NR[d]	2	NC[e]	NC	NC	0.002	0.004	0.006
	21259	100	NR	109	NC	NC	NC	0.098[f]	0.244	0.305
	21260	100	NR	61	NC	NC	NC	0.055	0.137	0.171
	24884	100	NR	16	NC	NC	NC	0.014	0.036	0.045
	24885	100	NR	14	NC	NC	NC	0.013	0.031	0.039
Average		100	NC	40	NC	NC	NC	0.036	0.090	0.113

a) Sources:
Wash St: Washington State Department of Ecology (1997)
CDFA: California Department of Food and Agriculture (1997)
b) Sample identification used by author
c) Listed as "sulfur"; assumed 100% sulfur
d) NR = not reported
e) NC = not calculated
f) Shading indicates highest yearly addition values of this metal from sulfur pH adjustment products

Table G-10e. Yearly Zn Additions to Soil (kg/ha) from S (as pH) Fertilizers

Source[a]	ID[b]	Percent Sulfur in product	Zn mg/kg	Yearly Zn addition in kg/ha soil at 800 lb S/A 896 kg/ha	2000 lb S/A 2240 kg/ha	2500 lb S/A 2800 kg/ha
CDFA	26310	100[c]	NR[d]	NC[e]	NC	NC
	21259	100	NR	NC	NC	NC
	21260	100	NR	NC	NC	NC
	24884	100	NR	NC	NC	NC
	24885	100	NR	NC	NC	NC
Average		100	NC	NC	NC	NC

a) Sources:
CDFA: California Department of Food and Agriculture (1997)
b) Sample identification used by author
c) Listed as "sulfur"; assumed 100% sulfur
d) NR = not reported
e) NC = not calculated

Table G-11a. Yearly Cd and Pb Additions to Soil (kg/ha) from Liming Materials

Source[a]	ID[b]	Percent $CaCO_3$ in product	Cd mg/kg	Pb mg/kg	Yearly Cd addition in kg/ha soil at: 4000 lb lime/A 4480 kg/ha	8000 lb lime/A 8960 kg/ha	15,000 lb lime/A 16,800 kg/ha	Yearly Pb addition in kg/ha soil at: 4000 lb lime/A 4480 kg/ha	8000 lb lime/A 8960 kg/ha	15,000 lb lime/A 16,800 kg/ha
Raven	calcite	100	0.7	1.1	0.003	0.006	0.012	0.005	0.010	0.018
	dolomite	100	0.1	0.7	0.000	0.001	0.002	0.003	0.006	0.012
Wash St	H2529	33	1.5	10	0.020	0.041	0.076	0.136	0.272	0.509
	H4763	85	3.6	150	0.019	0.038	0.071	0.791	1.581	**2.965**[c]
	H4775	7.6	0.75	125	0.044[d]	0.088	**0.165**	**7.368**	**14.737**	**27.632**
	H4759	96	1.5	1	0.007	0.014	0.026	0.005	0.009	0.018
	H4764	91	1.5	10	0.007	0.015	0.028	0.049	0.098	0.185
	H2550	100	0.75	49	0.003	0.007	0.013	0.220	0.439	0.823
CDFA	21827	100	8.1	45.5	0.036	0.073	**0.136**	0.204	0.408	0.764
	20882	100	6.5	53	0.029	0.058	**0.109**	0.237	0.475	0.890
Average[e]		81.3	2.5	44.53	0.017	0.034	0.064	0.902	1.804	**3.383**
3-yr Avg[f]					0.006	0.011	0.021	0.300	0.601	1.127

a) Sources:
Raven: Raven and Loeppert (1997)
Wash St: Washington State Department of Ecology (1997)
CDFA: California Department of Food and Agriculture (1997)
b) Sample identification used by author
c) Bold indicates that the yearly addition exceeds the Canadian Fertilizer Act limits for this metal
d) Shading indicates highest yearly addition values for this metal from liming materials
e) Yearly addition of metal for year in which the lime is added. Typically, lime is added once every 3 years
f) Average yearly addition of metal ammortized over the 3 year application period

Table G-11b. Yearly As and Cr Additions to Soil (kg/ha) from Liming Materials

Source[a]	ID[b]	Percent $CaCO_3$ in product	As mg/kg	Cr mg/kg	Yearly As addition in kg/ha soil at: 4000 lb lime/A 4480 kg/ha	8000 lb lime/A 8960 kg/ha	15,000 lb lime/A 16,800 kg/ha	Yearly Cr addition in kg/ha soil at: 4000 lb lime/A 4480 kg/ha	8000 lb lime/A 8960 kg/ha	15,000 lb lime/A 16,800 kg/ha
Raven	calcite	100	1	NR[c]	0.004	0.009	0.017	NC[d]	NC	NC
	dolomite	100	1.2	32.3	0.005	0.011	0.020	0.145	0.289	0.543
Wash St	H2529	33	15	2.5	0.204	**0.407**[e]	**0.764**	0.034	0.068	0.127
	H4763	85	37	73	0.195	**0.390**	**0.731**	0.385	0.770	1.443
	H4775	7.6	48	34	**2.829**[f]	**5.659**	**0.611**	2.004	4.008	7.515
	H4759	96	15	2.5	0.070	0.140	0.263	0.012	0.023	0.044
	H4764	91	15	2.5	0.074	0.148	0.277	0.012	0.025	0.046
	H2550	100	7.5	1.25	0.034	0.067	0.126	0.006	0.011	0.021
CDFA	21827	100	1.1	NR	0.005	0.010	0.018	NC	NC	NC
	20882	100	5.1	NR	0.023	0.046	0.086	NC	NC	NC
Average[g]		81.3	14.6	21.2	**0.344**	**0.689**	**1.292**	0.371	0.742	1.391
3 yr Avg[h]					0.115	0.230	**0.431**	0.124	0.247	0.464

a) Sources:
Raven: Raven and Loeppert (1997)
Wash St: Washington State Department of Ecology (1997)
CDFA: California Department of Food and Agriculture (1997)
b) Sample identification used by author
c) NR = not reported
d) NC = not calculated
e) Bold indicates that the yearly addition exceeds the Canadian Fertilizer Act limits for this metal
f) Shading indicates highest yearly addition values of this metal from liming materials
g) Yearly addition of metal for year in which the lime is added. Typically, lime is added only once every 3 years
h) Average yearly addition of metal ammortized over the 3 year application period

Table G-11c. Yearly Hg and Ni Additions to Soil (kg/ha) from Liming Materials

Source[a]	ID[b]	Percent $CaCO_3$ in product	Hg mg/kg	Ni mg/kg	Yearly Hg addition in kg/ha soil at: 4000 lb lime/A 4480 kg/ha	8000 lb lime/A 8960 kg/ha	15,000 lb lime/A 16,800 kg/ha	Yearly Ni addition in kg/ha soil at: 4000 lb lime/A 4480 kg/ha	8000 lb lime/A 8960 kg/ha	15,000 lb lime/A 16,800 kg/ha
Raven	calcite	100	0.2	1.4	0.001	0.002	0.003	0.006	0.013	0.024
	dolomite	100	0.2	3.3	0.001	0.002	0.003	0.015	0.300	0.055
Wash St	H2529	33	0.01	5	0.000	0.000	0.000	0.068	0.136	0.255
	H4763	85	0.041	18	0.000	0.000	0.001	0.095	0.190	0.356
	H4775	7.6	0.414	23	**0.024**[c,d]	**0.049**	**0.086**	**1.356**	**2.712**	**5.085**
	H4759	96	0.01	5	0.000	0.000	0.000	0.023	0.047	0.088
	H4764	91	0.01	5	0.000	0.000	0.000	0.025	0.049	0.092
	H2550	100	0.022	2.5	0.000	0.000	0.000	0.011	0.022	0.042
CDFA	21827	100	NR[e]	NR	NC[f]	NC	NC	NC	NC	NC
	20882	100	NR	NR	NC	NC	NC	NC	NC	NC
Average[g]		81.3	0.11	11.6	0.003	0.007	0.013	0.200	0.400	0.750
3 yr Avg[h]					0.001	0.002	0.004	0.067	0.133	0.250

a) Sources:
Raven: Raven and Loeppert (1997)
Wash St: Washington State Department of Ecology (1997)
CDFA: California Department of Food and Agriculture (1997)
b) Sample identification used by author
c) Shading indicates highest yearly addition values for this metal from liming materials
d) Bold indicates that the yearly addition exceeds the Canadian Fertilizers Act limits for this metal
e) NR = not reported
f) NC = not calculated
g) Yearly addition of metal for year in which the lime is added. Typically, lime is added only once every 3 years
h) Average yearly addition of metal ammortized over the 3 year application period

Table G-11d. Yearly V and Cu Additions to Soil (kg/ha) from Liming Materials

Source[a]	ID[b]	Percent $CaCO_3$ in product	V mg/kg	Cu mg/kg	Yearly V addition in kg/ha soil at: 4000 lb lime/A 4480 kg/ha	8000 lb lime/A 8960 kg/ha	15,000 lb lime/A 16,800 kg/ha	Yearly Cu addition in kg/ha soil at: 4000 lb lime/A 4480 kg/ha	8000 lb lime/A 8960 kg/ha	15,000 lb lime/A 16,800 kg/ha
Raven	calcite	100	3	2.3	0.013	0.027	0.050	0.010	0.021	0.039
	dolomite	100	15	NR[c]	0.067	0.134	0.252	NC[d]	NC	NC
Wash St	H2529	33	1	5	0.014	0.027	0.051	0.068	0.136	0.255
	H4763	85	49	158	0.258	0.517	0.968	0.833	1.666	3.123
	H4775	7.6	41	116	2.417[e]	4.834	9.064	6.838	13.676	25.643
	H4759	96	1	5	0.005	0.009	0.018	0.023	0.047	0.088
	H4764	91	1	5	0.005	0.010	0.018	0.025	0.049	0.092
	H2550	100	1.1	3	0.005	0.010	0.018	0.013	0.027	0.050
CDFA	21827	100	NR	38	NC	NC	NC	0.170	0.340	0.638
	20882	100	NR	46	NC	NC	NC	0.206	0.412	0.773
Average[f]		81	14	42	0.348	0.696	1.305	0.910	1.819	3.411
3 yr Avg[g]					0.116	0.232	0.435	0.303	0.606	1.137

a) Sources:
Raven: Raven and Loeppert (1997)
Wash St: Washington State Department of Ecology (1997)
CDFA: California Department of Food and Agriculture (1997)
b) Sample identification used by author
c) NR = not reported
d) NC = not calculated
e) Shading indicates highest yearly addition values for this metals from liming agents
f) Yearly addition of metal for year in which the lime is added. Typically, lime is added only once every 3 years
g) Average yearly addition of metal ammortized over the 3 year application period

Table G-11e. Yearly Zn Additions to Soil (kg/ha) from Liming Materials

Source[a]	ID[b]	Percent $CaCO_3$ in product	Zn mg/kg	Yearly Zn addition in kg/ha soil at		
				4000 lb lime/A	8000 lb lime/A	15,000 lb lime/A
				4480 kg/ha	8960 kg/ha	16,800 kg/ha
Raven	calcite	100	NR[c]	NC[d]	NC	NC
	dolomite	100	8.01	0.036	0.072	0.135
Wash St	H2529	33	7.7	0.105	0.209	0.392
	H4763	85	1770	**9.329**[e]	**18.658**	**34.984**
	H4775	7.6	424	**24.994**[f]	**49.987**	**93.726**
	H4759	96	16	0.075	0.149	0.280
	H4764	91	21	0.103	0.207	0.388
	H2550	100	224	1.004	2.007	3.763
CDFA	21827	100	NR	NC	NC	NC
	20882	100	NR	NC	NC	NC
Average[g]		81.26	353.0	4.456	**8.911**	**16.708**
3 yr Avg[h]				1.485	2.970	5.569

a) Sources:
Raven: Raven and Loeppert (1997)
Wash St: Washington State Department of Ecology (1997)
CDFA: California Department of Food and Agriculture (1997)
b) Sample identification used by author
c) NR = not reported
d) NC = not calculated
e) Bold indicates that the yearly addition exceeds the Canadian Fertilizers Act limits for this metal
f) Shading indicates highest yearly addition values for this metal from liming materials
g) Yearly addition of metal for year in which the lime is added. Typically, lime is added only once every 3 years
h) Average yearly addition of metal ammortized over the 3 year application period

Table G-12a. Yearly Cd and Pb Additions to Soil (kg/ha) from Gypsum Products

Source[a]	ID[b]	Percent Gypsum	Cd mg/kg	Pb mg/kg	Yearly Cd addition in kg/ha soil at: 2000 lb gyp/A 2240 kg/ha	4000 lb gyp/A 4480 kg/ha	8000 lb gyp/A 8960 kg/ha	Yearly Pb addition in kg/ha soil at: 2000 lb gyp/A 2240 kg/ha	4000 lb gyp/A 4480 kg/ha	8000 lb gyp/A 8960 kg/ha
Wash St	H4766	100[c]	0.8	11	0.002	0.004	0.007	0.025[d]	0.049	0.099
CDFA	25855	100	0	3	0.000	0.000	0.000	0.007	0.013	0.027
	25854	100	0	3	0.000	0.000	0.000	0.007	0.013	0.027
	25853	100	2.5	1.5	0.006	0.011	0.022	0.003	0.007	0.013
Average		100	0.8	4.6	0.002	0.004	0.007	0.010	0.021	0.041

a) Sources:
Wash St: Washington State Department of Ecology (1997)
CDFA: California Department of Food and Agriculture (1997)
b) Sample identification used by author
c) Assumed 100% product for application
d) Shading indicates highest yearly addition values of this metal from gypsum products

Table G-12b. Yearly As and Cr Additions to Soil (kg/ha) from Gypsum Products

Source[a]	ID[b]	Percent Gypsum	As mg/kg	Cr mg/kg	Yearly As addition in kg/ha soil at: 2000 lb gyp/A 2240 kg/ha	4000 lb gyp/A 4480 kg/ha	8000 lb gyp/A 8960 kg/ha	Yearly Cr addition in kg/ha soil at: 2000 lb gyp/A 2240 kg/ha	4000 lb gyp/A 4480 kg/ha	8000 lb gyp/A 8960 kg/ha
Wash St	H4766	100[c]	8.5	1.4	0.019[d]	0.038	0.076	0.003	0.006	0.013
CDFA	25855	100	3	NR[e]	0.007	0.013	0.027	NC[f]	NC	NC
	25854	100	3.4	NR	0.008	0.015	0.030	NC	NC	NC
	25853	100	3	NR	0.007	0.013	0.027	NC	NC	NC
Average		100	4.5	1.4	0.010	0.020	0.040	0.003	0.006	0.013

a) Sources:
Wash St: Washington State Department of Ecology (1997)
CDFA: California Department of Food and Agriculture (1997)
b) Sample identification used by author
c) Assumed 100% product for application
d) Shading indicates highest yearly addition values of this metal from gypsum products
e) NR = not reported
f) NC = not calculated

Table G-12c. Yearly Hg and Ni Additions to Soil (kg/ha) from Gypsum Products

Source[a]	ID[b]	Percent Gypsum	Hg mg/kg	Ni mg/kg	Yearly Hg addition in kg/ha soil at:			Yearly Ni addition in kg/ha soil at:		
					2000 lb gyp/A	4000 lb gyp/A	8000 lb gyp/A	2000 lb gyp/A	4000 lb gyp/A	8000 lb gyp/A
					2240 kg/ha	4480 kg/ha	8960 kg/ha	2240 kg/ha	4480 kg/ha	8960 kg/ha
Wash St	H4766	100[c]	0.011	3	0.000[d]	0.000	0.000	0.007	0.013	0.027
CDFA	25855	100	NR[e]	NR	NC[f]	NC	NC	NC	NC	NC
	25854	100	NR	NR	NC	NC	NC	NC	NC	NC
	25853	100	NR	NR	NC	NC	NC	NC	NC	NC
Average		100	0.011	3	0.000	0.000	0.000	0.007	0.013	0.027

a) Sources:
Wash St: Washington State Department of Ecology (1997)
CDFA: California Department of Food and Agriculture (1997)
b) Sample identification used by author
c) Assumed 100% product for application
d) Shading indicates highest yearly addition values of this metal from gypsum products
e) NR = not reported
f) NC = not calculated

Table G-12d. Yearly V and Cu Additions to Soil (kg/ha) from Gypsum Products

Source[a]	ID[b]	Percent Gypsum	V mg/kg	Cu mg/kg	Yearly V addition in kg/ha soil at:			Yearly Cu addition in kg/ha soil at:		
					2000 lb gyp/A	4000 lb gyp/A	8000 lb gyp/A	2000 lb gyp/A	4000 lb gyp/A	8000 lb gyp/A
					2240 kg/ha	4480 kg/ha	8960 kg/ha	2240 kg/ha	4480 kg/ha	8960 kg/ha
Wash St	H4766	100[c]	1.4	7.2	0.003	0.006	0.013	0.016	0.032	0.065
CDFA	25855	100	43	25	0.096	0.193	0.385	0.056	0.112	0.224
	25854	100	41	42	0.092	0.184	0.367	0.094[d]	0.188	0.376
	25853	100	50	20.5	0.112	0.224	0.448	0.046	0.092	0.184
Average		100	33.9	23.7	0.076	0.152	0.303	0.053	0.106	0.212

a) Sources:
Wash St: Washington State Department of Ecology (1997)
CDFA: California Department of Food and Agriculture (1997)
b) Sample identification used by author
c) Assumed 100% product for application
d) Shading indicates highest yearly addition values of this metal from gypsum products

Table G-12e. Yearly Zn Additions to Soil (kg/ha) from Gypsum Products

Source[a]	ID[b]	Percent Gypsum in product	Zn mg/kg	Yearly Zn addition in kg/ha soil at		
				2000 lb gypsum/A	4000 lb gypsum/A	8000 lb gypsum/A
				2240 kg/ha	4480 kg/ha	8960 kg/ha
Wash St	H4766	100[c]	53.8	0.121[d]	0.241	0.482
CDFA	25855	100	NR[e]	NC[f]	NC	NC
	25854	100	NR	NC	NC	NC
	25853	100	NR	NC	NC	NC
Average		100	53.8	0.121	0.241	0.482

a) Sources:
Wash St: Washington State Department of Ecology (1997)
CDFA: California Department of Food and Agriculture (1997)
b) Sample identification used by author
c) Assumed 100% product for application
d) Shading indicates highest yearly addition values of this metal from gypsum products
e) NR = not reported
f) NC = not calculated

Table G-13a. Yearly Cd and Pb Additions to Soil (kg/ha) from Micronutrient Mixes

Source[a]	ID[b]	Cd mg/kg	Pb mg/kg	Yearly Cd addition in kg/ha soil at			Yearly Pb addition in kg/ha soil at		
				7.5 lb mix/A	30 lb mix/A	36 lb mix/A	7.5 lb mix/A	30 lb mix/A	36 lb mix/A
				8.4 kg/ha	33.6 kg/ha	40.3 kg/ha	8.4 kg/ha	33.6 kg/ha	40.3 kg/ha
Wash St	H4772	0.85	5.5	0.000	0.000	0.000	0.000	0.000	0.000
	H4756	55	3590	0.000[c]	0.002	0.002	0.030	0.121	0.145
Average		27.93	1797.8	0.000	0.001	0.001	0.015	0.060	0.072

a) Sources:
Wash St: Washington State Department of Ecology (1997)
b) Sample identification used by author
c) Shading indicates highest yearly addition values of this metal from micronutrient mixes

Table G-13b. Yearly As and Cr Additions to Soil (kg/ha) from Micronutrient Mixes

Source[a]	ID[b]	As mg/kg	Cr mg/kg	Yearly As addition in kg/ha soil at			Yearly Cr addition in kg/ha soil at		
				7.5 lb mix/A	30 lb mix/A	36 lb mix/A	7.5 lb mix/A	30 lb mix/A	36 lb mix/A
				8.4 kg/ha	33.6 kg/ha	40.3 kg/ha	8.4 kg/ha	33.6 kg/ha	40.3 kg/ha
Wash St	H4772	0.85	3.1	0.000	0.000	0.000	0.000	0.000	0.000
	H4756	83	457	0.001[c]	0.003	0.003	0.004	0.015	0.018
Average		41.93	230.1	0.000	0.001	0.002	0.002	0.008	0.009

a) Sources:
Wash St: Washington State Department of Ecology (1997)
b) Sample identification used by author
c) Shading indicates highest yearly addition values of this metal from micronutrient mixes

Table G-13c. Yearly Hg and Ni Additions to Soil (kg/ha) from Micronutrient Mixes

Source[a]	ID[b]	Hg mg/kg	Ni mg/kg	Yearly Hg addition in kg/ha soil at			Yearly Ni addition in kg/ha soil at		
				7.5 lb mix/A	30 lb mix/A	36 lb mix/A	7.5 lb mix/A	30 lb mix/A	36 lb mix/A
				8.4 kg/ha	33.6 kg/ha	40.3 kg/ha	8.4 kg/ha	33.6 kg/ha	40.3 kg/ha
Wash St	H4772	0.03	21	0.000	0.000	0.000	0.000[c]	0.001	0.001
	H4756	0.226	4	0.000	0.000	0.000	0.000	0.000	0.000
Average		0.127	12.5	0.000	0.000	0.000	0.000	0.000	0.001

a) Sources:
Wash St: Washington State Department of Ecology (1997)
b) Sample identification used by author
c) Shading indicates highest yearly addition values of this metal from micronutrient mixes

Table G-13d. Yearly V and Cu Additions to Soil (kg/ha) from Micronutrient Mixes

Source[a]	ID[b]	V mg/kg	Cu mg/kg	Yearly V addition in kg/ha soil at 7.5 lb mix/A 8.4 kg/ha	30 lb mix/A 33.6 kg/ha	36 lb mix/A 40.3 kg/ha	Yearly Cu addition in kg/ha soil at 7.5 lb mix/A 8.4 kg/ha	30 lb mix/A 33.6 kg/ha	36 lb mix/A 40.3 kg/ha
Wash St	H4772	0.5	19400	0.000	0.000	0.000	0.163	0.652	0.782
	H4756	33	39900	0.000[c]	0.001	0.001	0.335	1.341	1.608
Average		16.8	29650	0.000	0.001	0.001	0.249	0.996	1.195

a) Sources:
Wash St: Washington State Department of Ecology (1997)
b) Sample identification used by author
c) Shading indicates highest yearly addition values of this metal from micronutrient mixes

Table G-13e. Yearly Zn Additions to Soil (kg/ha) from Micronutrient Mixes

Source[a]	ID[b]	Zn mg/kg	Yearly Zn addition in kg/ha soil at 7.5 lb mix/A 8.4 kg/ha	30 lb mix/A 33.6 kg/ha	36 lb mix/A 40.3 kg/ha
Wash St	H4772	60300	0.507	2.026	2.430
	H4756	94300	0.792[c]	3.168	3.800
Average		77300	0.649	2.597	3.115

a) Sources:
Wash St: Washington State Department of Ecology (1997)
b) Sample identification used by author
c) Shading indicates highest yearly addition values of this metal from micronutrient mixes

APPENDIX H
HEAVY METALS IN FERTILIZER DATA SUBMITTED TO EPA BY THE PENNSYLVANIA DEPARTMENT OF AGRICULTURE (PDA)

Table H-1. Concentrations of Heavy Metals in Solid NPK Fertilizer Blends

			Concentration of metal, mg/kg								
Type	ID[b]	Grade[c]	Cd	Pb	As	Cr	Hg	Ni	V	Cu	Zn
Ag Blend	B960243	19-19-19	3.5	2.2	6.6	45.4	0.0	11.2	85.2	25.6	36.0
	B960244	12-24-24	4.3	4.6	9.8	59.0	0.0	14.7	119.0	49.3	44.5
	B960249	7-35-12	4.6	3.9	9.7	66.8	0.0	20.9	116.0	45.0	55.1
	B960282	9-44-9	2.3	3.5	13.2	90.7	0.0	14.5	163.0	30.1	49.8
	B960325	10-21-15	2.7	11.1	7.2	46.3	0.2	13.4	87.7	10.2	872.0
	B960333	8-32-16	3.9	5.3	11.2	68.1	0.0	14.9	126.0	22.2	43.9
	B960389	19-19-19	1.6	1.4	5.2	43.5	0.0	0.0	77.7	0.0	0.0
	B960412	7-26-26	2.6	2.8	6.0	51.8	0.0	11.5	79.4	26.2	37.0
	B960418	19-19-19	2.2	3.8	7.5	62.0	0.0	9.2	97.8	13.7	33.1
	B960441	9-34-10	3.3	3.6	10.7	67.4	0.0	12.2	121.0	16.3	34.6
	B960442	9-3-10	3.6	3.0	9.2	88.8	0.0	14.5	159.0	6.6	53.1
	B960453	10-20-20	4.3	3.0	3.6	68.7	0.0	18.0	67.1	16.4	60.9
	B960475	9-40-5	14.3	422.0	10.0	107.9	0.0	29.2	130.0	90.5	4442
	B960510	9-43-10	5.2	1.7	11.2	79.4	0.0	17.8	136.0	7.1	66.2
	B960580	10-10-10	1.8	3.6	4.1	51.4	0.0	14.6	68.8	13.6	803.0
	B960584	10-20-20	2.6	2.5	6.9	52.8	0.0	15.7	83.4	10.6	0.5
	B960599	15-15-15	2.1	2.1	4.9	42.5	0.0	11.4	73.2	7.2	0.6
	B960611	19-19-19	24.4	1.1	0.0	160.0	0.0	36.9	47.2	3.9	6.9
	B960639	6-2-0	5.7	6.9	4.7	40.3	0.0	11.2	18.6	24.3	1.1
	B960708	7-27-11	6.4	153.0	9.0	73.2	0.0	22.7	99.2	544.0	57.8
Ag ammoniated	B960711	8-24-8	9.5	14.0	3.5	60.5	0.0	11.9	47.3	13.6	177.0
Ag Blended	B960713	10-20-10	2.4	6.7	5.4	42.0	0.0	10.1	68.9	32.0	84.5
	B960715	15-15-15	2.0	1.8	4.7	28.0	0.0	6.2	49.2	3.9	0.3
	B980726	19-19-19	4.1	3.7	7.8	48.8	0.0	11.5	85.1	7.9	74.5
	B960820	26-9-9	2.0	2.3	4.1	34.2	0.0	8.0	61.6	14.4	45.7
	B960896	10-20-20	3.3	3.6	7.0	39.0	0.0	8.6	64.5	25.5	23.6
	B960900	10-20-20	3.1	3.3	7.4	201.0	0.0	85.7	70.3	12.9	25.5
	B960909	3-17-40	2.4	2.6	5.1	34.3	0.0	5.7	64.2	4.9	39.5
	B960912	3-17-40	4.3	3.9	10.5	67.4	0.0	12.0	138.0	7.8	52.2
	B960913	8-41-12	1.5	18.0	6.2	68.3	0.0	14.8	18.4	454.0	484.0
	B961058	8-17-34	1.0	2.4	3.1	30.8	0.0	8.9	27.8	5.0	18.3
	B961321	9-43-10	4.7	6.9	10.7	69.8	0.0	13.3	152.0	60.1	44.8

a) Sample type as listed by Pennsylvania Department of Agriculture.
b) Sample identification as listed by Pennsylvania Department of Agriculture.
c) NPK rating of fertilizer as listed by Pennsylvania Department of Agriculture.

Table H-2. Concentrations of Heavy Metals in Solid NPK Fertilizers Blended with Micronutrient Fertilizers

			Concentrations of Metals, mg/kg								
Source	ID	Grade	Cd	Pb	As	Cr	Hg	Ni	V	Cu	Zn
Ag Blend w/Micros	B960278	8-24-8	5.9	129	10.1	97.8	0.53	59.8	96.2	919	12342
Ag Blend w/Micros	B960292	8-24-8	4.7	108	8.8	87.6	0.42	54.5	84.4	843	49.8
Ag ammoniated w/Micros	B960345	10-10-10	7.8	43.6		64.1		11.9	12	39.5	43.9
Ag ammoniated w/Micros	B960355	8-32-18	10.6	56.9	5.9	97.8		13.4	97.3	43.2	732
Ag ammoniated w/Micros	B960429	8-24-8	9.8	9.5	3.9	86.9		15.3	64.9	34	7516
Ag Blend w/Micros	B960463	13-13-13	2.7	2.6	3.6	27.1		4.2	52.7	7.8	12353
Ag Blend w/Micros	B960468	8-24-8	4.1	66.4	8.9	82.5	0.21	46.3	85.7	622	10180
Ag Blend w/Micros	B960518	10-20-10	9.7	31.6	7.4	100.5		31.9	52.3	82.9	1065
Ag Blend w/Micros	B960640	10-20-20	2.8	46.2	5.8	48.6	0.29	20.9	58	325	20.9
Ag Blend w/Micros	B960722	9-24-9	8	313	10.4	78.7		32.4	79.8	813	4322
Ag Blend w/Micros	B960735	8-24-8	4.5	58.2	5.8	67.2		15.8	63	145	2773
Ag ammoniated w/Micros	B960738	10-20-20	6.6	7.9	3.6	56.6		6.3	55.6	6.9	172
Ag ammoniated w/Micros	B960745	10-20-20	6.9	36.1	3.5	53.2		6.5	50	20.2	494
Ag Blend w/Micros	B960757	8-24-8	4.2	337	13.6	80.1	0.14	52	71.6	1183	15173
Ag Blend w/Micros	B960934	10-20-20	3.6	26.6	19.4	48		23.9	61.2	981	1661
Ag Blend w/Micros	B960984	10-20-10	3.3	99.3	5.9	42		18.9	60.7	83.7	1916
Ag Blend w/Micros	B961019	10-20-10	6.3	200	8.9	56.7		22.8	72.4	633	3026
Ag Blend w/Micros	B961102	3-9-36	0.6	1.5	2.1	25.4		6.3	23	18.2	16
Ag Blend w/Micros	B961114	8-24-8	4.6	115	6.9	72.2		27.3	67.2	747	1980
Ag ammoniated w/Micros	B961154	10-20-20	7.8	59.1	3.4	59.1		6.9	50.5	20.1	677

Table H-3. Concentrations of Heavy Metals in Liquid NPK Fertilizer Blends

			Concentrations of Metals, mg/kg								
Source	ID	Grade	Cd	Pb	As	Cr	Hg	Ni	V	Cu	Zn
Ag Liquid	B960360	30-0-0		0.15						0.19	0.72
Ag Liquid	B960673	10-34-0	9.54		6.4	98.3		7.4	58.9	7.82	92.3
Ag Liquid	B960674	9-18-9		0.32	41.5	4.16				1.7	0.85
Ag Liquid	B960675	5-15-15	0.06	0.63	41.2	4.06		0.54	0.28	5.75	4.38
Ag Liquid	B960810	7-22-5	12.5		8.46	109		11.6	6.6	8.2	139
Ag Liquid	B960811	7-22-5	12.1		8.98	109		11.4	6.62	8.4	139
Ag Liquid	B960966	4-8-10	4.01		1.1			0.94		1.33	62.9
Ag Liquid	B961106	7-21-7	7.7	0.13	2.13	101			30.1	0.15	405
Ag Liquid	B961111	30-0-0	0.06	0.21		2.45			4.82	0.38	2.06
Ag Liquid	B961128	1-4-14	2.74	0.15	1.27	20.6		1.6	12.4	2.29	19
Ag Liquid	B961193	2-6-12	3.77	0.12		40.2			11.1	0.14	52.1
Ag Liquid	B961194	4-10-10	5.28		2.23	58.5		2.04	23.2	1.59	63
Ag Liquid	B961195	4-8-10	4.83	0.1	1.4	51.3		1.54	19.9	3.41	54.6
Ag Liquid	B961196	4-5-10	3.12	0.17	0.86	32.4		0.97	12.5	2.49	34.2
Ag Liquid	B961207	8-26-4	12.5	0.11	19.8	142		6.08	60.9	4.59	145
Ag Liquid	B961246	10-34-0	19.6	0.17	12.7	184		14.3	104	8.27	178
Ag Liquid	B961251	4-10-10	5.81	0.24	1.92	58.6		2.38	24.7	1.94	60.8
Ag Liquid	B961252	4-5-10	2.86	0.15	1.07	28.8		1.07	12	4.17	29.9
Ag Liquid	B961253	4-10-10	6.02	0.1	3.68	47.1		3.95	28.9	6.24	41.5
Ag Liquid	B961254	4-5-10	3.59		1.78	27.2		2.27	16.5	4.81	24.3
Ag Liquid	B961255	4-8-10	5.46		3.09	40.4		3.48	24.4	6.03	36.1
Ag Liquid	B961284	7-21-6.5	9.15	0.32	5.73	100		3.91	43.3	4.27	

Table H-4. Concentrations of Heavy Metals in Specialty Fertilizers for Residential Market

			Concentrations of Metals, mg/kg								
Source	ID	Grade	Cd	Pb	As	Cr	Hg	Ni	V	Cu	Zn
Specialty/Liquid	B960205	10-60-10			2.8		0.2		4.1		533
Specialty/Liquid	B960262	10-60-10			2.3		0.13		5.6		517
Specialty Fish Liquid	B960424	2-4-0.5	0.09		4.1	0.65	0.04		0.58	0.35	8.51
Specialty/Poly Coated Urea	B960192	18-6-12		2		2.2		2.5	13.4	19	5.1
Specialty/Fish	B960266	5-1-1		1	12.3	2.4				28.2	33
Specialty	B960648	18-24-12	4.1	2.1	3.4	54.5		6	61.5	18	1.08
Specialty Organic	B960763	.05-.05-.05	14	5.7	40.1		25.9	40.7	74.5	89	
Specialty Blend	B960814	18-24-5	4.8	5.6	8.3	71		15.7	117	47.1	41.2
Specialty Fish	B960836	3-2-2	0.1	0.16	7.81	0.66			0.48	5.6	7.8
Specialty Organic	B960851	2-1-2		12.5		17.8		11.9	39.5	32.7	92.4
Specialty Organic	B960891	18-8-6	2	23	4.6	2455		21.4	47.4	136	340
Specialty Bio-solid	B960894	6-2-0	3.9	88.9	4.1	306	0.67	53	8.6	272	517
Specialty Blend	B960969	19-26-6	2.1	1.2	6.1	46.5		6.3	81.3	8.7	21.4
Specialty Organic	B960992	3-2-3	5.9	8.1	3.2	233	0.12	9.6		104	517
Specialty ammoniated	B961077	13-25-12	8.3	11.5	4.2	83.8		12.5	66.4	41.9	210
Specialty Organic	B961082	5-4-5	3.6	85.2	11.7	123	0.4	30.9	12.6	270	3488
Specialty Organic	B961083	14-2-5		19	12.1	40	0.11	10.8	16.4	201	626
Specialty Blend	B961087	16-8-8	2.9	79.9	4.3	47.9		21.6	24.9	496	1886
Specialty Organic	B961094	8-2-2		6.2		13.1		9.1	7.3	1060	282
Specialty Organic	B961095	1-1-1		14.5	5.7	24.3		13.7	22.3	461	308
Specialty Bio-solid	B961145	6-2-0	5.2	54.3	3.7	391	0.59	29.9		236	414
Specialty	B961152	17-4-28				1.9	0.09			128	83.7
Specialty Blend	B961286	10-20-20	3	20	6.3	43.7	0.38	11.1	60	70.9	136
Specialty Blend	B961297	27-3-3	2.7	1.7		22.5		4.6		17.4	25.6
Specialty Organic	B961326	1-1-1		6.9		7.5	0.2	10.1		34.1	83.3

Table H-4. Continued

	Concentrations of Metals, mg/kg										
Source	ID	Grade	Cd	Pb	As	Cr	Hg	Ni	V	Cu	Zn
Specialty Organic	B961327	.49-.14-.29	26.6		4.3	0.1			20.6	82.3	
Specialty/Micros	B960193	17-6-12	1.7	1.7		3		8.4	14.7	584	457
Specialty w/Micros	B960221	4-12-4	3.4	49.2	4.4	47.5		27	48.2	972	1729
Specialty w/Micros	B960344	18-6-12		1.9		22.5		8	18.7	486	525
Specialty w/Micros	B960536	20-20-20		0.8		5.6		3.2		512.7	556
Specialty w/Micros	B960539	13-25-12	7.8	6.5	4	76.6		11.6	65.2	43.6	171
Specialty w/Micros	B960626	18-3-18	2.3	1.9	3.8	37.2		11.6	11.1	63.5	4.02
Specialty w/Micros	B960634	12-10-10	11.9	4.2		70.9		20.9	17.4	43.9	3.41
Specialty w/Micros	B960680	Organic	1.9	28.9	4.8	1864		22.7	23.3	465	14.6
Specialty w/Micros	B960687	5-20-10	11.7	5.4	3.7	96.8		21	53.8	59	2.51
Specialty w/Micros	B960793	Organic	2.6	25.6	6.8	608	0.06	13.5	10.3	478	592
Specialty w/Micros	B960923	Organic	3.4	274	19.8	60.4		44.9	62.4	711	13460
Specialty w/Micros	B961150	20-27-5	4	5	6	59		11.4	109	9.1	36

Table H-5. Concentrations of Heavy Metals in Fertilizer Ingredients

			Concentrations of Metals, mg/kg								
Source	ID	Grade	Cd	Pb	As	Cr	Hg	Ni	V	Cu	Zn
Urea	B960368	46-0-0				5.3			4.2		46.6
Monoammonium phosphate	B960557	11-52-0	4.8	1.9	13	92.6		19.9	160	5.7	64.5
Diammonium phosphate	B960582	18-48-0	4.6	4.4	13.8	77.6		16.8	151	11.3	0.83
Ammonium Nitrate	B960601	34-0-0				3.1					0.06
Ammonium Sulfate	B960603	21-0-0									0.02
Specialty WIN	B960750	38-0-0								2.5	1.8
Ammonium Sulfate	B960834	21-0-0		0.8		2.9				6.5	4
Muriate of Potash	B960839	0-0-60		2		1.3				1.9	2
Ammonium Nitrate	B960878	34-0-0				0.8					1.6
Muriate of Potash	B960897	0-0-62				3.1					3
Ammonium Sulfate	B961007	21-0-0		0.8		1.5				15	4.9
Monoammonium phosphate	B961304	10-50-0	3.4	4.6	13.2	72.9		16.7	133	32.3	40.5
Ammonium Sulfate	B970433	21-0-0		1.2		3.1				29.7	6.2
Triple Super Phosphate	B970434	0-46-0	6.4	13.2	13.9	90.1		21.9	132	45.1	87.1
Muriate of Potash	B970435	0-0-60		1.1		2.5				2.5	2.3
Urea	B970436	46-0-0		1.3		1.5					5.4
Monoammonium phosphate	B970437	11-52-0	4.9	6.8	18.7	96.3		19.4	132	24.2	59.4
Diammonium phosphate	B970438	18-46-0	3.4	6.1	16.3	74.4		16.7	95.2	25.6	43
Limestone filler	B970439	0-0-0	0.9	10.3		41.3		25.7	3.9	169	20.4
Micro-mix	B960991	20% Zn	9	1202	76.6	363	2.7	448	46.5	180	192645

Table H-6. Yearly Cd and Pb Additions to Soil (kg/ha) from NPK Fertilizers, Fertilizers Applied for N, P, or K Content

Source	%N %P_2O_5 %K_2O	Cd mg/kg	Pb mg/kg	Yearly Cd addition in kg/ha at			Yearly Pb addition in kg/ha at		
				lb/A			lb/A		
				124 N 84 P_2O_5 103 K_2O	206 N 173 P_2O_5 177 K_2O	414 N 252 P_2O_5 534 K_2O	124 N 84 P_2O_5 103 K_2O	206 N 173 P_2O_5 177 K_2O	414 N 252 P_2O_5 534 K_2O
				kg/ha			kg/ha		
				139 N 94 P_2O_5 115 K_2O	231 N 194 P_2O_5 198 K_2O	464 N 282 P_2O_5 598 K_2O	139 N 94 P_2O_5 115 K_2O	231 N 194 P_2O_5 198 K_2O	464 N 282 P_2O_5 598 K_2O
Ag Blend B960243 19-19-19	19	3.5	2.2	0.003	0.004	0.009	0.002	0.003	0.005
	19	3.5	2.2	0.002	0.004	0.005	0.001	0.002	0.003
	19	3.5	2.2	0.002	0.004	0.011	0.001	0.002	0.007
Ag Blend B960244 12-24-24	12	4.3	4.6	0.005	0.008	0.017	0.005	0.009	0.018
	24	4.3	4.6	0.002	0.003	0.005	0.002	0.004	0.005
	24	4.3	4.6	0.002	0.004	0.011	0.002	0.004	0.011
Ag Blend B960249 7-35-12	7	4.6	3.9	0.009	0.015	0.030	0.008	0.013	0.026
	35	4.6	3.9	0.001	0.003	0.004	0.001	0.002	0.003
	12	4.6	3.9	0.004	0.008	0.023	0.004	0.006	0.019
Ag Blend B960282 9-44-9	9	2.3	3.5	0.004	0.006	0.012	0.005	0.009	0.018
	44	2.3	3.5	0.000	0.001	0.001	0.001	0.002	0.002
	9	2.3	3.5	0.003	0.005	0.015	0.004	0.008	0.023
Ag Blend B960325 10-21-15	10	2.7	11.1	0.004	0.006	0.013	0.015	0.026	0.052
	21	2.7	11.1	0.001	0.002	0.004	0.005	0.010	0.015
	15	2.7	11.1	0.002	0.004	0.011	0.009	0.015	0.044
Ag Blend B960333 8-32-16	8	3.9	5.3	0.007	0.011	0.023	0.009	0.015	0.031
	32	3.9	5.3	0.001	0.002	0.003	0.002	0.003	0.005
	16	3.9	5.3	0.003	0.005	0.015	0.004	0.007	0.020
Ag Blend B960389 19-19-19	19	1.6	1.4	0.001	0.002	0.004	0.001	0.002	0.003
	19	1.6	1.4	0.001	0.002	0.002	0.001	0.001	0.002
	19	1.6	1.4	0.001	0.002	0.005	0.001	0.001	0.004
Ag Blend B960412 7-26-26	7	2.6	2.8	0.005	0.009	0.017	0.006	0.009	0.019
	26	2.6	2.8	0.001	0.002	0.003	0.001	0.002	0.003
	26	2.6	2.8	0.001	0.002	0.006	0.001	0.002	0.006
Ag Blend B960418 19-19-19	19	2.2	3.8	0.002	0.003	0.005	0.003	0.005	0.009
	19	2.2	3.8	0.001	0.002	0.003	0.002	0.004	0.006
	19	2.2	3.8	0.001	0.002	0.007	0.002	0.004	0.012
Ag Blend B960441 9-34-10	9	3.3	3.6	0.005	0.008	0.017	0.006	0.009	0.019
	34	3.3	3.6	0.001	0.002	0.003	0.001	0.002	0.003
	10	3.3	3.6	0.004	0.007	0.020	0.004	0.007	0.022
Ag Blend B960442 9-3-10	9	3.6	3	0.006	0.009	0.019	0.005	0.008	0.015
	3	3.6	3	0.011	0.023	0.034	0.009	0.019	0.028
	10	3.6	3	0.004	0.007	0.022	0.003	0.006	0.018
Ag Blend B960453 10-20-20	10	4.3	3	0.006	0.010	0.020	0.004	0.007	0.014
	20	4.3	3	0.002	0.004	0.006	0.001	0.003	0.004
	20	4.3	3	0.002	0.004	0.013	0.002	0.003	0.009

Table H-6. Continued

Source	%N %P_2O_5 %K_2O	Cd mg/kg	Pb mg/kg	Yearly Cd addition in kg/ha at lb/A: 124 N, 84 P_2O_5, 103 K_2O	206 N, 173 P_2O_5, 177 K_2O	414 N, 252 P_2O_5, 534 K_2O	Yearly Pb addition in kg/ha at lb/A: 124 N, 84 P_2O_5, 103 K_2O	206 N, 173 P_2O_5, 177 K_2O	414 N, 252 P_2O_5, 534 K_2O
				kg/ha: 139 N, 94 P_2O_5, 115 K_2O	231 N, 194 P_2O_5, 198 K_2O	464 N, 282 P_2O_5, 598 K_2O	kg/ha: 139 N, 94 P_2O_5, 115 K_2O	231 N, 194 P_2O_5, 198 K_2O	464 N, 282 P_2O_5, 598 K_2O
Ag Blend B960475 9-40-5	9	14.3	422	0.022	0.037	0.074	0.652	1.083	2.176
	40	14.3	422	0.003	0.007	0.010	0.099	0.205	0.298
	5	14.3	422	0.033	0.057	0.171	0.971	1.671	5.047
Ag Blend B960510 9-43-10	9	5.2	1.7	0.008	0.013	0.027	0.003	0.004	0.009
	43	5.2	1.7	0.001	0.002	0.003	0.000	0.001	0.001
	10	5.2	1.7	0.006	0.010	0.031	0.002	0.003	0.010
Ag Blend B960580 10-10-10	10	1.8	3.6	0.003	0.004	0.008	0.005	0.008	0.017
	10	1.8	3.6	0.002	0.003	0.005	0.003	0.007	0.010
	10	1.8	3.6	0.002	0.004	0.011	0.004	0.007	0.022
Ag Blend B960584 10-20-20	10	2.6	2.5	0.004	0.006	0.012	0.003	0.006	0.012
	20	2.6	2.5	0.001	0.003	0.004	0.001	0.002	0.004
	20	2.6	2.5	0.001	0.003	0.008	0.001	0.002	0.007
Ag Blend B960599 15-15-15	15	2.1	2.1	0.002	0.003	0.006	0.002	0.003	0.006
	15	2.1	2.1	0.001	0.003	0.004	0.001	0.003	0.004
	15	2.1	2.1	0.002	0.003	0.008	0.002	0.003	0.008
Ag Blend B960611 19-19-19	19	24.35	1.1	0.018	0.030	0.059	0.001	0.001	0.003
	19	24.35	1.1	0.012	0.025	0.036	0.001	0.001	0.002
	19	24.35	1.1	0.015	0.025	0.077	0.001	0.001	0.003
Ag Blend B960639 6-2-0	6	5.7	6.9	0.013	0.022	0.044	0.016	0.027	0.053
	2	5.7	6.9	0.027	0.055	0.080	0.032	0.067	0.097
	0	5.7	6.9	ERR	ERR	ERR	ERR	ERR	ERR
Ag Blend B960708 7-27-11	7	6.4	153	0.013	0.021	0.042	0.304	0.505	1.014
	27	6.4	153	0.002	0.005	0.007	0.053	0.110	0.160
	11	6.4	153	0.007	0.012	0.035	0.160	0.275	0.832
Ag ammoniated B960711 8-24-8	8	9.5	14	0.017	0.027	0.055	0.024	0.040	0.081
	24	9.5	14	0.004	0.008	0.011	0.005	0.011	0.016
	8	9.5	14	0.014	0.024	0.071	0.020	0.035	0.105
Ag Blend B960713 10-20-10	10	2.4	6.7	0.003	0.006	0.011	0.009	0.015	0.031
	20	2.4	6.7	0.001	0.002	0.003	0.003	0.006	0.009
	10	2.4	6.7	0.003	0.005	0.014	0.008	0.013	0.040
Ag Blend B960715 15-15-15	15	2	1.8	0.002	0.003	0.006	0.002	0.003	0.006
	15	2	1.8	0.001	0.003	0.004	0.001	0.002	0.003
	15	2	1.8	0.002	0.003	0.008	0.001	0.002	0.007
Ag Blend B980726 19-19-19	19	4.1	3.7	0.003	0.005	0.010	0.003	0.004	0.009
	19	4.1	3.7	0.002	0.004	0.006	0.002	0.004	0.005
	19	4.1	3.7	0.002	0.004	0.013	0.002	0.004	0.012
AG Blend B960820 26-9-9	26	2	2.3	0.001	0.002	0.004	0.001	0.002	0.004
	9	2	2.3	0.002	0.004	0.006	0.002	0.005	0.007
	9	2	2.3	0.003	0.004	0.013	0.003	0.005	0.015

Table H-6. Continued

Source	%N %P_2O_5 %K_2O	Cd mg/kg	Pb mg/kg	Yearly Cd addition in kg/ha at			Yearly Pb addition in kg/ha at		
				lb/A			lb/A		
				124 N 84 P_2O_5 103 K_2O	206 N 173 P_2O_5 177 K_2O	414 N 252 P_2O_5 534 K_2O	124 N 84 P_2O_5 103 K_2O	206 N 173 P_2O_5 177 K_2O	414 N 252 P_2O_5 534 K_2O
				kg/ha			kg/ha		
				139 N 94 P_2O_5 115 K_2O	231 N 194 P_2O_5 198 K_2O	464 N 282 P_2O_5 598 K_2O	139 N 94 P_2O_5 115 K_2O	231 N 194 P_2O_5 198 K_2O	464 N 282 P_2O_5 598 K_2O
Ag Blend B960896 10-20-20	10	3.3	3.6	0.005	0.008	0.015	0.005	0.008	0.017
	20	3.3	3.6	0.002	0.003	0.005	0.002	0.003	0.005
	20	3.3	3.6	0.002	0.003	0.010	0.002	0.004	0.011
Ag Blend B960900 10-20-20	10	3.1	3.3	0.004	0.007	0.014	0.005	0.008	0.015
	20	3.1	3.3	0.001	0.003	0.004	0.002	0.003	0.005
	20	3.1	3.3	0.002	0.003	0.009	0.002	0.003	0.010
Ag Blend B960909 3-17-40	3	2.4	2.6	0.011	0.018	0.037	0.012	0.020	0.040
	17	2.4	2.6	0.001	0.003	0.004	0.001	0.003	0.004
	40	2.4	2.6	0.001	0.001	0.004	0.001	0.001	0.004
Ag Blend B960912 3-17-40	3	4.3	3.9	0.020	0.033	0.067	0.018	0.030	0.060
	17	4.3	3.9	0.002	0.005	0.007	0.002	0.004	0.006
	40	4.3	3.9	0.001	0.002	0.006	0.001	0.002	0.006
Ag Blend B960913 8-41-12	8	1.5	18	0.003	0.004	0.009	0.031	0.052	0.104
	41	1.5	18	0.000	0.001	0.001	0.004	0.009	0.012
	12	1.5	18	0.001	0.002	0.007	0.017	0.030	0.090
Ag Blend B961058 8-17-34	8	1	2.4	0.002	0.003	0.006	0.004	0.007	0.014
	17	1	2.4	0.001	0.001	0.002	0.001	0.003	0.004
	34	1	2.4	0.000	0.001	0.002	0.001	0.001	0.004
Ag Blend B961321 9-43-10	9	4.7	6.9	0.007	0.012	0.024	0.011	0.018	0.036
	43	4.7	6.9	0.001	0.002	0.003	0.002	0.003	0.005
	10	4.7	6.9	0.005	0.009	0.028	0.008	0.014	0.041

Table H-7. Yearly As and Cr Additions to Soil (kg/ha) from NPK Fertilizers, Fertilizers Applied for N, P, or K Content

Source	%N %P_2O_5 %K_2O	As mg/kg	Cr mg/kg	Yearly As addition in kg/ha at			Yearly Cr addition in kg/ha at		
				lb/A			lb/A		
				124 N 84 P_2O_5 103 K_2O	206 N 173 P_2O_5 177 K_2O	414 N 252 P_2O_5 534 K_2O	124 N 84 P_2O_5 103 K_2O	206 N 173 P_2O_5 177 K_2O	414 N 252 P_2O_5 534 K_2O
				kg/ha			kg/ha		
				139 N 94 P_2O_5 115 K_2O	231 N 194 P_2O_5 198 K_2O	464 N 282 P_2O_5 598 K_2O	139 N 94 P_2O_5 115 K_2O	231 N 194 P_2O_5 198 K_2O	464 N 282 P_2O_5 598 K_2O
Ag Blend B960243 19-19-19	19	6.6	45.4	0.005	0.008	0.016	0.033	0.055	0.111
	19	6.6	45.4	0.003	0.007	0.010	0.022	0.046	0.067
	19	6.6	45.4	0.004	0.007	0.021	0.027	0.047	0.143
Ag Blend B960244 12-24-24	12	9.8	59	0.011	0.019	0.038	0.068	0.114	0.228
	24	9.8	59	0.004	0.008	0.012	0.023	0.048	0.069
	24	9.8	59	0.005	0.008	0.024	0.028	0.049	0.147
Ag Blend B960249 7-35-12	7	9.7	66.8	0.019	0.032	0.064	0.133	0.220	0.443
	35	9.7	66.8	0.003	0.005	0.008	0.018	0.037	0.054
	12	9.7	66.8	0.009	0.016	0.048	0.064	0.110	0.333
Ag Blend B960282 9-44-9	9	13.2	90.7	0.020	0.034	0.068	0.140	0.233	0.468
	44	13.2	90.7	0.003	0.006	0.008	0.019	0.040	0.058
	9	13.2	90.7	0.017	0.029	0.088	0.116	0.200	0.603
Ag Blend B960325 10-21-15	10	7.2	46.3	0.010	0.017	0.033	0.064	0.107	0.215
	21	7.2	46.3	0.003	0.007	0.010	0.021	0.043	0.062
	15	7.2	46.3	0.006	0.010	0.029	0.035	0.061	0.185
Ag Blend B960333 8-32-16	8	11.2	68.1	0.019	0.032	0.065	0.118	0.197	0.395
	32	11.2	68.1	0.003	0.007	0.010	0.020	0.041	0.060
	16	11.2	68.1	0.008	0.014	0.042	0.049	0.084	0.255
Ag Blend B960389 19-19-19	19	5.2	43.5	0.004	0.006	0.013	0.032	0.053	0.106
	19	5.2	43.5	0.003	0.005	0.008	0.022	0.044	0.065
	19	5.2	43.5	0.003	0.005	0.016	0.026	0.045	0.137
Ag Blend B960412 7-26-26	7	6	51.8	0.012	0.020	0.040	0.103	0.171	0.343
	26	6	51.8	0.002	0.004	0.007	0.019	0.039	0.056
	26	6	51.8	0.003	0.005	0.014	0.023	0.039	0.119
Ag Blend B960418 19-19-19	19	7.5	62	0.005	0.009	0.018	0.045	0.075	0.151
	19	7.5	62	0.004	0.008	0.011	0.031	0.063	0.092
	19	7.5	62	0.005	0.008	0.024	0.038	0.065	0.195
Ag Blend B960441 9-34-10	9	10.7	67.4	0.017	0.027	0.055	0.104	0.173	0.347
	34	10.7	67.4	0.003	0.006	0.009	0.019	0.038	0.056
	10	10.7	67.4	0.012	0.021	0.064	0.078	0.133	0.403
Ag Blend B960442 9-3-10	9	9.2	88.8	0.014	0.024	0.047	0.137	0.228	0.458
	3	9.2	88.8	0.029	0.059	0.086	0.278	0.574	0.835
	10	9.2	88.8	0.011	0.018	0.055	0.102	0.176	0.531
Ag Blend B960453 10-20-20	10	3.6	68.7	0.005	0.008	0.017	0.095	0.159	0.319
	20	3.6	68.7	0.002	0.003	0.005	0.032	0.067	0.097
	20	3.6	68.7	0.002	0.004	0.011	0.040	0.068	0.205

Table H-7. Continued

Source	%N %P_2O_5 %K_2O	As mg/kg	Cr mg/kg	Yearly As addition in kg/ha at			Yearly Cr addition in kg/ha at		
				lb/A			lb/A		
				124 N 84 P_2O_5 103 K_2O	206 N 173 P_2O_5 177 K_2O	414 N 252 P_2O_5 534 K_2O	124 N 84 P_2O_5 103 K_2O	206 N 173 P_2O_5 177 K_2O	414 N 252 P_2O_5 534 K_2O
				kg/ha			kg/ha		
				139 N 94 P_2O_5 115 K_2O	231 N 194 P_2O_5 198 K_2O	464 N 282 P_2O_5 598 K_2O	139 N 94 P_2O_5 115 K_2O	231 N 194 P_2O_5 198 K_2O	464 N 282 P_2O_5 598 K_2O
Ag Blend B960475 9-40-5	9	10	107.9	0.015	0.026	0.052	0.167	0.277	0.556
	40	10	107.9	0.002	0.005	0.007	0.025	0.052	0.076
	5	10	107.9	0.023	0.040	0.120	0.248	0.427	1.290
Ag Blend B960510 9-43-10	9	11.2	79.4	0.017	0.029	0.058	0.123	0.204	0.409
	43	11.2	79.4	0.002	0.005	0.007	0.017	0.036	0.052
	10	11.2	79.4	0.013	0.022	0.067	0.091	0.157	0.475
Ag Blend B960580 10-10-10	10	4.1	51.4	0.006	0.009	0.019	0.071	0.119	0.238
	10	4.1	51.4	0.004	0.008	0.012	0.048	0.100	0.145
	10	4.1	51.4	0.005	0.008	0.025	0.059	0.102	0.307
Ag Blend B960584 10-20-20	10	6.9	52.8	0.010	0.016	0.032	0.073	0.122	0.245
	20	6.9	52.8	0.003	0.007	0.010	0.025	0.051	0.074
	20	6.9	52.8	0.004	0.007	0.021	0.030	0.052	0.158
Ag Blend B960599 15-15-15	15	4.9	42.5	0.005	0.008	0.015	0.039	0.065	0.131
	15	4.9	42.5	0.003	0.006	0.009	0.027	0.055	0.080
	15	4.9	42.5	0.004	0.006	0.020	0.033	0.056	0.169
Ag Blend B960611 19-19-19	19	0	160	0.000	0.000	0.000	0.117	0.195	0.391
	19	0	160	0.000	0.000	0.000	0.079	0.163	0.237
	19	0	160	0.000	0.000	0.000	0.097	0.167	0.504
Ag Blend B960639 6-2-0	6	4.7	40.3	0.011	0.018	0.036	0.093	0.155	0.312
	2	4.7	40.3	0.022	0.046	0.066	0.189	0.391	0.568
	0	4.7	40.3	ERR	ERR	ERR	ERR	ERR	ERR
Ag Blend B960708 7-27-11	7	9	73.2	0.018	0.030	0.060	0.145	0.242	0.485
	27	9	73.2	0.003	0.006	0.009	0.025	0.053	0.076
	11	9	73.2	0.009	0.016	0.049	0.077	0.132	0.398
Ag ammoniated B960711 8-24-8	8	3.5	60.5	0.006	0.010	0.020	0.105	0.175	0.351
	24	3.5	60.5	0.001	0.003	0.004	0.024	0.049	0.071
	8	3.5	60.5	0.005	0.009	0.026	0.087	0.150	0.452
Ag Blend B960713 10-20-10	10	5.4	42	0.008	0.012	0.025	0.058	0.097	0.195
	20	5.4	42	0.003	0.005	0.008	0.020	0.041	0.059
	10	5.4	42	0.006	0.011	0.032	0.048	0.083	0.251
Ag Blend B960715 15-15-15	15	4.7	28	0.004	0.007	0.015	0.026	0.043	0.087
	15	4.7	28	0.003	0.006	0.009	0.018	0.036	0.053
	15	4.7	28	0.004	0.006	0.019	0.021	0.037	0.112
Ag Blend B980726 19-19-19	19	7.8	48.8	0.006	0.009	0.019	0.036	0.059	0.119
	19	7.8	48.8	0.004	0.008	0.012	0.024	0.050	0.072
	19	7.8	48.8	0.005	0.008	0.025	0.030	0.051	0.154
AG Blend B960820 26-9-9	26	4.1	34.2	0.002	0.004	0.007	0.018	0.030	0.061
	9	4.1	34.2	0.004	0.009	0.013	0.036	0.074	0.107
	9	4.1	34.2	0.005	0.009	0.027	0.044	0.075	0.227

Table H-7. Continued

Source	%N %P_2O_5 %K_2O	As mg/kg	Cr mg/kg	Yearly As addition in kg/ha at			Yearly Cr addition in kg/ha at		
				lb/A			lb/A		
				124 N 84 P_2O_5 103 K_2O	206 N 173 P_2O_5 177 K_2O	414 N 252 P_2O_5 534 K_2O	124 N 84 P_2O_5 103 K_2O	206 N 173 P_2O_5 177 K_2O	414 N 252 P_2O_5 534 K_2O
				kg/ha			kg/ha		
				139 N 94 P_2O_5 115 K_2O	231 N 194 P_2O_5 198 K_2O	464 N 282 P_2O_5 598 K_2O	139 N 94 P_2O_5 115 K_2O	231 N 194 P_2O_5 198 K_2O	464 N 282 P_2O_5 598 K_2O
Ag Blend B960896 10-20-20	10	7	39	0.010	0.016	0.032	0.054	0.090	0.181
	20	7	39	0.003	0.007	0.010	0.018	0.038	0.055
	20	7	39	0.004	0.007	0.021	0.022	0.039	0.117
Ag Blend B960900 10-20-20	10	7.4	201	0.010	0.017	0.034	0.279	0.464	0.933
	20	7.4	201	0.003	0.007	0.010	0.094	0.195	0.283
	20	7.4	201	0.004	0.007	0.022	0.116	0.199	0.601
Ag Blend B960909 3-17-40	3	5.1	34.3	0.024	0.039	0.079	0.159	0.264	0.531
	17	5.1	34.3	0.003	0.006	0.008	0.019	0.039	0.057
	40	5.1	34.3	0.001	0.003	0.008	0.010	0.017	0.051
Ag Blend B960912 3-17-40	3	10.5	67.4	0.049	0.081	0.162	0.312	0.519	1.042
	17	10.5	67.4	0.006	0.012	0.017	0.037	0.077	0.112
	40	10.5	67.4	0.003	0.005	0.016	0.019	0.033	0.101
Ag Blend B960913 8-41-12	8	6.2	68.3	0.011	0.018	0.036	0.119	0.197	0.396
	41	6.2	68.3	0.001	0.003	0.004	0.016	0.032	0.047
	12	6.2	68.3	0.006	0.010	0.031	0.065	0.113	0.340
Ag Blend B961058 8-17-34	8	3.1	30.8	0.005	0.009	0.018	0.054	0.089	0.179
	17	3.1	30.8	0.002	0.004	0.005	0.017	0.035	0.051
	34	3.1	30.8	0.001	0.002	0.005	0.010	0.018	0.054
Ag Blend B961321 9-43-10	9	10.7	69.8	0.017	0.027	0.055	0.108	0.179	0.360
	43	10.7	69.8	0.002	0.005	0.007	0.015	0.031	0.046
	10	10.7	69.8	0.012	0.021	0.064	0.080	0.138	0.417

Table H-8. Yearly Hg and Ni Additions to Soil (kg/ha) from NPK Fertilizers, Fertilizers Applied for N, P, or K Content

Source	%N %P_2O_5 %K_2O	Hg mg/kg	Ni mg/kg	Yearly Hg addition in kg/ha at			Yearly Ni addition in kg/ha at		
				lb/A			lb/A		
				124 N 84 P_2O_5 103 K_2O	206 N 173 P_2O_5 177 K_2O	414 N 252 P_2O_5 534 K_2O	124 N 84 P_2O_5 103 K_2O	206 N 173 P_2O_5 177 K_2O	414 N 252 P_2O_5 534 K_2O
				kg/ha			kg/ha		
				139 N 94 P_2O_5 115 K_2O	231 N 194 P_2O_5 198 K_2O	464 N 282 P_2O_5 598 K_2O	139 N 94 P_2O_5 115 K_2O	231 N 194 P_2O_5 198 K_2O	464 N 282 P_2O_5 598 K_2O
Ag Blend B960243 19-19-19	19	0	11.2	0.000	0.000	0.000	0.008	0.014	0.027
	19	0	11.2	0.000	0.000	0.000	0.006	0.011	0.017
	19	0	11.2	0.000	0.000	0.000	0.007	0.012	0.035
Ag Blend B960244 12-24-24	12	0	14.7	0.000	0.000	0.000	0.017	0.028	0.057
	24	0	14.7	0.000	0.000	0.000	0.006	0.012	0.017
	24	0	14.7	0.000	0.000	0.000	0.007	0.012	0.037
Ag Blend B960249 7-35-12	7	0	20.9	0.000	0.000	0.000	0.042	0.069	0.139
	35	0	20.9	0.000	0.000	0.000	0.006	0.012	0.017
	12	0	20.9	0.000	0.000	0.000	0.020	0.034	0.104
Ag Blend B960282 9-44-9	9	0	14.5	0.000	0.000	0.000	0.022	0.037	0.075
	44	0	14.5	0.000	0.000	0.000	0.003	0.006	0.009
	9	0	14.5	0.000	0.000	0.000	0.019	0.032	0.096
Ag Blend B960325 10-21-15	10	0.17	13.4	0.000	0.000	0.001	0.019	0.031	0.062
	21	0.17	13.4	0.000	0.000	0.000	0.006	0.012	0.018
	15	0.17	13.4	0.000	0.000	0.001	0.010	0.018	0.053
Ag Blend B960333 8-32-16	8	0	14.9	0.000	0.000	0.000	0.026	0.043	0.086
	32	0	14.9	0.000	0.000	0.000	0.004	0.009	0.013
	16	0	14.9	0.000	0.000	0.000	0.011	0.018	0.056
Ag Blend B960389 19-19-19	19	0	0	0.000	0.000	0.000	0.000	0.000	0.000
	19	0	0	0.000	0.000	0.000	0.000	0.000	0.000
	19	0	0	0.000	0.000	0.000	0.000	0.000	0.000
Ag Blend B960412 7-26-26	7	0	11.5	0.000	0.000	0.000	0.023	0.038	0.076
	26	0	11.5	0.000	0.000	0.000	0.004	0.009	0.012
	26	0	11.5	0.000	0.000	0.000	0.005	0.009	0.026
Ag Blend B960418 19-19-19	19	0	9.2	0.000	0.000	0.000	0.007	0.011	0.022
	19	0	9.2	0.000	0.000	0.000	0.005	0.009	0.014
	19	0	9.2	0.000	0.000	0.000	0.006	0.010	0.029
Ag Blend B960441 9-34-10	9	0	12.2	0.000	0.000	0.000	0.019	0.031	0.063
	34	0	12.2	0.000	0.000	0.000	0.003	0.007	0.010
	10	0	12.2	0.000	0.000	0.000	0.014	0.024	0.073
Ag Blend B960442 9-3-10	9	0	14.5	0.000	0.000	0.000	0.022	0.037	0.075
	3	0	14.5	0.000	0.000	0.000	0.045	0.094	0.136
	10	0	14.5	0.000	0.000	0.000	0.017	0.029	0.087
Ag Blend B960453 10-20-20	10	0	18	0.000	0.000	0.000	0.025	0.042	0.084
	20	0	18	0.000	0.000	0.000	0.008	0.017	0.025
	20	0	18	0.000	0.000	0.000	0.010	0.018	0.054

Table H-8. Continued

Source	%N %P_2O_5 %K_2O	Hg mg/kg	Ni mg/kg	Yearly Hg addition in kg/ha at			Yearly Ni addition in kg/ha at		
				lb/A			lb/A		
				124 N 84 P_2O_5 103 K_2O	206 N 173 P_2O_5 177 K_2O	414 N 252 P_2O_5 534 K_2O	124 N 84 P_2O_5 103 K_2O	206 N 173 P_2O_5 177 K_2O	414 N 252 P_2O_5 534 K_2O
				kg/ha			kg/ha		
				139 N 94 P_2O_5 115 K_2O	231 N 194 P_2O_5 198 K_2O	464 N 282 P_2O_5 598 K_2O	139 N 94 P_2O_5 115 K_2O	231 N 194 P_2O_5 198 K_2O	464 N 282 P_2O_5 598 K_2O
Ag Blend B960475 9-40-5	9	0	29.2	0.000	0.000	0.000	0.045	0.075	0.151
	40	0	29.2	0.000	0.000	0.000	0.007	0.014	0.021
	5	0	29.2	0.000	0.000	0.000	0.067	0.116	0.349
Ag Blend B960510 9-43-10	9	0	17.8	0.000	0.000	0.000	0.027	0.046	0.092
	43	0	17.8	0.000	0.000	0.000	0.004	0.008	0.012
	10	0	17.8	0.000	0.000	0.000	0.020	0.035	0.106
Ag Blend B960580 10-10-10	10	0	14.6	0.000	0.000	0.000	0.020	0.034	0.068
	10	0	14.6	0.000	0.000	0.000	0.014	0.028	0.041
	10	0	14.6	0.000	0.000	0.000	0.017	0.029	0.087
Ag Blend B960584 10-20-20	10	0	15.7	0.000	0.000	0.000	0.022	0.036	0.073
	20	0	15.7	0.000	0.000	0.000	0.007	0.015	0.022
	20	0	15.7	0.000	0.000	0.000	0.009	0.016	0.047
Ag Blend B960599 15-15-15	15	0	11.4	0.000	0.000	0.000	0.011	0.018	0.035
	15	0	11.4	0.000	0.000	0.000	0.007	0.015	0.021
	15	0	11.4	0.000	0.000	0.000	0.009	0.015	0.045
Ag Blend B960611 19-19-19	19	0	36.9	0.000	0.000	0.000	0.027	0.045	0.090
	19	0	36.9	0.000	0.000	0.000	0.018	0.038	0.055
	19	0	36.9	0.000	0.000	0.000	0.022	0.038	0.116
Ag Blend B960639 6-2-0	6	0	11.2	0.000	0.000	0.000	0.026	0.043	0.087
	2	0	11.2	0.000	0.000	0.000	0.053	0.109	0.158
	0	0	11.2	ERR	ERR	ERR	ERR	ERR	ERR
Ag Blend B960708 7-27-11	7	0	22.7	0.000	0.000	0.000	0.045	0.075	0.150
	27	0	22.7	0.000	0.000	0.000	0.008	0.016	0.024
	11	0	22.7	0.000	0.000	0.000	0.024	0.041	0.123
Ag ammoniated B960711 8-24-8	8	0	11.9	0.000	0.000	0.000	0.021	0.034	0.069
	24	0	11.9	0.000	0.000	0.000	0.005	0.010	0.014
	8	0	11.9	0.000	0.000	0.000	0.017	0.029	0.089
Ag Blend B960713 10-20-10	10	0	10.1	0.000	0.000	0.000	0.014	0.023	0.047
	20	0	10.1	0.000	0.000	0.000	0.005	0.010	0.014
	10	0	10.1	0.000	0.000	0.000	0.012	0.020	0.060
Ag Blend B960715 15-15-15	15	0	6.2	0.000	0.000	0.000	0.006	0.010	0.019
	15	0	6.2	0.000	0.000	0.000	0.004	0.008	0.012
	15	0	6.2	0.000	0.000	0.000	0.005	0.008	0.025
Ag Blend B980726 19-19-19	19	0	11.5	0.000	0.000	0.000	0.008	0.014	0.028
	19	0	11.5	0.000	0.000	0.000	0.006	0.012	0.017
	19	0	11.5	0.000	0.000	0.000	0.007	0.012	0.036
AG Blend B960820 26-9-9	26	0	8	0.000	0.000	0.000	0.004	0.007	0.014
	9	0	8	0.000	0.000	0.000	0.008	0.017	0.025
	9	0	8	0.000	0.000	0.000	0.010	0.018	0.053

Table H-8. Continued

Source	%N %P_2O_5 %K_2O	Hg mg/kg	Ni mg/kg	Yearly Hg addition in kg/ha at			Yearly Ni addition in kg/ha at		
				lb/A			lb/A		
				124 N 84 P_2O_5 103 K_2O	206 N 173 P_2O_5 177 K_2O	414 N 252 P_2O_5 534 K_2O	124 N 84 P_2O_5 103 K_2O	206 N 173 P_2O_5 177 K_2O	414 N 252 P_2O_5 534 K_2O
				kg/ha			kg/ha		
				139 N 94 P_2O_5 115 K_2O	231 N 194 P_2O_5 198 K_2O	464 N 282 P_2O_5 598 K_2O	139 N 94 P_2O_5 115 K_2O	231 N 194 P_2O_5 198 K_2O	464 N 282 P_2O_5 598 K_2O
Ag Blend B960896 10-20-20	10	0	8.6	0.000	0.000	0.000	0.012	0.020	0.040
	20	0	8.6	0.000	0.000	0.000	0.004	0.008	0.012
	20	0	8.6	0.000	0.000	0.000	0.005	0.009	0.026
Ag Blend B960900 10-20-20	10	0	85.7	0.000	0.000	0.000	0.119	0.198	0.398
	20	0	85.7	0.000	0.000	0.000	0.040	0.083	0.121
	20	0	85.7	0.000	0.000	0.000	0.049	0.085	0.256
Ag Blend B960909 3-17-40	3	0	5.7	0.000	0.000	0.000	0.026	0.044	0.088
	17	0	5.7	0.000	0.000	0.000	0.003	0.007	0.009
	40	0	5.7	0.000	0.000	0.000	0.002	0.003	0.009
Ag Blend B960912 3-17-40	3	0	12	0.000	0.000	0.000	0.056	0.092	0.186
	17	0	12	0.000	0.000	0.000	0.007	0.014	0.020
	40	0	12	0.000	0.000	0.000	0.003	0.006	0.018
Ag Blend B960913 8-41-12	8	0	14.8	0.000	0.000	0.000	0.026	0.043	0.086
	41	0	14.8	0.000	0.000	0.000	0.003	0.007	0.010
	12	0	14.8	0.000	0.000	0.000	0.014	0.024	0.074
Ag Blend B961058 8-17-34	8	0	8.9	0.000	0.000	0.000	0.015	0.026	0.052
	17	0	8.9	0.000	0.000	0.000	0.005	0.010	0.015
	34	0	8.9	0.000	0.000	0.000	0.003	0.005	0.016
Ag Blend B961321 9-43-10	9	0	13.3	0.000	0.000	0.000	0.021	0.034	0.069
	43	0	13.3	0.000	0.000	0.000	0.003	0.006	0.009
	10	0	13.3	0.000	0.000	0.000	0.015	0.026	0.080

Table H-9. Yearly V and Cu Additions to Soil (kg/ha) from NPK Fertilizers, Fertilizers Applied for N, P, or K Content

Source	%N %P_2O_5 %K_2O	V mg/kg	Cu mg/kg	Yearly V addition in kg/ha at			Yearly Cu addition in kg/ha at		
				lb/A			lb/A		
				124 N 84 P_2O_5 103 K_2O	206 N 173 P_2O_5 177 K_2O	414 N 252 P_2O_5 534 K_2O	124 N 84 P_2O_5 103 K_2O	206 N 173 P_2O_5 177 K_2O	414 N 252 P_2O_5 534 K_2O
				kg/ha			kg/ha		
				139 N 94 P_2O_5 115 K_2O	231 N 194 P_2O_5 198 K_2O	464 N 282 P_2O_5 598 K_2O	139 N 94 P_2O_5 115 K_2O	231 N 194 P_2O_5 198 K_2O	464 N 282 P_2O_5 598 K_2O
Ag Blend B960243 19-19-19	19	85.2	25.6	0.062	0.104	0.208	0.019	0.031	0.063
	19	85.2	25.6	0.042	0.087	0.126	0.013	0.026	0.038
	19	85.2	25.6	0.052	0.089	0.268	0.015	0.027	0.081
Ag Blend B960244 12-24-24	12	119	49.3	0.138	0.229	0.460	0.057	0.095	0.191
	24	119	49.3	0.047	0.096	0.140	0.019	0.040	0.058
	24	119	49.3	0.057	0.098	0.297	0.024	0.041	0.123
Ag Blend B960249 7-35-12	7	116	45	0.230	0.383	0.769	0.089	0.149	0.298
	35	116	45	0.031	0.064	0.093	0.012	0.025	0.036
	12	116	45	0.111	0.191	0.578	0.043	0.074	0.224
Ag Blend B960282 9-44-9	9	163	30.1	0.252	0.418	0.840	0.046	0.077	0.155
	44	163	30.1	0.035	0.072	0.104	0.006	0.013	0.019
	9	163	30.1	0.208	0.359	1.083	0.038	0.066	0.200
Ag Blend B960325 10-21-15	10	87.7	10.2	0.122	0.203	0.407	0.014	0.024	0.047
	21	87.7	10.2	0.039	0.081	0.118	0.005	0.009	0.014
	15	87.7	10.2	0.067	0.116	0.350	0.008	0.013	0.041
Ag Blend B960333 8-32-16	8	126	22.2	0.219	0.364	0.731	0.039	0.064	0.129
	32	126	22.2	0.037	0.076	0.111	0.007	0.013	0.020
	16	126	22.2	0.091	0.156	0.471	0.016	0.027	0.083
Ag Blend B960389 19-19-19	19	77.7	0	0.057	0.094	0.190	0.000	0.000	0.000
	19	77.7	0	0.038	0.079	0.115	0.000	0.000	0.000
	19	77.7	0	0.047	0.081	0.245	0.000	0.000	0.000
Ag Blend B960412 7-26-26	7	79.4	26.2	0.158	0.262	0.526	0.052	0.086	0.174
	26	79.4	26.2	0.029	0.059	0.086	0.009	0.020	0.028
	26	79.4	26.2	0.035	0.060	0.183	0.012	0.020	0.060
Ag Blend B960418 19-19-19	19	97.8	13.7	0.072	0.119	0.239	0.010	0.017	0.033
	19	97.8	13.7	0.048	0.100	0.145	0.007	0.014	0.020
	19	97.8	13.7	0.059	0.102	0.308	0.008	0.014	0.043
Ag Blend B960441 9-34-10	9	121	16.3	0.187	0.311	0.624	0.025	0.042	0.084
	34	121	16.3	0.033	0.069	0.100	0.005	0.009	0.014
	10	121	16.3	0.139	0.240	0.724	0.019	0.032	0.097
Ag Blend B960442 9-3-10	9	159	6.6	0.246	0.408	0.820	0.010	0.017	0.034
	3	159	6.6	0.498	1.028	1.495	0.021	0.043	0.062
	10	159	6.6	0.183	0.315	0.951	0.008	0.013	0.039
Ag Blend B960453 10-20-20	10	67.1	16.4	0.093	0.155	0.311	0.023	0.038	0.076
	20	67.1	16.4	0.032	0.065	0.095	0.008	0.016	0.023
	20	67.1	16.4	0.039	0.066	0.201	0.009	0.016	0.049

Table H-9. Continued

Source	%N %P_2O_5 %K_2O	V mg/kg	Cu mg/kg	Yearly V addition in kg/ha at			Yearly Cu addition in kg/ha at		
				lb/A			lb/A		
				124 N 84 P_2O_5 103 K_2O	206 N 173 P_2O_5 177 K_2O	414 N 252 P_2O_5 534 K_2O	124 N 84 P_2O_5 103 K_2O	206 N 173 P_2O_5 177 K_2O	414 N 252 P_2O_5 534 K_2O
				kg/ha			kg/ha		
				139 N 94 P_2O_5 115 K_2O	231 N 194 P_2O_5 198 K_2O	464 N 282 P_2O_5 598 K_2O	139 N 94 P_2O_5 115 K_2O	231 N 194 P_2O_5 198 K_2O	464 N 282 P_2O_5 598 K_2O
Ag Blend B960475 9-40-5	9	130	90.5	0.201	0.334	0.670	0.140	0.232	0.467
	40	130	90.5	0.031	0.063	0.092	0.021	0.044	0.064
	5	130	90.5	0.299	0.515	1.555	0.208	0.358	1.082
Ag Blend B960510 9-43-10	9	136	7.1	0.210	0.349	0.701	0.011	0.018	0.037
	43	136	7.1	0.030	0.061	0.089	0.002	0.003	0.005
	10	136	7.1	0.156	0.269	0.813	0.008	0.014	0.042
Ag Blend B960580 10-10-10	10	68.8	13.6	0.096	0.159	0.319	0.019	0.031	0.063
	10	68.8	13.6	0.065	0.133	0.194	0.013	0.026	0.038
	10	68.8	13.6	0.079	0.136	0.411	0.016	0.027	0.081
Ag Blend B960584 10-20-20	10	83.4	10.6	0.116	0.193	0.387	0.015	0.024	0.049
	20	83.4	10.6	0.039	0.081	0.118	0.005	0.010	0.015
	20	83.4	10.6	0.048	0.083	0.249	0.006	0.010	0.032
Ag Blend B960599 15-15-15	15	73.2	7.2	0.068	0.113	0.226	0.007	0.011	0.022
	15	73.2	7.2	0.046	0.095	0.138	0.005	0.009	0.014
	15	73.2	7.2	0.056	0.097	0.292	0.006	0.010	0.029
Ag Blend B960611 19-19-19	19	47.2	3.9	0.035	0.057	0.115	0.003	0.005	0.010
	19	47.2	3.9	0.023	0.048	0.070	0.002	0.004	0.006
	19	47.2	3.9	0.029	0.049	0.149	0.002	0.004	0.012
Ag Blend B960639 6-2-0	6	18.6	24.3	0.043	0.072	0.144	0.056	0.094	0.188
	2	18.6	24.3	0.087	0.180	0.262	0.114	0.236	0.343
	0	18.6	24.3	ERR	ERR	ERR	ERR	ERR	ERR
Ag Blend B960708 7-27-11	7	99.2	544	0.197	0.327	0.658	1.080	1.795	3.606
	27	99.2	544	0.035	0.071	0.104	0.189	0.391	0.568
	11	99.2	544	0.104	0.179	0.539	0.569	0.979	2.957
Ag ammoniated B960711 8-24-8	8	47.3	13.6	0.082	0.137	0.274	0.024	0.039	0.079
	24	47.3	13.6	0.019	0.038	0.056	0.005	0.011	0.016
	8	47.3	13.6	0.068	0.117	0.354	0.020	0.034	0.102
Ag Blend B960713 10-20-10	10	68.9	32	0.096	0.159	0.320	0.044	0.074	0.148
	20	68.9	32	0.032	0.067	0.097	0.015	0.031	0.045
	10	68.9	32	0.079	0.136	0.412	0.037	0.063	0.191
Ag Blend B960715 15-15-15	15	49.2	3.9	0.046	0.076	0.152	0.004	0.006	0.012
	15	49.2	3.9	0.031	0.064	0.092	0.002	0.005	0.007
	15	49.2	3.9	0.038	0.065	0.196	0.003	0.005	0.016
Ag Blend B980726 19-19-19	19	85.1	7.9	0.062	0.103	0.208	0.006	0.010	0.019
	19	85.1	7.9	0.042	0.087	0.126	0.004	0.008	0.012
	19	85.1	7.9	0.052	0.089	0.268	0.005	0.008	0.025
AG Blend B960820 26-9-9	26	61.6	14.4	0.033	0.055	0.110	0.008	0.013	0.026
	9	61.6	14.4	0.064	0.133	0.193	0.015	0.031	0.045
	9	61.6	14.4	0.079	0.136	0.409	0.018	0.032	0.096

Table H-9. Continued

Source	%N %P_2O_5 %K_2O	V mg/kg	Cu mg/kg	Yearly V addition in kg/ha at			Yearly Cu addition in kg/ha at		
				lb/A			lb/A		
				124 N 84 P_2O_5 103 K_2O	206 N 173 P_2O_5 177 K_2O	414 N 252 P_2O_5 534 K_2O	124 N 84 P_2O_5 103 K_2O	206 N 173 P_2O_5 177 K_2O	414 N 252 P_2O_5 534 K_2O
				kg/ha			kg/ha		
				139 N 94 P_2O_5 115 K_2O	231 N 194 P_2O_5 198 K_2O	464 N 282 P_2O_5 598 K_2O	139 N 94 P_2O_5 115 K_2O	231 N 194 P_2O_5 198 K_2O	464 N 282 P_2O_5 598 K_2O
Ag Blend B960896 10-20-20	10	64.5	25.5	0.090	0.149	0.299	0.035	0.059	0.118
	20	64.5	25.5	0.030	0.063	0.091	0.012	0.025	0.036
	20	64.5	25.5	0.037	0.064	0.193	0.015	0.025	0.076
Ag Blend B960900 10-20-20	10	70.3	12.9	0.098	0.162	0.326	0.018	0.030	0.060
	20	70.3	12.9	0.033	0.068	0.099	0.006	0.013	0.018
	20	70.3	12.9	0.040	0.070	0.210	0.007	0.013	0.039
Ag Blend B960909 3-17-40	3	64.2	4.9	0.297	0.494	0.993	0.023	0.038	0.076
	17	64.2	4.9	0.035	0.073	0.106	0.003	0.006	0.008
	40	64.2	4.9	0.018	0.032	0.096	0.001	0.002	0.007
Ag Blend B960912 3-17-40	3	138	7.8	0.639	1.063	2.134	0.036	0.060	0.121
	17	138	7.8	0.076	0.157	0.229	0.004	0.009	0.013
	40	138	7.8	0.040	0.068	0.206	0.002	0.004	0.012
Ag Blend B960913 8-41-12	8	18.4	454	0.032	0.053	0.107	0.789	1.311	2.633
	41	18.4	454	0.004	0.009	0.013	0.104	0.215	0.312
	12	18.4	454	0.018	0.030	0.092	0.435	0.749	2.262
Ag Blend B961058 8-17-34	8	27.8	5	0.048	0.080	0.161	0.009	0.014	0.029
	17	27.8	5	0.015	0.032	0.046	0.003	0.006	0.008
	34	27.8	5	0.009	0.016	0.049	0.002	0.003	0.009
Ag Blend B961321 9-43-10	9	152	60.1	0.235	0.390	0.784	0.093	0.154	0.310
	43	152	60.1	0.033	0.069	0.100	0.013	0.027	0.039
	10	152	60.1	0.175	0.301	0.909	0.069	0.119	0.359

Table H-10. Yearly Zn Additions to Soil (kg/ha) from NPK Fertilizers, Fertilizers Applied for N, P, or K Content

Source	%N %P_2O_5 %K_2O	Zn mg/kg	Yearly Zn addition in kg/ha at		
			lb/A		
			124 N 84 P_2O_5 103 K_2O	206 N 173 P_2O_5 177 K_2O	414 N 252 P_2O_5 534 K_2O
			kg/ha		
			139 N 94 P_2O_5 115 K_2O	231 N 194 P_2O_5 198 K_2O	464 N 282 P_2O_5 598 K_2O
Ag Blend B960243 19-19-19	19	19	0.026	0.044	0.088
	19	36	0.018	0.037	0.053
	19	36	0.022	0.038	0.113
Ag Blend B960244 12-24-24	12	44.5	0.052	0.086	0.172
	24	44.5	0.017	0.036	0.052
	24	44.5	0.021	0.037	0.111
Ag Blend B960249 7-35-12	7	55.1	0.109	0.182	0.365
	35	55.1	0.015	0.031	0.044
	12	55.1	0.053	0.091	0.275
Ag Blend B960282 9-44-9	9	49.8	0.077	0.128	0.257
	44	49.8	0.011	0.022	0.032
	9	49.8	0.064	0.110	0.331
Ag Blend B960325 10-21-15	10	872	1.212	2.014	4.046
	21	872	0.390	0.806	1.171
	15	872	0.669	1.151	3.476
Ag Blend B960333 8-32-16	8	43.9	0.076	0.127	0.255
	32	43.9	0.013	0.027	0.039
	16	43.9	0.032	0.054	0.164
Ag Blend B960389 19-19-19	19	0	0.000	0.000	0.000
	19	0	0.000	0.000	0.000
	19	0	0.000	0.000	0.000
Ag Blend B960412 7-26-26	7	37	0.073	0.122	0.245
	26	37	0.013	0.028	0.040
	26	37	0.016	0.028	0.085
Ag Blend B960418 19-19-19	19	33.1	0.024	0.040	0.081
	19	33.1	0.016	0.034	0.049
	19	33.1	0.020	0.034	0.104
Ag Blend B960441 9-34-10	9	34.6	0.053	0.089	0.178
	34	34.6	0.010	0.020	0.029
	10	34.6	0.040	0.069	0.207
Ag Blend B960442 9-3-10	9	53.1	0.082	0.136	0.274
	3	53.1	0.166	0.343	0.499
	10	53.1	0.061	0.105	0.318
Ag Blend B960453 10-20-20	10	60.9	0.085	0.141	0.283
	20	60.9	0.029	0.059	0.086
	20	60.9	0.035	0.060	0.182

Table H-10. Continued

Source	%N %P_2O_5 %K_2O	Zn mg/kg	Yearly Zn addition in kg/ha at		
			lb/A		
			124 N 84 P_2O_5 103 K_2O	206 N 173 P_2O_5 177 K_2O	414 N 252 P_2O_5 534 K_2O
			kg/ha		
			139 N 94 P_2O_5 115 K_2O	231 N 194 P_2O_5 198 K_2O	464 N 282 P_2O_5 598 K_2O
Ag Blend B960475 9-40-5	9	4442	6.860	11.401	22.901
	40	4442	1.044	2.154	3.132
	5	4442	10.217	17.590	53.126
Ag Blend B960510 9-43-10	9	66.2	0.102	0.170	0.341
	43	66.2	0.014	0.030	0.043
	10	66.2	0.076	0.131	0.396
Ag Blend B960580 10-10-10	10	803	1.116	1.855	3.726
	10	803	0.755	1.558	2.264
	10	803	0.923	1.590	4.802
Ag Blend B960584 10-20-20	10	0.48	0.001	0.001	0.002
	20	0.48	0.000	0.000	0.001
	20	0.48	0.000	0.000	0.001
Ag Blend B960599 15-15-15	15	0.55	0.001	0.001	0.002
	15	0.55	0.000	0.001	0.001
	15	0.55	0.000	0.001	0.002
Ag Blend B960611 19-19-19	19	6.93	0.005	0.008	0.017
	19	6.93	0.003	0.007	0.010
	19	6.93	0.004	0.007	0.022
Ag Blend B960639 6-2-0	6	1.1	0.003	0.004	0.009
	2	1.1	0.005	0.011	0.016
	0	1.1	ERR	ERR	ERR
Ag Blend B960708 7-27-11	7	57.8	0.115	0.191	0.383
	27	57.8	0.020	0.042	0.060
	11	57.8	0.060	0.104	0.314
Ag ammoniated B960711 8-24-8	8	177	0.308	0.511	1.027
	24	177	0.069	0.143	0.208
	8	177	0.254	0.438	1.323
Ag Blend B960713 10-20-10	10	84.5	0.117	0.195	0.392
	20	84.5	0.040	0.082	0.119
	10	84.5	0.097	0.167	0.505
Ag Blend B960715 15-15-15	15	0.3	0.000	0.000	0.001
	15	0.3	0.000	0.000	0.001
	15	0.3	0.000	0.000	0.001
Ag Blend B980726 19-19-19	19	74.5	0.055	0.091	0.182
	19	74.5	0.037	0.076	0.111
	19	74.5	0.045	0.078	0.234
AG Blend B960820 26-9-9	26	45.7	0.024	0.041	0.082
	9	45.7	0.048	0.099	0.143
	9	45.7	0.058	0.101	0.304

Table H-10. Continued

Source	%N %P_2O_5 %K_2O	Zn mg/kg	Yearly Zn addition in kg/ha at		
			lb/A		
			124 N 84 P_2O_5 103 K_2O	206 N 173 P_2O_5 177 K_2O	414 N 252 P_2O_5 534 K_2O
			kg/ha		
			139 N 94 P_2O_5 115 K_2O	231 N 194 P_2O_5 198 K_2O	464 N 282 P_2O_5 598 K_2O
Ag Blend B960896 10-20-20	10	23.6	0.033	0.055	0.110
	20	23.6	0.011	0.023	0.033
	20	23.6	0.014	0.023	0.071
Ag Blend B960900 10-20-20	10	25.5	0.035	0.059	0.118
	20	25.5	0.012	0.025	0.036
	20	25.5	0.015	0.025	0.076
Ag Blend B960909 3-17-40	3	39.5	0.183	0.304	0.611
	17	39.5	0.022	0.045	0.066
	40	39.5	0.011	0.020	0.059
Ag Blend B960912 3-17-40	3	52.2	0.242	0.402	0.807
	17	52.2	0.029	0.060	0.087
	40	52.2	0.015	0.026	0.078
Ag Blend B960913 8-41-12	8	484	0.841	1.398	2.807
	41	484	0.111	0.229	0.333
	12	484	0.464	0.799	2.412
Ag Blend B961058 8-17-34	8	18.3	0.032	0.053	0.106
	17	18.3	0.010	0.021	0.030
	34	18.3	0.006	0.011	0.032
Ag Blend B961321 9-43-10	9	44.8	0.069	0.115	0.231
	43	44.8	0.010	0.020	0.029
	10	44.8	0.052	0.089	0.268

Table H-11. Summary Statistics for Application of NPK Blends for either N, P, or K Content

				Yearly Metal Addition to Soil, kg/ha		
Metal	Application Rate	Nutrient Applied[a]	No. of Samples	Mean	Median	Range
Cd	Average	N	32	0.007	0.005	(0.001 , 0.022)
		P	32	0.003	0.001	(0.000 , 0.027)
		K	31	0.004	0.002	(0.000 , 0.033)
	High	N	32	0.011	0.008	(0.002 , 0.037)
		P	32	0.006	0.003	(0.001 , 0.055)
		K	31	0.007	0.004	(0.001 , 0.057)
	Maximum	N	32	0.022	0.016	(0.004 , 0.074)
		P	32	0.009	0.004	(0.001 , 0.080)
		K	31	0.022	0.011	(0.002 , 0.171)
Pb	Average	N	32	0.037	0.005	(0.001 , 0.652)
		P	32	0.008	0.002	(0.000 , 0.099)
		K	31	0.040	0.002	(0.001 , 0.971)
	High	N	32	0.061	0.009	(0.001 , 1.083)
		P	32	0.016	0.003	(0.001 , 0.205)
		K	31	0.069	0.004	(0.001 , 1.671)
	Maximum	N	32	0.123	0.017	(0.003 , 2.176)
		P	32	0.023	0.005	(0.001 , 0.298)
		K	31	0.209	0.012	(0.003 , 5.047)
As	Average	N	32	0.012	0.010	(0.000 , 0.049)
		P	32	0.004	0.003	(0.000 , 0.029)
		K	31	0.006	0.005	(0.000 , 0.023)
	High	N	32	0.019	0.017	(0.000 , 0.081)
		P	32	0.009	0.006	(0.000 , 0.059)
		K	31	0.011	0.008	(0.000 , 0.040)
	Maximum	N	32	0.039	0.034	(0.000 , 0.162)
		P	32	0.013	0.009	(0.000 , 0.086)
		K	31	0.033	0.025	(0.000 , 0.120)

Table H-11. Continued

				Yearly Metal Addition to Soil, kg/ha		
Metal	Application Rate	Nutrient Applied[a]	No. of Samples	Mean	Median	Range
Cr	Average	N	32	0.101	0.099	(0.018 , 0.312)
		P	32	0.041	0.023	(0.015 , 0.278)
		K	31	0.059	0.044	(0.010 , 0.248)
	High	N	32	0.168	0.165	(0.030 , 0.519)
		P	32	0.084	0.047	(0.031 , 0.574)
		K	31	0.101	0.075	(0.017 , 0.427)
	Maximum	N	32	0.337	0.331	(0.061 , 1.042)
		P	32	0.122	0.068	(0.046 , 0.835)
		K	31	0.304	0.227	(0.051 , 1.290)
Hg	Average	N	32	0.000	0.000	(0.000 , 0.000)
		P	32	0.000	0.000	(0.000 , 0.000)
		K	31	0.000	0.000	(0.000 , 0.000)
	High	N	32	0.000	0.000	(0.000 , 0.000)
		P	32	0.000	0.000	(0.000 , 0.000)
		K	31	0.000	0.000	(0.000 , 0.000)
	Maximum	N	32	0.000	0.000	(0.000 , 0.001)
		P	32	0.000	0.000	(0.000 , 0.000)
		K	31	0.000	0.000	(0.000 , 0.001)
Ni	Average	N	32	0.024	0.021	(0.000 , 0.119)
		P	32	0.010	0.006	(0.000 , 0.053)
		K	31	0.014	0.010	(0.000 , 0.067)
	High	N	32	0.041	0.035	(0.000 , 0.198)
		P	32	0.020	0.012	(0.000 , 0.109)
		K	31	0.024	0.018	(0.000 , 0.116)
	Maximum	N	32	0.081	0.071	(0.000 , 0.398)
		P	32	0.029	0.017	(0.000 , 0.158)
		K	31	0.073	0.054	(0.000 , 0.349)

Table H-11. Continued

				Yearly Metal Addition to Soil, kg/ha		
Metal	Application Rate	Nutrient Applied[a]	No. of Samples	Mean	Median	Range
V	Average	N	32	0.142	0.097	(0.032 , 0.639)
		P	32	0.053	0.035	(0.004 , 0.498)
		K	31	0.081	0.057	(0.009 , 0.299)
	High	N	32	0.237	0.161	(0.053 , 1.063)
		P	32	0.108	0.072	(0.009 , 1.028)
		K	31	0.139	0.098	(0.016 , 0.515)
	Maximum	N	32	0.475	0.323	(0.107 , 2.134)
		P	32	0.158	0.104	(0.013 , 1.495)
		K	31	0.421	0.297	(0.049 , 1.555)
Cu	Average	N	32	0.088	0.023	(0.000 , 1.080)
		P	32	0.020	0.007	(0.000 , 0.189)
		K	31	0.053	0.012	(0.000 , 0.569)
	High	N	32	0.146	0.038	(0.000 , 1.795)
		P	32	0.042	0.014	(0.000 , 0.391)
		K	31	0.090	0.020	(0.000 , 0.979)
	Maximum	N	32	0.292	0.076	(0.000 , 3.606)
		P	32	0.061	0.020	(0.000 , 0.568)
		K	31	0.273	0.060	(0.000 , 2.957)
Zn	Average	N	32	0.375	0.071	(0.000 , 6.860)
		P	32	0.092	0.016	(0.000 , 1.044)
		K	31	0.430	0.035	(0.000 , 10.217)
	High	N	32	0.624	0.119	(0.000 , 11.401)
		P	32	0.190	0.032	(0.000 , 2.154)
		K	31	0.741	0.060	(0.000 , 17.590)
	Maximum	N	32	1.253	0.238	(0.000 , 22.901)
		P	32	0.276	0.047	(0.000 , 3.132)
		K	31	2.238	0.182	(0.000 , 53.126)

a) Application rates for N, P, and K, see Table 5-1.