APPENDIX D

SCREENING-LEVEL ECOLOGICAL RISK ASSESSMENT

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APPENDIX D

SCREENING-LEVEL ECOLOGICAL RISK ASSESSMENT

ECOTOXICITY DATA

D-1.0 Ecotoxicity

The ecotoxicological properties of the constituents detected in the various environmental media at the fill areas are discussed in the following sections.

D-1.1 Aluminum

Aluminum does not exist as a free metal in nature due to its reactivity, but rather partitions between the solid and liquid phases by reacting with water, chloride, fluoride, sulfate, nitrate, phosphate, humic materials, and clay. Soils with a greater mineral content result in reduced mobility of aluminum (U.S. Environmental Protection Agency [USEPA], 1999).

Aluminum adsorbs to suspended solids and sediment. If large amounts of organic matter or fulvic acid are present, aluminum binds to them. In water, aluminum undergoes hydrolysis to form hydroxy aluminum species. The pH of the water determines which hydrolysis products are formed (USEPA, 1999).

Exposure routes for aquatic organisms include ingestion, gill uptake, and dermal absorption. Aluminum has the potential to bioconcentrate in aquatic species (Cleveland et al., 1989). The toxicity of aluminum to fish is dependent on the properties of the receiving water. Water with high alkalinity and/or turbidity will significantly reduce the toxic effects of aluminum in the aquatic environment. The mechanism of intoxication in fish probably involves gill damage which deprives the fish of oxygen (Associated Water and Air Resources Engineers, Inc. [AWARE], 1974).

Aluminum can be toxic to fish, with 96-hour median tolerance levels varying from 0.1 to 37 milligrams per liter (mg/L), depending on the species and water characteristics. Toxicity to invertebrates, including crustaceans, molluscs, and planaria ranges from 1 to 100 mg/L (AWARE, 1974).

Exposure routes for mammals include ingestion, inhalation, and dermal exposure. Aluminum is poorly absorbed. Aluminum is distributed to the brain, bone, muscle, and kidneys (Greger and Donnaubauer, 1986). The median lethal dose when administered via intraperitoneal injection to mice as aluminum sulfate is approximately 20 milligrams per kilogram (mg/kg), while the LD_{50} for mice receiving aluminum sulfate in drinking water is approximately 100 mg/kg (AWARE, 1974). The mechanism of mammalian intoxication involves disruption of normal phosphate metabolism.

Aluminum is taken up by plants. Some plants bioaccumulate aluminum in the root tissue. Plant uptake of aluminum and the transport to stems and leaves varies considerably between plant species and is largely dependent upon soil and water characteristics (Kabata-Pendias and Pendias, 1992). Aluminum at 4 mg/L may inhabit the growth of some higher level plants grown in water.

D-1.2 Antimony

Antimony binds to soil and particulates (especially those containing iron, manganese, or aluminum) and is oxidized by bacteria in soil. Exposure routes for aquatic organisms include ingestion and gill uptake. Antimony bioconcentrates in aquatic organisms to a small degree. Exposure routes for mammals include ingestion and inhalation. It does not biomagnify in terrestrial food chains. Antimony is not significantly metabolized and is excreted in the urine and feces. Antimony causes reproductive, pulmonary, and hepatic effects in mammals (USEPA, 1999).

Mammals. Female mice exposed to 5.0 mg/L antimony as antimony potassium tartrate in their drinking water showed a reduction in their lifespan. This dose was equivalent to a lowest-observed-adverse-effects-level (LOAEL) of 1.25 milligrams per kilogram per day (mg/kg/day), which can be converted to a no-observed-adverse-effects-level (NOAEL) of 0.125 mg/kg/day.

Aquatic Life. The available data for antimony indicate that acute and chronic toxicity to freshwater aquatic life occur at concentrations as low as 9.0 and 1.6 mg/L, respectively, and would occur at lower concentrations among species that are more sensitive than those tested. Toxicity to algae can occur at concentrations as low as 0.61 mg/L.

Invertebrates. Effects from antimony exposure on benthic community composition have been detected at levels between 3.2 and 150 mg/kg (Long and Morgan, 1990). Data on antimony suggest an effects range-low (ER-L) of 2 mg/kg, and an effects range-medium (ER-M) of 25 mg/kg.

D-1.3 Arsenic

Arsenic naturally occurs as sulfides and as complex sulfides of iron, nickel, and cobalt (Woolson, 1975). In one form or another, arsenic is present in rocks, soils, water, and living organisms at concentrations of parts per billion to parts per million (National Academy of Sciences [NAS], 1977a). Arsenic is ubiquitous in living tissue and is constantly being oxidized, reduced, or otherwise metabolized. In soils, insoluble or slightly soluble arsenic compounds are

constantly being resolubilized, and the arsenic is being presented for plant uptake or reduction by organisms and chemical processes (NAS, 1977a). In abundance of elements, arsenic ranks 20th in the earth's crust (1.5 to 2 mg/kg), 14th in sea water, and 12th in the human body (Woolson, 1975). It occurs in various forms, including inorganic and organic compounds and trivalent and pentavalent states (Pershagen and Vahter, 1979).

Mammals. Arsenic is more toxic to wildlife in the trivalent form as compared to either pentavalent arsenic or organic arsenicals. Arsenic poisoning has been reported in acute episodes but chronic arsenosis is rarely encountered (NAS, 1977a). The probability of chronic arsenic poisoning from continuous ingestion of small doses is rare, because detoxification and excretion are rapid (Woolson, 1975). General signs of arsenic toxicosis include intense abdominal pain, staggering gait, extreme weakness, trembling, fast and feeble pulse, collapse, and death (Eisler, 1988a). Adverse effects in mammals were noted in single oral doses of 2.5 to 33 mg/kg body weight, and at chronic oral doses of 1 to 10 mg/kg body weight. As little as 1.7 mg/kg has been shown to produce fetal death and malformations during critical stages of hamster embryogenesis. Various species of rodents, exposed to cacodylic acid through various routes, exhibited lethal dose for 50 percent of population tested (LD_{50}) ranging from 470 to 830 mg/kg body weight (Hood, 1985).

Birds. As with mammals, arsenic poisoning in birds has been reported in acute episodes but chronic arsenosis is rarely encountered. Signs of inorganic trivalent arsenite poisoning in birds include muscular incoordination, debility, slowness, jerkiness, falling hyperactivity, immobility, and seizures (Eisler, 1988a). Studies reported by Hudson et al. (1984), using mallard ducks (*Anas platyrhynchos*) fed sodium arsenite, determined an lethal concentration for 50 percent of population tested (LC_{50}) of 323 mg/kg body weight. Copper acetoarsenite fed to the northern bobwhite (*Colinus virginianus*) at 480 mg/kg proved fatal to 50 percent of the test organisms in 11 days (NAS, 1977a). The grey partridge (*Perdix perdix*) succumbed to 300 mg/kg body weight of lead arsenate in 52 hours (NAS, 1977a).

Fish. Toxic and other effects of arsenicals to aquatic life are significantly modified by numerous biological and abiotic factors (Woolson, 1975; NAS, 1977a; National Research Council of Canada [NRCC], 1978; USEPA, 1980a; Howard et al., 1984; Michnowicz and Weaks, 1984; Bryant et al., 1985; USEPA, 1985; Sanders, 1986). The LC_{50} values, for example, are markedly affected by water temperature, pH, oxidation-reduction potential, organic content, phosphate concentration, suspended solids, and presence of other substances and toxicants, as well as arsenic speciation, and duration of exposure. In general, inorganic arsenicals are more toxic than organoarsenicals to aquatic biota, and trivalent species are more toxic than pentavalent

species. Early life stages are most sensitive, and large interspecies differences have been recorded, even among those closely related taxonomically. Juvenile bluegills (*Lepomis machrochirus*) exhibited reduced survival after sixteen weeks when exposed to a single treatment of trivalent arsenic at 0.69 mg/L (USEPA, 1980a; USEPA, 1985). The adult bluegill population was reduced 42 percent after several monthly applications of 4 mg/L trivalent arsenic (NAS, 1977a).

Invertebrates. As with fish, toxic and other effects of arsenicals to aquatic invertebrates are significantly modified by numerous biological and abiotic factors (Woolson, 1975; NAS, 1977a; NRCC, 1978; USEPA, 1980a; Howard et al., 1984; Michnowicz and Weaks, 1984; Bryant et al., 1985; USEPA, 1985; Sanders, 1986). The cladaceran *Daphnia magna* population exposed to 4.3 mg/L trivalent arsenic exhibited a 50 percent immobilization after 96 hours, and the amphipod *Gammarus pseudolimnaeus* experienced 50 percent immobilization following 96 hours of 0.96 mg/L trivalent arsenic exposure (Lima et al., 1984).

D-1.4 Barium

Barium, a silvery-white metal, is used in various alloys, paints, soap, paper and rubber; also, it is used for the manufacturing of ceramics and glass. Two forms of barium, barium sulfate and barium carbonate, are often found in nature as underground ore deposits. Barium is relatively abundant in nature as it is found in both plants and animal tissue. Plants can accumulate barium from the soil.

Most of the barium that enters the body of an animal is removed within a few days and almost all of it is gone within 1 to 2 weeks. Most of the barium that stays in the body goes into the bones and teeth. Rats exposed to barium in their diet at lower doses, but for longer time periods, showed increased blood pressure and changes in the function and chemistry of the heart (Agency for Toxic Substances and Disease Registry [ATSDR], 1992a).

Mammals. Barium administered to rats via their drinking water at doses of 1, 10, and 100 mg/L had no effect on food or water consumption, or growth. Because the highest dose tested (100 mg/L) did not elicit any adverse effects, it was considered the NOAEL (5.1 mg/kg/day).

D-1.5 Beryllium

In environmental media, beryllium usually exists as beryllium oxide. Beryllium has limited solubility and mobility in sediment and soil. Exposure routes for aquatic organisms include ingestion and gill uptake. Beryllium does not bioconcentrate in aquatic organisms. Beryllium uptake from water is low, resulting in low bioconcentration rates. Bicmagnification of beryllium

in aquatic food chains does not occur. Beryllium can be toxic to warm water fish, especially in soft water. The major exposure route for mammals is inhalation. Beryllium is poorly absorbed from the gastrointestinal tract; also, it is not absorbed through intact skin to any significant degree. Mammals exposed via inhalation exhibit pulmonary effects which may last long after exposure ceases.

Based on animal studies, beryllium is poorly absorbed through both the gastrointestinal tract and the skin. The most important route of exposure for beryllium is inhalation, although absorption by this route does not appear to be extensive. Once beryllium is absorbed, it is circulated in the blood as an orthophosphate colloid and is then distributed primarily to the bone, liver, and kidneys in both humans and animals. Beryllium and its compounds are not biotransformed, but soluble beryllium compounds are partially converted to more insoluble forms in the lungs.

Following inhalation of soluble beryllium compounds in both humans and animals, the lung appears to be the main target organ for toxicity. Acute exposure may cause chemical pneumonitis; chronic exposure to insoluble forms may lead to chronic beryllium disease (berylliosis), a fibrotic lung disease (ATSDR, 1993).

A variety of beryllium compounds have been demonstrated to cause pulmonary tumors following inhalation in animals and, the USEPA has classified beryllium as a B2 carcinogen for both oral and respiratory route exposures (Integrated Risk Information Service [IRIS], 2001). However, it is thought that oral administration does not lead to carcinogenesis due to poor absorption of the constituent from the gastrointestinal tract. The NOAEL for a rat lifetime chronic exposure to beryllium in drinking water was 0.54 mg/kg/day (Health Effects Assessment Summary Tables [HEAST], 1997).

D-1.6 Boron

Boron is a non-volatile metalloid that occurs in combination with most of the other elements known. Water-borne boron may be adsorbed by soils and sediments. Adsorption-desorption reactions are expected to be the only significant mechanisms that will influence the fate of boron in water. Boron compounds rapidly transform to borates, the naturally occurring form of boron, in the presence of water. No further degradation is possible. Borates are removed from soil by water leaching and by assimilation by plants.

Boron is an essential nutrient for plants. Boron is assimilated by plants from soil and is therefore a natural constituent of many foods, mainly fruits and vegetables. The Food and Drug

Administration (FDA) has set a tolerance limit of 8 parts per million (ppm) boron for citrus fruit (ATSDR, 1992b).

Prenatal exposure of mice (79 mg/kg/day as boric acid) and rats (13.6 mg/kg/day as boric acid) during gestation caused developmental effects consisting of reduced fetal body weight or minor skeletal changes and possibly delay in maturation. Degeneration of the seminiferous tubules and impaired spermatogenesis was also noted in mice exposed to dose levels of 111 mg/kg/day.

D-1.7 Cadmium

Plants. Cadmium is a non-essential element for plant growth that can be absorbed from air or soil. The availability of cadmium in soil is influenced by organic content, clay content, pH, and redox potential (Sharma, 1980). The distribution of accumulated cadmium within plants is generally roots>stem and leaves>fruits, grains, seeds, or nutrient storage organs (Eisler, 1985a). Concentrations from 10 to 20 mg/kg in plant tissue are expected to result in 10 percent loss in crop yield. Concentrations in leaf tissue that are excessive or toxic to various plant species range from 5 to 30 mg/kg. General symptoms of cadmium poisoning in plants include growth retardation, root damage, chlorosis of leaves, and red-brown coloration of leaf margins or veins (Kabata-Pendias and Pendias, 1992).

Wildlife. Cadmium uptake by most animals is relatively low. Cadmium tends to accumulate in the viscera, especially in liver and kidney tissues. The biological half-life of cadmium in muscle, kidney, and liver tissues ranges from 10 to 30 years. About 5 percent of ingested cadmium is absorbed, whereas between 10 and 50 percent of inhaled cadmium is absorbed (Friberg et al., 1986).

Mammals are relatively resistant to cadmium toxicity. The production of metallothioneins helps to protect mammals from cadmium toxicosis. The lowest published toxic dose of cadmium for mammals is 21.5 mg/kg, which was reported to induce adverse effects on the fertility of rats (Registry of Toxic Effects of Chemical Substances [RTECS], 1996). Based on an oral NOAEL (0.19 mg/kg/day) for mice exposed to cadmium, Sample et al., (1996) estimated NOAELs for the white-footed mouse, cottontail rabbit, and red fox to be 0.21, 0.057, and 0.037 mg/kg/day, respectively. Drinking water NOAELs for these species were estimated as 0.71, 0.59, and 0.43 mg/L.

Exposure to cadmium has been shown to induce teratogenic effects in laboratory animals. The teratogenic effects of cadmium can be synergized by lead and mercury salts and antagonized by selenium (Ferm and Layton, 1981).

Birds. Birds, like mammals, are relatively resistant to cadmium toxicity. In one experiment, drake mallards were fed up to 200 mg/kg cadmium chloride in their diet for 90 days, and all survived with no loss in body weight. Egg production was, however, suppressed in mallard hens fed 200 mg/kg cadmium chloride in their diet (White and Finley, 1978). As in mammals, metallothionein binds to cadmium and thus aids in the reduction of a toxic response. Japanese quail that were fed 75 mg/kg cadmium in their diets developed signs of bone marrow hyperplasia, anemia, and hypertrophy of both heart ventricles after six weeks of exposure (Richardson, et al., 1974). Based on NOAELs for mallards exposed orally to cadmium chloride (1.45 mg/kg/day), Sample, et al., (1996) estimated NOAELs for the great blue heron and red-tailed hawk to be 1.14 and 1.46 mg/kg/day, respectively. The drinking water NOAEL for these birds was estimated to be 25.7 mg/L.

Aquatic Life. Freshwater organisms are more sensitive to elevated cadmium concentrations than are wildlife or plant species (Eisler, 1985a). The USEPA's National Ambient Water Quality Criteria is 3.9 micrograms per liter (µg/L) for acute exposure and 1.1 µg/L for chronic exposure of freshwater aquatic life to cadmium (based on a water hardness of 100 mg/L). Concentrations of cadmium in freshwater biota from uncontaminated areas are usually less than 1.0 mg/kg in fish and less than 5 mg/kg in molluscs, annelids, and macrophytes (Eisler, 1985a). Bioconcentration factors of 2,000 have been reported in insects, fish, and algae.

D-1.8 Calcium

Calcium is an essential nutrient in most living organisms; therefore, most organisms have metabolic processes designed to regulate concentrations of calcium within their tissues. For this reason, toxicity from calcium would potentially only occur at extremely high concentrations. Data regarding calcium toxicity is not readily available.

D-1.9 Chromium

Plants. Chromium does not play an essential role in plant metabolism. The concentration of chromium in terrestrial plants is controlled primarily by soluble chromium in the soil (Kabata-Pendias and Pendias, 1992). Chromium concentrations in plants are usually higher in roots than in leaves or shoots. Concentrations of chromium in leaf tissue that are excessive or toxic to various plant species range from 5 to 30 mg/kg soil (Kabata-Pendias and Pendias, 1992).

General symptoms of chromium toxicity in plants include chlorosis of new leaves, necrotic spots and purpling tissues, and injured root growth (Kabata-Pendias and Pendias, 1992).

Wildlife. Chromium is a required element in animal nutrition. In general, hexavalent chromium compounds are more toxic than the trivalent chromium compounds. Adverse effects on blood and serum chemistry and morphological changes in liver have been reported in rabbits and rats exposed to chromium concentrations of 1.7 mg/kg/day for six weeks. Rats exposed to hexavalent chromium concentrations of 134 mg/L in drinking water over a two to three month period were found to develop lesions in kidney and liver tissues (Eisler, 1986).

Examples of extrapolated NOAELs for chronic exposure of various mammalian wildlife species to hexavalent chromium are 8.17 mg/kg/day for white-footed mouse, 2.18 mg/kg/day for cottontail rabbit, and 1.41 mg/kg/day for red fox (Sample, et al., 1996). Calculated chronic drinking water NOAELs for mammalian wildlife are 27.2 mg/L for the white-footed mouse, 22.6 mg/L for the cottontail rabbit, and 16.7 mg/l for the red fox (Sample, et al., 1996). Mammalian laboratory studies have shown chromium to be mutagenic, carcinogenic and teratogenic (Eisler, 1986).

Birds. Data on the effects of chromium to avian species is limited. Haseltine, et al. (1985) did not observe changes in survival, reproduction or blood chemistry following exposure of adult black ducks (*Anas rubripes*) to diets containing between 10 and 50 mg/kg chromium III. Based on an oral NOAEL for black ducks exposed to chromium III (1 mg/kg/day), Sample, et al., (1996) estimated NOAELs for the great blue heron and red-tailed hawk to be 0.81 and 1.04 mg/kg/day, respectively. The drinking water NOAEL for these birds was 18.2 mg/L.

Aquatic Life. In freshwater systems, hexavalent chromium appears to be more toxic than the trivalent form. Water quality standards for chromium are set for both chromium III and chromium VI. Federal Water Quality Criteria for the protection of aquatic life set the criteria for acute exposure at 1.7 mg/L for chromium III and 0.016 mg/L for chromium VI. Chronic exposure values are 0.21 mg/L for chromium III and 0.011 mg/L for chromium VI (USEPA, 1986), based on a water hardness of 100 mg/L.

D-1.10 Cobalt

Cobalt is a natural element and is widely distributed in the earths crust at 0.001 to 0.002 percent (Merck Index, 1983). Small amounts of cobalt are found in rocks, soil, surface and groundwater. Natural cobalt can stay airborne for a few days, but will stay for years in the soil. In most soils, the transfer of cobalt from soils to plants is not significant, although higher transfer rates have

been observed in some higher plants and in acidic soils (Boikat et al, 1985; Francis et al., 1980). Some cobalt may seep from acid soil into groundwater. It is present in trace quantities in most foods and is readily absorbed by the gut in humans (International Commission on Radiological Protection [ICRP], 1979).

Mammals. No information has been located at this time on chronic toxic effects of cobalt to terrestrial wildlife; however, some acute studies have been completed. Additionally, there is little biomagnification of cobalt in animals of higher trophic levels (Jenkins, 1980).

Young rats are unable to survive repeated 30 mg doses of cobalt metal powder in their diet for a month (total dosage about 900 milligrams [mg]), whereas they can tolerate 1,250 mg of the metal in a single dose (Venugopal and Luckey, 1978). Cobalt was embryotoxic to rat fetuses when it was administered during the entire gestation (dose of 0.05 mg/kg). A dose of 0.005 mg/kg was non-toxic to the females, however the progeny of treated females had a reduced rate (Shepard, 1986). At doses under 2 milligrams per kilogram of body weight per day (mg/kgbw/day) no adverse effects to sheep were noted. However, at 6 mg/kgbw/day sheep exhibited loss of appetite, loss of weight, and debilitation were noted (National Research Council [NRC], 1977).

Birds. No information has been located at this time on chronic toxic effects of cobalt to birds, however some acute studies have been completed. Additionally, there is little biomagnification of cobalt in animals of higher trophic levels (Jenkins, 1980).

Chickens were administered 50 mg/kg of diet/day with acute effects of loss of appetite, loss of weight, and debilitation. At doses under 2 mg/kgbw/day no adverse effects to chickens were noted (NRC, 1977).

Fish. In most surface water bodies, cobalt is primarily associated with the sediment. However, some mobilization may occur in acidic water and in the presence of chloride ions or chelating agents. Bioaccumulation factors for freshwater fish range from 40 to 1,000 (Smith and Carson, 1981).

Invertebrates. Research by Evans et al. (1988) indicates that cobalt does not significantly bioaccumulate in benthic bottom feeders.

D-1.11 Copper

Copper is ubiquitously distributed in nature in the free state and in sulfides, arsenides, chlorides, and carbonates. Several copper containing proteins have been identified in biological systems as

oxygen binding hemomcyanin, cytochrome oxidase, tyrosinase, and laccase. Copper has also been identified with the development of metalloproteins employed in the sequestering and cellular detoxification of metals.

Copper has been known to sorb rapidly to sediment. The rate of sorption is of course dependent upon factors such as the sediment grain size, organic fraction, pH, competing cations, and the presence of ligands. In industrialized freshwater environments around the world total copper levels within sediments can range from 7 to 2,350 ppm (Moore and Ramamoorthy, 1984).

Mammals. Copper is an essential trace element to plants and animals (Callahan et al., 1979), but becomes toxic at concentrations only slightly higher than essential levels (USEPA, 1985). No evidence of bioaccumulation was obtained in a study of pollutant concentrations in the muscles and livers of 10 species of herbivorous, omnivorous, and carnivorous animals in Donana National Park in Spain (Hernandez et al., 1985). Increased fetal mortality was observed in the fetuses of mice fed more than 104 mg/kg/day of copper as copper sulfate (Lecyk, 1980). Increased mortality rates in mink offspring have been observed at levels above 3.21 mg/kg/day (Aulerich et al., 1985).

Birds. No data were found regarding the toxicity of copper to avian species.

Invertebrates. Invertebrates inhabiting "polluted" freshwaters worldwide have been known to have tissue residues of copper ranging from 5 to 200 ppm (Moore and Ramamoorthy, 1984). Field studies have shown that there is virtually no accumulation of this metal through the food chain (Fuller and Averett, 1975). Studies by Kosalwat and Knight (1987) indicated that copper present in the substrate or sediment was significantly less toxic to chironomid species than overlying water column levels. The substrate copper concentration that chironomid larval growth was reduced 50 percent (effects concentration for 50 percent of a population [EC_{50}]) was 1,602 mg/kg. These researchers found that deformities in larval mouth parts were observed in elevated concentrations, and adult emergence was inhibited when the sediment concentration exceeded 1,800 mg/kg. Carins et al. (1984) reported copper toxicity in sediment for several chironomus midges and cladocerans with LC_{50} ranging from 681 to 2296 mg/kg.

D-1.12 Iron

Iron is an essential nutrient in most living organisms; therefore, most organisms have metabolic processes designed to regulate concentrations of iron within their tissues. For this reason, toxicity from iron would potentially only occur at extremely high concentrations. Data regarding iron toxicity is not readily available.

D-1.13 Lead

Global production of lead from both smelter and mining operations has been high throughout this century. Lead is commonly used in storage batteries as well as ammunition, solder, and casting materials. In addition, tetraethyl lead was a principal additive to gasolines as an anti-knock agent, and was commonly used as an additive in paints. In short, lead is one of the most ubiquitous pollutants in the civilized world.

Lead is strongly sorbed in sediments and the rate is strongly correlated with grain size and organic content. In the absence of soluble complexing species, lead is almost totally adsorbed to clay particles at pHs greater than 6 (Moore and Ramamoorthy, 1984).

Mammals. In laboratory studies, breeding mice exposed to low doses of lead in drinking water (25 ppm) resulted in loss of the strain in two generations with many abnormalities (Schroeder, et al., 1971). Exposure of rats in this same experiment resulted in many early deaths and runts. Blood δ-aminolevulinic acid dehydratase (ALAD) activity associated with exposure to lead was reduced in white-footed mice living near a metal smelter (Beyer et al., 1985). Amounts of whole-body lead content and feeding habits of roadside rodents have been correlated with highest body burdens in insectivores such as shrews; intermediate in herbivores, and lowest in granivores (Boggess, 1977; Getz, et al., 1977).

Birds. Most of the information on the effects of lead to terrestrial vertebrates is concerned with the poisoning of waterfowl by lead shot. Apparent symptoms include loss of appetite and mobility, avoidance of other birds, lethargy, weakness, emaciation, tremors, dropped wings, green feces, impaired locomotion, loss of balance and depth perception, nervous system damage, inhibition of heme synthesis, damage to kidneys and liver, and death (Eisler, 1988b; Mudge, 1983). Anemia, kidney disease, testicular and liver lesions, and neurological disorders have been associated with high brain lead concentrations in mourning doves (*Zenaida macroura*) (Kendall, 1992). Hatchlings of chickens, Japanese quail, mallards and pheasants are relatively more tolerant to moderate lead exposure, including no effect on growth at dietary levels of 500 ppm and no effect on survival at 2,000 ppm (Hoffman, et al., 1985).

Fish. All life stages are sensitive to the toxic effects of lead; however, embryos are more sensitive to lead than are later juvenile stages (Davies et al., 1976). Lead uptake depends on exposure time, aqueous concentration, pH, temperature, salinity, diet, and other factors. For example, gill, liver, kidney, and erythrocytes accumulate lead from aqueous sources in

proportion to exposure time and concentration (Holcombe, et al., 1976). Direct erythrocyte injury is considered the first and most important sign of lead poisoning in catfish (Dawson, 1935). Respiratory distress occurs in fish living in rivers receiving lead mining wastes in England (Carpenter, 1924; 1925; 1926). Fish are thought to be asphyxiated as a result of a mucous coating over the gills (NAS, 1972).

Invertebrates. The majority of benthic invertebrates do not bioconcentrate lead from water or abiotic sediment particles. There is some evidence of bioaccumulation through the food web of organic forms of lead, such as tetraethyl lead. Anderson et al. (1980) reported lead LC_{50} of 258 ppm for the chironomid and that growth of this amphipod was not reduced above this level in freshwater sediments. In addition, Suter and Mabrey (1994) reported effect levels in the water flea (*Daphnia magna*) to be in the 12.26 parts per billion (ppb) range, while Khangrot and Ray (1989) reported a *D. magna* LC_{50} of 4.89 ppm.

D-1.14 Magnesium

Magnesium is an essential nutrient in most living organisms; therefore, most organisms have metabolic processes designed to regulate concentrations of magnesium within their tissues. For this reason, toxicity from magnesium would potentially only occur at extremely high concentrations. Data regarding magnesium toxicity is not readily available.

D-1.15 Manganese

Manganese, a silver-colored metal with chemical properties similar to iron, is a naturally occurring substance found in many minerals. Manganese is usually combined with oxygen, sulfur, and/or chlorine. Manganese and its compounds are used in making steel alloys, dry-cell batteries, electrical coils, ceramics, matches, glass, dyes, in fertilizers, welding rods, as oxidizing agents and as animal food additives.

Manganese is present in all living organisms and manganese is an essential element for adequate human nutritional needs. The principal portion of manganese intake is derived from food. Vegetables, the germinal portions of grains, fruits, nuts, tea, and some spices are rich in manganese. Manganese is poorly absorbed from the intestinal tract; about 3-5 percent of the oral dose of manganese is absorbed. Absorption efficiency is also related to dietary intake of iron and calcium. Sufficient body stores of iron decrease absorption of manganese (ATSDR, 1992c).

Inhalation exposure to manganese dioxide can result in severe health effects. The lung and the central nervous system are the two target organs of concern. Under chronic inhalation exposure conditions to high concentrations of manganese dust (> 10 milligrams per cubic meter [mg/m^3]),

the incidence of respiratory disease is 30 times greater than normal. However, this disease incidence rate is not exclusively related to manganese as most mineral dusts in high concentrations cause lung disease.

The second and more serious type of disease resulting from chronic inhalation exposure to manganese dioxide, generally over a period of more than two years, involves the central nervous system. This neurologic disorder is termed "manganism" and those who develop chronic manganese poisoning exhibit a psychiatric disorder characterized by irritability, difficulty in walking, speech disturbances and compulsive behavior that may include running, fighting and singing. Victims of chronic manganese poisoning tend to recover slowly, even when removed from excessive exposure (Klaassen et al, 1991).

At this time there is little evidence to suggest that oral exposure to manganese at low concentrations in water leads to neurologic disorders in animals or humans. Studies using rodents and monkeys suggest that apparently these species are not susceptible to manganese-induced neurologic disorders (ATSDR, 1992c).

D-1.16 Mercury

Plants. Mercury is not required for plant growth. In general, the concentration of mercury in plants will be elevated when mercury concentrations in soils are high; however, concentrations in plants generally do not exceed those in associated soils. Concentrations of mercury in leaf tissue that are excessive or toxic to various plant species range from 1 to 3 mg/kg (Kabata-Pendias and Pendias, 1992). Concentrations of mercury in plant tissues that are expected to result in a 10 percent loss in crop yield range from 1 to 8 mg/kg. General symptoms of mercury toxicity in plants include severe stunting of seedlings and roots, leaf chlorosis, and browning of leaf points (Kabata-Pendias and Pendias, 1992).

Wildlife. Mercury is not an essential element for animal life. Mercury is bioaccumulated and biomagnified in terrestrial food chains (Eisler, 1987a). Organic mercury compounds, especially methyl mercury, are more toxic to mammals than inorganic forms of mercury. Selenium has been shown to have an antagonistic effect on mercury toxicity (Ganther, et al., 1972). Based on methyl mercury toxicity data for the rat and mink, extrapolated NOAELs for chronic exposure of various mammalian wildlife species to methyl mercury are 0.08 mg/kg/day for the white-footed mouse, 0.021 mg/kg/day for the cottontail rabbit, and 0.009 mg/kg/day for the red fox. Calculated chronic drinking water NOAELs for mammalian wildlife are 0.27 mg/L for the white-footed mouse, 0.22 mg/L for the cottontail rabbit, and 0.11 mg/L for the red fox (Sample, et al.,

1996). Mercury has been shown to be teratogenic, mutagenic, and carcinogenic in animal studies (Eisler, 1987a). Signs of mercury poisoning that have been observed in mink include anorexia, weight loss, ataxia and splaying of hind legs, irregular vocalization, salivation, and convulsions (Wren, 1986).

Birds. Concentrations of mercury that are acutely toxic to birds following oral exposure range from 2.2 to 31 mg/kg (Eisler, 1987a). Based on avian test data for mallards exposed to methyl mercury, extrapolated NOAELs for chronic exposure of avian species to methyl mercury are 0.005 mg/kg/day for the great blue heron and 0.006 mg/kg/day for the red -tailed hawk. The calculated drinking water NOAEL for wild birds consuming methyl mercury through drinking water is 0.11 mg/L (Sample, et al., 1996). Physical signs of mercury poisoning in birds include muscular incoordination, falling, slowness, fluffed feathers, calmness, withdrawal, hyporeactivity, and eyelid drooping (Eisler, 1987a).

Aquatic Life. Exposure of aquatic organisms to elevated mercury concentrations can result in reduced growth and reproduction (Eisler, 1987a). Elevated concentrations of mercury in fish have often been associated with low pH, low calcium concentrations in the water, and low water hardness. Methylating bacteria in sediments actively convert inorganic mercury into methyl mercury. This results in an increase in the bioavailability of mercury. The Federal Water Quality Criteria for the protection of aquatic life for acute and chronic exposures to methyl mercury in freshwater systems are 2.4 and 0.012 µg/L, respectively (USEPA, 1986). Physical signs of acute mercury poisoning in fish include the flaring of gills, an increase in the frequency of respiratory movements, loss of equilibrium, and sluggishness (Eisler, 1987a).

D-1.17 Nickel

Nickel is a naturally occurring silvery metal that is found in the earth's crust in the form of various nickel minerals. Exposure of organisms to nickel and its compounds results from breathing air, ingesting water and food that contain nickel and compounds, and skin contact with a media contaminated with nickel.

Mammals. Rats fed nickel in their diet as nickel sulfate hexahydrate over three generations were studied for effects on reproduction. They were fed three dose levels (250, 500, and 1,000 ppm nickel [Ni]) in their diet and only the highest dose level caused reduced offspring body weights. No adverse effects were observed in the other dose levels. Because this study considered exposures over multiple generations, the 500 ppm dose was considered to be the chronic NOAEL and the 1,000 ppm dose was considered to be the chronic LOAEL (USEPA, 1999).

Birds. Mallard ducklings were fed nickel as nickel sulfate in their diet for a duration of 90 days to study the effects on mortality, growth, and behavior. They were fed three dose levels (176, 774, and 1,069 ppm Ni) and only the highest dose reduced growth and resulted in 70 percent mortality. Because the study considered exposure over 90 days, the 774 ppm dose was considered to be the chronic NOAEL and the 1,069 dose was considered to be the chronic LOAEL (USEPA, 1999).

D-1.18 Selenium

Plants. The role of selenium in plant growth is not fully understood. It is generally not considered essential in plant nutrition (Kabata-Pendias and Pendias, 1992). The concentration of selenium in plants has been shown to be positively correlated with the concentration of selenium in soil. Soil parameters such as pH, oxidation-reduction potential, and moisture content determine the amount of selenium available for plant uptake. Concentrations of selenium in leaf tissues that have been shown to be toxic to various plant species range from 5 to 30 mg/kg (Kabata-Pendias and Pendias, 1992). General symptoms of selenium toxicity in plants include the signs of interveinal chlorosis or black spots in plants containing approximately 4 mg/kg selenium, complete bleaching or yellowing of younger leaves at higher concentrations, and the presence of pinkish spots on roots (Kabata-Pendias and Pendias, 1992).

Wildlife. Selenium is an essential trace element for animal life. Concentrations that are essential to animals are in the range of 0.05 to 0.1 mg/kg in the diet (Arthur, et al., 1992). According to Ganther (1974), selenium concentrations in healthy, unexposed, laboratory animals and livestock range between 0.1 and 1 mg/kg. Selenium offers a protective effect against some carcinogens such as benzo(a)pyrene and benzo(a)anthracene (Hammond and Beliles, 1980). Selenium also functions as an antidote to the toxic effects of mercury, thallium, copper, arsenic and cadmium (Frost and Lish, 1975).

Acute poisoning has been reported in livestock that consumed plant material containing 400 to 800 mg/kg selenium (Eisler, 1985b). Signs of acute poisoning in livestock include abnormal movements, lowered head, drooped ears, diarrhea, elevated temperature, rapid pulse, labored breathing, bloating with abdominal pain, increased urination, and dialated pupils (Eisler, 1985b). Chronic poisoning may occur in animals exposed to dietary selenium concentrations between 1 and 44 mg/kg (Eisler, 1985b). Based on an estimated oral NOAEL of 0.075 mg/kg/day for mice exposed to selenate, Sample, et al., (1996) calculated NOAELs for the white-footed mouse,

cottontail rabbit, and red fox to be 0.083, 0.022, and 0.014, respectively. Drinking water NOAELs for these species were estimated to be 0.28. 0.23, and 0.17 mg/L, respectively.

Birds. Toxicity from selenium has also been documented in birds. The major toxic effect of selenium on avian species is on reproductive success. Both sodium selenite and selenomethionine have been reported to be embryotoxic and teratogenic (Heinz, et al., 1987). Reproductive impairment is likely to occur as concentrations of selenium approach 5 mg/kg. Mortality in mallard ducklings does not occur until selenium concentrations in the diet reach 40 mg/kg. Extrapolated NOAELs for chronic exposure of various avian wildlife species to selenomethionine, based on an estimated NOAEL for mallards of 0.4 mg/kg/day, are 0.3 mg/kg/day for the great blue heron and 0.385mg/kg/day for the red-tailed hawk. The NOAEL for selenomethionine consumed in drinking water has been estimated to be 6.8 mg/L for wild birds (Sample, et al., 1996).

Aquatic Life. Selenium is an essential micro-nutrient for fish. Dietary requirements of selenium for fish range from 0.07 to 0.25 mg/kg, depending on the fish species (Gatlin and Wilson, 1984). The bioconcentration of selenium from water is highly dependent on the species of selenium present. Laboratory studies have shown bioconcentration factors for selenomethionine to be greater than those for selenite and selenate. Bioconcentration factors for aquatic biota exposed to 1 µg/L selenomethionine were approximately 16,000 for algae, 200,000 for daphnids, and 5,000 for bluegills (Besser, et al., 1993).

The USEPA's National Ambient Water Quality Criteria for selenium in freshwater is 20 µg/L for chronic exposure (USEPA, 1986). The toxicity of selenium to freshwater fish appears to be correlated more closely with dietary than waterborne exposure (Coyle, et al., 1993).

D-1.19 Silver

Plants. Silver is not considered essential for plant growth. Silver concentrations in plants generally range between 0.03 and 0.5 mg/kg (Kabata-Pendias and Pendias, 1992). The availability of silver in soils to plants is dependent on soil pH, the soil organic matter content, and the concentration of manganese oxides in soil (Kabata-Pendias and Pendias, 1992). Concentrations of silver in leaf tissue that are excessive or toxic to various plant species range from 5 to 10 mg/kg.

Wildlife. Silver is not an essential element for animal life. The toxicity of silver is dependent on the form of silver and the route of exposure. Internal antagonistic reactions between silver

and selenium have been noted. Repeated exposure of animals to silver may induce anemia, enlargement of the heart, growth retardation, and degenerative changes in the liver (National Library of Medicine [NLM], 1996). A value of 89 mg/kg/day has been estimated as the chronic LOAEL for rats (USEPA, 1986).

Aquatic Life. Accumulation of silver has been reported in algae, daphnids, freshwater mussels, and fathead minnows. Biomagnification of silver, however, has not been observed in freshwater systems (NLM, 1996). The Federal Ambient Water Quality Criteria for the protection of aquatic life for acute exposure to silver in freshwater systems is 0.92 µg/L (USEPA, 1986). The chronic criteria is 0.12 µg/L (USEPA, 1986).

D-1.20 Thallium

Thallium is widely distributed in trace amounts in the earth's crust and is one of the more toxic metals. In the environment, thallium exists in either the monovalent (thallous) or trivalent (thallic) form. Thallium is chemically reactive with air and moisture, undergoing oxidation. Thallium is relatively insoluble in water. Thallium adsorbs to soil and sediment and is not transformed or biodegraded. In aquatic organisms, thallium is absorbed primarily from ingestion and thereafter bioconcentrates in the organism. Toxic effects have been observed in numerous aquatic organisms including daphnia, fathead minnow, bluegill sunfish, and others (USEPA, 1999).

Birds and mammals are exposed to thallium via ingestion of soil, water, and plant material. In mammals, thallium is absorbed primarily from ingestion and is distributed to several organs and tissues, with the highest levels reported in the kidneys. Thallium exposure in mammals causes cardiac, neurologic, reproductive, and dermatological effects. Various effects and toxic responses have been reported, including paralysis and pathological changes in the liver, kidneys, and stomach mucosa in rabbits exposed to thallium. Testicular toxicity in rats has also been reported (USEPA, 1999).

D-1.21 Vanadium

Vanadium, a white to gray metal, occurs naturally in fuel oils and coal. It is used as a catalyst in the production of various chemicals including sulfuric acid. It is also used in the hardening of steel, the manufacture of pigments, and photography. The general population and many ecological receptors is exposed to background levels of vanadium primarily through ingestion of food.

Mammals. Experimental animal investigations have suggested that the liver, adrenal, and bone marrow may be adversely affected by subacute exposure to high levels of vanadium (ATSDR, 1992d; Klaassen, et al., 1991). Vanadium fed to rats prior to gestation, during gestation, and through delivery and lactation were studied for effects on reproduction. The rats were fed three dose levels (5, 10, and 20 mg $NaVO_3$/kg/day or 2.1 mg vanadium [V]/kg/day). Significant differences in reproductive parameters (e.g., number of dead young per litter, size and weight of offspring, etc.) were observed at all dose levels. Therefore, the lowest dose was considered to be a chronic LOAEL. A chronic NOAEL was estimated by applying an uncertainty factor of 0.1 (chronic NOAEL = 0.21 mg V/kg/day) (USEPA, 1999).

Birds. Mallard ducks were fed vanadium as vanadyl sulfate in their diet for 12 weeks and observed for effects on mortality, body weight, and blood chemistry. The ducks were fed three different doses (2.84, 10.36, and 110 ppm V). No effects were observed at any of the dose levels. Because this study was greater than ten weeks in duration, and did not consider a critical lifestage, the maximum dose was considered to be a chronic NOAEL.

D-1.22 Zinc

Zinc is a naturally occurring element, which may be found in both organic and inorganic forms, and as such, is commonly found in the environment. In general, zinc is concentrated in the sediments of water bodies. NAS (1977b) has reported that zinc will probably be detected in 75 percent of all water bodies examined for the compound at various locations. The fate of zinc in soils appears to have a pH basis. Studies have shown that a pH of less than 7 often favors zinc desorption (USEPA, 1984).

Mammals. Zinc is an essential trace element for normal fetal growth and development. However, exposure to high levels of zinc in the diet has been associated with reduced fetal weights, altered concentrations of fetal iron and copper, and reduced growth in offspring (Cox et al., 1969). Poisoning has been observed in ferrets and mink from chewing corroded galvanized cages (Clark et al., 1981). Symptoms of zinc toxicity are lassitude, slower tendon reflexes, bloody enteritis, diarrhea, lowered leukocyte count, depression of the central nervous system, and paralysis of the extremities (Venugopal and Luckey, 1978). A study by Kinnamon (1963) showed a NOAEL for oral exposure to a zinc compound over a period of 73 days to be 250 mg/kg body weight, and mice given 500 mg/L of zinc, as zinc sulfate, in drinking water have shown hypertrophy of the adrenal cortex and pancreas. Young animals are much more susceptible to poisoning by zinc than are mature animals (Clark et al., 1981).

Birds. No data were found regarding the toxicity of zinc to avian species.

Fish. Zinc residues in freshwater and marine fish are generally much lower than those found in algae and invertebrates. Thus there is little evidence for accumulation (Moore and Ramamoorthy, 1984). Rainbow trout (*Oncorhyncus mykiss*) have the ability to detect and avoid areas of water containing 5.6 ppb zinc (Sprague, 1968). Cairns and Scheier (1968) reported 96-hour LC_{50} ranging from 10.13 to 12.5 ppm in hard water for bluegills (*Lepomis macrochirus*), and 96-hour LC_{50} ranging from 2.86 to 3.78 ppm in soft water. These results demonstrate that water hardness affects the toxicity of zinc to fish. Chronic toxicity tests have been conducted with five species of freshwater fish. Chronic values ranged from 47 µg/L for flagfish (*Jordanella floridae*) to 852 µg/L for brook trout (*Salvenius fontinallis*) (USEPA, 1980b).

Invertebrates. Acute toxicity to freshwater invertebrates is relatively low, and as with other metals, increasing water hardness decreases the toxicity of zinc (Moore and Ramamoorthy, 1984). As reported by Baudouin and Scoppa (1974), the 48-hour LC_{50} for the cladaceran *Daphnia hyalina* was 0.055 mg/L, and 5.5 mg/L for the copepod *Cyclops abyssorum.* Four chronic toxicity tests are reported for *Daphnia magna*, with chronic values ranging from 47 µg/L to 136 µg/L (USEPA, 1980b). Chronic testing with the saltwater species *Mysidopsis bahia* resulted in a chronic value of 166 µg/L (USEPA, 1980b).

D-1.23 Acetone

Volatilization and biodegradation are the major fate processes affecting acetone in the environment. The volatilization half-life for acetone is approximately 18 hours in a riverine system. In addition, acetone does not partition well to sediments because it is highly soluble in water. Biodegradation is the most significant degradation process of acetone in water. Studies on wastewater have shown that aquatic microbial communities quickly acclimate to acetone, and rapidly degrade it (USEPA, 1999).

In most aquatic systems, acetone will exist in water rather than sediment, due to acetone's high water solubility and low sediment adsorption coefficient. Bioaccumulation does not occur in aquatic organisms as suggested by its low octonal-water partition coefficient (K_{ow}) value. Biomagnification in the food chain is also considered insignificant.

Because of acetone's high volatility, it may be inhaled and rapidly absorbed into the blood stream and dispersed throughout the body. A large portion of the absorbed acetone will be excreted primarily unchanged through the lungs and urine, with only a small portion reduced and excreted as carbon dioxide. Because acetone is quickly eliminated, wildlife receptors will not accumulate it in tissues (USEPA, 1999).

D-1.24 Bis(2-ethylhexyl)phthalate

Bis(2-ethylhexyl)phthalate (BEHP) is a high molecular weight, semi-volatile organic compound. BEHP adsorbs strongly to soil and sediment, and it may be biodegraded in aerobic environments. It has a low water solubility and low vapor pressure. It does not undergo significant photolysis, hydrolysis, or volatilization in soil or water. Receptors may be exposed to BEHP by the oral, inhalation, and dermal routes. BEHP bioconcentration in aquatic organisms is generally low, therefore significant food chain biomagnification in upper-trophic-level fish is unlikely. Mammalian and avian wildlife can metabolize and eliminate BEHP, therefore, it does not biomagnify in these receptors (USEPA, 1999).

BEHP adsorbs strongly to soil and sediment and does not undergo significant volatilization or photolysis. BEHP has a low water solubility. A half-life of approximately one month, due to microbial degradation, has been reported for BEHP in river water (USEPA, 1999).

Aquatic receptors may be exposed through ingestion of contaminated food or water, dermal exposure, or in the case of fish, by direct contact of the gills with the surrounding water. Based on its low water solubility and high soil partition coefficient, dietary uptake is the most significant route of exposure for BEHP (USEPA, 1999).

Invertebrates may bioaccumulate BEHP from surface water and sediment. The level of bioaccumulation is receptor-specific, because some invertebrates can metabolize BEHP, while some have limited capability. BEHP has a short half-life in fish, indicating that it is quickly eliminated. Fish eliminate BEHP by metabolizing it to polar byproducts, which are quickly excreted. Therefore, food chain accumulation and biomagnification of BEHP in aquatic food webs is not significant (USEPA, 1999).

BEHP is absorbed by mammals following oral or dermal exposure, with oral exposure being the route with the greatest absorption efficiency. Following absorption, BEHP is distributed primarily to the liver and kidney, and in some species, the testes (USEPA, 1999).

D-1.25 Chlordane

Chlordane is a chlorinated insecticide which is a mixture of some 50 different compounds; the major constituents being alpha-, beta-, and gamma-chlordane (Howard, 1991). Chlordane is generally immobile in soil; however, movement in groundwater can occur. The compound is biodegraded at a very slow rate and is not expected to undergo significant hydrolysis, photolysis, or oxidation.

Plants. Chlordane concentrations greater than 100 µg/L were found to inhibit the growth of blue-green algae, whereas, concentrations greater than 1,000 µg/L inhibited the growth of green algae (Glooschenko and Lott, 1977).

Wildlife. Absorption of chlordane can occur through the skin, diet and inhalation. Oxychlordane and heptachlor epoxide are metabolites of the components of technical grade chlordane. Oxychlordane is more toxic and persistent than any of the parent compounds (Eisler, 1990).

Acute oral LD_{50} values for exposure of sensitive mammalian species to technical grade chlordane generally range from 25 to 50 mg/kg body weight. Based on a NOAEL for mice orally exposed to chlordane, Sample, et al., (1996) estimated NOAELs for the white-footed mouse, cottontail rabbit, and red fox to be 5.07, 1.36, and 0.88 mg/kg/day, respectively. Drinking water NOAELs for these species ranged from 10.4 to 16.9 mg/L. Symptoms of acute chlordane poisoning in mammals include diarrhea, avoidance of food and water, hair loss, hunched appearance, abdominal distension, labored respiration, salivation, muscle tremors, incoordination, convulsions, and death in some cases. Chlordane has also been shown to adversely affect growth and reproduction and has also been shown to be carcinogenic in mice (Eisler, 1990).

Birds. Toxic responses to technical grade chlordane are primarily attributed to the metabolite oxychlordane. Based on a NOAEL of 2.14 mg/kg/day for red-winged blackbirds exposed to chlordane, NOAELs for the great blue heron and red-tailed hawk have been estimated to be 0.65 and 0.83 mg/kg/day, respectively. A drinking water NOAEL of 14.6 µg/L has been estimated for wild birds exposed to chlordane (Sample, et al., 1996). Signs of chlordane poisoning in birds include sluggishness, drooped eyelids, fluffed feathers, altered resting patterns, reduced appetite, weight loss, quivering and panting, neck arched over back, and arched back (Eisler, 1990).

Aquatic Life. Bioconcentration factors for aquatic organisms range from 108 for frogs to 38,000 for fathead minnows (Howard, 1991). There is some evidence for biomagnification of chlordane in freshwater fish (Eisler, 1990). Variations in the response of aquatic organisms to chlordane are related to both biological factors of the biota and physical factors of chlordane and the aquatic environment.

The USEPA's National Ambient Water Quality Criteria for the protection of aquatic life is 2.4 µg/L for acute exposure and 0.0043 µg/L for chronic exposure (USEPA, 1986). Signs of

chlordane poisoning in fish include hyperexcitability, increased respiration rate, erratic swimming, loss of equilibrium, convulsions, and death (Eisler, 1990).

D-1.26 4,4'-DDT and Metabolites

Dichlorodiphenyltrichloroethane (DDT) is a chlorinated pesticide that has been banned in the United States since 1972. Dichlorodiphenyldichloroethene (DDE) and dichlorodiphenyldichloroethane (DDD) are metabolites of DDT. DDT and its metabolites will adsorb very strongly to soil and are subject to evaporation and photodegradation at the soil surface. DDT and related compounds are very persistent in soils (NLM, 1996).

Plants. DDT can be taken up by plant roots and translocated to the above-ground plant parts. Concentrations of DDT and its metabolites are usually greatest in the roots of the plants (Voerman and Besemer, 1975). The effects of DDT, DDD, and DDE on plant growth and reproduction are not well documented.

Wildlife. As in plants, DDT and its major metabolites DDE and DDD are ubiquitous in wild mammals and birds. Because DDT can be biomagnified through food chains, insectivorous shrews generally contain higher concentrations than herbivorous small mammals collected from the same site. DDT residues were found to be higher in juveniles than adults and increased with increased body fat content (Talmage and Walton, 1991).

The most significant exposure route for vertebrates to DDT and its metabolites is oral exposure. Dermal exposure is believed to be very limited, and inhaled DDT and associated particulates are believed to be deposited in the upper respiratory tract and eventually swallowed. The toxicity of DDT and its metabolites to mammalian and avian wildlife is dependent on the fat content within the animal. In both mammals and birds the storage of DDT and DDE in fat is protective, because it decreases the amount of chemical in circulation that may reach the brain, which is the site of toxic action (NLM, 1996).

Based on an estimated oral NOAEL for rats exposed to DDT and its metabolites of 0.8 mg/kg/day, NOAELs for the white-footed mouse, cottontail rabbit, and red fox were calculated to be 2.0, 0.53, and 0.34 mg/kg/day (Sample, et al., 1996). Drinking water NOAELs for these species ranged from 4.08 to 6.65 mg/L. Signs of acute DDT poisoning in animals include paresthesia of the tongue, lips and face; apprehension; dizziness; tremor; disturbed equilibrium; and convulsions (Murphy, 1980).

Birds. DDE concentrations in eggs have been negatively correlated with eggshell thickness in bald eagles. Studies have shown reduced reproductive success at DDE egg residue concentrations of greater than 3 mg/kg for the white-faced ibis, 5 mg/kg for the snowy egret, and 8 mg/kg for the black-crowned night heron. Extrapolated NOAELs for chronic exposure to DDT and its metabolites based on experiments with brown pelicans are 3.2×10^{-4} mg/kg/day for the great blue heron and 4.1×10^{-4} mg/kg/day for the red-tailed hawk (Sample, et al., 1996). Signs of DDT poisoning in birds include ataxia, wing-drop, jerkiness in gait, continuous whole-body tremors, falling, and convulsions (Hudson, et al., 1984).

Aquatic Life. DDT in freshwater environments partitions primarily into sediment. Biodegradation of DDT in sediment may be significant. Bioconcentration factors between 51,000 and 100,000 have been reported for fathead minnows exposed to DDT (NLM, 1996). The Federal Water Quality Criteria for the protection of aquatic life for acute and chronic exposures to DDT and its metabolites in freshwater systems are 1.1 and 0.001 µg/L, respectively (USEPA, 1986).

D-1.27 Ethylbenzene

When released to soil, part of the ethylbenzene will evaporate, and some may adsorb to soil particles. Biodegradation is not considered a significant removal process.

Wildlife. Absorption of ethylbenzene is primarily by inhalation. Most of the inhaled compound is excreted in urine as metabolites. Absorption through the skin is slow. Exposure to high concentrations of ethylbenzene via ingestion, inhalation, or dermal absorption can cause depression of the central nervous system in animals (Friberg, et al., 1986). Concentrations of ethylbenzene greater than 2 mg/L have been reported to be acutely toxic to laboratory animals. Adverse impacts on fertility have been reported in female rats exposed to 97 ppm ethylbenzene. Ethylbenzene has been shown to be phytotoxic and teratogenic (RTECS, 1996).

Aquatic Life. Bioconcentration of ethylbenzene by fish is expected to be insignificant (NLM, 1996). Experimentally determined bioconcentration factors for ethylbenzene in goldfish and clams are 79 and 4.68, respectively. A value of 32 mg/L is listed by USEPA (1986) as the lowest effect level in freshwater environments.

D-1.28 Polycyclic Aromatic Hydrocarbons

Polycyclic aromatic hydrocarbons (PAH) are a diverse group of organic chemicals consisting of substituted and unsubstituted polycyclic and heterocyclic aromatic rings in which interlinked rings have at least two carbon atoms in common (Zander, 1983). They are formed as a result of

incomplete combustion of organic materials such as wood, coal, and oil and exist in the environment in quantity, both from anthropogenic and natural sources. Activities associated with large releases of PAHs include coke production, petroleum refining, the manufacture of carbon black, coal tar pitch and asphalt, heating and power generation, and emissions from internal combustion engines. It is estimated that approximately 270,000 metric tons of PAHs reach the environment yearly (Eisler, 1987b).

Mammals. Sims and Overcash (1983) have reported LC_{50} values for rodents (*Rattus* spp. and *Mus* spp.) as 50 mg/kg/day benzo(a)pyrene, 700 mg/kg/day phenanthrene, and 2,000 mg/kg/day fluoranthene. Sublethal effects manifested as decreased pup weight in mice has been reported at 10 mg/kg/day benzo(a)pyrene (MacKenzie and Angevine, 1981). Subchronic and chronic effects of exposure to PAHs in rats include liver and kidney damage, unspecified changes in peripheral blood pattern, body weight loss, genetic aberrations, and increased serum aminotransferase activity (Knobloch et al., 1969).

Birds. Hoffman and Gay (1981) measured embryotoxicity of various PAHs applied externally to the surface of mallard duck eggs. Approximately 0.002 μg/egg of 7,12-dimethylbenz(a)anthracene (DMBA) caused 26 percent mortality in 18 days, and among the survivors, produced significant reduction in embryonic growth and a significant increase in the percent of abnormalities, e.g., incomplete skeletal ossification, defects in eye, brain liver, feathers, and bill. At 0.1 μg DMBA/egg, only 10 percent survived to day 18.

Fish. In general, PAHs as a group are not appreciably acutely toxic (Eisler, 1987b; Neff, 1985). For aquatic organisms, only PAHs in the molecular weight range from naphthalene to pyrene are considered acutely toxic. Toxicity in this group increases with increasing molecular weight. There is some evidence to suggest that PAHs are responsible for the production of reproductive and teratogenic effects in eggs of the sand sole (*Psettichthys melanostictus*) exposed to 0.1 μg benzo(a)pyrene/L for five days showed reduced and delayed hatch and, when compared to controls, produced larvae with high accumulations (2.1 mg/kg fresh weight) and gross abnormalities, such as tissue overgrowths, in 50 percent of the test larvae (Hose et al., 1982).

Invertebrates. Inhibited reproduction of daphnids and the delayed emergence of larval midges by fluorene was reported by Finger, et al. (1985). When sediment PAH levels are elevated, benthic organisms obtain a majority of their PAHs from sediments through their ability to mobilize PAHs from the sediment/pore water matrix. The elevated levels in the tissues of these

organisms could provide a significant source of PAHs to predatory fish. However, fish do have the ability to efficiently metabolize and degrade PAHs.

D-1.29 m,p-Xylenes

Xylenes are somewhat mobile in soil and may leach into groundwater. In soil, xylene may be degraded by microbes. The dominant removal process for xylene in water is volatilization (NLM, 1996).

Wildlife. Exposure to xylenes occurs primarily through inhalation and ingestion. Xylenes are eliminated in exhaled air with xylene metabolites excreted in urine (NLM, 1996). Xylene is primarily a central nervous system depressant. Adverse impacts on fertility have been reported in female mice orally exposed to xylene concentrations of 31 mg/kg and in rabbits exposed to an inhalation dose of 1 g/m^3. Wildlife NOAELs for mixed xylenes based on extrapolations from laboratory mouse studies are 2.28 mg/kg/day for the white-footed mouse. 0.61 mg/kg/day for the cottontail rabbit, and 0.39 mg/kg/day for the red fox. Calculated chronic drinking water NOAELs for mammalian wildlife range from 2.61 to 20.3 mg/l (Sample, et al., 1996). Signs of xylene poisoning in small mammals include dullness, stupor, anesthesia, central nervous system depression, and coma. Xylenes have not been shown to be carcinogenic or mutagenic.

Aquatic Life. Data on the toxicity of xylenes to freshwater biota are limited. Bioconcentration in aquatic environments is not expected to be significant (NLM, 1996). LC_{50} values for fathead minnows, rainbow trout, and goldfish exposed to xylene for 96 hours are 42, 13.5, and 16.9 mg/L, respectively (NLM, 1996).

D-1.30 References

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APPENDIX D

SCREENING-LEVEL ECOLOGICAL RISK ASSESSMENT

TABLES

TABLE D-1
FEEDING GUILDS AND EXPOSURE PATHWAYS FOR TERRESTRIAL ECOSYSTEMS AT FILL AREAS
Fort McClellan
Calhoun County, Alabama

Trophic Level	Feeding Guild	Exposure Pathways
1	Primary Producers	Direct uptake from soil
2	Terrestrial Invertebrates	Ingestion of soil Direct contact with soil
	Herbivorous Birds	Ingestion of soil Ingestion of surface water Ingestion of terrestrial plants
	Herbivorous Mammals	Ingestion of soil Ingestion of surface water Ingestion of terrestrial plants
3	Omnivorous Birds	Ingestion of soil Ingestion of surface water Ingestion of terrestrial plants Ingestion of terrestrial invertebrates
	Omnivorous Mammals	Ingestion of soil Ingestion of surface water Ingestion of terrestrial plants Ingestion of terrestrial invertebrates Ingestion of prey
	Invertivorous Birds	Ingestion of soil Ingestion of surface water Ingestion of terrestrial invertebrates
	Invertivorous Mammals	Ingestion of soil Ingestion of surface water Ingestion of terrestrial invertebrates
4	Carnivorous Birds (raptors)	Ingestion of soil Ingestion of surface water Ingestion of prey
	Carnivorous Mammals	Ingestion of soil Ingestion of surface water Ingestion of prey

TABLE D-2
FEEDING GUILDS AND EXPOSURE PATHWAYS FOR STREAM / POND ECOSYSTEMS AT FILL AREAS
Fort McClellan
Calhoun County, Alabama

Trophic Level	Feeding Guild	Exposure Pathways
1	Primary Producers	Direct uptake from surface water Direct uptake from sediment
2	Benthic Invertebrates	Ingestion of sediment Direct contact with sediment
	Herbivorous Waterfowl	Ingestion of sediment Ingestion of surface water Ingestion of aquatic plants
	Herbivorous Mammals	Ingestion of sediment Ingestion of surface water Ingestion of aquatic plants
	Forage Fish	Ingestion of plankton Ingestion of aquatic plants and algae Absorption through gills
3	Omnivorous Mammals	Ingestion of sediment Ingestion of surface water Ingestion of aquatic plants Ingestion of benthic invertebrates
	Omnivorous Waterfowl	Ingestion of sediment Ingestion of surface water Ingestion of aquatic plants Ingestion of benthic invertebrates
	Invertivorous Waterfowl	Ingestion of sediment Ingestion of surface water Ingestion of benthic invertebrates
4	Piscivorous Birds	Ingestion of sediment Ingestion of surface water Ingestion of fish
	Piscivorous Mammals	Ingestion of sediment Ingestion of surface water Ingestion of fish

TABLE D-3

CONSTITUENTS OF POTENTIAL ECOLOGICAL CONCERN IN SURFACE SOIL
Landfill No. 1, Parcel 78(6)
Fort McClellan, Alabama

Detected Constituents	Background Soil Conc.[a] (mg/kg)	Ecological Screening Value[b] (mg/kg)	Maximum Detected Conc. (mg/kg)	Minimum Detected Conc. (mg/kg)	Arithmetic Mean Conc. (mg/kg)	Frequency Of Detection	Maximum Hazard Quotient	Mean Hazard Quotient	Constituent of Potential Ecological Concern
METALS									
Aluminum	1.63E+04	5.00E+01	3.12E+04	1.92E+04	2.27E+04	4 / 4	624.00	454.50	Yes
Arsenic	1.37E+01	1.00E+01	8.76E+00	3.45E+00	5.89E+00	4 / 4	0.88	0.59	1,2
Barium	1.24E+02	1.65E+02	1.82E+02	9.79E+01	1.32E+02	4 / 4	1.10	0.80	Yes
Beryllium	8.00E-01	1.10E+00	3.16E+00	1.52E+00	2.11E+00	4 / 4	2.87	1.91	Yes
Boron	2.21E+01	NA	1.09E+01	9.64E+00	6.80E+00	2 / 4	NA	NA	1
Calcium	1.72E+03	NA	1.52E+03	9.29E+01	9.89E+02	4 / 4	NA	NA	1,3
Chromium	3.70E+01	4.00E-01	3.14E+01	2.16E+01	2.65E+01	4 / 4	78.50	66.31	1
Cobalt	1.52E+01	2.00E+01	1.86E+01	6.11E+00	1.00E+01	3 / 4	0.93	0.50	2
Copper	1.27E+01	4.00E+01	5.34E+01	1.86E+01	3.67E+01	4 / 4	1.34	0.92	Yes
Iron	3.42E+04	2.00E+02	8.00E+04	2.71E+04	5.76E+04	4 / 4	400.00	288.13	3
Lead	4.01E+01	5.00E+01	2.04E+01	1.58E+01	1.81E+01	4 / 4	0.41	0.36	1,2
Magnesium	1.03E+03	4.40E+05	8.31E+03	1.86E+03	4.09E+03	4 / 4	0.0189	0.0093	2,3
Manganese	1.58E+03	1.00E+02	1.65E+02	2.19E+01	9.04E+01	4 / 4	1.65	0.90	1
Nickel	1.03E+01	3.00E+01	4.03E+01	1.39E+01	2.35E+01	4 / 4	1.34	0.78	Yes
Potassium	8.00E+02	NA	1.97E+03	1.04E+03	1.47E+03	4 / 4	NA	NA	3
Sodium	6.34E+02	NA	3.83E+02	1.06E+02	2.49E+02	4 / 4	NA	NA	1,3
Vanadium	5.88E+01	2.00E+00	4.41E+01	2.39E+01	3.73E+01	4 / 4	22.05	18.63	1
Zinc	4.06E+01	5.00E+01	1.25E+02	3.69E+01	7.04E+01	4 / 4	2.50	1.41	Yes
PESTICIDES									
4,4'-DDE	NA	2.50E-03	1.10E-02	5.18E-03	2.10E-02	2 / 4	4.40	8.42	Yes
SEMI-VOLATILE ORGANIC COMPOUNDS									
Benzo(a)anthracene	NA	5.21E+00	1.70E-01	1.70E-01	5.79E-02	1 / 4	0.033	0.011	2
Benzyl Alcohol	NA	NA	5.70E-02	5.70E-02	2.63E-02	1 / 4	NA	NA	5
Chrysene	NA	4.73E+00	1.70E-01	1.70E-01	5.45E-02	1 / 4	0.036	0.012	2
Fluoranthene	NA	1.00E-01	1.90E-01	1.90E-01	5.95E-02	1 / 4	1.90	0.60	Yes
Phenanthrene	NA	1.00E-01	2.50E-01	2.50E-01	7.45E-02	1 / 4	2.50	0.75	Yes
Pyrene	NA	1.00E-01	2.80E-01	2.80E-01	1.01E-01	1 / 4	2.80	1.01	Yes

Notes:

[a] - SAIC, 1998. Final Background Metals Survey Report.

[b] - Ecological Screening Values developed as described in the *Human Health and Ecological Screening Values & PAH Background Summary Report (IT, July, 2000).*

NA - Not applicable

Conc. - Concentration

1 - Maximum detected concentration is less than background concentration.

2 - Maximum detected concentration is less than ecological screening value (ESV).

3 - Essential macronutrient, only toxic at extremely high concentrations (i.e. 10-times naturally-occurring background concentration).

4 - Detected concentrations in the site samples were less than 10-times the concentrations of common laboratory contaminants (e.g. acetone, 2-butanone, methylene chloride, toluene, and phthalate esters) or 5-times the concentrations of other constituents detected in associated balnks.

5 - No ESV available; however, maximum detected concentration is similar to concentrations of other VOAs which are below their respective ESVs.

TABLE D-4

CONSTITUENTS OF POTENTIAL ECOLOGICAL CONCERN IN SURFACE WATER
Landfill No. 1, Parcel 78(6)
Fort McClellan, Alabama

Detected Constituents	Background Surface Water Conc [a] (mg/L)	Ecological Screening Value [b] (mg/L)	Maximum Detected Conc. (mg/L)	Minimum Detected Conc. (mg/L)	Arithmetic Mean Conc. (mg/L)	Frequency Of Detection	Maximum Hazard Quotient	Mean Hazard Quotient	Constituent of Potential Ecological Concern
METALS									
Aluminum	5.26E+00	8.70E-02	4.61E-01	4.61E-01	4.61E-01	1 / 1	5.30	5.30	1
Arsenic	2.17E-03	1.90E-01	5.48E-03	5.48E-03	5.48E-03	1 / 1	0.029	0.029	2
Barium	7.54E-02	3.90E-03	3.71E-02	3.71E-02	3.71E-02	1 / 1	9.51	9.51	1
Calcium	2.52E+01	1.16E+02	2.31E+01	2.31E+01	2.31E+01	1 / 1	0.20	0.20	1,2,3
Iron	1.96E+01	1.00E+00	9.10E-01	9.10E-01	9.10E-01	1 / 1	0.91	0.91	1,2,3
Lead	8.67E-03	1.32E-03	7.84E-03	7.84E-03	7.84E-03	1 / 1	5.94	5.94	1
Magnesium	1.10E+01	8.20E+01	1.04E+01	1.04E+01	1.04E+01	1 / 1	0.13	0.13	1,2,3
Manganese	5.65E-01	8.00E-02	2.18E-02	2.18E-02	2.18E-02	1 / 1	0.27	0.27	1,2
Sodium	3.44E+00	6.80E+02	5.34E+00	5.34E+00	5.34E+00	1 / 1	0.0079	0.0079	2,3
EXPLOSIVES									
1,3-Dinitrobenzene	NA	2.00E-02	7.07E-04	7.07E-04	4.68E-04	1 / 2	0.035	0.023	2
VOLATILE ORGANIC COMPOUNDS									
1,1,1-Trichloroethane	NA	5.28E-01	1.50E-03	1.50E-03	1.50E-03	1 / 1	0.0028	0.0028	2
Chlorobenzene	NA	1.95E-01	1.90E-03	1.90E-03	1.90E-03	1 / 1	0.0097	0.0097	2

Notes:

a - SAIC, 1998. Final Background Metals Survey Report.

[b] - Ecological Screening Values developed as described in the *Human Health and Ecological Screening Values & PAH Background Summary Report (IT, July, 2000).*

Conc. - Concentration

NA - Not applicable

1 - Maximum detected concentration is less than background concentration.

2 - Maximum detected concentration is less than ecological screening value (ESV).

3 - Essential macronutrient, only toxic at extremely high concentrations (i.e. 10-times naturally-occurring background concentration).

4 - Detected concentrations in the site samples were less than 10-times the concentrations of common laboratory contaminants (e.g. acetone, 2-butanone, methylene chloride, toluene, and phthalate esters) or 5-times the concentrations of other constituents detected in associated blanks.

5 - No ESV available; however, maximum detected concentration is similar to concentrations of other VOAs which are below their respective ESVs.

TABLE D-5

CONSTITUENTS OF POTENTIAL ECOLOGICAL CONCERN IN SEDIMENT
Landfill No. 1, Parcel 78(6)
Fort McClellan, Alabama

Detected Constituents	Background Sediment Conc. [a] (mg/kg)	Ecological Screening Value [b] (mg/kg)	Maximum Detected Conc. (mg/kg)	Minimum Detected Conc. (mg/kg)	Arithmetic Mean Conc. (mg/kg)	Frequency Of Detection	Maximum Hazard Quotient	Mean Hazard Quotient	Constituent of Potential Ecological Concern
METALS									
Aluminum	8.59E+03	NA	7.44E+03	7.44E+03	7.44E+03	1 / 1	NA	NA	1
Arsenic	1.13E+01	7.24E+00	1.60E+01	1.60E+01	1.60E+01	1 / 1	2.21	2.21	Yes
Barium	9.89E+01	NA	4.67E+01	4.67E+01	4.67E+01	1 / 1	NA	NA	1
Beryllium	9.70E-01	NA	8.54E-01	8.54E-01	8.54E-01	1 / 1	NA	NA	1
Calcium	1.11E+03	NA	5.41E+04	5.41E+04	5.41E+04	1 / 1	NA	NA	Yes
Chromium	3.12E+01	5.23E+01	1.61E+01	1.61E+01	1.61E+01	1 / 1	0.31	0.31	1,2
Cobalt	1.10E+01	5.00E+01	8.23E+00	8.23E+00	8.23E+00	1 / 1	0.16	0.16	1,2
Copper	1.71E+01	1.87E+01	1.33E+01	1.33E+01	1.33E+01	1 / 1	0.71	0.71	1,2
Iron	3.53E+04	NA	2.95E+04	2.95E+04	2.95E+04	1 / 1	NA	NA	1,3
Lead	3.78E+01	3.02E+01	1.69E+01	1.69E+01	1.69E+01	1 / 1	0.56	0.56	1,2
Magnesium	9.06E+02	NA	3.05E+04	3.05E+04	3.05E+04	1 / 1	NA	NA	Yes
Manganese	7.12E+02	NA	3.38E+02	3.38E+02	3.38E+02	1 / 1	NA	NA	1
Nickel	1.30E+01	1.59E+01	1.04E+01	1.04E+01	1.04E+01	1 / 1	0.65	0.65	1,2
Potassium	1.01E+03	NA	4.74E+02	4.74E+02	4.74E+02	1 / 1	NA	NA	1,3
Sodium	6.92E+02	NA	8.45E+01	8.45E+01	8.45E+01	1 / 1	NA	NA	1,3
Vanadium	4.09E+01	NA	1.98E+01	1.98E+01	1.98E+01	1 / 1	NA	NA	1
Zinc	5.27E+01	1.24E+02	5.01E+01	5.01E+01	5.01E+01	1 / 1	0.40	0.40	1,2
PESTICIDES									
4,4'-DDT	NA	3.30E-03	5.17E-03	5.17E-03	5.17E-03	1 / 1	1.57	1.57	Yes
SEMI-VOLATILE ORGANIC COMPOUNDS									
Benzyl Alcohol	NA	NA	5.90E-02	5.90E-02	5.90E-02	1 / 1	NA	NA	5

Notes:

[a] - SAIC, 1998. Final Background Metals Survey Report.

[b] - Ecological Screening Values developed as described in the *Human Health and Ecological Screening Values & PAH Background Summary Report (IT, July, 2000).*

Conc. - Concentration

NA - Not applicable

1 - Maximum detected concentration is less than background concentration.

2 - Maximum detected concentration is less than ecological screening value (ESV).

3 - Essential macronutrient, only toxic at extremely high concentrations (i.e. 10-times naturally-occurring background concentration).

4 - Detected concentrations in the site samples were less than 10-times the concentrations of common laboratory contaminants (e.g. acetone, 2-butanone, methylene chloride, toluene, and phthalate esters) or 5-times the concentrations of other constituents detected in associated blanks.

5 - No ESV available; however, maximum detected concentration is similar to concentrations of other VOAs which are below their respective ESVs.

TABLE D-6

CONSTITUENTS OF POTENTIAL ECOLOGICAL CONCERN IN SURFACE SOIL
Landfill No. 2, Parcel 79(6)
Fort McClellan, Alabama

Detected Constituents	Background Soil Conc. [a] (mg/kg)	Ecological Screening Value [b] (mg/kg)	Maximum Detected Conc. (mg/kg)	Minimum Detected Conc. (mg/kg)	Arithmetic Mean Conc. (mg/kg)	Frequency Of Detection	Maximum Hazard Quotient	Mean Hazard Quotient	Constituent of Potential Ecological Concern
METALS									
Aluminum	1.63E+04	5.00E+01	1.66E+04	8.72E+03	1.33E+04	5 / 5	332.00	266.16	Yes
Antimony	1.99E+00	3.50E+00	1.84E+01	1.19E+01	9.54E+00	3 / 5	5.26	2.73	Yes
Arsenic	1.37E+01	1.00E+01	6.20E+01	4.38E+00	2.95E+01	5 / 5	6.20	2.95	Yes
Barium	1.24E+02	1.65E+02	1.56E+03	1.30E+02	7.83E+02	5 / 5	9.45	4.75	Yes
Beryllium	8.00E-01	1.10E+00	2.15E+00	3.21E-01	1.08E+00	5 / 5	1.95	0.98	Yes
Cadmium	2.90E-01	1.60E+00	3.86E+00	2.77E-01	2.22E+00	4 / 5	2.41	1.39	Yes
Calcium	1.72E+03	NA	2.27E+04	2.13E+03	1.18E+04	5 / 5	NA	NA	Yes
Chromium	3.70E+01	4.00E-01	1.40E+02	1.39E+01	8.58E+01	5 / 5	350.00	214.60	Yes
Cobalt	1.52E+01	2.00E+01	2.00E+01	3.38E+00	9.70E+00	5 / 5	1.00	0.49	2
Copper	1.27E+01	4.00E+01	1.22E+03	2.83E+01	3.77E+02	5 / 5	30.50	9.42	Yes
Iron	3.42E+04	2.00E+02	1.60E+05	1.24E+04	6.14E+04	5 / 5	800.00	306.90	3
Lead	4.01E+01	5.00E+01	2.52E+03	1.31E+02	1.23E+03	5 / 5	50.40	24.60	Yes
Magnesium	1.03E+03	4.40E+05	4.92E+03	6.08E+02	2.67E+03	5 / 5	0.0112	0.0061	2
Manganese	1.58E+03	1.00E+02	1.73E+03	2.07E+02	8.33E+02	5 / 5	17.30	8.33	Yes
Mercury	8.00E-02	1.00E-01	1.24E+00	6.40E-02	4.61E-01	5 / 5	12.40	4.61	Yes
Nickel	1.03E+01	3.00E+01	8.25E+01	5.41E+00	3.40E+01	5 / 5	2.75	1.13	Yes
Potassium	8.00E+02	NA	2.00E+03	1.31E+03	1.59E+03	3 / 3	NA	NA	3
Selenium	4.80E-01	8.10E-01	6.95E-01	6.95E-01	2.94E-01	1 / 5	0.86	0.36	2
Silver	3.60E-01	2.00E+00	2.40E+01	2.40E+01	5.02E+00	1 / 5	12.00	2.51	Yes
Sodium	6.34E+02	NA	2.74E+02	3.93E+01	1.68E+02	5 / 5	NA	NA	1,3
Thallium	3.43E+00	1.00E+00	1.86E+00	1.12E+00	9.69E-01	3 / 5	1.86	0.97	1
Vanadium	5.88E+01	2.00E+00	3.58E+01	2.13E+01	2.94E+01	5 / 5	17.90	14.71	1
Zinc	4.06E+01	5.00E+01	2.96E+03	1.63E+02	1.34E+03	5 / 5	59.20	26.87	Yes
SEMI-VOLATILE ORGANIC COMPOUNDS									
Acenaphthene	NA	6.82E+02	1.30E+00	1.30E+00	4.48E-01	1 / 5	0.0019	0.0007	2
Anthracene	NA	1.00E-01	3.00E+00	3.00E+00	7.54E-01	1 / 5	30.00	7.54	Yes
Benzo(a)anthracene	NA	5.21E+00	6.70E+00	6.70E+00	1.49E+00	1 / 5	1.29	0.29	Yes
Benzo(a)pyrene	NA	1.00E-01	6.00E+00	6.00E+00	1.37E+00	1 / 5	60.00	13.72	Yes
Benzo(b)fluoranthene	NA	5.98E+01	1.20E+01	1.20E+01	2.61E+00	1 / 5	0.201	0.044	2
Benzo(ghi)perylene	NA	1.19E+02	2.20E+00	2.20E+00	5.75E-01	1 / 5	0.0185	0.0048	2
Carbazole	NA	NA	2.40E+00	2.40E+00	7.15E-01	1 / 5	NA	NA	Yes
Chrysene	NA	4.73E+00	6.70E+00	6.70E+00	1.51E+00	1 / 5	1.42	0.32	Yes

TABLE D-6

CONSTITUENTS OF POTENTIAL ECOLOGICAL CONCERN IN SURFACE SOIL
Landfill No. 2, Parcel 79(6)
Fort McClellan, Alabama

Detected Constituents	Background Soil Conc. [a] (mg/kg)	Ecological Screening Value [b] (mg/kg)	Maximum Detected Conc. (mg/kg)	Minimum Detected Conc. (mg/kg)	Arithmetic Mean Conc. (mg/kg)	Frequency Of Detection	Maximum Hazard Quotient	Mean Hazard Quotient	Constituent of Potential Ecological Concern
Dibenz(a,h)anthracene	NA	1.84E+01	7.40E-01	7.40E-01	2.67E-01	1 / 5	0.0402	0.0145	2
Dibenzofuran	NA	NA	6.20E-01	6.20E-01	3.03E-01	1 / 5	NA	NA	**Yes**
Fluoranthene	NA	1.00E-01	7.80E+00	7.80E+00	1.71E+00	1 / 5	78.00	17.14	**Yes**
Fluorene	NA	1.22E+02	1.40E+00	1.40E+00	4.52E-01	1 / 5	0.0115	0.0037	2
Indeno(1,2,3-cd)pyrene	NA	1.09E+02	2.20E+00	2.20E+00	5.55E-01	1 / 5	0.0202	0.0051	2
Phenanthrene	NA	1.00E-01	6.80E+00	6.80E+00	1.53E+00	1 / 5	68.00	15.26	**Yes**
Pyrene	NA	1.00E-01	9.80E+00	9.80E+00	2.13E+00	1 / 5	98.00	21.34	**Yes**
VOLATILE ORGANIC COMPOUNDS									
Acetone	NA	2.50E+00	3.30E-01	2.60E-01	2.24E-01	3 / 5	0.13	0.09	2
Benzene	NA	5.00E-02	1.80E-03	1.80E-03	3.71E-03	1 / 5	0.036	0.074	2
p-Cymene	NA	NA	2.90E-03	2.90E-03	1.18E-02	1 / 5	NA	NA	5

Notes:

[a] - SAIC, 1998. Final Background Metals Survey Report.

[b] - Ecological Screening Values developed as described in the *Human Health and Ecological Screening Values & PAH Background Summary Report (IT, July, 2000).*

Conc. - Concentration

NA - Not applicable

1 - Maximum detected concentration is less than background concentration.

2 - Maximum detected concentration is less than ecological screening value (ESV).

3 - Essential macronutrient, only toxic at extremely high concentrations (i.e. 10-times naturally-occurring background concentration).

4 - Detected concentrations in the site samples were less than 10-times the concentrations of common laboratory contaminants (e.g. acetone, 2-butanone, methylene chloride, toluene, and phthalate esters) or 5-times the concentrations of other constituents detected in associated blanks.

5 - No ESV available; however, maximum detected concentration is similar to concentrations of other VOAs which are below their respective ESVs.

TABLE D-7

CONSTITUENTS OF POTENTIAL ECOLOGICAL CONCERN IN SURFACE WATER
Landfill No. 2, Parcel 79(6)
Fort McClellan, Alabama

Detected Constituents	Background Surface Water Conc. [a] (mg/L)	Ecological Screening Value [b] (mg/L)	Maximum Detected Conc. (mg/L)	Minimum Detected Conc. (mg/L)	Arithmetic Mean Conc. (mg/L)	Frequency Of Detection	Maximum Hazard Quotient	Mean Hazard Quotient	Constituent of Potential Ecological Concern
METALS									
Aluminum	5.26E+00	8.70E-02	1.57E-01	1.57E-01	1.57E-01	1 / 1	1.80	1.80	1
Barium	7.54E-02	3.90E-03	1.85E-02	1.85E-02	1.85E-02	1 / 1	4.74	4.74	1
Calcium	2.52E+01	1.16E+02	1.19E+01	1.19E+01	1.19E+01	1 / 1	0.10	0.10	1,3
Iron	1.96E+01	1.00E+00	2.55E-01	2.55E-01	2.55E-01	1 / 1	0.26	0.26	1,2,3
Magnesium	1.10E+01	8.20E+01	6.73E+00	6.73E+00	6.73E+00	1 / 1	0.082	0.082	1,2,3
Manganese	5.65E-01	8.00E-02	1.37E-02	1.37E-02	1.37E-02	1 / 1	0.17	0.17	1,2
Potassium	2.56E+00	5.30E+01	1.33E+00	1.33E+00	1.33E+00	1 / 1	0.0251	0.0251	1,2,3
Sodium	3.44E+00	6.80E+02	1.13E+00	1.13E+00	1.13E+00	1 / 1	0.0017	0.0017	1,2,3

Notes:

a - SAIC, 1998. Final Background Metals Survey Report.

[b] - Ecological Screening Values developed as described in the *Human Health and Ecological Screening Values & PAH Background Summary Report (IT, July, 2000).*

Conc. - Concentration

NA - Not applicable

1 - Maximum detected concentration is less than background concentration.

2 - Maximum detected concentration is less than ecological screening value (ESV).

3 - Essential macronutrient, only toxic at extremely high concentrations (i.e. 10-times naturally-occurring background concentration).

4 - Detected concentrations in the site samples were less than 10-times the concentrations of common laboratory contaminants (e.g. acetone, 2-butanone, methylene chloride, toluene, and phthalate esters) or 5-times the concentrations of other constituents detected in associated blanks.

5 - No ESV available; however, maximum detected concentration is similar to concentrations of other VOAs which are below their respective ESVs.

TABLE D-8

CONSTITUENTS OF POTENTIAL ECOLOGICAL CONCERN IN SEDIMENT
Landfill No. 2, Parcel 79(6)
Fort McClellan, Alabama

Detected Constituents	Background Sediment Conc. [a] (mg/kg)	Ecological Screening Value [b] (mg/kg)	Maximum Detected Conc. (mg/kg)	Minimum Detected Conc. (mg/kg)	Arithmetic Mean Conc. (mg/kg)	Frequency Of Detection	Maximum Hazard Quotient	Mean Hazard Quotient	Constituent of Potential Ecological Concern
METALS									
Aluminum	8.59E+03	NA	3.85E+03	3.85E+03	3.85E+03	1 / 1	NA	NA	1
Barium	9.89E+01	NA	2.51E+01	2.51E+01	2.51E+01	1 / 1	NA	NA	1
Calcium	1.11E+03	NA	4.78E+02	4.78E+02	4.78E+02	1 / 1	NA	NA	1,3
Chromium	3.12E+01	5.23E+01	1.51E+01	1.51E+01	1.51E+01	1 / 1	0.29	0.29	1,2
Cobalt	1.10E+01	5.00E+01	3.63E+00	3.63E+00	3.63E+00	1 / 1	0.0726	0.0726	1,2
Copper	1.71E+01	1.87E+01	1.02E+01	1.02E+01	1.02E+01	1 / 1	0.55	0.55	1,2
Iron	3.53E+04	NA	2.01E+04	2.01E+04	2.01E+04	1 / 1	NA	NA	1,3
Lead	3.78E+01	3.02E+01	1.81E+01	1.81E+01	1.81E+01	1 / 1	0.60	0.60	1,2
Magnesium	9.06E+02	NA	7.35E+02	7.35E+02	7.35E+02	1 / 1	NA	NA	1,3
Manganese	7.12E+02	NA	2.06E+02	2.06E+02	2.06E+02	1 / 1	NA	NA	1
Nickel	1.30E+01	1.59E+01	6.78E+00	6.78E+00	6.78E+00	1 / 1	0.43	0.43	1,2
Potassium	1.01E+03	NA	2.89E+02	2.89E+02	2.89E+02	1 / 1	NA	NA	1,3
Vanadium	4.09E+01	NA	1.46E+01	1.46E+01	1.46E+01	1 / 1	NA	NA	1
Zinc	5.27E+01	1.24E+02	2.24E+01	2.24E+01	2.24E+01	1 / 1	0.18	0.18	1,2
SEMI-VOLATILE ORGANIC COMPOUNDS									
Benzyl Alcohol		NA	6.60E-02	6.60E-02	6.60E-02	1 / 1	NA	NA	5

Notes:

[a] - SAIC, 1998. Final Background Metals Survey Report.

[b] - Ecological Screening Values developed as described in the *Human Health and Ecological Screening Values & PAH Background Summary Report (IT, July, 2000).*

Conc. - Concentration

NA - Not applicable

1 - Maximum detected concentration is less than background concentration.

2 - Maximum detected concentration is less than ecological screening value (ESV).

3 - Essential macronutrient, only toxic at extremely high concentrations (i.e. 10-times naturally-occurring background concentration).

4 - Detected concentrations in the site samples were less than 10-times the concentrations of common laboratory contaminants (e.g. acetone, 2-butanone, methylene chloride, toluene, and phthalate esters) or 5-times the concentrations of other constituents detected in associated blanks.

5 - No ESV available; however, maximum detected concentration is similar to concentrations of other VOAs which are below their respective ESVs.

TABLE D-12

CONSTITUENTS OF POTENTIAL ECOLOGICAL CONCERN IN SURFACE SOIL
Fill Area North of Landfill No. 2, Parcel 230(7)
Fort McClellan, Alabama

Detected Constituents	Background Soil Conc. [a] (mg/kg)	Ecological Screening Value [b] (mg/kg)	Maximum Detected Conc. (mg/kg)	Minimum Detected Conc. (mg/kg)	Arithmetic Mean Conc. (mg/kg)	Frequency Of Detection	Maximum Hazard Quotient	Mean Hazard Quotient	Constituent of Potential Ecological Concern
METALS									
Aluminum	1.63E+04	5.00E+01	8.98E+03	3.45E+03	4.78E+03	10 / 10	179.60	95.52	1
Arsenic	1.37E+01	1.00E+01	5.80E+00	1.30E+00	3.00E+00	10 / 10	0.58	0.30	1,2
Barium	1.24E+02	1.65E+02	8.04E+01	2.56E+01	3.99E+01	10 / 10	0.49	0.24	1,2
Beryllium	8.00E-01	1.10E+00	7.60E-01	2.60E-01	4.26E-01	10 / 10	0.69	0.39	1,2
Calcium	1.72E+03	NA	3.26E+03	1.57E+02	1.15E+03	10 / 10	NA	NA	3
Chromium	3.70E+01	4.00E-01	1.40E+01	5.70E+00	8.11E+00	10 / 10	35.00	20.28	1
Cobalt	1.52E+01	2.00E+01	4.10E+00	1.20E+00	2.20E+00	10 / 10	0.21	0.11	1,2
Copper	1.27E+01	4.00E+01	1.36E+01	1.70E+00	5.34E+00	10 / 10	0.34	0.13	2
Iron	3.42E+04	2.00E+02	1.55E+04	3.82E+03	9.64E+03	10 / 10	77.50	48.21	1,3
Lead	4.01E+01	5.00E+01	7.95E+01	9.00E+00	2.30E+01	10 / 10	1.59	0.46	**Yes**
Magnesium	1.03E+03	4.40E+05	5.05E+02	1.62E+02	2.64E+02	10 / 10	0.0011	0.0006	1,2,3
Manganese	1.58E+03	1.00E+02	3.11E+02	1.70E+01	1.43E+02	10 / 10	3.11	1.43	1
Mercury	8.00E-02	1.00E-01	1.50E+00	3.10E-02	1.97E-01	10 / 10	15.00	1.97	**Yes**
Nickel	1.03E+01	3.00E+01	6.60E+00	1.90E+00	3.20E+00	10 / 10	0.22	0.11	1,2
Potassium	8.00E+02	NA	2.53E+02	1.22E+02	1.84E+02	10 / 10	NA	NA	1,3
Selenium	4.80E-01	8.10E-01	1.10E+00	4.40E-01	6.88E-01	10 / 10	1.36	0.85	**Yes**
Vanadium	5.88E+01	2.00E+00	2.71E+01	8.30E+00	1.32E+01	10 / 10	13.55	6.58	1
Zinc	4.06E+01	5.00E+01	6.70E+01	6.70E+00	1.94E+01	10 / 10	1.34	0.39	**Yes**
PESTICIDES									
4,4'-DDE	NA	2.50E-03	6.20E-03	6.20E-03	3.47E-03	1 / 10	2.48	1.39	**Yes**
4,4'-DDT	NA	2.50E-03	5.10E-03	3.50E-03	3.42E-03	2 / 10	2.04	1.37	**Yes**
SEMI-VOLATILE ORGANIC COMPOUNDS									
Benzo(a)pyrene	NA	1.00E-01	6.50E-02	6.50E-02	1.91E-01	1 / 10	0.65	1.91	2
Benzo(b)fluoranthene	NA	5.98E+01	5.40E-02	5.40E-02	1.90E-01	1 / 10	0.0009	0.0032	2
Benzo(ghi)perylene	NA	1.19E+02	6.90E-02	6.90E-02	1.91E-01	1 / 10	0.0006	0.0016	2
Chrysene	NA	4.73E+00	6.00E-02	6.00E-02	1.91E-01	1 / 10	0.013	0.040	2
Fluoranthene	NA	1.00E-01	9.30E-02	9.30E-02	1.94E-01	1 / 10	0.93	1.94	2
Pyrene	NA	1.00E-01	7.10E-02	7.10E-02	1.92E-01	1 / 10	0.71	1.92	2
VOLATILE ORGANIC COMPOUNDS									
1,2,4-Trimethylbenzene	NA	1.00E-01	7.00E-03	7.00E-03	3.52E-03	1 / 10	0.070	0.035	2

TABLE D-12

CONSTITUENTS OF POTENTIAL ECOLOGICAL CONCERN IN SURFACE SOIL
Fill Area North of Landfill No. 2, Parcel 230(7)
Fort McClellan, Alabama

Detected Constituents	Background Soil Conc. [a] (mg/kg)	Ecological Screening Value [b] (mg/kg)	Maximum Detected Conc. (mg/kg)	Minimum Detected Conc. (mg/kg)	Arithmetic Mean Conc. (mg/kg)	Frequency Of Detection	Maximum Hazard Quotient	Mean Hazard Quotient	Constituent of Potential Ecological Concern
1,2-Dimethylbenzene	NA	1.00E-01	3.30E-02	7.30E-03	6.57E-03	2 / 10	0.33	0.07	2
Acetone	NA	2.50E+00	1.80E-02	1.60E-02	1.70E-02	2 / 2	0.007	0.007	2
Ethylbenzene	NA	5.00E-02	3.50E-02	2.30E-03	6.73E-03	3 / 10	0.70	0.13	2
m,p-Xylenes	NA	5.00E-02	1.10E-01	7.40E-03	1.64E-02	3 / 10	2.20	0.33	**Yes**
Naphthalene	NA	1.00E-01	3.90E-03	3.90E-03	3.21E-03	1 / 10	0.039	0.032	2
n-Butylbenzene	NA	NA	3.70E-03	3.70E-03	3.19E-03	1 / 10	NA	NA	5
p-Cymene	NA	NA	5.10E-03	4.80E-03	3.59E-03	3 / 10	NA	NA	5
Toluene	NA	5.00E-02	1.70E-02	2.30E-03	4.47E-03	2 / 10	0.34	0.09	2
Trichlorofluoromethane	NA	1.00E-01	4.10E-03	3.10E-03	5.77E-03	2 / 10	0.041	0.058	2

Notes:

a - SAIC, 1998. Final Background Metals Survey Report.

[b] - Ecological Screening Values developed as described in the *Human Health and Ecological Screening Values & PAH Background Summary Report (IT, July, 2000).*

Conc. - Concentration

NA - Not applicable

1 - Maximum detected concentration is less than background concentration.

2 - Maximum detected concentration is less than ecological screening value (ESV).

3 - Essential macronutrient, only toxic at extremely high concentrations (i.e. 10-times naturally-occurring background concentration).

4 - Detected concentrations in the site samples were less than 10-times the concentrations of common laboratory contaminants (e.g. acetone, 2-butanone, methylene chloride, toluene, and phthalate esters) or 5-times the concentrations of other constituents detected in associated blanks.

5 - No ESV available; however, maximum detected concentration is similar to concentrations of other VOAs which are below their respective ESVs.

TABLE D-13
CONSTITUENTS OF POTENTIAL ECOLOGICAL CONCERN IN SURFACE WATER
Fill Area North of Landfill No. 2, Parcel 230(7)
Fort McClellan, Alabama

Detected Constituents	Background Surface Water Conc. [a] (mg/L)	Ecological Screening Value [b] (mg/L)	Maximum Detected Conc. (mg/L)	Minimum Detected Conc. (mg/L)	Arithmetic Mean Conc. (mg/L)	Frequency Of Detection	Maximum Hazard Quotient	Mean Hazard Quotient	Constituent of Potential Ecological Concern
METALS									
Aluminum	5.26E+00	8.70E-02	1.35E+00	1.69E-01	5.31E-01	5 / 5	15.52	6.10	1
Barium	7.54E-02	3.90E-03	6.38E-02	1.53E-02	3.35E-02	6 / 6	16.36	8.58	1
Calcium	2.52E+01	1.16E+02	1.09E+02	1.64E+00	2.49E+01	6 / 6	0.94	0.21	2,3
Iron	1.96E+01	1.00E+00	2.46E+00	5.83E-02	8.38E-01	6 / 6	2.46	0.84	1,3
Magnesium	1.10E+01	8.20E+01	7.86E+00	9.63E-01	3.80E+00	6 / 6	0.10	0.05	1,2,3
Manganese	5.65E-01	8.00E-02	8.45E-01	5.00E-03	2.70E-01	6 / 6	10.56	3.38	**Yes**
Potassium	2.56E+00	5.30E+01	2.69E+00	1.74E+00	2.34E+00	3 / 6	0.05	0.04	2,3
Zinc	4.04E-02	5.89E-02	1.16E-02	1.16E-02	1.03E-02	1 / 6	0.20	0.17	1,2
SEMI-VOLATILE ORGANIC COMPOUNDS									
bis(2-Ethylhexyl)phthalate	NA	3.00E-04	1.30E-03	1.30E-03	4.38E-03	1 / 6	4.33	14.61	**Yes**

Notes:

a - SAIC, 1998. Final Background Metals Survey Report.

[b] - Ecological Screening Values developed as described in the *Human Health and Ecological Screening Values & PAH Background Summary Report (IT, July, 2000).*

Conc. - Concentration

NA - Not applicable

1 - Maximum detected concentration is less than background concentration.

2 - Maximum detected concentration is less than ecological screening value (ESV).

3 - Essential macronutrient, only toxic at extremely high concentrations (i.e. 10-times naturally-occurring background concentration).

4 - Detected concentrations in the site samples were less than 10-times the concentrations of common laboratory contaminants (e.g. acetone, 2-butanone, methylene chloride, toluene, and phthalate esters) or 5-times the concentrations of other constituents detected in associated blanks.

5 - No ESV available; however, maximum detected concentration is similar to concentrations of other VOAs which are below their respective ESVs.

TABLE D-14

CONSTITUENTS OF POTENTIAL ECOLOGICAL CONCERN IN SEDIMENT
Fill Area North of Landfill No. 2, Parcel 230(7)
Fort McClellan, Alabama

Detected Constituents	Background Sediment Conc. [a] (mg/kg)	Ecological Screening Value [b] (mg/kg)	Maximum Detected Conc. (mg/kg)	Minimum Detected Conc. (mg/kg)	Arithmetic Mean Conc. (mg/kg)	Frequency Of Detection	Maximum Hazard Quotient	Mean Hazard Quotient	Constituent of Potential Ecological Concern
METALS									
Aluminum	8.59E+03	NA	2.25E+03	1.35E+03	1.66E+03	3 / 3	NA	NA	1
Arsenic	1.13E+01	7.24E+00	1.60E+00	7.20E-01	1.04E+00	3 / 3	0.22	0.14	1,2
Barium	9.89E+01	NA	1.86E+01	8.70E+00	1.20E+01	3 / 3	NA	NA	1
Beryllium	9.70E-01	NA	3.80E-01	1.60E-01	2.90E-01	3 / 3	NA	NA	1
Calcium	1.11E+03	NA	3.65E+02	1.71E+02	2.38E+02	3 / 3	NA	NA	1,3
Chromium	3.12E+01	5.23E+01	3.50E+00	2.90E+00	3.23E+00	3 / 3	0.067	0.062	1,2
Cobalt	1.10E+01	5.00E+01	1.00E+00	6.90E-01	8.13E-01	3 / 3	0.020	0.016	1,2
Copper	1.71E+01	1.87E+01	3.70E+00	1.40E+00	2.40E+00	3 / 3	0.20	0.13	1,2
Iron	3.53E+04	NA	5.76E+03	2.56E+03	4.01E+03	3 / 3	NA	NA	1,3
Lead	3.78E+01	3.02E+01	1.05E+01	3.80E+00	6.17E+00	3 / 3	0.35	0.20	1,2
Magnesium	9.06E+02	NA	1.51E+02	1.08E+02	1.24E+02	3 / 3	NA	NA	1,3
Manganese	7.12E+02	NA	6.29E+01	2.92E+01	4.07E+01	3 / 3	NA	NA	1
Mercury	1.10E-01	1.30E-01	2.30E-01	1.80E-02	9.07E-02	3 / 3	1.77	0.70	**Yes**
Potassium	1.01E+03	NA	1.15E+02	1.15E+02	2.27E+02	1 / 2	NA	NA	1,3
Vanadium	4.09E+01	NA	9.10E+00	5.20E+00	6.57E+00	3 / 3	NA	NA	1
Zinc	5.27E+01	1.24E+02	7.10E+00	4.80E+00	5.93E+00	3 / 3	0.057	0.048	1
PESTICIDES									
4,4'-DDT	NA	3.30E-03	1.40E-03	1.40E-03	2.67E-03	1 / 3	0.42	0.81	2
Endosulfan sulfate	NA	3.46E-02	1.10E-03	1.10E-03	2.57E-03	1 / 3	0.032	0.074	2
VOLATILE ORGANIC COMPOUNDS									
2-Butanone	NA	1.37E-01	3.90E-03	3.90E-03	3.90E-03	1 / 1	0.028	0.028	2
Acetone	NA	4.53E-01	1.90E-02	7.20E-03	1.31E-02	2 / 2	0.042	0.029	2

Notes:

[a] - SAIC, 1998. Final Background Metals Survey Report.

[b] - Ecological Screening Values developed as described in the *Human Health and Ecological Screening Values & PAH Background Summary Report (IT, July, 2000).*

Conc. - Concentration

NA - Not applicable

1 - Maximum detected concentration is less than background concentration.

2 - Maximum detected concentration is less than ecological screening value (ESV).

3 - Essential macronutrient, only toxic at extremely high concentrations (i.e. 10-times naturally-occurring background concentration).

4 - Detected concentrations in the site samples were less than 10-times the concentrations of common laboratory contaminants (e.g. acetone, 2-butanone, methylene chloride, toluene, and phthalate esters) or 5-times the concentrations of other constituents detected in associated blanks.

5 - No ESV available; however, maximum detected concentration is similar to concentrations of other VOAs which are below their respective ESVs.

TABLE D-28

SUMMARY OF CONSTITUENTS OF POTENTIAL ECOLOGICAL CONCERN AT THE LANDFILLS AND FILL AREAS
Fort McClellan, Alabama

Landfill No. 1, (Parcel 78) :

Surface Soil	Surface Water	Sediment
Aluminum	None	Arsenic
Barium		Calcium
Beryllium		Magnesium
Copper		4,4'-DDT
Nickel		
Zinc		
4,4'-DDE		
Fluoranthene		
Phenanthrene		
Pyrene		

Landfill No. 2, (Parcel 79) :

Surface Soil	Surface Water	Sediment
Aluminum	None	None
Antimony		
Arsenic		
Barium		
Beryllium		
Cadmium		
Calcium		
Chromium		
Copper		
Lead		
Manganese		
Mercury		
Nickel		
Silver		
Zinc		
Anthracene		
Benzo(a)anthracene		
Benzo(a)pyrene		
Carbazole		
Chrysene		
Dibenzofuran		
Fluoranthene		
Phenanthrene		
Pyrene		

TABLE D-28

SUMMARY OF CONSTITUENTS OF POTENTIAL ECOLOGICAL CONCERN AT THE LANDFILLS AND FILL AREAS
Fort McClellan, Alabama

Landfill No. 3, (Parcel 80) :

Surface Soil	Surface Water	Sediment
Aluminum	Boron	Aluminum
Barium	Lead	Barium
Beryllium		Beryllium
Boron		Boron
Chromium		Copper
Cobalt		Nickel
Manganese		Vanadium
Nickel		Benzo(a)anthracene
Thallium		Benzo(b)fluoranthene
Vanadium		Chrysene
Zinc		Fluoranthene
Fluoranthene		Pyrene
Pyrene		4,4'-DDE
4,4'-DDE		
Chlordane		

Fill Area North of Landfill No. 2, (Parcel 230) :

Surface Soil	Surface Water	Sediment
Lead	Manganese	Mercury
Mercury	Bis(2-ethylhexyl)phthalate	
Selenium		
Zinc		
4,4'-DDE		
4,4'-DDT		
m,p-Xylenes		

Fill Area East of Reilly Airfield and Former Post Garbage Dump, (Parcels 227 & 126) :

Surface Soil	Surface Water	Sediment
Chromium	Manganese	Aluminum
Copper	Mercury	Arsenic
Lead	Bis(2-ethylhexyl)phthalate	Barium
Manganese		Beryllium
Mercury		Cobalt
Selenium		Copper
Zinc		Lead
4,4'-DDE		Manganese
4,4'-DDT		Nickel
		Selenium
		Acetone

TABLE D-28

SUMMARY OF CONSTITUENTS OF POTENTIAL ECOLOGICAL CONCERN AT THE LANDFILLS AND FILL AREAS
Fort McClellan, Alabama

Fill Area Northwest of Reilly Airfield, (Parcel 229) :

Surface Soil	Surface Water	Sediment
Mercury	Mercury	Barium
Selenium		Beryllium
1,2-Dimethylbenzene		Cadmium
Ethylbenzene		Cobalt
m,p-Xylenes		Copper
		Manganese
		Nickel
		Selenium

Fill Area at Range 30, (Parcel 231) :

Surface Soil	Surface Water	Sediment
Arsenic	Barium	None
Lead		
Mercury		
Selenium		
Vanadium		
4,4'-DDE		
4,4'-DDT		
Anthracene		
Benzo(a)pyrene		
Fluoranthene		
Pyrene		

Fill Area West of Range 19, (Parcel 233) :

Surface Soil	Surface Water	Sediment
Barium	None	None
Beryllium		
Cobalt		
Manganese		
Acetone		

Stump Dump, (Parcel 82) :

Surface Soil	Surface Water	Sediment
Aluminum	Aluminum	Aluminum
Barium		Barium
Beryllium		Beryllium
Cobalt		Copper
Copper		Selenium
Manganese		4,4'-DDE
Mercury		4,4'-DDT
Nickel		Benzo(a)anthracene
Selenium		Benzo(a)pyrene
Zinc		Chrysene
		Fluoranthene
		Phenanthrene
		Pyrene
		Trichlorofluoromethane

TABLE D-29
IDENTIFICATION OF COPECs AT FILL AREAS USING ADDITIONAL LINES OF EVIDENCE
Fort McClellan
Calhoun County, Alabama

Fill Area	Constituents Whose Maximum Conc. Exceed ESVs [a]	Rationale for Inclusion / Exclusion	Refined ID of COPECs
Landfill No.1, Parcel 78(6) :			
Soil -	aluminum (624)	3, 4, 5	No
	barium (1.1)	1, 4, 5	No
	beryllium (2.87)	1, 4, 5	No
	copper (1.34)	1, 4, 5	No
	iron (400)	3, 4, 5	No
	nickel (1.34)	1, 4, 5	No
	zinc (2.5)	1, 4, 5	No
	4,4'-DDE (4.4)	1, 4	No
	fluoranthene (1.9)	1, 2, 4	No
	phenanthrene (2.5)	1, 2, 4	No
	pyrene (2.8)	1, 2, 4	No
Surface Water -	None		None
Sediment -	arsenic (2.21)	1, 4, 5	No
	calcium (NA)	1, 3, 4, 5	No
	magnesium (NA)	1, 3, 4, 5	No
	4,4'-DDT (1.57)	1, 4	No
Landfill No. 2, Parcel 79(6) :			
Soil -	aluminum (332)	4, 5	No
	antimony (5.26)	1, 4, 5	No
	arsenic (6.2)	1, 4, 5	No
	barium (9.45)	1, 4, 5	No
	beryllium (1.95)	1, 4, 5	No
	cadmium (2.41)	1, 4	No
	calcium (NA)	3, 4, 5	No
	chromium (350)	6, 7	Yes
	copper (30.5)	6, 7	Yes
	iron (800)	3, 4, 5	No
	lead (50.4)	6, 7	Yes
	manganese (17.3)	4, 5	No
	mercury (12.4)	6, 9	Yes
	nickel (2.75)	1, 4, 5	No
	silver (12)	2, 6, 9	Yes
	zinc (59.2)	6, 7	Yes
	anthracene (30)	2, 9	Yes
	benzo(a)anthracene (1.29)	1, 2, 9	Yes
	benzo(a)pyrene (60)	2, 6, 9	Yes
	carbazole (NA)	2, 9	Yes
	chrysene (1.42)	1, 2, 9	Yes
	dibenzofuran (NA)	2, 9	Yes
	fluoranthene (78)	2, 6, 9	Yes
	phenanthrene (68)	2, 6, 9	Yes
	pyrene (98)	2, 6, 9	Yes
Surface Water -	None		None
Sediment -	None		None

TABLE D-29
IDENTIFICATION OF COPECs AT FILL AREAS USING ADDITIONAL LINES OF EVIDENCE
Fort McClellan
Calhoun County, Alabama

Fill Area	Constituents Whose Maximum Conc. Exceed ESVs [a]	Rationale for Inclusion / Exclusion	Refined ID of COPECs
Landfill No. 3, Parcel 80(6) :			
Soil -	aluminum (1302)	3, 4, 5	No
	barium (1.2)	1, 4, 5	No
	beryllium (2.21)	1, 4, 5	No
	boron (NA)	4, 5	No
	chromium (169.5)	4, 5	No
	cobalt (1.04)	1, 4, 5	No
	manganese (39)	4, 5	No
	nickel (1.39)	1, 4, 5	No
	thallium (138)	2, 4	No
	vanadium (40.15)	4, 5	No
	zinc (2.38)	1, 4, 5	No
	fluoranthene (1.9)	1, 4	No
	pyrene (3)	1, 4	No
	4,4'-DDE (5.56)	1, 4	No
	chlordane (5.68)	1, 2, 4	No
Surface Water -	boron (NA)	2, 4, 5	No
	lead (53.64)	2, 4, 5	No
Sediment -	aluminum (NA)	4, 5	No
	barium (NA)	4, 5	No
	beryllium (NA)	4, 5	No
	boron (NA)	4, 5	No
	copper (1.33)	1, 4	No
	nickel (1.32)	1, 4, 5	No
	vanadium (NA)	4, 5	No
	benzo(a)anthracene (2.42)	1, 2, 4	No
	benzo(b)fluoranthene (1.4)	1, 2, 4	No
	chrysene (1.91)	1, 2, 4	No
	fluoranthene (2.7)	1, 2, 4	No
	pyrene (3.64)	1, 2, 4	No
	4,4'-DDE (1.15)	1, 2, 4	No

TABLE D-29
IDENTIFICATION OF COPECs AT FILL AREAS
USING ADDITIONAL LINES OF EVIDENCE
Fort McClellan
Calhoun County, Alabama

Fill Area	Constituents Whose Maximum Conc. Exceed ESVs [a]	Rationale for Inclusion / Exclusion	Refined ID of COPECs
Landfill No. 4, Parcel 81(5) & Industrial Landfill, Parcel 175(5) :			
	No samples collected		
Fill Area North of Landfill No. 2, Parcel 230(7) :			
Soil -	lead (1.59)	1, 4, 5	No
	mercury (15)	6, 7, 8, 9	**Yes**
	selenium (1.36)	1, 4	No
	zinc (1.34)	1, 4, 5	No
	4,4'-DDE (2.48)	1, 2, 4	No
	4,4'-DDT (2.04)	1, 2, 4	No
	m,p-xylenes (2.2)	1, 2, 4, 5	No
Surface Water -	manganese (10.56)	6, 7, 8	**Yes**
	bis(2-ethylhexyl)phthalate (4.33)	1, 2	No
Sediment -	mercury (1.77)	1, 7, 8, 9	**Yes**
Former Post Garbage Dump, Parcel 126(7) & Fill Area East of Reilly Airfield, Parcel 227(7) :			
Soil -	chromium (119.8)	4, 6, 7	**Yes**
	copper (1.19)	1, 4	No
	lead (1.02)	1, 4, 5	No
	manganese (18.2)	4, 6, 7	**Yes**
	mercury (1.6)	1, 4	No
	selenium (1.48)	1, 4	No
	zinc (1.87)	1, 4, 5	No
	4,4'-DDE (4.8)	1, 2, 4	No
	4,4'-DDT (3.76)	1, 2, 4	No
Surface Water -	manganese (138.75)	6, 7, 8	**Yes**
	mercury (14.17)	6, 7, 8, 9	**Yes**
	bis(2-ethylhexyl)phthalate (7.67)	1, 8, 9	**Yes**
Sediment -	aluminum (NA)	1, 5	No
	arsenic (8.29)	1, 5	No
	barium (NA)	1, 5	No
	beryllium (NA)	1, 5	No
	cobalt (1.37)	1, 5	No
	copper (2.29)	1	No
	lead (4.04)	1, 5	No
	manganese (NA)	1, 5	No
	nickel (1.49)	1, 5	No
	selenium (NA)	1	No
	acetone (1.06)	1, 5	No

TABLE D-29
IDENTIFICATION OF COPECs AT FILL AREAS
USING ADDITIONAL LINES OF EVIDENCE
Fort McClellan
Calhoun County, Alabama

Fill Area	Constituents Whose Maximum Conc. Exceed ESVs [a]	Rationale for Inclusion / Exclusion	Refined ID of COPECs
Fill Area Northwest of Reilly Airfield, Parcel 229(7) :			
Soil -	mercury (1.4)	1, 4	No
	selenium (1.85)	1, 4	No
	1,2-dimethylbenzene (2.8)	1, 2, 4, 5	No
	ethylbenzene (5.2)	1, 2, 4, 5	No
	m,p-xylenes (15.2)	2, 4, 5	No
Surface Water -	mercury (5.17)	1, 7, 8, 9	**Yes**
Sediment -	barium (NA)	1, 5	No
	beryllium (NA)	1, 5	No
	cadmium (2.5)	1, 2	No
	cobalt (1.24)	1, 5	No
	copper (1.12)	1	No
	manganese (NA)	1, 5	No
	nickel (4.47)	1, 5	No
	selenium (NA)	1	No
Fill Area at Range 30, Parcel 231(7) :			
Soil -	arsenic (1.45)	1, 4, 5	No
	lead (1.85)	1, 4, 5	No
	mercury (1.4)	1, 4	No
	selenium (1.85)	1, 4	No
	vanadium (31.65)	4, 5, 6, 7	No
	4,4'-DDE (9.2)	1, 2, 4	No
	4,4'-DDT (15.6)	2, 4	No
	anthracene (1.6)	1, 2, 4	No
	benzo(a)pyrene (1.8)	1, 2, 4	No
	fluoranthene (1.6)	1, 2, 4	No
	pyrene (1.7)	1, 2, 4	No
Surface Water -	barium (21.85)	4, 5, 6, 7	No
Sediment -	None		None

TABLE D-29
IDENTIFICATION OF COPECs AT FILL AREAS USING ADDITIONAL LINES OF EVIDENCE
Fort McClellan
Calhoun County, Alabama

Fill Area	Constituents Whose Maximum Conc. Exceed ESVs [a]	Rationale for Inclusion / Exclusion	Refined ID of COPECs
Fill Area West of Iron Mountain Road Range 19, Parcel 233(7) :			
Soil -	barium (11.03)	4, 5	No
	beryllium (1.55)	1, 4, 5	No
	cobalt (6)	1, 4, 5	No
	manganese (90.7)	4, 5	No
	acetone (1.16)	1, 4, 5	No
Surface Water -	None		None
Sediment -	None		None
Stump Dump, Parcel 82(7) :			
Soil -	aluminum (352)	4, 5, 6, 7	No
	barium (1.59)	1, 4, 5	No
	beryllium (2.64)	1, 4, 5	No
	cobalt (1.6)	1, 4	No
	copper (1.1)	1, 4, 5	No
	manganese (30)	4, 5, 6, 7	No
	mercury (2.1)	1, 4	No
	nickel (1.25)	1, 4, 5	No
	selenium (1.73)	1, 4	No
	zinc (2.56)	1, 4, 5	No
Surface Water -	aluminum (72.87)	4, 5, 6, 7	No
Sediment -	aluminum (NA)	1, 4, 5	No
	barium (NA)	1, 4, 5	No
	beryllium (NA)	1, 4, 5	No
	copper (2.17)	1, 4	No
	selenium (NA)	1, 4	No
	4,4'-DDE (1.64)	1, 2, 4	No
	4,4'-DDT (1.09)	1, 2, 4	No
	benzo(a)anthracene (1.48)	1, 2, 4	No
	benzo(a)pyrene (1.48)	1, 2, 4	No
	chrysene (1.82)	1, 2, 4	No
	fluoranthene (4.42)	1, 2, 4	No
	phenanthrene (1.85)	1, 2, 4	No
	pyrene (3.64)	1, 2, 4	No
	trichlorofluoromethane (2.25)	1, 4	No

[a] Maximum hazard quotients are in parentheses

Rationale for Inclusion/Exclusion:

1 - Hazard Quotient < 10
2 - Low frequency of detection
3 - Essential macro-nutrients
4 - Low quality habitat
5 - Low bioaccumulation potential
6 - Hazard Quotient > 10
7 - Frequently detected
8 - Unique and/or sensitive habitat
9 - High bioaccumulation potential

- Indicates a constituent of potential ecological concern (COPEC)

APPENDIX D

SCREENING-LEVEL ECOLOGICAL RISK ASSESSMENT

FIGURES

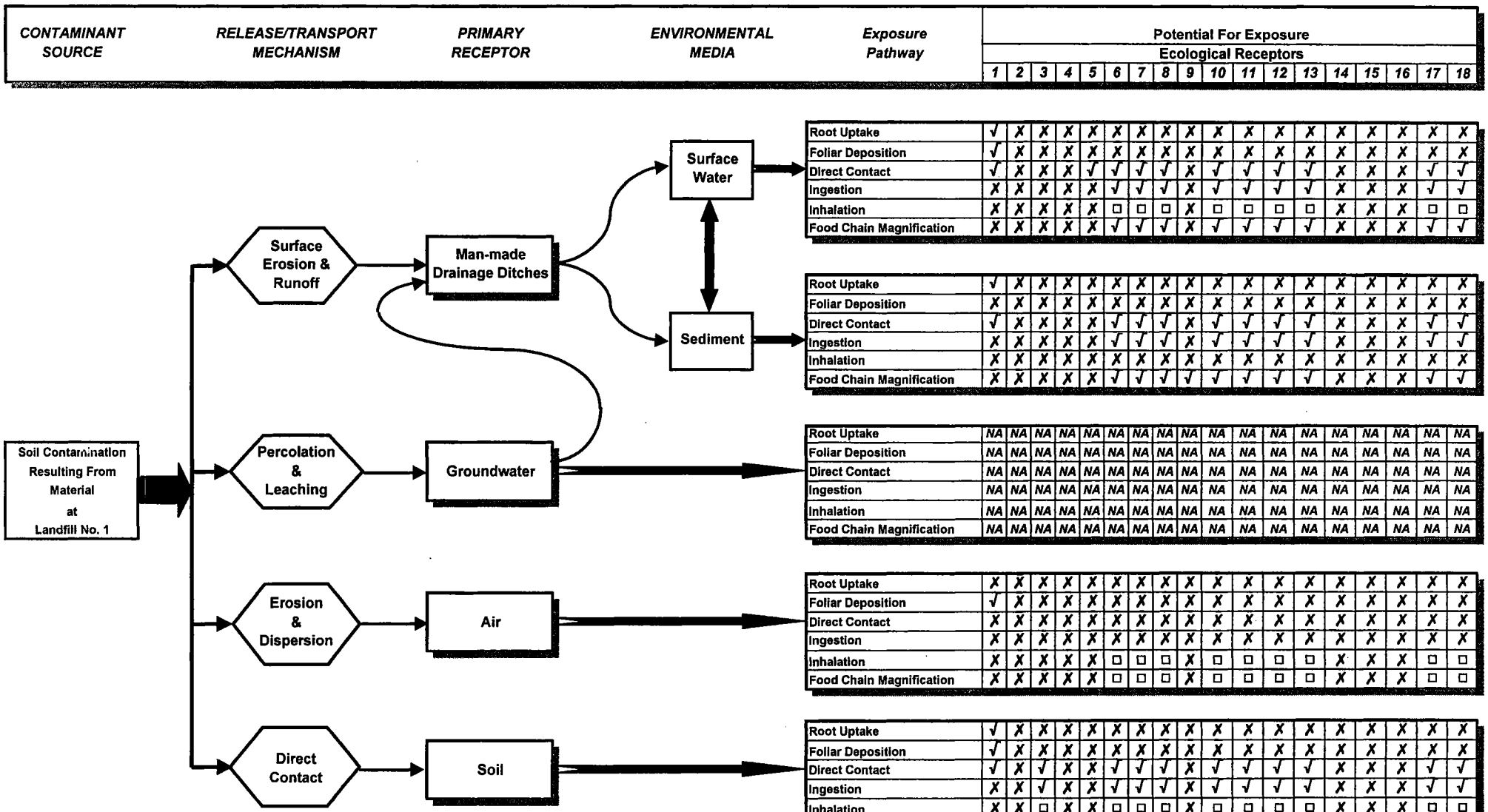
FIGURE D-1

SITE CONCEPTUAL MODEL

FOR LANDFILL NO. 1 (Parcel 78)

Fort McClellan

Calhoun County, Alabama



Note: See key on the page following Figure 3.4-9 for descriptions of receptors and pathways

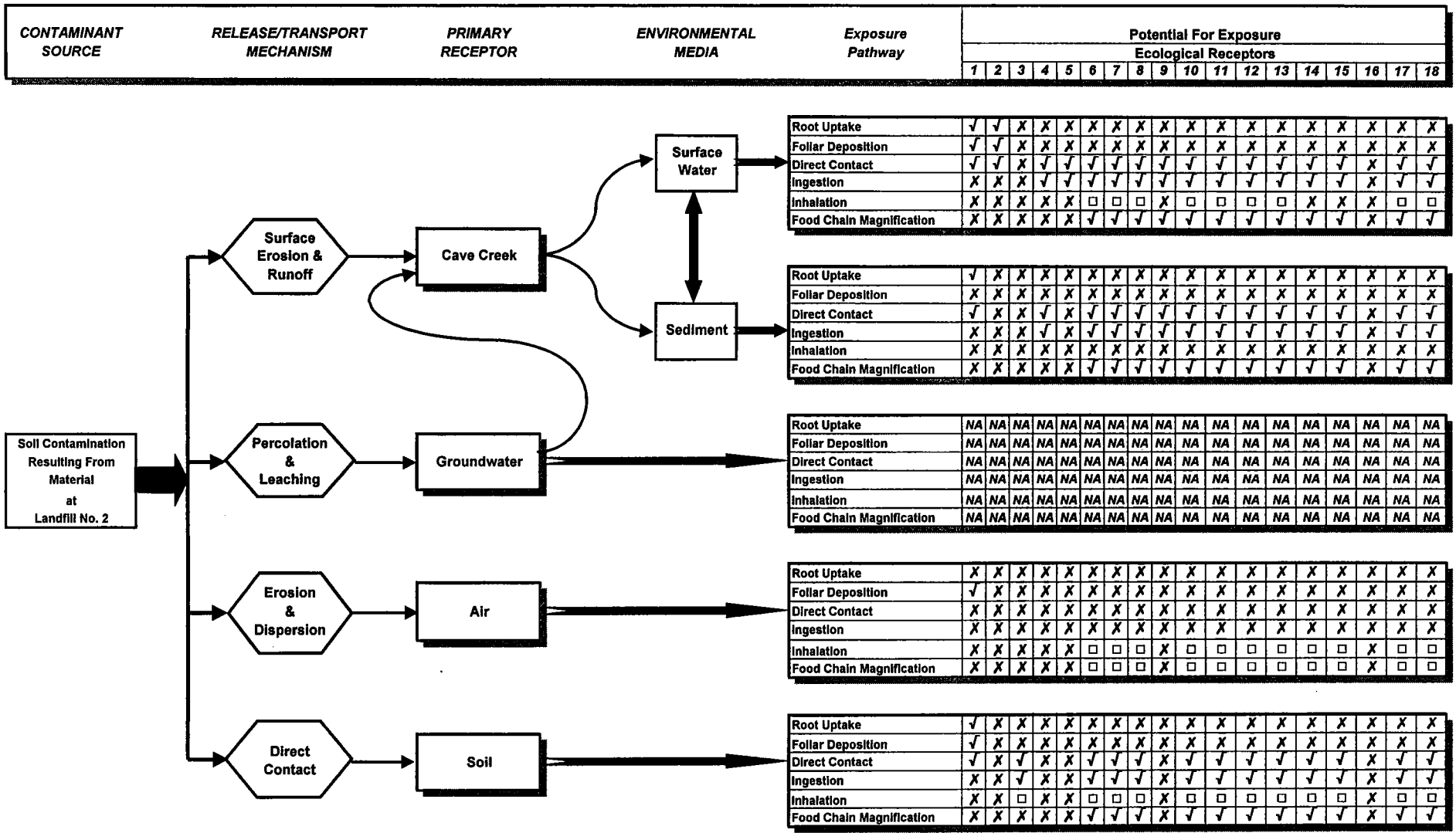
FIGURE D-2

SITE CONCEPTUAL MODEL

FOR LANDFILL NO. 2 (Parcel 79)

Fort McClellan

Calhoun County, Alabama



Note: See key on the page following Figure 3.4-9 for descriptions of receptors and pathways

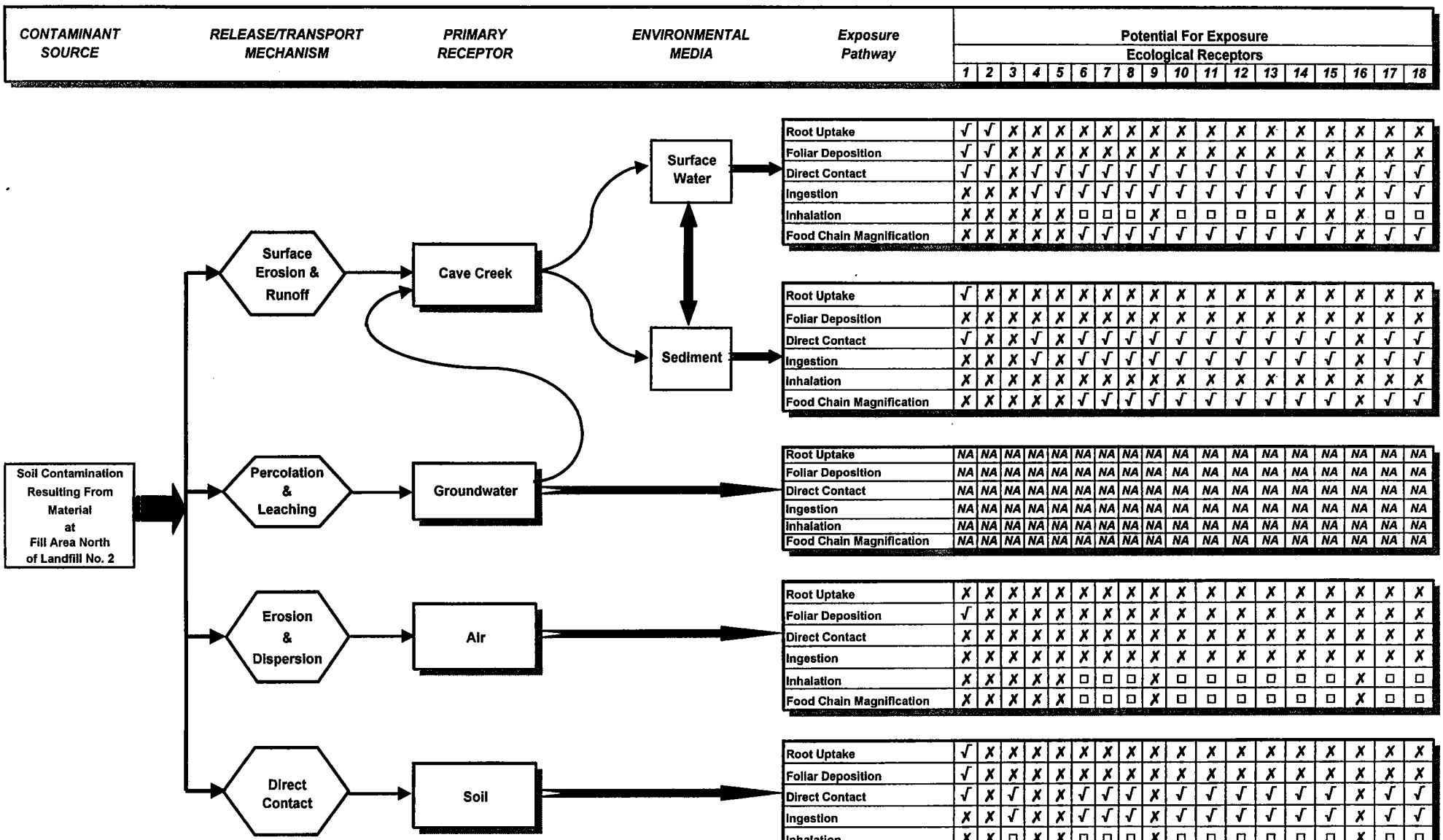
FIGURE D-4

SITE CONCEPTUAL MODEL

FOR FILL AREA NORTH OF LANDFILL NO. 2 (Parcel 230)

Fort McClellan

Calhoun County, Alabama



Note: See key on the page following Figure 3.4-9 for descriptions of receptors and pathways

KEY TO SITE CONCEPTUAL MODELS FOR LANDFILLS AND FILL AREAS

Fort McClellan

Calhoun County, Alabama

Key To Potential Receptors

1 - Rooted plants
2 - Floating aquatic plants
3 - Terrestrial invertebrates
4 - Benthic invertebrates
5 - Water column invertebrates
6 - Amphibians & reptiles
7 - Herbivorous mammals
8 - Herbivorous birds
9 - Planktivorous fish
10 - Omnivorous mammals
11 - Omnivorous birds
12 - Invertivorous mammals
13 - Invertivorous birds
14 - Piscivorous mammals
15 - Piscivorous birds
16 - Piscivorous fish
17 - Carnivorous mammals
18 - Carnivorous birds

Key To Potential Exposure Routes

√ - Potentially complete exposure pathway
✗ - Incomplete exposure pathway
□ - Potentially complete exposure pathway but insignificant
NA - Not applicable