ENCYCLE/TEXAS, INC.
Corpus Christi, Texas

BASELINE RISK ASSESSMENT

Volume I of II

April 14, 2004

ARCADIS

Infrastructure, buildings, environment, communications

ARCADIS

Baseline Risk Assessment

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EXECUTIVE SUMMARY

A baseline risk assessment (BLRA) has been prepared for the Encycle/Texas, Inc., (Encycle) facility (the site) in Corpus Christi, Texas, for groundwater and soils at the site, and surface water and sediment in the Corpus Christi Ship Channel adjacent to the site. This BLRA was completed under Risk Reduction Standard No. 3 (RRS3) of the Texas Risk Reduction Rules, pursuant to Section 30: Texas Administrative Code (TAC), Chapter 335, Subchapters A and S. This Standard requires the completion of a baseline risk assessment and, as warranted based on potential current or future risks, the development of preliminary remediation goals (PRGs). This document was prepared using Texas Natural Resource Conservation Commission (TNRCC) and U.S. Environmental Protection Agency (USEPA) guidance. On September 1, 2002, the TNRCC underwent a name change. All statements regarding the agency from here forward will reflect the new name, Texas Commission on Environmental Quality (TCEQ), with the exception of actual document references released prior to the name change.

HUMAN HEALTH RISK ASSESSMENT

Groundwater

Shallow groundwater at the site occurs in two separate water-bearing units, the Beaumont Formation in the topographically higher southern portion of the site, and the Fill/Alluvium in the topographically lower northern portion of the site. Water level data from monitor wells show that groundwater in the Beaumont Formation at the site flows northerly and discharges into the Fill/Alluvium. Groundwater in the Beaumont Formation is moderately saline, with a background total dissolved solids (TDS) concentration between 6,000 and 9,000 mg/L. Groundwater in the Fill/Alluvium is saline with a background TDS concentration above 10,000 mg/L.

No constituents in the Fill/Alluvium Water-Bearing Unit were identified as constituents of potential concern (COPCs) following screening against the adjusted Risk-Based Screening Values (RBSVs), therefore it was not necessary to calculate risks for this medium.

The calculated Hazard Index (HI) for hypothetical future adult resident exposure to groundwater (2) and for hypothetical future child resident exposure to groundwater (3) from the Beaumont Formation Water-Bearing Unit exceed the regulatory target HI of 1. An Excess Lifetime Cancer Risk (ELCR) for the hypothetical future adult resident (and child resident) was not calculated because all of the carcinogenic COPCs have federal Maximum Contaminant Levels (MCLs) for drinking water, and therefore, in accordance with TCEQ guidance (TCEQ, 1998), the site concentrations for the COPCs should be compared to their respective MCLs, but not included in a quantitative risk calculation (TCEQ, 1998). The maximum concentration or sample quantitation limit (SQL) of all of the constituents analyzed in groundwater were compared to their respective RBSVs. Those constituents exceeding their respective RBSVs but not included in the risk evaluation due to existing federally promulgated MCLs are: antimony, arsenic, cadmium, cyanide, and selenium. Lead has an action level rather than an MCL. The action level for lead was exceeded; however as with constituents with MCLs, lead was not included in the quantitative risk evaluation.

Therefore, as discussed in the recommendations section (Section 20), ingestion of groundwater from the Beaumont Formation at the site will be further evaluated as part of the Corrective Measures Study (CMS) for the Encycle facility.

Surface Soil

The calculated HI for a potential current site worker exposure to COPCs (1) in soil 0 to 2 ft below ground surface (bgs) meets the regulatory acceptable target HI of 1. The calculated ELCR for the potential current site worker exposure to COPCs (9×10^{-7}) is less than the regulatory acceptable target risk range of 10^{-4} to 10^{-6}.

The calculated HI for a potential current excavation worker exposure to COPCs (1) in soil 0 to 5 ft bgs is equal to the regulatory acceptable target HI of 1. The calculated ELCR for the potential current excavation worker exposure to COPCs (1×10^{-9}) is less than the regulatory acceptable target risk range of 10^{-4} to 10^{-6}. The calculated ELCR for the potential current excavation worker exposure to COPCs (1×10^{-7}) is less than the regulatory acceptable target risk range of 10^{-4} to 10^{-6}.

The calculated HI for an age-averaged hypothetical future child/adult resident exposure to COPCs (10) in soil 0 to 15 ft bgs is above the regulatory acceptable target HI of 1. The calculated, cumulative ELCR for an age-adjusted hypothetical future child/adult resident (1×10^{-7}) is below the target risk range of 10^{-4} to 10^{-6} for cumulative cancer risk.

The HI for age-averaged child/adult resident exposure to surface soil exceeded the regulatory target. Therefore, it was necessary to calculate PRGs for this scenario. The Exposure Point Concentrations (EPCs) for arsenic (120 mg/kg) and cadmium (140 mg/kg) exceeded their respective PRGs of 20 mg/kg and 77 mg/kg. Because no

USEPA-verified toxicity values exist for lead, the risks associated with exposure to lead cannot be evaluated using conventional risk assessment methods. The TCEQ's pre-calculated clean-up value for residential exposure to lead is 500 mg/kg and the value for commercial/industrial exposure is 1,600 mg/kg. The concentration of lead in soils 0 to 15 ft bgs (1,300 mg/kg) exceeds the TCEQ's pre-calculated clean-up value of 500 mg/kg for residential exposure. Calculations evaluating potential current risks to site workers and excavation workers exposed to soil indicate that no unacceptable regulatory risk is present to those receptors with the exception of lead. The 95 percent upper confidence limit (UCL) concentrations of lead in soils 0 to 2 ft bgs (2,700 mg/kg) and 0 to 5 ft bgs (1,800 mg/kg) exceed the TCEQ health-based clean-up value of 1,600 mg/kg for commercial/industrial land use.

Therefore, as discussed in the recommendations section (Section 20), exposure to arsenic, cadmium, and lead in soils will be further evaluated as part of the CMS for the Encycle facility.

Surface Soil Protective of Groundwater

The potential for cross-media contamination (from soil to groundwater) was evaluated in this BLRA. The available groundwater data from the Encycle facility indicate that only very limited leaching of constituents from soil has occurred in the past. Although some of the soil samples at the site contain concentrations of some constituents above the adjusted groundwater protection – industrial medium-specific concentrations (GWP-Ind MSCs), an evaluation of the leaching potential of the COPCs by the synthetic precipitation leaching procedure (SPLP) analyses indicated that the residual concentrations of the COPCs, with the exception of cadmium, in soils should not represent a significant continuing release source to the groundwater. Therefore, as discussed in the recommendations section (Section 20), leaching of cadmium in soil to groundwater will be further evaluated as part of the CMS for the Encycle facility.

Surface Water

Exposure to surface water concentrations by an adult consuming fish caught locally was evaluated in the BLRA even though swimming, wading, recreational fishing, and boating are prohibited in the Corpus Christi Ship Channel. The rationale is that fish are not constrained by institutional boundaries and may travel freely in and out of the channel and may be caught outside of the restricted area after having been exposed to surface water constituents in the channel. This evaluation did not result in an unacceptable risk to human health. The calculated HI for a potential current adult exposure to surface water COPCs via fish tissue ingestion (1) meets the regulatory acceptable target HI of 1. An ELCR could not be calculated for surface water exposure via fish tissue ingestion because the COPCs included in the evaluation are all classified by USEPA as non-carcinogens.

SCREENING-LEVEL ECOLOGICAL RISK ASSESSMENT

A screening-level ecological risk assessment (SLERA) was conducted for the groundwater, soils, sediment, and surface water associated with the facility in a manner consistent with the TCEQ Ecological Risk Guidance (TCEQ, 2001). The SLERA used the analytical results from the sampling of environmental media during the RFI and Phase II RFI soil, sediment, and surface water sampling events. Soils were analyzed for metals and cyanide. Corpus Christi Ship Channel sediments, pore water and surface water were analyzed for metals. Background concentrations of metals in soil, surface water and sediment, and the TCEQ's ecological screening benchmarks were used to eliminate from this study those chemical compounds that were not likely to pose a risk of adverse ecological effects at the site. A smaller list of chemicals of potential ecological concern (COPECs) was identified through this step in the SLERA process. The COPECs were evaluated further in the effects characterization and risk characterization steps.

The environmental conditions and ecosystems of the site were examined. An ecological conceptual site model was created to identify significant potential exposure pathways. These efforts led to the selection of four wildlife receptors that are potentially sensitive to the toxic effects of the COPECs and meant to be representative of many components of the involved food webs at the site. These receptors are the white footed mouse, great blue heron, raccoon, and red-tailed hawk.

The hazard quotient methodology used in this SLERA characterizes the potential risks of adverse effects from the COPECs at the site to the representative ecological receptors. To evaluate fish, invertebrates and plants, the concentration in soil, sediment and water is divided by the applicable TCEQ benchmark intended for the protection of these receptors to calculate the hazard quotient. To evaluate wildlife effects, the estimated total oral daily dose is divided by the toxicity reference value to compute the hazard quotient. If the concentration/dose rate that represents the estimated exposure is greater than the benchmark/toxicity reference value, then the hazard quotient will be greater than one. A hazard quotient greater than one for a SLERA does not indicate that the COPEC is causing adverse effects to the representative ecological receptors at the site. Rather, a hazard quotient greater than one indicates that further evaluation of the exposure to the particular COPEC is warranted.

The results of the wildlife risk characterization and uncertainty evaluation for the site conservatively demonstrates that there is no unacceptable risk of adverse effects to the representative wildlife receptors or their related food webs from exposure to the COPECs detected in soil, sediment and surface water; and additional evaluation of these media is not considered necessary to protect the representative wildlife receptors or their related food webs.

Soil concentrations for the following metals, however, do exceed their respective TCEQ screening benchmarks for the protection of soil invertebrates and terrestrial plants: arsenic, bismuth, cadmium, chromium, cobalt, copper, cyanide, lead, manganese, mercury, nickel, selenium, silver, thallium, and zinc. Based on direct observations of terrestrial plants at the facility, no evidence of adverse impacts are present. Also, metals in soil that exceed PRGs in the Human Health Risk Assessment (arsenic, lead, cadmium) will be addressed in the CMS. Therefore, additional investigation of soil invertebrates and terrestrial plants at the Encycle facility is not warranted.

The comparison of the sediment and sediment pore water concentrations to the appropriate screening values in concert with the sediment acid volatile sulfide/simultaneously extracted metals (AVS/SEM) results, and the comparison of the pore water concentrations to reported adverse effects levels indicates that several metals in sediment (i.e., antimony, arsenic, cadmium, copper, lead, manganese, mercury, selenium, thallium, tin and zinc) will require further evaluation in a CMS. The area of affected sediments to be addressed in the CMS are located between the Ship Channel shoreline (rip rap) directly north of the 01 Landfill and the dredge line approximately 60 feet north of the shoreline. Metals concentrations in sediment beyond a distance of 60 feet north of the shoreline decrease rapidly and approach background concentrations. The area beyond a distance of 60 feet from the shoreline also corresponds to a sharp increase in water depth resulting from dredging operations for navigational purposes in the Corpus Christi Ship Channel.

1. Introduction

Following TCEQ approval in a January 15, 2004 letter, Encycle/Texas, Inc. (Encycle) retained ARCADIS G&M, Inc. (ARCADIS) to complete a baseline risk assessment (BLRA) for the Encycle facility in Corpus Christi, Texas. The BLRA provides an evaluation of potential risks associated with current constituent concentrations and potential exposures to groundwater and soils at the site, and surface water and sediment in the Corpus Christi Ship Channel adjacent to the site. The BLRA provides a basis for determining concentrations of chemicals that can remain in groundwater, soils, surface water, and sediment that are protective of human health and the environment. These activities are being conducted according to the Texas Risk Reduction Rules (30 Texas Administrative Code [TAC] 335, Subchapters A and S) as specified in Section VII.B. of the October 1999 Consent Decree issued to Encycle and ASARCO, Inc.

1.1 Scope of Risk Assessment

This assessment was completed according to the Risk Reduction Standard No. 3 (30 TAC 335.561), TCEQ guidance (1998; 2001), and appropriate U. S. Environmental Protection Agency (USEPA) guidance referenced in the Risk Reduction Rules. The scope of this assessment includes evaluating baseline risks to human health and the environment using analytical data from samples of groundwater, soils, surface water, and sediment. The concentrations of constituents in groundwater, soils, surface water, and sediment were evaluated directly by laboratory analyses of groundwater, soil, surface water, and sediment samples.

1.2 Organization of Report

This baseline risk assessment report is divided into twenty-one sections, including the Executive Summary, this introduction, and the following sections:

- Section 2, Site Characterization, briefly describes the Encycle facility and operations, summarizes the history of the facility, and reviews the previous soil, groundwater, surface water, and sediment investigations.

- Section 3, Data Summary, summarizes the occurrence of constituents in groundwater, soils and surface water, identifies the constituents of potential concern, and discusses the physical and chemical properties influencing constituent migration.

- Section 4, Toxicity Assessment, identifies information on the inherent toxicological properties of the constituents detected in groundwater, soils, and surface water and describes the toxicity values used to evaluate the carcinogenic and systemic toxicant effects of the COPCs on exposed receptors.

- Section 5, Exposure Assessment, discusses potential exposure pathways and receptors exposed to constituents detected in groundwater, soils, and surface water. This section evaluates the mechanisms by which potential receptors are exposed to constituents of potential concern.

- Section 6, Risk Characterization, identifies the combination of exposure scenarios and toxicity values used to assess risks and summarizes the potential risk to human health from exposure to constituents detected in groundwater, soils, and surface water. This section also presents the method used to calculate Preliminary Remediation Goals (PRGs) and compare these PRGs to present constituent levels in the groundwater, soils, and surface water.

- Section 7, Ecological Risk Assessment, assesses the risks to ecological receptors from exposure to affected media.

- Section 8, Site Background, briefly describes the Encycle facility operations and land use, and identifies the ecological habitats present on-site and in surrounding areas.

- Section 9, Tier I Exclusion Criteria Checklist, is intended to aid the TCEQ in determining whether or not any further ecological evaluation is necessary at a site.

- Section 10, Constituent Characterization, summarizes the occurrence of constituents in soils, sediment, and surface water, identifies the constituents of potential concern, and summarizes past soil, sediment and surface water investigations. Some of the same data summaries and occurrence tables generated in the human health portion of the BLRA will be utilized in this section.

- Section 11, Use of Ecological Screening Benchmarks, compares concentrations of measured chemicals in environmental media at the Encycle site to ecological screening benchmarks. The ecological screening benchmarks are meant to conservatively represent the upper limit of chemical concentrations that will not cause adverse effects to populations or communities of exposed biota inhabiting the environmental medium that are considered to be the most exposed within a given food web.

- Section 12, Communities, Feeding Guilds, and Representative Species, identifies communities, feeding guilds, and representative species that may be supported by habitats present at the site and are important to the development of the ecological conceptual site model. Additionally, exposure estimation and measures of effect will be determined based on the identification of such levels of ecosystem organization for the site.

- Section 13, Ecological Conceptual Site Model, identifies and discusses, in narrative and pictorial form, complete and significant potentially complete exposure pathways on-site. The exposure pathways connect the source of the contamination in the environmental media to the exposed or potentially exposed wildlife receptors. The ecological conceptual site model will be based on the details about exposure pathways within ecological food chains provided in the conceptual food webs.

- Section 14, Fate and Transport/Ecotoxicological Profiles, presents the fate and transport processes for each COPEC, and discuss whether the COPECs are expected to persist or degrade in the environment. The mechanisms of toxic action associated with each COPEC will be presented in the COPEC-specific ecotoxicological profiles.

- Section 15, Screening-Level Ecological Exposure Characterization, estimates the potential exposure of the measurement receptors. A number of variables must be considered in predicting exposures to biota including bioavailability, bioaccumulation/bioconcentration potential, home range, body weight, dietary fractions, and ingestion rates for food, soil, sediment, and water.

- Section 16, Screening-Level Ecological Effects Characterization, predicts whether adverse effects are likely to be occurring to wildlife at the site, by characterizing the ecological effects that might be possible. The characterization will be done by collecting and evaluating literature information about the potential toxicological effects of the COPECs on biota, and extrapolating this information to the representative wildlife receptors at the site.

- Section 17, Screening-Level Ecological Risk Characterization, characterizes the potential risks of adverse effects from the COPECs at the site to the representative wildlife receptors.

- Section 18, Calculation of Media Cleanup Standards for Ecological Receptors, provides medium-specific protective levels intended for ecological receptors if it is determined an unacceptable risk exists. Uncertainties in the SLERA, the interpretation of the SLERA results are aided by a recognition and understanding of the source and nature of the known set of uncertainties that can influence the risk characterization results.

- Section 19, Uncertainties in the BLRA, the interpretation of the BLRA results are aided by a recognition and understanding of the source and nature of the known set of uncertainties that can influence the risk characterization results.

- Section 20, Conclusions and Recommendations, provides results and conclusions for the HHRA and the SLERA.

- Section 21, References Cited.

2. Site Characterization

2.1 Site Description

The Encycle facility (site) is approximately 108 acres in size and is located at 5500 Up River Road in Corpus Christi, Nueces County, Texas. The facility is bordered by the Corpus Christi Ship Channel to the north; McBride lane and Valero Refining (formerly Coastal Refining) to the east; Up River Road, a gasoline service station, and vacant lots to the south; and a 54-acre public grain elevator to the west. The site location is presented in Figure 2-1. As shown on Figures 2-1 and 2-2, the 108-acre Encycle facility includes 16.8 acres in the western portion of the site that is leased to Encycle and is referred to herein as the "Meaney Tract". A Union Pacific Railroad right-of-way ranging in width from approximately 100 to 150 feet runs east-west near the northern end of the site. The remainder of the site is owned by Encycle.

The site was originally developed by American Smelting and Refining Company (now ASARCO, Inc.) in 1941 to process mineral ores for the production of high grade zinc. The facility began operation in 1942 and produced high grade zinc from sulfide ore concentrations using electrolyte purification circuits and pyro-metallurgical processes. Facility operations expanded in 1956 to increase production of zinc, and the zinc products including high grade zinc, continuous galvanizing grade zinc, and zinc alloys. Cadmium and zinc sulfate powder were other by-products produced at the facility. The facility was shut down during 1985 and the site was inactive from 1986 until 1988 (ARCADIS, 2002).

The facility was operated by Encycle from 1988 through 2002 as a commercial waste management facility treating primarily inorganic hazardous and non-hazardous material for the purpose of recycling, reclamation, and reduction in volume using hydro-metallurgical processes. Products have included copper, lead, zinc, nickel, chromium, cobalt, and silver-bearing materials (ARCADIS, 2002). Facility operations ceased in 2003, and final facility closure activities are currently in progress.

The site is located within an industrialized area of Corpus Christi, Texas between the Corpus Christi Ship Channel and Up River Road (Figure 2-1). The ship channel is heavily industrialized and is a high traffic navigational segment that is periodically maintained (dredged) for navigational purposes. The ship channel is tidally influenced and is approximately 1,000 feet in width adjacent to the Encycle facility.

There are 21 solid waste management units (SWMUs) and areas of concern (AOCs) at the Encycle facility. A summary of each SWMU is as follows:

- 01 Landfill – An approximate 5.8-acre Class I non-hazardous landfill that was covered with a clay cap and closed during 1986.

- East and West Lagoons – Active storm water storage lagoons consisting of an approximate 0.5-acre West Lagoon with an 80-millimeter high-density polyethylene (HDPE) liner and an approximate 3.5-acre East Lagoon with a clay bottom. The East and West Lagoons are connected via a concrete spillway, and both lagoons have 9-foot-high perimeter concrete walls. The sediments above the HDPE liner in the West Lagoon, and the sediments and affected soils in the East Lagoon were excavated and disposed of offsite at an the US Ecology Texas landfill between November 2003 and March 2004 in accordance with the TCEQ-approved December 1999 Closure Plan for the East and West Lagoons.

- Waste Pile – An approximate 3.9-acre grass and brush-covered area formerly used during the 1970s and early 1980s for drying of neutralization plant sludge that may have contained metals. The former waste pile area is currently empty, and is located on the Meaney Tract.

- Railroad Tracks Area – Several parallel railroad tracks approximately 500 feet in length located on both the north and south sides of Product Storage Building C. The railroad tracks were used during ASARCO operations for transport of zinc ore concentrates and zinc products. The railroad tracks were used by Encycle for rail transport and unloading of metal-bearing materials received from off-site sources, and for loading of products.

- Feed Tank 1 – A 22,500-gallon wooden and brick tank located within a concrete secondary containment area that extends to approximately 10 feet below grade. Feed Tank 1 was used during ASARCO operations for leaching of zinc oxide material, and was used by Encycle for slurrying of solid waste materials as part of the recycling process.

- Feed Tank 2 – A 24,000-gallon wooden and brick tank located within a concrete secondary containment area that extends to approximately 10 feet below grade. Feed Tank 2 was used during ASARCO operations for leaching of zinc oxide material, and was used by Encycle for slurrying of solid waste materials as part of the recycling process.

- Road Leading to the West of Building C – A concrete road approximately 20 feet in width and 1,000 feet in length extending from Product Storage Building C on the west to the Old Casting Building on the east. The road was used during ASARCO operations for vehicular transport of zinc ore concentrates and zinc products. The road was used by Encycle for vehicular transport of metal-bearing materials.

- Grain Elevator – An off-site, public grain elevator on an approximate 54-acre tract located directly west of the Encycle facility. No wastes or products at the Encycle facility were stored or managed at the grain elevator property.

- Former Sludge Drying Beds – An approximate 200-foot by 60-foot concrete slab with 18-inch-high perimeter walls. The former sludge drying beds are currently empty, and were previously used for drying of wastewater treatment system sludge until the early 1990's.

- Reactor Clarifier – Two above-ground steel tanks (400,000-gallon and 570,000-gallon capacity, respectively) currently used for the settlement of solids and sludge from wastewater.

- Facility No. 1 – An approximate 50,000 square foot building used during ASARCO operations for purification of zinc sulfate solution in tanks and other process equipment. Facility No. 1 was used by Encycle for wastewater treatment and for storage and processing of hazardous and non-hazardous metal-bearing materials. The metal-bearing materials were stored in containers, and processing occured in tanks and filter presses. Final facility closure activities for permitted and non-permitted units in Facility No. 1 are currently in progress.

- Facility No. 2 - An approximate 54,000 square foot building used during ASARCO operations for leaching of zinc ore concentrates in tanks and other process equipment. Facility No. 2 was used by Encycle for storage and processing of non-hazardous metal-bearing materials. The metal-bearing materials were stored in containers, and processing occured in tanks and filter presses. Final facility closure activities for non-permitted units in Facility No. 2 are currently in progress. There are no permitted units in Facility No. 2.

- Facility No. 3 - An approximate 15,000 square foot building used during ASARCO operations for pre-leaching of zinc ore concentrates in tanks and other process equipment. Facility No. 3 was currently used by Encycle for storage and processing of hazardous and non-hazardous metal-bearing materials. The metal-bearing materials were stored in containers, and processing occurs in tanks and filter presses. Final facility closure activities for permitted and non-permitted units in Facility No. 3 are currently in progress.

- West Cell House – An approximate 40,000 square foot building used during ASARCO operations for electrowinning of zinc in lined concrete tanks filled with electrolytic solutions consisting of zinc sulfate and sulfuric acid. The West Cell House is currently inactive and has not been used during Encycle operations.

- NOR 43 Building – An approximate 12,000 square foot building used during ASARCO operations for melting of zinc using natural gas-fired furnaces, and casting the molten metal in various sized moldings to produce metallic zinc product. The NOR 43 building is currently used for storage of non-hazardous materials.

- Product Storage Building (Building C) – An approximate 55,000 square foot building used during ASARCO operations for storage of incoming feedstock consisting of granular concentrated zinc oxide or zinc sulfide ore concentrates. The building was used by Encycle for storage of bulk solids in concrete storage bins. Final facility closure activities for Product Storage Building C are currently in progress.

- Product Storage Bins (Numbered Bins) – An approximate 30,000 square foot building used during ASARCO operations for storage of incoming feedstock consisting of granular concentrated zinc oxide or zinc sulfide ore concentrates. The building was currently used by Encycle for storage of bulk solids in concrete storage bins. Final facility closure activities for the Product Storage Bins were conducted between November 2003 and January 2004. The Final Closure Certification Report for the Product Storage Bins was submitted to the TCEQ Waste Permits Division on February 2, 2004, and approved by the TCEQ on March 11, 2004.

- Building North of Facility 2 (3-sided bin) – An empty, 750 square foot concrete slab formerly used during ASARCO operations for storage of intermediate zinc-bearing materials.

- Old Casting Building – An approximate 20,000 square foot building used during ASARCO operations for melting of zinc using natural gas-fired furnaces, and casting the molten metal in various sized moldings to produce metallic zinc product. The Old Casting Building is currently used for storage of non-hazardous materials.

- Storm Sewer System – Approximately 2 linear miles of underground piping accessed via approximately 200 storm drains with metal grates. The storm sewer system is used to collect and gravity-drain storm water into a concrete storm water sump that pumps the storm water into the South Demin Tank. When the South Demin Tank is full, the storm water in the concrete storm water sump flows into the West Lagoon. The storm sewer piping was mapped, cleaned, and repaired during 2000 and 2001 as part of the TCEQ-approved closure activities for the East and West Lagoons.

- Boneyard – A former 1,660 cubic yard soil and debris pile that had been located in the northwest portion of the facility. Samples of the soil and debris pile were collected during 2000 and 2001 as part of the RFI. Following receipt of the analytical data, the soil and debris were removed from the site and disposed of at the Texas Ecologists (now US Ecology Texas) landfill in Robstown, Texas. The boneyard is currently empty and unpaved (i.e., earthen and grass-covered), and is located on the Meaney Tract.

For the purposes of the human health risk assessment, soils were evaluated on a site-wide basis, and no distinction between SWMU/AOC soils was made in the evaluation.

2.2 Surrounding Land Use

Immediately surrounding land use is predominately commercial/industrial. Undeveloped, grass-covered tracts are also present south of the site on the south side of Up River Road.

2.3 Previous Investigations

The data used in this BLRA were generated during numerous sampling investigations conducted at the facility over a number of years (1986 thru 2004). A brief description of these investigations is presented in the following paragraphs.

Prior to initiating the facility-wide RFI in June 2000, several other environmental investigations have been conducted at the Encycle facility, including (1) installation of a groundwater monitoring system around the closed 01 Landfill in 1986 and 1987, (2) conducting an RFI of three SWMUs (01 Landfill, East and West Lagoons, Waste Pile) in 1993, (3) conducting a soil investigation in the railroad tracks and Feed Tank No. 2 areas in 1993 and 1994 as part of an Administrative Order, (4) installing a groundwater monitoring system around the East and West Lagoons in 1999, and (5) conducting closure activities for the East and West Lagoons as detailed in the December 1999 Closure Plan for the East and West Lagoons.

The facility wide RFI was conducted between 2000 and 2002, and included investigation of 21 solid waste management units (SWMUs). Four SWMUs (waste pile, boneyard, East and West Lagoons, 01 Landfill) were further investigated during February 2003 as part of the Phase II RFI. A Phase II RFI addendum also was conducted during 2003 and included sediment sample collection from the Corpus Christi Ship Channel. Additional sediment and surface water samples were collected from the Corpus Christi Ship Channel during January and February 2004 to obtain data for this BLRA and the upcoming Corrective Measures Study.

A summary of these environmental investigations is provided below.

Following closure of the 01 Landfill, a groundwater monitoring system consisting of four monitor wells (MW-2 through MW-5) was installed around the perimeter of the 01 Landfill during 1986 and 1987. Monitor well locations are shown on Figure 4-1. Groundwater samples were collected annually from the monitor wells between 1986 and 1992 for analysis of arsenic, copper, lead, zinc, pH, and conductivity. The groundwater analytical data showed the shallow groundwater was saline, and metal concentrations were low to non-detectable. Discontinuation of groundwater monitoring around the 01 Landfill was approved by the TCEQ in a May 29, 1992 letter. Additional details regarding the 01 Landfill groundwater monitoring program are provided in reports submitted to the TCEQ entitled "ASARCO Landfill Closure Groundwater Monitoring" dated March 1986, and "ASARCO Monitor Well Installation and Groundwater Sampling" dated February 1987.

A RCRA Facility Assessment (RFA) was conducted at the site by the Texas Water Commission (now TCEQ) on July 24, 1987. In response to the RFA, Encycle submitted an RFI Work Plan to the TCEQ on December 22, 1988 for three SWMUs: the 01 Landfill, the Waste Pile Area, and the storm water lagoons (East and West Lagoons). The RFI was approved with modifications by the TCEQ on November 6, 1992. The RFI was conducted by K.W. Brown Environmental Services during 1993. The 1993 RFI included soil sample collection and analysis from:

- Seven soil borings around the perimeter of the 01 Landfill (soil borings B-9 through B-12 and B-30 through B-32);
- Six soil borings within the East Lagoon (soil borings B-24 through B-29);
- Five soil borings around the perimeter of the West Lagoon (soil borings B-13 through B-17); and
- Six soil borings in the Waste Pile Area (soil borings B-18 through B-23).

Soil boring locations are shown on Figure 4-2. Two monitor wells (MW-6 and MW-7) also were installed during the RFI, and groundwater samples were collected from the monitor wells for laboratory analysis. The conclusions of the 1993 RFI were that total arsenic, cadmium, copper, lead, manganese, and zinc concentrations in soil exceeded background levels in portions of the 01 Landfill, East and West Lagoons, and Waste Pile areas. The concentrations of total nickel in soil also exceeded background levels in portions of the 01 Landfill and East and West Lagoons areas, but not in the Waste Pile Area. The 1993 RFI also concluded that no appreciable releases of metals to groundwater occurred from the three SWMUs investigated. Additional details regarding the 1993 RFI are provided in the September 1993 report submitted to the TCEQ entitled "RCRA Facility Investigation Report for Solid Waste Management Units at Encycle/Texas, Inc., Corpus Christi, Texas."

A soil investigation was conducted during 1993 and 1994 in two areas of the Encycle facility as part of an Administrative Order issued to Encycle by the TCEQ on November 6, 1992. These two areas are the railroad tracks area directly northeast of Product Storage Building C, and the area directly northwest of Feed Tank No. 2. Soil sample analytical data showed that the concentrations of metals (arsenic, barium, cadmium, chromium, copper, lead, manganese, nickel, silver, tin and zinc) in several surface soil samples collected in these two areas exceeded background concentrations. Metals concentrations in soil declined with depth and attenuated to background concentrations within 6 feet below ground surface. Soils in these two areas with metal concentrations above TCEQ Risk Reduction Standard No. 2 (RRS2) medium specific concentrations (MSCs) were excavated and disposed of at an offsite authorized landfill. Additional details regarding the Administrative Order soil sampling and excavation program are provided in a letter report submitted to the TCEQ on November 7, 1994. The TCEQ approved Administrative Order activities in letters dated April 10, 1993, June 29, 1993, and November 3, 1995.

A groundwater monitoring program for the East and West Lagoons was initiated during 1999 in accordance with Part VII.A, Paragraph 36 of the Consent Decree. The groundwater monitoring program includes groundwater sample collection from two hydraulically upgradient monitor wells (MW-3 and MW-10) and three hydraulically downgradient monitor wells (MW-6, MW-8, MW-9). Monitor well locations are shown on Figure 5. Groundwater samples were collected from the monitor wells quarterly during 1999 and semiannually beginning in 2000. The groundwater monitoring data collected to date shows the shallow groundwater was saline, and metal concentrations are low to non-detectable. The concentrations of total metals (arsenic, barium, cadmium, chromium, lead, mercury, selenium, silver) in the groundwater samples collected hydraulically downgradient of the East and West Lagoons generally have been within the range of background values, and have consistently been below the TCEQ RRS2 adjusted groundwater MSCs (adjusted for saline groundwater in accordance with 30 TAC Chapter 335.559(d)(3)). Additional details regarding the groundwater monitoring system for the East and West Lagoons are provided in Annual Groundwater Monitoring Reports submitted to the TCEQ on July 17, 2000, August 23, 2001, August 16, 2002, and August 25, 2003.

A Closure Plan for the East and West Lagoons was submitted to the TCEQ on December 29, 1999 as specified in Section VII.A. of the Consent Decree, and the Closure Plan was approved by the TCEQ on March 30, 2000. Closure plan activities that have been completed include mapping, cleaning, and repair of the storm sewer system piping; collection of rinsate samples from the storm sewer system piping demonstrating that the piping has been decontaminated; collection of sediment samples above the West Lagoon HDPE liner and above the East Lagoon clay bottom; collection of soil samples from the East Lagoon clay bottom and subsurface soils; removal (excavation) of sediment above the West Lagoon HDPE liner and above the East Lagoon clay bottom, and excavation of soils from the East Lagoon clay bottom that exceed target cleanup levels specified in the approved Closure Plan. During sediment removal above the West Lagoon HDPE liner, three tears were identified at the base of the liner, and soil samples were collected directly below the tears during November 2003. Soil sample analytical data below the West Lagoon HDPE liner is summarized in Appendix B. Following soil sample collection, the tears in the HDPE liner were repaired during November 2003.

A facility-wide soil and groundwater investigation was conducted during the Phase I RFI between 2000 and 2002. The Phase I RFI included advancement of two geotechnical soil borings, 12 lithologic soil borings, 173 soil sample borings, and eleven new monitor wells (MW-11 through MW-21). RFI monitor well and soil boring locations are shown on Figures 4-1 and 4-2, respectively, and soil and groundwater analytical data are summarized in Appendix A and B, respectively. Additional details regarding the Phase I RFI are provided the August 2002 report submitted to the TCEQ entitled "RCRA Facility Investigation Report."

As requested in December 12, 2002 TCEQ letter regarding the Phase I RFI, a Phase II RFI was conducted during February 2003. The Phase II RFI involved additional soil delineation at four SWMUs (waste pile, boneyard, East and West Lagoons, 01 Landfill). The results of the Phase II RFI are provided in the May 2003 report submitted to the TCEQ entitled "Phase II RCRA Facility Investigation Report."

As requested in the September 4, 2003 TCEQ letter regarding the Phase II RFI, sediment samples were collected from the Corpus Christi Ship Channel north of the Encycle 01 Landfill. Thirty-six sediment samples (SED-1 through SED-36) were collected north of the 01 Landfill during September and October 2003, and sediment sample locations are shown on Figure 4-3. Sixteen background sediment samples (BKG-N1 through BKG-N8, BKG-S1 through BKG-S8) also were collected from the Corpus Christi Ship Channel during September 2003. The sediment sample analytical data showed that the concentrations of several metals in sediment adjacent to the 01 Landfill exceeded background concentrations. Metals concentrations in sediment generally decreased with distance away from the 01 Landfill and approach or reached background concentrations within 60 feet of the Ship Channel shoreline (rip rap) north of the 01 Landfill. Sediment sample analytical results are summarized in Appendix E. The sediment sample results are also discussed in more detail in the December 2003 report submitted to the TCEQ entitled "Phase II RCRA Facility Investigation Report Addendum – Sediment Sample Results."

Sediment, sediment pore water, and surface water samples were collected from the Corpus Christi Ship Channel during January and February 2004 to obtain analytical data for use in the BLRA and the upcoming Corrective Measures Study. Four sediment samples (SED-1, SED-4, SED-7, SED-10) were collected adjacent to the Encycle 01 Landfill in two-foot water depths on January 30, 2004 for analyses of metals in the sediment and in the sediment pore water. Sediment and pore water sample locations are shown on Figure 4-4. Sediment pore water analytical results are provided in Appendix D, and sediment sample analytical results are provided in Appendix E. Copies of the analytical laboratory reports for the sediment and pore water samples are provided in Appendix I.

Eight surface water samples were collected from the Corpus Christi Ship Channel on February 16, 2004 for total and dissolved metals analyses. Four surface water samples (SED-1, SED-4, SED-7, SED-10) were collected adjacent to the Encycle 01 Landfill at the same locations as the January 30, 2004 pore water samples, and the other four surface water samples were background samples (BKG-1 through BKG-4) collected at least ½-mile from the Encycle facility. Surface water sample locations are shown on Figure 4-4. These surface water samples were collected using a clean stainless steel bacon-bomb sampler with a manually operated bottom-opening valve. The surface water samples were each collected in water depths of two feet at a point one foot above the sediment and one foot below the water surface. Surface water sample analytical results are summarized in Appendix C, and copies of the analytical laboratory reports are provided in Appendix H. These surface water, sediment, and sediment pore water analytical results are discussed in more detail in Sections 3 through 20 of this BLRA.

Final facility closure activities for the permitted and non-permitted units at the Encycle facility are currently in progress. These closure activities are being conducted in accordance with the November 1999 Closure Plan entitled "Final Facility Closure and Post-Closure Plan for Permitted, Interim-Authorized, and Planned Permitted Units" as revised on February 4, 2000; the November 1999 Closure Plan for non-permitted units entitled "Final Facility Closure and Post-Closure Plan for Non-Permitted Units" that was approved by the TCEQ on April 27, 2000; the Facility Permit No. HW-50221-001 issued by the TCEQ on September 27, 2002; and the 2003 Agreed Final Judgment. As part of the approved closure plans, soil samples are being collected below cracks in the concrete floors of these units. To date, soil samples have been collected below the concrete floors of the Containment Building and Facility No. 3. Soil sample analytical data is summarized in Appendix B.

3. Data Summary

This section describes the occurrence of constituents detected in groundwater, soil, and surface water at the facility. Groundwater data from the Fill/Alluvium Formation Water-Bearing Unit and the Beaumont Formation Water-Bearing Unit were evaluated separately.

3.1 Data Reduction

The data were reduced and analyzed for use in the BLRA according to the guidelines provided by the USEPA (1989a) and the TCEQ (TNRCC, 1998) as described below:

- Constituents that were not detected in a particular medium and that had detection limits less than their respective commercial/industrial medium-specific concentration were eliminated from further analysis for that group.

- All analytical results reported as detections were used at the reported value, including laboratory estimated data (J-qualified).

- For constituents within a data group reported as non-detected (non-detects), the sample quantitation limit (SQL) was used as a proxy concentration rather than using zero or eliminating the data point.

- For groundwater and surface water data, the greater of the SQL or the detected concentration was used as the EPC when the analyte was detected in less than 100 per cent of samples

- For soil data, the 95 percent upper confidence limit (UCL) was used as the exposure point concentration (EPC) for those compounds that were analyzed in ten or more samples. For those compounds that were analyzed for in less than 10 samples, the maximum reported concentration (detected value or SQL, whichever is greater) was used as the EPC.

The results of the statistical analyses are presented in the constituent occurrence tables (Tables 3-1 through 3-7). The information in these tables includes for each detected constituent:

- The frequency of detection (ratio of the number of detects to the total number of samples in that group);

- The range of SQLs used as proxy concentrations for non-detects in the statistical calculations;
- The range of detected values;
- The total range of detected values and SQL values;
- The average detected value;
- The arithmetic mean;
- The 95 percent upper confidence level (UCL) on the arithmetic mean (assuming a one-tailed distribution); and
- The exposure point concentration (EPC) used in the risk calculations for COPCs.

Both mean and UCL concentrations were calculated using proxy concentrations for non-detects.

The one-sided UCL is a statistical number calculated using the following formula:

$$UCL_{95} = \bar{x} + \frac{s * t_{0.05,n-1}}{\sqrt{n}}$$

where:

n sample size (number of data points);
s sample standard deviation;
$t_{0.05,\,n-1}$ 0.05 critical value for the t_{n-1} distribution;
UCL_{95} 95 percent upper confidence level for the mean; and
$\bar{x}$ sample mean (average).

If the samples were selected randomly from the facility, there is a 95 percent chance that the arithmetic mean concentration at each of the areas lies below the UCL concentration. A high level of confidence (95 percent) is used to compensate for the uncertainty involved in representing the site conditions with a finite number of samples.

3.2 Occurrence in Groundwater Samples

Shallow groundwater at the site occurs in two separate water-bearing units, the Fill/Alluvium Formation Water-Bearing Unit and the Beaumont Formation Water-Bearing Unit. Each of these units is examined individually in the following sections.

3.2.1 Fill/Alluvium Formation Water-Bearing Unit

Groundwater samples from the Fill/Alluvium Formation Water-Bearing Unit were collected between 1986 and 2003 from 8 monitor wells at the site (MW-2, MW-3, MW-4, MW-5, MW-6, MW-8, MW-9, and MW-10). Groundwater from the Fill/Alluvium Formation Water-Bearing Unit was analyzed for 19 inorganic constituents. Of these 19 inorganic constituents, 16 were detected. The results of the sampling from the Fill/Alluvium Formation Water-Bearing Unit are summarized statistically in Table 3-1. All of the groundwater analytical data are summarized in Appendix A.

3.2.2 Beaumont Formation Water-Bearing Unit

Groundwater samples from the Beaumont Formation Water-Bearing Unit were collected from 12 monitor wells between 1993 and 2002. These Beaumont Formation monitor wells are MW-7, MW-11, MW-12, MW-13, MW-14, MW-15, MW-16, MW-17, MW-18, MW-19, MW-20, and MW-21. Groundwater from this unit was analyzed for 19 inorganic constituents. A total of 14 out of the 19 inorganic constituents analyzed for were detected. Table 3-2 statistically summarizes the data collected from the Beaumont Formation Water-Bearing Unit.

3.3 Occurrence in Soil Samples

The results of all of the sampling events taken together from the following reports are used to evaluate risk from exposure to soils at the facility:

- RCRA Facility Investigation Report, Encycle/Texas, Inc., Corpus Christi, Texas. August (ARCADIS Geraghty & Miller, 2002);

- Phase II RCRA Facility Investigation Report, Encycle/Texas, Inc., Corpus Christi, Texas. May (ARCADIS Geraghty & Miller, 2003);

The results of the above sampling events, taken together, have delineated the lateral and vertical extent of releases to soils of the COPCs. Samples from various sampling events were analyzed for different parameters, resulting in varying sample frequencies.

For the purposes of this risk assessment, the samples from the affected soils were divided into two depth intervals: surface and total (surface to water table). As defined in the Risk Reduction Rules, the surface interval is classified as follows: samples collected between 0 and 2 feet below ground surface (ft bgs) for site worker exposure; samples collected between 0 and 5 ft bgs for excavation worker exposure; and samples collected between 0 and 15 ft bgs for residential exposure. For the total group, all samples collected from 0 feet to the top of the water table were evaluated.

3.3.1 Total Soil

The total soil group includes the 932 soil samples in the data set between ground surface and the lower water-bearing unit, collected between 1993 and 2003 from a total of 210 borings. Soil samples were analyzed for 19 inorganic constituents with varying frequencies. The total soil data set includes detections of all 19 inorganic constituents. The results of soil sampling at the facility are presented statistically in Table 3-3. A summary of the soil analytical results is presented in Appendix B.

3.3.2 Surface Soil 0 to 2 ft bgs

The surface soil data set for site worker exposure is comprised of all soil samples collected between 0 and 2 feet below ground surface. A total of 221 out of the 932 soil samples were from the 0 to 2 ft depth interval. Surface soil samples were analyzed for 19 inorganic constituents, all of which were detected. The results of the surface soil sampling are summarized statistically in Table 3-4.

3.3.3 Surface Soil 0 to 5 ft bgs

The surface soil data set for excavation worker exposure is comprised of all soil samples collected between 0 and 5 feet below ground surface. A total of 373 out of the 932 soil samples were from the 0 to 5 ft depth interval. Surface soil samples were analyzed for 19 inorganic constituents, all of which were detected. The results of the surface soil sampling are summarized statistically in Table 3-5.

3.3.4 Surface Soil 0 to 15 ft bgs

The surface soil data set for residential exposure is comprised of all soil samples collected between 0 and 15 feet below ground surface. A total of 815 out of the 932 soil samples were from the 0 to 15 ft depth interval. Surface soil samples were analyzed for 19 inorganic constituents, all of which were detected. The results of the surface soil sampling are summarized statistically in Table 3-6.

3.4 Occurrence in Surface Water Samples

The surface water data set is comprised of four samples (SED-1, SED-4, SED-7, SED-10) collected in February 2004 along the south shoreline of the Corpus Christi Ship Channel adjacent to the 01 Landfill. Surface water samples were analyzed for 14 total and dissolved metals. Five total metals were detected in surface water. The total metals data used for the human health risk assessment is summarized statistically in Table 3-7.

3.5 Selection of Constituents of Potential Concern

The COPCs for the human health risk assessment were identified following USEPA (1989a) and TCEQ (TNRCC, 1998) guidance. The term "constituent of potential concern" does not indicate that risk is attributable to the constituent discussed at the concentration detected during sampling. The term is used by the USEPA to describe those constituents on which the risk assessment will focus. Conclusions concerning risk are made only following the quantitative risk assessment.

3.5.1 COPC Selection in Groundwater

COPCs in each of the groundwater-bearing units were selected by comparing the greater of the maximum detection or maximum SQL for each constituent to the Risk-Based Screening Value (RBSV) for groundwater. If the RBSV was exceeded, then the compound was retained as a COPC. For the Fill/Alluvial Formation Water-Bearing Unit, the RBSVs were adjusted by 100x to reflect the saline conditions of the water-bearing unit per RRR citation 30 TAC Chapter 335.559(g).

None of the inorganic constituents analyzed in the Fill/Alluvial Formation Water-Bearing Unit exceeded their respective adjusted RBSVs, therefore no constituents were identified as COPCs.

For the Beaumont Formation Water-Bearing Unit, the following constituents were selected as COPCs: antimony, arsenic, cadmium, cyanide, lead, manganese, and selenium. It is important to note that antimony was not detected in groundwater and the maximum SQL was below the site specific background value for antimony in groundwater. Lead was detected in one out of forty-four samples and neither the detection or associated SQLs exceeded the site specific background concentration for lead.

3.5.2 COPC Selection in Soil

All constituents analyzed for in soil were detected in all of the soil depth ranges considered in this risk assessment (i.e., 0 to 2 ft bgs; 0 to 5 ft bgs; and 0 to 15 ft bgs). For COPC selection purposes, the greater of the maximum detected value and maximum SQL was used. The respective maximum concentrations for each depth interval were compared to the soil RBSVs. If an exceedence occurred then the constituent was retained as a COPC.

The following constituents were selected as COPCs in soil for potential current site worker and excavation worker exposure: antimony, arsenic, barium, cadmium, cobalt, copper, manganese, mercury, nickel, selenium, silver, thallium, vanadium, and zinc.

The following constituents were selected as COPCs in soil for hypothetical future residential exposure: antimony, arsenic, barium, cadmium, cobalt, copper, manganese, mercury, nickel, selenium, silver, thallium, vanadium, and zinc.

3.5.3 COPC Selection in Surface Water

The greater of the maximum detected concentration or maximum SQL for constituents analyzed in surface water were compared to their respective GW-Res MSC values as a conservative measure. Only antimony was detected above the GW-Res MSC, however, all of the detected constituents were retained as COPCs for risk calculation.

The COPCs for surface water are: antimony, copper, manganese, nickel, and zinc.

4. Toxicity Assessment

Risk associated with exposure to chemical constituents is a function of the toxicity and exposure dose. In assessing human-health risks, a distinction is made between non-carcinogenic and carcinogenic effects. This section discusses these two categories of toxic effects and the general approach to deriving toxicity values used to calculate human-health risk for each. For potential carcinogens, the current default regulatory guidelines (USEPA, 1996) use an extremely conservative approach that assumes any level of exposure to a carcinogen hypothetically could cause cancer. This is contrary to the traditional toxicological approach, which still is applied to non-carcinogenic chemicals, where finite thresholds are identified below which toxic effects have not been observed or demonstrated. In general, a threshold approach is used to derive toxicity values protective of non-cancer endpoints and a non-threshold approach that assumes risk at any level of exposure, is used to derive toxicity values that can be used to relate exposure to estimate lifetime risk.

It is worth noting that the USEPA is in the process of revising the classification scheme for carcinogens. As announced in the Federal Register on March 3, 2003, the Draft Final Guidelines for Carcinogen Risk Assessment (February 2003) were made available for public comment. The public comment period ended June 2, 2003. According to the USEPA, the revisions are intended to make greater use of the increasing scientific understanding of the mechanisms that underlie the carcinogenic process.

4.1 Non-Carcinogenic Effects

For many non-carcinogenic effects, protective mechanisms must be overcome before the effect is manifested. Therefore, a finite dose (threshold), below which adverse effects will not occur, is believed to exist for non-carcinogens. A single compound might elicit several adverse effects depending on the dose, the exposure route and the duration of exposure. Chemicals may exhibit toxic effects at the point of application or contact (local effect), or they may exhibit systemic effects after they have been distributed throughout the body. Most chemicals that produce systemic toxicity do not cause similar degrees of toxicity in all organs. They exhibit the major toxicity on one or two target organs.

For a given chemical, the dose or concentration that elicits no effect when evaluating the most sensitive response (the adverse effect which occurs at the lowest dose) in the most sensitive species is referred to as the "no observed adverse effect level" (NOAEL). The NOAEL is used to establish toxicity values (called reference doses [RfDs] for oral exposures and reference concentrations [RfCs] for inhalation exposure). The RfD and RfC are estimates of a daily exposure level that is unlikely to cause non-carcinogenic health effects. Therefore, exposure levels must exceed a threshold dose to produce toxic effects. Chronic RfDs and RfCs are used to assess long-term exposures ranging from 7 years to a lifetime. Chronic RfDs and RfCs are used to evaluate the potential current and future site worker. Chronic RfDs and RfCs are provided on Table 4-1.

While the RfD is an estimated dose of a chemical that will not cause adverse health effects, the RfC is an estimated concentration in air that will not cause adverse health effects. The RfC accounts for the dynamics of the respiratory system, diversity between species and the difference in physical and chemical properties of chemical constituents. Therefore, parameters such as deposition, clearance mechanisms and the physical and chemical properties of the inhaled agent are considered in the determination of the effective dose delivered to the target organ. Consistent with TCEQ guidance, the RfD and RfC values used in this risk assessment were obtained from the TCEQ, or if toxicological data were not available from the TCEQ, the Integrated Risk Information System (IRIS) (2002) and Health Effects Assessment Summary Tables (HEAST) (USEPA, 1997a) were used.

Whenever possible, route-specific toxicity values are used; however, toxicity values for dermal exposure are not available (appropriate toxicity data are scarce). Therefore, the oral reference doses are adjusted to an absorbed dose, using the constituent-specific oral absorption efficiency, as recommended by the USEPA (1989). The oral RfD is multiplied by the constituent-specific oral absorption efficiency value to calculate an adjusted RfD. Oral absorption efficiency values are shown on Table 4-2. Per TCEQ guidance, if the oral absorption efficiency value is greater than 50 percent then the oral absorption efficiency is assumed to be 100 percent (TNRCC, 1999). The adjusted RfDs are shown in Table 4-3. When calculating dermal exposure to COPCs from soil, the adjusted RfD is multiplied by a dermal absorption efficiency value. When calculating dermal exposure to COPCs from groundwater, permeability coefficients are used instead of dermal absorption efficiency. Permeability coefficients can be found on Table 4-4.

4.2 Carcinogenic Effects

The induction of cancer in humans and in animals by chemicals proceeds through a complex series of reactions and processes. As with non-carcinogenic effects, chemicals may exhibit their toxic effects at the point of application or contact (local effect), or they may exhibit systemic effects after they have been distributed throughout the body. In the case of carcinogens, the target organ is the site of tumor formation or effected organ system (e.g., leukemias, lymphomas, etc.).

Chemical constituents are classified as known, probable or possible human carcinogens based on a USEPA weight-of-evidence scheme in which chemicals are systematically evaluated for their ability to cause cancer in humans or laboratory animals. The USEPA classification scheme (USEPA, 1996) contains six classes based on the weight of available evidence, as follows:

A Known human carcinogen;

B1 Probable human carcinogen -- limited evidence in humans;

B2 Probable human carcinogen -- sufficient evidence in animals and inadequate data in humans;

C Possible human carcinogen -- limited evidence in animals;

D Inadequate evidence to classify; and

E Evidence of non-carcinogenicity.

Constituents in Classes A, B1, B2, and C generally are included in risk assessments as potential human carcinogens; however, Class C carcinogens may be evaluated on a case-by-case basis (USEPA, 1989a).

Currently, the USEPA uses the linearized multistage model for extrapolating cancer risk from high doses associated with occupational exposure or laboratory animal studies to low doses typically associated with environmental exposures. The model provides a 95 percent upperbound estimate of cancer incidence at a given dose. The slope of the extrapolated curve, called the cancer slope factor (CSF), is used to calculate the probability of cancer associated with an ingested dose. Inhalation exposures are evaluated using the inhalation unit risk factor (UR_i). The unit risk is the expected excess cancer risk resulting from continuous, lifetime exposure to air containing 1 microgram per cubic meter ($\mu g/m^3$) of the chemical constituent. CSFs and UR_is used in this risk assessment are taken from the Texas Risk Reduction Program (2002b) or if necessary, IRIS (2002) or HEAST (USEPA, 1997a). CSFs and UR_is are derived from the assumption that any dose level has a probability of causing cancer. The cumulative dose, regardless of the exposure period, determines the risk; therefore, separate CSFs and UR_is are not derived for subchronic and chronic exposure periods. CSFs and URis for the COPCs are shown on Table 4-5.

Whenever possible, route-specific toxicity values are used; however, toxicity values for dermal exposure are not available (appropriate toxicity data are scarce). Therefore, the oral toxicity values are adjusted to an absorbed dose, using the constituent-specific oral absorption efficiency, as recommended by the USEPA (1989a). Oral absorption efficiency values are shown on Table 4-2. Per TCEQ guidance, if the oral absorption efficiency value is greater than 50 percent than the oral absorption efficiency is assumed to be 100 percent (TNRCC, 1999). The adjusted CSFs are shown in Table 4-3. When calculating dermal exposure to COPCs from the affected soil, the adjusted CSFs are multiplied by a dermal absorption efficiency value. When calculating the dermal exposure to COPCs from groundwater, permeability coefficients are used instead of a dermal absorption coefficient. Permeability coefficients can be found on Table 4-4.

4.2.1 Inorganics

Of the inorganic constituents selected as COPCs, only cadmium and nickel are identified as potential carcinogens, however only for inhalation, not for ingestion. The available CSFs and UR_is for the carcinogenic COPCs are shown on Table 4-5.

4.2.2 Lead

The USEPA has not developed toxicity values for lead. Lead is classified by the USEPA as a B2 carcinogen, however is regulated to protect against neurological effects. The TCEQ has calculated a health-based value of 1,600 mg/kg for lead in soil that is protective of industrial/commercial exposure conditions and a value of 500 mg/kg that is protective of residential exposure. The health-based value for commercial/industrial exposure and the health-based value for residential exposure were calculated using the USEPA Model for Assessing Risks Associated with Adult Exposures to Lead in Soil (USEPA, 1996) and the USEPA Lead Uptake/Biokinetic Model (USEPA, 1996), respectively. The Model assumes no threshold, even though this is a non-cancer endpoint. If soil lead concentrations are below the health-based value, then lead is not considered to represent a risk to the associated receptor.

5. Exposure Assessment

This section addresses the potential for human exposure to constituents detected in the groundwater, soil and surface water at the facility. This section identifies the potential receptors, exposure points, exposure routes and potentially complete exposure pathways considered in the BLRA. Subsequent sections of the BLRA combine the results of the exposure assessment with constituent-specific toxicity information to characterize potential risks.

Exposure can occur only when the potential exists for a receptor to directly contact released constituents or when a mechanism exists for the released constituents to be transported to a receptor. Without exposure, there is no risk; therefore, the exposure assessment is one of the key elements of a risk assessment. An exposure pathway is defined by four elements: (1) a source and mechanism of constituent release to the environment; (2) an environmental transport medium for the released constituent; (3) a point of potential contact with the contaminated medium (the exposure point); and (4) an exposure route at the exposure point. The objective of the exposure assessment is to estimate the types and magnitudes of exposure to the COPCs known (through sampling) to occur in soil and groundwater.

In accordance with TCEQ guidance for human health risk assessment (TNRCC, 1998), the soil EPC for a COPC is the maximum concentration (either a detected value or a SQL value) if the data set had less than 10 data points. If the data set had 10 or more data points, the 95% UCL can be used as the EPC. The EPC for the groundwater and surface water COPCs are the maximum of the detected concentration and the SQL. EPCs are assumed to remain constant over the expected exposure period. Use of the maximum detected concentration is likely to be a conservative assumption, as the sampling events were biased and exposure in most cases would be to a range of concentrations that are likely to be less than the maximum concentration, and levels of certain constituents are expected to decrease with time. The physical and chemical properties of COPCs affect intermedia transfer rates, migration potential, and future concentrations. A summary of the physical and chemical properties of the COPCs, as well as a discussion of potential migration pathways, is presented to provide a more thorough evaluation of the protectiveness of assumed exposure point concentrations.

5.1 Physical and Chemical Properties of Constituents of Potential Concern

An evaluation of the environmental fate and transport of constituents is important to understanding the current and future distribution of constituents in various media, the migration of constituents between various media and potential future migration pathways and exposure routes. The environmental fate and transport of constituents are dependent on the physical and chemical properties of the constituents, the environmental transformation processes affecting the constituents and the media through which they are migrating. The physical and chemical properties of COPCs affect intermediate transfer rates, migration to off-site exposure points and future concentrations. The primary physical and chemical properties of the COPCs and their influence on the potential for migration and persistence of the COPCs are discussed below. Then, the mechanisms of migration for the COPCs with regard to source characterization, potential migration pathways and potential for inter-media transfer are discussed.

The physical and chemical properties summarized in Table 5-1 for the inorganic COPCs include molecular weight, Henry's Law Constant, soil-water partition coefficient (K_d), diffusivity, solubility, vapor pressure and octanol-water partition coefficient (K_{ow}). For metals, many of these properties are not measurable or are dependent upon ionic state; therefore, for the metal COPCs only available properties are included in Table 5-1.

The solubility of a compound in water is the maximum or saturated concentration of the compound in pure water at a specific temperature, pH and pressure. The higher the solubility value, the greater the tendency of a constituent to dissolve in water. Highly soluble constituents are generally mobile in soil. Soluble compounds may be leached from soils into groundwater. As shown in Table 5-1, inorganics have solubilities ranging from 0 to 100,000 mg/L (only cyanide and thallium exceed 1 mg/L); therefore, they are not likely to be very mobile. Pure metals generally are insoluble, but they may form salts and complexes that can be soluble; therefore, the solubility depends on the form of the inorganic constituent, as well as the presence of other constituents.

Volatilization of a constituent from an environmental medium depends on the vapor pressure, water solubility, soil and water partitioning and diffusion coefficient. Vapor pressure, a relative measure of the volatility of constituents in their pure state, is an indication of the rate of volatilization. The diffusion coefficient can be used as a means to predict the rate at which a compound moves through the environment. Molecular diffusion is determined by both molecular properties (e.g., size and weight) and by the presence of a concentration gradient, which means that molecules of a chemical will migrate from an area of high concentration to an area of low concentration. Solubility and vapor pressure generally decrease with increasing molecular weight. Highly soluble compounds generally have lower volatilization rates from water unless they also have high vapor pressures. Inorganic constituents, especially metals, generally have both low solubility and low vapor pressure, therefore they are not considered to be volatile.

The Henry's Law Constant, combining vapor pressure with solubility and molecular weight, can be used to estimate releases from water to air. Compounds with Henry's Law Constants in the range of 10^{-3} atmospheres-cubic meters per mole (atm-m^3/mol) and greater can be expected to volatilize readily from water; those with values ranging from 10^{-3} to 10^{-5} atm-m^3/mol are associated with possibly significant volatilization, although not as readily as more volatile compounds, while compounds with values less than 10^{-5} atm-m^3/mol will only volatilize from water slowly and to a limited extent (Howard, 1989; Lyman et al., 1990). In evaluating volatilization, USEPA guidance recommends including constituents with a Henry's Law Constant value greater than 10^{-5} and a molecular weight less than 200 grams per mole (g/mol) (USEPA, 1991a). None of the inorganic constituents examined in this risk assessment meet the volatilization criteria.

The potential for a constituent to adsorb to soil particles will affect migration through soil. Sorption to soil reduces volatilization, leaching and biodegradation. The term "sorption" includes adsorption (constituent bound to the outside of soil particles) and absorption (constituent distributed throughout the particle matrix). A chemical that is adsorbed is not as mobile because it is not easily released from the particle. Conversely, a chemical that is absorbed is more easily released and therefore, more mobile. The K_d reflects the propensity of a compound to adsorb to the organic matter found in the soil. Soil with a high organic content will adsorb more organic constituents than soil with a low organic content, therefore retarding mobility. High values of K_d, coupled with low solubility characterize organic constituents with low leaching potential (low mobility), and such constituents tend to remain adsorbed to soil.

In summary, inorganics such as those found at the Encycle facility are not readily volatile, tend to adsorb onto soils, and are generally insoluble in water under neutral or slightly alkaline conditions. They can become more soluble under increasingly acidic conditions.

5.2 Potential Mechanisms of Migration

There are several mechanisms through which constituents may migrate at the facility. The constituent-containing soil can act as a source of constituents to other environmental media. Migration into air potentially can occur via volatilization from soil or fugitive dust emissions from soil; and migration from soil to groundwater potentially can occur by percolation of infiltrating rainwater that dissolves the COPCs in soil. The mechanisms of migration are discussed in this section from a conceptual standpoint together with a discussion of constituent persistence and transformations that may occur in the source or transport medium.

5.2.1 Migration in Soil

Constituents migrate in the subsurface soil primarily in the dissolved aqueous phase. Solubility in water, the tendency to bind to soil and organic carbon, type of soil (particle size distribution, clay content, organic material content, porosity and permeability) and the depth to groundwater are significant factors in determining the potential for COPCs to leach from soil to groundwater. The more soluble constituents may migrate through soil to shallow groundwater with infiltrating precipitation. The more volatile constituents, or those strongly adsorbed to dust, may migrate into air. Typically, organic constituents with high water solubilities and low K_{oc}s are particularly susceptible to these phenomena. The inorganic constituents detected in soil at the Encycle site have low solubilities and a high affinity to adsorb to soil; therefore, they are not considered very mobile.

The nature of the site soils significantly affects transport within the soil. Clays and minerals exhibit adsorptive behavior, while organic matter is capable of both adsorption and absorption. Coarse sands are very poor at sorbing chemicals. Because sorption is an equilibrium process, some of the sorbed constituents may "desorb" from the particles into the dissolved phase and be released into the soil moisture and be transported with infiltrating precipitation. These dissolved constituents then may again become sorbed to aquifer materials, followed by dispersion by groundwater transport.

The retardation factor, which provides an estimate of the rate of constituent migration, is determined by site-specific factors including soil density, effective porosity and the fraction of organic carbon. Increasing either the fraction of organic carbon in the soil, soil density or the organic carbon partition coefficient would increase the retardation factor and therefore, decrease the rate of migration from soil to groundwater.

The migration of inorganic chemicals from and through soil to groundwater is influenced by soil characteristics and water movement. Soil parameters of importance are cation and anion exchange capacities of the soil (i.e., the interaction between positively and negatively charged ions), organic carbon content, pH, oxidation-reduction potential and porosity. In general, positively charged inorganic constituents (cations) will be retarded by clays, which exhibit an overall negative charge.

5.2.2 Migration Into Air

There are two processes controlling migration of constituents into air. Organic constituents may volatilize and migrate into the air, or constituents adsorbed to surface soil may migrate into the air through the generation of dust either through wind erosion or mechanical disturbance. Constituents released into the atmosphere are subject to transport and dispersion by prevailing winds. The COPCs that have high Henry's Law Constants, vapor pressure and solubility and low K_{oc}s are more likely to be associated with the water or vapor phases than remain in soil; thus, these constituents could migrate into air via vapor emissions. Any vapors reaching the ground surface would be quickly dispersed into ambient air, thereby reducing the potential for significant exposure. The inorganic constituents detected have low Henry's Law Constants, vapor pressure and solubility, therefore vapor migration into air is not likely.

5.2.3 Migration Into Groundwater

The purpose of this section is to provide an assessment of whether constituents in soils represent a significant continuing release source to the affected groundwater beneath the facility.

The maximum concentrations for the soil constituents were compared to the residential use groundwater protection medium-specific concentrations for saline groundwater (Adj. GWP-Res MSCs). Twelve constituents had maximum concentrations that exceeded their respective Adj. GWP-Res MSC. Those constituents are: antimony, arsenic, cadmium, chromium, copper, lead, manganese, mercury, nickel, selenium, thallium, and zinc. Several soil samples with elevated total metals concentrations were analyzed for leachable metal concentrations using the synthetic precipitation leaching procedure (SPLP). SPLP metal concentrations were generally low. With the exception of cadmium in several soil samples, SPLP metal concentrations did not exceed the Adj. GW-Res values for residential exposure to saline groundwater. The SPLP data indicates the mobility of metals in soil at the site is relatively low. SPLP data is presented with the soil analytical data in Appendix B.

The topographically higher southern half of the site is located on the Beaumont Formation, and shallow groundwater in the Beaumont Formation is moderately saline. The topographically lower northern half of the site is located on fill and spoil materials and alluvium (fill/alluvium), and shallow groundwater in the fill/alluvium is saline. Groundwater from the Beaumont Formation flows into the fill/alluvium, which contains naturally saline groundwater.

5.2.4 Migration In Groundwater

Based on the groundwater data, constituents are either present in low concentrations or non-detectable in groundwater at the facility. Given the low mobility of inorganics in soils, these low levels are not expected to increase significantly over time as the inorganics potentially leach to groundwater.

5.2.5 Biodegradation and Biotransformation Processes

Biological and chemical processes occurring in the affected media can be important in determining the ultimate fate of the constituents at the areas of interest. The extent and rates of these reactions, however, are difficult to predict. Microorganisms naturally occurring in soils are able to use several organic compounds as a food source, degrading the components ultimately to carbon dioxide and water (Kostecki and Calabrese, 1989). In most cases, an organic contaminant is not broken down immediately and/or completely to carbon dioxide and water by a bacterium, but is metabolized to an intermediate compound, which is in turn further degraded. The metabolites isolated depend primarily on the time at which the reaction is monitored. Factors which contribute to the degree to which biodegradation occurs include: biodegradability rates, toxicity to microbial populations, available nutrients, pH, temperature, dissolved oxygen content, production of intermediates and the effects of mixtures. In general, these intermediate metabolites are more soluble than the parent compound and are, therefore, more mobile and more likely to be found away from the original source.

The inorganic compounds will not undergo degradation in soil and may persist, although their form may change depending on pH and availability of their ions. However, elevated inorganic concentrations typically decrease with time as a result of transport and associated dispersion processes.

5.3 Conceptual Site Model

The characteristics of the Encycle facility, the distribution of the COPCs in the affected media, and the understanding of the processes that affect fate and transport were used to develop a conceptual site model. The purpose of a conceptual site model is to provide an overview of the release sources, release mechanisms, exposure pathways, exposure points and receptors. The conceptual site models for the soil and groundwater is depicted schematically on Figure 5-1. Historical, current, and future conditions for the facility are considered in the conceptual site model.

5.3.1 Potential Human Exposure Pathways and Receptors

The human exposure pathways identified as potentially complete for each of the affected media (i.e., groundwater, soil, or surface water) at the facility include:

- Hypothetical future adult resident exposed to site-specific constituents in groundwater from a future on-site water well via ingestion and dermal contact;

- Hypothetical future child resident exposed to site-specific constituents in groundwater from a future on-site water well via ingestion and dermal contact;

- Potential current site worker exposed to site-specific constituents in surface soil (0 to 2 ft bgs) via incidental ingestion, dermal contact and inhalation of vapors and particulates;

- Potential current excavation worker exposed to site-specific constituents in surface and subsurface soil (0 to 5 ft bgs) via incidental ingestion, dermal contact and inhalation of vapors and particulates;

- Hypothetical future on-site resident exposed to site-specific constituents in surface soil (0 to 15 ft bgs) via incidental ingestion, dermal contact and inhalation of vapors and particulates; and

- Potential current adult exposure to site-specific constituents in surface water via fish tissue ingestion.

Potential risks to potential current workers associated with exposure to groundwater were not evaluated in the BLRA. There currently are no drinking water wells at the facility to facilitate an ingestion pathway and groundwater in the Beaumont Formation is deep enough (i.e., greater than 15 ft bgs) such that an excavation worker would not encounter groundwater during normal excavation activities. Additionally, no water wells are located within a ½-mile radius of the site and water for the site and surrounding area is provided by the City of Corpus Christi municipal water supply. Potential risks to direct exposure to surface water and sediments associated with the facility were not evaluated in the BLRA due to strictly enforced restrictions. Swimming, wading, recreational fishing, and boating are prohibited in the Inner Harbor where the Corpus Christi Ship Channel and Encycle facility are located (e-mail correspondence between Sarah Kowalski, Port of Corpus Christ Authority, and Ken Brandner, ARCADIS). As stated previously, risks to surface water via fish tissue ingestion were evaluated using the rationale that fish travel freely in and out of the channel and may be caught outside the prohibited area.

Potential exposure by an occasional visitor would be infrequent and short. The potential risk associated with this type of transient exposure is likely to be significantly less than that of a site worker because of the duration of exposure. Therefore, this type of exposure scenario is not warranted and is not included in the BLRA.

5.3.1.1 Exposure Point Concentrations

A basic conservative assumption underlying all exposure calculations was that the EPCs would remain constant throughout the exposure period. Natural attenuation processes were not considered. Over the entire chronic exposure period, the concentrations will likely be reduced by naturally occurring processes. Therefore, using the lesser of the maximum concentration (i.e., detected concentration or SQL) and the 95 percent UCL concentration in soil (calculated using proxy concentrations for non-detects) as the representative EPC over the entire exposure period will result in an overestimation of exposure. For groundwater and surface water, the EPC is the greater of the maximum detected concentration and the maximum SQL.

5.3.1.2 Exposure Assumptions and Equations

This section presents the exposure assumptions used to estimate average daily intakes and risks posed by the COPCs identified in Section 3.0 (see Table 5-2). Unless otherwise noted in Table 5-2, standard TCEQ default exposure assumptions were used where appropriate; however, site-data and professional judgment were used to develop some exposure assumptions. Workplace controls (e.g., use of personal protective equipment and clothing and OSHA training), which act to reduce exposure, were not factored into this BLRA.

Current risk assessment guidance requires that the averaging period used to calculate average daily exposure doses depend on the toxic effect (cancer or non-cancer). For cancer effects, the total cumulative dose was averaged over a lifetime (70 years), whereas the total cumulative dose was averaged over the exposure period for non-cancer effects. The approach for carcinogens is based on the assumptions that any dose may induce a response (non-threshold), and that a given dose has the same probability of inducing a response regardless of the exposure period. In other words, a higher dose received over a short exposure period is equivalent to a lower dose received over a lifetime, as long as the total dose is the same.

Potentially complete human exposure pathways identified include: (1) hypothetical future on-site adult resident exposure to groundwater via ingestion, and dermal contact; (2) hypothetical future on-site child resident exposure to groundwater via ingestion, and dermal contact; (3) potential current site worker exposure to soils via incidental ingestion, dermal contact, and inhalation of fugitive dust and inhalation of vapors; (4) potential current excavation worker exposure to soils via incidental ingestion, dermal contact, and inhalation of fugitive dust and inhalation of vapors; (5) hypothetical future resident exposure to soils via incidental ingestion, dermal contact, and inhalation of fugitive dust and inhalation of vapors; and (6) potential current adult exposure to surface water via fish tissue ingestion.

5.3.1.3 Hypothetical Future Adult and Child Resident Scenarios – Groundwater Exposure

Currently there are no drinking water wells at the Encycle facility. This condition is not expected to change in the future based on past, present, and anticipated future land use for the site and surrounding area. However, hypothetical future on-site resident exposure to groundwater from a hypothetical future well installed on the property was evaluated in this BLRA. Hypothetical future adult and child residents were assumed to be exposed to groundwater at a future on-site well via direct ingestion, and dermal contact. Residential exposure assumptions for groundwater exposure reflect current USEPA and TCEQ default values (USEPA, 1989a,c; 1991a,b; 1992a; TAC, 1993; TNRCC, 1998; 1999). The exposure assumptions for an adult resident and child resident (when different) exposed to groundwater are listed below and summarized in Table 5-2:

(1) Body weight of 70 kilograms (kg) (adult resident), 15 kg (child resident) (USEPA, 1991a);

(2) Exposure frequency of 350 days per year (USEPA, 1991a);

(3) Exposure period of 33 years (adult resident), 6 years (child resident) (TNRCC, 1998);

(4) Ingestion rate of 2 liters of groundwater per day (L/day) (adult resident), 0.64 L/day (child resident) (TCEQ recommended values);

(5) Exposure time for groundwater contact of 1 hour per day (hr/day) (adult resident), 0.58 hr/day (child resident) (EPA, 2001);

(6) Exposed skin surface area of 18,000 square centimeters (cm^2) (adult resident), 6,600 cm^2 (child resident) (EPA, 2001);

(7) Averaging period of 70 years (25,550 days) for carcinogenic effects (adult and child resident) and 33 years (12,045 days) for non-carcinogenic effects (adult resident), 6 years (2,190 days) for non-carcinogenic effects (child resident) (TCEQ recommended values); and

(8) Constituent-specific permeability coefficient.

The equations used to estimate hypothetical future adult and child resident exposure to groundwater are presented in Table 5-4.

5.3.1.4 Potential Current Site Worker and Excavation Worker Scenarios - Soil Exposure

Currently, those soil areas at the Encycle facility that are not covered by buildings, pavement, equipment, or other structures represent potential exposure points. Site workers and excavation workers could be exposed to soil through incidental ingestion, dermal contact, and inhalation of vapors and fugitive dust. Site worker and excavation worker exposure assumptions for soil exposure reflect current USEPA and TCEQ default values (USEPA 1989a,c; 1991a,b; TAC, 1993; TNRCC, 1999). The exposure assumptions for a site worker and excavation worker (when different) exposed to soil are listed below and summarized in Table 5-2:

(1) Body weight of 70 kilograms (kg) (USEPA, 1991a);

(2) Exposure frequency of 250 days per year (site worker) (USEPA, 1991a); 5 days per week (excavation worker) (professional judgement);

(3) Exposure period of 25 years (site worker) (USEPA, 1991a); 12 weeks (excavation worker) (professional judgement);

(4) Ingestion rate of 50 milligrams of soil per day (mg/day) (site worker); 480 mg/day (excavation worker) (TCEQ recommended values);

(5) Soil adherence rate of 0.2 $mg/cm^2/day$;

(6) Exposed skin surface area of 2,500 square centimeters (cm^2) for the skin surface area of the face, neck, hands, and lower arms (TCEQ recommended value);

(7) Averaging period of 70 years (25,550 days) for carcinogenic effects (site worker and excavation worker); 25 years (9,125 days) for non-carcinogenic effects (site worker) (USEPA, 1989a); or 84 days for non-carcinogenic effects (excavation worker) (TCEQ recommended values and professional judgement); and

(8) Constituent-specific absorption efficiency.

The equations used to estimate current and hypothetical future site worker exposure to soil are presented in Table 5-5.

5.3.1.5 Hypothetical Future Age-Averaged Child/Adult Resident Scenarios - Soil Exposure

Hypothetical future residents occupying the property could be exposed to surface soil through incidental ingestion, dermal contact, and inhalation of vapors and fugitive dust. Age-averaged child/adult resident exposure assumptions for soil exposure reflect current USEPA and TCEQ default values (USEPA 1989a,c; 1991a,b; TAC, 1993; TNRCC, 1999). For carcinogenic effects age-averaged exposure parameters are used. For non-carcinogenic effects child exposure parameters are used. The exposure assumptions for age-averaged child/adult resident exposed to soil are listed below and summarized in Table 5-2:

(1) Body weight of 15 kilograms (kg) (USEPA, 1991a);

(2) Exposure frequency of 350 days per year (USEPA, 1991a);

(3) Exposure duration of 6 years (USEPA, 1991a);

(4) Ingestion rate of 200 milligrams of soil per day (mg/day) (TCEQ recommended value);

(5) Soil adherence rate of 0.2 mg/cm^2/day;

(6) Exposed skin surface area of 2,200 square centimeters (cm^2) (TCEQ recommended value);

(7) Age-adjusted soil oral intake factor of 114 mg-yr/kg-day (TNRCC, 1998)

(8) Averaging period of 70 years (25,550 days) for carcinogenic effects and 6 years (2,190 days) for non-carcinogenic effects (USEPA 1989a), 12,045 days for non-carcinogenic effects of cadmium only (TCEQ recommended value); and

(9) Constituent-specific absorption efficiency.

The equations used to estimate age-averaged hypothetical future child/adult resident exposure to soil are presented in Table 5-6.

5.3.1.6 Potential Current Adult Scenario – Fish Ingestion

Currently, swimming, wading, recreational fishing, and boating are prohibited in the Inner Harbor where the Corpus Christi Ship Channel and Encycle facility are located (e-mail correspondence between Sarah Kowalski, Port of Corpus Christ Authority, and

Ken Brandner, ARCADIS), therefore, direct exposure to surface water in the ship channel adjacent to the facility was not evaluated as a complete pathway. However, for the purposes of this risk assessment the assumption was made that fish exposed to surface water off-shore of the facility can swim freely in and out of the reach of the channel that is adjacent to the facility and may be caught by recreational fishermen outside of the channel. Adult exposure assumptions for surface water via fish tissue ingestion reflect current USEPA and TCEQ default values (USEPA 1991a; TAC, 1993; TNRCC, 1999). Bioconcentration factors were taken from the Superfund Chemical Data Matrix (1997), Agency for Toxic Substances and Disease Registry (1996), and USEPA (1999). The exposure assumptions for the fish ingestion by an adult engaged in recreational fishing are listed below and summarized in Table 5-2:

(1) Body weight of 70 kilograms (kg) (USEPA, 1991a);

(2) Exposure frequency of 350 days per year (USEPA, 1991a);

(3) Exposure period of 33 years (TCEQ recommended value);

(4) Ingestion rate of 0.015 kilograms of locally caught saltwater fish per day (kg/day) (TNRCC, 1993);

(5) Averaging period of 70 years (25,550 days) for carcinogenic effects and 33 years (12,045 days) for non-carcinogenic effects (TCEQ recommended value); and

(6) Constituent-specific bioconcentration factor.

The equations used to estimate current adult exposure to surface water via fish tissue ingestion are presented in Table 5-7.

6. Risk Characterization

This section discusses the potential risks to human health associated with exposure to constituents in soil, groundwater, and surface water at the Encycle facility, using the exposure scenarios presented in the previous section. The estimated exposure doses are combined with toxicity values presented in Section 4.0 to quantitatively identify potential risks to human health.

6.1 General Principles

A distinction is made between non-carcinogenic and carcinogenic effects, and two general criteria are used to describe risk: the hazard quotient (HQ) for non-carcinogenic effects and the excess lifetime cancer risk (ELCR) (for Class A, B, or C carcinogens). HQs were calculated for all COPCs, and ELCRs were calculated for only the carcinogenic COPCs. A brief discussion of HQs, ELCRs, and the criteria for interpreting these values is provided below.

The HQ is the ratio of the estimated exposure dose to the RfD, or the estimated air concentration to the RfC. This ratio is used to evaluate systemic toxicant effects associated with exposure to a constituent. An HQ of 1 or less indicates that the estimated exposure dose is at or below acceptable levels for protection against non-carcinogenic effects. If the HQ exceeds 1, there may be regulatory concern for potential non-carcinogenic effects. However, the HQ does not provide the probability of an adverse effect as does the ELCR. An HQ greater than 1 indicates that the estimated exposure dose for that constituent exceeds the RfD, but it does not necessarily imply that adverse health effects will occur, because RfDs typically are set an order of magnitude or more below the NOAEL as discussed in Section 4.0. Furthermore, the level of concern does not increase linearly with increasing HQs because RfDs have different levels of confidence, are based on different toxic effects, and do not consider the slope of the dose-response curve. HQs for each constituent may be summed to derive a total non-carcinogenic hazard index (HI).

Current regulatory methodology (USEPA, 1989a) advises summing HIs across exposure routes for all media to derive a "Total Site HI." However, if the HI exceeds 1, constituents may be grouped according to critical toxic effects, and HIs may be calculated separately for each effect. This grouping by toxic effects or target organ was not done in this BLRA because none of the HIs exceeded 1. The USEPA has indicated that when the HI calculated for a site is less than 1, action generally is not warranted (USEPA, 1991c). The TCEQ uses a HI of 1 as a goal for managing systemic risks as part of site cleanups.

The ELCR is an estimate of the increased risk or probability of developing cancer that results from exposure to constituents in affected media. The ELCR is an upperbound estimate; therefore, the true risks are less than those presented. The ELCR, equal to the product of the exposure dose and the CSF or UR_i, is estimated for each known, probable, or possible carcinogenic constituent. The risk values provided in this report are indications of the increased risk, above that applying to the general population, which may result from the exposure scenarios described in Section 5.0.

Current regulatory methodology assumes that ELCRs can be summed across routes and media of exposure and COPCs to derive a "Total Site Risk" (USEPA, 1989a). The TCEQ uses the 10^{-4} (1 in 10,000) to 10^{-6} (1 in 1,000,000) ELCR range as a "target range" within which the agency strives to manage the cumulative ELCRs as part of site cleanups. The TCEQ has promulgated a policy that states that the ELCR for any one single COPC must not exceed 10^{-6}. If the cumulative ELCR exceeds the target range (i.e., cumulative ELCR greater than 10^{-4}) or the ELCR for any one COPC exceeds the target goal of 10^{-6} for single COPC risk, then PRGs must be calculated pursuant to TCEQ policy.

6.2 Human-Health Risk

A discussion of the calculated human health risks for groundwater, soil and surface water is presented in the following sections.

6.2.1 Groundwater

When calculating human health risks for groundwater exposure, the TCEQ states in the 1998 Consistency Memorandum, as well as in Section 335.563(h) of the Risk Reduction Rules, it is not necessary to include in the cumulative risk calculation COPCs that have promulgated MCLs under the Safe Drinking Water Act. It is assumed that the individual MCLs are considered to be protective of human health even in situations where a receptor is exposed to drinking water with multiple contaminants present at their respective MCLs. Following this guidance, only those COPCs that do not have MCLs and exceeded the appropriate standard, in this case the RBSV, were included in the calculations. COPCs that have MCLs and were not included in the risk calculations are discussed in the sections below.

6.2.1.1 Fill/Alluvium Formation Water-Bearing Unit

No constituents in the Fill/Alluvium Formation Water-Bearing Unit were identified as COPCs following screening against the adjusted RBSVs for groundwater, therefore it was not necessary to calculate risks for this media.

6.2.1.2 Beaumont Formation Water-Bearing Unit

The calculated HI for hypothetical future adult resident exposure to groundwater (2) exceeds the regulatory target HI of 1 (Table 6-1).

The calculated HI for hypothetical future child resident exposure to groundwater (3) exceeds the regulatory target HI of 1 (Table 6-2).

An ELCR for the hypothetical future adult resident (and child resident) was not calculated because all of the carcinogenic COPCs have federal MCLs, and therefore, in accordance with TCEQ guidance (1998 Consistency Memorandum), the site concentrations for the COPCs should be compared to their respective MCLs, but not included in a quantitative risk calculation (TCEQ, 1998). The maximum concentration or SQL of all of the constituents analyzed in groundwater were compared to their respective MCLs (Table 3-2). Those constituents exceeding their respective MCLs but not included in the risk evaluation are: antimony, arsenic, cadmium, cyanide, and selenium. Lead has an action level rather than an MCL. The action level for lead was exceeded, however as with COPCs with MCLs, lead was not included in the risk evaluation.

The only COPC included in the risk calculations for future hypothetical exposure for adult residents and future hypothetical exposure for child residents to groundwater in the Beaumont Formation Water-Bearing Unit is manganese. The HIs for hypothetical future adult resident exposure as well as child resident exposure to groundwater from the Beaumont Formation Water-Bearing Unit exceed the target goal of 1 for noncancer risks, and are considered to be unacceptable. It is important to note, however, that the risk to the background concentration of manganese (i.e., 7.6 mg/L) is essentially equal to the risk to the manganese concentration in groundwater (i.e., 7.7 mg/L) from the Beaumont Formation Water-Bearing Unit. Therefore, potential risks from impacted groundwater from the Beaumont Formation Water-Bearing Unit are not significantly different than the risks from naturally occurring groundwater.

6.2.2 Soil

Human health risks to soil were evaluated for a site worker exposed to surface soil at a depth of 0 to 2 ft bgs; an excavation worker exposed to surface/subsurface soil at a depth of 0 to 5 ft bgs; and for an age-averaged child/adult resident exposed to surface soil at a depth of 0 to 15 ft bgs. These risks are discussed individually below.

6.2.2.1 Potential Current Site Worker

The calculated HI for a potential current site worker exposure to COPCs (1) in soil meets the regulatory acceptable target HI of 1.The calculated ELCR for the potential current site worker exposure to COPCs (9 x 10^{-7}) is less than the regulatory acceptable target risk range of 10^{-4} to 10^{-6} (Table 6-3).

The COPCs that were included in the risk calculation for potential current site worker exposure to surface soils are: antimony, arsenic, barium, cadmium, cobalt, copper, manganese, mercury, nickel, selenium, silver, thallium, vanadium, and zinc. Arsenic was the primary contributor to the HI. Cadmium and nickel were the only contributors to the ELCR.

6.2.2.2 Potential Current On-Site Excavation Worker

The calculated HI for a potential current excavation worker exposure to COPCs (1) in soil meets the regulatory acceptable target HI of 1.The calculated ELCR for the potential current excavation worker exposure to COPCs (1 x 10^{-9}) is less than the regulatory acceptable target risk range of 10^{-4} to 10^{-6}. (Table 6-4).

The COPCs that were included in the risk calculation for potential current excavation worker exposure to surface/subsurface soils are: antimony, arsenic, barium, cadmium, cobalt, copper, manganese, mercury, nickel, selenium, silver, thallium, vanadium, and zinc. Arsenic was the primary contributor to the HI. Cadmium and nickel were the primary contributors to the ELCR.

6.2.2.3 Hypothetical Future On-Site Resident

The calculated HI for an age-averaged hypothetical future child/adult resident exposure to COPCs (10) in soil is above the regulatory acceptable target HI of 1. The calculated ELCR for the hypothetical future child/adult resident exposure to COPCs (1 x 10^{-7}) is less than the regulatory acceptable target risk range of 10^{-4} to 10^{-6} (Table 6-5).

The COPCs that were included in the risk calculation for hypothetical future on-site resident exposure to surface soils are: antimony, arsenic, barium, cadmium, cobalt, copper, manganese, mercury, nickel, selenium, silver, thallium, vanadium, and zinc. Arsenic was the primary contributor to the HI. Cadmium and nickel were the primary contributors to the ELCR. The calculated HI for hypothetical future child/adult resident exposure to surface soils exceeds the target goal of 1 for noncancer risks, and is considered to be unacceptable.

6.2.3 Fish Ingestion

The calculated HI for a potential current adult exposure to surface water COPCs via fish tissue ingestion (1) meets the regulatory acceptable target HI of 1. It was not possible to calculate an ELCR for exposure to surface water via fish tissue ingestion because all of the COPCs identified are classified as non-carcinogens (Table 6-6).

The COPCs that were included in the risk calculation for potential current adult exposure to surface water via fish tissue ingestion are: antimony, copper, manganese, and zinc. Antimony was the primary contributor to the HI.

6.2.4 Exposure to Lead

Because no USEPA-verified toxicity values exist for lead, the risks associated with exposure to lead cannot be evaluated using conventional risk assessment methods. The TCEQ's pre-calculated clean-up value for residential exposure to lead is 500 mg/kg and 1,600 mg/kg for commercial industrial exposure. The concentrations of lead in soils 0 to 2 ft bgs (2,700 mg/kg) and 0 to 5 ft bgs (1,800 mg/kg) exceed the pre-calculated TCEQ clean-up value of 1,600 mg/kg for commercial industrial exposure. The concentration of lead in soils 0 to 15 ft bgs (1,300 mg/kg) exceeds the TCEQ's pre-calculated clean-up value of 500 mg/kg for residential exposure.

6.3 Preliminary Remediation Goals

TCEQ guidance (Section 30: TAC, Chapter 335, Subchapters A and S) states that PRGs must be calculated for an individual COPC if its ELCR exceeds 1×10^{-6}, or its HQ exceeds 1, or if the cumulative ELCR for all COPCs exceeds 1×10^{-4}, or the cumulative HI exceeds 1. The potential exposure to groundwater from the Beaumont Formation Water-Bearing Unit by a future hypothetical adult resident and child resident, as well as the age-averaged hypothetical future child/adult resident exposure to surface soils, resulted in HIs in excess of the target risk goals for each receptor. Therefore, PRGs were calculated for each of the COPCs that were included in the risk calculations for those hypothetical future scenarios.

Two methods can be used to calculate the PRGs. The first method involves combining the intake levels of each chemical receptor from all of the routes of exposure (i.e. inhalation, dermal, and incidental ingestion) for a particular medium and manipulating the site-specific risk equation to solve for the concentration. However, a simplified ratio method based on site-specific exposure data can be completed when the site specific risk has previously been calculated (USEPA, 1995). The ratio is between the target risk and calculated risk from a specific COPC and medium using the EPC as a multiplier. This ratio method was used to calculate PRGs for this BLRA. In the PRG calculation tables (Tables 6-7, 6-8, and 6-9), an asterisk "*" next to a PRG indicates that the COPC EPC exceeds the respective PRG.

The COPC PRGs presented in the BLRA may be compared to maximum detected media concentrations that reflect current conditions. Comparison of scenario-specific PRGs to individual COPC concentrations is a valid approach to evaluate the necessity for risk management and to help evaluate the need for remedial activity at the site.

The results of the PRG calculations for each media are presented in the following sections.

6.3.1 Beaumont Formation Water-Bearing Unit

The EPC and PRG for hypothetical future adult resident exposure to groundwater from the Beaumont Formation Water-Bearing Unit are provided in Table 6-7. The EPC for manganese (7.7 mg/L) exceeded the calculated PRG (4.7 mg/L).

The PRG for hypothetical future child resident exposure to groundwater from the Beaumont Formation Water-Bearing Unit are provided in Table 6-8. The EPC for manganese (7.7 mg/L) exceeded the calculated PRG (2.6 mg/L). It is important to note that even though the concentration of manganese exceeds the calculated PRG, it is only slightly above the site-specific background concentration for manganese of 7.6 mg/L.

6.3.2 Soil 0 to 15 ft bgs

The EPCs and PRGs for age-averaged hypothetical future child/adult resident exposure to surface soils are provided in Table 6-9. The EPCs for cadmium (140 mg/kg) exceeds the calculated PRG of 77 mg/kg. The concentrations of arsenic (120 mg/kg) and lead (1,300 mg/kg) exceed their respective TCEQ health-based clean-up values of 20 mg/kg and 500 mg/kg for residential exposure. The EPCs for all of the remaining COPCs are below their respective PRGs (Table 6-9).

7. Ecological Risk Assessment

This section of the report contains a screening-level ecological risk assessment (SLERA) for the Encycle site. The site includes 21 SWMUs discussed in the RCRA Facility Investigation Report (ARCADIS 2002). This SLERA has been prepared in accordance with Section VII.B. of the Consent Decree issued to Encycle/Texas, Inc., and ASARCO, Inc., which was entered in the United States District Count for the Southern District of Texas on October 6, 1999.

The SLERA follows the methodology outlined in the guidance for conducting ecological risk assessments issued by the Texas Commission on Environmental Quality (TCEQ, 2001). The Texas Risk Reduction Program (TRRP) Rule (30 TAC §350) cites the general outline and minimum requirements for an ecological risk assessment. The TRRP Rule states that properties with suspected contamination under the jurisdiction of the TCEQ's corrective action programs need to evaluate the potential hazards to human health and the environment.

The objectives of the SLERA are the following:

a) Compare conservative, representative media concentrations to the guidance ecological screening benchmarks in order to eliminate from further consideration any contaminants in environmental media that is not likely to cause adverse effects to the biota of the local ecosystem(s);

b) Consider the significant and likely exposure pathways by which constituents of potential ecological concern (COPECs) in the media can affect the biota of the local ecosystem(s);

c) Roughly estimate, with marked conservatism, the magnitude of exposure and toxicological effects to representative biota of the local ecosystem(s);

d) Use the hazard quotient methodology to dismiss additional COPECs from further consideration, and discuss the likelihood of adverse ecological effects being caused by the remaining COPECs; and

e) Provide risk management recommendations to mitigate any potential adverse effects caused by chemical contamination of environmental media at the affected properties.

8. Site Background

8.1 Site Description

The site is located within a heavily industrialized area of Corpus Christi, Texas between the Corpus Christi Ship Channel and Up River Road (Figure 2-1). The Corpus Christi Ship Channel is located directly north of the site, and the ship channel enters Corpus Christi Bay approximately 4 miles east of the site. The ship channel in the site area is industrialized and is a high traffic navigational segment that is periodically maintained (dredged) for navigational purposes.

The biological diversity and productivity of the Corpus Christi Bay system, including the Corpus Christi Ship Channel, is threatened by anthropogenic activities, including oil and gas production, petrochemical refining, industrial expansion, shipping, surface mining, agricultural development, reduction and redirection of surface water flows, navigation channel dredging, and urbanization. The Inner Harbor (i.e., ship channel) covers approximately 2 square miles of surface area and receives the discharges of one municipal and 44 industrial permitted outfalls (TWC, 1992). Historically, discharges from chemical and petrochemical facilities, as well as spills from shipping transfer activities, have been sources for the deposition of heavy metals and organic pollutants in sediments (Barrera et al., 1995).

8.2 Ecological Habitat

Information on land cover on-site and in the vicinity of the affected areas was obtained from U.S. Geological Survey topographical maps, U.S. Corps of Engineers Final Environmental Impact Statement for the Corpus Christi Ship Channel, and on-site field visits. Land cover types are presented in Figure 2-3 and are classified as follows:

- *Open Water* includes streams, rivers, lakes, and estuaries.
- *Emergent Wetland* includes areas with herbaceous aquatic vegetation such as a cattail marsh (*Typha* spp.).
- *Shrub/Scrub* land cover is upland dominated by woody vegetation less than six meters in height.
- *Agriculture/Open Urban* land cover encompasses primarily agricultural fields and areas of weedy, dense herbaceous vegetation including various grasses (*Cynodon dactylon*.) and wildflowers.

- *Urban* land cover includes industrial, commercial, and residential land use.
- *Barren* areas consist of exposed soil devoid of vegetation.

The following sections provide detail on the terrestrial habitat, aquatic habitat, land use and habitat in the surrounding area, and threatened and endangered species information.

8.2.1 Terrestrial Habitat

The Encycle property measures approximately 108 acres, however not all of it is easily accessible to wildlife. The Encycle plant (production area) is characterized as urban land use, and comprises approximately 73 acres of the 108 total acres. The plant production area is enclosed by a fence and is further separated from the lower coastal area (fill/alluvium) by a steep, vegetated embankment. There were no large trees within the site; however a few small trees/shrubs are present along the fenceline at the north end of the plant production area, in the Waste Pile Area located in the southwest corner of the site, and adjacent to the East and West Lagoon perimeter concrete wall. The land cover outside of the plant production area (which comprises approximately 35 acres of the Encycle property plus the 54-acre Grain Elevator) is predominantly weedy, dense herbaceous vegetation including various grasses (P*anicum spp*). The 01 Landfill is a 5.8-acre landfill that was covered with a clay cap and closed in 1986. The landfill is located in the northeast corner of the site and is currently covered with dense grass, providing suitable habitat for wildlife. The Grain Elevator (west of Encycle), Boneyard (northwest corner of site), Waste Pile and the open area along the railroad tracks right-of-way north of the Encycle plant production area are all covered with grasses or shrubs and offer limited habitat to wildlife. Direct observations and/or physical signs of shore birds and raccoons (*Procyon lotor)* were noted during the site visit. Photographs of the site are provided in Appendix F.

8.2.2 Aquatic Habitat

The East and West Lagoons are located between the ship channel and the Encycle plant production area. The East Lagoon is approximately 3.5 acres and has an earthen bottom. The West Lagoon is approximately 0.5 acres in size, and has a concrete wall and a polyethylene liner on the bottom and supports no vegetation. The sediments above the West Lagoon HDPE liner, and the sediments and affected clay bottom of the East Lagoon were remediated (excavated) between November 2003 and March 2004 as part of the approved closure plan for the East and West Lagoons. However, the lagoons will continue to be used for storage of storm water from the Encycle plant production area. During the January 30, 2004 site inspection, numerous water fowl species (gulls, terns, shorebirds) were observed using the lagoon area as a resting point (see Appendix F, photograph 6).

The Corpus Christi Ship Channel is located north of the site and measures approximately 1000 feet wide at that point. The channel is approximately 9 miles in length and enters into Corpus Christi Bay approximately 4 miles east of the Encycle facility. Banks are lined with cement rip-rap in the vicinity of the site and a small depositional area is located along the south bank in the extreme northeast corner of the property. Water depths measure two feet or less near the shoreline and increase rapidly at approximately 10 feet from the shore. Sediment observed during the January 30, 2004 sampling event was silty to sandy clay and clayey fine sand with large amounts of bivalves measuring 1-2 cm in length. Oysters were also observed attached to the rip-rap along the shoreline. No aquatic vegetation was observed along the ship channel shoreline. The use classification of the ship channel is non-contact recreation and intermediate aquatic life (30 TAC Chapter 307.10). The Corpus Christi Ship Channel is heavily industrialized with high navigational traffic.

8.2.3 Surrounding Land Use and Habitat

Surrounding land use is predominately industrial. Major petroleum and other various processing refineries line the Corpus Christi Ship Channel. However, on a regional scale, this area is located within a large coastal estuarine ecosystem. The surrounding coastal area, or the Corpus Christi Bay complex, lies within the southeastern portion of the Gulf Prairies and Marshes vegetational region (Gould, 1975). The bay complex is classified as "the low marshes with tide water influence". It is a highly adaptive community that changes in response to the fluctuating environmental conditions (Army Corps of Engineers [ACE], 2003). Vegetational habitats include submerged aquatic vegetation, coastal wetlands, open water/reef habitat, and coastal shore habitat. The area is semi-arid and hot with marked deficiency of moisture for plants (ACE, 2003). Wildlife habitats found within this area include upland prairies, salt marsh and seagrass beds, and tidally influenced lowlands.

Wildlife present in the Corpus Christi Bay Complex include numerous species of snakes (western diamondback rattlesnake, ground snake) and other reptiles (western glass lizard), and many birds (herons, gulls, shorebirds, wading birds) both regional and migratory. Texas is one the most significant waterfowl wintering regions in North America with three to five million waterfowl annually wintering in the state (Texas Coastal Management Program (TCMP), 1996). Terrestrial mammals likely to occur in the Corpus Christi Bay Complex include the black tailed jack rabbit (*Lepus californicus*), common raccoon, striped skunk (*Mephitis mephitis*), and coyote (*Canis latrans*) (ACE, 2003).

8.2.4 Threatened and Endangered Species

Information on threatened and endangered species in the Corpus Christi Bay Complex was obtained from the Final Environmental Impact Statement (EIS) for the Corpus Christi Ship Channel Improvements Project (ACE, 2003). County lists of special species provided by the Texas Parks and Wildlife Biological Conservation Data System (TXBCD) and the most recent list of threatened and endangered species of Texas by county provided by the Fish and Wildlife Service (FWS) were reviewed for production of the Final EIS. TXBCD data files were also reviewed in order to obtain specific species' locations within the study area. Listed endangered and threatened species and species of concern determined by the Corps of Engineers as potentially occurring in the Corpus Christi Bay complex and tabulated in Table 3.6-1 of the EIS are presented in Table 8-1. A number of federally listed endangered and threatened species of reptiles, birds, and mammals utilize the estuary ecosystem for migratory, wintering, or resident habitat (Barrera et al., 1995); however, because of the present and historical industrial land use of the site and the immediate surrounding land use of the ship channel, listed species are not expected to occur on the Encycle property. Two species, one plant and one bird, may be exceptions because of their habitat preferences. A species of concern, the Texas windmillgrass (*Chloris texana*) has been recorded in Nueces County along the Gulf Coast. It prefers silty and sandy loam soils which are found on the Encycle site. The federally and state endangered brown pelican (*Pelecanus occidentalis*) has been observed utilizing the Inner Harbor for foraging (Barrera et al., 1995). No threatened, endangered, or species of concern were observed during the January 30, 2004 site inspection.

9. Tier 1 Exclusion Criteria Checklist

The Tier I Exclusion Criteria Checklist is intended to aid the TCEQ in determining whether or not any further ecological evaluation is necessary at a site. This SLERA, which supersedes the Tier I Checklist, has been prepared in accordance with the Consent Decree which requires the completion of a baseline risk assessment that shall "identify and evaluate risk for all potential receptors, and if necessary, identify and evaluate corrective measure alternatives and recommend appropriate corrective measure(s) to protect human health and the environment". Therefore, the completion of the Tier 1 Exclusion Criteria Checklist is considered unnecessary and is not included with this report.

10. Constituent Characterization

This section describes the occurrence of constituents detected in surface water, pore water, soil, and sediment at the Encycle site.

The data were reduced and analyzed for use in the SLERA according to the guidelines provided by the TCEQ (1999, 2001) and EPA (1989, 1995), as described below:

- All analytical results reported as detections were used at the reported value, including laboratory estimated data (J-qualified).

- For constituents within a data group reported as non-detected (non-detects), one-half of the sample quantitation limit (SQL) was used as a proxy concentration rather than using zero or eliminating the data point. In instances where one-half of the SQL exceeded the maximum detected concentration for that constituent in that data group (i.e., as in an unusually high SQL), the maximum detect was used as the proxy value for that non-detect.

- For duplicate soil samples, the result for each sample was used as a separate data point. Due to the non-homogenous nature of the soil and sediment, samples were not averaged.

The results of the statistical analyses are presented in the constituent occurrence tables (Tables 10-1 through 10-5). The information in these tables includes:

- the frequency of detection (ratio of the number of detects to the total number of samples in that group);

- the percent of detects;

- the range of SQLs used as proxy concentrations for non-detects in the statistical calculations;

- the range of detected values; and

- the arithmetic mean; arithmetic mean concentrations were calculated using proxy concentrations for non-detects.

10.1 Data Compilation

Analytical data used in this SLERA are provided in Appendix A, B, C, D, and E. Data sources and constituent concentrations are summarized below. Soil, sediment, and surface water sample locations are presented in Figures 4-2, 4-3 and 4-4, respectively.

Over 300 soil samples from 0 to 5 feet below ground surface (bgs) have been collected from the site from 1993 to the present. Below is a brief description of the soil sampling events. A more detailed discussion of the investigations is presented in the 2002 RFI (ARCADIS, 2002) and the 2003 Phase II RFI (ARCADIS, May 2003).

- In May and June 1993, K.W. Brown Environmental Services (KW Brown) sampled soil from 0 to 5 feet bgs from the 01 Landfill perimeter, Waste Pile Area, East Lagoon, and West Lagoon perimeter. Samples were analyzed for metals including arsenic, cadmium, copper, lead, manganese, nickel and zinc. This investigation was part of the 1993 RFI (KW Brown, 1993).

- In June and July 2000, ARCADIS, in accordance with the RFI Work Plan (ARCADIS, 2000), collected soil from 0 to 5 feet (bgs) in a plant wide sampling event. Sampled areas included Building C, Former Sludge Drying Beds, North and South Demin Tanks, Old Casting Building, Landfill 01, Storm Sewer, Boneyard, Waste Pile Area, and the East and West Lagoons. Samples were analyzed for total metals.

- In November 2001, ARCADIS installed RFI step out soil borings on the Union Pacific Railroad Company Right-of-Way. Samples were collected (0 to 4 bgs) from the right-of-way as well as the 01 Landfill (step out), Old Casting Building, East and West Lagoons (step out), the Boneyard and the Grain Elevator (west of Encycle). Samples were analyzed for total metals.

- In February 2003, soil was collected from 0 to 5 feet bgs from the Waste Pile (step out), East and West Lagoons (step out) and the Grain Elevator. Samples were analyzed for total metals.

- In September 2003, 12 sediment samples were collected from the Corpus Christi Ship Channel close to (within 40 feet) of the south shoreline. Sediment was sampled from 0 to 6 inches in depth and analyzed for total metals. Concentrations of metals in one or more samples exceeded site-specific background except for chromium and cyanide.

- In October 2003, 24 additional sediment samples (SED-13 through SED-36) were collected (0 to 6 inches in depth) radially outward (further north) of sediment samples SED-1 through SED-12 to complete the delineation of affected sediment associated with the Encycle 01 Landfill. These additional sediment samples included samples from the center of the Ship Channel and near the north shoreline in water depths of up to 53 feet. The sediment samples were analyzed for total metals. Cadmium, copper, manganese, mercury and zinc concentrations exceeded site-specific background in one or more samples.

- In January and February 2004, sediment and surface water samples were collected from previous sampling locations SED-1, SED-4, SED-7, and SED-10 near the south shoreline of the Corpus Christi Ship Channel adjacent to the 01 Landfill in water depths of 2 feet. Four background surface water samples also were collected from the ship channel during this time. The sediment samples were collected from 0 to 6 inches and analyzed for total metals, simultaneously extracted metals (SEM), acid volatile sulfide (AVS), and total organic carbon. All metals exceeded site-specific background sediment concentrations in one or more samples. Pore water was extracted from the sediment and analyzed for dissolved metals. Surface water was analyzed for total and dissolved metals. In surface water, dissolved antimony and manganese exceeded dissolved background concentrations in one or more samples. Total manganese and total nickel concentrations in the surface water sample from SED-1 exceeded their associated total background concentrations. For two surface water samples (SED-1, SED-4), dissolved antimony was detected at concentrations greater than the corresponding total antimony concentrations. Due to this discrepancy, the samples were reanalyzed and yielded similar results. The March 29, 2004 laboratory case narrative in Appendix H states the reason for the discrepancy between total and dissolved antimony is due to a high sodium concentration in the samples. The original concentrations reported by the laboratory were used in this risk assessment.

11. Use of Ecological Screening Benchmarks

Per the TCEQ ERA guidance, the first step of a SLERA is the comparison of environmental concentrations to ecological screening benchmarks. The ecological screening benchmarks used are those found in Tables 3-2 through 3-4 of the TCEQ ERA guidance. The details of their literature sources and mathematical derivation can be found in Appendix A of the ERA guidance. The ecological screening benchmarks are meant to conservatively represent the upper limit of constituent concentrations that will not cause adverse effects to exposed biota inhabiting the environmental medium. The exception is bioaccumulative constituents that may cause greater exposure to certain species of higher trophic levels in the food chains of the food web. The list of bioaccumulative constituents and elements are in Table 3-1 of the guidance. Non-bioaccumulative constituents in an environmental medium that have concentrations below the ecological screening benchmarks can be considered to be of no further ecological concern for that environmental medium and can be eliminated from additional evaluation in the ERA process. Measured constituents in an environmental medium, bioaccumulative or not, that have concentrations below site-specific background concentrations can likewise be eliminated. Measured constituents in an environmental medium that have concentrations above the ecological screening benchmarks, or that are considered bioaccumulative and are above the background concentrations, are labeled chemicals of potential ecological concern (COPECs) and are evaluated further in the SLERA.

11.1 Water

The occurrence summary information and comparison of measured surface water concentrations to background concentrations and ecological screening benchmarks is presented in Tables 10-1 and 11-1. Specific parameters have screening values for the dissolved portion of water and some have values for the total concentration. Since both dissolved and total concentrations were measured for the site, the appropriate concentration was compared to the screening value. The results show there are no constituents retained as a COPEC in surface water. Arsenic, cadmium, cobalt, copper, lead, mercury, nickel, selenium, silver, thallium, tin and zinc were eliminated from further evaluation because their maximum concentrations did not exceed the background upper tolerance limit (UTL). Total nickel was detected above the background UTL in one surface water sample (SED-1). However, the TCEQ screening benchmark for nickel is based on the dissolved nickel concentration (TCEQ, 2001), and dissolved nickel was not detected in any of the samples.

Manganese concentrations in the surface water samples from SED-1 exceed background but do not exceed the ecological screening benchmark, and manganese is not bioaccumulative. Therefore, manganese is eliminated from further evaluation. Dissolved antimony concentrations in the surface water samples from SED-1 and SED-2 exceeded background. However, the TCEQ screening benchmark for antimony is based on the total antimony concentration (TCEQ, 2001) which did not exceed background.

11.2 Sediment

The occurrence summary information and comparison of measured sediment concentrations to background concentrations and ecological screening benchmarks is in Tables 10-3 and 11-2. The results show that metals (antimony, arsenic, cadmium, cobalt, copper, lead, manganese, mercury, nickel, selenium, silver, thallium, tin and zinc) will be retained as COPECs and further evaluated, because of sediment screening value exceedances or lack of ecological benchmarks for this medium. Thallium is the only sediment COPEC that lacked a screening value and it did exceed the background concentration. It is interesting to note however, that the maximum thallium concentration (0.9 mg/kg) only slightly exceeds the site-specific background UTL for the ship channel sediment (0.88 mg/kg). Bioaccumulative COPECs that will be evaluated in sediment include cadmium, copper, mercury, nickel, selenium, and zinc.

For cadmium, copper, lead, nickel, and zinc, SEM data are also considered in this SLERA. Occurrence summary information is presented in Table 10-3. The SEM-AVS approach is further discussed in Section 16. As a third line of evidence, concentrations of dissolved metals in sediment pore water are compared in this SLERA to TCEQ ecological screening criteria (2001) developed for surface water, consistent with the equilibrium partitioning approach (EPA, 2000a,b,). Pore water occurrence summary information is presented in Table 10-2. Sediment pore water is further discussed in Section 16. Site-specific analyses (i.e., AVS/SEM, pore water) were conducted on selected near-shore sediment samples from the Corpus Christi Ship Channel adjacent to the Encycle site to determine the degree of bioavailability posed by the metal COPECs.

11.3 Soil

The occurrence summary information and comparison of measured surface and total soil concentrations to background concentrations and ecological screening benchmarks is presented in Tables 10-4, 10-5, 11-3 and 11-4. Surface soil is defined in this SLERA as soil collected from 0 to 0.5 feet bgs while total soil is defined as soil collected from 0 to 5 feet bgs. The results show that all constituents (antimony, arsenic, barium, bismuth, cadmium, chromium, cobalt, copper, cyanide, lead, manganese, mercury, nickel, selenium, silver, thallium, tin, vanadium and zinc) for both surface and total soils will be retained as COPECs and further evaluated, due to an exceedance of screening values or a lack of ecological benchmarks for this medium. Bismuth and cyanide lacked ecological soil screening values and therefore were retained for further evaluation. Both constituents did exceed site-specific background concentrations. Bioaccumulative compounds, as listed in the TCEQ guidance were also retained for food web evaluation. Bioaccumulative COPECs in soil include cadmium, chromium, copper, lead, mercury, nickel, selenium, and zinc.

12. Communities, Feeding Guilds, and Representative Species

Identification of communities, feeding guilds, and representative species that might be supported by habitats present at the site is important to the development of the ecological conceptual site model (Section 13). Additionally, exposure estimation and measures of effect are determined based on the identification of such levels of ecosystem organization for the site. This is the second required element of the TCEQ Tier 2 SLERA process. The TCEQ guidance for ERAs defines ecological communities as those that reside in environmental media potentially contaminated by the COPECs: soil invertebrates, terrestrial vegetation, benthic invertebrates, water-column invertebrates, algae, and rooted aquatic vegetation. Feeding guilds are primarily meant to describe broad aggregations of various species that share a common feeding strategy (e.g., herbivores) and often have similar physiological characteristics and related taxonomy (e.g., mammals or raptors). The representative species are the "selected ecological receptors of interest (ROIs)" used in the SLERA to evaluate the magnitude of exposure, type of adverse effects, and presence of risk to the feeding guild or community they represent at the site.

Assessment endpoints are explicit expressions of the environmental value that is to be protected, operationally defined by an ecological entity (e.g., fish, birds, mammals) and its attributes (e.g, community structure, survival, growth, reproduction). Assessment endpoints are selected based on ecological relevance, susceptibility (which is a combination of toxicological sensitivity and potential for exposure), and relevance to management goals. Assessment endpoints are listed in Section 17 for terrestrial and aquatic communities.

A measurement endpoint is defined as a measurable ecological characteristic that is related to the valued characteristic chosen as the assessment endpoint, and is a measure of biological effects. In some cases, it is possible to directly measure the assessment endpoints selected for evaluation (e.g., surveys of biological community quality). Direct measurement of assessment endpoints minimizes the need to extrapolate between the measurement and the goal. Comparisons of estimated exposures with toxicological information for each COPEC facilitate the interpretation of biological community data and serve as the primary measurement endpoint where biological community data are not available. Thus, more than one measurement endpoint may be selected for a given assessment endpoint. Measurement endpoints are discussed in this section for terrestrial and aquatic communities.

12.1 Terrestrial Communities

Terrestrial ecological communities within the Encycle property include soil invertebrates, terrestrial vegetation, omnivorous mammals and carnivorous birds. The site covers barren areas that lack vegetation within the Encycle plant and areas outside the main plant that offer large grassy and vegetative areas as well as open water that are easily accessible to wildlife. This lower coastal area sits between the main Encycle plant and the Corpus Christi Ship Channel and contains the 01 Landfill and East and West Lagoons (Figure 2-3). There are no large trees within the entire property and only small shrubs and brush within the coastal area and the Waste Pile. The Grain Elevator and Boneyard are currently covered with sparse vegetation.

The terrestrial conceptual food web (Figure 12-1) for the site was adapted from Figure 3-5, Example Texas Upland Forest Food Web, included in the TCEQ ERA guidance. Even though there are no large trees on the site the upland forest example best approximates the vegetation of the site. A species inventory was not performed at the affected properties, but it is likely that not all of the species noted in Figure 12-1 inhabit or frequent the Encycle property due to the size and industrial setting of the surrounding lands. It is possible, however, that at least one species of some of the depicted feeding guilds frequents the site, especially the lower coastal area, on occasion and may be exposed to soil COPECs. The depicted feeding guilds are the following: herbivorous mammals, herbivorous birds, omnivorous amphibians/reptiles, omnivorous mammals, omnivorous birds, carnivorous mammals, carnivorous reptiles, and carnivorous birds. Some of the feeding guilds are not being directly evaluated for exposure and adverse effects, and the reasoning is as follows:

- Herbivorous and Omnivorous Birds: The species of these feeding guilds are not anticipated to be as exposed to the soil COPECs, either directly or indirectly, as the carnivorous birds. The carnivorous birds' guild, being higher in trophic level, exhibits higher biomagnification of bioaccumulative COPECs and, thus, would be more greatly exposed than herbivorous or omnivorous birds. Therefore, the use of a representative receptor from the carnivorous birds feeding guild to estimate the potential for adverse effects should be protective of the herbivorous and omnivorous birds' guilds.

- Herbivorous Mammals: The species of this feeding guild are not anticipated to be as exposed to the bioaccumulative COPECs as the omnivorous mammals that are at a higher trophic level in the food chain. Omnivorous mammals typically have larger foraging ranges than herbivorous mammals and therefore would be more likely to be exposed to a larger area of affected soil within the Encycle property. Additionally, some members of the omnivorous mammals' guild have higher incidental soil ingestion rates than species of the herbivorous mammals' guild, increasing their exposure.

- Omnivorous Amphibians/Reptiles: Literature data for exposure parameters and toxicological effects to these taxa are lacking at this time. There would be a great amount of uncertainty in attempting to quantify exposure and the potential for adverse effects.

- Carnivorous Mammals: The species of the omnivorous feeding guild are more likely to occur on-site for a longer duration and derive a larger portion of their diet than any carnivorous mammals that might access the site. Most typical carnivorous mammals, such as the coyote or red fox have home ranges that are significantly larger than the site, and as such it is unlikely that they could derive a significant portion of their diet from the Encycle site. The non-production areas of the site (e.g., Landfill 01) that contain some amount of vegetative cover comprise approximately 89 acres of the total 162 acre site, including the 54-acre grain elevator property. Home ranges of 1,920 acres to 19,840 acres (3 to 31 square miles) have been reported for coyotes (Bekoff, 1978), and for red fox, home ranges have been reported from 193 acres to 4,860 acres (78 to 1,967 hectares) (EPA, 1993). Additionally, the site is enclosed by a fence on three sides and by the ship channel to the north, and surrounding land use is industrial with high road and navigational traffic. For these reasons, it is unlikely that carnivorous mammals access the site on a regular basis, and even if exposure does occur, it is most likely of a transient nature. Therefore, it was not considered necessary to include this guild in the quantitative evaluation.

- Carnivorous Reptiles: Literature data for exposure parameters and toxicological effects to the reptile taxon are lacking at this time. There would be a great amount of uncertainty in attempting to quantify exposure and the potential for adverse effects.

The representative species that have been chosen to be the terrestrial ROIs for their respective feeding guilds are noted in Figure 12-1 by asterisks. They are the following:

- White Footed Mouse (Burrowing Omnivorous Mammals feeding guild);

- Raccoon (Non-Burrowing Omnivorous Mammals feeding guild); and

- Red-tailed Hawk (Carnivorous Birds).

The assessment endpoint for each of the feeding guilds represented by the selected ROIs is the following: sustainable productivity of the guild and the viability of other guilds that are primarily dependent on the selected guild. Other assessment endpoints include terrestrial invertebrate community structure and function; and terrestrial plants community structure and reproduction. The corresponding measurement endpoints are:

- For terrestrial invertebrates and plants: comparison of COPEC concentrations in soil to benchmark concentrations intended for the protection of earthworms and plants; and

- For the ROIs: comparison of the predicted intake of COPECs in soil and biota to toxicity reference values (TRVs). It is assumed that the raccoon is exposed to surface soil while the burrowing white footed mouse and carnivorous red tailed hawk are exposed to total soil.

12.2 Aquatic Communities

Aquatic ecological communities within and adjacent to the Encycle property include benthic invertebrates, fish, and wading/shore birds. The Corpus Christi Ship Channel is a highly navigated, tidally influenced, ship channel that is maintained (dredged) approximately every three to five years (ARCADIS, 2003). The banks of the ship channel are covered with rip-rap down to the low-tide water line where oysters are abundant, and the sediment is silty to sandy clay. A portion of the sediment is composed of bivalve shells. Other macroinvertebrates were not observed during the site visit. Water depths in the ship channel range from approximately 2 feet near the shore to over 50 feet in the center of the channel. Rooted aquatic vegetation was not observed during the site visit, however algae was present on the rip-rap along the water line. Riparian vegetation consists of weeds and various grasses. Aquatic habitat areas are depicted in Figure 2-3.

The East and West Lagoons are permitted active storm water retention lagoons and are considered an on-site SWMU. The West Lagoon is approximately 0.5 acre with an 80-millimeter high-density polyethylene (HDPE) liner and the East Lagoon is approximately 3.5 acres with an earthen bottom. The East and West Lagoons are periodically dry during drought conditions but generally contain water throughout most the year. They are connected via a concrete spillway and both have 9 foot high perimeter concrete walls. As described previously, the lagoons are permitted storm water retention lagoons that have been recently remediated in accordance with the approved Closure Plan for the East and West Lagoons. Therefore, in accordance with TCEQ guidance (TCEQ, 2001) these permitted storm water impoundments meet the

TCEQ's exclusion criteria for an incomplete pathway and do not warrant further evaluation in this SLERA.

The aquatic conceptual food web (Figure 12-2) for the Corpus Christi Ship Channel was adapted from Figure 3-11, Example Texas Estuarine/Wetland Food Web, included in the TCEQ ERA guidance. A species inventory was not performed in the ship channel, but it is likely that not all of the species noted in Figure 12-2 inhabit or frequent the area due to the industrial setting of the site and surrounding lands. It is possible, however, that at least one species of some of the depicted feeding guilds frequent the ship channel on occasion and may be exposed to sediment and surface water COPECs. The depicted feeding guilds are the following: herbivorous/planktivorous fish, herbivorous mammals, herbivorous birds, omnivorous fish, omnivorous amphibians/reptiles, omnivorous mammals, omnivorous birds, carnivorous fish, carnivorous amphibians/reptiles, carnivorous mammals, carnivorous shore birds, and carnivorous birds. Some of the feeding guilds are not being directly evaluated for exposure and adverse effects, and the reasoning is as follows:

- Herbivorous/Planktivorous Fish: This feeding guild is expected to exist in the Corpus Christi Ship Channel. However, toxicological information in the form of dose and effects for fish, as a general taxonomic group, are deficient in the scientific literature at this time. Thus, quantifying the potential for adverse effects (i.e., computing hazard quotients) from the COPECs is not possible.

- Herbivorous Mammals: The species of this feeding guild are not likely to be as exposed to the sediment and surface water COPECs, either directly or indirectly, as the omnivorous mammals' guild. The omnivorous mammals' guild, for the most part, tends to consume more sediment and surface water incidental to their feeding habits (i.e., feeding on aquatic food items in the ship channel). The omnivorous mammals, being higher in trophic level, exhibit higher biomagnification of bioaccumulative COPECs and, thus, would be more greatly exposed than herbivorous mammals. Therefore, the use of a representative receptor from the omnivorous mammals feeding guild to estimate the potential for adverse effects should be protective of the herbivorous mammals' guild.

- Herbivorous Birds: The species of this feeding guild are not anticipated to be as exposed to the sediment and surface water COPECs, either directly or indirectly, as carnivorous shore birds. The carnivorous shore birds guild, being higher in trophic level, exhibits higher biomagnification of bioaccumulative COPECs and, thus, would be more greatly exposed than herbivorous birds. Therefore, the use of a representative receptor from the carnivorous shore birds feeding guild to estimate the potential for adverse effects should be protective of the herbivorous birds' guild. In addition, aquatic vegetation is not present at the site at sufficient amounts to support herbivorous species.

- Omnivorous Fish: Species of this feeding guild are expected to exist in the ship channel. Toxicological information in the form of dose and effects for fish, as a general taxonomic group, are deficient in the scientific literature at this time. Thus, quantifying the potential for adverse effects (i.e., computing hazard quotients) from the COPECs is not possible.

- Omnivorous Amphibians/Reptiles: Literature data for exposure parameters and toxicological effects to these taxa are lacking at this time. There would be a great amount of uncertainty in attempting to quantify exposure and the potential for adverse effects.

- Omnivorous Birds: The species of this feeding guild are not anticipated to be as exposed to the sediment and surface water COPECs, either directly or indirectly, as carnivorous shore birds. The carnivorous birds' guild, being higher in trophic level, exhibits higher biomagnification of bioaccumulative COPECs and, thus, would be more greatly exposed than omnivorous birds. Therefore, the use of a representative receptor from the carnivorous birds feeding guild to estimate the potential for adverse effects should be protective of the omnivorous birds' guild.

- Carnivorous Fish: Species of this feeding guild are expected to exist in the Corpus Christi Ship Channel. However, toxicological information in the form of dose and effects for fish, as a general taxonomic group, are deficient in the scientific literature at this time. Thus, quantifying the potential for adverse effects (i.e., computing hazard quotients) from the COPECs is not possible.

- Carnivorous Amphibians/Reptiles: Literature data for exposure parameters and toxicological effects to the reptile taxon are lacking at this time. There would be a great amount of uncertainty in attempting to quantify exposure and the potential for adverse effects.

- Carnivorous Birds: The species of this feeding guild are not anticipated to be as exposed to the sediment and surface water COPECs, either directly or indirectly, as carnivorous shore birds. The carnivorous shore birds are more likely to occur at the site and for longer durations than carnivorous birds and therefore have a higher exposure of COPECs. The use of a representative receptor from the carnivorous shore bird feeding guild to estimate the potential for adverse effects should be protective of the carnivorous birds' guild.

- Carnivorous Mammals: The species of the omnivorous feeding guild are more likely to occur on-site for a longer duration and derive a larger portion of their diet than any carnivorous mammals that might access the site. Most typical carnivorous mammals, such as the coyote or red fox have home ranges that are significantly larger than the site, and as such it is unlikely that they could derive a significant portion of their diet from the Encycle site. The non-production areas of the site (e.g., Landfill 01) that contain some amount of vegetative cover comprise approximately 89 acres of the total 162 acre site, including the 54-acre grain elevator property. Home ranges of 1,920 acres to 19,840 acres (3 to 31 square miles) have been reported for coyotes (Bekoff, 1978), and for red fox, home ranges have been reported from 193 acres to 4,860 acres (78 to 1,967 hectares) (EPA, 1993). Additionally, the entire site is enclosed by a fence on three sides and by the ship channel to the north, and surrounding land use is industrial with high road and navigational traffic. For these reasons, it is unlikely that carnivorous mammals access the site on a regular basis, and even if exposure does occur, it is most likely of a transient nature. Therefore, it was not considered necessary to include this guild in the quantitative evaluation.

- The representative species that have been chosen to be the aquatic ROIs for their respective feeding guilds are noted in Figure 12-2 by asterisks. They are the following:

    - Great Blue Heron (Carnivorous Shore Birds); and

    - Raccoon (Omnivorous Mammals).

The assessment endpoint for each of the feeding guilds represented by the selected ecological ROIs is the following: sustainable productivity of the guild and the viability of other guilds that are primarily dependent on the selected guild. Other assessment endpoints include benthic macroinvertebrate community structure and function; and fish community survival and reproduction. The corresponding measurement endpoints are:

- For benthic macroinvertebrates: comparison of COPEC concentrations in pore water to benchmarks intended for the protection of aquatic life; and comparison of sediment COPEC concentrations associated with adverse effects on macroinvertebrates;

- For fish: comparison of COPEC concentrations in surface water to benchmarks intended for the protection of aquatic life; and

- For omnivorous and carnivorous wildlife: comparison of the predicted intake of COPECs in sediment, surface water, and biota to toxicity reference values (TRVs).

13. Ecological Conceptual Site Model

An ecological conceptual site model is meant, in narrative and pictorial form, to identify and explain the complete and significant potentially complete exposure pathways. The exposure pathways connect the source of the contamination in the environmental media to the exposed or potentially exposed wildlife receptors. The ecological conceptual site model is based on the details about exposure pathways within ecological food chains provided in the conceptual food webs (Section 12). Additional details about the fate and transport of the COPECs within the environmental media are provided in the following section (Section 14).

13.1 Terrestrial Habitat

The ecological conceptual site model for the upland habitat on the Encycle property is illustrated in Figure 13-1. COPECs from aerial deposition, surface runoff from areas within the plant, and waste disposal in landfills can lead to a secondary source of COPECs in soil. This secondary affected media can lead to direct exposure of biota via soil ingestion (i.e., white footed mouse) and soil contact by small animals and terrestrial invertebrates, and root and leaf surface uptake by terrestrial plants. In turn, indirect exposure to other animals can occur via food chain exposure to directly-exposed organisms. These higher trophic-level animals can include terrestrial omnivores that frequent the Encycle property.

13.2 Aquatic Habitat

The ecological conceptual site model for the aquatic habitat on or adjacent to the Encycle property is illustrated in Figure 13-2. The soil COPECs in portions of the site are capable, to varying degrees, of leaching to groundwater beneath the site or being carried via surface runoff into the surface water and sediment of the Corpus Christi Ship Channel. These secondary affected media can lead to direct exposure of biota via sediment and surface water ingestion (i.e. raccoon) and direct contact in the ship channel. In turn, indirect exposure to other animals can occur via food chain exposure to directly-exposed organisms. These higher trophic-level animals can include terrestrial and aquatic omnivores, carnivores, and piscivores that frequent the ship channel.

14. Fate and Transport/Ecotoxicological Profiles

Details of the fate and transport, as well as the ecotoxicological properties, of the COPECs are provided in Appendix G, Ecotoxicological Profiles.

15. Screening-Level Ecological Exposure Characterization

A characterization of ecological exposures fulfills the guidance's (TCEQ, 2001) requirements 5 and 7 and it is necessary to estimate the potential risk of adverse effects to the measurement receptors. A number of variables must be considered in predicting exposures to biota. The exposure variables used in this SLERA are bioavailability, bioaccumulation/ bioconcentration potential, home range, body weight, dietary fractions, and ingestion rates for food, soil, and water. A detailed discussion of these variables is included in Section 15.1.

Tables 15-1 and 15-2 contain the input exposure variables and bioaccumulation/ bioconcentration factors (BAF, BCF) for the total oral dose equation that will be used for the various measurement receptors. The exposure input variables used in this SLERA are not site-specific, with the exception of the refined estimate of the area use factor.

15.1 Wildlife Exposure Input Variables

Information in the scientific literature was used to choose the most appropriate values for the input variables included in the total oral dose equation. For the most part, secondary sources such as the EPA (1993) *Wildlife Exposure Factors Handbook* and the draft EPA (1999) *Screening Level Ecological Risk Assessment Protocol for Hazardous Waste Combustion Facilities* were reviewed and the most relevant values were chosen for the input variables. Preference was given to studies that: 1) were conducted within Texas or the southeast region of the U.S., and/or; 2) were conducted in habitat similar to the site and its surroundings, and/or; 3) had larger sample sizes, while meeting the other two criteria. The lowest or highest values found in the literature for a given input variable were not automatically chosen. When ranges of values, and no average value, were provided for a particular study, the geometric mean (if the range spanned one order of magnitude or more, otherwise an arithmetic mean was computed) of the minimum and maximum value was computed and used for the input variable.

It is often difficult to extrapolate literature information concerning the degree of bioavailability of various constituent compounds to environmental conditions at a particular site. Bioavailability of COPECs to the representative wildlife receptors was conservatively assumed to be 100 percent for both the maximum and refined estimates of exposure.

The approaches used to identify appropriate values for these exposure parameters are described below.

The area use factor (AUF) is meant to account for the likelihood of exposure, depending on whether the representative wildlife receptor's foraging or home range is larger or smaller than the site. The conservative estimate of exposure includes the conservative assumption for each representative wildlife receptor that its foraging range is equivalent to the areal extent of the site. The refined estimate of exposure includes literature information, when available, about a representative wildlife receptor's approximate foraging range. Thus, the receptor's AUF is less than 100 percent or one when the receptor's foraging range is larger than the site (e.g., the red-tailed hawk receptor, raccoon). The receptor's AUF cannot be greater than 100 percent when the receptor's foraging range is less than the site (e.g., the white footed mouse receptor).

The values used for the various representative wildlife receptors' body weight (BW) exposure input variable were the provided arithmetic mean. Per TCEQ guidance, the mean body weight value was used for the conservative and the refined estimates of exposure.

Information regarding the dietary preferences of the representative wildlife receptors was obtained mostly from the secondary literature (EPA, 1993). For an initial screening effort, the number of dietary items was kept to a minimum and adjusted to reflect what is known about the site's environmental conditions and habitat quality. In other words, not every possible food chain was analyzed, but primary food items are included. Dietary fraction values were not altered for the refined estimate of exposure.

The ingestion rates (IRs) for food, soil, and water were computed based on the body weight variable, and the study-based values or allometric equations provided in EPA (1993). The use of the generic equations to compute the values for the ingestion rate input variable was used when provided studies were not applicable to the site. The use of the equations is technically defensible and at times less susceptible to the biases involved with choosing one study over another. Soil and sediment ingestion is assumed to occur only if the ROI's feeding strategy promotes the incidental ingestion of soil or sediment (i.e., white footed mouse, raccoons). For the remaining wildlife ROIs (e.g., red-tailed hawk), the equation is modified to exclude (soil/sediment concentration [C_s] x soil/sediment ingestion rate [IR_s]). EPA (1993) cites data from Beyer on soil and sediment ingestion rates, which were unpublished at the time EPA released its (1993) guidance but were subsequently published by Beyer, et al. (1994). Hence, for this SLERA, soil and sediment ingestion rates are obtained from Beyer, et al. (1994).

Beyer, et al. (1994) present rates of soil and sediment ingestion as a percentage of ingested food, on a dry weight basis. For this ERA, COPEC concentrations and ingestion rates for soil and sediment are presented on a dry weight basis, but for wildlife food items these parameters are presented on a wet weight basis. Therefore, for the purpose of calculating soil and sediment ingestion rates (IRs), the food ingestion rates described above are multiplied by a wet to dry weight conversion factor of 0.2 prior to applying the soil and sediment intake rates developed by Beyer, et al. (1994).

Likewise water ingestion is assumed to occur only if the ROI's feeding strategy promotes the incidental ingestion of sea water. In this SLERA, the great blue heron is assumed to incidentally ingest the salt water from the Corpus Christi Ship Channel. For the remaining wildlife ROIs, the equation is modified to exclude (water concentration [C_w] x water ingestion rate [IR_w]). EPA (1993) cites data on water ingestion rates for the great blue heron. The ingestion rate is considered conservative since the heron would not drink sea water intentionally; the water ingested would be incidental while eating fish.

15.2 Dose Calculation

The potential for bioconcentration and bioaccumulation between trophic levels and through the food chains of a food web is an important consideration for estimating exposures to the representative wildlife receptors. These processes are incorporated in the oral daily dose equations of this SLERA. The values used were applied such that there is a conservative, but simplified, representation of COPEC uptake via food chains to the wildlife receptors. The same values are used for both the maximum and refined estimates of exposure.

Exposure of wildlife receptors is evaluated in this SLERA by calculating the average daily intake of COPECs, generally based on the methodology described by EPA (1993) in the *Wildlife Exposure Factors Handbook.* Daily intake calculations are required because wildlife are exposed via multiple pathways, including diet, incidental surface water ingestion, and incidental soil ingestion. The following basic equation is used to calculate daily intakes for avian and mammalian receptors.

$$Dose = \frac{\left[(C_f \times P_f \times IR_f) + (C_p \times P_p \times IR_f) + (C_i \times P_i \times IR_f) + (C_w \times IR_w) + (C_s \times IR_s)\right] \times AUF}{BW}$$

Where:
Dose = daily intake (mg/kg-day)
C_f = concentration of COPEC in fish (mg/kg)

P_f = portion of diet as fish (unitless)
IR_f = food ingestion rate (kg/day)
C_p = concentration of COPEC in plants (mg/kg)
P_p = portion of diet as plants (unitless)
C_i = concentration of COPEC in invertebrates (mg/kg)
P_i = portion of diet as invertebrates (unitless)
C_w = concentration of COPEC in water (mg/L)
IR_w = water ingestion rate (L/day)
C_s = concentration of COPEC in soil/sediment (mg/kg)
IR_s = soil/sediment ingestion rate (kg/day)
AUF = area use factor (unitless)
BW = body weight (kg)

15.2.1 Exposure Concentrations

For the maximum scenario exposure calculations, the maximum detected concentrations for soil, sediment, or surface water (Cs, Cw) were used to represent the exposure concentrations. However, the maximum site concentration for each COPEC may not be representative of potential exposure because terrestrial animals, with the exception of plants, move across affected areas, thereby coming into contact with various concentrations of constituents. Therefore, mean concentrations were used to represent the exposure concentrations in the refined scenario exposure calculations.

16. Screening-Level Ecological Effects Characterization

16.1 Effects Characterization for Metals

The screening-level ecological effects evaluation involves the identification of screening values and background concentrations for each detected constituent in each environmental medium at the site. As noted above, the screening values applied in the SLERA include those defined in TCEQ guidance for ecological risk assessments (TCEQ, 2001). For constituents that do not have values in the guidance, National Oceanic and Atmospheric Administration (NOAA) Screening Quick Reference Tables (SQiRTs) (1999) and US EPA Region 5 Ecological Screening Levels (August 2003) were used.

One of the limitations in conducting SLERAs is the lack of robust ecotoxicity data. Although screening values are available from a variety of sources, no individual set of screening values is applicable to the variety of systems encountered in the natural environment. However, conservative screening values provide a starting point for the ERA, in that they may provide an indication of the worst-case measure of the potential for adverse impacts.

The screening values and background concentrations for surface water, sediment and soil are summarized in Tables 11-1 through 11-4. It should be noted that these tables present only highly conservative screening values, as is appropriate for a SLERA (TCEQ, 2001). These tables do not show the ranges of values that are available from a variety of other regulatory and scientific sources.

16.1.1 Identification of Screening-Level Exposure Estimates

Exposure estimates for the SLERA are the maximum detected concentrations for each constituent for each environmental medium (TCEQ, 2001). This conservative approach is appropriate for a screening-level effort. Maximum exposure estimates are presented in Tables 11-1 through 11-4 for surface water, sediment, and soil.

16.1.2 Screening-Level Risk Calculations

HQs are calculated in this SLERA by dividing the exposure estimates (i.e., the maximum concentrations) by the conservative screening values. HQ values are highly conservative surrogates for the assessment endpoints, which are the sustainability of populations of benthic and aquatic organisms, small mammals, birds, and terrestrial plant communities. HQ values equal to or less than a value of 1 (to one significant figure) indicate that adverse ecological impacts are unlikely (EPA, 1997). HQ values greater than 1 indicate that further evaluation is warranted. Therefore, the constituents with HQ values greater than 1, and have concentrations above background, are carried forward as COPCs. Tables 11-1 through 11-4 present the HQ values for surface water, sediment, and soil.

16.1.3 Refinement

The refinement of the COPECs identified in the SLERA is necessary to help focus further risk assessment activities on the constituents that pose the greatest potential risks to ecological receptors (EPA, 1997). It is intended as an "incremental iteration of exposure, effects, and risk characterization" (EPA, 2001). The outcome of this screening is that constituents are either excluded as COPECs or retained for further evaluation in the risk assessment process. The refinement of surface water was not necessary since the initial screening process using maximum concentrations eliminated all constituents from further evaluation.

The process for refining COPECs is appropriate for the type of exposures that are likely to occur for ecological receptors exposed to constituents in sediment, and soil associated with the site. This process consists of the comparison of EPCs (i.e., arithmetic mean) with conservative SLERA screening values. Tables 16-1 through 16-3 present the refinement process of COPECs for sediment and soil.

16.1.4 Metal Bioavailability in Sediment

Concentrations of dissolved metals in sediment pore water are compared to TCEQ ecological screening criteria (2001) developed for surface water, consistent with the equilibrium partitioning approach (EPA, 2000a,b). This approach provides more information about the bioavailability and potential toxicity of metals in sediment than the evaluation of total metal concentrations. However, it is subject to two significant sources of uncertainty (EPA, 2000a): (1) pore water extraction procedures such as centrifugation can result in an overestimation of the metal concentrations occurring in the pore water of undisturbed sediment, and (2) characteristics of pore water, such as elevated concentrations of dissolved organic carbon, can reduce the bioavailability of metals in pore water compared with water-only exposures. These sources of uncertainty will tend to result in an overestimation of risks. Comparison of measured pore water concentrations (maximum and refined) to ecological screening benchmarks are presented in Tables 16-4 and 16-5. The results show that manganese, mercury, and selenium in pore water are retained for further evaluation. Manganese is retained due to an exceedance of background and its ecological screening value. Mercury and selenium are both considered bioaccumulative in water and have concentrations exceeding surface water background UTLs. Thallium is bioaccumulative in water but was not at concentrations above background and therefore is eliminated. Antimony, arsenic, cobalt, and tin are not bioaccumulative and have concentrations below surface water screening values. These constituents were eliminated from further evaluation.

The results of SEM and AVS analyses are interpreted according to EPA (2000a) guidelines for assessing the risk of sediment toxicity due to mixtures of six divalent metals: cadmium, copper, lead, nickel, silver and zinc. These guidelines are based on an understanding of the primary factors controlling the concentrations of these metals in sediment pore water. Whereas total organic carbon (TOC) is recognized as the key factor controlling the partitioning (i.e., bioavailability) of hydrophobic organic constituents in sediment, the most important factor controlling the bioavailability of these metals is the concentration of AVS. Thus, if the concentration of AVS is greater than the concentration of SEM in sediment on a molar basis, the metals are not present in the pore water and do not cause toxicity (Ankley, Di Toro et al., 1996; EPA, 2000a). This premise has been shown to hold true in toxicity tests of sediments collected from sites contaminated primarily with metals (Hansen, Berry et al., 1996). The interpretation of SEM and AVS analyses is not subject to the potential (conservative) biases described above, associated with pore water extraction and pore water composition. However, loss of AVS during sampling is a potential source of conservative bias.

A recent refinement of the SEM/AVS approach addresses the role of TOC as a secondary factor controlling the bioavailability of these metals, in sediments where SEM concentrations exceed the concentrations of AVS. As described by EPA (2000a), one can predict with 90 percent confidence that sediment toxicity due to metals will not occur if the organic-carbon normalized concentration of "excess" metals ([ΣSEM-AVS]/f_{oc}) is less than 130 µmol per gram organic carbon (µmol/gOC). Similarly, sediment toxicity is expected with 90 percent confidence if (ΣSEM-AVS)/f_{oc} exceeds 3,000 µmol/gOC. The likelihood of toxicity associated with intermediate values is uncertain. These effects benchmarks for (ΣSEM-AVS)/f_{oc} are applied in the SLERA on a sample-by-sample basis. Results are presented in Table 16-6.

16.2 Effects Characterization for Wildlife

In order to predict whether adverse effects are likely to be occurring to wildlife at the site, it is necessary to characterize the ecological effects that might be possible. The characterization can be done by collecting and evaluating literature information about the potential toxicological effects of the COPECs on biota, and extrapolating this information to the representative wildlife receptors at the affected properties. The collection of this information fulfills Requirement 5 of TCEQ's guidance (TCEQ, 2001).

Toxicological information about the COPECs was obtained from the published scientific literature, primarily from secondary sources (i.e., EPA, 1999, Sample et al., 1996). It is assumed that the studies included in secondary sources have already undergone a peer review and, thus, can be considered reliable and relevant to conditions at the site. The best study among those reviewed was used to compute the toxicity reference value (TRV). Appropriate scientific studies were found in the published literature for all of the representative wildlife receptors, but not for each of the COPECs. Uncertainty, or safety, factors were used to account for the uncertainty of extrapolation of laboratory results to conditions appropriate for field exposures at the site. The uncertainty factor values were obtained from TCEQ guidance (2001) for conducting ecological risk assessments [Calabrese and Baldwin (1993), and Army Corps of Engineers (ACE, 1996)]. The uncertainty factors are divided into the test dose rate to compute a lower, thus more conservative, TRV. That is, all test dose rates were converted to chronic no-observed-adverse-effects-level (NOAEL) endpoints. The endpoints were then scaled from the test species body weight to the body weight of the particular wildlife receptor (Sample and Arenal, 1999) to achieve the NOAEL TRVs for the representative wildlife receptors. The TRVs, and the information used to compute them, are listed in Tables 16-7 through 16-10. Section 16.2.1 describes the methodology used to calculate TRVs.

16.2.1 Toxicity Reference Value Derivation

Extrapolation Factors (EFs) and uncertainty factors (UFs) are identified for this SLERA based on three characteristics of the experimental conditions associated with the test species dose: a) the duration of exposure; b) the endpoint measured; and c) differences in body weights among test and receptor species (Sample and Arenal, 1999; Sample, et al., 1996; Opresko, et al 1994). The TRV is then calculated as follows:

$$TRV = \frac{\text{Test Species Dose} \times \text{Body Weight EF}}{\text{Duration UF} \times \text{Endpoint UF}}$$

The derivation of test species dose, UFs and EFs used in this SLERA is described in the following subsections.

16.2.1.1 Test species dose

Critical toxicological values are identified for use in this SLERA from carefully qualified literature references. In cases where preferred toxicological endpoints are not available, other toxicity values are used, but additional UFs may be incorporated. All toxicological values chosen for TRV derivation are presented on a milligram COPEC per kilogram body weight per day (mg/kg-day) basis. These units allow comparisons among organisms of different body sizes (Sample, et al., 1996).

The test species dose is a daily dose of a constituent associated with a particular endpoint and effect. In some cases, this dose is explicitly stated within the study; in other cases, only partial or related information is available. For studies that report an effects level as a concentration in food or drinking water, but do not report specific body weights or feeding rates of the test species, default weights (Sample, et al., 1996) are used to derive the test species dose:

$$Dose = \frac{C \times IR}{BW}$$

where:

Dose = test species dose of COPEC (mg/kg-day)
C = concentration of COPEC in food or water (mg/kg)
IR = ingestion rate of food or water by the test species (kg/day)
BW = body weight of the test species (kg).

16.2.1.2 Uncertainty factors

In order to ensure a SLERA is protective of chronic effects on wildlife, duration uncertainty factors are used where toxicity data are available only from subchronic or acute studies. Chronic studies occur over the lifetime or a majority of the lifespan of the test organism, generally longer than one year for mammals and ten weeks for birds. Additionally, studies in which the test organism is dosed during a critical life stage (e.g., gestation) are grouped with chronic duration studies. Subchronic studies include exposures of two weeks to one year for mammals or two to ten weeks for birds that do not occur during a critical life stage. Acute studies typically have exposures of less than two weeks. NOAELs and lowest-observed-adverse-effects-levels (LOAELs) are usually reported from chronic and subchronic studies, with acute studies often reporting frank effect levels (FELs; e.g., LD50 data). Test species doses from chronic studies are used preferentially over data from acute and subchronic studies.

Additional endpoint UFs are used in this SLERA to account for uncertainties in extrapolation between effect- and no-effect levels. In this SLERA, both the NOAEL and LOAEL were applied in the TRV calculation (Tables 16-7 through 16-10). As necessary, a LOAEL test species dose was estimated from a NOAEL value. If a

LOAEL was provided in Sample et al (1996), additional endpoint UFs are not applicable in deriving a TRV. However, if a LOAEL was not provided by Sample et al, an endpoint UF of 5, along with a duration UF and an EF as described below, was applied to NOAEL values to estimate the LOAEL TRV (ACE, 1996); this factor is considered conservative (TCEQ, 2001).

16.2.1.3 Body-weight extrapolation factor

Body weight scaling factors are used in this ERA to account for differences in species sensitivity based on the body sizes of mammalian test species and ROIs (Sample and Arenal, 1999). Numerous studies have shown that many physiological functions, such as metabolic rates and responses to chemicals, are a function of body size for mammals. Smaller mammals have higher metabolic rates and are usually more resistant to chemicals because of more rapid rates of detoxification. Sample and Arenal (1999) developed body weight scaling methods for numerous chemicals, based on an extensive compilation of toxicity data for multiple mammals. Dosimetric differences between the mammalian test species and wildlife receptors are accounted for using:

$$NOAEL_w = NOAEL_t \times \left(\frac{BW_t}{BW_w}\right)^{1-b}$$

Where:

$NOAEL_w$ = NOAEL for the mammalian wildlife ROI (mg/kg-day)
$NOAEL_t$ = NOAEL for the mammalian test species (mg/kg-day)
BW_t= test species body weight (kg)
BW_w= wildlife ROI body weight (kg)
b = chemical-specific allometric scaling factor.

Where chemical-specific scaling factors are unavailable, default allometric scaling factors of 0.94 and 1.2 are used for mammals and birds respectively, based on the average scaling factor among the chemicals evaluated by Sample and Arenal (1999).

17. Screening-Level Ecological Risk Characterization

The ecological risk characterization for the Encycle site incorporates the results of the chemical analyses and the wildlife evaluation. Site chemistry is evaluated first through the mathematical comparison of exposure and effects estimates. If the initial risk estimation identifies a potential risk, the magnitude and nature of the risk is further examined, based on an analysis of uncertainties and biases in the exposure and effects assessments.

17.1 Surface Water, Sediment, and Soil

- After the refinement process of comparing the EPCs to screening values, the following COPECs could not be eliminated from further evaluation. All exceeded the screening value or could not be excluded because a screening value was not available for comparison (Tables 16-1 through 16-3).
- Surface water: none
- Sediment: antimony, arsenic, cadmium, copper, lead, manganese, mercury, selenium, thallium, tin and zinc; and
- Soil: arsenic, cadmium, bismuth, cadmium, chromium, cobalt, copper, cyanide, lead, manganese, mercury, nickel, selenium, silver, thallium, and zinc.

Function and structure of terrestrial invertebrates, terrestrial plants, and fish were evaluated based on the comparison of applicable media to screening values intended for the protection of the ROI. Based on those results, arsenic, cadmium, bismuth, cadmium, chromium, cobalt, copper, cyanide, lead, manganese, mercury, nickel, selenium, silver, thallium, and zinc may represent potential risks to terrestrial invertebrates and plants. However, there was no gross evidence of stress (e.g., dead/dying plants, spotting and discoloration of leaves and stems, chlorosis, stunted growth) to the terrestrial vegetation observed at the site during the site visit and as discussed in the Uncertainties Section, there is a significant amount of uncertainty and lack of site-specificity associated with the screening values. Additionally, there were no areas at the site that were devoid of vegetation (i.e., there was vegetation present in those areas not covered by pavement, buildings, gravel, or roadways). Natural, undisturbed soils that lack vegetative cover are often an indication of phytotoxic conditions in the soil. However, this condition was not observed at the site. Based on direct observations of the existing plant communities at the site and the lack of any observable impact, there is no evidence to suggest that soil conditions at the site are causing adverse effects to the terrestrial plant and invertebrate communities at the site.

Since no constituents were retained for surface water, no unacceptable risks to fish are expected.

The ecological screening values used in this SLERA are extremely conservative and are not meant to be used as remediation clean up numbers. Further evaluation of sediment conditions is necessary to determine the potential impact of constituents to the sediment dwelling organisms.

17.1.1 SEM/AVS and Sediment Pore Water

Impacts to benthic invertebrates were evaluated by two types of analyses: comparison of concentrations in pore water to screening values intended for the protection of aquatic life, and SEM/AVS analysis discussed below. Based on the pore water results from the near-shore sediment samples, a potential risk to benthic life exists from manganese, mercury, and selenium. Again, the ecological screening values used for comparison are extremely conservative. Further evaluation is necessary to determine the potential impact of constituents to benthic invertebrates.

Sediment samples were collected for SEM/AVS analysis along the south shoreline of the ship channel adjacent to the site, to determine the bioavailability of metals to aquatic life (i.e., benthic invertebrates). Results are presented in Table 16-6. The $(\Sigma SEM\text{-}AVS)/f_{oc}$ results for all four samples were reported above the effects benchmark of 130 μmol/gOC. Additionally, since the results all exceeded 3,000 μmol/gOC, sediment toxicity is expected with 90 percent confidence at the four sediment sampling locations (i.e., SED-1, SED-4, SED-7 and SED-10). Benthic invertebrate community structure and function is potentially at risk due to high levels of available metals.

17.2 Wildlife Risk Characterization

To estimate ecological risks to mammalian and avian ROIs, wildlife hazard quotients (HQ) are calculated for each ROI and each COPEC. A wildlife HQ is the ratio of the measure of exposure (e.g., measured concentration or modeled dose) to a literature-based value (with comparable units) that is associated with no adverse effects (TRV):

$$HQ = \frac{Exposure}{TRV}$$

Where:
HQ = hazard quotient (unitless)
Exposure = daily intake (mg COPEC/kg body weight-day)
TRV = COPEC toxicity reference value (mg COPEC/kg body weight-day)

In general, HQ values equal to or less than one indicate that there is no ecological risk, while HQ values greater than one suggest that ecological risk is possible, contingent on the degree of certainty in the variables and methods used to calculate the HQ. Although HQ values much greater than one can be assumed to describe risks that are more severe than those associated with HQs that slightly exceed one, HQ values should not be interpreted literally or as probabilities. For example, an HQ of 0.5 does not reflect a 50 percent probability of adverse effects and an HQ of 4 does not necessarily indicate adverse effects twice as bad as those associated with an HQ of 2. Given the paucity of data available on effects of chemical mixtures on wildlife, risks due to different classes of chemicals are not assumed to be additive.

The results of the risk characterization, and the required input data, for the various representative wildlife receptors are contained in Tables 17-1 through 17-7. The COPECs that exhibit HQ values less than one when a NOAEL toxicity reference value is used are not considered to pose any unacceptable risk to the representative wildlife receptors and, by extension, the ecosystem of the site. These COPECs are dismissed from further consideration.

In instances where the total oral dose rate that represents the estimated exposure is greater than the NOAEL TRV, then the HQ will be greater than one. A hazard quotient greater than one does not indicate that the COPEC is causing adverse effects to the representative wildlife receptors at the site, rather, a HQ greater than one indicates that further evaluation of the exposure to the particular COPEC is warranted. For those COPECs with NOAEL HQ values exceeding one, hazard quotients are computed using a lowest-observed-adverse-effects-level (LOAEL) TRV and less conservative exposure assumptions. A LOAEL HQ less than 1 may be eliminated based on sufficient supporting information included in the receptor sections below and the Uncertainty Section (Section 18). LOAEL HQs greater than 1 provide reasonable basis for further evaluation either in a sensitivity analysis, additional sampling, or to begin remedial planning, as ecological impacts may be expected. Options for further evaluation, such as additional focused sampling or remediation, are considered in the risk management process. The risk characterization portion of the SLERA fulfills requirements 6 and 7 of the TCEQ's guidance.

All bioaccumulative COPECs were evaluated for each receptor even though certain constituents are not considered applicable in certain media (i.e., lead is only bioaccumulative in soil (Table 15-2)).

17.2.1 Great Blue Heron

The maximum and refined no-observed-adverse-effects-level hazard quotients (NOAEL HQs) for mercury, thallium and zinc exceeded 1 for the great blue heron or carnivorous shore birds feeding guild[1] (Table 17-1). To further evaluate these risks, LOAEL HQ values for mercury, thallium and zinc were calculated; all were less than or equal to 1. These results are considered conservative because the dose to the ROI incorporated maximum surface water exposure concentrations, a 100% diet of fish from the ship channel, and water ingestion even though any ingestion of sea water would be incidental. Additionally, mercury and thallium were reported as not-detected in surface water; the exposure concentrations used in the model are equal to ½ the maximum SQL. The result infers that carnivorous shore birds are very likely not subject to adverse impacts from the COPECs.

17.2.2 Red Tailed Hawk

Using maximum COPEC concentrations in surface soil, the maximum scenario NOAEL HQ values for all COPECs evaluated exceeded 1 (Table 17-2). However, in the refined scenario (Table 17-3), a more realistic, yet conservative EPC was applied (i.e., arithmetic mean). Under this scenario, only the refined NOAEL HQ for zinc exceeded 1 (HQ=10). The refined zinc LOAEL HQ equaled 1. Since carnivorous birds are unlikely to frequent the plant area of the site to forage, due to regular anthropogenic activity associated with active industrial land use and the presence of buildings, above-ground tanks and piping, concrete pavement, gravel, etc. in the plant area, risks from zinc to these birds is considered low. Additionally, the area of vegetated land on the site that would be capable of supporting prey species is limited (approximately 89 acres) and therefore limits the area available for foraging and consequently, exposure. The result infers that carnivorous birds are very likely not subject to adverse impacts from the COPECs.

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[1] Note: In accordance with TCEQ Guidance (2001), zinc bioaccumulation is not considered applicable in water.

17.2.3 White Footed Mouse

The maximum scenario NOAEL HQ of 1 was exceeded by all evaluated metals except chromium (both +3 and+6)[2], mercury and nickel[3] (Table 17-4). This scenario may be applicable in hot spots inside the plant area; however a more realistic exposure concentration for the site is the EPC (i.e., average concentration). In the refined scenario (Table 17-5), NOAEL HQ values for cadmium, copper, thallium and zinc exceeded 1. However, the LOAEL HQ values calculated for these metals did not exceed 1. The white footed mouse was used to represent burrowing omnivorous mammals and therefore the calculated dietary dose included soil ingestion along with a vegetation and invertebrate diet. The refined NOAEL HQ values that exceeded 1 were all less than 10 and the LOAEL HQ values were all equal to or less than 1. The result infers that omnivorous mammals are very likely not subject to adverse impacts from metals.

17.2.4 Raccoon

The maximum NOAEL HQ values for cadmium, copper, lead, selenium, thallium and zinc exceeded 1 for the omnivorous mammals' guild (Table 17-6). However, under the refined scenario (Table 17-7), only the NOAEL HQ value for cadmium exceeded 1 (HQ=2). The refined LOAEL HQ value for cadmium did not exceed 1. The raccoon was used to represent non-burrowing mammals with a larger range than a mouse and a diet that includes fish and incidental sediment ingestion along with terrestrial invertebrates and plants. Since the NOAEL HQ for cadmium exceeded 1, risks to this guild are possible if the raccoon foraged entirely on the affected area, which more than likely, it does not. The result infers that omnivorous mammals are very likely not subject to adverse impacts from metals.

In summary, based on the hazard quotient results, there does not appear to be any unacceptable risks to wildlife receptors at the Encycle property. Constituents with NOAEL HQ values that exceeded 1 include cadmium, copper, thallium and zinc; all were less than or equal to 10. No LOAEL HQ values exceeded 1. Therefore, due to the

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[2] Total chromium was analyzed in on-site soil and the present form is currently unknown. Therefore, because the toxicity of Cr+3 and Cr+6 differ dramatically, both forms were evaluated.

[3] Note: In accordance with TCEQ Guidance (2001), thallium bioaccumulation is only applicable in water.

conservativeness and uncertainty applied to this evaluation, risks to wildlife at the site are not expected. Additionally, no adverse effects on plants and wildlife were observed during the site visit; all observed species appeared normal and healthy.

18. Calculation of Media Cleanup Standards for Ecological Receptors

The Encycle/Texas, Inc. site in Corpus Christi, Texas is being evaluated under the Risk Reduction Rule's Standard 3 (RRS 3). As such, if there were a finding of unacceptable ecological risk, then media cleanup standards would need to be calculated to provide adequate protection of ecological receptors. In lieu of protective concentration levels that need to be calculated under the Texas Risk Reduction Program to provide adequate protection to ecological receptors, calculation of media cleanup standards, when necessary, satisfies requirement 9 of the TCEQ's 2001 guidance.

The results of the wildlife risk characterization and uncertainty evaluation for the site conservatively demonstrates there is no unacceptable risk of adverse effects to the representative wildlife receptors (i.e., white footed mouse, great blue heron, raccoon, and red-tailed hawk) or their related food webs from exposure to the COPECs detected in soil, sediment and surface water; and additional evaluation of these media is not considered necessary to protect the representative wildlife receptors or their related food webs. Therefore, there are no media cleanup standards for soil, sediment, or surface water required for closure under RRS 3 for these receptors.

Soil concentrations for the following metals, however, do exceed their respective TCEQ screening benchmarks for the protection of soil invertebrates and terrestrial plants: arsenic, bismuth, cadmium, chromium, cobalt, copper, cyanide, lead, manganese, mercury, nickel, selenium, silver, thallium, and zinc. Based on direct observations of terrestrial plants at the facility, no evidence of adverse impacts are present. Also, metals in soil that exceed PRGs in the Human Health Risk Assessment (arsenic, lead, cadmium) will be addressed in the CMS. Therefore, additional investigation of soil invertebrates and terrestrial plants at the Encycle facility is not warranted.

The comparison of the sediment and sediment pore water concentrations to the appropriate screening values in concert with the sediment AVS/SEM results, and the comparison of the pore water concentrations to reported adverse effects levels indicates that several metals in sediment (i.e., antimony, arsenic, cadmium, copper, lead, manganese, mercury, selenium, thallium, tin and zinc) will require further evaluation in a CMS. The area of affected sediments to be addressed in the CMS are located between the Ship Channel shoreline (rip rap) directly north of the 01 Landfill and the dredge line approximately 60 feet north of the shoreline. Metals concentrations in sediment beyond a distance of 60 feet north of the shoreline decrease rapidly and approach background concentrations. The area beyond a distance of 60 feet from the shoreline also corresponds to a sharp increase in water depth resulting from dredging operations for navigational purposes in the Corpus Christi Ship Channel.

19. Uncertainties Analysis

This risk assessment was based largely on standard, regulatory, default, exposure assumptions, which tend to be very conservative and likely overestimate actual risk. These assumptions are discussed in Section 5.3. The uncertainties present in this risk assessment are discussed below.

19.1 Uncertainties in the Human Health Risk Assessment

This BLRA assumed that the analytical data accurately reflect the nature and extent of COPCs in groundwater, soil, and surface water at the Encycle facility. It is likely that the maximum concentrations used as EPCs in the exposure calculations overestimate actual current or future exposure point concentrations.

Exposure scenarios also contribute uncertainty to the risk assessment. Actual exposure frequencies are unknown, and estimates were based on the available conservative guidance and judgment. Exposure doses were calculated based on the assumption that the current conditions would remain stable throughout the exposure period and that site workers would be regularly and periodically exposed for a period of years. This simplifies reality because natural attenuation processes are expected to reduce constituent concentrations over time. If the source is eliminated or reduced, natural attenuation processes will reduce constituent concentrations and the likelihood of exposure, thus reducing risks for the hypothetical future exposure scenarios. It is unlikely that site workers would be exposed to UCL or maximum constituent concentrations in surface soils for such an extended period of time.

The toxicity values and other toxicological (health effects) information used in this report are associated with uncertainty. Toxicity values used by the USEPA are typically 10 to 10,000 lower than the lowest concentration documented to produce adverse health effects. Most health effects information was developed using laboratory animals exposed to high doses, and the extrapolation to the low exposures for humans is difficult, producing significant uncertainty, however not all of the COPCs in this assessment have toxicity values based on animal data. Although differences in absorption, distribution, metabolism, excretion and target organ sensitivity between species are well documented, available data are usually insufficient to allow compensation for these differences. Most laboratory studies strictly control as many factors as possible, yet the human population is genetically diverse and affected by a variety of diets, occupations, pharmaceuticals and other factors. Reported toxicity values are subject to change as more information becomes available. For these reasons, current methods used to develop toxicity values are conservative and probably overestimate risk.

USEPA (1989a) guidance states that it is not appropriate to use the oral slope factor to evaluate risks associated with dermal exposure to carcinogens that cause skin cancer through a direct action at the point of application. Additionally, the USEPA is currently re-evaluating the assessment of chemical exposure by the dermal route (USEPA, 1992). The USEPA's interim guidance on dermal exposure from soil recommends that the quantitative risk calculations not be completed for most chemicals (USEPA, 2001). USEPA has stated that dermal exposure to compounds other than dioxins, polychlorinated biphenyls and cadmium should be treated qualitatively in the uncertainty section of the risk assessment. The USEPA plans to finalize the dermal interim guidance after receiving comments from the Office of Health and Environmental Assessment in the Office of Research and Development and the Science Advisory Board. Until this guidance is finalized, the potential risk from dermal contact with soil and groundwater will be conservatively estimated by converting the administered oral dose to an absorbed dermal dose. This approach was used in this risk assessment. However, this likely overestimates the risk associated with dermal exposure to the COPCs in soils and groundwater at the site.

Recent research on the mechanisms of carcinogenesis suggests that use of the linearized multistage model may overestimate the cancer risks associated with exposure to low doses of chemicals.

There is also considerable uncertainty associated with the toxicity of mixtures. For the most part, data about the toxicity of chemical mixtures are unavailable. Rather, toxicity studies generally are performed using a single chemical. Chemicals present in a mixture can interact chemically to yield a new chemical, or one can interfere with the absorption, distribution, metabolism, or excretion of another. Chemicals also may act by the same mechanism at the same target organ, or can act completely independently. This risk assessment assumes that toxicity is additive; the ELCRs and HQs were each summed across chemicals. This approach assumes that the mixture of constituents does not result in synergistic or antagonistic interactions.

Because of the uncertainty associated with risk assessment, conservative methods were used in estimating EPCs, exposure doses and toxicity values. Therefore, risk estimates in this report likely overestimate actual risks for the pathways evaluated.

19.2 Uncertainties in the Screening Level Ecological Risk Assessment

Uncertainties are an inherent part of any SLERA. The interpretation of the SLERA results are aided by a recognition and understanding of the source and nature of the known set of uncertainties that can influence the risk characterization results. An evaluation of the uncertainties fulfills requirement 8 of the TCEQ's 2001 guidance.

There are several sources of known uncertainty in the SLERA process, including: 1) uncertainty in the adequacy of the sampling design used and analytical results; 2) uncertainty in the conceptual site model used; 3) uncertainty in the food web model used; 4) uncertainty in the exposure input variables and toxicity reference values obtained from the scientific literature; and 5) uncertainty in the degree of natural variability associated with environmental conditions and processes at the affected properties.

The sampling design for the site was based on knowledge of historical practices and locations of contaminated materials and environmental media. Therefore, the purpose of the sampling designs was to collect samples of environmental media from areas within the site that were as highly contaminated as possible. Additionally, concentrations of some metals (i.e., zinc) may be overly conservative because of the use of possible data outliers in the assessment. The outcome from such a sampling and analysis design is an increase in the value of the exposure point concentration for the representative wildlife receptors that may contribute to an overestimation of risk.

The conceptual site model, as well as the food web models, was carefully considered before its implementation in the SLERA. Site observations by trained personnel, as well as experience from previous similar projects, provided information that led to the creation of an appropriate conceptual site model. Likewise, default food web examples were selected from the TCEQ's guidance and refined to slightly more suitable versions for the site. Several trophic levels were evaluated against the knowledge of what is believed to be the dominant food chains for the wildlife receptors that may exist at the site.

The uncertainty in the exposure input variables is expected to err on the side of conservatism, due to the values chosen for the total oral dose rate equation. The exception might be the area use factor values used in the refined estimates of exposure. It is not known if the literature values are completely relevant to the environmental conditions at the site, due to the differences from study conditions in habitat quality, degree of human disturbance, and climate. The other source of literature input to the dose estimates, the toxicity reference values, may hold some of the same types of uncertainty, due to the differences between study conditions and the environmental conditions at the site. It is believed that the use of uncertainty factors has adequately and conservatively accounted and compensated for these uncertainties.

Another source of uncertainty related to toxicity of the COPECs is the site-specific applicability of the screening benchmarks used to screen the soil data for potential effects on soil invertebrates and terrestrial plants. For example, most of the plant protective screening benchmarks are based on laboratory studies, and not field studies.

Additionally, most of the plant benchmarks are based on studies on the effects each metal has on growth of individual plants (rather than population – or community-level impacts), the majority of which are crops (e.g., ryegrass, fescue, wheat, oats, corn, radish, and lettuce). An exceedance of a screening value does not imply that an adverse effect will occur in plants at a site. Phytotoxicity is a complex interplay of chemical concentrations, soil chemistry, soil physical properties, and the physiology of the specific plant species under investigation. Therefore, the use of the screening benchmarks can be misleading because concentrations of some micronutrients that may stimulate growth in one soil type may reduce growth in another soil type at the same concentrations. Several other factors, including soil pH, can affect the solubility, and therefore bioavailability, of metals to plants (Kabata-Pendias and Pendias, 1992). In acidic soils, at soil pH less than approximately 5.0, the solubility of many metals increases, which in turn increases bioavailability and influences plant toxicity (Kabata-Pendias and Pendias, 1992). For these reasons, the exceedance of a benchmark should not be interpreted as directly indicative of phytotoxic conditions at the site.

The last source of uncertainty previously listed is that of natural variability in environmental conditions and the responses of ecological receptors. While it is important to recognize this source of uncertainty, if only to acknowledge that ecological risk assessments are rough approximations of reality, natural variability is very difficult to quantify. No attempt was made, either through field experimentation at the site or via extensive literature searches, to estimate the degree or pervasiveness of natural variability in the environmental conditions and ecosystems associated with the site. It is believed, though, that the careful consideration employed throughout the process and the use of conservatism at several steps in the process has produced highly reliable risk characterization results that are reasonably and appropriately conservative for a SLERA.

20. Conclusions and Recommendations

20.1 Human Health Risk Assessment Conclusions

The findings and conclusions of the human health risk assessment can be summarized as follows:

Adult Resident – Beaumont Formation Water-Bearing Unit Groundwater Exposure Scenario

- The calculated HI for a hypothetical future adult resident is 2, which exceeds the non-cancer goal of 1 used by the TCEQ. Manganese was the only COPC included in the hazard calculation (Table 6-1).

- An ELCR for the hypothetical future adult resident was not calculated because all of the carcinogenic COPCs have federal MCLs, and therefore, in accordance with TCEQ guidance (1998 Consistency Memorandum), the site concentrations for the COPCs should be compared to their respective MCLs, but not included in a quantitative risk calculation (TCEQ, 1998). The maximum concentration or SQL of all of the constituents analyzed in groundwater were compare to their respective MCLs. Those constituents exceeding their respective MCLs but not included in the risk evaluation are: antimony, arsenic, cadmium, cyanide, lead, and selenium.

The HI for adult resident exposure to groundwater from the Beaumont Formation Water-Bearing Unit exceeded the regulatory goal, therefore, it was necessary to calculate a PRG for this scenario. The EPC for manganese in groundwater is 7.7 mg/L which exceeds the calculated PRG of 4.7 mg/L (Table 6-7). It is important to note, however, that the risk associated with the background concentration of manganese (7.6 mg/L) is essentially equal to the risk to manganese in groundwater from the Beaumont Formation Water-Bearing Unit. Therefore, potential risks from impacted groundwater from the Beaumont Formation Water-Bearing Unit are not significantly different than the risks from naturally occurring groundwater.

Child Resident – Beaumont Formation Water-Bearing Unit Groundwater Exposure Scenario

- The calculated HI for a hypothetical future child resident is 3, which exceeds the non-cancer goal of 1 used by the TCEQ. Manganese was the only COPC included in the hazard calculation (Table 6-2).

- An ELCR for the hypothetical future child resident was not calculated because all of the carcinogenic COPCs have federal MCLs, and therefore, in accordance with TCEQ guidance (1998), the site concentrations for the COPCs should be compared to their respective MCLs, but not included in a quantitative risk calculation (TCEQ, 1998). The maximum concentration or SQL of all of the constituents analyzed in groundwater were compared to their respective MCLs. Those constituents exceeding their respective MCLs, or action level in the case of lead, but not included in the risk evaluation are: antimony, arsenic, cadmium, cyanide, lead, and selenium.

The HI for child resident exposure to groundwater from the Beaumont Formation Water-Bearing Unit exceeded the regulatory goal, therefore, it was necessary to calculate a PRG for this scenario. The EPC for manganese in groundwater is 7.7 mg/L which exceeds the calculated preliminary remediation goal of 2.9 mg/L (Table 6-8). As mentioned previously, it is important to note that the risk associated with the background concentration of manganese (7.6 mg/L) is essentially equal to the risk to manganese in groundwater from the Beaumont Formation Water-Bearing Unit. Therefore, potential risks from impacted groundwater from the Beaumont Formation Water-Bearing Unit are not significantly different than the risks from naturally occurring groundwater.

Site Worker – Surface Soil Exposure Scenario

- The calculated, cumulative HI for a potential current site worker is 1, which is equal to the non-cancer goal used by the TCEQ (Table 6-3). Arsenic is the primary contributor to the HI.

- The calculated, cumulative ELCR for a potential current site worker (9×10^{-7}) is less than the target risk range of 10^{-4} to 10^{-6} for cumulative cancer risk (Table 6-3). Cadmium and nickel were the only contributors to the ELCR.

Excavation Worker – Surface Soil Exposure Scenario

- The calculated, cumulative HI for a potential current excavation worker is 1, which is equal to the non-cancer goal used by the TCEQ (Table 6-4). Arsenic was the primary contributor to the HI.

- The calculated, cumulative ELCR for a potential current excavation worker (1×10^{-9}) is less than the target risk range of 10^{-4} to 10^{-6} for cumulative cancer risk (Table 6-4). Cadmium and nickel were the primary contributors to the ELCR.

Age-Averaged Hypothetical Future Child/Adult Resident – Surface Soil Exposure Scenario

- The calculated, cumulative HI for an age-averaged hypothetical future child/adult resident is 10, which is above the non-cancer goal used by the TCEQ (Table 6-5). Arsenic was the primary contributor to the HI.

- The calculated, cumulative ELCR for an age-adjusted hypothetical future child/adult resident (1×10^{-7}) is below the target risk range of 10^{-4} to 10^{-6} for cumulative cancer risk (Table 6-5). Cadmium and nickel were the primary contributors to the ELCR.

The HI for age-averaged child/adult resident exposure to surface soil exceeded the regulatory goal, therefore, it was necessary to calculate PRGs for this scenario. The EPCs for arsenic (120 mg/kg) and cadmium (140 mg/kg) exceeded their respective PRGs of 20 mg/kg and 77 mg/kg (Table 6-9). The EPCs for all of the remaining COPCs are below their respective PRGs (Table 6-9).

Adult – Surface Water Exposure Scenario

- The calculated, cumulative HI for a current adult exposure to surface water via fish tissue ingestion is 1, which is equal to the non-cancer goal used by the TCEQ (Table 6-6). Antimony was the primary contributor to the HI.

- It was not possible to calculate an ELCR for current adult exposure to surface water via fish tissue ingestion because all of the COPCs included in the evaluation are classified as non-carcinogenic.

Soil Protective of Groundwater

The potential for cross-media contamination (from soil to groundwater) was evaluated in this BLRA. The available groundwater data from the Encycle facility indicate that leaching of a few of the constituents from soil has occurred in the past. Although some of the soil samples at the site contain concentrations of some constituents above the adjusted GWP-Ind MSCs, an evaluation of the leaching potential of the COPCs by

SPLP analyses indicated that the residual concentrations of most of the COPCs, with the exception of cadmium, in the soils should not represent a significant continuing release source to the groundwater.

20.2 Screening-Level Ecological Risk Assessment Conclusions

The results of the SLERA and uncertainty evaluation for the site conservatively demonstrates there is no unacceptable risk of adverse effects to the representative wildlife receptors or their related food webs from exposure to the COPECs detected in soil, sediment and surface water; and additional evaluation of these media is not considered necessary to protect the representative wildlife receptors or their related food webs.

Soil concentrations for the following metals, however, do exceed their respective TCEQ screening benchmarks for the protection of soil invertebrates and terrestrial plants: arsenic, bismuth, cadmium, chromium, cobalt, copper, cyanide, lead, manganese, mercury, nickel, selenium, silver, thallium, and zinc. However, based on direct observations of terrestrial plants at the facility, no evidence of adverse impacts are present. Also, metals in soil that exceed PRGs in the Human Health Risk Assessment (arsenic, lead, cadmium) will be addressed in the CMS. Therefore, additional investigation of soil invertebrates and terrestrial plants at the Encycle facility is not warranted.

The comparison of the sediment and sediment pore water concentrations to the appropriate screening values in concert with the sediment AVS/SEM results, and the comparison of the pore water concentrations to reported adverse effects levels indicates that several metals in sediment (i.e., antimony, arsenic, cadmium, copper, lead, manganese, mercury, selenium, thallium, tin and zinc) will require further evaluation. The area of affected sediments to be further evaluated are located between the Ship Channel shoreline (rip rap) directly north of the 01 Landfill and the dredge line approximately 60 feet north of the shoreline. Metals concentrations in sediment beyond a distance of 60 feet north of the shoreline decrease rapidly and approach background concentrations. The area beyond a distance of 60 feet from the shoreline also corresponds to a sharp increase in water depth resulting from dredging operations for navigational purposes in the Corpus Christi Ship Channel.

20.3 Recommendations

Based on the results of the BLRA, preparation of a CMS is recommended for the Encycle facility. The CMS will identify and evaluate potential remedial alternatives for the releases at the Encycle facility that have been documented in the BLRA to pose potential risks above regulatorily acceptable levels as follows:

- Releases of antimony, arsenic, cadmium, cyanide, lead, manganese, and selenium to groundwater in the Beaumont Formation at the site.

- Releases of arsenic, cadmium, and lead to soils at the site.

- Releases of antimony, arsenic, cadmium, copper, lead, manganese, mercury, selenium, thallium, tin, and zinc to sediments located between the rip rap shoreline directly north of the 01 Landfill and the dredge line approximately 60 feet north of the rip rap shoreline.

The CMS will involve the following activities prior to preparation of the CMS report:

- Negotiations with the owners of the 16.8-acre leased property (Meaney Tract) regarding institutional controls (i.e., deed recordation) for the leased property.

- Collection of additional soil samples in the areas of the facility affected by arsenic, cadmium and lead above the PRGs to more precisely delineate the horizontal and vertical extent of arsenic, cadmium, and lead that will require remediation.

- Collection of representative soil samples from the soils affected by arsenic, cadmium and lead above the PRGs, and collection of sediment samples adjacent to the 01 Landfill for pilot-scale treatability tests to evaluate potential in-situ or ex-situ metal fixation/stabilization agents to reduce the mobility of metals. The fixation/stabilizing agents to be evaluated may include pozzolan-portland cement, kiln dust, and lime-fly ash mixtures.

- Collection of additional sediment samples adjacent to the 01 Landfill below a depth of six inches to determine the vertical extent of metals in sediment.

- Collection of additional sediment samples to conduct sediment toxicity testing to determine the bioavailability of COPECs in the sediment.

Following collection of the data described above, a CMS report will be prepared and will include the following elements:

- Introduction/Purpose
- Description of Current Conditions
- Corrective Action Objectives and Media Cleanup Standards
- Corrective Measures Pilot Study Results
- Identification, Screening and Development of Corrective Measure Alternatives
- Evaluation of a Final Corrective Measure Alternative
- Public Involvement Plan
- Progress Reports
- Proposed Schedule

Documents that may be referenced in the CMS Report include those listed in Appendix A (Corrective Action Reference List) in the Consent Decree.

Following TCEQ authorization to proceed, the CMS soil and sediment sampling and pilot testing activities will be conducted, and will require approximately 90 days to complete. The CMS report will then be prepared and will require approximately 30 days to complete. Therefore, the CMS report will be submitted to the TCEQ within 120 days following TCEQ approval to proceed.

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TABLES

Table 3-1. Occurrence Summary for Groundwater Samples, Fill/Alluvium Formation, Encycle/Texas, Inc., Corpus Christi, Texas.

Constituent	Frequency Detects / Total	Range of SQLs Min - Max	Range of Detects Min - Max	Total Range Min - Max	Average Detect	Mean	UCL	Adjusted RBSV	Is Max Detect or SQL Above RBSV?
Inorganics									
Antimony	3 / 27	0.05	0.052 - 0.18	0.05 - 0.18	0.11	0.056	0.065	0.6	NO
Arsenic	92 / 113	0.005 - 0.02	0.001 - 0.047	0.001 - 0.047	0.013	0.012	0.014	1	NO
Barium	58 / 74	0.05	0.022 - 0.55	0.022 - 0.55	0.075	0.07	0.086	200	NO
Bismuth	0 / 27	0.05	ND	0.05	ND	ND	ND	180	NO
Cadmium	16 / 78	0.002 - 0.01	0.002 - 0.1	0.002 - 0.1	0.017	0.01	0.012	0.5	NO
Chromium	8 / 80	0.01 - 0.02	0.013 - 0.08	0.01 - 0.08	0.034	0.013	0.015	10	NO
Cobalt	0 / 27	0.05	ND	0.05	ND	ND	ND	220	NO
Copper	10 / 66	0.008 - 0.05	0.01 - 0.1	0.008 - 0.1	0.04	0.031	0.036	130	NO
Cyanide	0 / 27	0.004	ND	0.004	ND	ND	ND	20	NO
Lead	37 / 112	0.001 - 0.02	0.001 - 0.11	0.001 - 0.11	0.014	0.012	0.014	1.5	NO
Manganese	93 / 93	NA	0.14 - 20	0.14 - 20	1.9	1.9	2.6	170	NO
Mercury	5 / 74	0.0005 - 0.0006	0.00044 - 0.00082	0.00044 - 0.00082	0.00065	0.00052	0.00053	0.2	NO
Nickel	1 / 31	0.02 - 0.05	0.08 - 0.08	0.02 - 0.08	0.08	0.047	0.051	7.3	NO
Selenium	59 / 90	0.005 - 0.01	0.005 - 0.28	0.005 - 0.28	0.066	0.046	0.058	5	NO
Silver	3 / 74	0.005 - 0.01	0.007 - 0.02	0.005 - 0.02	0.015	0.0061	0.0067	1.8	NO
Thallium	5 / 27	0.002	0.003 - 0.011	0.002 - 0.011	0.006	0.0027	0.0034	0.2	NO
Tin	3 / 27	0.05	0.1 - 0.84	0.05 - 0.84	0.4	0.089	0.14	2200	NO
Vanadium	6 / 27	0.05	0.056 - 0.066	0.05 - 0.066	0.061	0.052	0.054	2.6	NO
Zinc	49 / 67	0.01 - 0.05	0.01 - 10	0.01 - 10	0.97	0.72	1.2	110	NO

Concentrations are reported in milligrams per liter (mg/L).

Average Detect	Arithmetic average of the detected samples only.
Mean	Arithmetic average of the total number of samples, using proxy concentrations for non-detects.
NA	Not applicable.
ND	Not detected.
RBSV	Risk-Based Screening Value (TCEQ, 2004) for groundwater, that has been adjusted 100x for saline groundwater conditions (30 TAC Chapter 335.559(g)).
SQLs	Practical sample quantitation limits for the non-detects.
UCL	95 percent upper confidence limit (one-tailed) on the mean, assuming a normal distribution.

Table 3-2. Occurrence Summary for Groundwater Samples, Beaumont Formation, Encycle/Texas, Inc., Corpus Christi, Texas.

Constituent	Frequency Detects / Total	Range of SQLs Min - Max	Range of Detects Min - Max	Total Range Min - Max	Average Detect	Mean	UCL	SSBC	Is Max Detect or SQL Above SSBC?	GW RBSV	Is Max Detect or SQL Above RBSV?
Inorganics											
Antimony	0 / 40	0.05	ND	0.05	ND	ND	ND	0.127	NO	0.006	YES
Arsenic	28 / 44	0.005	0.005 - 0.063	0.005 - 0.063	0.022	0.016	0.019	0.036	YES	0.01	YES
Barium	19 / 40	0.05	0.056 - 0.24	0.05 - 0.24	0.1	0.074	0.086	0.62	NO	2	NO
Bismuth	1 / 40	0.05	0.059	0.059	0.059	0.05	0.051	0.05	YES	1.8	NO
Cadmium	1 / 44	0.003 - 0.01	0.056	0.003 - 0.056	0.056	0.011	0.013	0.02	YES	0.005	YES
Chromium	7 / 40	0.1	0.01 - 0.041	0.01 - 0.1	0.017	0.014	0.018	0.093	YES	0.1	NO
Cobalt	0 / 40	0.05	ND	0.05	ND	ND	ND	0.05	NO	2.2	NO
Copper	4 / 44	0.02 - 0.05	0.008 - 0.061	0.008 - 0.061	0.034	0.047	0.05	0.05	YES	1.3	NO
Cyanide	3 / 40	0.004	0.039 - 0.23	0.23	0.14	0.014	0.025	0.004	YES	0.2	YES
Lead	1 / 44	0.02	0.039	0.02 - 0.039	0.039	0.02	0.021	0.126	NO	0.015	YES
Manganese	39 / 44	0.015 - 0.05	0.019 - 7.7	0.015 - 7.7	0.97	0.86	1.3	7.6	YES	1.7	YES
Mercury	1 / 40	0.0005	0.00056	0.0005 - 0.00056	0.00056	0.0005	0.0005	0.0007	NO	0.002	NO
Nickel	1 / 44	0.02 - 0.05	0.053	0.02 - 0.053	0.053	0.047	0.05	0.05	YES	0.073	NO
Selenium	23 / 40	0.01	0.011 - 0.49	0.01 - 0.49	0.16	0.095	0.13	0.34	YES	0.05	YES
Silver	0 / 40	0.005	ND	0.005	ND	ND	ND	0.0025	YES	0.018	NO
Thallium	0 / 40	0.002	ND	0.002	ND	ND	ND	0.002	NO	0.002	NO
Tin	0 / 40	0.05	ND	0.05	ND	ND	ND	0.05	NO	22	NO
Vanadium	8 / 40	0.05	0.054 - 0.11	0.05 - 0.11	0.081	0.056	0.06	0.12	NO	0.026	YES
Zinc	21 / 44	0.05	0.013 - 0.71	0.013 - 0.71	0.16	0.1	0.14	1.02	NO	1.1	NO

Concentrations are reported in milligrams per liter (mg/L).

Average Detect	Arithmetic average of the detected samples only.
Mean	Arithmetic average of the total number of samples, using proxy concentrations for non-detects.
ND	Not detected.
SSBC	Site-specific background concentration in groundwater.
SQLs	Practical sample quantitation limits for the non-detects.
RBSV	Risk-Based Screening Value (TCEQ, 2004) for groundwater.
UCL	95 percent upper confidence limit (one-tailed) on the mean, assuming a normal distribution.

Table 3-3. Occurrence Summary for Soil Data, 0 ft bgs to Groundwater, Encycle/Texas, Inc., Corpus Christi, Texas.

Constituent	Frequency Detects / Total	Range of SQLs Min - Max	Range of Detects Min - Max	Total Range Min - Max	Average Detect	Mean	UCL	EPC
Inorganics								
Antimony	475 / 695	0.8 - 1.5	0.8 - 606	0.8 - 606	9.7	6.9	9.4	9.4
Arsenic	295 / 473	5	5 - 8018	5 - 8018	110	71	110	110
Barium	318 / 318	NA	43 - 1665	43 - 1665	290	290	310	310
Bismuth	52 / 343	4 - 50	4 - 142	4 - 142	21	6.8	8.1	8.1
Cadmium	408 / 587	1 - 2.5	1 - 3911	1 - 3911	150	100	130	130
Chromium	547 / 549	5	5 - 4691	5 - 4691	44	44	61	61
Cobalt	344 / 399	5	5 - 14450	5 - 14450	82	72	140	140
Copper	528 / 551	5	5 - 104400	5 - 104400	720	690	1100	1100
Cyanide	58 / 321	0.04 - 0.1	0.04 - 21	0.04 - 21	1.3	0.27	0.41	0.41
Lead	477 / 497	5	5 - 65760	5 - 65760	850	820	1200	1200
Manganese	570 / 570	NA	26 - 37520	26 - 37520	1000	1000	1300	1300
Mercury	194 / 442	0.05	0.05 - 363	0.05 - 363	6.2	2.7	4.4	4.4
Nickel	409 / 423	5	5 - 18280	5 - 18280	86	83	160	160
Selenium	120 / 408	0.8 - 5	0.8 - 1620	0.8 - 1620	30	9.7	17	17
Silver	206 / 465	0.5	0.52 - 352	0.5 - 352	18	8.2	11	11
Thallium	195 / 442	1 - 40	1 - 20	1 - 40	2.9	2.8	3.1	3.1
Tin	134 / 380	5	5 - 2073	5 - 2073	74	29	41	41
Vanadium	328 / 331	5	5 - 88	5 - 88	24	24	25	25
Zinc	932 / 932	NA	6 - 239900	6 - 239900	3700	3700	4500	4500

Concentrations are reported in milligrams per kilogram (mg/kg).

Average Detect	Arithmetic average of the detected samples only.
ft bgs	Feet below ground surface.
EPC	Exposure point concentration; lesser of the UCL and the maximum detected concentration (when there are >/=10 data points).
Mean	Arithmetic average of the total number of samples, using proxy concentrations for non-detects.
NA	Not available.
SQLs	Practical quantitation limits for the non-detects.
UCL	95 percent upper confidence limit (one-tailed) on the mean, assuming a normal distribution.

Table 3-4. Occurrence Summary for Soil Data, 0 to 2 ft bgs, Encycle/Texas, Inc., Corpus Christi, Texas.

Constituent	Frequency Detects / Total	Range of SQLs Min - Max	Range of Detects Min - Max	Total Range Min - Max	Average Detect	Mean	UCL	EPC	RBSV	Is Max Detect or SQL Above MSC?
Inorganics										
Antimony	137 / 194	0.8	0.82 - 606	0.8 - 606	26	19	28	28	7.2	YES
Arsenic	128 / 184	5	5 - 8018	5 - 8018	240	170	260	260	20 [a]	YES
Barium	138 / 138	NA	56 - 1665	56 - 1665	310	310	350	350	910	YES
Bismuth	39 / 158	4 - 50	4 - 142	4 - 142	26	9.7	12	12	9900	NO
Cadmium	203 / 221	1 - 2.5	1 - 3911	1 - 3911	230	210	270	270	5.2	YES
Chromium	195 / 196	5	7.6 - 4691	5 - 4691	92	91	140	140	5900	NO
Cobalt	144 / 163	5	5 - 14450	5 - 14450	180	160	320	320	1500	YES
Copper	205 / 205	NA	5 - 104400	5 - 104400	1700	1700	2800	2800	1000	YES
Cyanide	49 / 144	0.04 - 0.1	0.04 - 21	0.04 - 21	1.4	0.52	0.83	0.83	510	NO
Lead	202 / 203	5	5.7 - 65760	5 - 65760	1900	1900	2700	2700	500 [b]	YES
Manganese	214 / 214	NA	40 - 37520	40 - 37520	1600	1600	2200	2200	1700	YES
Mercury	137 / 194	0.05	0.05 - 213	0.05 - 213	4.7	3.3	5.4	5.4	0.011	YES
Nickel	166 / 169	5	5.2 - 18280	5 - 18280	190	190	370	370	190	YES
Selenium	77 / 180	0.8	0.89 - 1620	0.8 - 1620	31	14	29	29	130	YES
Silver	130 / 191	0.5	0.52 - 352	0.5 - 352	25	17	24	24	47	YES
Thallium	53 / 159	1 - 20	1 - 20	1 - 20	3.4	3.4	4.1	4.1	2	YES
Tin	95 / 160	5	5 - 2073	5 - 2073	82	50	77	77	9300	NO
Vanadium	145 / 147	5	7 - 88	5 - 88	20	20	21	21	48	YES
Zinc	200 / 200	NA	28 - 239900	28 - 239900	12000	12000	16000	16000	5900	YES

Concentrations are reported in milligrams per kilogram (mg/kg).

[a]	The risk-based screening value for arsenic is equivalent to the cleanup level established by the Executive Director (interoffice memo entitled "Arsenic Soil Cleanup Standards" from Dan Pearson on May 19, 1995).
Average Detect	Arithmetic average of the detected samples only.
[b]	The risk-based screening value for lead was calculated by the USEPA using the Lead Uptake/Biokinetic Model.
ft bgs	Feet below ground surface.
EPC	Exposure point concentration; lesser of the UCL and the maximum detected concentration (when there are >/=10 data points).
Mean	Arithmetic average of the total number of samples, using proxy concentrations for non-detects.
NA	Not available.
RBSV	Risk-based screening value.
SQLs	Practical quantitation limits for the non-detects.
UCL	95 percent upper confidence limit (one-tailed) on the mean, assuming a normal distribution.

Table 3-5. Occurrence Summary for Soil Data, 0 to 5 ft bgs, Encycle/Texas, Inc., Corpus Christi, Texas.

Constituent	Frequency Detects / Total	Range of SQLs Min - Max	Range of Detects Min - Max	Total Range Min - Max	Average Detect	Mean	UCL	EPC	RBSV	Is Max Detect or SQL Above MSC?
Inorganics										
Antimony	220 / 334	0.8 - 1.5	0.8 - 606	0.8 - 606	18	12	17	17	7.2	YES
Arsenic	195 / 291	5	5 - 8018	5 - 8018	160	110	170	170	20 [a]	YES
Barium	190 / 190	NA	56 - 1665	56 - 1665	310	310	340	340	910	YES
Bismuth	50 / 217	4 - 50	4 - 142	4 - 142	22	8.4	10	10	9900	NO
Cadmium	309 / 361	1 - 2.5	1 - 3911	1 - 3911	180	160	200	200	5.2	YES
Chromium	326 / 328	5	7 - 4691	5 - 4691	62	62	90	90	5900	NO
Cobalt	217 / 249	5	5 - 14450	5 - 14450	130	110	210	210	1500	YES
Copper	340 / 342	5	5 - 104400	5 - 104400	1100	1100	1700	1700	1000	YES
Cyanide	55 / 195	0.04 - 0.1	0.04 - 21	0.04 - 21	1.4	0.42	0.65	0.65	510	NO
Lead	307 / 312	5	5.7 - 65760	5 - 65760	1300	1300	1800	1800	500 [b]	YES
Manganese	364 / 364	NA	26 - 37520	26 - 37520	1300	1300	1600	1600	1700	YES
Mercury	179 / 294	0.05	0.05 - 363	0.05 - 363	6.3	3.9	6.3	6.3	0.011	YES
Nickel	261 / 268	5	5.1 - 18280	5 - 18280	130	120	240	240	190	YES
Selenium	100 / 258	0.8 - 5	0.89 - 1620	0.8 - 1620	36	14	26	26	130	YES
Silver	170 / 300	0.5	0.52 - 352	0.5 - 352	20	12	16	16	47	YES
Thallium	91 / 257	1 - 20	1 - 20	1 - 20	3.2	3.1	3.5	3.5	2	YES
Tin	121 / 238	5	5 - 2073	5 - 2073	76	41	60	60	9300	NO
Vanadium	192 / 195	5	7 - 88	5 - 88	22	22	23	23	48	YES
Zinc	373 / 373	NA	14 - 239900	14 - 239900	7900	7900	9900	9900	5900	YES

Concentrations are reported in milligrams per kilogram (mg/kg).

[a]	The risk-based screening value for arsenic is equivalent to the cleanup level established by the Executive Director (interoffice memo entitled "Arsenic Soil Cleanup Standards" from Dan Pearson on May 19, 1995).
Average Detect	Arithmetic average of the detected samples only.
[b]	The risk-based screening value for lead was calculated by the USEPA using the Lead Uptake/Biokinetic Model.
ft bgs	Feet below ground surface.
EPC	Exposure point concentration; lesser of the UCL and the maximum detected concentration (when there are >/=10 data points).
Mean	Arithmetic average of the total number of samples, using proxy concentrations for non-detects.
NA	Not available.
RBSV	Risk-based screening value.
SQLs	Practical quantitation limits for the non-detects.
UCL	95 percent upper confidence limit (one-tailed) on the mean, assuming a normal distribution.

Table 3-6. Occurrence Summary for Soil Data, 0 to 15 ft bgs, Encycle/Texas, Inc., Corpus Christi, Texas.

Constituent	Frequency Detects / Total	Range of SQLs Min - Max	Range of Detects Min - Max	Total Range Min - Max	Average Detect	Mean	UCL	EPC	RBSV	Is Max Detect or SQL Above MSC?
Inorganics										
Antimony	428 / 633	0.8 - 1.5	0.8 - 606	0.8 - 606	11	7.4	10	10	7.2	YES
Arsenic	277 / 431	5	5 - 8018	5 - 8018	120	77	120	120	20 [a]	YES
Barium	293 / 293	NA	49 - 1665	49 - 1665	300	300	320	320	910	YES
Bismuth	52 / 319	4 - 50	4 - 142	4 - 142	21	7	8.4	8.4	9900	NO
Cadmium	402 / 542	1 - 2.5	1 - 3911	1 - 3911	150	110	140	140	5.2	YES
Chromium	509 / 511	5	5 - 4691	5 - 4691	46	46	64	64	5900	NO
Cobalt	321 / 372	5	5 - 14450	5 - 14450	88	76	150	150	1500	YES
Copper	495 / 509	5	5 - 104400	5 - 104400	760	740	1200	1200	1000	YES
Cyanide	58 / 297	0.04 - 0.1	0.04 - 21	0.04 - 21	1.3	0.29	0.44	0.44	510	NO
Lead	440 / 455	5	5 - 65760	5 - 65760	920	890	1300	1300	500 [b]	YES
Manganese	525 / 525	NA	26 - 37520	26 - 37520	1100	1100	1300	1300	1700	YES
Mercury	194 / 418	0.05	0.05 - 363	0.05 - 363	6.2	2.9	4.6	4.6	0.011	YES
Nickel	375 / 387	5	5 - 18280	5 - 18280	93	90	170	170	190	YES
Selenium	113 / 379	0.8 - 5	0.8 - 1620	0.8 - 1620	32	10	18	18	130	YES
Silver	202 / 438	0.5	0.52 - 352	0.5 - 352	18	8.6	12	12	47	YES
Thallium	179 / 411	1 - 40	1 - 20	1 - 40	2.9	2.9	3.2	3.2	2	YES
Tin	134 / 355	5	5 - 2073	5 - 2073	74	31	44	44	9300	NO
Vanadium	303 / 306	5	6 - 88	5 - 88	24	24	25	25	48	YES
Zinc	815 / 815	NA	7 - 239900	7 - 239900	4200	4200	5100	5100	5900	YES

Concentrations are reported in milligrams per kilogram (mg/kg).

[a]	The risk-based screening value for arsenic is equivalent to the cleanup level established by the Executive Director (interoffice memo entitled "Arsenic Soil Cleanup Standards" from Dan Pearson on May 19, 1995).
Average Detect	Arithmetic average of the detected samples only.
[b]	The risk-based screening value for lead was calculated by the TCEQ using the USEPA Lead Uptake/ Biokentic Model.
ft bgs	Feet below ground surface.
EPC	Exposure point concentration; lesser of the UCL and the maximum detected concentration (when there are >/=10 data points).
Mean	Arithmetic average of the total number of samples, using proxy concentrations for non-detects.
NA	Not available.
RBSV	Risk-based screening value.
SQLs	Practical quantitation limits for the non-detects.
UCL	95 percent upper confidence limit (one-tailed) on the mean, assuming a normal distribution.

Table 3-7 . Occurrence Summary for Total Surface Water Data, Encycle/Texas, Inc., Corpus Christi, Texas.

Constituent	Frequency Detects / Total	Detection Frequency	Range of SQLs Min - Max	Range of Detects Min - Max	Total Range Min - Max	Average Detect	Mean	UCL	GW-Res MSC	Is Max Detect or SQL Above MSC?
Total Metals										
Antimony	1 / 4	25%	0.006	0.017 - 0.017	0.006 - 0.017	0.017	0.0088	0.015	0.006	YES
Arsenic	0 / 4	0%	0.01	ND	0.01	ND	0.01	0.01	0.01	NO
Cadmium	0 / 4	0%	0.005	ND	0.005	ND	0.005	0.005	0.005	NO
Cobalt	0 / 4	0%	0.01	ND	0.01	ND	0.01	0.01	2.2	NO
Copper	2 / 4	50%	0.01	0.02 - 0.04	0.01 - 0.04	0.03	0.02	0.037	1.3	NO
Lead	0 / 4	0%	0.01	ND	0.01	ND	0.01	0.01	0.015	NO
Manganese	4 / 4	100%	NA	0.02 - 0.04	0.02 - 0.04	0.025	0.025	0.037	1.7	NO
Mercury	0 / 4	0%	0.002	ND	0.002	ND	0.002	0.002	0.002	NO
Nickel	2 / 4	50%	0.01	0.01 - 0.07	0.01 - 0.07	0.04	0.025	0.06	0.73	NO
Selenium	0 / 4	0%	0.01	ND	0.01	ND	0.01	0.01	0.05	NO
Silver	0 / 4	0%	0.005	ND	0.005	ND	0.005	0.005	0.18	NO
Thallium	0 / 4	0%	0.002	ND	0.002	ND	0.002	0.002	0.002	NO
Tin	0 / 4	0%	0.02	ND	0.02	ND	0.02	0.02	22	NO
Zinc	4 / 4	100%	NA	0.07 - 0.11	0.07 - 0.11	0.088	0.088	0.11	11	NO

Concentrations are reported in milligrams per liter (mg/L).

Average Detect	Arithmetic average of the detected samples only.
Mean	Arithmetic average of the total number of samples, using proxy concentrations for non-detects.
GW-Res MSC	Groundwater medium-specific concentration for residential use.
NA	Not applicable.
ND	Not detected.
SQLs	Practical sample quantitation limits for the non-detects.
UCL	95 percent upper confidence limit (one-tailed) on the mean, assuming a normal distribution.

Table 4-1. Oral Reference Doses, Inhalation Reference Concentrations, Target Sites, and Confidence Levels for Constituents of Potential Concern Encycle/Texas, Inc., Corpus Christi, Texas.

Contaminant	RfDo (mg/kg-day)		RfC (mg/m^3)	Target Sites		Confidence level/ Uncertainty Factor	
	Chronic		Chronic	Oral	Inhalation	Oral	Inhalation
Inorganics							
Antimony	4.0E-04		5.0E-04	increased mortality/blood	NA	low/1000	NA
Arsenic	3.0E-04		NA	skin	NA	medium/3	NA
Barium	7.0E-02		5.0E-04	cardiovascular	fetus	medium/3	NA/1000
Cadmium	1.0E-03		2.0E-04	kidney	NA	high/10	NA
	5.0E-04	[a]					
Cobalt	6.0E-02		2.0E-05	skin	NA	NA	NA
Copper	4.0E-02		1.0E-03	gastrointestine	NA	NA	NA
Cyanide	2.0E-02		5.0E-03	increased mortality/thyroid/NS	NA	medium/100	NA
Lead (inorganic)	NA		NA	CNS	CNS	NA	NA
Manganese	1.4E-01	[b]	5.0E-05	CNS	CNS	medium/1	medium/1000
Mercury	3.0E-04		3.0E-04	kidney	CNS	NA	medium/30
Nickel	2.0E-02		2.0E-04	decreased body weight	NA	medium/300	NA
Selenium	5.0E-03		2.0E-04	selenosis	NA	high/3	NA
Silver	5.0E-03		1.0E-05	skin	NA	low/3	NA
Thallium	8.0E-05		1.0E-04	liver,blood,hair	NA	low/3000	NA
Vanadium	7.0E-03		5.0E-05	liver	NA	low/100	NA
Zinc	3.0E-01		NA	blood	NA	medium/3	NA

References: TCEQ, 2003; IRIS, 2001.

[a]	Value based on water.
[b]	Value used for residential and commercial industrial soil pathways.
CNS	Central nervous system.
mg/kg/day	Millligram per kilogram per day.
mg/m^3	Millligram per cubic meter.
NA	Not available.
RfDo	Oral reference dose.
RfC	Inhalation reference concentration.

Table 4-2. Dermal and Oral Absorption Efficiencies, Encycle/Texas, Inc., Corpus Christi, Texas.

Constituents	Absorption Efficiency	
	Oral	Dermal
Inorganics		
Antimony	1.5E-01	1.0E-02
Arsenic	9.5E-01	3.0E-02
Barium	7.0E-02	1.0E-02
Cadmium	2.5E-02	1.0E-03
Cobalt	8.0E-01	1.0E-02
Copper	5.7E-01	1.0E-02
Cyanide	5.0E-01	1.0E-02
Lead (inorganic)	1.5E-01	1.0E-02
Manganese	6.0E-02	1.0E-02
Mercury	7.0E-02	1.0E-02
Nickel	4.0E-02	1.0E-02
Selenium	5.0E-01	1.0E-02
Silver	4.0E-02	1.0E-02
Thallium	1.0E+00	1.0E-02
Vanadium	2.6E-02	1.0E-02
Zinc	2.0E-01	1.0E-02

Reference: TCEQ, 2003.

Table 4-3. Adjusted Toxicity Values Used to Assess Dermal Exposure for Constituents of Potential Concern, Encycle/Texas, Corpus Christi, Texas.

Constituent	RfDo (mg/kg/day) Chronic		CSFo (kg-day/mg)	Oral Absorption Efficiency	RfDa (mg/kg/day) Chronic	CSFa (kg-day/mg)
Inorganics						
Antimony	4.0E-04		NC	1.5E-01	6.0E-05	NC
Arsenic	3.0E-04		NC	9.5E-01	3.0E-04	NC
Barium	7.0E-02		NC	7.0E-02	4.9E-03	NC
Cadmium	1.0E-03		NC	2.5E-02	2.5E-05	NC
	5.0E-04	[a]	NC	2.5E-02	1.3E-05	NC
Cobalt	6.0E-02		NC	8.0E-01	6.0E-02	NC
Copper	4.0E-02		NC	5.7E-01	4.0E-02	NC
Cyanide	2.0E-02		NC	5.0E-01	2.0E-02	NC
Lead (inorganic)	NA		NC	1.5E-01	NA	NC
Manganese	1.4E-01		NC	6.0E-02	8.4E-03	NC
Mercury	3.0E-04		NC	7.0E-02	2.1E-05	NC
Nickel	2.0E-02		NC	4.0E-02	8.0E-04	NC
Selenium	5.0E-03		NC	5.0E-01	5.0E-03	NC
Silver	5.0E-03		NC	4.0E-02	2.0E-04	NC
Thallium	8.0E-05		NC	1.0E+00	8.0E-05	NC
Vanadium	7.0E-03		NC	2.6E-02	1.8E-04	NC
Zinc	3.0E-01		NC	2.0E-01	6.0E-02	NC

[a] Value based on water.
CSFa Adjusted cancer slope factor.
CSFo Oral cancer slope factor.
kg-day/mg Kilogram day per milligram.
mg/kg/day Milligrams per kilogram per day.
NA Not available.
NC Not evaluated as a carcinogen.
RfDa Adjusted reference dose.
RfDo Oral reference dose.

Table 4-4. Permeability Coefficients for Constituents of Potential Concern, Encycle/Texas, Inc., Corpus Christi, Texas.

Constituent	Permeability Coefficient (cm/hr)
Inorganics	
Antimony	1.0E-03
Arsenic	1.0E-03
Barium	1.0E-03
Cadmium	1.0E-03
Cobalt	4.0E-04
Copper	1.0E-03
Cyanide	1.0E-03
Lead	1.0E-04
Manganese	1.0E-03
Mercury	1.0E-03
Nickel	2.0E-04
Selenium	1.0E-03
Silver	6.0E-04
Thallium	1.0E-03
Vanadium	1.0E-03
Zinc	6.0E-04

Reference: USEPA, (2001).

cm/hr Centimeters per hour.

Table 4-5. Oral Cancer Slope Factors, Inhalation Unit Risks, Tumor Sites, and USEPA Cancer Classifications for Constituents of Potential Concern, Encycle/Texas, Inc., Corpus Christi, Texas.

Constituent	Oral CSF (kg-day/mg)	Inhalation Unit Risk ($m^3/\mu g$)	Tumor site		USEPA Classification
			Oral	Inhalation	
Inorganics					
Cadmium	NA	1.8E-03	NA	respiratory tract	B1
Nickel	NA	4.8E-04	NA	respiratory tract	A

References: TCEQ, 2003; IRIS, 2001; USEPA,1997.

CSF Cancer slope factor.
kg-day/mg Kilograms-day per milligram.
$m^3/\mu g$ Cubic meters per microgram.

Table 5-1. Physical and Chemical Properties of Inorganic Constituents of Potential Concern, Encycle/Texas, Inc., Corpus Christi, Texas.

Constituent	M.W. (g/mole)	H (atm-m^3/mol)	H ' (cm^3 -H_2O/ cm^3 -air)	K_d (unitless)	Dair (cm^2 /s)	Dwat (cm^2 /s)	Solubility (mg/L)	Vapor Pressure (mm Hg)	Log K_{ow}	Fish Bioconcentration Factors (L/kg)
Inorganics										
Antimony	122	0.00E+00	0.00E+00	44.668	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	40
Arsenic	74.9	0.00E+00	0.00E+00	25.119	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.79E-01	NAP
Barium	137	0.00E+00	0.00E+00	10.965	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	NAP
Cadmium	112	0.00E+00	0.00E+00	15.136	0.00E+00	0.00E+00	0.00E+00	0.00E+00	-7.10E-02	NAP
Cobalt	58.9	0.00E+00	0.00E+00	44.668	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	NAP
Copper	63.5	0.00E+00	0.00E+00	39.811	0.00E+00	0.00E+00	0.00E+00	0.00E+00	-5.71E-01	710
Cyanide	26	0.00E+00	0.00E+00	9.908	5.21E-01	2.28E-05	1.00E+05	1.38E+01	-6.93E-01	NAP
Lead (inorganic)	207	0.00E+00	0.00E+00	10	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.29E-01	NAP
Manganese	54.9	0.00E+00	0.00E+00	50.119	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	100
Mercury	201	1.16E-02	4.74E-01	52.481	3.07E-02	6.30E-06	3.00E-02	1.30E-03	-4.71E-01	NAP
Nickel	58.7	0.00E+00	0.00E+00	15.850	0.00E+00	0.00E+00	0.00E+00	0.00E+00	-5.71E-01	NAP
Selenium	79	0.00E+00	0.00E+00	2.198	NA	NA	0.00E+00	0.00E+00	2.39E-01	NAP
Silver	108	0.00E+00	0.00E+00	0.1	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	NAP
Thallium	240	0.00E+00	0.00E+00	43.652	NA	NA	2.90E+03	0.00E+00	NA	NAP
Vanadium	50.9	0.00E+00	0.00E+00	1000	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	NAP
Zinc	65.4	0.00E+00	0.00E+00	15.849	0.00E+00	0.00E+00	0.00E+00	0.00E+00	-4.71E-01	126.2

Chemical/Physical Parameters: TCEQ recommended values (2003)
Fish Bioconcentration Factors: EPA (1999), SCDM (1997), ATSDR (1996).

atm-m^3/mol	Atmospheres-cubic meter per mole.
ATSDR	Agency for Toxic Substances and Disease Registry.
cm^2 /s	Square centimeters per second.
cm^3 -H_2O/cm3 -air	Cubic centimeters water per cubic centimeters air.
Dair	Diffusion coefficient in air.
Dwat	Diffusion coefficient in water.
EPA	Environmental Protection Agency.
g/mol	Grams per mole.
H'	Dimensionless Henry's Law Constant H'.
H	Henry's Law Constant; H=H' x 0.02446.
Kd	Soil organic carbon-water partition coefficient for inorganics.
Kow	Octanol-water partition coefficient
L/kg	Liters per kilogram.
mg/L	Milligram per liter.
mm Hg	Millimeters of mercury.
M.W.	Molecular weight .
NA	Not available.
NAP	Not applicable, because constituent is not a COPC in surface water.
SCDM	Superfund Chemical Data Matrix.
TCEQ	Texas Commission on Environmental Quality.

Table 5-2. Receptor-Specific Exposure Parameters, Encycle/Texas, Inc., Corpus Christi, Texas.

		Potential Current		Hypothetical Future		
Parameter	(units)	Excavation Worker	Site Worker	Age-Averaged Child/Adult Resident	Resident Adult	Resident Child
ATc	(days)	25,550	25,550	25,550	25,550	25,550
ATnc	(days)	84	9,125	2,190	12,045	2,190
BW	(kg)	70	70	15	70	15
EF	(days/year)	–	250	350	350	350
EFx	(days/week)	5	–	–	–	–
ED	(years)	–	25	6	33	6
EPx	(weeks)	12	–	–	–	–
ETgw	(hours/day)	–	–	–	0.58	1
IFo	(mg-yr/kg-day)	–	–	114	–	–
IRfish	(kg/day)	–	–	–	0.015	–
IRgw	(L/day)	–	–	–	2	0.64
IRs	(mg/day)	480	50	200	–	–
SAR	(mg/cm²/day)	0.2	0.2	0.2	–	–
SSAgw	(cm²)	–	–	–	18,000	6,600
SSAs	(cm²)	2,500	2,500	2,200	–	–

References: TCEQ, 1999a; USEPA, 1989a,c; 1991a,b.

ATc	Averaging time period for cancer risk.
ATnc	Averaging time period for non-cancer risk.
BW	Body weight.
cm²	Square centimeter.
EF	Exposure frequency.
ED	Exposure duration.
ETgw	Exposure time for ground water contact.
IFo	Age-adjusted oral intake factor.
IRfish	Ingestion rate of fish.
IRgw	Ingestion rate of groundwater for hypothetical future site worker.
IRs	Incidental ingestion rate of soil.
kg	Kilogram.
L	Liter
mg	Milligram.
SAR	Soil-to-skin adherence rate.
SSAgw	Skin surface area for groundwater contact.
SSAs	Skin surface area for soil contact.

Table 5-3. Weighted Average Soil Geotechnical Data, Encycle/Texas, Inc., Corpus Christi, Texas.

Boring ID	Date Sampled	Sample Depth (ft)	Intrinsic Permeability (cm/sec)	Bulk Density (gm/cc)	Effective Porosity (percent)	Moisture Content (percent)	Fraction Organic Carbon (percent)
Beaumont Formation							
Geotech 1 Unsaturated	7/12/2000	5-7	2.99E-05	2.07	20.6	13.2	2.5
Weighted Average (82.5% of value)			2.47E-05	1.71	17.0	10.9	2.1
Fill/Alluvium							
Geotech 2 Unsaturated	7/12/2000	3-4	1.34E-04	1.93	26.4	15.0	1.5
Weighted Average (16.5% of value)			2.21E-05	0.32	4.4	2.5	0.2
Sum Weighted Average			**4.68E-05**	**2.03**	**21.4**	**13.4**	**2.3**

Geotechnical data from the two soil formations were weighted based on the percentage of samples present in each formation. The geotechnical weighted averages were then summed for use in risk calculations.

cm/sec	Centimeters per second.
ft	Feet.
gm/cc	Grams per cubic centimeter.

Table 5-4. Risk and Hazard Equations with Sample Calculations for Hypothetical Future Resident Adult or Child Exposure to Groundwater, Encycle/Texas, Inc., Corpus Christi, Texas.

ROUTE-SPECIFIC RISKS:

Oral:

$$ELCR_o \text{ or } HQ_o = \frac{EPC_{GW} \times IR_W \times EF \times EP}{BW \times (AP_C \text{ or } AP_{NC}) \times [(1/CSF_o) \text{ or } RfD_o]}$$

Dermal:

$$ELCR_d \text{ or } HQ_d = \frac{EPC_{GW} \times SSA \times PC \times (0.001\,L/cm^3) \times ET \times EF \times EP}{BW \times (AP_C \text{ or } AP_{NC}) \times [(1/CSF_a) \text{ or } RfD_a]}$$

Inhalation:

$$ELCR_i = \frac{EPC_{GW} \times VF_W \times EF \times EP \times 1000\,ug/mg}{(AP_C) \times [1/UR_i]}$$

$$HQ_i = \frac{EPC_{GW} \times VF_W \times EF \times EP}{(AP_{NC}) \times [RfC]}$$

CANCER RISK:

$$ELCR = ELCR_o + ELCR_d + ELCR_i$$

NON-CANCER RISK:

$$HI = HO_o + HQ_d + HQ_i$$

where:

AP_C	Averaging period for cancer effects (25,550 days).
AP_{NC}	Averaging period for non-cancer effects (days); EP x 365 days/year.
BW	Body weight (kg) (Table 5-2).
CSF	Cancer slope factor for oral (CSF_o) or dermal (adjusted to an absorbed dose, CSF_a) exposure (inverse of milligrams per kilogram per day [mg/kg/day]). (Table 4-3).
EF	Exposure frequency (days/year) (Table 5-2).
ELCR	Excess lifetime cancer risk (unitless).
ET	Exposure time (hours/day) (Table 5-2).
EP	Exposure period (years) (Table 5-2).
EPCgw	Exposure point concentration in groundwater (milligrams per liter [mg/L](Table 3-2).
HQ	Hazard quotient (unitless).
IR_w	Incidental ingestion rate of groundwater (liters/day) (Table 5-2).
NC	Non-carcinogenic.
PC	Permeability constant (centimeters per hour [cm/hour]) (Table 4-4)
RfC	Subchronic reference concentration for inhalation exposure (mg/m^3) (Table 4-1).

RfD	Chronic reference dose for oral (RfD_o) or dermal (adjusted to an absorbed dose, RfD_a) exposure (mg/kg/day) (Table 4-3).
SSA	Exposed skin surface area (square centimeters [cm^2]) (Table 5-2).
UR_i	Unit cancer risk for inhalation exposure (inverse of microgram per cubic meter [$ug/m^3]^{-1}$) (Table 4-5).
VF_W	Volatilization factor (0.5 L/m^3) (USEPA, 1991a).

SAMPLE CALCULATION: Manganese - Adult

CANCER RISK:

$$ELCR_o = \frac{7.7\ mg/L \times 2\ L \times 350\ days/yr \times 33\ yrs}{70\ kg \times (25{,}550\ days) \times [(1/NC)]}$$

$$= NC$$

$$ELCR_d = \frac{7.7\ mg/L \times 18000\ cm^2 \times 0.001\ cm/hr \times 0.001\ L/cm^3 \times 0.58\ hr/day \times 350\ days/yr \times 33\ yrs}{70\ kg \times 25{,}550\ days \times [(1/NC)]}$$

$$= NC$$

$ELCR_i$ = Not calculated for inorganic constituents.

$$ELCR = NC + NC = NC$$

NON-CANCER RISK:

$$HQ_o = \frac{7.7\ mg/L \times 2\ L \times 350\ days/yr \times 33\ yrs}{70\ kg \times (12045\ days) \times [(0.14\ mg/kg/day)]}$$

$$= 1.5$$

$$HQ_d = \frac{(7.7\ mg/L) \times (18000\ cm^2) \times (0.001\ cm/hr) \times (0.001\ L/cm^3) \times (0.58\ hr/day) \times (350\ days/yr) \times (33\ yrs)}{(70\ kg) \times (12045\ days) \times (0.0084\ mg/kg/day)}$$

$$= 1.3 \times 10^{-1}$$

HQ_i = Not calculated for inorganic constituents.

$$HI = 1.5 + 1.3 \times 10^{-1} = 2$$

Table 5-5. Risk and Hazard Equations with Sample Calculations for Potential Current Worker Exposure to Soil, Encycle/Texas, Inc., Corpus Christi, Texas.

ROUTE-SPECIFIC RISKS:

Oral:

$$ELCR_O \text{ or } HQ_O = \frac{EPC_S \times IR_S \times EF \times EP}{UC_1 \times BW \times (AP_C \text{ or } AP_{NC}) \times [(1/CSF_O) \text{ or } RfD_O]}$$

Dermal:

$$ELCR_d \text{ or } HQ_d = \frac{EPC_S \times SSA \times SAR \times ABS \times EF \times EP}{UC_1 \times BW \times (AP_C \text{ or } AP_{NC} \times [(1/CSF_a) \text{ or } RfD_a]}$$

Inhalation:

$$ELCR_i \text{ or } HQ_i = \frac{EPC_S \times (1/PEF) \times EF \times EP}{(AP_C \text{ or } AP_{NC}) \times [(UC_2/UR_i) \text{ or } RfC]}$$

where:

$$PEF = Q/C \times \frac{3{,}600 \text{ sec/hr}}{RPF \times (1 - G) \times (Um/Ut)^3 \times F_x}$$

Cancer Risk:

$$ELCR = ELCR_O + ELCR_d + ELCR_i$$

Non-Cancer Risk:

$$HI = HQ_o + HQ_d + HQ_i$$

where:

ABS Dermal absorption efficiency (Table 4-2).
AP_C Averaging period for cancer effects (days) (Table 5-2).
AP_{NC} Averaging period for non-cancer effects days; (EP x 365 days/year)(Table 5-2).
BW Body weight (kg) (Table 5-2).
CSF Cancer slope factor for oral (CSF_o) or dermal (adjusted to an absorbed dose, CSF_a) exposure (kg-day/mg; inverse of mg/kg/day) (Table 4-3).
EF Exposure frequency (days/year) (Table 5-2).
ELCR Excess lifetime cancer risk for oral ($ELCR_o$), dermal ($ELCR_d$), inhalation ($ELCR_i$) or total (ELCR) exposure (unitless).
EPCs Exposure point concentration (mg/kg) (Table 3-4).
EP Exposure period (years) (Table 5-2).

Table 5-5. Risk and Hazard Equations with Sample Calculations for Potential Current Worker Exposure to Soil, Encycle/Texas, Inc., Corpus Christi, Texas.

F_x	Function of Ut/Um (0.41) (unitless); $F_x = 0.18 \times [8x^3 + 12x] \times \exp[-(x^2)]$, where x = 0.886 x (Ut/Um).
G	Fraction of vegetative cover (unitless) (0.5) (default).
HI	Hazard index (unitless); sum of the HQs.
HQ	Hazard quotient for oral (HQ_o), dermal (HQ_d), or inhalation (HQ_i) (unitless).
IR_s	Ingestion rate of soil (mg/day) (default) (Table 5-2).
NC	Non-carcinogenic.
PEF	Particulate emission factor (m^3/kg) (calculated).
Q/C	Emission flux per unit concentration (40.69 g/m^2/sec)/(kg/m^3)(default for 30 acre site).
RfC	Reference concentration for inhalation exposure (mg/m^3) (Table 4-1).
RfD	Reference dose for oral (RfD_o) or dermal (adjusted to an absorbed dose, RfD_a) intake (mg/kg/day) (Table 4-3).
RPF	Respirable particle fraction (0.036 g/m^2/hr) (default).
SAR	Soil adherence rate (mg/cm^2/day) (Table 5-2).
SSA	Exposed skin surface area (2,500 cm^2) (Table 5-2).
UC_1	Unit conversion #1 (10^6 mg/kg).
UC_2	Unit conversion #2 (0.001 mg/µg).
Um	Wind speed (5.4 m/sec) (site specific, Corpus Christi, Texas; www.ncdc.noaa.gov).
Ur_i	Unit cancer risk for inhalation exposure (m^3/µg) (Table 4-5).
Ut	Equivalent threshold value of windspeed at 7 meters (11.32 m/sec) (default).

SAMPLE CALCULATION: Cadmium – Site Worker

$$x = 0.886 \times [(11.32\ \text{m/sec})/(5.4\ \text{m/sec})] = 1.87$$

$$F_x = 0.18 \times [(8 \times 1.87^3) + (12 \times 1.87] \times \exp[-(1.87^2)] = 0.4076$$

$$PEF = [40.69\ (\text{g/m}^2/\text{sec})/(\text{kg/m}^3)] \times \frac{(3{,}600\ \text{sec/hr})}{(0.036\ \text{g/m}^2/\text{hr}) \times (1 - 0.5) \times [(5.4\ \text{m/sec})/(11.32\ \text{m/sec})]^3 \times (0.4076)}$$

$$= 1.88 \times 10^8\ \text{m}^3/\text{kg}$$

CANCER RISK:

$$ELCR_o = \frac{(270\ \text{mg/kg}) \times (50\ \text{mg/day}) \times (250\ \text{day/yr}) \times (25\ \text{yrs})}{(10^6\ \text{mg/kg}) \times (70\ \text{kg}) \times (25{,}550\ \text{days}) \times NC}$$

$$= NC$$

Table 5-5. Risk and Hazard Equations with Sample Calculations for Potential Current Worker Exposure to Soil, Encycle/Texas, Inc., Corpus Christi, Texas.

$$ELCR_d = \frac{(270\ mg/kg) \times (2{,}500\ cm^2) \times (0.2\ mg/cm^2/day) \times (0.001) \times (250\ days/yr) \times (25\ yrs)}{(10^6\ mg/kg) \times (70\ kg) \times (25{,}550\ days) \times NC}$$

$$= NC$$

$$ELCR_i = \frac{(270\ mg/kg) \times (1/1.88 \times 10^8\ m^3/kg) \times (250\ day/yr) \times (25\ yrs)}{(25{,}550\ days) \times (0.001/\ 0.0018)}$$

$$= 6.3 \times 10^{-6}$$

$$ELCR = (NC) + (NC) + (6.3 \times 10^{-6}) = 6 \times 10^{-6}$$

NON-CANCER RISK:

$$HQ_o = \frac{(270\ mg/kg) \times (50\ mg/day) \times (250\ days/yr) \times (25\ yrs)}{(10^6\ mg/kg) \times (70\ kg) \times (9125\ days) \times (0.001)}$$

$$= 1.3 \times 10^{-1}$$

$$HQ_d = \frac{(270\ mg/kg) \times (2{,}500\ cm^2) \times (0.2\ mg/cm^2/day) \times (0.001) \times (250\ days/yr) \times (25\ yrs)}{(10^6\ mg/kg) \times (70\ kg) \times (9125\ days) \times (0.000025)}$$

$$= 5.3 \times 10^{-2}$$

$$HQ_i = \frac{(270\ mg/kg) \times (1/1.88 \times 10^8\ m^3/kg) \times (250\ days/yr) \times (25\ yrs)}{(9125\ days) \times (0.0002)}$$

$$= 4.9 \times 10^{-3}$$

$$HI = (1.3 \times 10^{-1}) + (5.3 \times 10^{-2}) + (4.9 \times 10^{-3}) = 1 \times 10^{-1}$$

Table 5-6. Risk and Hazard Equations with Sample Calculations for Future Hypothetical Age-Averaged Future Child/ Adult Resident Exposure to Soil, Encycle/Texas, Inc., Corpus Christi, Texas.

ROUTE-SPECIFIC RISKS:

Oral:

$$ELCR_O = \frac{EPC_S \times IFo \times EF}{UC_1 \times (AP_C) \times [(1/CSF_O)]}$$

$$HQ_O = \frac{EPC_S \times IR_S \times EF \times EP}{UC_1 \times BW \times AP_{NC} \times [RfD_O]}$$

Dermal:

$$ELCR_d = \frac{EPC_S \times ABS \times IFd \times EF}{UC_1 \times (AP_C \times [(1/CSF_a)]}$$

$$HQ_d = \frac{EPC_S \times SSA \times SAR \times ABS \times EF \times EP}{UC_1 \times BW \times AP_{NC} \times [RfD_a]}$$

Inhalation:

$$ELCR_i = \frac{EPC_S \times (1/PEF) \times EF \times EP}{(AP_C) \times [(UC_2/UR_i)]}$$

$$HQ_i = \frac{EPC_S \times (1/PEF) \times EF \times EP}{AP_{NC} \times [RfC]}$$

where:

$$PEF = Q/C \times \frac{3{,}600 \text{ sec/hr}}{RPF \times (1 - G) \times (Um/Ut)^3 \times F_x}$$

Cancer Risk:

$$ELCR = ELCR_O + ELCR_d + ELCR_i$$

Non-Cancer Risk:

$$HI = HQ_o + HQ_d + HQ_i$$

where:

ABS Dermal absorption efficiency (Table 4-2).
AP_C Averaging period for cancer effects (days) (Table 5-2).

Table 5-6. Risk and Hazard Equations with Sample Calculations for Future Hypothetical Age-Averaged Future Child/ Adult Resident Exposure to Soil, Encycle/Texas, Inc., Corpus Christi, Texas.

AP_{NC}	Averaging period for non-cancer effects (days); (EP x 365 days/year)(Table 5-2).
BW	Body weight (kg) (Table 5-2).
CSF	Cancer slope factor for oral (CSF_o) or dermal (adjusted to an absorbed dose, CSF_a) exposure (kg-day/mg; inverse of mg/kg/day) (Table 4-3).
EF	Exposure frequency (days/year) (Table 5-2).
ELCR	Excess lifetime cancer risk for oral ($ELCR_o$), dermal ($ELCR_d$), inhalation ($ELCR_i$) or total (ELCR) exposure (unitless).
EPCs	Exposure point concentration (mg/kg) (Table 3-4).
EP	Exposure period (years) (Table 5-2).
F_x	Function of Ut/Um (0.41) (unitless); $F_x = 0.18 \times [8x^3 + 12x] \times \exp[-(x^2)]$, where $x = 0.886 \times (Ut/Um)$.
G	Fraction of vegetative cover (unitless) (0.5) (default).
HI	Hazard index (unitless); sum of the HQs.
HQ	Hazard quotient for oral (HQ_o), dermal (HQ_d), or inhalation (HQ_i) (unitless).
IFd	Age-adjusted intake factor for dermal exposure[(mg-yr)/(kg-day)].
IFo	Age adjusted intake factor for oral exposure [(mg-yr)/(kg-day)].
IR_s	Ingestion rate of soil (mg/day) (default) (Table 5-2).
NC	Non-carcinogenic.
PEF	Particulate emission factor (m^3/kg) (calculated).
Q/C	Emission flux per unit concentration (40.69 g/m^2/sec)/(kg/m^3)(default for 30 acre site).
RfC	Reference concentration for inhalation exposure (mg/m^3) (Table 4-1).
RfD	Reference dose for oral (RfD_o) or dermal (adjusted to an absorbed dose, RfD_a) intake (mg/kg/day) (Table 4-3).
RPF	Respirable particle fraction (0.036 g/m^2/hr) (default).
SAR	Soil adherence rate (mg/cm^2/day) (Table 5-2).
SSA	Exposed skin surface area (2,500 cm^2) (Table 5-2).
UC_1	Unit conversion #1 (10^6 mg/kg).
UC_2	Unit conversion #2 (0.001 mg/μg).
Um	Wind speed (5.4 m/sec) (site specific, Corpus Christi, Texas; www.ncdc.noaa.gov).
Ur_i	Unit cancer risk for inhalation exposure (m^3/μg) (Table 4-5).
Ut	Equivalent threshold value of windspeed at 7 meters (11.32 m/sec) (default).

SAMPLE CALCULATION: Nickel – Child/Adult Resident

$$x = 0.886 \times [(11.32\ \text{m/sec})/(5.4\ \text{m/sec})] = 1.87$$

$$F_x = 0.18 \times [(8 \times 1.87^3) + (12 \times 1.87] \times \exp[-(1.87^2)] = 0.4076$$

$$PEF = [40.69\ (\text{g/m}^2/\text{sec})/(\text{kg/m}^3)] \times \frac{(3{,}600\ \text{sec/hr})}{(0.036\ \text{g/m}^2/\text{hr}) \times (1 - 0.5) \times [(5.4\ \text{m/sec})/(11.32\ \text{m/sec})]^3 \times (0.4076)}$$

$$= 1.88 \times 10^8\ \text{m}^3/\text{kg}$$

CANCER RISK:

$$ELCR_o = \frac{(170\ mg/kg) \times (114(mg - yr)/(kg - day)) \times (350\ day/yr)}{(10^6\ mg/kg) \times (25{,}550\ days) \times NC}$$

$$= NC$$

$$ELCR_d = \frac{(170\ mg/kg) \times (0.001) \times (300(mg - yr)/(kg - day)) \times (350\ days/yr)}{(10^6\ mg/kg) \times (25{,}550\ days) \times NC}$$

$$= NC$$

$$ELCR_i = \frac{(170\ mg/kg) \times (1/1.88 \times 10^8\ m^3/kg) \times (350\ day/yr) \times (6\ yrs)}{(25{,}550\ days) \times (0.001/\ 0.00048)}$$

$$= 3.6 \times 10^{-8}$$

$$ELCR = (NC) + (NC) + (3.6 \times 10^{-8}) = 3.6 \times 10^{-8}$$

NON-CANCER RISK:

$$HQ_o = \frac{(170\ mg/kg) \times (200\ mg/day) \times (350\ days/yr) \times (6\ yrs)}{(10^6\ mg/kg) \times (15kg) \times (2190\ days) \times (0.02)}$$

$$= 1.1 \times 10^{-1}$$

$$HQ_d = \frac{(170\ mg/kg) \times (2{,}200\ cm^2) \times (0.2\ mg/cm^2/day) \times (0.01) \times (350\ days/yr) \times (6\ yrs)}{(10^6\ mg/kg) \times (15\ kg) \times (2190\ days) \times (0.0008)}$$

$$= 6.0 \times 10^{-2}$$

$$HQ_i = \frac{(170\ mg/kg) \times (1/1.88 \times 10^8\ m^3/kg) \times (350\ days/yr) \times (6\ yrs)}{(2190\ days) \times (0.0002)}$$

$$= 4.3 \times 10^{-3}$$

Table 5-6. Risk and Hazard Equations with Sample Calculations for Future Hypothetical Age-Averaged Future Child/ Adult Resident Exposure to Soil, Encycle/Texas, Inc., Corpus Christi, Texas.

$$HI = (1.1 \times 10^{-1}) + (6.0 \times 10^{-2}) + (4.3 \times 10^{-3}) = 1.7 \times 10^{-1}$$

Table 5-7. Risk and Hazard Equations with Sample Calculations for Potential Current Adult Exposure to Surface Water by Fish Ingestion, Encycle/Texas, Inc., Corpus Christi, Texas.

CANCER RISK:

$$ELCR = \frac{EPC_{sw} \times BCF \times IR_{fish} \times EF \times EP \times CSF_o}{BW \times AP_C}$$

NON-CANCER HAZARD:

$$HQ = \frac{EPC_{sw} \times BCF \times IR_{fish} \times EF \times EP}{BW \times AP_{NC} \times RfD_o]}$$

where:

AP_C	Averaging period for cancer effects (days) (Table 5-2).
AP_{NC}	Averaging period for non-cancer effects days; (EP x 365 days/year) (Table 5-2).
BW	Body weight (kg) (Table 5-2).
CSF	Cancer slope factor for oral (CSF_o) exposure (kg-day/mg; inverse of mg/kg/day) (Table 4-3).
BCF	Fish bioconcentration factor (L/kg) (Table 5-1)
EF	Exposure frequency (days/year) (Table 5-2).
ELCR	Excess lifetime cancer risk exposure (unitless).
EPC_{sw}	Exposure point concentration in surface water (mg/L) (Table 3-7).
EP	Exposure period (years) (Table 5-2).
HQ	Hazard quotient (unitless).
IR_{fish}	Ingestion rate of fish (kg/day) (Table 5-2).
NC	Non-carcinogenic.
RfD	Reference dose for oral (RfD_o) intake (mg/kg/day) (Table 4-3).

SAMPLE CALCULATION: Copper

CANCER RISK:

$$ELCR = \frac{(0.04\ mg/L) \times (710\ L/kg) \times (0.015\ kg/day) \times (350\ days) \times (33\ yrs) \times NC}{(70\ kg) \times (25{,}550\ days)}$$

$$= NC$$

NON-CANCER HAZARD:

$$HQ = \frac{(0.04\ mg/L) \times (710\ L/kg) \times (0.015\ kg/day) \times (350\ days/yr) \times (33\ yrs)}{(70\ kg) \times (12045\ days) \times (0.04\ mg/kg/day)}$$

$$= 1.5 \times 10^{-1}$$

Table 6-1. Risk and Hazard Calculations for Hypothetical Future Adult Resident Exposure to Groundwater, Beaumont Formation, Encycle/Texas, Inc., Corpus Christi, Texas.

Constituent	EPCgw (mg/L)	CANCER RISK: Route-Specific Risks: Oral	CANCER RISK: Route-Specific Risks: Dermal	CANCER RISK: Route-Specific Risks: Inhalation	Calculated Risk	Percent Total ELCR	NON-CANCER HAZARD: Route-Specific Risks: Oral	NON-CANCER HAZARD: Route-Specific Risks: Dermal	NON-CANCER HAZARD: Route-Specific Risks: Inhalation	Calculated Hazard	Percent Total HI
		ELCRo	ELCRd	ELCRi	ELCR		HQo	HQd	HQi	HI	
Inorganics											
Manganese	7.7	NC	NC	—	NC	-	1.5E+00	1.3E-01	—	1.6E+00	100%
		Total ELCR			**NAP**	**0%**	**Total HI ****			**2**	**100%**

**	Calculated HI exceeds acceptable regulatory limits.	HQ	Hazard quotient.
—	Not applicable.	mg/L	Milligrams per liter.
ELCR	Excess lifetime cancer risk.	NAP	Not applicable.
EPCgw	Exposure point concentration in groundwater.	NC	Not evaluated as a carcinogen.
HI	Hazard index (sum of the HQs).		

Table 6-2. Risk and Hazard Calculations for Hypothetical Future Child Resident Exposure to Groundwater, Beaumont Formation, Encycle/Texas, Inc., Corpus Christi, Texas.

Constituent	EPCgw (mg/L)	CANCER RISK Route-Specific Risks Oral	Dermal	Inhalation	Calculated Risk	Percent Total ELCR	NON-CANCER HAZARD Route-Specific Risks Oral	Dermal	Inhalation	Calculated Hazard	Percent Total HI
		ELCRo	ELCRd	ELCRi	ELCR		HQo	HQd	HQi	HI	
Inorganics											
Manganese	7.7	NC	NC	—	NC	-	2.3E+00	3.9E-01	—	2.6E+00	100%
		Total ELCR			**NAP**	**0%**	**Total HI ****			**3**	**100%**

**	Calculated HI exceeds acceptable regulatory limits.
—	Not applicable.
ELCR	Excess lifetime cancer risk.
EPCgw	Exposure point concentration in groundwater.
HI	Hazard index (sum of the HQs).
HQ	Hazard quotient.
mg/L	Milligrams per liter.
NAP	Not applicable.
NC	Not evaluated as a carcinogen.

Table 6-3. Risk and Hazard Calculations for Potential Current Site Worker Exposure to Soil (0 to 2 ft bgs), Encycle/Texas, Inc., Corpus Christi, Texas.

Constituent	EPCs (mg/kg)	CANCER RISK Route-Specific Risks Oral	Dermal	Inhalation	Calculated Risk	Percent Total ELCR	NON-CANCER HAZARD Route-Specific Risks Oral	Dermal	Inhalation	Calculated Hazard	Percent Total HI
		ELCRo	ELCRd	ELCRi	ELCR		HQo	HQd	HQi	HI	
Inorganics											
Antimony	28	NC	NC	NC	NC	–	3.4E-02	2.3E-02	2.0E-04	5.7E-02	5%
Arsenic	260	NC	NC	NC	NC	–	4.2E-01	1.3E-01	NA	5.5E-01	44%
Barium	350	NC	NC	NC	NC	–	2.4E-03	3.5E-03	2.6E-03	8.5E-03	1%
Cadmium	270	NC	NC	6.3E-07	6.3E-07	73%	1.3E-01	5.3E-02	4.9E-03	1.9E-01	15%
Cobalt	320	NC	NC	NC	NC	–	2.6E-03	2.6E-04	5.8E-02	6.1E-02	5%
Copper	2,800	NC	NC	NC	NC	–	3.4E-02	3.4E-03	1.0E-02	4.8E-02	4%
Manganese	2,200	NC	NC	NC	NC	–	7.7E-03	1.3E-02	1.6E-01	1.8E-01	14%
Mercury	5.4	NC	NC	NC	NC	–	8.8E-03	1.3E-02	6.6E-05	2.1E-02	2%
Nickel	370	NC	NC	2.3E-07	2.3E-07	27%	9.1E-03	2.3E-02	6.7E-03	3.8E-02	3%
Selenium	29	NC	NC	NC	NC	–	2.8E-03	2.8E-04	5.3E-04	3.6E-03	0%
Silver	24	NC	NC	NC	NC	–	2.3E-03	5.9E-03	8.7E-03	1.7E-02	1%
Thallium	4.1	NC	NC	NC	NC	–	2.5E-02	2.5E-03	1.5E-04	2.8E-02	2%
Vanadium	21	NC	NC	NC	NC	–	1.5E-03	5.7E-03	1.5E-03	8.7E-03	1%
Zinc	16,000	NC	NC	NC	NC	–	2.6E-02	1.3E-02	NA	3.9E-02	3%
		Total ELCR			**9E-07**	**100%**	**Total HI**			**1**	**100%**

Concentrations are presented in mg/kg.

–	Not applicable.	HQ	Hazard quotient.
ELCR	Excess lifetime cancer risk.	mg/kg	Milligrams per kilogram.
EPCs	Exposure point concentration in soil.	NA	Not available.
ft bgs	Feet below ground surface.	NC	Not evaluated as a carcinogen.
HI	Hazard index (sum of the HQs).		

Table 6-4. Risk and Hazard Calculations for Potential Current Excavation Worker Exposure to Soil (0 to 5 ft bgs), Encycle/Texas, Inc., Corpus Christi, Texas.

Constituent	EPCs (mg/kg)	CANCER RISK Route-Specific Risks Oral	Dermal	Inhalation	Calculated Risk	Percent Total ELCR	NON-CANCER HAZARD Route-Specific Risks Oral	Dermal	Inhalation	Calculated Hazard	Percent Total HI
		ELCRo	ELCRd	ELCRi	ELCR		HQo	HQd	HQi	HI	
Inorganics											
Antimony	17	NC	NC	NC	NC	–	4.8E-02	3.3E-03	3.0E-05	5.1E-02	4%
Arsenic	170	NC	NC	NC	NC	–	6.4E-01	2.0E-02	NA	6.6E-01	54%
Barium	340	NC	NC	NC	NC	–	5.5E-03	8.1E-04	5.9E-04	6.9E-03	1%
Cadmium	200	NC	NC	1.0E-09	1.0E-09	76%	2.3E-01	9.4E-03	8.7E-04	2.4E-01	19%
Cobalt	210	NC	NC	NC	NC	–	3.9E-03	4.1E-05	9.2E-03	1.3E-02	1%
Copper	1,700	NC	NC	NC	NC	–	4.8E-02	5.0E-04	1.5E-03	5.0E-02	4%
Manganese	1,600	NC	NC	NC	NC	–	1.3E-02	2.2E-03	2.8E-02	4.3E-02	4%
Mercury	6.3	NC	NC	NC	NC	–	2.4E-02	3.5E-03	1.8E-05	2.7E-02	2%
Nickel	240	NC	NC	3.3E-10	3.3E-10	24%	1.4E-02	3.5E-03	1.0E-03	1.8E-02	1%
Selenium	26	NC	NC	NC	NC	–	5.9E-03	6.1E-05	1.1E-04	6.0E-03	0%
Silver	16	NC	NC	NC	NC	–	3.6E-03	9.4E-04	1.4E-03	5.9E-03	0%
Thallium	3.5	NC	NC	NC	NC	–	4.9E-02	5.1E-04	3.1E-05	5.0E-02	4%
Vanadium	23	NC	NC	NC	NC	–	3.7E-03	1.5E-03	4.0E-04	5.6E-03	0%
Zinc	9,900	NC	NC	NC	NC	–	3.7E-02	1.9E-03	NA	3.9E-02	3%
			Total ELCR		**1E-09**	**100%**		**Total HI**		**1**	**100%**

Concentrations are presented in mg/kg.

–	Not applicable.	HQ	Hazard quotient.
ELCR	Excess lifetime cancer risk.	mg/kg	Milligrams per kilogram.
EPCs	Exposure point concentration in soil.	NA	Not available.
ft bgs	Feet below ground surface.	NC	Not evaluated as a carcinogen.
HI	Hazard index (sum of the HQs).		

Table 6-5. Risk and Hazard Calculations for Age-Averaged Hypothetical Future Child/Adult Resident Exposure to Soil (0 to 15 ft bgs), Encycle/Texas, Inc., Corpus Christi, Texas.

Constituent	EPCs (mg/kg)	CANCER RISK Route-Specific Risks Oral	Dermal	Inhalation	Calculated Risk	Percent Total ELCR	NON-CANCER HAZARD Route-Specific Risks Oral	Dermal	Inhalation	Calculated Hazard	Percent Total HI
		ELCRo	ELCRd	ELCRi	ELCR		HQo	HQd	HQi	HI	
Inorganics											
Antimony	10	NC	NC	NC	NC	–	3.2E-01	4.7E-02	1.0E-04	3.7E-01	4%
Arsenic	120	NC	NC	NC	NC	–	5.1E+00	3.4E-01	NA	5.5E+00	55%
Barium	320	NC	NC	NC	NC	–	5.8E-02	1.8E-02	3.3E-03	8.0E-02	1%
Cadmium	140	NC	NC	1.1E-07	1.1E-07	76%	1.8E+00	2.9E-02	3.6E-03	1.8E+00	18%
Cobalt	150	NC	NC	NC	NC	–	3.2E-02	7.0E-04	3.8E-02	7.1E-02	1%
Copper	1,200	NC	NC	NC	NC	–	3.8E-01	8.4E-03	6.1E-03	4.0E-01	4%
Manganese	1,300	NC	NC	NC	NC	–	1.2E-01	4.4E-02	1.3E-01	2.9E-01	3%
Mercury	4.6	NC	NC	NC	NC	–	2.0E-01	6.2E-02	7.8E-05	2.6E-01	3%
Nickel	170	NC	NC	3.6E-08	3.6E-08	24%	1.1E-01	6.0E-02	4.3E-03	1.7E-01	2%
Selenium	18	NC	NC	NC	NC	–	4.6E-02	1.0E-03	4.6E-04	4.7E-02	0%
Silver	12	NC	NC	NC	NC	–	3.1E-02	1.7E-02	6.1E-03	5.4E-02	1%
Thallium	3.2	NC	NC	NC	NC	–	5.1E-01	1.1E-02	1.6E-04	5.2E-01	5%
Vanadium	25	NC	NC	NC	NC	–	4.6E-02	3.9E-02	2.6E-03	8.7E-02	1%
Zinc	5,100	NC	NC	NC	NC	–	2.2E-01	2.4E-02	NA	2.4E-01	2%
		Total ELCR			**1E-07**	**100%**	**Total HI ****			**10**	**100%**

**	Calculated HI exceeds acceptable regulatory limits.	HI	Hazard index (sum of the HQs).
–	Not applicable.	HQ	Hazard quotient.
ELCR	Excess lifetime cancer risk.	mg/kg	Milligrams per kilogram.
EPCs	Exposure point concentration in soil (mg/kg).	NA	Not available.
ft bgs	Feet below ground surface.	NC	Not evaluated as a carcinogen.

Table 6-6. Risk and Hazard Calculations for Potential Current Adult Exposure to Surface Water via Fish Tissue Ingestion, Encycle/Texas, Inc., Corpus Christi, Texas.

Constituent	EPCsw (mg/L)	BCF (L/kg)	CANCER EFFECTS CSFo $(mg/kg/day)^{-1}$	CANCER EFFECTS Calculated Risk	Percent Total ELCR	NON-CANCER EFFECTS RfDo (mg/kg/day)	NON-CANCER EFFECTS Calculated Hazard	Percent Total HI
				ELCR			HI	
Inorganics								
Antimony	0.017	40	NC	NC	–	4.0E-04	3.5E-01	62%
Copper	0.04	710	NC	NC	–	4.0E-02	1.5E-01	26%
Manganese	0.04	100	NC	NC	–	1.4E-01	5.9E-03	1%
Nickel	0.07	78	NC	NC	–	2.0E-02	5.6E-02	10%
Zinc	0.11	126.2	NC	NC	–	3.0E-01	9.5E-03	2%
			Total ELCR	**NAP**	**0%**	**Total HI**	**1**	**100%**

BCF	Fish bioconcentration factor.	mg/kg/day	Milligrams per kilogram per day.
ELCR	Excess lifetime cancer risk.	mg/L	Milligrams per liter.
EPCsw	Exposure point concentration in surface water. (Table 3-7)	NAP	Not applicable.
HI	Hazard index (sum of the HQs).	NC	Not evaluated as a carcinogen.
HQ	Hazard quotient.	RfDo	Oral reference dose.
L/kg	Liters per kilogram.		

Table 6-7. PRG Calculations for Hypothetical Future Adult Resident Exposure to Groundwater, Beaumont Formation, Encycle/Texas, Inc., Corpus Christi, Texas.

		CANCER RISK			NON-CANCER RISK				
Constituent	EPC (mg/L)	ELCR	TCR	PRGc (mg/L)	HQ	THQ	PRGnc (mg/L)	PRG [a] (mg/L)	
Inorganics									
Manganese	7.7	NC	1E-06	NC	2E+00	1	4.7E+00	4.7E+00	*

*	EPC exceeds the minimum PRG.
[a]	The minimum of the PRG_C ($TCR = 10^{-6}$) and the PRG_{NC} ($THQ = 1$).
EPC	Constituent concentration in groundwater (mg/L) (Table 3-2).
ELCR	Excess lifetime cancer risk.
HQ	Hazard quotient.
mg/L	Milligrams per liter.
NC	Not evaluated as a carcinogen.
PRG	Preliminary remediation goals.
TCR	Target cancer risk
THQ	Target hazard quotient.

Table 6-8. PRG Calculations for Hypothetical Future Child Resident Exposure to Groundwater, Beaumont Formation, Encycle/Texas, Inc., Corpus Christi, Texas.

Constituent	EPC (mg/L)	CANCER RISK			NON-CANCER RISK			PRG [a] (mg/L)	
		ELCR	TCR	PRGc (mg/L)	HQ	THQ	PRGnc (mg/L)		
Inorganics									
Manganese	7.7	NC	1E-06	NC	3E+00	1	2.9E+00	2.9E+00	*

*	EPC exceeds the minimum PRG.	mg/L	Milligrams per liter.
[a]	The minimum of the PRG_C ($TCR = 10^{-6}$) and the PRG_{NC} ($THQ = 1$).	NC	Not evaluated as a carcinogen.
EPC	Constituent concentration in groundwater (mg/L) (Table 3-2).	PRG	Preliminary remediation goals.
ELCR	Excess lifetime cancer risk.	TCR	Target cancer risk.
HQ	Hazard quotient.	THQ	Target hazard quotient.

Table 6-9. PRG Calculations for Age-Averaged Hypothetical Future Child/Adult Resident Exposure to Soil (0-15 ft bgs), Encycle/Texas, Inc., Corpus Christi, Texas.

Constituent	EPC (mg/kg)	CANCER RISK ELCR	CANCER RISK TCR	CANCER RISK PRGc (mg/kg)	NON-CANCER RISK HQ	NON-CANCER RISK THQ	NON-CANCER RISK PRGnc (mg/kg)	PRG [a] (mg/kg)	
Inorganics									
Antimony	10	NC	1E-06	NC	4E-01	1	2.7E+01	2.7E+01	
Arsenic	120	NC	1E-06	NC	5E+00	1	2.2E+01	2.0E+01 [b]	*
Barium	320	NC	1E-06	NC	8E-02	1	4.0E+03	4.0E+03	
Cadmium	140	1E-07	1E-06	1.3E+03	2E+00	1	7.7E+01	7.7E+01	*
Cobalt	150	NC	1E-06	NC	7E-02	1	2.1E+03	2.1E+03	
Copper	1,200	NC	1E-06	NC	4E-01	1	3.0E+03	3.0E+03	
Manganese	1,300	NC	1E-06	NC	3E-01	1	4.4E+03	4.4E+03	
Mercury	4.6	NC	1E-06	NC	3E-01	1	1.8E+01	1.8E+01	
Nickel	170	4E-08	1E-06	4.8E+03	2E-01	1	9.8E+02	9.8E+02	
Selenium	18	NC	1E-06	NC	5E-02	1	3.8E+02	3.8E+02	
Silver	12	NC	1E-06	NC	5E-02	1	2.2E+02	2.2E+02	
Thallium	3.2	NC	1E-06	NC	5E-01	1	6.1E+00	6.1E+00	
Vanadium	25	NC	1E-06	NC	9E-02	1	2.9E+02	2.9E+02	
Zinc	5,100	NC	1E-06	NC	2E-01	1	2.1E+04	2.1E+04	

*	EPC exceeds the minimum PRG.
[a]	The minimum of the PRG_C ($TCR = 10^{-6}$) and the PRG_{NC} ($THQ = 1$).
[b]	The SAI-Ind MSC for arsenic is based on the cleanup levels established by the TCEQ Executive Director (Interoffice Memorandum entitled "Arsenic Soil Cleanup Standards for Commercial/ Industrial Areas" from Jeff Saitas on September 11, 1998).
C	Carcinogenic.
EPC	Constituent concentration in soil (mg/kg). (Table 3-6)
ELCR	Excess lifetime cancer risk.
ft bgs	Feet below ground surface
HQ	Hazard quotient.
mg/kg	Milligrams per kilogram.
NC	Non-carcinogenic.
PRG	Preliminary remediation goals.
TCR	Target cancer risk
THQ	Target hazard quotient.

Table 8-1

ENDANGERED, THREATENED, AND SPECIES OF CONCERN
POTENTIALLY OCCURRING IN THE PROJECT AREA,
NUECES AND SAN PATRICIO COUNTIES, TEXAS[1]

Common Name[2]	Scientific Name[2]	Status[3]	
		FWS	TPWD
AMPHIBIANS			
Sheep frog	*Hypopachus variolosus*	*	T
Black-spotted newt	*Notophthalmus meridionalis*	*	T
South Texas siren	*Siren sp.* [1]	*	T
Rio Grande lesser siren	*Siren intermedia texana*	SOC	*
BIRDS			
Brown pelican	*Pelcanus occidentalis*	E	E
Reddish egret	*Egretta rufescens*	*	T
White-faced ibis	*Plegadis chihi*	*	T
Bald eagle	*Haliaeetus leucocephalus*	T/PDL	T
Northern gray hawk	*Buteo mitidus maximus*	SOC	*
White-tailed hawk	*Buteo albicaudatus*	*	T
Ferruginous hawk	*Buteo regalis*	SOC	*
American peregrine hawk	*Falco peregrinus anatum*	*	E
Artic peregrine falcon	*Falco peregrinus tundrius*	*	T
Black rail	*Lateralus jamaicensis*	SOC	*
Whooping crane	*Grus americana*	E	E
Piping plover	*Charadrius melodus*	T	T
Mountain plover	*Charadrius montanus*	PT	*
Eskimo curlew	*Numenius borealis*	E	E
Sooty tern	*Sterna fuscata*	SOC	T
Black tern	*Chilidonias niger*	SOC	*
Loggerhead shrike	*Lanis ludovicianus*	SOC	*
Cerulean warbler	*Dendroica cerulea*	SOC	*
Texas olive sparrow	*Arremonops rufivirgatus*	SOC	*
Texas Botteri's sparrow	*Aimophila botteri texana*	SOC	T
Sennett's hooded oriole	*Icterus cucullatus sennetti*	SOC	*
Audubon's oriole	*Icterus graduacauda audubonii*	SOC	*
Wood stork	*Mycteria americana*	*	T
FISH			
Opossum pipefish	*Microphis brachyurus*	*	T
MAMMALS			
Southern yellow bat	*Lasiurus ega*	*	T
Maritime pocket gopher	*Geomys personatus maritimus*	SOC	*
Red wolf (extirpated)	*Canus rufus*	E	E
Ocelot	*Leopardus pardalis*	E	E
Jaguarundi	*Herpailurus yagouaroundi*	E	E
West Indian manatee	*Trichechus manatus*	E	E
REPTILES			
Loggerhead sea turtle	*Caretta caretta*	T	T
Green sea turtle	*Chelonia mydas*	T	T
Leatherback sea turtle	*Dermochelys coriacea*	E	E
Atlantic hawksbill sea turtle	*Eretmochelys imbricata*	E	E

Table 8-1

ENDANGERED, THREATENED, AND SPECIES OF CONCERN POTENTIALLY OCCURRING IN THE PROJECT AREA, NUECES AND SAN PATRICIO COUNTIES, TEXAS[1]

Common Name[2]	Scientific Name[2]	Status[3] FWS	TPWD
Texas tortoise	*Gopherus berlandieri*	*	T
Kemp's Ridley sea turtle	*Lepidochelys kempii*	E	E
Texas diamondback terrapin	*Malaclemys terrapin littoralis*	SOC	*
American alligator	*Alligator mississippiensis*	T/SA	*
Texas horned lizard	*Phrynosoma cornutum*	*	T
Scarlet Snake	*Cemophora coccinea*	*	*
Timber/ canebrake rattlesnake	*Crotalus horridus*	*	T
Indigo snake	*Drymarchon corais*	*	T
Northern cat-eyed snake	*Leptodeira septentrionalis*	*	T
Gulf saltmarsh snake	*Nerodia clarkii*	SOC	*
PLANTS			
Black-laced cactus	*Echinocereus reichenbachii var,*	E	E
South texas ambrosia	*Ambrosia cheiranthifolia*	E	E
Slender rush-pea	*Hoffmanseggia tenella*	E	E
Lila de los llanos	*Echeandia chandleri*	SOC	*
Texas windmill grass	*Chloris texana*	SOC	*
Theiret's skullcap	*Scutellaria thieretii*	SOC	*
Roughseed sea-purslane	*Sesuvium trianthemoides*	SOC	*
Welder machaeranthera	*Psilactis heterocarpa*	SOC	*
Mathis spiderling	*Boerhavia mathisiana*	SOC	*
INSECTS			
Maculated manfreda skipper	*Stallingsia maculosus*	SOC	*

(Note: Table is a reproduction of Table 3-6.1 in the Final Environmental Impact Assessment for the Corpus Christi Ship Channel Improvements Project produced by the U.S. Corps of Engineers in April 2003.)

1 According to FWS (1995), TPWD (1997) and TXBCD (1999).

2 Nomenclature follows AOU (1998), Collins (1990), Hatch et al. (1990), and Jones et al. (1997)

3 FWS - U.S. Fish and Wildlife Service; TPWD - Texas Parks and Wildlife Department

E Endangered; in danger of extinction E/SA, T/SA - No longer biologically threatened or endangered but because of the similarity of appearance to other protected species, it is necessary to restrict commercialactivities of specimens taken in the USA to ensure the conservation of similar species that are biologically threatened or endangered.

T Threatened; severly depleted or impacted by man.

* Not listed.

PDL Proposed delisting.

PT Federally proposed threatened.

SOC Species of concern - species for which there is some information showing evidence of vulnerability but not enough data to support listing at this time.

References:

American Ornithologist's Union (AOU). 1998. Check-list of North American birds. 7th edition. Allen Press, Lawrence, Kansas. 829 pp.

Collins, J.T. 1990. Standard common and current scientific names for North American amphibians and reptiles. Third ed. Society for the Study of Amphibians and Reptiles, miscellaneous publications,Herpetological Circular No. 19. 41 pp.

Table 8-1

ENDANGERED, THREATENED, AND SPECIES OF CONCERN
POTENTIALLY OCCURRING IN THE PROJECT AREA,
NUECES AND SAN PATRICIO COUNTIES, TEXAS[1]

Common Name[2]	Scientific Name[2]	Status[3]	
		FWS	TPWD

Hatch, S.L., K.N. Gandhi, and L.E. Brown. 1990. Checklist of the vascular plants of Texas. TAES, Texas A&M University. College Station, Texas. 158 pp.

Jones, C., R.S. Hoffmann, D.W. Rice, M.D. Engstrom, R.D. Bradley, D.J. Schmidly, G.A. Jones, and R.J.Baker. 1997. Revised checklist of North American mammals north of Mexico, 1997. Occ. Papers, Museum of Texas Tech University, Number 173. 19 pp.

Table 10-1
Occurrence of Surface Water Constituents
Encycle/Texas, Inc.
Corpus Christi, Texas

Constituent	Frequency Detects / Total	Percent Detection Frequency	Range of SQLs Min - Max (mg/l)	Range of Detects Min - Max (mg/l)	Arithmetic Mean (mg/l)
Dissolved Metals					
Antimony	2 / 4	50%	0.003 - 0.003	0.012 - 0.055	0.018
Arsenic	0 / 4	0%	0.005 - 0.005	ND	0.005
Cadmium	1 / 4	25%	0.0025 - 0.0025	ND	0.0025
Cobalt	0 / 4	0%	0.005 - 0.005	ND	0.005
Copper	4 / 4	100%	NA	0.01 - 0.02	0.015
Lead	0 / 4	0%	0.005 - 0.005	ND	0.005
Manganese	3 / 4	75%	0.005 - 0.005	0.01 - 0.03	0.014
Mercury	0 / 4	0%	0.001 - 0.001	ND	0.001
Nickel	0 / 4	0%	0.005 - 0.005	ND	0.005
Selenium	0 / 4	0%	0.005 - 0.005	ND	0.005
Silver	0 / 4	0%	0.0025 - 0.0025	ND	0.003
Thallium	0 / 4	0%	0.001 - 0.001	ND	0.001
Tin	0 / 4	0%	0.01 - 0.01	ND	0.01
Zinc	4 / 4	100%	NA	0.06 - 0.09	0.078
Total Metals					
Antimony	1 / 4	25%	0.003 - 0.003	0.017	0.0065
Arsenic	0 / 4	0%	0.005 - 0.005	ND	0.005
Cadmium	0 / 4	0%	0.0025 - 0.0025	ND	0.0025
Cobalt	0 / 4	0%	0.005 - 0.005	ND	0.005
Copper	2 / 4	50%	0.005 - 0.005	0.02 - 0.04	0.018
Lead	0 / 4	0%	0.005 - 0.005	ND	0.005
Manganese	4 / 4	100%	NA	0.02 - 0.04	0.025
Mercury	0 / 4	0%	0.001 - 0.001	ND	0.001
Nickel	2 / 4	50%	0.005 - 0.005	0.01 - 0.07	0.023
Selenium	0 / 4	0%	0.005 - 0.005	ND	0.005
Silver	0 / 4	0%	0.0025 - 0.0025	ND	0.003
Thallium	0 / 4	0%	0.001 - 0.001	ND	0.001
Tin	0 / 4	0%	0.01 - 0.01	ND	0.01
Zinc	4 / 4	100%	NA	0.07 - 0.11	0.09

Notes:
mg/l Milligrams per liters.
SQLs Practical sample quantitation limits where the analyte was not detected.
Min Minimum.
Max Maximum.
NA SQL is not listed because all sample results exceed the SQL.
ND Not Detected.

Table 10-2
Occurrence of Pore Water Constituents
Encycle/Texas, Inc.
Corpus Christi, Texas

Constituent	Frequency Detects / Total	Percent Detection Frequency	Range of SQLs Min - Max (mg/l)	Range of Detects Min - Max (mg/l)	Arithmetic Mean (mg/l)
Dissolved Metals					
Antimony	4 / 4	100%	NA	0.0026 - 0.356	0.11
Arsenic	4 / 4	100%	NA	0.011 - 0.028	0.017
Cobalt	2 / 4	50%	0.003	0.008 - 0.021	0.0085
Mercury	4 / 4	100%	NA	0.0013 - 0.016	0.008
Manganese	4 / 4	100%	NA	0.154 - 31	8.4
Selenium	4 / 4	100%	NA	0.0019 - 0.011	0.008
Thallium	4 / 4	100%	NA	0.00003 - 0.0003	0.00012
Tin	0 / 4	0%	0.001	ND	0.0005

Notes:
mg/l Milligrams per liter.
SQLs Practical sample quantitation limits where the analyte was not detected.
Min Minimum.
Max Maximum.
NA SQL is not listed because all sample results exceed the SQL.
ND Not Detected.

Table 10-3
Occurrence of Sediment Constituents
Encycle/Texas, Inc.
Corpus Christi, Texas

Constituent	Frequency Detects / Total	Percent Detection Frequency	Range of SQLs Min - Max (mg/kg)	Range of Detects Min - Max (mg/kg)	Arithmetic Mean (mg/kg)
Metals					
Antimony	11 / 22	50%	0.4 - 0.4	0.4 - 97	9.1
Arsenic	16 / 22	73%	2.5 - 2.5	6.0 - 83	16
Cadmium	37 / 40	93%	0.5 - 0.5	1.0 - 189	29
Cobalt	22 / 22	100%	NA	6.4 - 211	62
Copper	40 / 40	100%	NA	19.0 - 2,580	300
Lead	22 / 22	100%	NA	9.0 - 3,530	360
Manganese	40 / 40	100%	NA	76.0 - 14,900	1,700
Mercury	36 / 40	90%	0.025 - 0.025	0.1 - 19.5	0.76
Nickel	22 / 22	100%	NA	7.0 - 162	27
Selenium	9 / 22	41%	0.4 - 0.6	1.2 - 10.0	1.8
Silver	11 / 22	50%	0.25 - 0.25	0.2 - 6.1	0.96
Thallium	8 / 22	36%	0.25 - 2.5	0.2 - 0.9	0.97
Tin	9 / 22	41%	2.5 - 2.65	5.0 - 619	54
Zinc	40 / 40	100%	NA	66.0 - 36,400	4,100
Simultaneously Extracted Metals (SEM)					
Cadmium	4 / 4	100%	NA	55.6 - 374	190
Copper	3 / 4	75%	0.1 - 0.1	14.4 - 52	23
Lead	4 / 4	100%	NA	30.3 - 119	75
Nickel	4 / 4	100%	NA	3.2 - 23	15
Silver	0 / 4	0%	0.1 - 0.15	ND	0.13
Zinc	4 / 4	100%	NA	8,350 - 22,500	16,000
Acid Volatile Sulfide (AVS)	4 / 4	100%	NA	96 - 2,610	900

Notes:
mg/kg Milligrams per kilogram.
SQLs Practical sample quantitation limits where the analyte was not detected.
Min Minimum.
Max Maximum.
NA SQL is not listed because all sample results exceed the SQL.
ND Not Detected.

Table 10-4
Occurrence of Surface Soil Constituents (a)
Encycle/Texas, Inc.
Corpus Christi, Texas

Constituent	Frequency Detects / Total	Percent Detection Frequency	Range of SQLs Min - Max (mg/kg)	Range of Detects Min - Max (mg/kg)	Arithmetic Mean (mg/kg)
Inorganics					
Antimony	134 / 189	71%	0.4 - 0.4	0.8 - 606	19
Arsenic	120 / 173	69%	2.5 - 2.5	5.0 - 8,018	150
Barium	136 / 136	100%	NA	56.0 - 1,665	310
Bismuth	36 / 150	24%	2 - 5	4.0 - 142	8.1
Cadmium	191 / 207	92%	0.5 - 1.25	1.0 - 3,911	220
Chromium	188 / 189	99%	2.5 - 2.5	7.6 - 4,691	94
Cobalt	140 / 158	89%	2.5 - 2.5	5.0 - 14,450	160
Copper	194 / 194	100%	NA	5.0 - 104,400	1,500
Cyanide	48 / 141	34%	0.02 - 0.05	0.0 - 21	0.5
Lead	188 / 189	99%	2.5 - 2.5	6.0 - 65,760	1,900
Manganese	204 / 204	100%	NA	126.0 - 37,520	1,600
Mercury	129 / 184	70%	0.025 - 0.025	0.1 - 213	3.4
Nickel	159 / 161	99%	2.5 - 2.5	5.2 - 18,280	200
Selenium	73 / 172	42%	0.4 - 0.4	0.9 - 1,620	14
Silver	124 / 183	68%	0.25 - 0.25	0.5 - 352	18
Thallium	53 / 158	34%	0.5 - 10	1.0 - 20	2.3
Tin	89 / 153	58%	2.5 - 2.5	5.0 - 2,073	50
Vanadium	141 / 143	99%	2.5 - 2.5	7.0 - 88	20
Zinc	190 / 190	100%	NA	28.0 - 239,900	13,000

Notes:
mg/kg Milligrams per kilogram.
SQLs Practical sample quantitation limits where the analyte was not detected.
Min Minimum.
Max Maximum.
NA SQL is not listed because all sample results exceed the SQL.
a. Surface soil is defined as 0 to 0.5 feet below ground surface.

Table 10-5
Occurrence of Total Soil Constituents (a)
Encycle/Texas, Inc.
Corpus Christi, Texas

Constituent	Frequency Detects / Total	Percent Detection Frequency	Range of SQLs Min - Max (mg/kg)	Range of Detects Min - Max (mg/kg)	Arithmetic Mean (mg/kg)
Inorganics					
Antimony	219 / 333	66%	0.4 - 0.75	0.8 - 606	12
Arsenic	194 / 290	67%	2.5 - 2.5	5.0 - 8,018	110
Barium	190 / 190	100%	NA	56.0 - 1,665	310
Bismuth	50 / 216	23%	2 - 25	4.0 - 142	6.7
Cadmium	308 / 360	86%	0.5 - 1.25	1.0 - 3,911	160
Chromium	325 / 327	99%	2.5 - 2.5	7.0 - 4,691	62
Cobalt	216 / 248	87%	2.5 - 2.5	5.0 - 14,450	110
Copper	339 / 341	99%	2.5 - 2.5	5.0 - 104,400	1,100
Cyanide	55 / 195	28%	0.02 - 0.05	0.0 - 21	0.4
Lead	306 / 311	98%	2.5 - 2.5	5.7 - 65,760	1,300
Manganese	363 / 363	100%	NA	26.0 - 37,520	1,200
Mercury	178 / 293	61%	0.025 - 0.025	0.1 - 363	3.8
Nickel	260 / 267	97%	2.5 - 2.5	5.1 - 18,280	120
Selenium	99 / 257	39%	0.4 - 2.5	0.9 - 1,620	14
Silver	169 / 299	57%	0.25 - 0.25	0.5 - 352	12
Thallium	91 / 256	36%	0.5 - 10	1.0 - 20	2.1
Tin	120 / 237	51%	2.5 - 2.5	5.0 - 2,073	38
Vanadium	192 / 195	98%	2.5 - 2.5	7.0 - 88	22
Zinc	372 / 372	100%	NA	14.0 - 239,900	7,900

Notes:
mg/kg Milligrams per kilogram.
SQLs Practical sample quantitation limits where the analyte was not detected.
Min Minimum.
Max Maximum.
NA SQL is not listed because all sample results exceed the SQL.
a. Total soil is defined as 0 to 5 feet below ground surface.

Table 11-1
Surface Water Risk Characterization and Identification of COPECs
Encycle/Texas, Inc.
Corpus Christi, Texas

Constituent	Maximum Concentration in Surface Water (mg/L)	Background 95% UTL (mg/L)	Surface Water Screening Value (a) (mg/L)		Maximum HQ (c) (unitless)	COPEC? (d) (yes/no)	Rationale
Metals							
Antimony	0.017	0.09	0.5	e	0.03	no	≤ Background; HQ ≤ 1
Arsenic	0.005	0.005	0.078		0.1	no	≤ Background; HQ ≤ 1
Cadmium	0.0025	0.0025	0.01		0.3	no	≤ Background; HQ ≤ 1
Cobalt	0.005	0.005	1.5	b,e	0.003	no	≤ Background; HQ ≤ 1
Copper	0.02	0.047	0.0036		6	no	≤ Background
Lead	0.005	0.005	0.0053		0.9	no	≤ Background; HQ ≤ 1
Manganese	0.04	0.02	0.12	b,e	0.3	no	HQ ≤ 1
* Mercury	0.001	0.001	0.0011	e	0.9	no	≤ Background; HQ ≤ 1
Nickel	0.005	0.005	0.0131		0.4	no	≤ Background; HQ ≤ 1
* Selenium	0.005	0.005	0.136	e	0.04	no	≤ Background; HQ ≤ 1
Silver	0.0025	0.0025	0.00011		20	no	≤ Background
* Thallium	0.001	0.001	0.0213	e	0.1	no	≤ Background; HQ ≤ 1
Tin	0.01	0.01	0.073	b,e	0.1	no	≤ Background; HQ ≤ 1
Zinc	0.09	0.097	0.0842		1	no	≤ Background; HQ ≤ 1

Notes:
COPEC Constituent of Potential Ecological Concern.
HQ Hazard Quotient.
mg/L Milligrams per liter.
NA Not available.
UTL Background Upper Tolerance Limit.
* Constituent is considered bioaccumulative by the TCEQ (TCEQ, 2001; Table 3.1).
a. Screening values are Marine Surface Water Ecological Benchmarks (TCEQ 2001) unless otherwise noted.
b. No marine benchmark is available; screening value that is presented is a freshwater benchmark (TCEQ 2001).
c. The maximum HQ is the ratio of the maximum constituent concentration to the water screening value. HQs are rounded to 1 significant digit.
d. Designated as a COPEC if the concentration for a non-bioaccumulative constituent is greater than background and either (1) the HQ is greater than one or (2) the constituent lacks an ecotoxicity screening value, or if the concentration for a bioaccumulative constituent is greater than background.
e. Values are for total metals; all others are for dissolved metals.

Table 11-2
Sediment Risk Characterization and Identification of COPECs
Encycle/Texas, Inc.
Corpus Christi, Texas

Constituent	Maximum Concentration in Surface Sediment (mg/kg)	Background 95% UTL (north - south side of channel) (mg/kg) North - South	Sediment Screening Value (a) (mg/kg)		Maximum HQ (d) (unitless)	COPEC? (e) (yes/no)	Rationale
Metals							
Antimony	97	0.4 - 0.4	2.0	f	50	YES	HQ > 1
Arsenic	83	9.5 - 2.5	8.2		10	YES	HQ > 1
* Cadmium	189	2.4 - 2.5	1.2		200	YES	> Background; bioaccumulative
Cobalt	211	193 - 155	50	b	4	YES	HQ > 1
* Copper	2580	23.3 - 28.4	34		80	YES	> Background; bioaccumulative
Lead	3530	50.4 - 43.7	46.7		80	YES	HQ > 1
Manganese	14900	249 - 115	460	f	30	YES	HQ > 1
* Mercury	20	0.093 - 0.093	0.15		100	YES	> Background; bioaccumulative
* Nickel	162	47.6 - 42.0	20.9		8	YES	> Background; bioaccumulative
* Selenium	10	1.14 - 0.4	1.0	c	10	YES	> Background; bioaccumulative
Silver	6	0.25 - 0.25	1.0		6	YES	HQ > 1
Thallium	0.9	0.88 - 0.25	NA		NA	YES	No Screening Value
Tin	619	2.5 - 2.5	3.4	c	200	YES	HQ > 1
* Zinc	36400	165 - 165	150		200	YES	> Background; bioaccumulative

Notes:
COPEC Constituent of Potential Ecological Concern.
HQ Hazard Quotient.
mg/kg Milligrams per kilogram.
NA Not available.
UTL Upper Tolerance Limit.
* Constituent is considered bioaccumulative by the TCEQ (TCEQ, 2001; Table 3.1).
a. Marine benchmarks are from TCEQ (2001) unless otherwise noted.
b. No screening benchmark available in TCEQ guidance (2001). Value shown is the USEPA Region 5 Ecological Screening Level (August 2003).
c. No screening benchmark available in TCEQ guidance (2001). Value shown is the NOAA SQiRT Apparent Effects Threshold (AET) (NOAA, 1999).
d. The maximum HQ is the ratio of the maximum constituent concentration to the sediment screening value. HQs are rounded to 1 significant digit.
e. Designated as a COPEC if the concentration for a non-bioaccumulative constituent is greater than background and either (1) the HQ is greater than one or (2) the constituent lacks an ecotoxicity screening value, or if the concentration for a bioaccumulative constituent is greater than background.
f. No marine benchmark is available; screening value that is presented is a freshwater benchmark (TCEQ 2001).

Table 11-3
Surface Soil Risk Characterization and Identification of COPECs (a)
Encycle/Texas, Inc.
Corpus Christi, Texas

Constituent	Maximum Concentration in Surface Soil (mg/kg)	Site Specific Background Concentrations (b) (mg/kg)	Soil Screening Value (c) (mg/kg)	Maximum HQ (d) (unitless)	COPC? (e) (yes/no)	Rationale
Inorganics						
Antimony	606	0.77-0.8	5	100	YES	HQ > 1
Arsenic	8,018	16.7	37	200	YES	HQ > 1
Barium	1,665	202-720	500	3	YES	HQ > 1
Bismuth	142	4.9	NA	NA	YES	No Screening Value
* Cadmium	3,911	11.7	29	100	YES	> Background; Bioaccumulative
* Chromium	4,691	14.9-35.9	0.4	10000	YES	> Background; Bioaccumulative
Cobalt	14,450	9.7	20	700	YES	HQ > 1
* Copper	104,400	40.3	61	2000	YES	> Background; Bioaccumulative
Cyanide	21	0.24	NA	NA	YES	No Screening Value
* Lead	65,760	109	50	1000	YES	> Background; Bioaccumulative
Manganese	37,520	334	500	80	YES	HQ > 1
* Mercury	213	0.09	0.1	2000	YES	> Background; Bioaccumulative
* Nickel	18,280	25.8	30	600	YES	> Background; Bioaccumulative
* Selenium	1,620	0.89	1.0	2000	YES	> Background; Bioaccumulative
Silver	352	0.5-0.54	2.0	200	YES	HQ > 1
Thallium	20	1.0-1.02	1.0	20	YES	HQ > 1
Tin	2,073	7.65	50	40	YES	HQ > 1
Vanadium	88	15.7-35.6	2	40	YES	HQ > 1
* Zinc	239,900	15.7-35.7	120	2000	YES	> Background; Bioaccumulative

Notes:

COPEC Constituent of Potential Ecological Concern.

HQ Hazard Quotient.

mg/kg Milligrams per kilogram.

NA Not available.

* Constituent is considered bioaccumulative by the TCEQ (TCEQ, 2001; Table 3.1).

a. Surface soil is 0 to 0.5 feet below ground surface.

b. TCEQ approved concentrations from 0 to 0.5 feet and when not available, lithology specific concentration ranges for clay/silt strata (ARCADIS RFI 2002 RFI Report).

c. Screening values are taken from TCEQ 2001.

d. *The maximum HQ is the ratio of the maximum constituent concentration to the soil screening value.* HQs are rounded to 1 significant digit.

e. Designated as a COPEC if the concentration for a non-bioaccumulative constituent is greater than background and either (1) the HQ is greater than one or (2) the constituent lacks an ecotoxicity screening value, or if the concentration for a bioaccumulative constituent is greater than background.

Table 11-4
Total Soil Risk Characterization and Identification of COPECs (a)
Encycle/Texas, Inc.
Corpus Christi, Texas

Constituent	Maximum Concentration in Surface Soil (mg/kg)	Site Specific Background Concentrations (b) (mg/kg)	Soil Screening Value (c) (mg/kg)	Maximum HQ (d) (unitless)	COPEC? (e) (yes/no)	Rationale
Inorganics						
Antimony	606	0.77-0.8	5	100	YES	HQ > 1
Arsenic	8,018	16.7	37	200	YES	HQ > 1
Barium	1,665	202-720	500	3	YES	HQ > 1
Bismuth	142	4.9	NA	NA	YES	No Screening Value
* Cadmium	3,911	11.7	29	100	YES	>Background; Bioaccumulative
* Chromium	4,691	14.9-35.9	0.4	10000	YES	>Background; Bioaccumulative
Cobalt	14,450	9.7	20	700	YES	HQ > 1
* Copper	104,400	40.3	61	2000	YES	>Background; Bioaccumulative
Cyanide	21	0.24	NA	NA	YES	No Screening Value
* Lead	65,760	109	50	1000	YES	>Background; Bioaccumulative
Manganese	37,520	334	500	80	YES	HQ > 1
* Mercury	363	0.09	0.1	4000	YES	>Background; Bioaccumulative
* Nickel	18,280	25.8	30	600	YES	>Background; Bioaccumulative
* Selenium	1,620	0.89	1.0	2000	YES	>Background; Bioaccumulative
Silver	352	0.5-0.54	2.0	200	YES	HQ > 1
Thallium	20	1.0-1.02	1.0	20	YES	HQ > 1
Tin	2,073	7.65	50	40	YES	HQ > 1
Vanadium	88	15.7-35.6	2	40	YES	HQ > 1
* Zinc	239,900	NA	120	2000	YES	>Background; Bioaccumulative

Notes:

COPEC Constituent of Potential Ecological Concern.
HQ Hazard Quotient.
mg/kg Milligrams per kilogram.
NA Not available.
* Constituent is considered bioaccumulative by the TCEQ (TCEQ, 2001; Table 3.1).
a. Total soil is 0 to 5 feet below ground surface.
b. TCEQ approved concentrations from 0 to 0.5 feet and when not available, lithology specific concentration ranges for clay/silt strata (ARCADIS RFI 2002 RFI Report).
c. Screening values are taken from TCEQ 2001.
d. The maximum HQ is the ratio of the maximum constituent concentration to the soil screening value. HQs are rounded to 1 significant digit.
e. Designated as a COPEC if the concentration for a non-bioaccumulative constituent is greater than background and either (1) the HQ is greater than one or (2) the constituent lacks an ecotoxicity screening value, or if the concentration for a bioaccumulative constituent is greater than background.

Table 15-1
Exposure Assumptions for Receptors of Interest
Encycle/Texas, Inc.
Corpus Christi, Texas

Exposure Parameter (a)	Units	Great Blue Heron		Red Tailed Hawk		White Footed Mouse (f)		Raccoon	
Body Weight (BW)	kg	2.3	(a)	1.09	(a)	0.022	(d)	8.5	(d)
Proportion of Diet (P)	unitless	Maximum Scenario: Fish - 100%	 (a)	Maximum Scenario: Small mammals - 100%	 (a)	Maximum Scenario: Plants - 80% Invertebrates - 20%	 (e) (e)	Maximum Scenario fish 5% plants 55% Invertebrates 40%	 (a) (a) (a)
		Refined Scenario: Fish - 100%	 (a)	Refined Scenario: Small mammals - 100%	 (a)	Refined Scenario: Plants - 80% Invertebrates - 20%	 (e) (e)	Refined Scenario fish 5% plants 55% Invertebrates 40%	 (a) (a) (a)
Food Ingestion Rate (IRf)	kg/d	0.414	cal	0.06	(c)	0.004	(c)	0.399	(c)
Water Ingestion Rate (IRw)	L/d	0.10	cal	NA		NA		NA	
Soil/Sediment Ingestion Rate (IRs)	kg/d	NA		NA		0.00001	(b)	0.0075	(b)
Home Range	hectare	8.4	(a)	697	(a)	0.15-0.2	(d)	259	(a)
Area Use Factor (AUF)	unitless	Maximum Scenario: 1		Maximum Scenario: 1		Maximum Scenario: 1		Maximum Scenario 1	
		Refined Scenario: 1		Refined Scenario: 0.07	(g)	Refined Scenario: 1		Refined Scenario 0.25	(g)

Notes:
(a) USEPA, 1993.
(b) Beyer et al., 1994.
(c) Nagy, 1987 in USEPA 1993.
(d) Mammals of Texas, online.
(e) Whitaker, 1966 in USEPA 1993.
(f) Parameter values are for related deer mouse except for those from Mammals of Texas website.
(g) AUF=affected property area (162 acres)/ home range.
cal - calculated from USEPA, 1993; converted from g/g-day to kg/day.
NA - Not Applicable.

Table 15-2
Bioaccumulation Factors for Bioaccumulative COPECs in Surface Soil, Sediment, and Surface Water
Encycle/Texas Inc., Corpus Christi, Texas

Constituent (a)	Applicable Media	BCFi (b) *(invertebrate)*		BCFv (c) *(vegetation)*		BCFf (d) *(fish)*		BAFm (e) *(mammal)*	
Cadmium	Sediment, Soil	9.6E-01	(f)	1.1E-01	(g)	907	(h)	2.8E-02	(i)
Copper	Sediment, Soil	4.0E-02	(f)	8.0E-02	(g)	710	(h)	5.0E-01	(i)
Lead	Soil	3.0E-02	(f)	9.0E-03	(g)	0.09	(h)	1.5E-02	(i)
Mercury	Water, Sediment, Soil	2.2E-01	(f)	1.8E-01	(g)	11,168	(h)	1.3E+01	(i)
Nickel	Sediment, Soil	2.0E-02	(f)	1.2E-02	(g)	78	(h)	3.0E-01	(i)
Selenium	Water, Sediment, Soil	2.2E-01	(f)	5.0E-03	(g)	129	(h)	7.5E-01	(i)
Thallium	Water	2.2E-01	(f)	8.0E-04	(g)	10,000	(h)	2.0E+00	(i)
Zinc	Sediment, Soil	5.6E-01	(f)	3.0E-01	(g)	2059	(h)	5.0E+00	(i)

Notes:

BAF	Bioaccumulation Factor.
BCF	Bioconcentration Factor (unitless); BCF = (Tissue Concentration)/(Media Concentration).
Log Kow	Log of the octanol-water partition coefficent.
(a)	Constituents identified as bioaccumulative COPECs are included.
(b)	BCFi denotes BAF for terrestrial invertebrates.
(c)	BCFv denotes BAF for terrestrial vegetation.
(d)	BCFf denotes BAF for fish.
(e)	BAFm denotes BAF for mammals.
(f)	EPA 1999, Human Health Risk Assessment Protocol for Hazardous Waste Combustion Facilities.
(g)	BCFs for vegetation were obtained from Baes et al., 1984. Values for uptake into leafy material, stem, and straw were used. Dry weight values were converted to wet weight (each was multiplied by 0.2, assuming vegetation was 80 % moisture).
(h)	BCFs for fish were obtained from EPA, 1999.
(i)	BAFs for small mammals were estimated from biotransfer factors (BTFs) presented in Baes et al. (1984). BTFs were converted to BAFs by multiplying by an average food ingestion rate of 50 kg/day. BAF values were assumed to be wet weight.

Table 16-1
Refinement of Sediment COPECs
Encycle/Texas, Inc.
Corpus Christi, Texas

Constituent (a)	Frequency of Detection	Maximum Concentration (mg/kg)	EPC (b)	Background 95% UTL (north - south side of channel) (mg/kg) North - South	Sediment Screening Value (mg/kg)	COPEC? (c) (yes/no)	Rationale (c)
Metals							
Antimony	11 / 22	97	9.1	0.4 - 0.4	2.0	YES	Above Screening Value
Arsenic	16 / 22	83	16	9.5 - 2.5	8	YES	Above Screening Value
Cadmium	37 / 40	189	29	2.4 - 2.5	1.2	YES	Above Screening Value
Cobalt	22 / 22	211	62	193 - 155	50	no	≤Background
Copper	40 / 40	2,580	300	23.3 - 28.4	34	YES	Above Screening Value
Lead	22 / 22	3,530	360	50.4 - 43.7	47	YES	Above Screening Value
Manganese	40 / 40	14,900	1,700	249 - 115	460	YES	Above Screening Value
Mercury	36 / 40	20	0.8	0.093 - 0.093	0.2	YES	Above Screening Value
Nickel	22 / 22	162	27	47.6 - 42	21	no	≤Background
Selenium	9 / 22	10	1.8	1.14 - 0.4	1.0	YES	Above Screening Value
Silver	11 / 22	6	0.96	0.25 - 0.25	1.0	no	Below Screening Value
Thallium	8 / 22	1	0.97	0.88 - 0.25	NA	YES	No Screening Value
Tin	9 / 22	619	54	2.5 - 2.5	3.4	YES	Above Screening Value
Zinc	40 / 40	36,400	4,100	165 - 165	150	YES	Above Screening Value

Notes:
COPEC Constituent of Potential Ecological Concern.
EPC The exposure point concentration (EPC).
mg/kg Milligrams per kilogram.
NA Not applicable.
NC Not calculated due to small sample size.
(a) Only chemicals identified as COPECs in Table 11-3 are included.
(b) The EPC is equal to the arithmetic mean.
(c) Designated as a COPEC if the EPC is greater than background and the appropriate screening value.

Table 16-2
Refinement of Surface Soil COPECs
Encycle/Texas, Inc.
Corpus Christi, Texas

Constituent (a)	Frequency of Detection	Maximum Concentration (mg/kg)	EPC (b)	Site Specific Background Concentrations (mg/kg)	Soil Screening Value (mg/kg)	COPEC? (c) (yes/no)	Rationale (c)
Inorganics							
Antimony	134 / 189	606	19	0.77-0.8	5	YES	Above Screening Value
Arsenic	120 / 173	8,018	150	16.7	37	YES	Above Screening Value
Barium	136 / 136	1,665	310	202-720	500	no	≤Background
Bismuth	36 / 150	142	8.1	4.9	NA	YES	No Screening Value
Cadmium	191 / 207	3,911	220	11.7	29	YES	Above Screening Value
Chromium	188 / 189	4,691	94	14.9-35.9	0.4	YES	Above Screening Value
Cobalt	140 / 158	14,450	160	9.7	20	YES	Above Screening Value
Copper	194 / 194	104,400	1,500	40.3	61	YES	Above Screening Value
Cyanide	48 / 141	21	0.5	0.24	NA	YES	No Screening Value
Lead	188 / 189	65,760	1,900	109	50	YES	Above Screening Value
Manganese	204 / 204	37,520	1,600	334	500	YES	Above Screening Value
Mercury	129 / 184	213	3.4	0.09	0.1	YES	Above Screening Value
Nickel	159 / 161	18,280	200	25.8	30	YES	Above Screening Value
Selenium	73 / 172	1,620	14	0.89	1	YES	Above Screening Value
Silver	124 / 183	352	18	0.5-0.54	2	YES	Above Screening Value
Thallium	53 / 158	20	2.3	1.0-1.02	1	YES	Above Screening Value
Tin	89 / 153	2,073	50	7.65	50	no	Below Screening Value
Vanadium	141 / 143	88	20	15.7-35.6	2	no	≤Background
Zinc	190 / 190	239,900	13,000	15.7-35.7	120	YES	Above Screening Value

Notes:
COPEC Constituent of Potential Ecological Concern.
EPC The exposure point concentration (EPC).
mg/kg Milligrams per kilogram.
NA Not available.
(a) Only constituents identified as COPECs in Table 11-4 are included.
(b) The EPC is equal to the arithmetic mean.
(c) Designated as a COPEC if the EPC is greater than background and the appropriate screening value.

Table 16-3
Refinement of Total Soil COPECs
Encycle/Texas, Inc.
Corpus Christi, Texas

Constituent (a)	Frequency of Detection	Maximum Concentration (mg/kg)	EPC (b)	Site Specific Background Concentrations (mg/kg)	Soil Screening Value (mg/kg)	COPEC? (c) (yes/no)	Rationale (c)
Inorganics							
Antimony	219 / 333	606	12	0.77-0.8	5	YES	Above Screening Value
Arsenic	194 / 290	8,018	110	16.7	37	YES	Above Screening Value
Barium	190 / 190	1,665	310	202-720	500	no	≤Background
Bismuth	50 / 216	142	6.7	4.9	NA	YES	No Screening Value
Cadmium	308 / 360	3,911	160	11.7	29	YES	Above Screening Value
Chromium	325 / 327	4,691	62	14.9-35.9	0.4	YES	Above Screening Value
Cobalt	216 / 248	14,450	110	9.7	20	YES	Above Screening Value
Copper	339 / 341	104,400	1,100	40.3	61	YES	Above Screening Value
Cyanide	55 / 195	21	0.4	0.24	NA	YES	No Screening Value
Lead	306 / 311	65,760	1,300	109	50	YES	Above Screening Value
Manganese	363 / 363	37,520	1,200	334	500	YES	Above Screening Value
Mercury	178 / 293	363	3.8	0.09	0.1	YES	Above Screening Value
Nickel	260 / 267	18,280	120	25.8	30	YES	Above Screening Value
Selenium	99 / 257	1,620	14	0.89	1	YES	Above Screening Value
Silver	169 / 299	352	12	0.5-0.54	2	YES	Above Screening Value
Thallium	91 / 256	20	2.1	1.0-1.02	1	YES	Above Screening Value
Tin	120 / 237	2,073	38	7.65	50	no	Below Screening Value
Vanadium	192 / 195	88	22	15.7-35.6	2	no	≤Background
Zinc	372 / 372	239,900	7,900	15.7-35.7	120	YES	Above Screening Value

Notes:
COPEC Constituent of Potential Ecological Concern.
EPC The exposure point concentration (EPC).
mg/kg Milligrams per kilogram.
NA Not available.
(a) Only constituents identified as COPECs in Table 11-5 are included.
(b) The EPC is equal to the arithmetic mean.
(c) Designated as a COPEC if the EPC is greater than background and the appropriate screening value.

Table 16-4
Sediment Pore Water Risk Characterization
Encycle/Texas, Inc.
Corpus Christi, Texas

Constituent	Maximum Concentration in Pore Water (mg/l)	Surface Water Background 95% UTL (mg/L)	Surface Water Screening Value (a) (mg/l)		Maximum HQ (c) (unitless)	COPEC? (d) (yes/no)	Rationale
Dissolved Metals							
Antimony	0.356	0.09	0.5	e	0.7	no	HQ ≤ 1
Arsenic	0.028	0.005	0.078		0.4	no	HQ ≤ 1
Cobalt	0.021	0.005	1.5	b,e	0.01	no	HQ ≤ 1
Manganese	31	0.02	0.12	b,e	300	YES	HQ > 1
* Mercury	0.016	0.001	0.0011	e	10	YES	> Background; Bioaccumulative
* Selenium	0.011	0.005	0.136	e	0.08	YES	> Background; Bioaccumulative
* Thallium	0.0003	0.001	0.0213	b,e	0.01	no	≤ Background; HQ ≤ 1
Tin	0.001	0.01	0.073	e	0.007	no	HQ ≤ 1

Notes:
COPEC Constituent of Potential Ecological Concern.
HQ Hazard Quotient.
mg/l Milligrams per liter.
NA Not available.
UTL Background Upper Tolerance Limit.
* Constituent is considered bioaccumulative by the TCEQ (TCEQ, 2001; Table 3.1).
a. Screening values are Marine Surface Water Ecological Benchmarks (TCEQ 2001) unless otherwise noted.
b. No marine benchmark is available; screening value that is presented is a freshwater benchmark (TCEQ 2001).
c. The maximum HQ is the ratio of the maximum constituent concentration to the water screening value. HQs are rounded to 1 significant digit.
d. Designated as a COPEC if the concentration for a non-bioaccumulative constituent is greater than background and either (1) the HQ is greater than one or (2) the constituent lacks an ecotoxicity screening value, or if the concentration for a bioaccumulative constituent is greater than background.
e. Values are for total metals; all others are for dissolved metals.

Table 16-5
Refinement of Sediment Pore Water COPECs
Encycle/Texas, Inc.
Corpus Christi, Texas

Constituent (a)	Frequency of Detection	Maximum Concentration (mg/l)	EPC (b)	Surface Water Background 95% UTL (mg/L)	Surface Water Screening Value (c) (mg/l)	COPEC? (d) (yes/no)	Rationale
Dissolved Metals							
Manganese	4 / 4	31	8.4	0.02	0.12	YES	Above Screening Value
Mercury	4 / 4	0.016	0.008	0.001	0.0011	YES	Above Screening Value
Selenium	4 / 4	0.011	0.008	0.005	0.136	YES	>Background; Bioaccumulative

Notes:
COPEC Constituent of Potential Ecological Concern.
EPC The exposure point concentration (EPC).
ug/l Micrograms per liter.
NA Not applicable.
NC Not calculated due to small sample size.
(a) Only constituents identified as COPECs in Table 11-2 are included.
(b) The EPC is equal to the arithmetic mean.
(c) Screening values are for total metals.
(d) Designated as a COPEC if the EPC is greater than background and the appropriate screening value.

Table 16-6. Evaluation of Acid Volatile Sulfide (AVS) and Simultaneously Extracted Metal (SEM) Concentrations in Sediment, Encycle/Texas, Inc., Corpus Christi, Texas.

	SEM Metal Concentration											
Location	SEM Cadmium (moles/kg)	SEM Copper (moles/kg)	SEM Lead (moles/kg)	SEM Nickel (moles/kg)	SEM Silver (moles/kg)	SEM Zinc (moles/kg)	Sum SEM (moles/kg)	AVS (moles/kg)	Total Organic Carbon %	Organic Carbon Normalized Excess SEM (umol/gOC)	Effects Benchmark (umol/gOC) [a]	Effects Benchmark Exceeded?
SED-1	5.01E-04	1.57E-06	5.74E-04	5.45E-05	4.64E-07	1.28E-01	1.29E-01	7.66E-02	1.46	3,577	130	Yes
SED-4	4.95E-04	2.27E-04	1.46E-04	3.75E-04	4.64E-07	2.46E-01	2.47E-01	1.65E-02	1.03	29,996	130	Yes
SED-7	2.54E-03	4.23E-04	1.87E-04	2.30E-04	6.95E-07	2.66E-01	2.70E-01	9.60E-03	0.77	33,755	130	Yes
SED-10	3.33E-03	8.25E-04	5.41E-04	3.87E-04	6.95E-07	3.44E-01	3.49E-01	2.82E-03	0.21	164,954	130	Yes

[a] From DiToro, Hansen, et al. (1999).
AVS - Acid Volatile Sulfide concentration in sediment.
SEM - Simultaneously Extracted Metals.
moles/kg - moles per kilogram.
umol/gOC - micromole per gram organic carbon.

Table 16-7
Great Blue Heron Toxicity Reference Values for Bioaccumulative COPECs
Encycle/Texas Inc., Corpus Christi, Texas

Constituent (a)	Test Species Dose (mg/kg BW-day) Chronic NOAEL	Test Species	Test Duration	Test Endpoint	Reference	Uncertainty Factor (UF) (b) (unitless)	Test Species Body Weight (kg)	Receptor Body Weight (kg)	Allometric Scaling Factor (unitless) (c)	Body-Weight EF(d) (unitless)	Receptor NOAEL TRV (e) (mg/kg-BW/day)	Receptor LOAEL TRV (e) (mg/kg-BW/day)	
Cadmium [cadmium chloride]	1.45	Mallard ducks	90 days	Reproduction	Sample et al., 1996	1	1.15	2.3	1.2	1.1	1.7	23	f
Chromium [$CrK(SO_4)_2$]	1	Black duck	10 months	Reproduction	Sample et al., 1996	1	1.25	2.3	1.2	1.1	1.1	6	f
Copper [copper oxide]	47	Chicken	10 weeks	Growth, mortality	Sample et al., 1996	1	0.53	2.3	1.2	1.3	63.0	83	f
Lead [metallic]	3.85	American Kestrel	7 months	Reproduction	Sample et al., 1996	1	0.13	2.3	1.2	1.8	6.8	34	g
Mercury [mercuric chloride]	0.45	Japanese Quail	12 months	Reproduction	Sample et al., 1996	1	0.15	2.3	1.2	1.7	0.8	2	f
Nickel [nickel sulfate]	77.4	Mallard duckling	90 days	Growth, mortality	Sample et al., 1996	1	0.782	2.3	1.2	1.2	96.0	133	f
Selenium [sodium selenite]	0.5	Mallard duck	78 days	Reproduction	Sample et al., 1996	1	1	2.3	1.2	1.2	0.6	1	f
Thallium	35	Starling	7-14 days	Mortality	Schafer, 1972	100	0.08	2.3	1.2	2.0	0.7	3	g
Zinc [zinc sulfate]	14.49	White Leghorn Hens	44 weeks	Reproduction	Sample et al., 1996	1	1.9	2.3	1.2	1.0	15.1	136	f

Notes:
LOAEL Lowest Observed Adverse Effects Level.
NOAEL No Observed Adverse Effects Level.
TRV Toxicity Reference Value.
(a) Only constituents identified as bioaccumulative COPECs are included.
(b) Uncertainty Source: Calabrese and Baldwin, 1993.
(c) Allometric scaling factor source: Sample and Arenal, 1999.
(d) Body Weight Exposure Factor (EF) = [Test Species Body Weight / Receptor Body Weight]^{B}; where B=allometric scaling factor.
(e) TRVs calculated as described in Section 16.
(f) The test species chronic LOAEL reported in Sample et al (1996) was adjusted to the receptor LOAEL using the UF and body weight EF. Test species chronic LOAELs (mg/kg-bw/day): Cd=20.03; Cr=5; Cu=61.72; Hg=0.9; Ni=107; Se=1; Zn=131.
(g) No test species LOAEL was reported in the study, therefore, a chronic LOAEL TRV was calculated using the test species chronic NOAEL multiplied by an endpoint UF of 5 (ACE 1996) and adjusted using the UF and body weight EF.

Table 16-8

Red Tailed Hawk Toxicity Reference Values for Bioaccumulative COPECs

Encycle/Texas Inc., Corpus Christi, Texas

Constituent (a)	Test Species Dose (mg/kg BW-day) Chronic NOAEL	Test Species	Test Duration	Test Endpoint	Reference	Uncertainty Factor (UF) (b) (unitless)	Test Species Body Weight (kg)	Receptor Body Weight (kg)	Allometric Scaling Factor (unitless) (c)	Body-Weight EF(d) (unitless)	Receptor NOAEL TRV (e) (mg/kg-BW/day)	Receptor LOAEL TRV (e) (mg/kg-BW/day)
Cadmium [cadmium chloride]	1.45	Mallard ducks	90 days	Reproduction	Sample et al., 1996	1	1.15	1.09	1.2	1.0	1.4	20 f
Chromium [$CrK(SO_4)_2$]	1	Black duck	10 months	Reproduction	Sample et al., 1996	1	1.25	1.09	1.2	1.0	1.0	5 f
Copper [copper oxide]	46	Chicken	10 weeks	Growth, mortality	Sample et al., 1996	1	0.53	1.09	1.2	1.2	53	71 f
Lead [metallic]	3.85	American Kestrel	7 months	Reproduction	Sample et al., 1996	1	0.13	1.09	1.2	1.5	5.9	29 g
Mercury [mercuric chloride]	0.45	Japanese Quail	12 months	Reproduction	Sample et al., 1996	1	0.15	1.09	1.2	1.5	0.7	1 f
Nickel [nickel sulfate]	77.4	Mallard duckling	90 days	Growth, mortality	Sample et al., 1996	1	0.782	1.09	1.2	1.1	83	114 f
Selenium [sodium selenite]	0.5	Mallard duck	78 days	Reproduction	Sample et al., 1996	1	1	1.09	1.2	1.0	0.5	1 f
Thallium	35	Starling	7-14 days	Mortality	Schafer, 1972	100	0.078	1.09	1.2	1.7	0.6	3 g
Zinc [zinc sulfate]	14.5	White Leghorn Hens	44 weeks	Reproduction	Sample et al., 1996	1	1.9	1.09	1.2	0.9	13.0	117 f

Notes:

LOAEL Lowest Observed Adverse Effects Level.

NOAEL No Observed Adverse Effects Level.

TRV Toxicity Reference Value.

(a) Only constituents identified as bioaccumulative COPECs are included.

(b) Uncertainty Source: Calabrese and Baldwin, 1993.

(c) Allometric scaling factor source: Sample and Arenal, 1999.

(d) Body Weight Exposure Factor (EF) = [Test Species Body Weight / Receptor Body Weight]^B; where B=allometric scaling factor.

(e) TRVs calculated as described in Section 16.

(f) The test species chronic LOAEL reported in Sample et al (1996) was adjusted to the receptor LOAEL using the UF and body weight EF. Test species chronic LOAELs (mg/kg-bw/day): Cd=20.03; Cr=5; Cu=61.72; Hg=0.9; Ni=107; Se=1; Zn=131.

(g) No test species LOAEL was reported in the study, therefore, a chronic LOAEL TRV was calculated using the test species chronic NOAEL multiplied by an endpoint UF of 5 (ACE 1996) and adjusted using the UF and body weight EF.

Table 16-9
White Footed Mouse Toxicity Reference Values for Bioaccumulative COPECs
Encycle/Texas Inc., Corpus Christi, Texas

Constituent (a)	Test Species Dose (mg/kg BW-day) Chronic NOAEL	Test Species	Test Duration	Test Endpoint	Reference	Uncertainty Factor UF (b) (unitless)	Test Species Body Weight (kg)	Receptor Body Weight (kg)	Allometric Scaling Factor (unitless) (c)	Body-Weight EF(d) (unitless)	Receptor NOAEL TRV (e) (mg/kg-BW/day)	Receptor LOAEL TRV (e) (mg/kg-BW/day)	
Cadmium [$CdCl_2$]	1	Rat	6 weeks	Reproduction	Sample et al., 1996	1	0.303	0.022	0.893	1.3	1.3	13	f
Chromium [Cr^{+3} as Cr_2O_3]	2,737	Rat	2 years	Reproduction and Longevity	Sample et al., 1996	1	0.35	0.022	0.94	1.2	3,231	16,156	g
Chromium [Cr^{+6}]	3.28	Rat	1 year	Growth	Sample et al., 1996	1	0.35	0.022	0.94	1.2	3.9	19	g
Copper [gluconate]	8.47	Mouse	850 days	Longevity and Mortality	Massie and Aiello, 1984	1	0.03	0.022	0.94	1.0	8.6	43	h
Lead [lead acetate]	8	Rat	>1 year	Reproduction	Sample et al., 1996	1	0.3	0.022	0.94	1.2	9	94	f
Mercury [mercuric sulfide]	13.2	Mouse	20 months	Reproduction	Sample et al., 1996	1	0.03	0.022	0.94	1.0	13	67	g
Nickel sulfate	40	Rat	3 generations	Growth	Sample et al., 1996	1	0.35	0.022	0.94	1.2	47	94	f
Selenium [selanate SeO_4]	0.2	Rat	1 year	Reproduction	Sample et al., 1996	1	0.35	0.022	0.94	1.2	0.2	0.4	f
Thallium [thallium sulfate]	0.0074	Rat	60 days	Reproduction	Opresko et al., 1994	1	0.365	0.022	0.94	1.2	0.009	0.1	f
Zinc [zinc oxide]	160	Rat	16 days	Reproduction	Sample et al., 1996	1	0.3	0.022	0.94	1.2	187	374	f

Notes:
LOAEL Lowest Observed Adverse Effects Level.
NOAEL No Observed Adverse Effects Level.
TRV Toxicity Reference Value.
(a) Only constituents identified as bioaccumulative COPECs are included.
(b) Uncertainty Source: Calabrese and Baldwin, 1993.
(c) Allometric scaling factor source: Sample and Arenal, 1999.
(d) Body Weight Exposure Factor (EF) = [Test Species Body Weight / Receptor Body Weight]$^{1-B}$; where B=allometric scaling factor.
(e) TRVs calculated as described in Section 16.
(f) The test species chronic LOAEL reported in Sample et al (1996) was adjusted to the receptor LOAEL using the UF and body weight EF. Test species chronic LOAELs (mg/kg-bw/day): Cd=10; Pb=80; Ni=80; Se=0.33; Tl=0.074; Zn=320.
(g) No test species LOAEL was reported in the study, therefore, the chronic NOAEL was multiplied by an UF of 5 (ACE 1996) and adjusted using the UF and body weight EF to yield a chronic LOAEL.
(h) The test species chronic LOAEL of 42.4 mg/kg-BW/day reported in Massie and Aiello (1984) was adjusted to the receptor species LOAEL of 43 mg/kg-BW/day using the UF and body weight EF.

Table 16-10

Raccoon Toxicity ReferenceValues for Bioaccumulative COPECs

Encycle/Texas Inc., Corpus Christi, Texas

Constituent (a)	Test Species Dose (mg/kg BW-day) Chronic NOAEL	Test Species	Test Duration	Test Endpoint	Reference	Uncertainty Factor UF (b) (unitless)	Test Species Body Weight (kg)	Receptor Body Weight (kg)	Allometric Scaling Factor (unitless) (c)	Body-Weight EF(d) (unitless)	Receptor NOAEL TRV (e) (mg/kg-BW/day)	Receptor LOAEL TRV (e) (mg/kg-BW/day)	
Cadmium [$CdCl_2$]	1	Rat	6 weeks	Reproduction	Sample et al., 1996	1	0.303	8.5	0.893	0.7	0.7	7	f
Chromium [Cr^{+3} as Cr_2O_3]	2,737	Rat	2 years	Reproduction and Longevity	Sample et al., 1996	1	0.35	8.5	0.94	0.8	2,260	11,301	g
Chromium [Cr^{+6}]	3.28	Rat	1 year	Growth	Sample et al., 1996	1	0.35	8.5	0.94	0.8	2.7	14	g
Copper [gluconate]	8.47	Mouse	850 days	Longevity and Mortality	Massie and Aiello, 1984	1	0.03	8.5	0.94	0.7	6.0	30	h
Lead [lead acetate]	8	Rat	>1 year	Reproduction	Sample et al., 1996	1	0.3	8.5	0.94	0.8	7	65	f
Mercury [mercuric sulfide]	13.2	Mouse	20 months	Reproduction	Sample et al., 1996	1	0.03	8.5	0.94	0.7	9	47	g
Nickel sulfate	40	Rat	3 generations	Growth	Sample et al., 1996	1	0.35	8.5	0.94	0.8	33	66	f
Selenium [selanate SeO_4]	0.2	Rat	1 year	Reproduction	Sample et al., 1996	1	0.35	8.5	0.94	0.8	0.2	0.3	f
Thallium [thallium sulfate]	0.0074	Rat	60 days	Reproduction	Opresko et al., 1994	1	0.365	8.5	0.94	0.8	0.006	0.1	f
Zinc [zinc oxide]	160	Rat	16 days	Reproduction	Sample et al., 1996	1	0.3	8.5	0.94	0.8	131	262	f

Notes:

LOAEL Lowest Observed Adverse Effects Level.

NOAEL No Observed Adverse Effects Level.

TRV Toxicity Reference Value.

NA Not applicable, because body weight extrapolations are not appropriate for avain species.

(a) Only constituents identified as bioaccumulative COPECs are included.

(b) Uncertainty Source: Calabrese and Baldwin, 1993.

(c) Allometric scaling factor source: Sample and Arenal, 1999.

(d) Body Weight Exposure Factor (EF) = [Test Species Body Weight / Receptor Body Weight]^{B}; where B=allometric scaling factor.

(e) TRVs calculated as described in Section 16.

(f) The test species chronic LOAEL reported in Sample et al (1996) was adjusted to the receptor LOAEL using the UF and body weight EF. Test species chronic LOAELs (mg/kg-bw/day): Cd=10; Pb=80; Ni=80; Se=0.33; Tl=0.074; Zn=320.

(g) No test species LOAEL was reported in the study, therefore, the chronic NOAEL was multiplied by an UF of 5 (ACE 1996) and adjusted using the UF and body weight EF to yield a chronic LOAEL.

(h) The test species chronic LOAEL of 42.4 mg/kg-BW/day reported in Massie and Aiello (1984) was adjusted to the receptor species LOAEL of 30 mg/kg-BW/day using the UF and body weight EF.

Table 17-1
Maximum and Refined Scenario Food Web Modeling for Great Blue Heron
Encycle/Texas Inc., Corpus Christi, Texas

Constituent (a)	EPC/Maximum Concentration in Surface Water (b)	Bioaccumulation Factor (BAF) for Fish	Estimated Tissue Concentration-fish (c)	Receptor Maximum Estimated Dietary Dose (d)	Receptor NOAEL Toxicity Reference Value	Maximum Scenario NOAEL HQ (e)	Does NOAEL HQ Exceed 1?	Receptor LOAEL Toxicity Reference Value	Maximum Scenario LOAEL HQ (e)	Does LOAEL HQ Exceed 1?
	(mg/L)	BCFf	(mg/kg)	(mg/kg-BW-day)	(mg/kg-BW-day)			(mg/kg-BW-day)		
Cadmium	0.0025	907	2.3	0.41	1.7	0.2	No	-	-	-
Copper	0.04	710	28.4	5.11	63	0.08	No	-	-	-
Lead	0.005	0.09	0.00045	0.0003	6.8	0.00004	No	-	-	-
Mercury	0.001	11,168	11.2	2.01	0.8	3	Yes	2	1	No
Nickel	0.07	78	5.46	0.99	96	0.01	No	-	-	-
Selenium	0.005	129	0.65	0.12	0.6	0.2	No	-	-	-
Thallium	0.001	10,000	10	1.8	0.7	3	Yes	3	0.5	No
Zinc	0.11	2059	226	40.8	15	3	Yes	136	0.3	No

Notes:

BAF Bioaccumlation Factor (unitless); BAF = (Tissue Concentration)/(Media Concentration). BCFs identified in Table 15-2.

LOAEL Lowest observed adverse effect level.

TRV Toxicity Reference Value.

mg/kg Milligrams per kilogram.

mg/kg-BW-day Milligrams per kilogram of body weight each day.

mg/L Milligrams per liter.

NOAEL No observed adverse effect level.

(a) Only those constituents identified as bioaccumulative COPCs are included.

(b) Total metals concentrations; due to low sample numbers, the maximum and EPC values are the same.

(c) Estimated Fish Tissue Concentation (Cf)=Cw*BCF*FCM; where Cw= Concentration in surface water (mg/L), FCM=Food chanin multiplier (All log Kows were less than 2.0, therefore the FCM of 1 was used).

(d) Dose = [((Cf x Pf x IRf) + (Cw x IRw)) x AUF]/BW. Where Cf=estimated fish tissue concentration, Cw=surface water concentration, Pf=proportion of diet consisting of fish; IRf=food ingestion rate, IRw=water ingestion rate, AUF=area use factor, BW=body weight.

(e) Hazard quotient (HQ) = (Dose)/(TRV); LOAEL HQs were calculated only for those chemicals whose NOAEL HQ exceeded 1.

Table 17-2
Maximum Scenario Food Web Modeling for Red Tailed Hawk
Encycle/Texas Inc., Corpus Christi, Texas

Constituent (a)	Maximum Surface Soil Concentration	Bioaccumulation Factor for Mammals	Estimated Tissue Concentration-Mammal (b)	Receptor Maximum Estimated Dietary Dose (c)	NOAEL Toxicity Reference Value	Maximum Scenario NOAEL HQ (d)	Does NOAEL HQ Exceed 1?
	(mg/kg)	BAFm	(mg/kg)	(mg/kg-BW-day)	(mg/kg-BW-day)		
Cadmium	3,911	0.028	108	5.7	1.4	4	Yes
Chromium	4,691	0.276	1,292	68	0.97	70	Yes
Copper	104,400	0.5	52,200	2754	53	50	Yes
Lead	65,760	0.015	986	52	5.9	9	Yes
Mercury	363	12.5	4,538	239	0.7	400	Yes
Nickel	18,280	0.3	5,484	289	83	3	Yes
Selenium	1,620	0.75	1,215	64	0.51	100	Yes
Thallium	20	2	40	2.1	0.59	4	Yes
Zinc	239,900	5	1,199,500	63,277	13	5000	Yes

Notes:
BAF Bioaccumlation Factor (unitless); BAF = (Tissue Concentration)/(Media Concentration).
TRV Toxicity Reference Value.
mg/kg Milligrams per kilogram.
mg/kg-BW-day Milligrams per kilogram of body weight each day.
NOAEL No observed adverse effects level.
(a) Only those constituents identified as bioaccumulative COPECs are included.
(b) Estimated Tissue Concentration = Cs * BAFm; where Cs=soil concentration
(c) Dose = [(Cm x Pm x IRf) x AUF]/BW. Where Cm=estimated mammal tissue concentration, Pm=proportion of diet consisting of mammals; IRf=food ingestion rate, AUF=area use factor, BW=body weight.
(d) Hazard quotient (HQ) = (Dose)/(TRV); LOAEL HQs were calculated only for those chemicals whose NOAEL HQ exceeded 1.0.

Table 17-3
Refined Scenario Food Web Modeling for Red Tailed Hawk
Encycle/Texas Inc., Corpus Christi, Texas

Chemical (a)	Total Soil EPC (mg/kg)	Bioaccumulation Factors for Mammals BAFm	Estimated Tissue Concentration-Mammal (b) (mg/kg)	Receptor Refined Estimated Dietary Dose (c) (mg/kg-BW-day)	NOAEL Toxicity Reference Value (mg/kg-BW-day)	Refined Scenario NOAEL HQ (d)	Does NOAEL HQ Exceed 1?	LOAEL Toxicity Reference Value (mg/kg-BW-day)	Refined Scenario LOAEL HQ (d)	Does LOAEL HQ Exceed 1?
Cadmium	160	0.0275	4.4	0.02	1.4	0.01	No	-	-	-
Chromium	62	0.276	17	0.061	0.97	0.06	No	-	-	-
Copper	1,100	0.5	550	2.0	53.1	0.04	No	-	-	-
Lead	1,300	0.015	20	0.07	5.9	0.01	No	-	-	-
Mercury	3.8	12.5	48	0.17	0.7	0.3	No	-	-	-
Nickel	120	0.3	36	0.13	82.7	0.002	No	-	-	-
Selenium	14	0.75	11	0.04	0.5	0.07	No	-	-	-
Thallium	2.1	2	4.2	0.02	0.6	0.03	No	-	-	-
Zinc	7,900	5	39,500	141	13	10	Yes	117	1	No

Notes:
EPC Exposure Point Concentration, equal to the arithmetic mean.
BAF Bioaccumlation Factor (unitless); BAF = (Tissue Concentration)/(Media Concentration).
LOAEL Lowest observed adverse effects level.
TRV Toxicity Reference Value.
mg/kg Milligrams per kilogram.
mg/kg-BW-day Milligrams per kilogram of body weight each day.
NOAEL No observed adverse effects level.
(a) Only those chemicals identified as bioaccumulative COPCs are included.
(b) Estimated Tissue Concentration = Cs * BAFm; where Cs=soil concentration.
(c) Dose = [(Cm x Pm x IRf) x AUF]/BW. Where Cm=estimated mammal tissue concentration, Pm=proportion of diet consisting of mammals; IRf=food ingestion rate, AUF=area use factor, BW=body weight.
(d) Hazard quotient (HQ) = (Dose)/(TRV); LOAEL HQs were calculated only for those chemicals whose NOAEL HQ exceeded 1.0.

Table 17-4
Maximum Scenario Food Web Modeling for White Footed Mouse
Encycle/Texas Inc., Corpus Christi, Texas

Constituent (a)	Maximum Total Soil Concentration (mg/kg)	Bioaccumulation Factors (BAF) Invertebrate BCFi	Bioaccumulation Factors (BAF) Vegetation BCFv	Estimated Tissue Concentrations (b) Invertebrate (mg/kg)	Estimated Tissue Concentrations (b) Vegetation (mg/kg)	Receptor Maximum Estimated Dietary Dose (c) (mg/kg-BW-day)	NOAEL Toxicity Reference Value (mg/kg-BW-day)	Maximum Scenario NOAEL HQ (d)	Does NOAEL HQ Exceed 1?
Cadmium	3,911	0.96	0.11	3,755	430	179	1.3	100	Yes
Chromium (Cr^{+3})	4,691	0.01	0.002	47	7.0	5.4	3,231	0.002	No
Chromium (Cr^{+6})	4,691	0.01	0.002	47	7.0	5.4	3.9	1	No
Copper	104,400	0.04	0.08	4,176	8,352	1,280	8.6	100	Yes
Lead	65,760	0.03	0.01	1,973	592	183	9.4	20	Yes
Mercury	363	0.22	0.18	80	65	11.2	13.4	0.8	No
Nickel	18,280	0.02	0.01	366	219	52	47.2	1	No
Selenium	1,620	0.22	0.01	356	8.1	13.6	0.2	60	Yes
Thallium	20	0.22	0.001	4.4	0.02	0.16	0.01	20	Yes
Zinc	239,900	0.56	0.30	134,344	71,970	13,781	187	70	Yes

Notes:
BAF Bioaccumlation Factor (unitless); BAF = (Tissue Concentration)/(Media Concentration). BCFs identified in Table 15-2.
TRV Toxicity Reference Value.
mg/kg Milligrams per kilogram.
mg/kg-BW-day Milligrams per kilogram of body weight each day.
NOAEL No observed adverse effects level.
(a) Only those constituents identified as bioaccumulative COPECs are included.
(b) Estimated Tissue Concentration = Cs * BAF; where Cs=soil concentration
(c) Dose = [((Ci x Pi x IRf) + (Cv x Pv x IRf) + (Cs x IRs)) x AUF]/BW. Where Ci= estimated invertebrate tissue concentration, Pi=proportion of diet consisting of invertebrates, IRf=food ingestion rate, Cv=estimated plant tissue concentration, Pv=proportion of diet consisting of plants, Cs=soil concentration, IRs=ingestion rate of soil, AUF=area use factor, BW=body weight.
(d) Hazard quotient (HQ) = (Dose)/(TRV); LOAEL HQs were calculated only for those chemicals whose NOAEL HQ exceeded 1.0.

Table 17-5
Refined Scenario Food Web Modeling for White Footed Mouse
Encycle/Texas Inc., Corpus Christi, Texas

Constituent (a)	Total Soil EPC (mg/kg)	Bioaccumulation Factors (BAF)		Estimated Tissue Concentrations (b)		Receptor Refined Estimated Dietary Dose (c) (mg/kg-BW-day)	NOAEL Toxicity Reference Value (mg/kg-BW-day)	Refined Scenario NOAEL HQ (d)	Does NOAEL HQ Exceed 1?	LOAEL Toxicity Reference Values (mg/kg-BW-day)	Refined Scenario LOAEL HQ (d)	Does LOAEL HQ Exceed 1?
		Invertebrate BCFi	Vegetation BCFv	Invertebrate (mg/kg)	Vegetation (mg/kg)							
Cadmium	160	0.96	0.11	154	18	7	1.3	6	Yes	13	0.6	No
Chromium (Cr^{+3})	62	0.01	0.002	0.6	0.1	0.1	3,231	0.00002	No	-	-	-
Chromium (Cr^{+6})	62	0.01	0.002	0.6	0.1	0.1	3.9	0.02	No	-	-	-
Copper	1,100	0.04	0.08	44	88	13	8.6	2	Yes	43	0.3	No
Lead	1,300	0.03	0.01	39	12	4	9.4	0.4	No	-	-	-
Mercury	3.8	0.22	0.18	0.8	1	0.1	13.4	0.009	No	-	-	-
Nickel	120	0.02	0.01	2.4	1	0.3	47.2	0.007	No	-	-	-
Selenium	14	0.22	0.01	3.1	0.1	0.1	0.2	0.5	No	-	-	-
Thallium	2.1	0.22	0.001	0.5	0.002	0.02	0.01	2	Yes	0.1	0.2	No
Zinc	7,900	0.56	0.30	4,424	2,370	454	187	2	Yes	374	1	No

Notes:

EPC Exposure Point Concentration, equal to the arithmetic mean.
BAF Bioaccumlation Factor (unitless); BAF = (Tissue Concentration)/(Media Concentration). BCFs identified in Table 15-2.
LOAEL Lowest observed adverse effects level.
TRV Toxicity Reference Value.
mg/kg Milligrams per kilogram.
mg/kg-BW-day Milligrams per kilogram of body weight each day.
NOAEL No observed adverse effects level.
(a) Only those constituents identified as bioaccumulative COPECs are included.
(b) Estimated Tissue Concentration = Cs * BAF; where Cs=soil concentration
(c) Dose = [((Ci x Pi x IRf) + (Cv x Pv x IRf) + (Cs x IRs)) x AUF]/BW. Where Ci= estimated invertebrate tissue concentration, Pi=proportion of diet consisting of invertebrates, IRf=food ingestion rate, Cv=estimated plant tissue concentration, Pv=proportion of diet consisting of plants, Cs=soil concentration, IRs=ingestion rate of soil, AUF=area use factor, BW=body weight.
(d) Hazard quotient (HQ) = (Dose)/(TRV); LOAEL HQs were calculated only for those chemicals whose NOAEL HQ exceeded 1.0.

Table 17-6
Maximum Scenario Food Web Modeling for Raccoon
Encycle/Texas Inc., Corpus Christi, Texas

Constituent (a)	Maximum Surface Soil Concentration (mg/kg)	Maximum Water Concentration (mg/L)	Maximum Sediment Concentration (mg/kg)	Bioaccumulation Factors (BAF) Invertebrate BCFi	Vegetation BCFv	Fish BCFf	Estimated Dietary Tissue Concentrations (b) Invertebrate (mg/kg)	Vegetation (mg/kg)	Fish (mg/kg)	Receptor Maximum Estimated Dietary Dose (c) (mg/kg-BW-day)	NOAEL Toxicity Reference Value (mg/kg-BW-day)	Maximum Scenario NOAEL HQ (d)	Does NOAEL HQ Exceed 1?
Cadmium	3,911	0.0025	189	0.96	0.11	907	3,755	430	2.3	82	0.7	100	Yes
Chromium	4,691	NA	NA	0.01	0.002	NA	47	7.0	NA	1.1	2260	0.0005	No
Chromium	4,691	NA	NA	0.01	0.002	NA	47	7.0	NA	1.1	2.7	0.4	No
Copper	104,400	0.04	2580	0.04	0.08	710	4,176	8,352	28	296	6	50	Yes
Lead	65,760	0.005	3530	0.03	0.01	0.09	1,973	592	0.00045	55	7	8	Yes
Mercury	213	0.001	19.5	0.22	0.18	11,168	47	38	11.2	2	9	0.2	No
Nickel	18,280	0.07	162.0	0.02	0.01	78	366	219	5.5	13	33	0.4	No
Selenium	1,620	0.005	10.0	0.22	0.01	129	356	8.1	0.6	7	0.2	40	Yes
Thallium	20	0.001	0.9	0.22	0.001	10,000	4.4	0.02	10	0.11	0.006	20	Yes
Zinc	239,900	0.11	36400	0.56	0.30	2,059	134,344	71,970	226	4,413	131	30	Yes

Notes:

BAF Bioaccumlation Factor (unitless); BAF = (Tissue Concentration)/(Media Concentration). BCFs identified in Table 15-2.

TRV Toxicity Reference Value.

mg/kg Milligrams per kilogram.

mg/L Milligrams per liter.

mg/kg-BW-day Milligrams per kilogram of body weight each day.

NA Not Analyzed in surface water or sediment.

NOAEL No observed adverse effects level.

(a) Only those constituents identified as bioaccumulative COPECs are included.

(b) Estimated Tissue Concentration = Cs * BCFi, Cs * BCFv, and Cw * BCFf; where Cs=soil concentration and Cw=surface water concentration.

(c) Dose = [((Ci x Pi x IRf) + (Cv x Pv x IRf) + (Cf x Pf x IRf) +(Cs x IRs)) x AUF]/BW.Where Ci= estimated invertebrate tissue concentration, Pi=proportion of diet consisting of invertebrates, IRf=food ingestion rate, Cv=estimated plant tissue concentration, Pv=proportion of diet consisting of plants, Cf=estimated fish tissue concentration, Pf=proportion of diet consisting of fish, Cs=sediment concentration, IRs=ingestion rate of sediment, AUF=area use factor, BW=body weight.

(d) Hazard quotient (HQ) = (Dose)/(TRV); LOAEL HQs were calculated only for those chemicals whose NOAEL HQ exceeded 1.0.

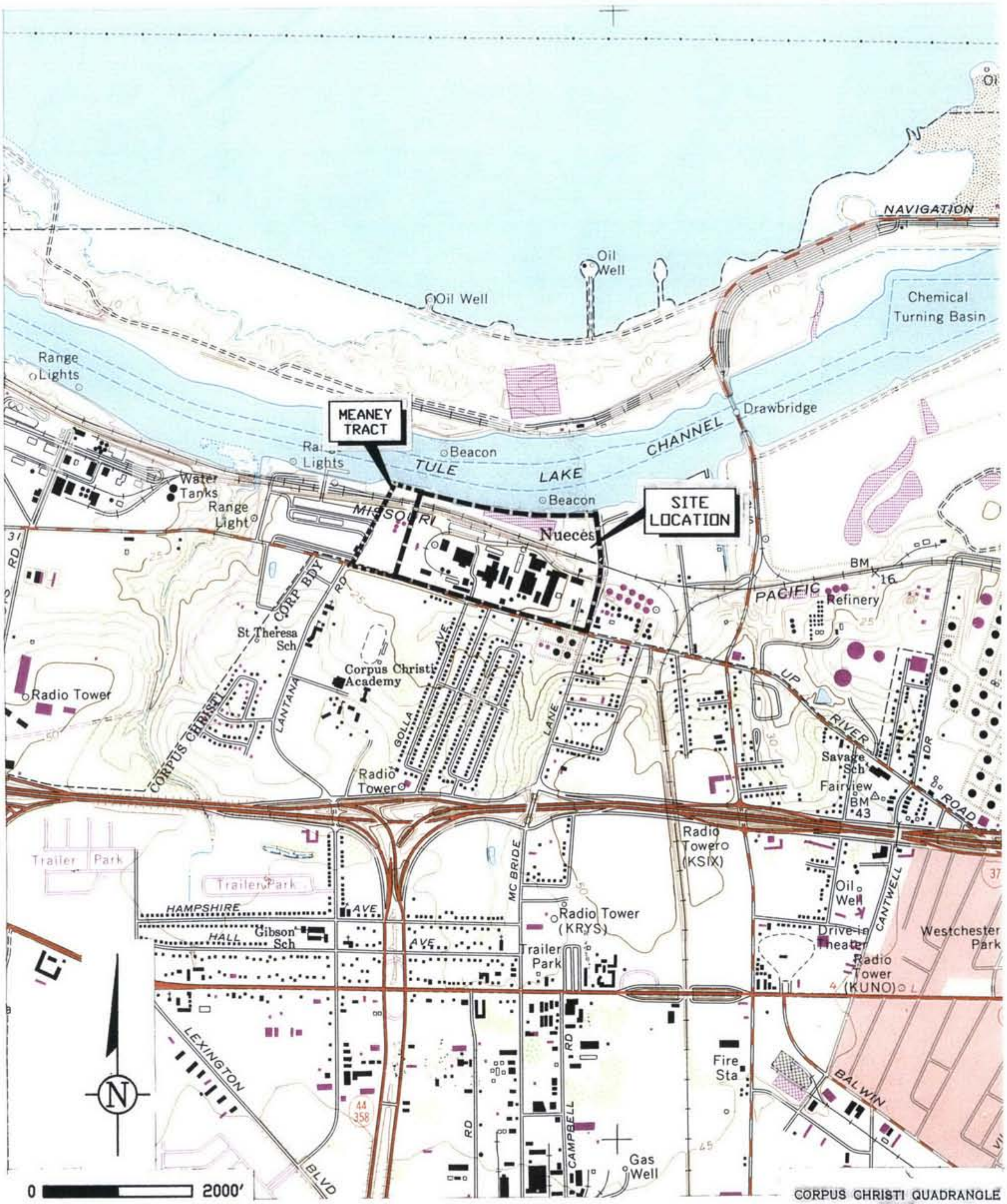
Table 17-7
Refined Scenario Food Web Modeling for Raccoon
Encycle/Texas Inc., Corpus Christi, Texas

Constituent (a)	Surface Soil EPC (mg/kg)	Surface Water EPC (mg/L)	Sediment EPC (mg/kg)	Bioaccumulation Factors (BAF)			Estimated Tissue Concentrations (b)			Receptor Refined Estimated Dietary Dose (c) (mg/kg-BW-day)	NOAEL Toxicity Reference Values (mg/kg-BW-day)	Refined Scenario NOAEL HQ (d)	Does NOAEL HQ Exceed 1?	LOAEL Toxicity Reference Value (mg/kg-BW-day)	Refined Scenario LOAEL HQ (d)	Does LOAEL HQ Exceed 1?
				Invertebrate BCFi	Vegetation BCFv	Fish BCFf	Invertebrate (mg/kg)	Vegetation (mg/kg)	Fish (mg/kg)							
Cadmium	220	0.0025	42	0.96	0.11	907	211	24	2.3	1.2	0.70	**2**	Yes	7.0	**0.2**	No
Chromium	94	NA	NA	0.01	0.002	NA	0.9	0.1	NA	0.01	2,260	**0.000002**	No	-	-	-
Chromium	94	NA	NA	0.01	0.002	NA	1.4	0.2	NA	0.01	2.7	**0.003**	No	-	-	-
Copper	1,500	0.04	450	0.04	0.08	710	60	120	28	1.2	6.0	**0.2**	No	-	-	-
Lead	1,900	0.005	680	0.03	0.01	0.09	57	17	0.0005	0.5	6.5	**0.08**	No	-	-	-
Mercury	3.4	0.001	1.60	0.22	0.18	11,168	0.7	0.6	11.2	0.015	9.4	**0.002**	No	-	-	-
Nickel	200	0.07	39	0.02	0.01	78	4.0	2.4	5.5	0.0	33	**0.001**	No	-	-	-
Selenium	14	0.005	2.6	0.22	0.01	129	3.1	0.1	0.6	0.0	0.2	**0.1**	No	-	-	-
Thallium	2.3	0.001	0.9	0.22	0.001	10,000	0.5	0.00	10	0.01	0.01	**1**	No	-	-	-
Zinc	13,000	0.11	6000	0.56	0.30	2,059	7,280	3,900	226	62	131	**0.5**	No	-	-	-

Notes:

EPC — Exposure Point Concentration, equal to the arithmetic mean.
BAF — Bioaccumlation Factor (unitless); BAF = (Tissue Concentration)/(Media Concentration). BCFs identified in Table 15-2.
LOAEL — Lowest observed adverse effects level.
TRV — Toxicity Reference Value.
mg/kg — Milligrams per kilogram.
mg/L — Milligrams per liter.
mg/kg-BW-day — Milligrams per kilogram of body weight each day.
NA — Not Analyzed in surface water or sediment.
NOAEL — No observed adverse effects level.
(a) Only those constituents identified as bioaccumulative COPECs are included.
(b) Estimated Tissue Concentration = Cs * BCFi, Cs * BCFv, and Cw * BCFf; where Cs=soil concentration and Cw=surface water concentration.
(c) Dose = [((Ci x Pi x IRf) + (Cv x Pv x IRf) + (Cf x Pf x IRf) +(Cs x IRs)) x AUF]/BW.Where Ci= estimated invertebrate tissue concentration, Pi=proportion of diet consisting of invertebrates, IRf=food ingestion rate, Cv=estimated plant tissue concentration, Pv=proportion of diet consisting of plants, Cf=estimated fish tissue concentration, Pf=proportion of diet consisting of fish, Cs=sediment concentration, IRs=ingestion rate of sediment, AUF=area use factor, BW=body weight.
(d) Hazard quotient (HQ) = (Dose)/(TRV); LOAEL HQs were calculated only for those chemicals whose NOAEL HQ exceeded 1.0.

FIGURES



CORPUS CHRISTI QUADRANGLE
TEXAS
7.5 MINUTE SERIES (TOPOGRAPHIC)
SW/4 CORPUS CHRISTI 15' QUADRANGLE

ARCADIS

SITE LOCATION MAP

ENCYCLE/TEXAS, INC.
CORPUS CHRISTI, TEXAS

FIGURE

2-1

DRAFTER:
APPROVED:
CHECKED:
DRAWING:
PRJCT NO.: CC00642.001 | FILE:
DWG DATE:

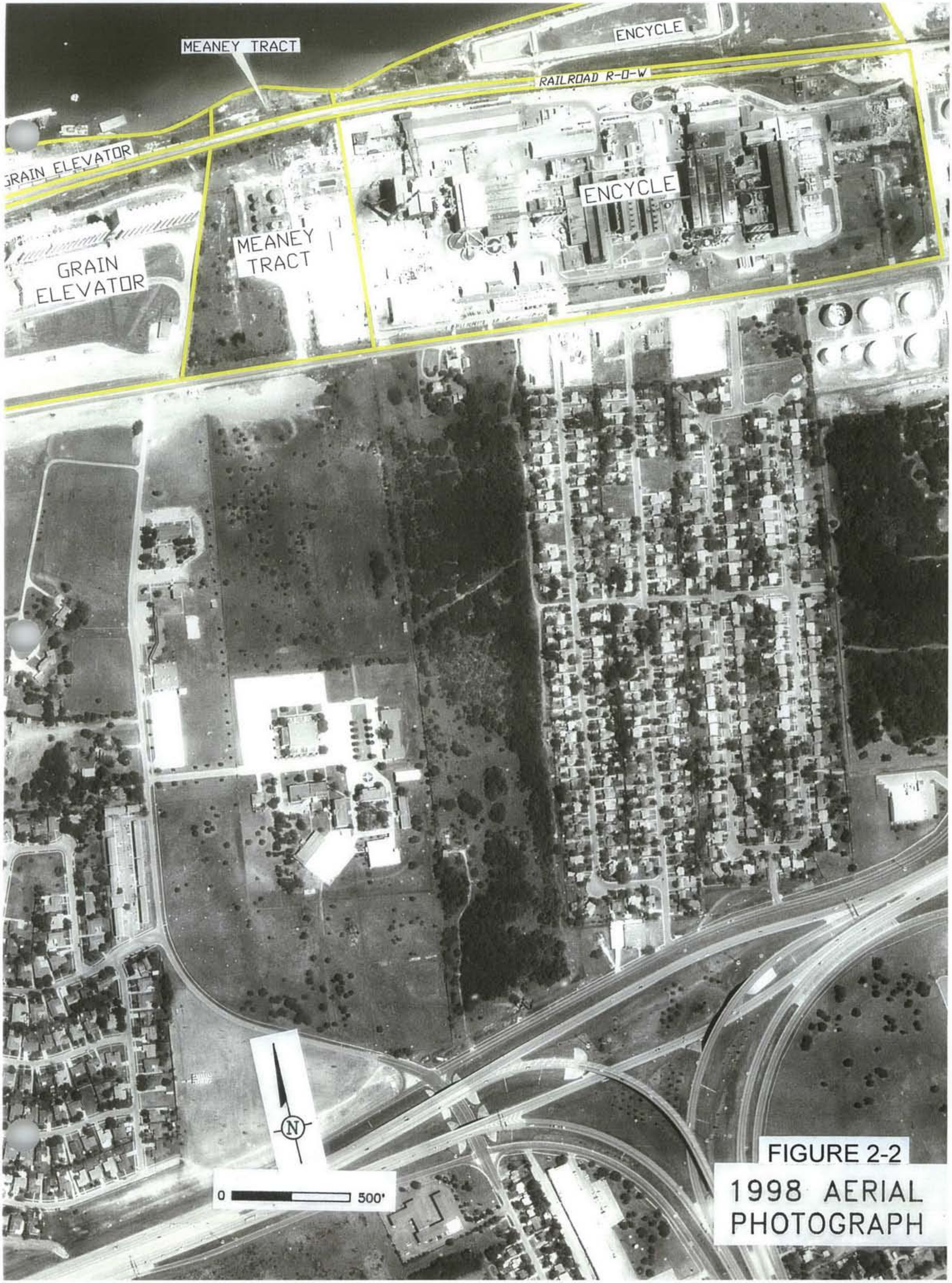
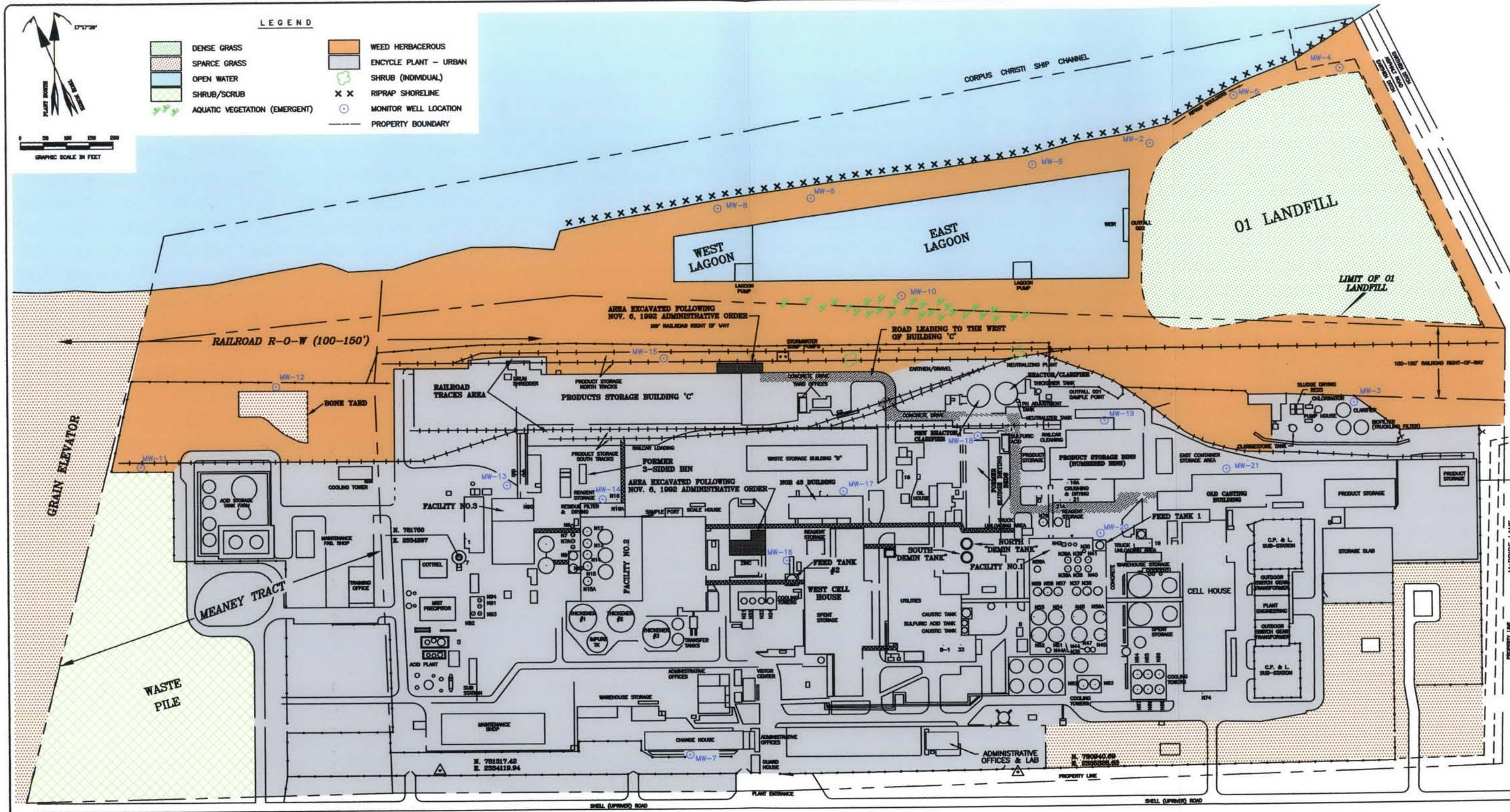


FIGURE 2-2
1998 AERIAL PHOTOGRAPH



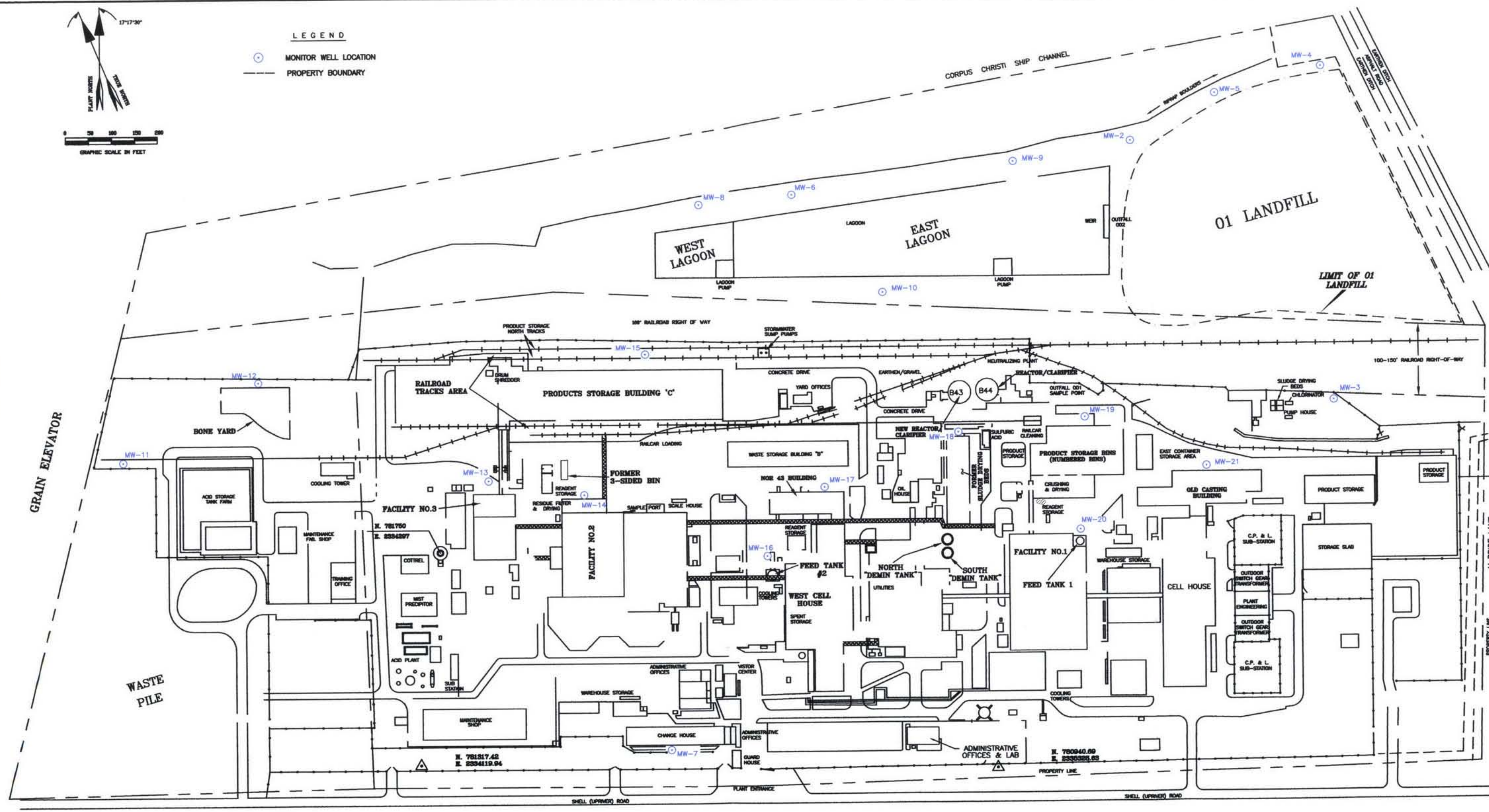
SCALE VERIFICATION	REV. NO.	DATE	DESCRIPTION	BY	APPR.	PROJECT NO.: / DRAWING: LAND COVER	FILE NO: / PLOT SIZE: 1=1200
THIS BAR REPRESENTS ONE INCH ON THE ORIGINAL DRAWING: USE TO VERIFY FIGURE REPRODUCTION SCALE						DRAFTED BY: / CHECKED BY: / APPROVED BY:	DATE: / DATE: / DATE:

ARCADIS

LAND COVER MAP

ENCYCLE/TEXAS, INC.
CORPUS CHRISTI, TEXAS

FIGURE 2-3



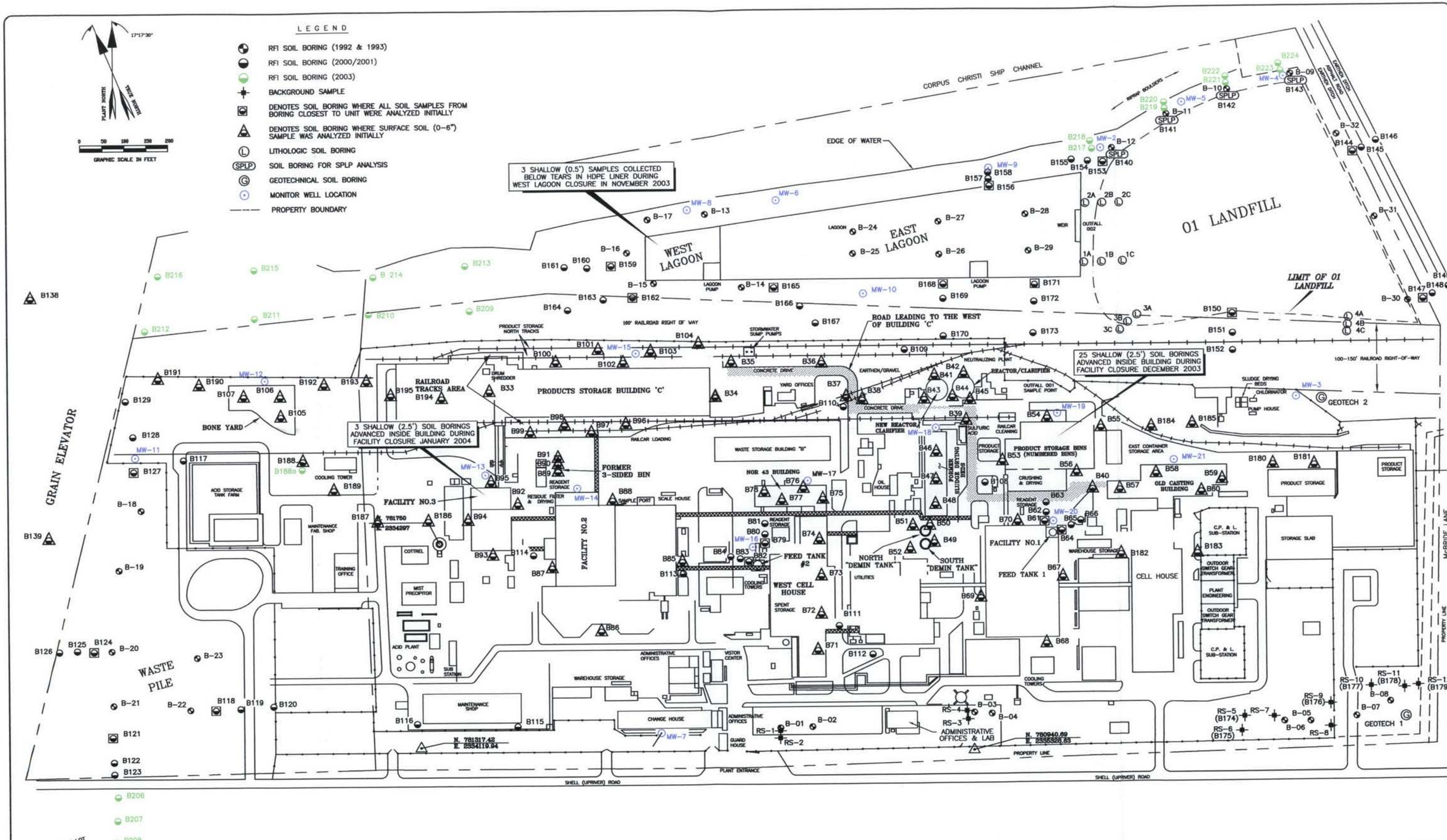
SCALE VERIFICATION	REV. NO.	DATE	DESCRIPTION	BY	APPR.		
THIS BAR REPRESENTS ONE INCH ON THE ORIGINAL DRAWING: USE TO VERIFY FIGURE REPRODUCTION SCALE						PROJECT NO.: [illegible]	FILE NO:
						DRAWING: [illegible]	PLOT SIZE: 1=1200
						DRAFTED BY:	DATE: 25MAR04
						CHECKED BY:	DATE:
						APPROVED BY:	DATE:

ARCADIS

MONITOR WELL LOCATION MAP

ENCYCLE/TEXAS, INC.
CORPUS CHRISTI, TEXAS

FIGURE 4-1



SCALE VERIFICATION	REV. NO.	DATE	DESCRIPTION	BY	APPR.
THIS BAR REPRESENTS ONE INCH ON THE ORIGINAL DRAWING: USE TO VERIFY FIGURE REPRODUCTION SCALE					

PROJECT NO.: C0000642.0001	FILE NO:
DRAWING: 3-BOR-LOC3-04	PLOT SIZE: 1=1200
DRAFTED BY:	DATE:
CHECKED BY:	DATE:
APPROVED BY:	DATE:

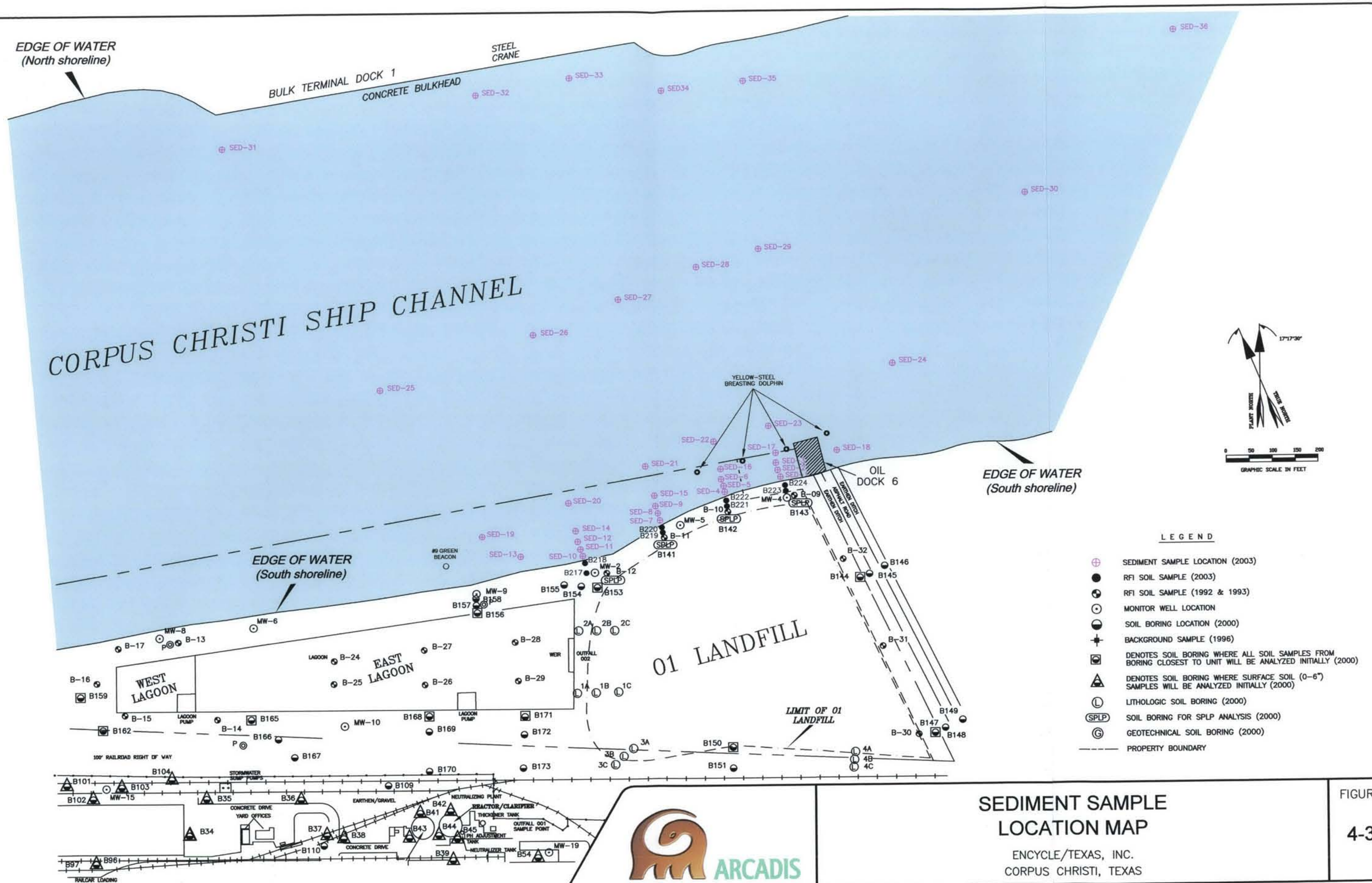
ARCADIS

SOIL BORING LOCATION MAP

UPDATED MARCH 2004

ENCYCLE/TEXAS, INC.
CORPUS CHRISTI, TEXAS

FIGURE 4-2



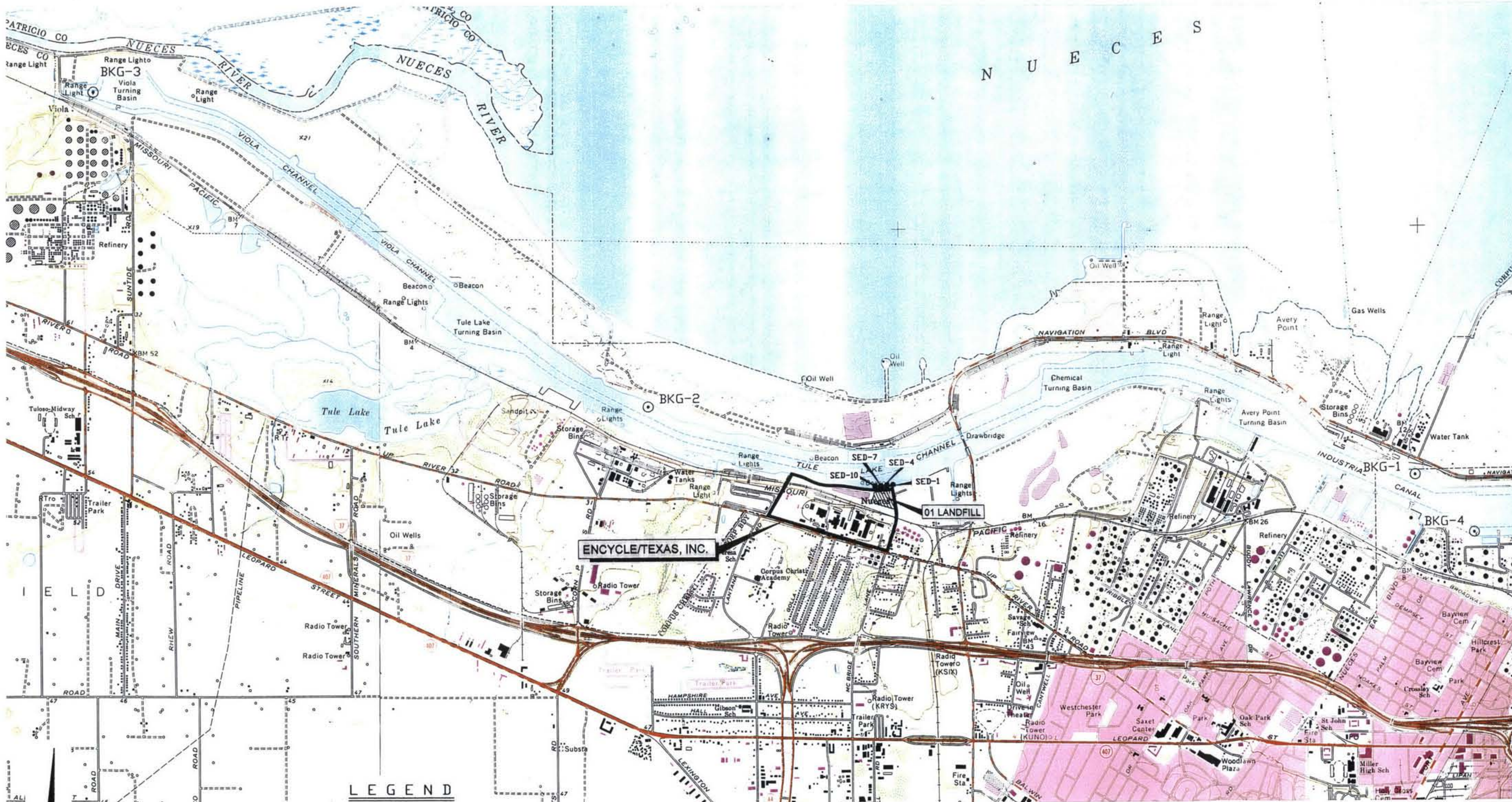
ARCADIS

SEDIMENT SAMPLE LOCATION MAP

ENCYCLE/TEXAS, INC.
CORPUS CHRISTI, TEXAS

FIGURE 4-3

DWG DATE: 24NOV03 | PRJCT NO.: CC000878.0001 | FILE: | DRAWING: SEDI-SAMPs | CHECKED: K. BRANDNER | APPROVED: K. BRANDNER | DRAFTER: LGF



LEGEND

BKG-1 ⊙ BACKGROUND SURFACE WATER SAMPLE LOCATION (FEBRUARY 16, 2004)

SED-1 ● SURFACE WATER SAMPLE LOCATION (February 16, 2004) AND PORE WATER SAMPLE LOCATION (January 30, 2004)

0 2666'

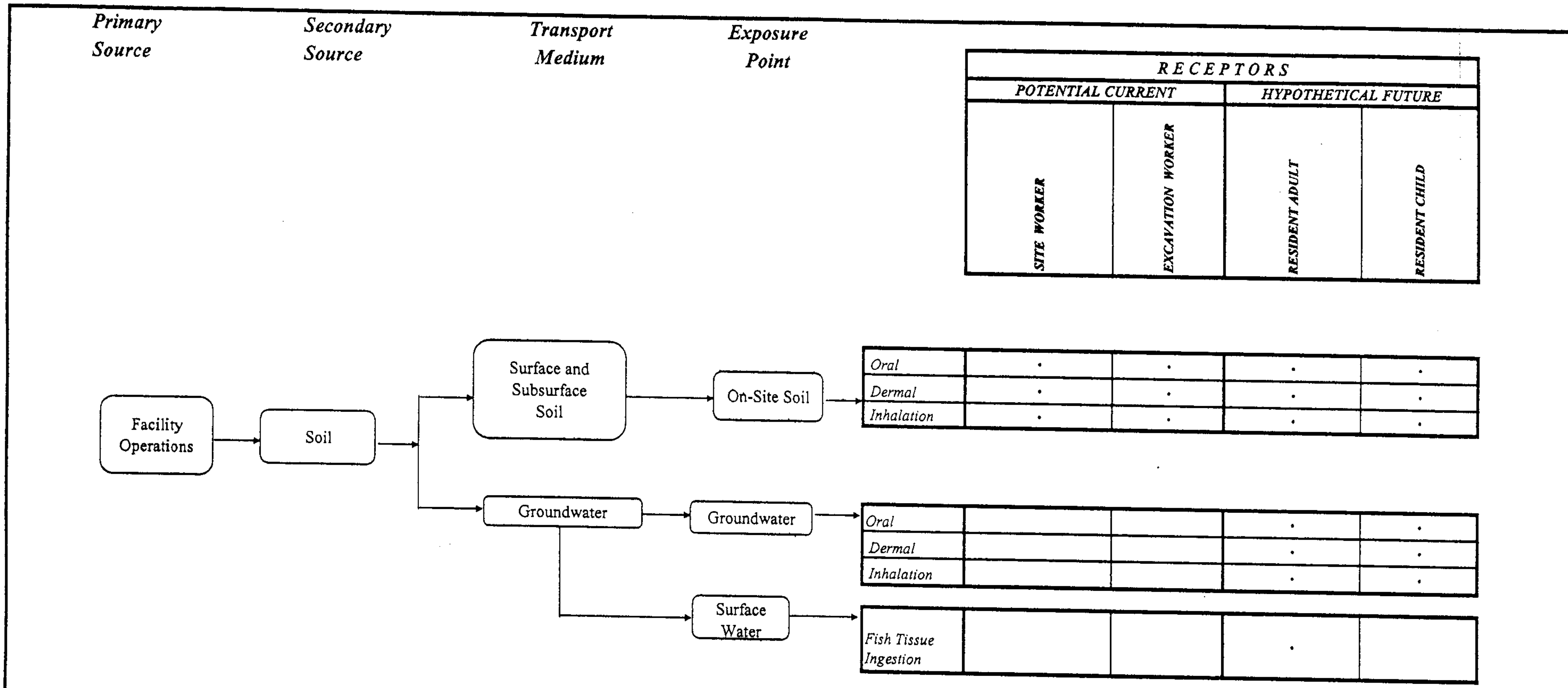
ARCADIS

SURFACE WATER AND PORE WATER SAMPLE LOCATION MAP

ENCYCLE/TEXAS, INC.
CORPUS CHRISTI, TEXAS

FIGURE 4-4

DWG DATE: | PRJCT NO.: CC000878.0001 | FILE: | DRAWING: WTR-SAMP-TOP | CHECKED: K. BRANDNER | APPROVED: K. BRANDNER | DRAFTER:

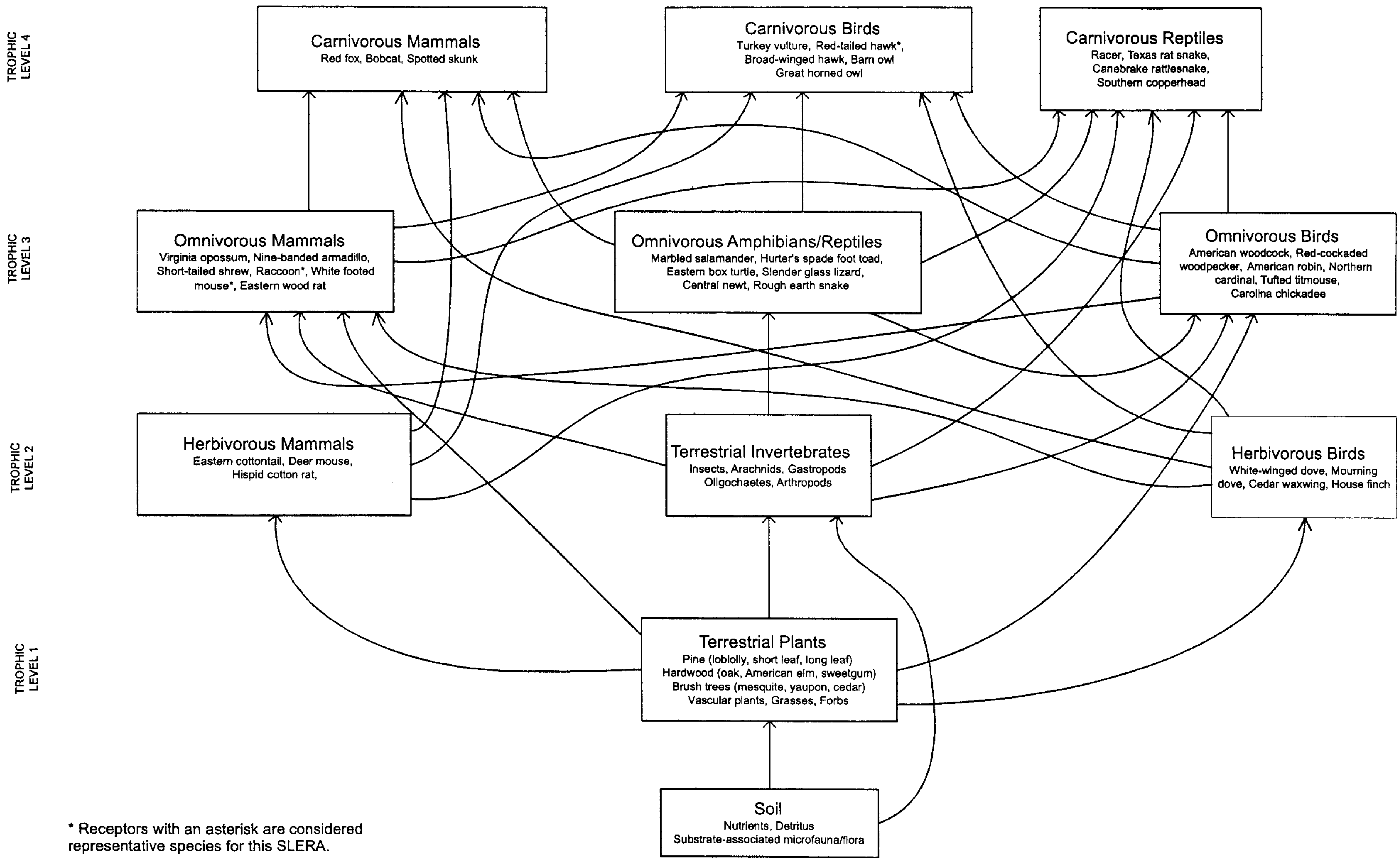


ARCADIS G&M

CONCEPTUAL SITE MODEL FOR
POTENTIAL HUMAN EXPOSURE - Encycle/Texas, Inc.
Corpus Christi, Texas

FIGURE
5-1

CC000878.0001

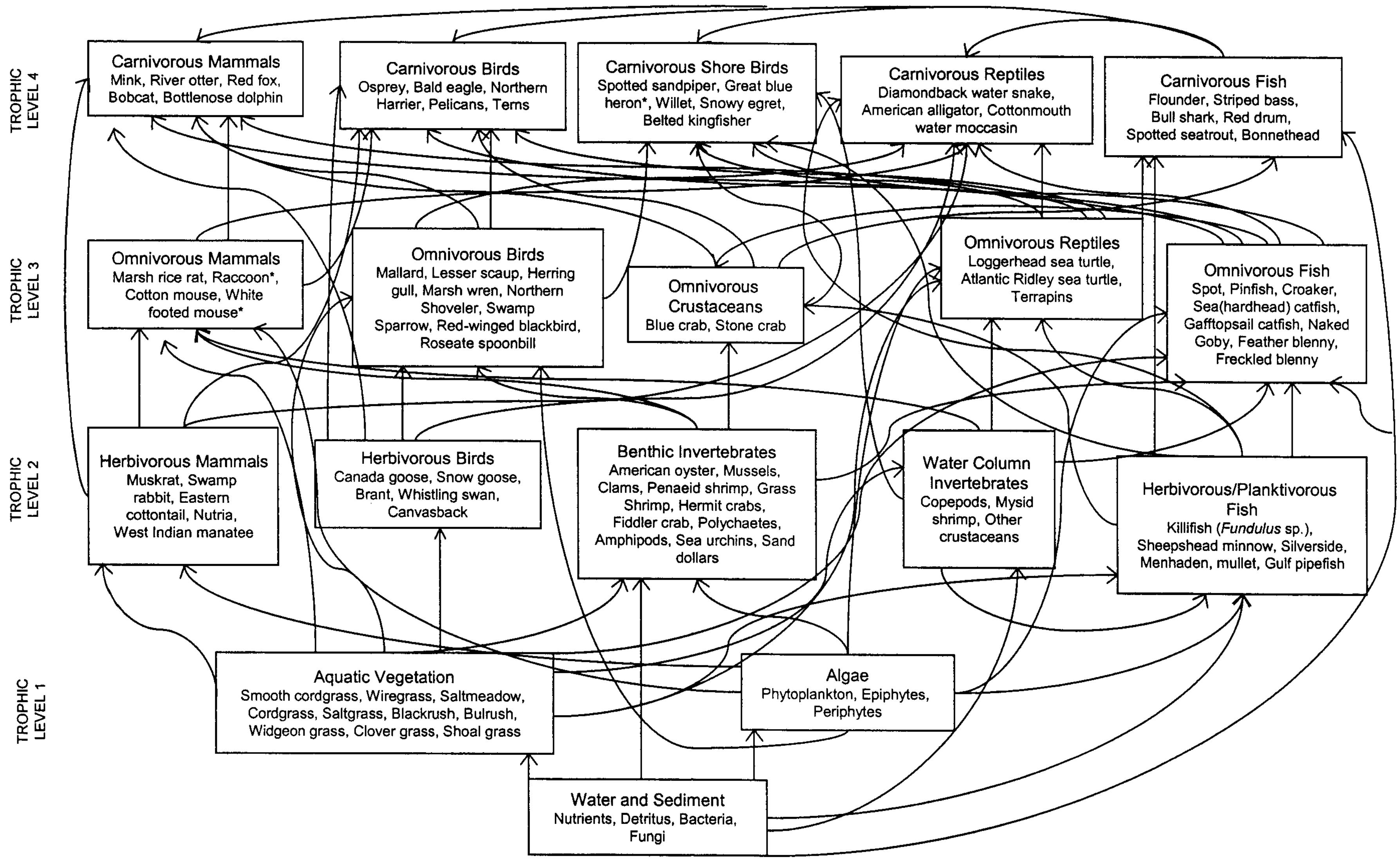


* Receptors with an asterisk are considered representative species for this SLERA.

FIGURE 12-1.Terrestrial Conceptual Food Web.
Screening-Level Ecological Risk Assessment.
Encycle/Texas, Inc., Corpus Christi, Texas.

EncycleFood Webs-terr.pdf
Revision Date 3/17/2004

ARCADIS G&M
Houston, Texas



*Receptor with an asterisk are considered representative species for this SLERA.

FIGURE 12-2. Aquatic Conceptual Food Web.
Screening-Level Ecological Risk Assessment.
Encycle/Texas, Inc., Corpus Christi, Texas.

EncycleWebs-aqu.pdf
Revision Date 2/10/2004

ARCADIS G&M
Houston, Texas

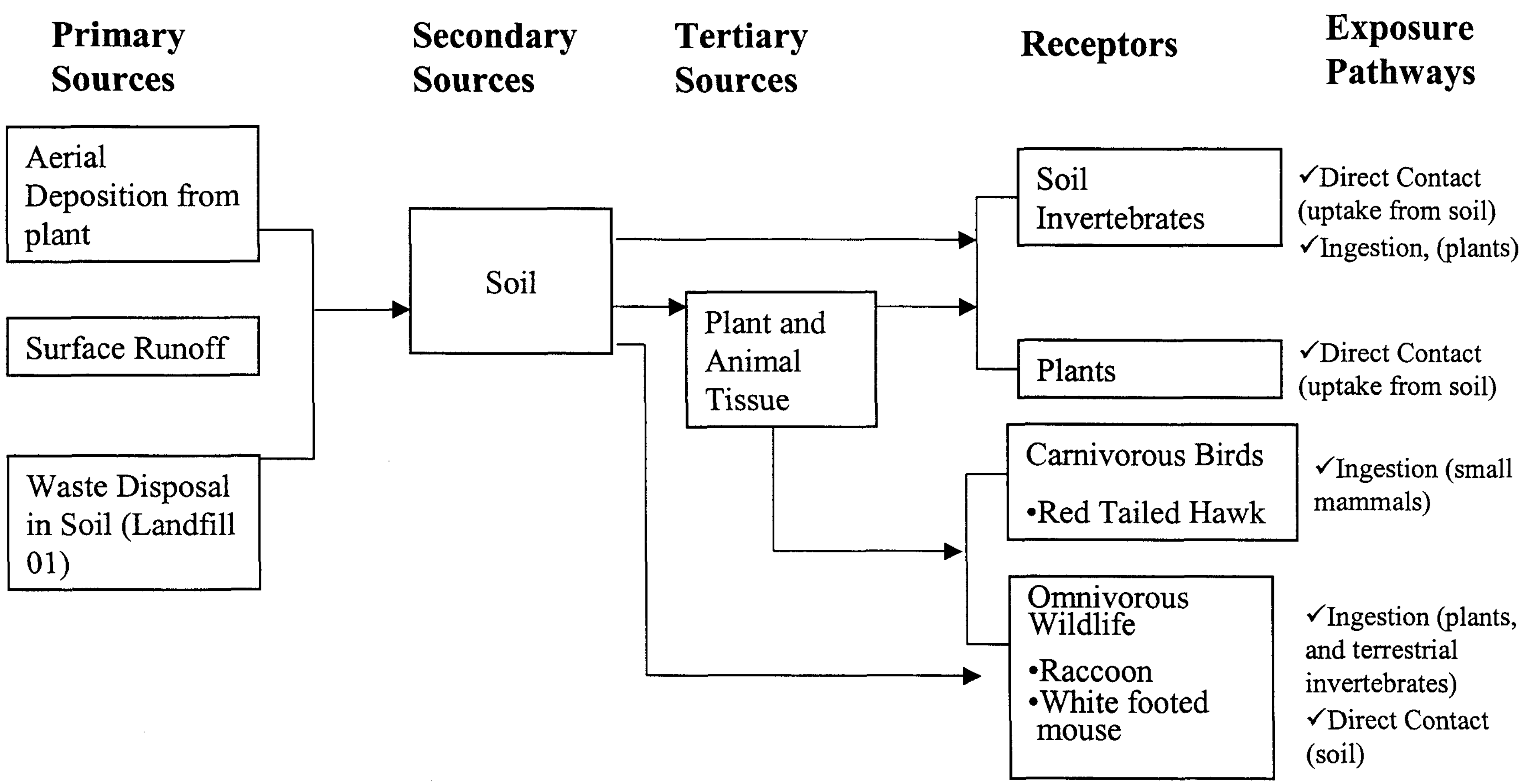


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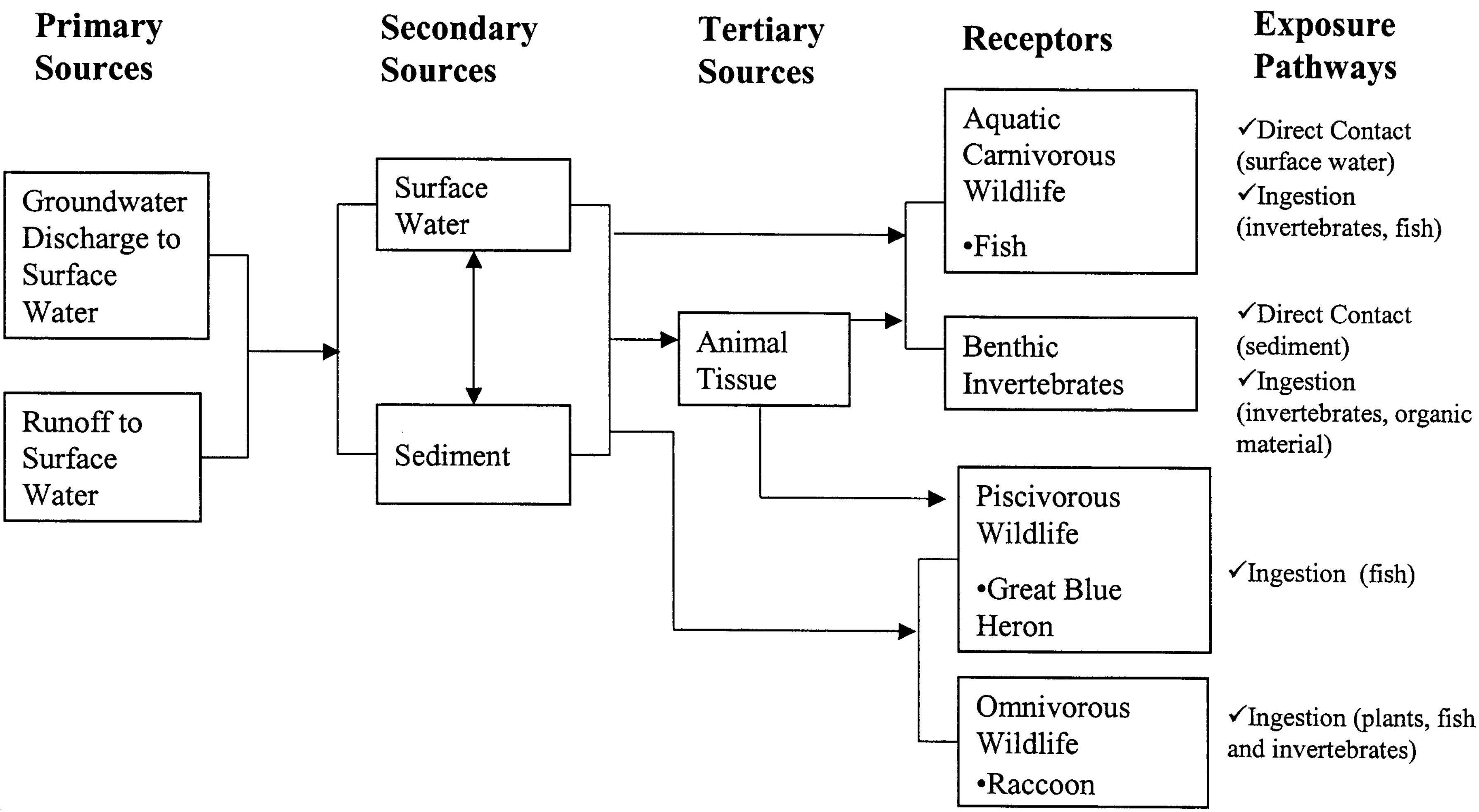
Figure 13-1. Terrestrial Ecological Conceptual Site Model, Encycle/Texas, Inc., Corpus Christi, Texas.



ARCADIS G&M

Figure 13-2. Aquatic Ecological Conceptual Site Model, Encycle/Texas, Inc., Corpus Christi, Texas.