The electronic version of this file/report should have the file name:

Type of document.Spill Number.Year-Month.File *Year-Year* or Report name.pdf

letter.__________.______-_____.File spillfile.pdf

report.hw907014.1991-05-01.SCREENING METHODOLOGY.pdf

Project Site numbers will be proceeded by the following:

Municipal Brownfields - b
Superfund - hw
Spills - sp
ERP - e
VCP - v
BCP - c

non-releasable - put .nf.pdf
Example: letter.sp9875693.1998-01.Filespillfile.nf.pdf

A SCREENING METHODOLOGY TO EVALUATE HSL DATA FROM SOIL AND GROUND WATER SAMPLES COLLECTED AT TENNESSEE GAS PIPELINE COMPANY COMPRESSOR STATIONS

Prepared for

Tennessee Gas Pipeline Company
Houston, Texas

Prepared by

ENVIRON Corporation
Princeton, New Jersey

May 1991

CONTENTS

Page

I. INTRODUCTION 1
  A. Background and Purpose 1
  B. General Principles of Screening Methodology 2

II. METHODOLOGY FOR EVALUATING HSLs IN SOIL 4
  A. Introduction 4
  B. Screening Methodology 6
    1. Exclusion of Non-Industrial Elements 6
    2. Comparison of Metal Concentrations to Regional/Local Background Levels 6
    3. Comparison of Measured Pesticide Levels to Other Reported Residue Levels 6
    4. Comparison to USEPA-Proposed Subpart S Soil Levels 6
    5. Modeling of Potential for Leaching to Ground Water, and Comparison to Federal/State Water Standards/USEPA-Proposed Subpart S Levels 7
      a) Modeling of Potential for Leaching to Ground Water 8
      b) Comparison of Modeled Ground Water Concentrations to MCLs or USEPA-Proposed Subpart S Levels 11
    6. Comparison to Benchmark Concentrations 12
      a) Soil Benchmarks 12
      b) Ground Water Benchmarks 17
      c) Evaluation of HSLs with No USEPA-Established Toxicity Values 17
    7. Sample-Specific Analysis 22
      a) Sample-Specific Evaluation Criteria 22
      b) Samples to Be Further Evaluated 25

III. METHODOLOGY FOR EVALUATING HSLs IN GROUND WATER 26
  A. Introduction 26
  B. Screening Methodology 26
    1. Exclusion of Non-Industrial Elements 26
    2. Comparison of HSL Concentrations to Site-Specific Background 26
    3. Comparison to Federal/State Drinking Water Standards or USEPA-Proposed Subpart S Levels 28
    4. Comparison to Benchmark Concentrations 28
    5. Sample-Specific Analysis 29
      a) Sample-Specific Evaluation Criteria 29
      b)Samples to Be Further Evaluated 30

REFERENCES 31

CONTENTS
(Continued)

Page

TABLES

Table 1: Assumptions for Hypothetical Exposures Used to Derive Benchmark Concentrations 16
Table 2: HSLs Identified at TGPL Sites for which USEPA Toxicity Values Have Not Been Published 18
Table 3: Toxicity Values for Constituents or Surrogates Based on USEPA Methodology 19

FIGURES

Figure 1: Procedure for Evaluating HSLs in Soil 5
Figure 2: Procedure for Evaluating HSLs in Ground Water 27

APPENDICES

Appendix I: Metal Background Concentrations in Soil
Appendix II: HSL Substances and Regulatory Criteria for Screening
Appendix III: Modeling of Hypothetical Airborne Concentrations
Appendix IV: Derivation of Toxicity Values for HSLs without USEPA-published Toxicity Values
Appendix V: Derivation of Benchmark Concentrations
Appendix VI: USEPA Methodology for Derivation of Subpart S Levels

I. INTRODUCTION

A. Background and Purpose

Tennessee Gas Pipeline Company (TGPL) owns and operates a natural gas pipeline system which runs from southern Texas to New England. Compressor stations are located at intervals along the pipeline to restore losses in pipeline pressure resulting from user demand and friction as the gas passes through the pipeline. The main components present at these compressor stations are the gas compressor engines, which are either reciprocating or turbine engines. The reciprocating gas compressor engines are started with compressed air from on-site compressed air systems comprised of air compressors, compressed air storage tanks and associated piping. In the course of normal operations, small amounts of air compressor lubricant may become entrained in the compressed air stream.

Historically, TGPL used Pydraul, a lubricating oil containing polychlorinated biphenyls (PCBs), in the starting air compressors at its gas compressor stations. In 1974 TGPL stopped purchasing Pydraul. In some cases, residual amounts of PCBs from historical use of Pydraul remain in the starting air compressors and the associated air system. Residual PCBs have also been found in the drainage systems and in soil at some TGPL compressor stations as a result of historical releases of condensate from the starting air system. This practice has since been discontinued and condensate is presently collected in drums for disposal by incineration.

TGPL has undertaken an extensive project to investigate and remediate PCBs as necessary at its compressor stations. The first step involves the characterization of the extent of any PCBs that may be present at these stations. As part of the site characterization activities, TGPL decided to include the analysis of samples for other substances on EPA's Hazardous Substance List (HSLs), as defined in the U.S. Environmental Protection Agency's (USEPA) Superfund Contract Laboratory Program (see Appendix II for a complete list of HSLs). Since TGPL compressor stations are designed specifically for the transmission of natural gas and are not industrial production or manufacturing facilities, HSLs are not widely used at these facilities. The use or presence of HSLs at these sites would result from ancillary operational or maintenance activities, or from activities of adjacent property owners. However, to ensure that the site characterization activities undertaken were comprehensive and that any investigation and remediation activities could be done in conjunction with the PCB investigation/remediation efforts to the extent practicable, analysis for a broad range of HSL substances was performed. HSL sampling was conducted at TGPL gas compressor stations as described in station-specific site-characterization plans.

This document presents an HSL screening methodology which is designed to evaluate soil and ground water HSL data collected at each compressor station. The intent of this screening methodology is to identify those HSL sampling locations where additional characterization of the vertical and lateral extent of HSLs may be conducted, and, where indicated, to determine appropriate remedies.

B. General Principles of Screening Methodology

The HSL screening methodology was designed to provide an efficient means of evaluating soil and ground water HSL data from TGPL sites. In developing this screening process, a number of assumptions typically utilized by various regulatory agencies in carrying out their statutory responsibilities have been used, and various toxicity values promulgated by those agencies have been cited. The validity of those assumptions or those values is not addressed in this document, and the use of those assumptions or values as part of this screening methodology does not imply endorsement of such approaches. TGPL has elsewhere expressed serious reservations about the validity of such regulatory approaches and the extent of their applicability in the assessment of human risk.

Data for soils and ground water are evaluated separately, as described in Sections II and III of this report, respectively. In general, the HSL screening methodology involves sequential, hierarchical comparisons of site sampling data to various screening criteria, based upon background concentrations, regulatory standards, or benchmark concentrations derived from hypothetical exposure scenarios based upon general knowledge of the fuel storage and transmission industry. While the overall approach is intended for system-wide application, it may be modified where necessary to address agency-specific differences and site-specific factors. Sampling data that fall below a particular screening criterion concentration are considered not to warrant further evaluation. Sampling data that pass through or remain proceed to the next screening level. Samples that pass through all the general screening criteria are then evaluated on a sample-specific basis to determine whether additional site characterization and possible remediation are warranted. Because an individual sample may contain more than one HSL constituent, each constituent detected in a given sample is screened separately. Thus, the same sample may pass through different levels of the screen for different constituents being evaluated.

Prior to being screened, HSL data for compressor stations are subjected to a quality assurance/quality control check, to ensure that constituent concentrations reflecting laboratory artifacts or sampling errors are eliminated from the screening evaluation. Any constituents detected in compressor station HSL samples that also were detected in associated field blanks are evaluated according to the Quality Assurance/Quality Control (QA/QC) criteria outlined in USEPA's *Risk Assessment Guidance for Superfund* (1989d).

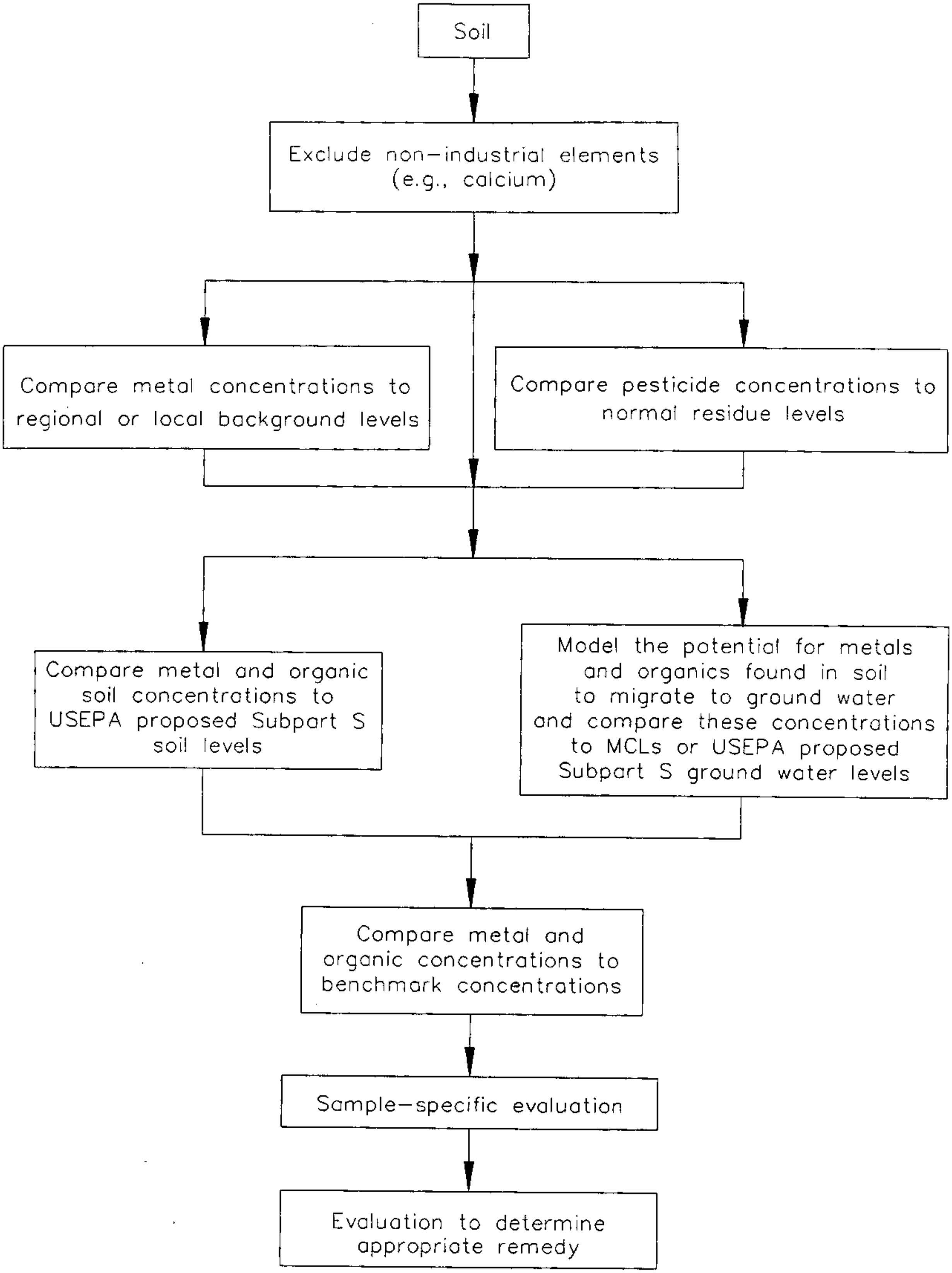
II. METHODOLOGY FOR EVALUATING HSLs IN SOIL

A. Introduction

The screening methodology for HSL soil data involves a sequential comparison of sampling data to a series of screening criteria. Constituents present below a particular screening criterion concentration are considered not to warrant further evaluation; data exceeding the criterion proceed to the next screening level. The initial screening evaluation of HSL soil concentrations includes the following steps: initial screen to exclude non-industrial elements; followed by comparison of metal concentrations to regional/local background levels; and comparison of measured pesticide concentrations to other reported residue levels. Samples that exceed these screening criteria are next evaluated in two parallel steps. The first step includes comparison to USEPA's proposed soil levels developed under the proposed RCRA Corrective Action Program, 40 CFR 264 Subpart S (Subpart S), and to benchmark concentrations based on hypothetical exposure scenarios. The proposed Subpart S soil levels are employed here as guidance in the screening evaluation of HSLs. However, their use in the screening process does not imply endorsement of the principles or procedures set forth in the proposed Corrective Action Program for RCRA sites.

In the second step, the potential impact on ground water is evaluated using a leaching model to estimate maximum potential HSL concentrations in ground water. These estimated concentrations are then compared to state or federal drinking water standards, or, if no standards have been promulgated or proposed, to ground water levels proposed by USEPA under Subpart S.

Samples that pass through all of the above-described screening criteria are then evaluated on a sample-specific basis to determine whether additional action is warranted. The methodology used for evaluating soil data is described more fully below and shown schematically in Figure 1.



F:\021031c\1031c07

ENVIRON
Counsel in Health and Environmental Science

PROCEDURE FOR
EVALUATING HSLS IN SOIL

Figure
1

B. Screening Methodology

1. Exclusion of Non-Industrial Elements

Some substances on the HSL list are naturally occurring elements in the earth's crust. They are ubiquitous and non-industrial in origin. Their presence in soil is to be expected, and does not trigger the need for further characterization or evaluation. These substances include aluminum, calcium, iron, magnesium, potassium and sodium.

2. Comparison of Metal Concentrations to Regional/Local Background Levels

Metal HSL data collected from compressor stations within a given state are compared to the range of available county-specific or state-specific background values reported in the literature for that state. In those instances, if any, where local/statewide data are not available or are insufficient, a comparison is made to ranges established for the eastern U.S. (Shacklette and Boerngen 1984). Background concentrations for the eastern U.S. used in the HSL screen are shown in Appendix I.

3. Comparison of Measured Pesticide Levels to Other Reported Residue Levels

Pesticides may be present at TGPL sites as a result of use in routine grounds maintenance on TGPL property or from use by adjacent property owners for weed or pest control. Measured pesticide concentrations are compared to other reported residue levels in soil, as identified from a search of the scientific literature and pesticide data bases. Pesticide constituents that exceed these residue levels are continued into the next level of the HSL screen for evaluation.

4. Comparison to USEPA-Proposed Subpart S Soil Levels

Proposed Resource Conservation and Recovery Act (RCRA) Corrective Action Regulations, 40 CFR 264 Subpart S, were published in the *Federal Register* by the USEPA on July 27, 1990 (FR55:30798-30884). The proposed rules present USEPA criteria for determining levels for HSLs that USEPA states represent "...valid, reasonable estimates in media at or below which corrective action is unlikely to be necessary" for soil, air, and water at RCRA sites. These proposed regulations are intended by USEPA to establish the framework for implementing the Corrective Action Program under RCRA, and provide a basis for USEPA's assessment of levels of HSLs present in soil. While directly applicable only to RCRA sites where consideration of potential corrective action is required, USEPA's proposed Subpart S levels are useful guidance in other contexts for evaluating HSL concentrations in soil.

Specific elements of USEPA's proposed approach include the use of conservative assumptions for hypothetical exposures, USEPA toxicity values, and specified levels of theoretical risk established by USEPA. The proposed Subpart S soil levels were based upon the most current published USEPA toxicity values, as well as the USEPA hypothetical exposure scenario for soil ingestion. For substances classified by USEPA as noncarcinogens, USEPA's proposed Subpart S levels are based upon a conservative assumption of hypothetical exposure to a 16-kg child ingesting 0.2 g soil per day over a 5-year exposure period. For USEPA-designated carcinogens, the Agency's proposed Subpart S levels are based upon a conservative assumption of hypothetical exposure to a 70-kg adult ingesting soil at a rate of 0.1 g per day over a 70-year exposure period. These assumptions are overly conservative for application to the fuel storage and transmission industry, where typically the only on-site receptors would be adult workers rather than children; exposure would not continue for 70 years; and any incidental soil ingestion would be expected to be from contact with soil from throughout the worker's areas of operation, not solely from the discrete area containing the HSLs under consideration. USEPA's proposed Subpart S levels are nevertheless included in the screening process because they are conservative, were derived using USEPA methodology and can be used to identify samples to receive further scrutiny.

The levels used by the USEPA for theoretical risks in setting proposed Subpart S soil levels are 1×10^{-6} (one in one million) upper-bound excess risk for USEPA-designated Class A and Class B carcinogens, and 1×10^{-5}(one in 100,000) upper-bound excess risk for USEPA-designated Class C carcinogens. For USEPA-designated noncarcinogens, the Subpart S levels proposed by USEPA are set not to exceed the reference doses (RfDs) established by USEPA for a specific substance.

Soil Subpart S levels for HSLs are listed in Appendix II. Some of these reflect values directly listed in proposed 40 CFR 264 Subpart S. Others were calculated or updated using the stated USEPA regulatory approach (USEPA 1990b) for development of Subpart S levels, which is based upon USEPA's assumption criteria for hypothetical exposures, and current USEPA-published toxicity values available through the Integrated Risk Information System (IRIS) database, or the USEPA quarterly Health Effects Assessment summary tables (USEPA 1990a).

5. Modeling of Potential for Leaching to Ground Water, and Comparison to Federal/State Water Standards/USEPA-Proposed Subpart S Levels

The HSL screen not only directly evaluates soil concentrations (via comparisons to USEPA soil criteria), but also incorporates an evaluation of the potential for HSLs in soil to migrate to ground water. The screen incorporates a leaching model, which provides conservative estimates of hypothetical HSL concentrations that could potentially migrate in ground water. These estimated concentrations are then compared to state drinking water standards, if available, or to federal standards promulgated or proposed under the Safe Drinking Water Act (Maximum Contaminant Levels, or MCLs) or, if no MCLs have been promulgated or proposed for a specific substance, to the ground water levels proposed by the USEPA under Subpart S (USEPA 1990b). The use of MCLs and Subpart S levels as screening criteria is consistent with USEPA guidance provided under both CERCLA and RCRA which refer to cleanup of ground water to MCLs, where available, or to health-based criteria where MCLs are not available (USEPA 1990b, 1988b).

a) Modeling of Potential for Leaching to Ground Water

In order to incorporate into the screen the potential for soil constituents to migrate to ground water, a solution to the transport equation used by USEPA in its *Guidance on Remedial Actions for Superfund Sites with PCB Contamination* (USEPA 1990c) was employed. This solution predicts the potential concentration of leachate at any given soil depth as a function of time.

This basic transport equation simulates advection, dispersion, adsorption and biological decay in one dimension. Although some degree of lateral dispersion (lateral to the vertical flow) will take place, this factor is not incorporated into the equation, such that the results will tend to be a conservative (i.e. higher) approximation of potential concentrations.

The following conservative assumptions were made for screening purposes in selecting the input parameters to the equation:

- A recharge rate of 28.71 inches/year has been assumed for all cases. This is the highest rate of percolation reported in a USEPA (1988c) database over seven of the nine states in which TGPL stations are located. Percolation data for the two remaining states are not available; however, recharge rates at compressor stations in these states are anticipated to be similar to rates in neighboring states based on proximity and similarities in meteorologic conditions.

- A constant value of f_{oc} = 0.0019 has been assumed throughout. f_{oc} values (organic carbon content of soil) were measured at 14 TGPL stations. Although the range of average f_{oc} values at these stations is 0.0019 to 0.0279, the minimum (i.e. most conservative) value was used for screening purposes. This value compares well to the range of 0.001-0.01 presented in USEPA (1986d).

- The depth of the soil layer containing HSLs is assumed to be 2 feet. Actual depth is related to site-specific HSL use and soil conditions; however, 2 feet is considered conservative for screening use, because HSLs are not widely used at TGPL stations, and any presence of HSLs at these sites would be the result of ancillary operational or maintenance activities on-site or activities at neighboring properties.

- Where available, site-specific data are used for determining depth to ground water. When site-specific data are not available, an assumed hypothetical depth to ground water based on regional hydrogeologic information from state or federal geological surveys and other available sources is used.

- Longitudinal dispersivity in the vertical direction is assumed to be 0.1 times the mean travel distance (USEPA 1985a), which in this case is the state-specific depth to ground water, or the assumed depth to ground water based on regional information. This value is a measure of dispersion of HSLs in the direction of flow as they migrate in solution downward from the soil source area.

- Biodegradation rates for HSLs in leachate during downward migration from the soil source area are assumed to be the same as in soils. Half-lives of constituents were established from available literature. Constituents with no reported half-lives were assumed not to degrade. USEPA (1986a) lists half-lives of many substances in soil, water and air. Review of this document suggests that many substances persist longer in soil than water. It was, therefore assumed as a conservative approach for this analysis that degradation rates in leachate are equivalent to the rates in soil.

- It is assumed that the concentration in a monitoring well is diluted 25-fold from the leachate, based on a conservative three-dimensional analytical transport model developed by Yeh (1981), and used by the USEPA (1990c) for long-term remediation of sites containing PCBs.

This model predicts the potential concentration in a monitoring well resulting from leachate infiltration of the saturated zone. Actual water concentrations at a specific site will depend on the following parameters: the velocity (magnitude and direction) of ground water flow; location of the monitoring well; screen length and position; the areal extent of the leachate impact; the leachate arrival rate to the water table; biodegradation; adsorption properties of the soil matrix (K_{oc} {partition coefficient for organic carbon] and f_{oc}), and physical properties of the soil matrix (porosity and bulk density).

Many of these parameters may vary on a site-specific basis over considerable ranges. To keep the possible permutations to a manageable size, conservative assumptions were made about a number of parameters for screening purposes. These assumptions are discussed below:

- In the saturated zone no biodegradation occurs.
- The areal extent of impact of leachate was assumed to be 15 ft x 15 ft (the areal extent to which HSLs are assumed to be present).
- The monitoring well was located at various distances from the center of the source area along the axis of symmetry of the plume.
- The leachate mass loading was arrived at by assuming a steady recharge rate of 28.71 inches/yr with a constituent concentration of C_o over the 15 ft x 15 ft area described above. The 28.71 inches/yr corresponds to the highest rate in a USEPA (1988c) database over seven of the nine states in which TGPL stations are located. The assumption of steady leachate rate is conservative since with source depletion, the actual mass loading will diminish with time and may not attain the asymptotic peak concentration obtained from a steady rate of mass loading.
- The concentration in a monitoring well sample is expected to be an average over the monitoring well screen length. The concentrations of the constituents in the plume decrease with depth. Thus, to capture the highest concentration, a 10 foot screen was assumed to be vertically located at the top 10 feet of the saturated zone.
- In the absence of biodegradation, the effect of adsorption is only to retard the transport process. Adsorption does not lower

concentration, it only delays the process. The simulations were carried out over long periods of time to result in the maximum predicted concentration in the monitoring well.

- The regional ground water velocity may vary substantially from site to site. The USEPA (1986d) quoted a range between 1 m/yr and 100 m/yr. A geometric mean of 10 m/yr was used for establishing dilution, which for this screening purpose is defined as the ratio of the constituent concentration in leachate C_o at arrival (to the water table) to the average concentration in the monitoring well C_{MW}. The geometric mean is biased towards the lower end of the range and will cause a higher concentration in the monitoring well than would the use of the arithmetic average.

The model provides the dilution C_o/C_{mw} for a monitoring well located at various distances. The 25-fold dilution factor obtained for a hypothetical well 50 meters from the center of the source area was used in the screening. This distance is a conservative estimate of the nearest hypothetical off-site receptor, based upon the generally isolated locations of fuel storage and transmission facilities.

b) Comparison of Modeled Ground Water Concentrations to MCLs or USEPA-Proposed Subpart S Levels

MCLs promulgated by the USEPA under the Safe Drinking Water Act are incorporated into the proposed USEPA Subpart S levels, consistent with current RCRA ground water protection standards (USEPA 1990b). Under USEPA's Subpart S, proposed ground water levels are derived for HSLs in the absence of a promulgated MCL. As with soil levels, USEPA's approach to deriving ground water levels includes the following elements: the use of hypothetical exposure assumptions, USEPA toxicity values, and USEPA-established risk levels. Subpart S ground water levels were based on the most current published USEPA toxicity values as well as the USEPA hypothetical exposure scenario for ground water consumption. The specific USEPA assumptions for the hypothetical exposure scenario are a 70-kg adult consuming 2 liters of water per day over a 70-year period. Levels used by USEPA for theoretical risk under proposed Subpart S are upper-bound excess risks of 1 x 10^{-6} for USEPA-designated Class A and Class B carcinogens, and 1 x 10^{-5} for USEPA-designated Class C carcinogens. For USEPA-designated noncarcinogens, the Subpart S level is set by USEPA not to exceed a USEPA-established RfD.

Ground water concentrations predicted from a leaching model are compared to promulgated or proposed federal drinking water standards (as shown in Appendix II), where available, as the next step in the screen. This is consistent with USEPA guidance, provided under both CERCLA and RCRA, for cleanup of ground water that may be a potable water source to MCLs, where available (USEPA 1990b, 1988b), as well as with the USEPA use of MCLs in establishing Subpart S action levels. While directly applicable only to RCRA or CERCLA sites, MCLs may serve as useful guidance in other contexts for evaluating HSL concentrations in ground water. This step of the screen is thus predicated upon the conservative general assumption that the ground water is a potential drinking water source. Samples that exceed MCLs are continued to the next screening step.

For HSLs for which MCLs have not been promulgated or proposed, ground water concentrations predicted from the leaching model are compared to the ground water levels established as part of the USEPA proposed Corrective Action Regulations (40 CFR 264 Subpart S) (FR55:30798-30884). The proposed Subpart S ground water levels for HSLs are shown in Appendix II. Some of these reflect values directly listed in proposed 40 CFR 264 Subpart S. Others were calculated or updated using the stated USEPA regulatory approach (USEPA 1990b) for development of Subpart S levels, which is based upon USEPA's assumption criteria for hypothetical exposures, and current USEPA-published toxicity values available through the Integrated Risk Information System (IRIS) database, or the USEPA quarterly Health Effects Assessment summary tables (USEPA 1990a). Samples that exceed the Subpart S ground water levels are continued to the next step in the screening process.

6. Comparison to Benchmark Concentrations

a) Soil Benchmarks

Benchmark soil concentrations are developed to evaluate those samples that exceed metal background concentrations or reported pesticide residue levels and MCLs/Subpart S levels. A two-step process is used to develop these benchmarks. First, hypothetical exposure scenarios are used to estimate potential exposures to HSL-containing soils via inhalation, dermal absorption and ingestion.

Absorption factors are used to estimate potential doses received through the barriers of the lungs, gastrointestinal tract and skin. In general, the animal studies that usually are the basis of USEPA-published toxicity values report the doses administered to the animals, rather than doses actually absorbed; thus, the resulting USEPA toxicity values are not reflective of actual absorbed doses. Under these circumstances, according to USEPA guidance on risk assessment (USEPA 1989d), when determining doses potentially received via ingestion and inhalation, absorption via the gastrointestinal tract and lungs is assumed to be 100% of the absorption factors encountered in the original studies. Dermal absorption is assumed to be less than that via the gastrointestinal tract or lungs, due to the barrier provided by the skin, and preferential binding of some chemicals to soil. For example, metals, particularly those that are hydrophilic or water soluble, generally do not absorb readily through the skin, which is hydrophobic (Emmett 1986). To be conservative, a 10% dermal absorption factor (relative to gastrointestinal and lung absorption) was assumed, even though a number of HSLs probably have smaller absorption factors.

Other elements of these hypothetical scenarios are based upon general knowledge of work practices in and characteristics of fuel storage and transmission facilities, including the types of activities during which exposure may potentially occur, the potential duration of exposure, and the distance between potential receptors and an HSL source area.

To evaluate the potential inhalation pathway, air concentrations of vapor and particulates are estimated based on soil concentrations. Both particulate and vapor emissions are estimated using USEPA models (USEPA 1985b, 1985c, 1986b). Air concentrations are computed using a modified on-site "box" model and a USEPA off-site dispersion model (USEPA 1987a). To estimate air concentrations on-site, USEPA used a simplified box model approach to estimate on-site air concentrations in the development of advisory levels for PCBs cleanup (USEPA 1986b). A modification of this box model was selected for the HSL screening methodology because of the limitations inherent in the simplified box model, which were acknowledged by USEPA (1986b). The modified box model includes additional factors such as wind shear near the surface, development of plume thickness and atmospheric stability (Li et al. 1990). The box model only provides estimates of air concentrations directly above a source area, and thus it is applicable only for estimation of on-site air concentrations.

The USEPA off-site air dispersion model was developed to estimate potential atmospheric concentrations associated with point, line, area, and volume sources of emissions. It has been reviewed and recommended by the USEPA to calculate chemical concentrations at locations downwind of various emission sources

(USEPA 1986c). Both the on-site box model and off-site dispersion models are discussed in greater detail in Appendix III.

Second, published USEPA chemical-specific toxicity values (USEPA-established carcinogenic slope factors [CSFs] and RfDs) are obtained from the Integrated Risk Information System (IRIS) data base or from USEPA quarterly Health Effects Assessment summary tables. These values are used for screening proposes without an independent review in this document of their validity. To develop hypothetical off-site receptor benchmarks for HSLs for which USEPA-designated CSFs are available, an excess risk level of 1×10^{-6} was employed for USEPA-designated Class A and B carcinogens, and an excess risk level of 1×10^{-5} was used for USEPA-designated Class C carcinogens. These are the levels of theoretical risk used by the USEPA in its Subpart S proposed rule (USEPA 1990b). For on-site workers, an excess risk level of 1×10^{-4} was used for all USEPA-designated Class A, B or C carcinogens. This is within the range of theoretical risks the USEPA utilizes for hazardous waste sites (USEPA 1987b), and is more stringent than the levels that could result from hypothetical exposure of workers to certain USEPA-designated carcinogens at permissible exposure limits (PELs) established by the Occupational Safety and Health Administration (OSHA).

USEPA-established RfDs are used in this document for the hypothetical off-site receptor. However, because USEPA RfDs are usually reduced by a factor of 10 to theoretically account for the broadest individual human variability (USEPA 1989d), USEPA's RfD values have hereby been multiplied by a factor of 10 for application to a healthier, more homogeneous working population. In applying this screening process, it is recognized that occupational exposure limits have been promulgated or proposed by OSHA, ACGIH, AIHA and others. These occupational exposure limits are not intended to be supplanted by the hypothetical short and long-term worker exposure scenarios in the environmental screening process. In fact, the sample-specific analysis discussed below makes reference to such occupational limits where appropriate.

Both short-term and long-term hypothetical soil exposure scenarios are derived for workers based upon general information about work activities at and characteristics of fuel storage and transmission facilities. These hypothetical scenarios are presented below. The resulting soil benchmark concentrations are used in the screening procedure.

- **Hypothetical Short-Term Construction Scenario**
  A hypothetical short-term construction scenario addresses occasional, brief periods when soil might be excavated for maintenance or repairs to underground utilities, or for facility construction. This hypothetical scenario assumes a worker potentially exposed to HSLs while excavating a hypothetical source area 15 feet x 15 feet (approximately 200 square feet) in dimension. Work at the excavation project is assumed to continue for a full 8-hour workday, for 5 days. Potential exposure routes are assumed to consist of inhalation, dermal contact involving the face and 2/3 of upper limbs (assuming the worker is wearing a short-sleeved shirt), and incidental ingestion of HSL-containing soil. Assumptions for hypothetical exposures are shown in Table 1.

- **Hypothetical Long-Term Worker Scenario**
  This hypothetical scenario considers potential exposure to surficial HSLs of a worker walking on a 15 foot x 15 foot source area for 0.5 hours per day in the course of his routine daily activities, for 250 days per year, over a 40-year working period. A half-hour potential exposure period was selected based on assumed tasks routinely performed at fuel storage and transmission facilities. The 40-year working period is based upon a conservative assumption that the work force is very stable. Potential exposure routes are inhalation, dermal contact involving the face and 2/3 of upper limbs, and incidental ingestion of HSL-containing soils. Assumptions for hypothetical exposures are shown in Table 1.

- **Hypothetical Long-Term Off-Site Receptor Scenario**
  In this hypothetical scenario, it is conservatively assumed that a 70-kg adult residing 50 meters downwind of an undisturbed, hypothetical 15 foot x 15 foot source area is potentially exposed for 16.6 hours per day, 350 days per year (USEPA 1991b) over a 30-year period via inhalation of windblown surface soils containing HSLs. USEPA presents 16.6 hours per day as the average amount of time spent engaged in various at-home activities (USEPA 1989a). The hypothetical duration of 30 years is based on USEPA's determination of the 90th percentile length of stay at one residence (USEPA 1989a). A 50-meter distance is a conservative estimate of the nearst residence, based upon the generally isolated locations of fuel storage and transmission facilities. Specific exposure assumptions for hypothetical exposures are shown in Table 1.

TABLE 1
Assumptions for Hypothetical Exposures Used to Derive Benchmark Concentrations

	Hypothetical Worker Short-Term	Hypothetical Worker Long-Term	Hypothetical Off-Site Long-Term Receptor	
			Soil	Drinking Water
Body weight (kg)[a]	70	70	70	70
Days/lifetime[a]	25,550	25,550	25,550	25,550
Hours/day exposed	8[a]	0.5[b]	16.6[c]	NA
Total days exposed[a,b] (days/yr x years)	5 (5[b] x 1[b])	10,000 (250[a] x 40[b])	10,500 (350[a] x 30[a])	10,500 (350[a] x 30[a])
Breathing rate (m^3/hr)	2.5[a]	1.25[d]	0.833[a]	NA
Distance from source (m)[e]	NA	NA	50	NA
Absorption from lungs (%)[f]	100	100	100	NA
Source area soil ingestion rate (mg/d)	480[a]	3.13[a,b]	NA	NA
Water ingestion rate (l/d)[a]	NA	NA	NA	2[a]
Gastrointestinal absorption (%)[f]	100	100	100	100
Body surface area exposed (cm^2)	3,188[b,c]	3,188[b,c]	NA	NA
Soil deposition on skin (kg/cm^2)	1.45×10^{-6}[g]	1.8×10^{-7}[b,g]	NA	NA
Dermal absorption (%)[f]	10	10	NA	NA

References:

[a] USEPA 1991b
[b] ENVIRON estimate
[c] USEPA 1989a
[d] USEPA 1986a, ICRP 1975, NIOSH 1991
[e] Based on the generally isolated locations of fuel storage and transmission facilities.
[f] Based on guidance from USEPA (1989d) regarding gastrointestinal and lung absorption, and information from Emmett (1986) regarding dermal absorption in general, relative to gastrointestinal and lung absorption. A number of HSLs probably have a smaller absorption factor.
[g] USEPA 1989d

b) Ground Water Benchmarks

To evaluate those samples where estimated leachate concentrations exceed state- or USEPA-established or proposed drinking water standards or USEPA-proposed Subpart S levels, ground water benchmark concentrations are developed. The benchmark concentrations are developed using a two-step process: first, a conservative hypothetical exposure scenario is developed; second, USEPA substance-specific toxicity values (USEPA-established CSFs and RfDs) are used for screening purposes without independent review in this document of their validity. A long-term potential exposure scenario has been conservatively selected as the basis for developing the ground water benchmark concentrations. This scenario hypothetically assumes that a 70-kg adult residing near a TGPL compressor station uses ground water as a drinking water source. Assumptions for hypothetical exposures are shown in Table 1.

c) Evaluation of HSLs with No USEPA-Established Toxicity Values

Of the 137 HSLs included in the screen, 27 have no USEPA toxicity values published either in the IRIS data base or in the USEPA quarterly Health Effects Assessment summary tables. The procedures described below (based on USEPA methodology) could be applied for screening purposes to evaluate all these substances for which no USEPA toxicity values are published; however, of those 27 substances only the 9 substances listed in Table 2 have actually been detected to date.

Samples containing these constituents are evaluated based on the toxicity values derived using USEPA methodology; or if insufficient information is available for the constituent, on toxicity values derived for usable structurally similar substances (surrogates).

For 2 of the 9 substances on Table 2 (2-methylnaphthalene and 1,3-dichlorobenzene), USEPA-published toxicity values are available for structurally similar substances. The toxicity values (acceptable daily intakes, or ADIs) for these surrogates are shown on Table 3. USEPA RfDs are usually reduced by a factor of 10 to theoretically account for the broadest individual human variability (USEPA 1989d); these toxicity values have for this screen been multiplied by a factor of 10 for application to a healthier, more homogeneous working population.

For two substances, (acenaphthylene and phenanthrene), which are polynuclear aromatic hydrocarbons (PAHs) categorized by the USEPA as Class D (i.e., not classified as to carcinogenicity), a recent USEPA memorandum (1991a) indicates that the use of the Agency's benzo(a)pyrene CSFs in the HSL screen for <u>all</u> PAHs

TABLE 2
HSLs Identified at TGPL Sites for which USEPA Toxicity Values Have Not Been Published

- 2-Methylnaphthalene
- Dibenzofuran (unchlorinated)
- Cobalt
- 2-Hexanone
- 1,3-Dichlorobenzene
- 3-Nitroaniline
- Lead
- Acenaphthylene
- Phenanthrene

1031C:PAA011A3.W51

TABLE 3
Toxicity Values for Constituents or Surrogates Based on USEPA Methodology

Detected Constituent	Surrogate	USEPA Methodology-Based ADI (mg/kg/d)	Reference
2-Methylnaphthalene	Naphthalene	0.004	USEPA 1990a
1,3-Dichlorobenzene	1,2-Dichlorobenzene	Chronic oral: 0.086 Subchro. oral: 0.9 Chronic inh: 0.04 Subchronic inh: 0.4	USEPA 1988a, USEPA 1990a
Acenaphthylene	Naphthalene	0.004	USEPA 1990a
Phenanthrene	Naphthalene	0.004	USEPA 1990a
Dibenzofuran	Unchlorinated dibenzo-p-dioxin	0.6	NCI 1978
Cobalt	NA	Oral: 0.0023 Inhal: 3.1×10^{-6}	Tipton et al. 1966 ATSDR 1990
2-Hexanone	NA	0.15	Allen et al. 1975
3-Nitroaniline	NA	0.0025	Nair et al. 1990

1031C:PAA011A3.W51

is inappropriate for Class D PAHs. However, no other USEPA toxicity values are available for acenaphthylene or phenanthrene. A surrogate approach is therefore used to evaluate samples containing these substances. The USEPA RfD for naphthalene (the lowest published RfD available for PAHs) is used as a surrogate for acenaphthylene and phenanthrene.

For dibenzofuran (unchlorinated), 2-hexanone, 3-nitroaniline and cobalt, no USEPA-published toxicity values are available. No usable surrogates have been identified for 2-hexanone, 3-nitroaniline and cobalt. For unchlorinated dibenzonfuran, USEPA-published toxicity values were unavailable for either the constituent, or a structurally similar substance investigated as a surrogate (unchlorinated dibenzo-p-dioxin). The following procedure using USEPA methodology has been undertaken for the screening procedure to derive a toxicity value for these constituents or surrogates:

- Literature searches of toxicological data bases to collect information on unchlorinated dibenzofuran and unchlorinated dibenzo-p-dioxin, 2-hexanone, 3-nitroaniline and cobalt.

- Critical review of information collected from the literature search, to derive toxicity values for these substances, and evaluate the selection of unchlorinated dibenzo-p-dioxin as a usable surrogate for unchlorinated dibenzofuran. The methodology used to derive these toxicity values (presented in Appendix IV) is that used by USEPA, and has not been independently reviewed in this document. The toxicity values derived for these constituents or their surrogates are presented in Table 3. USEPA RfDs are usually reduced by a factor of 10 to theoretically account for the broadest individual human variability (USEPA 1989d); these toxicity values have hereby been multiplied by a factor of 10 for application to a healthier, more homogeneous working population. In applying this screening process, it is recognized that workplace exposure limits have been promulgated or proposed by OSHA, ACGIH, AIHA and others. These workplace exposure limits are not intended to be supplanted by the hypothetical short and long-term worker exposure scenarios in the environmental screening process. In fact, the sample-specific analysis discussed below makes reference to such occupational limits where appropriate.

The USEPA has applied an uptake/biokinetic modeling approach for predicting potential blood lead levels and establishing cleanup levels for lead at hazardous waste sites, including the Bunker Hill site in Shoane County, ID; the Sharon Steel Midvale Tailings site in Midvale, UT; and the NL/Taracorp site in Grant City, IL. The "integrated uptake/biokinetic model" (IU/BK) for lead was developed through the efforts of USEPA (1990d) and New York University professors N.H. Harley and T.J. Kniep. It integrates a number of assumptions about the complex exposure pattern and physiological handling of lead by the body in order to predict potential blood lead levels and distributions in exposed populations. The model is extremely versatile in that hypothetical exposures from multiple sources can be input and potential uptake from each source estimated. It is based upon experimental data in laboratory animals (baboons) and has been validated by USEPA (1989e) at several sites where lead exposure data and human blood lead levels are available.

The USEPA has recently developed a computerized version of the IU/BK model that predicts blood lead levels and distributions for children ages 0-7 years. According to Agency officials, USEPA will be developing a version of this model specifically for adult blood lead level distributions. At the present time, it is possible to apply the model to predict potential blood lead levels in adults based upon published slope factors relating daily dose and blood lead levels in adults (Harley and Kneip 1985, Chamberlain and Heard 1981).

The IU/BK model is used to derive benchmark concentrations for lead under the hypothetical worker scenarios (applying adult intake and biokenetic slope factors) and the hypothetical off-site receptor scenario. In order to derive the benchmark concentrations, a blood lead level and distribution must be selected. There are several indications that the USEPA will soon be issuing guidance that the IU/BK model be applied at sites with lead. Blood lead levels and distribution are likely to be set by the Agency at 10 μg/dl, with 95% of the population not to exceed this level. This would be consistent with approaches taken by USEPA at hazardous waste sites at which the model has been applied. At these sites, USEPA's target blood lead levels have ranged from 10-15 μg/dl with the portion of the population allowed to exceed these levels of ranging from 1-8%.

7. Sample-Specific Analysis

a) Sample-Specific Evaluation Criteria

Samples containing HSLs that exceed benchmark concentrations are evaluated on a sample-specific basis to determine if further consideration is warranted. The following series of criteria have been developed to screen such samples based upon constituent- and site-specific factors. All appropriate criteria listed below are examined, in a non-sequential manner.

(1) Sample Does Not Exceed Benchmark Based upon Clement Relative Potency Scheme for USEPA-Designated Carcinogenic PAHs

Prior to the sample-specific screen all PAHs classified by the USEPA as B2 are treated as identical in potency to benzo(a)pyrene. However, there is a body of empirical data that suggests large differences in CSFs among the various USEPA-designated Class A and B PAHs. Clement Associates was requested by USEPA to use this information to develop "relative potency factors." Benzo(a)pyrene was assigned a potency of 1; the other USEPA-designated Class A and B PAHs were assigned CSFs by Clement Associates relative to that of benzo(a)pyrene (Clement Associates 1988).

As part of the sample-specific analysis for EPA-designated Class A and B PAHs, benchmarks are adjusted according to the Clement relative potency scheme developed for USEPA. Under the sample-specific screen, only PAHs that exceed the revised soil benchmark or leaching benchmark criteria will receive further consideration.

(2) Chromium Analysis Indicates Presence of Trivalent Rather than Hexavalent Chromium

Chromium benchmarks are based upon USEPA-established toxicity values for hexavalent chromium. Use of these values in this screen for all detected chromium is conservative, because USEPA has classified trivalent chromium as less toxic than the hexavalent form. Samples exceeding the chromium benchmark are checked to see if speciation (differentiation among the different valence states) was conducted as part of laboratory analysis. If data indicate that the sample contains the hexavalent form, or contains trivalent chromium and would exceed a benchmark based on the USEPA toxicity value for trivalent chromium, the sample will receive further consideration.

(3) Sample Taken at Location of Infrequent Worker Activity

Samples are further considered, based upon sampling locations at sites of infrequent worker activity, if the following conditions are met: concentrations in surface samples (defined as 0-2 foot horizon) exceed by more than 2-fold a benchmark based upon potential worker exposure; <u>and</u> the sample was taken in an area where it is highly unlikely the worker would be present for the amount of time assumed in the hypothetical scenario (30 minutes). A 2-fold factor has been selected based upon an assumed reduction of the 30-minute hypothetical exposure period to 15 minutes. This accounts for the fact that the conservative hypothetical scenarios used in developing the benchmark concentrations may be clearly inappropriate for evaluating certain samples, i.e., those taken in remote or infrequently visited locations that only slightly exceed the benchmark concentration. In these circumstances, if the sample concentration exceeds an alternative benchmark more accurately reflecting the infrequent nature of potential worker exposures in these remote areas, the sample will receive further consideration.

(4) Sample Is Taken from a Depth Greater than Two Feet

Benchmarks based upon hypothetical long-term worker exposures pertain only to surficial soils which are the soils likely to be contacted by the worker (0-2 feet depth). Thus, samples exceeding long-term worker-derived benchmarks will receive further consideration only if the samples were obtained at depths at or above 2 feet.

(5) Downgradient Distance between Source Area and Hypothetical Well

The leaching model predicts both potential maximum and average concentrations in leachate directly below the soil sampling point, and in monitoring wells located at various distances from the source area. A 25-fold dilution factor is obtained by the leaching model to estimate potential ground water concentrations at 50 meters from the source area; however, additional dilution occurs at greater distances. If a sample exceeds the leaching model benchmark for the hypothetical off-site receptor and there is evidence to suggest a greater than 50 meter distance from the source area to the hypothetical off-site receptor at the property boundary, the leaching model is rerun to provide dilution factors for these greater distances. If the sample exceeds the benchmark for the greater distance, it will receive further consideration.

(6) Use of Mean Ground Water Concentrations

As indicated above, the leaching model predicts both the potential maximum leachate concentration and the potential highest average concentration over any 30-year period. The screening process compares this potential maximum concentration to the screening criteria. However, the evaluation of USEPA-designated carcinogens under this scenario is based upon hypothetical assumptions that are better represented by the highest 30-year average leachate concentration for long-term exposures. Samples containing HSLs that are classified by USEPA as carcinogens by ingestion and for which mean leachate concentrations are above the leaching benchmark will receive further consideration.

(7) Use of Expected Dilution and Mean Ground Water Concentration

If a sample contains an HSL designated by the USEPA as carcinogenic by ingestion, and there is evidence that the location of the nearest potential off-site receptor is more than 50 meters from the source area, the sample is evaluated based on predicted ground water concentrations (maximum 30-year average), and the dilution factor predicted by the leaching model for the greater distance. If the adjusted sample concentration exceeds the leaching benchmark value, the sample will receive further consideration.

(8) Distance to Nearest Off-site Receptor

The soil benchmark concentration for inhalation of particulates by an off-site receptor is based upon a hypothetical conservative assumption of a distance of 50 meters between the source area and the potential nearest receptor at the property boundary. At some stations, aerial photographs indicate that the nearest hypothetical off-site receptor at the property boundary would be located at a greater distance from the source area. For these sites, alternative benchmarks are calculated based upon, for example, a more appropriate distance of 100 meters or 200 meters (the distance will depend on the information contained in the aerial photographs). If the constituent exceeds these alternative benchmarks, the sample will receive further evaluation.

(9) Comparison with Workplace Exposure Limits

For samples which exceed hypothetical worker-based benchmarks, the sample concentration is compared where appropriate with occupational exposure limits set by OSHA, ACGIH, and others. Samples which exceed these occupational exposure limits will receive further evaluation.

b) Samples to Be Further Evaluated

Samples that are not eliminated based upon the sample-specific screening criteria will be further evaluated in order to determine the appropriate remedies where indicated.

III. METHODOLOGY FOR EVALUATING HSLs IN GROUND WATER

A. Introduction

The screening methodology for ground water, as for soils, involves a sequential comparison of sampling data to various screening criteria. For the ground water screen, the criteria used for screening include: initial screen to exclude non-industrial elements; followed by comparison to site-specific background levels, as determined by concentrations found in upgradient wells; comparison to state and federal drinking water standards and USEPA-proposed Subpart S levels for ground water; and comparison to benchmark concentrations. Constituents present below a particular screening criterion concentration are considered not to warrant further evaluation; data that exceed the criterion proceed to the next screening level. Samples that pass through all screening criteria are evaluated on a sample-specific basis to determine whether additional site characterization and possible remediation are warranted. The methodology used for evaluating ground water data is shown schematically in Figure 2.

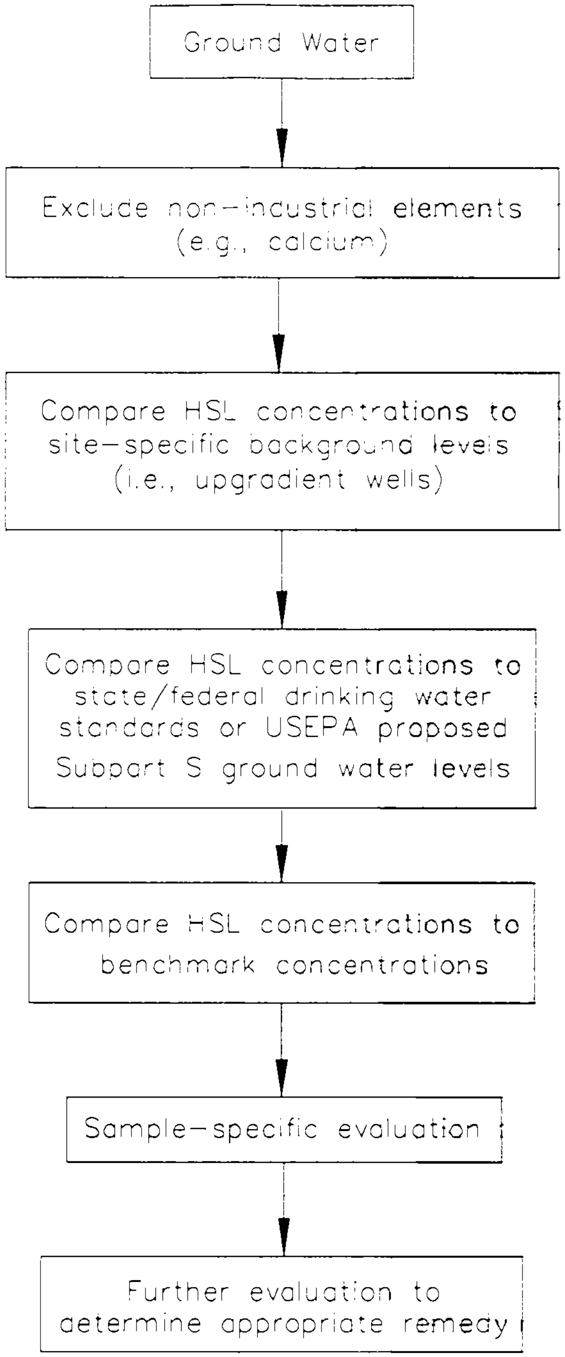
B. Screening Methodology

1. Exclusion of Non-Industrial Elements

In this step, certain substances that are ubiquitous and normally-occurring (e.g., aluminum, calcium, iron, magnesium, potassium and sodium) are eliminated from the HSL screening. Their presence in the environment is expected and does not trigger the need for further evaluation or characterization.

2. Comparison of HSL Concentrations to Site-Specific Background

The ground water investigations at TGPL facilities were designed to include placement of a well(s) upgradient from the areas where HSLs might be present in on-site soils. Where upgradient wells have been installed, sampling data from these upgradient wells represent site-specific "background" levels, i.e., the presence of substances in upgradient wells is unrelated to possible on-site sources. Thus any HSLs present in a background well are due to hydraulically upgradient site conditions unrelated to the compressor station. HSLs in downgradient samples warrant further



F:\021031C\1031CF06

ENVIRON
Counsel in Health and Environmental Science

PROCEDURE FOR EVALUATING HSLS IN GROUND WATER

Figure 2

evaluation only if their concentrations exceed the site-specific background concentrations.

3. Comparison to Federal/State Drinking Water Standards or USEPA-Proposed Subpart S Levels

The second step of the ground water screen involves comparison of ground water data with state (where available) and promulgated or proposed federal drinking water standards (shown in Appendix II). This is conservative for a number of reasons, among which is that it assumes all sampled ground water would be regulated as a potable water supply.

Constituents that pass through the background screen and for which no drinking water standards have been established or proposed by the state or by USEPA are compared to the ground water levels proposed under the USEPA proposed Corrective Action Regulations (40 CFR 264 Subpart S) discussed in Section I. These levels, shown in Appendix II, are based upon USEPA's hypothetical exposure scenario of 2-liter per day water consumption by a 70-kg adult, over a 70-year period. These exposure parameters are highly conservative for several reasons, including the following: according to USEPA (1989a), the 90th percentile residence time at one location is 30 years; thus, only a very small segment of the general population will be exposed to the same drinking water source for 70 years; furthermore, a 2-liter per day water consumption would include water consumed away from home (and thus, derived from a different water source). Some of these levels reflect values directly listed in proposed 40 CFR 264 Subpart S. Others were calculated or updated using the stated USEPA regulatory approach (USEPA 1990b) for development of Subpart S levels, which is based upon USEPA's assumption criteria for hypothetical exposures, and current USEPA published toxicity values available through the Integrated Risk Information System (IRIS) database, or the USEPA quarterly Health Effects Assessment summary tables (USEPA 1990a). Constituents present at concentrations greater than the proposed Subpart S levels are continued to the next stage of the screen.

4. Comparison to Benchmark Concentrations

Ground water benchmark concentrations have been developed based upon USEPA-published toxicity values, and a conservative, hypothetical exposure scenario in which it is assumed that the ground water is used as a drinking water source by a 70-kg adult. Assumptions for hypothetical exposures are shown in Table 1. Any constituents for which USEPA toxicity values are not available are evaluated as described in the

Soils section, subsection B.6.c. All constituents that pass through the complete ground water screen are retained for further sample-specific evaluation.

5. Sample-Specific Analysis

a) Sample-Specific Evaluation Criteria

Samples containing HSLs that exceed ground water benchmark concentrations are evaluated on a sample-specific basis to determine if further consideration is warranted. The following criteria have been developed to determine which samples will receive further consideration, based upon constituent- and site-specific factors. The criteria listed below are examined on a sample- and constituent-specific basis, in a non-sequential manner.

(1) Filtered Samples

Metals in ground water are often present on small particles of sediment contained in the sample. These sediment particles typically result during well installation. In order to determine whether sediment particles are contributing to detected metal levels, both filtered and unfiltered samples are collected for metals analysis. The unfiltered samples are used in the HSL screening process. However, if a sample passes through the screens for metals, a review of the filtered sample concentration data is conducted. If the filtered sample shows concentrations above the benchmark, the sample will receive further evaluation.

(2) Discharge to a Surface Water Body

In some cases, ground water discharges to a surface water body, where additional dilution naturally occurs. If a ground water sample passes through the ground water screens, the station setting is reviewed to determine whether there is an adjacent surface water body to which the ground water discharges. If a site-specific evaluation determines that the potential discharge of HSLs in ground water to a surface water body may affect the water quality of the surface water body, the sample will receive further consideration.

(3) Ground Water Use

In some cases, ground water is not a potential drinking water supply. This may be, for example, because the aquifer does not yield sufficient quantities of water for domestic purposes; because the ground water naturally contains elevated levels of substances that render it undesirable for drinking (e.g., iron, salt); or because alternative water supplies are available. If a sample passes through the ground water screens, a review of current and potential future ground water usage in the local area is conducted. If the aquifer is a potential drinking water source, the sample will receive further evaluation.

(4) Downgradient Concentration in Ground Water Is Considered

In most cases, there will be dilution of the HSL concentration in ground water between the point of monitoring and the assumed point of potential use by an off-site receptor. If there is evidence of greater than a 50-meter distance between the monitoring point and the potential off-site receptor, the additional dilution predicted by the leaching model for the greater distance is applied. If the concentration exceeds the benchmark after application of the additional dilution factor, the sample will receive further consideration.

b) Samples to Be Further Evaluated

Samples that are not eliminated based upon the site-specific screening criteria presented above will be further evaluated in order to determine, where indicated, the appropriate remedy.

1031C:PAA011A3.W51

REFERENCES

Agency for Toxic Substances and Disease Registry (ATSDR). 1990. *Toxicological profile for cobalt*. Draft. U.S. Public Health Service.

Allen, N., J.R. Mendell, D.J. Billmair, R.E. Fontaine, and J.O'Neill. 1975. Toxic polyneuropathy due to methyl-n-butyl ketone. *Arch. Neurol.* 32:209-218.

Chamberlain, A.C. and M.J. Heard. 1981. *Lead tracers and lead balances*. In: Proc. 2nd Int. Symp.: Environmental Lead Research, Environmental Lead, December, 1978. Academic Press, Cincinnati, OH/New York, NY. p. 175-198.

Clement Associates, Inc. 1988. *Comparative potency approach for estimating the cancer risk associated with exposure to mixtures of polycyclic aromatic hydrocarbons.* Interim final report. Fairfax, Va.

Emmet, E.A. 1986. Toxic responses of the skin. In C.D. Klaassen, M.O. Amdur and J. Doull, eds. *Casarett and Doull's toxicology, the basic science of poisons.* 3rd Edition. New York: MacMillan Co.

Harley, N.H. and T.H. Kneip. 1985. *An integrated metabolic model for lead in humans of all ages*. Final report to the U.S. Environmental Protection Agency, Contract No. B44899. January.

International Commission on Radiological Protection (ICRP). 1975. *Report of the Task Group on Reference Man.* ICRP Publication 23. New York: Pergamon Press.

Li, W.W., M.P. Scott, and J.W. Bradstreet. 1990. Modeling of on-site air concentrations at Superfund sites. In *Proceedings of the 11th National Conference, Superfund 90,* Hazardous Materials Control Research Institute, 117-122. Washington, D.C.

Nair, R.S., C.S. Auletta, R.E. Schroeder, and F.R. Johannsen. 1990. Chronic toxicity, oncogenic potential, and reproductive toxicity of p-nitroaniline in rats. *Fund. Appl. Toxicol.* 15:607-621

National Cancer Institute (NCI). 1978. *Bioassay of dibenzo-p-dioxin for possible carcinogenicity (CAS No. 262-12-4).* U.S. Department of Health, Education and Welfare. NTIS PB-288-475.

National Institute for Occupational Safety and Health (NIOSH). 1991. Dr. David Manino. Respiratory Disease Group, Morgantown, W.Va. Telephone conversation with Peter Harnett of ENVIRON Corporation. February 20.

Shacklette, H.T., and J.G. Boerngen. 1984. *Element concentrations in soils and other surficial material of the coterminous United States.* U.S. Geological Survey. Professional Paper 1270.

Tipton, I.H., P.L. Stewart and P.G. Martin. 1966. *Health Phys.* 12:1683-1689. (Reported in Underwood 1975).

Underwood, E.J. 1975. Cobalt. *Nutrition Reviews* 33:65-69.

U.S. Environmental Protection Agency (USEPA). 1991a. Carcinogenicity information for PAHs. Memorandum from P-F Hurst, Chemical Mixtures Assessment Branch, Environmental Criteria and Assessment Office, to T. O'Bryan, Office of Toxic Substances. February 27.

U.S. Environmental Protection Agency (USEPA). 1991b. Human health evaluation manual, supplemental guidance: "Standard default exposure factors." Memorandum from T. Fields, Jr., Office of Emergency Remedial Response, to B. Diamond, Office of Waste Programs Enforcement. March 25. OSWER Directive 9285.6-03.

U.S. Environmental Protection Agency (USEPA). 1991c. National primary drinking water regulations-synthetic organic chemicals and inorganic chemicals; monitoring for unregulated contaminants; national primary drinking water regulations implementation; national secondary drinking water regulations. *Fed. Reg.* 56:3526-3597. January 30.

U.S. Environmental Protection Agency (USEPA). 1990a. *Health effects assessment summary tables.* Third quarter, FY-1990. OSWER (OS-230).

U.S. Environmental Protection Agency (USEPA). 1990b. Corrective action for solid waste management units (SWMUs) at hazardous waste management facilities. Proposed Rule. *Fed. Reg.* 55:30798-30884. July 27.

U.S. Environmental Protection Agency (USEPA). 1990c. Office of Emergency and Remedial Response. *Guidance on remedial actions for Superfund Sites with PCB contamination.* August. Washington D.C. OSWER Directive No. 9355.4-01.

U.S. Environmental Protection Agency (USEPA). 1990d. Office of Health and Environmental Assessment. *Technical support document on lead.* Final draft. Cincinnati, OH. ECAO-CIN-757.

U.S. Environmental Protection Agency (USEPA). 1990e. National primary and secondary drinking water regulations; synthetic organic chemicals. Proposed rule. *Fed. Reg.* 55:30370-30448. July 25.

U.S. Environmental Protection Agency (USEPA). 1989a. Office of Health and Environmental Assessment. *Exposure factors handbook.* USEPA/600/8-89/043.

U.S. Environmental Protection Agency (USEPA). 1989b. Interim final guidance for soil ingestion rates. Memorandum from J.W. Porter to USEPA Regional Administrators. January 27. OSWER Directive 9850.4.

U.S. Environmental Protection Agency (USEPA). 1989c. Interim final guidance on soil ingestion rates. Memorandum from B.M. Diamond, H.L. Longest II, and S. Lowrance. February 9.

U.S. Environmental Protection Agency (USEPA). 1989d. Office of Emergency and Remedial Response. *Risk assessment guidance for Superfund*. Vol. I. *Human health evaluation manual (Part A).* Interim Final. December. USEPA/540/1-89/002.

U.S. Environmental Protection Agency (USEPA). 1989e. *Review of the National Ambient Air Quality Standards for Lead: Exposure Analysis Methodology and Validation. Final Draft*. Office of Air Quality Planning and Standards, Air Quality Management Division, Research Triangle Park, NC.

U.S. Environmental Protection Agency (USEPA). 1988a. Office of Drinking Water. *Drinking water health document on o-dichlorobenzene.* Final draft. Washington, D.C. PB89-192231.

U.S. Environmental Protection Agency (USEPA) 1988b. Office of Emergency and Remedial Response. *CERCLA compliance with other laws manual.* Washington, D.C. OSWER Directive 9234.1-01.

U.S. Environmental Protection Agency (USEPA) 1988c. Office of Solid Waste. *Background document on subsurface fate and transport model (EPACML).* August. Washington, D.C. WH- 333.

U.S. Environmental Protection Agency (USEPA). 1987a. Office of Air Quality Planning and Standards. *Industrial source complex (ISC) dispersion model user's guide-second edition (revised).* Vol. I. Research Triangle Park, N.C. EPA-450/4-88-002a.

U.S. Environmental Protection Agency (USEPA). 1987b. Superfund program: Interim guidance on compliance with other applicable or relevant and appropriate requirements. *Fed. Reg.* 52:32496-32499.

U.S. Environmental Protection Agency (USEPA). 1986a. Office of Emergency and Remedial Response. *Superfund public health evaluation manual.* Washington, D.C. OSWER Directive 9285.4-1.

U.S. Environmental Protection Agency (USEPA). 1986b. Office of Health and Environmental Assessment. *Development of advisory levels for polychlorinated biphenyls (PCBs) cleanup.* Final. May. Washington, D.C. OHEA-E-187.

U.S. Environmental Protection Agency (USEPA). 1986c. Office of Air Quality and Standards. *Guideline on air quality models.* Revised. Research Triangle Park, N.C. EPA-450/2-78-027R.

U.S. Environmental Protection Agency (USEPA). 1986d. Hazardous waste management system; land disposal restrictions; proposed rule. *Fed. Reg.* 51(a):1603-1664. January 14.

U.S. Environmental Protection Agency (USEPA). 1985a. *Water quality assessment: A screening procedure for toxic and conventional pollutants in surface and ground water--Part II* (Revised 1985).

U.S. Environmental Protection Agency (USEPA). 1985b. Office of Health and Environmental Assessment. *Rapid assessment of exposure to particulate emissions from surface contamination sites.* Washington, D.C. USEPA/600/8-85/002.

U.S. Environmental Protection Agency (USEPA). 1985c. Office of Air Quality Planning and Standards. *Compilation of air pollution emission factors, Volume I: Stationary point and area sources.* Research Triangle Park, N.C. PB86-124906.

Yeh, G.T. 1981. *AT123D: Analytical transient one-, two-, and three-dimensional simulation of waste transport in the aquifer system.* Oak Ridge National Laboratory, U.S. Department of Commerce, National Technical Information Service. Oak Ridge, TN. ORNL-5602.

1031C:PAA011A3.W51

APPENDIX I

Metal Background Concentrations in Soil

TABLE I-1
Eastern U.S. Background Concentrations for Metals in Soil

Metal	Number of Samples	Range of Background Concentrations (ppm)
Antimony	115	1 - 9
Arsenic	518	0 - 73
Barium	532	10 - 1500
Beryllium	170	1 - 7
Cadmium	NA	NA
Chromium	531	1 - 1000
Cobalt	400	3 - 70
Copper	515	1 - 700
Cyanide, Total	NA	NA
Lead	430	10 - 300
Manganese	529	1 - 7000
Mercury	525	0 - 3
Nickel	454	5 - 700
Selenium	524	0 - 4
Silver	NA	NA
Thallium	NA	NA
Vanadium	510	7 - 300
Zinc	476	5 - 2890
NA - Not Available		

Source: Shacklette, H.T., and J.G. Boerngen. 1984. *Element concentrations in soils and other surficial material of the coterminous United States.* U.S. Geological Survey. Professional paper 1270.

1031C:PAA011**A3**.W51

APPENDIX II

HSL Substances and Regulatory Criteria for Screening

APPENDIX II

HSL Substances and Regulatory Criteria for Screening

ID	Substance	Proposed 40 CFR 264 **Subpart S** Soil Level (ppm)**	**U.S. Drinking** Water Standard (ppb)	Proposed 40 CFR 264 **Subpart S** Water Level (ppb)**
1	1,1-Dichloroethene	12	7	NA
2	1,1-Dichloroethane	8000	NS	3500
3	1,1,1-Trichloroethane	7200	200	NA
4	1,1,2-Trichloroethane	120	5[††]	NA
5	1,1,2,2-Tetrachloroethane	35	NS	1.7
6	1,2-Dichloroethane	7.7	5	NA
7	1,2-Dichloroethene, trans	1600	100[†]	NA
8	2-Butanone	4000	NS	1700
9	2-Chloroethylvinyl ether	ND	NS	ND
10	2-Hexanone	ND	NS	ND
11	4-Methyl-2-pentanone	4000	NS	1700
12	Acetone	8000	NS	3500
13	Benzene	24	5	NA
14	Bromoform	89	100	NA
15	Bromodichloromethane	5.4	100	NA
16	Carbon disulfide	8000	NS	3500
17	Carbon tetrachloride	5.4	5	NA
18	Chlorobenzene	1600	100[†]	NA
19	Chloroethane	ND	NS	ND

NA = Not Applicable

ND = Not Derived, no USEPA toxicity value available

NS = No Standard

[*] Based on CSF values for benzo(a)pyrene, which is used as a surrogate for other PAHs designated by USEPA as Class A or B carcinogens, in accordance with USEPA guidance (USEPA 1991a)

[**] Calculated from USEPA Subpart S assumptions for hypothetical exposures and recent USEPA published toxicity value for compound in accordance with USEPA procedures set out at 40 CFR 264 Subpart S (FR55:30798-30884) (USEPA 1990b)

[†] MCL not in effect until July 30, 1992; no current MCL (FR56:3526-3597) (USEPA 1991c)

[††] Proposed MCL (FR55:30371-30445) (USEPA 1990c)

APPENDIX II (continued)
HSL Substances and Regulatory Criteria for Screening

ID	Substance	Proposed 40 CFR 264 Subpart S Soil Level (ppm)**	U.S. Drinking Water Standard (ppb)	Proposed 40 CFR 264 Subpart S Water Level (ppb)**
20	Chloroform	110	100	NA
21	Chloromethane	540	NS	27
22	1,3-Dichloropropene	3.9	NS	0.19
23	Dibromochloropropene	ND	0.2†	NA
24	Ethylbenzene	8000	700†	NA
25	Methylene Chloride	93	5††	NA
26	Styrene	16000	100†	NA
27	Tetrachloroethene	14	5†	NA
28	Toluene	32000	1000†	NA
29	Benzidine	0.003	NS	0.00015
30	Trichloroethene	64	5	NA
31	Vinyl Acetate	4600	NS	2000
32	Vinyl Chloride	0.3	2	NA
33	Xylene	160,000	10000†	NA
34	1,2-Diphenylhydrazine	0.88	NS	0.044
35	1,2-Dichlorobenzene	6900	600†	NA
36	1,2,4-Trichlorobenzene	1600	9††	NA

NA = Not Applicable
ND = Not Derived, no USEPA toxicity value available
NS = No Standard

* Based on CSF values for benzo(a)pyrene, which is used as a surrogate for other PAHs designated by USEPA as Class A or B carcinogens, in accordance with USEPA guidance (USEPA 1991a)

** Calculated from USEPA Subpart S assumptions for hypothetical exposures and recent USEPA published toxicity value for compound in accordance with USEPA procedures set out at 40 CFR 264 Subpart S (FR55:30798-30884) (USEPA 1990b)

† MCL not in effect until July 30, 1992; no current MCL (FR56:3526-3597) (USEPA 1991c)

†† Proposed MCL (FR55:30371-30445) (USEPA 1990c)

APPENDIX II (continued)
HSL Substances and Regulatory Criteria for Screening

ID	Substance	Proposed 40 CFR 264 **Subpart S** Soil Level (ppm)**	**U.S. Drinking** Water Standard (ppb)	Proposed 40 CFR 264 **Subpart S** **Water Level** (ppb)**
37	1,3-Dichlorobenzene	ND	NS	ND
38	1,4-Dichlorobenzene	29	NS	1.5
39	2-Chloroaniline	ND	NS	ND
40	2-Chloronaphthalene	6400	NS	2800
41	2-Methylnaphthalene	ND	NS	ND
42	2-Nitroaniline	ND	NS	ND
43	2,4-Dinitrotoluene	1	NS	0.051
44	2,6-Dinitrotoluene	1	NS	0.051
45	3-Nitroaniline	ND	NS	ND
46	3,3-Dichlorobenzidine	1.6	NS	0.078
47	4-Bromophenyl phenyl ether	ND	NS	ND
48	4-Chloroaniline	320	NS	140
49	4-Chlorophenyl phenyl ether	ND	NS	ND
50	Acenaphthylene	ND	NS	ND
51	Anthracene	24000	NS	10,500
52	*Benzo (a) anthracene	0.058	0.1[††]	NA
53	Benzo (a) pyrene	0.058	0.2[††]	NA

NA = Not Applicable
ND = Not Derived, no USEPA toxicity value available
NS = No Standard

[*] Based on CSF values for benzo(a)pyrene, which is used as a surrogate for other PAHs designated by USEPA as Class A or B carcinogens, in accordance with USEPA guidance (USEPA 1991a)

[**] Calculated from USEPA Subpart S assumptions for hypothetical exposures and recent USEPA published toxicity value for compound in accordance with USEPA procedures set out at 40 CFR 264 Subpart S (FR55:30798-30884) (USEPA 1990b)

[†] MCL not in effect until July 30, 1992; no current MCL (FR56:3526-3597) (USEPA 1991c)

[††] Proposed MCL (FR55:30371-30445) (USEPA 1990e)

APPENDIX II (continued)
HSL Substances and Regulatory Criteria for Screening

ID	Substance	Proposed 40 CFR 264 Subpart S Soil Level (ppm)**	U.S. Drinking Water Standard (ppb)	Proposed 40 CFR 264 Subpart S Water Level (ppb)**
54	*Benzo (b) fluoranthene	0.058	0.2[††]	NA
55	*Benzo (g,h,i) perylene	0.058	NS	0.0029
56	*Benzo (k) pyrene	0.058	NS	0.0029
57	Benzyl alcohol	24000	NS	10000
58	Bis (2-chloroethoxy) methane	ND	NS	ND
59	Bis (2-chloroethyl) ether	0.64	NS	0.032
60	Bis (2-ethylhexyl) phthalate	50	4[††]	NA
61	Butyl benzyl phthalate	16000	100[††]	NA
62	*Chrysene	0.058	0.2[††]	NA
63	*Dibenzo (a,h) anthracene	0.058	0.3[††]	NA
64	Diethyl phthalate	64000	NS	28000
65	Di-n-butyl phthalate	8000	NS	3500
66	Di-n-octyl phthalate	ND	NS	ND
67	Fluorene	3200	NS	1400
68	Fluoranthene	3200	NS	1400
69	Hexachlorobenzene	0.44	1[††]	NA
70	Hexachlorobutadiene	90	NS	4.5

NA = Not Applicable
ND = Not Derived, no USEPA toxicity value available
NS = No Standard

[*] Based on CSF values for benzo(a)pyrene, which is used as a surrogate for other PAHs designated by USEPA as Class A or B carcinogens, in accordance with USEPA guidance (USEPA 1991a)

[**] Calculated from USEPA Subpart S assumptions for hypothetical exposures and recent USEPA published toxicity value for compound in accordance with USEPA procedures set out at 40 CFR 264 Subpart S (FR55:30798-30884) (USEPA 1990b)

[†] MCL not in effect until July 30, 1992; no current MCL (FR56:3526-3597) (USEPA 1991c)

[††] Proposed MCL (FR55:30371-30445) (USEPA 1990c)

APPENDIX II (continued)
HSL Substances and Regulatory Criteria for Screening

ID	Substance	Proposed 40 CFR 264 **Subpart S** Soil Level (ppm)**	**U.S. Drinking** Water Standard (ppb)	Proposed 40 CFR 264 **Subpart S** Water Level (ppb)**
71	Hexachlorocyclopentadiene	560	50††	NA
72	Hexachloroethane	80	NS	25
73	*Indeno (1,2,3-cd) pyrene	0.058	0.4††	NA
74	Isophorone	1700	NS	85
75	Naphthalene	320	NS	140
76	Nitrobenzene	40	NS	18
77	n-Nitrosodimethylamine	0.014	NS	0.00069
78	n-Nitroso-di-n-propylene	ND	NS	ND
79	N-Nitrosodiphenylamine	140	NS	7.1
80	Phenanthrene	ND	NS	ND
81	Pyrene	2400	NS	1050
82	Phenol	48000	NS	21000
83	2-Chlorophenol	400	NS	170
84	2-Methylphenol	4000	NS	1700
85	4-Methylphenol	4000	NS	1700
86	2-Nitrophenol	ND	NS	ND
87	2,4-Dimethylphenol	1600	NS	700

NA = Not Applicable
ND = Not Derived, no USEPA toxicity value available
NS = No Standard

* Based on CSF values for benzo(a)pyrene, which is used as a surrogate for other PAHs designated by USEPA as Class A or B carcinogens, in accordance with USEPA guidance (USEPA 1991a)

** Calculated from USEPA Subpart S assumptions for hypothetical exposures and recent USEPA published toxicity value for compound in accordance with USEPA procedures set out at 40 CFR 264 Subpart S (FR55:30798-30884) (USEPA 1990b)

† MCL not in effect until July 30, 1992; no current MCL (FR56:3526-3597) (USEPA 1991c)

†† Proposed MCL (FR55:30371-30445) (USEPA 1990e)

APPENDIX II (continued)
HSL Substances and Regulatory Criteria for Screening

ID	Substance	Proposed 40 CFR 264 Subpart S Soil Level (ppm)**	U.S. Drinking Water Standard (ppb)	Proposed 40 CFR 264 Subpart S Water Level (ppb)**
88	2,4-Dichlorophenol	240	NS	110
89	p-Choro-m-cresol	160,000	NS	70000
90	2,4,6-Trichlorophenol	64	NS	3.2
91	2,4,5-Trichlorophenol	8000	NS	3500
92	2,4-Dinitrophenol	160	NS	70
93	4,6-Dinitro-2-methylphenol	ND	NS	ND
94	4-Nitrophenol	ND	NS	ND
95	Pentachlorophenol	5.8	100†	NA
96	Benzoic acid	320,000	NS	140,000
97	alpha-BHC	0.11	NS	0.0056
98	beta-BHC	3.9	NS	0.19
99	delta-BHC	ND	NS	ND
100	gamma-BHC (Lindane)	0.54	4	NA
101	Heptachlor	0.16	0.4†	NA
102	Aldrin	0.041	NS	0.0021
103	Heptachlor epoxide	0.077	0.2†	NA
104	Endosulfan I	40	NS	18

NA = Not Applicable
ND = Not Derived, no USEPA toxicity value available
NS = No Standard

* Based on CSF values for benzo(a)pyrene, which is used as a surrogate for other PAHs designated by USEPA as Class A or B carcinogens, in accordance with USEPA guidance (USEPA 1991a)

** Calculated from USEPA Subpart S assumptions for hypothetical exposures and recent USEPA published toxicity value for compound in accordance with USEPA procedures set out at 40 CFR 264 Subpart S (FR55:30798-30884) (USEPA 1990b)

† MCL not in effect until July 30, 1992; no current MCL (FR56:3526-3597) (USEPA 1991c)

†† Proposed MCL (FR55:30371-30445) (USEPA 1990e)

APPENDIX II (continued)
HSL Substances and Regulatory Criteria for Screening

ID	Substance	Proposed 40 CFR 264 **Subpart S** Soil Level (ppm)**	**U.S. Drinking** Water Standard (ppb)	Proposed 40 CFR 264 **Subpart S** **Water Level** (ppb)**
105	Dieldrin	0.044	NS	0.0022
106	4,4′-DDD	2.9	NS	0.15
107	Endrin	24	0.2†	NA
108	Endosulfan II	ND	NS	ND
109	4,4′-DDE	2.1	NS	0.1
110	Endosulfan sulfate	ND	NS	ND
111	4,4′-DDT	2.1	NS	0.1
112	Endrin aldehyde	ND	NS	ND
113	Endrin ketone	ND	NS	ND
114	Methoxychlor	400	100	NA
115	Chlordane	0.54	2†	NA
116	Toxaphene	0.64	5	NA
117	*Benzo (k) fluoranthene	0.058	0.2††	NA
118	Dibenzofuran	ND	NS	ND
119	*Acenaphthene	0.058	NS	0.0029
120	Antimony	32	5††	NA
121	Arsenic	0.39	50	NA
122	Barium	5600	1000	NA

NA = Not Applicable
ND = Not Derived, no USEPA toxicity value available
NS = No Standard

* Based on CSF values for benzo(a)pyrene, which is used as a surrogate for other PAHs designated by USEPA as Class A or B carcinogens, in accordance with USEPA guidance (USEPA 1991a)

** Calculated from USEPA Subpart S assumptions for hypothetical exposures and recent USEPA published toxicity value for compound in accordance with USEPA procedures set out at 40 CFR 264 Subpart S (FR55:30798-30884) (USEPA 1990b)

† MCL not in effect until July 30, 1992; no current MCL (FR56:3526-3597) (USEPA 1991c)

†† Proposed MCL (FR55:30371-30445) (USEPA 1990e)

APPENDIX II (continued

HSL Substances and Regulatory Criteria for Screening

ID	Substance	Proposed 40 CFR 264 **Subpart S** Soil Level (ppm)**	**U.S. Drinking** Water Standard (ppb)	Proposed 40 CFR 264 **Subpart S** Water Level (ppb)**
123	Beryllium	0.16	1††	NA
124	Cadmium	40	10	NA
125	Chromium	400	50	NA
126	Cobalt	ND	NS	ND
127	Copper	3200	1000	NA
128	Cyanide, Total	1600	200††	NA
129	Lead	ND	50	ND
131	Manganese	8000	50	NA
132	Mercury	24	2	NA
133	Nickel	1600	100††	NA
135	Selenium	240	10	NA
136	Silver	240	50	NA
138	Thallium	5.6	1††	NA
139	Vanadium	560	NS	240
140	Zinc	16000	5000	NA

NA = Not Applicable
ND = Not Derived, no USEPA toxicity value available
NS = No Standard

* Based on CSF values for benzo(a)pyrene, which is used as a surrogate for other PAHs designated by USEPA as Class A or B carcinogens, in accordance with USEPA guidance (USEPA 1991a)

** Calculated from USEPA Subpart S assumptions for hypothetical exposures and recent USEPA published toxicity value for compound in accordance with USEPA procedures set out at 40 CFR 264 Subpart S (FR55:30798-30884) (USEPA 1990b)

† MCL not in effect until July 30, 1992; no current MCL (FR56:3526-3597) (USEPA 1991c)

†† Proposed MCL (FR55:30371-30445) (USEPA 1990c)

APPENDIX II (continued)
HSL Substances and Regulatory Criteria for Screening

ID	Substance	Proposed 40 CFR 264 **Subpart S** Soil Level (ppm)**	**U.S. Drinking** Water Standard (ppb)	Proposed 40 CFR 264 **Subpart S** Water Level (ppb)**
Additional HSLs (Naturally Occurring Elements)				
---	Aluminum	NA	NA	NA
---	Calcium	NA	NA	NA
---	Iron	NA	NA	NA
130	Magnesium	NA	NA	NA
134	Potassium	NA	NA	NA
137	Sodium	NA	NA	NA

NA = Not Applicable
ND = Not Derived, no USEPA toxicity value available
NS = No Standard

* Based on CSF values for benzo(a)pyrene, which is used as a surrogate for other PAHs designated by USEPA as Class A or B carcinogens, in accordance with USEPA guidance (USEPA 1991a)

** Calculated from USEPA Subpart S assumptions for hypothetical exposures and recent USEPA published toxicity value for compound in accordance with USEPA procedures set out at 40 CFR 264 Subpart S (FR55:30798-30884) (USEPA 1990b)

† MCL not in effect until July 30, 1992; no current MCL (FR56:3526-3597) (USEPA 1991c)

†† Proposed MCL (FR55:30371-30445) (USEPA 1990e)

APPENDIX III

Modeling of Hypothetical Airborne Concentrations

A. Introduction

The development of fuel storage and transmission industry-specific benchmark concentrations for the HSL screening methodology is based on both short-term and long-term hypothetical inhalation exposure scenarios associated with the presence of HSL compounds in soils at compressor stations. This appendix presents the approach to estimating particulate and vapor emissions from soils containing HSL compounds and the models used to predict potential on-site and off-site air concentrations resulting from these emissions.

Short-term hypothetical exposure to construction workers is evaluated under conditions of soil disturbance and particulate and vapor entrainment into the atmosphere. For the development of benchmarks applicable to long-term workers <u>not</u> engaged in activities that disrupt the soil, particulate emissions are estimated based solely on surface soil suspension from wind erosion. To develop benchmarks for hypothetical off-site receptors, air concentrations of vapor and particulates are modeled at 50 m from the source, using a USEPA air dispersion model, and "default" meteorological conditions set forth by the USEPA (1982).

B. Emission Estimates

1. Particulate Emissions

In the development of potential exposure-based benchmark concentrations for soil sampling data, both long-term and short-term inhalation exposures to suspended particulates are considered. Two potential sources of airborne particulate emissions from the site are considered:

- Suspension of surface soil due to wind erosion; and
- Suspension of surface soil due to possible construction and temporary disturbance of soil at the site.

Particulate emissions due to wind erosion are estimated from a published USEPA wind erosion model (USEPA 1985b). This model calculates fugitive emissions of respirable particulates (i.e., particles less than 10 microns in diameter) from surfaces characterized by a "limited reservoir" of erodible materials. Under the USEPA model, emissions generated by wind erosion of "limited reservoir" surfaces depend on the fraction of vegetative cover, the surficial wind erosion potential, and the frequency of disturbance. Although a portion of a site may be wooded, the erodible area is conservatively characterized for screening purposes as having no vegetative cover. The available surface erodible soil is conservatively estimated by assuming one soil disturbance each month to fully restore the erosion potential (USEPA 1990), where the erosion potential is defined as the quantity of erodible particles present on the surface prior to the onset of wind erosion. A disturbance is an action that results in the exposure of fresh surface material. Each time a surface is disturbed, its erosion potential is increased by destroying the mitigating effects of crusts, vegetation and friable non-erodible elements, and by exposing new surface fines.

Potential particulate emissions during site construction or temporary disturbance are predicted using the 1985 USEPA compilation of air pollution emission factors (USEPA 1985a). Meteorological data from nearby regional weather monitoring stations are input to the models to yield emission estimates.

2. Vapor Emissions

Excavation and temporary disturbance of soils containing organic compounds have the potential for enhancing the volatilization of these compounds. A model developed by the USEPA (1986) is used to predict chemical vapor emission rates from the site. The USEPA model is derived from the solution of a one-dimensional diffusion equation with the following hypothetical assumptions:

- The chemicals are uniformly distributed through the soil column;
- No transport of chemicals by water movement occurs, and the air-filled porosity is equal to the total porosity;
- The porosity is constant throughout the soil matrix over time;
- Soil adsorption is reversible; and
- Air concentrations in the soil column cannot exceed the saturation vapor concentration.

Using these assumptions, USEPA (1986) developed the following analytical solution for vapor transport through soil:

$$Q = \frac{2\ D_s}{\sqrt{\pi \alpha T}}\ C_a \tag{1}$$

where:

Q = average vapor flux rate, g/m^2-sec;
C_a = concentration of chemical in the vapor phase, g/m^3 soil air;
T = duration of emission, sec;
D_s = soil diffusivity, $m^2/sec = \left(\frac{D_i \theta_a^{10/3}}{\theta^2}\right)$

where:

D_i = air diffusivity, m^2/sec;
θ = total soil porosity, dimensionless; and
θ_a = air-filled soil porosity, dimensionless

$$\alpha = \frac{D_s}{(n + p(1-n)K_d/H)}$$

where:

p = density of soil, g/cm^3;
K_d = distribution coefficient, cm^3/g; and
H = Henry's Law Constant, dimensionless.

Q represents the average flux rate per unit soil source area over the duration of emission, T. To estimate the total average emission rate in grams per second, the flux rate defined in equation (1) must be multiplied by the soil source area.

C. Air Concentrations

1. On-site Air Concentrations

To estimate air concentrations on-site, USEPA used a simplified "box" model approach to estimate on-site air concentrations in the development of advisory levels for PCBs cleanup (USEPA 1986). A modification of this box model was selected for the HSL screening methodology because of the limitations inherent in the simplified box model, which were acknowledged by USEPA (1986). The modified box model includes additional factors such as wind shear near the surface, development of plume thickness and atmospheric stability (Li et al. 1990). The box model only provides estimates of air concentrations directly above a source area, and thus it is applicable only for estimation of on-site air concentrations.

Use of the box model avoids the disadvantages of a conventional Gaussian air dispersion model in the region near the source of emissions, where the diffusion parameters approach zero and cannot be estimated reliably. Specific parameters required in the model are annual average wind speed, average atmospheric stability, and local environmental setting (rural or urban). Particulate emissions from the site are assumed to be uniformly distributed across the surface of the area. Under these assumptions, atmospheric turbulence would then provide the primary mechanism by which these emissions would be transported into the atmosphere. The potential on-site air concentrations are calculated in accordance with the following relationship:

$$C = [U_{10}\,\sigma_z^{p+1}\,I(p)]^{-1}\,E\,X$$

where:

C = Potential on-site air concentration, g/m^3
X = Source length, m
E = Emission rate, g/sec-m^2
U_{10} = Surface wind speed at 10 m height, m/sec
σ_z = Vertical plume dispersion coefficient, m
$I(p)$ = Integration constant, m^{-p}
p = Exponent of the velocity profile, unitless

2. Off-site Air Concentrations

For the screening analysis, hypothetical off-site air concentrations are modeled by using the USEPA Industrial Source Complex Short-Term (ISCST) (USEPA 1987) air dispersion model in conjunction with 49 combinations of wind speed and atmospheric stability. The 49 meteorological conditions represent the regulatory default conditions set forth by the USEPA for a screening analysis (USEPA 1982). The hypothetical long-term average off-site concentrations are then calculated as one-tenth of the maximum hourly concentration. The major hypothetical assumptions used in the modeling are:

- The emission source is represented as a non-buoyant zero-momentum area source;
- The minimum distance between the source and hypothetical off-site receptors is greater than or equal to 50 m;
- All suspended particulates from the site remain suspended before reaching the receptors (i.e., deposition and resuspension are negligible);
- All sites are located in rural areas with no significant obstructions (e.g., tall buildings, abrupt topography) between the source and receptors; and
- Extreme meteorological upset conditions such as inversion or calm conditions do not occur frequently at the sites evaluated.

1031C:PAA011A3.W51

REFERENCES

Li, W.W., M.P. Scott, and J.W. Bradstreet. 1990. Modeling of on-site air concentrations at Superfund sites. In *Proceedings of the 11th National Conference, Superfund 90*, 117-122. Hazardous Materials Control Research Institute. Washington, D.C. November 26-28.

U.S. Environmental Protection Agency (USEPA). 1990. Atlas remedial investigation report and Phase I of Johns-Manville Coalinga remedial investigation report for the Atlas and Johns-Manville Coalinga sites, Fresno County, California. USEPA Region IX, San Francisco, CA. Document Control No. 239-RI1-RT-GDXV.

U.S. Environmental Protection Agency (USEPA). 1987. Office of Air Quality Planning and Standards. *Industrial Source Complex (ISC) Dispersion Model User's Guide- Second Edition (Revised).* Vol. I. Research Triangle Park, N.C. USEPA-450/4-88-002a.

U.S. Environmental Protection Agency (USEPA). 1986. Office of Research and Development. *Development of advisory levels for polychlorinated biphenyls (PCBs) cleanup.* Final. May. Washington, D.C. OHEA-E-187.

U.S. Environmental Protection Agency (USEPA). 1985a. Office of Air Quality Planning and Standards. *Compilation of air pollution emission factors.* Vol. I: *Stationary point and area sources.* Research Triangle Park, N.C. PB86-124906.

U.S. Environmental Protection Agency (USEPA). 1985b. Office of Health and Environmental Assessment. *Rapid assessment of exposure to particulate emissions from surface contamination sites.* USEPA/600/8-85/002. Washington, D.C.

U.S. Environmental Protection Agency (USEPA). 1982. Environmental Sciences Research Laboratory. *PTPLU - A single source Gaussian dispersion algorithm. Users guide.* EPA-600/8-82-014.

1031C:PAA011A3.W51

APPENDIX IV

Derivation of Toxicity Values for HSLs without USEPA-Published Toxicity Values

A. Introduction

For screening purposes only, the general methodology used by USEPA to derive acceptable daily intakes, or ADIs (also referred to by the USEPA as reference doses, or RfDs) was used to derive toxicity values for HSLs without USEPA-published values. In applying the USEPA methodology for assigning toxicity values to specific compounds, no evaluation of the validity or appropriateness of any of the elements of USEPA's methodology has been undertaken in this document. Therefore, any toxicity values so derived and included in this report are intended for use in the regulatory-type screen only. TGPL has not endorsed the USEPA procedures or assumptions that have been used to provide toxicity values. RfDs are derived by the USEPA by determining the highest no-observed-adverse-effect level (NOAEL, the highest dose not resulting in adverse affects to experimental animals) in the most sensitive animal species tested, or, if a NOAEL is unavailable, the lowest-observed-adverse-effect level (LOAEL). USEPA adjusts the NOAEL or LOAEL by a series of uncertainty factors intended to account for differences between the experimental conditions and conditions of expected human exposure, for extrapolation between species, and for variations in sensitivity within human populations. A value of 10 is commonly used by the USEPA for each individual uncertainty factor (USEPA 1988). Thus, for example, the USEPA would divide a NOAEL obtained in a chronic animal study by an overall uncertainty factor of 100, to account for extrapolation from animals to humans (10), and interhuman variability (10). In some cases, as where human populations are known to be less variable in their response to chemical exposure, the Agency may apply a smaller uncertainty factor. Presented below is a description of the toxicity value derivation for detected HSLs (or their surrogates) for which USEPA toxicity values were unavailable.

B. Dibenzofuran (unchlorinated)

An ADI of 0.6 mg/kg/day was calculated for unchlorinated dibenzofuran based on USEPA methodology, by using unchlorinated dibenzo-p-dioxin, or UDD, as a surrogate. This was based on a LOAEL observed in an NCI (1978) two-year bioassay of rats, in which evidence of hepatotoxicity was observed at 300 mg/kg/day. An uncertainty factor of 500 was applied.

A literature search for more recent information on UDD elicited only one article, by DeMarini and Simmons (1989). This study involved only one administration, and did not indicate UDD dose levels or establish an endpoint of toxicity; therefore, the NCI bioassay was used.

C. Cobalt

1. Oral Exposure

Since cobalt is an integral part of the vitamin B_{12} molecule, it is also an essential human nutrient (Calabrese et al. 1985, Underwood 1975). Based on a study by Tipton et al. (1966), the total cobalt intake for adults consuming North American diets is 0.16 to 0.17 mg/day. These levels are lower than in another study (Murthy et al. 1971) of the diets of children from 28 widely separated US institutions in which the total cobalt intake ranged from 0.30 to 1.77 mg/day, with a mean of 1.02 mg/day. Using the lower value of 0.16 mg/day and assuming a 70-kg body weight results in an ADI of 2.3×10^{-3} mg/kg/day.

2. Inhalation Exposure

According to ATSDR (1990), occupational exposure to cobalt levels ranging from 0.003 to 0.893 mg/m^3 for 2 to 17 years has resulted in respiratory effects. These effects have been observed in workers employed as hard metal workers, diamond polishers, and plate painters (painting with cobalt blue dye). The 0.003 mg/m^3 level was documented in a study of tungsten carbide production workers who had an increased incidence of interstitial lung disease (Sprince et al. 1988). Using this 0.003 mg/m^3 cobalt level and assuming that a 70-kg worker would breathe 10 m^3/day (during an 8-hour day) for 5 days a week, the cobalt dose would be 3.1×10^{-4} mg/kg/day. Applying an uncertainty factor of 100, an ADI of 3.1×10^{-6} mg/kg/day was derived.

D. 2-Hexanone

2-Hexanone, or methyl n-butyl ketone (MBK), has been associated with nervous system effects in both humans and animals. An ADI of 0.15 mg/kg/d was derived, which is based on two separate studies, one involving occupational exposure, and the other involving rats exposed via drinking water.

Allen et al. (1975) reported 86 cases of peripheral neuropathy in fabric printing plant employees. 2-Hexanone was identified as the causative agent based on spatial distribution of cases in the plant, and a recent switch from use of methyl ethyl ketone/methyl isobutyl ketone solvent to methyl ethyl ketone/MBK solvent. Air measurements taken in back of the printer machines showed MBK concentrations of 36 ppm (147 mg/m^3). An ADI of

0.15 mg/kg/d was derived based upon an occupational breathing volume of 10 m^3 per day, body weight of 70 kg, 5-day per week exposure, and an uncertainty factor of 100.

A very similar ADI of 0.14 mg/kg/d was calculated based upon a study by Krasavage et al. (1979), in which rats received 2-hexanone in drinking water for 10-13 months at 143 mg/kg, 266 mg/kg or 560 mg/kg. Central nervous system and muscle changes as well as reduced weight gain were observed in all dose groups. An uncertainty factor of 1000 was applied to the LOEL of 143 mg/kg to derive the ADI of 1.43×10^{-1} mg/kg/d. This is very similar to the 0.15 mg/kg/d ADI based upon the Allen et al. occupational study.

E. 3-Nitroaniline

Two studies were identified for 3-nitroaniline (Nair et al. 1990, 1985). One study (Nair et al. 1990) involved gavage administration of 3-nitroaniline to Sprague-Dawley rats at doses of 0.25, 1.5 or 9 mg/kg/d for two years; in a reproductive study, the same dose levels were administered to F_0 (parental) rats for 14 weeks prior to mating, and to the F_1 (first generation progeny) rats for 18 weeks prior to mating and throughout gestation. No treatment-related effects were observed in the reproductive study. In the chronic study, increased methemoglobin and increased hemosiderin pigmentation of the liver occurred at 1.5 mg/kg/d, with other blood effects at the 9 mg/kg/d dose level. No effects were observed at 0.25 mg/kg/d. An ADI of 2.5×10^{-3} mg/kg/d was derived by applying an uncertainty factor of 100 to the NOAEL of 0.25 mg/kg/d.

Nair et al. (1985) also conducted studies in which Sprague-Dawley rats and New Zealand white rabbits received doses of 25, 85, or 250 mg/kg/d (rats) or 15, 75, or 125 mg/kg/d (rabbits) by gavage during gestation. Yellow anogenital staining was observed in rabbits at all dose levels. Application of an uncertainty factor of 10,000 results in an ADI of 1.5×10^{-3} mg/kg/d. This is close to the ADI derived from the Nair et al. (1990) 2-year rat study.

In the rats receiving 3-nitroaniline on days 6-19 of gestation (Nair et al. 1985), pale eyes, dark urine and anogenital staining were observed at 85 mg/kg/d but not at 25 mg/kg/d. The use of an uncertainty factor of 1,000 results in an ADI of 0.025 mg/kg/d.

The ADI based on the Nair et al. 1990 study (2.5×10^{-3}) was selected, due to the chronic duration of the study. The ADIs derived from the Nair et al. (1985) studies are in close agreement to this value.

REFERENCES

Agency for Toxic Substances and Disease Registry (ATSDR). 1990. *Toxicological profile for cobalt*. Draft. U.S. Public Health Service.

Allen, N., J.R. Mendell, D.J. Billmaier, R.E. Fontaine, and J.O'Neill. 1975. Toxic polyneuropathy due to methyl-n-butyl ketone. *Arch. Neurol.* 32:209-218.

Calabrese, E.J., A.T. Canada, and C. Sacco. 1985. Trace elements and public health. *Ann. Rev. Public Health*. 6:131-146.

DeMarini, D.M. and J.E. Simmons. 1989. Toxicological evaluation of by-products from chemically dechlorinated 2,3,7,8-TCDD. *Chemosphere* 18:2293-2301.

Krasavage, W.J., J.L. O'Donaghue, and C.J. Terhaar. 1979. Oral chronic toxicity of methyl n-propyl ketone, methyl-n-butyl ketone and hexane in rats. *Tox. Appl. Pharm.* Part 2: A205.

Murthy, G.K., U. Rhea, and J.T. Peeler. 1971. *Environmental Science and Technology* 5:436-442. (Reported in Underwood 1975.)

Nair, R.S., C.S. Auletta, R.E. Schroeder, and F.R. Johannsen. 1990. Chronic toxicity, oncogenic potential, and reproductive toxicity of p-nitroaniline in rats. *Fund. Appl. Toxicol.* 15:607-621.

Nair, R.S., F.R. Johannsen, and R.E. Schroeder. 1985. Evaluation of teratogenic potential of para-nitroaniline and para-nitrochlorobenzene in rats and rabbits. Chapter 5 in D.E. Rickert, ed., *Toxicity of Nitroaromatic Compounds.* Washington: Hemisphere Publishing Corp.

National Cancer Institute (NCI). 1978. *Bioassay of dibenzo-p-dioxin for possible carcinogenicity (CAS No. 262-12-4).* U.S. Department of Health, Education and Welfare. NTIS PB-288-475.

Sprince, N.L., L.C. Oliver, E.A. Eisen, R.E. Greene, and R.I. Chamberlin. 1988. Cobalt exposure and lung disease in tungsten carbide production: A cross-sectional study of current workers. *Am. Rev. Respir. Dis.* 138:1220-1226.

Tipton, I.H., P.L. Stewart and P.G. Martin. 1966. *Health Phys.* 12:1683-1689. (Reported in Underwood 1975.)

Underwood, E.J. 1975. Cobalt. *Nutrition Reviews* 33:65-69.

U.S. Environmental Protection Agency (USEPA). 1990. *Health effects assessment summary tables*. Third quarter, FY-1990. OSWER (OS-230.)

U.S. Environmental Protection Agency (USEPA). 1988. *Background Document 1A: Reference dose (RfD): Description and use in health risk assessments.* Integrated Risk Information System (IRIS). Revised February 10, 1988.

1031C:PAA011A3.W51

APPENDIX V

Derivation of Benchmark Concentrations

I. SOIL

Soil benchmark concentrations are calculated for the following hypothetical exposure scenarios in accordance with formulas provided in USEPA (1989d):

• Short-term on-site worker:	Soil ingestion, dermal contact, particulate inhalation, vapor inhalation
• Long-term on-site worker:	Soil ingestion, dermal contact, particulate inhalation, vapor inhalation
• Off-site receptor:	Particulate inhalation, vapor inhalation

The screening program automatically calculates benchmarks for individual and combined potential routes of exposure, based on USEPA methodology-based ADIs and CSFs (where applicable), and selects the lowest (most conservative) benchmark to use in the HSL screening procedure.

A. Derivation of Benchmarks Using USEPA Methodology-Based ADIs

To derive benchmark soil concentrations that would yield chemical doses equal to toxicity values derived according to USEPA methodology, the following general equation is used:

$$C = \frac{RfD}{Average\ daily\ dose\ of\ affected\ soil} \qquad (1)$$

where:

C = Benchmark concentration, in mg chemical per kg soil.
RfD = Reference dose, or toxicity value, in mg/kg/day. General population RfDs are multiplied by a factor of 10 for application to on-site workers (see discussion in main text).

Average daily dose = Average daily dose (ADD) of soil in kg/kg/day, or of airborne chemical vapor in mg/kg/day per mg/kg soil.

Generally, RfDs have not been published by the USEPA for the dermal route of exposure. USEPA therefore applies oral RfDs both to oral and dermal routes (USEPA 1989d). Thus,

$$(2) \quad C_{ingestion\ +\ dermal} = \frac{RfD_{oral}}{ADD\ of\ soil\ received\ from\ ingestion\ +\ dermal\ contact}$$

Similarly, USEPA RfDs developed specifically for inhalation are used to determine benchmarks for inhalation exposure:

$$(3) \quad C_{inh\ of\ particulate} = \frac{RfD_{inh}}{ADD\ of\ particulate\ received\ from\ inhalation}$$

$$(4) \quad C_{inh\ of\ vapor} = \frac{RfD_{inh}}{ADD\ of\ chemical\ vapor\ received\ from\ inhalation,\ per\ mg/kg\ soil}$$

Vapor inhalation and particulate inhalation benchmarks may be derived separately, or may be combined to determine an overall benchmark for both inhalation routes. In cases where no inhalation RfD is available, USEPA applies the oral RfD to all routes (USEPA 1989d), e.g.:

$$(5) \quad C_{ingestion\ +\ dermal\ +\ inhal.} = \frac{RfD_{oral}}{Dose\ of\ soil\ received\ from\ ingestion\ +\ dermal\ +\ inhal.}$$

The following formulas are used to calculate the doses which are used in equations (1)-(5). For specific values used for the hypothetical short-term and long-term worker and off-site receptor, refer to Table 1 in the main report.

1. Soil Ingestion

$$(6) \quad Ingestion\ ADD = \frac{IR \cdot AF}{BW}$$

where

ADD = Average daily dose of soil, in kg/kg/d
IR = Soil ingestion rate, kg/day

AF = Gastrointestinal absorption factor
BW = Body weight, kg

2. Dermal Contact

$$\text{Dermal ADD} = \frac{SA \cdot SD \cdot AF}{BW} \tag{7}$$

where
SA = Skin surface area exposed, in cm^2
SD = Soil deposition on skin, in kg/cm^2
AF = Dermal absorption factor
BW = Body weight, kg

3. Particulate Inhalation

$$\text{Partic. Inhal. ADD} = \frac{ER \cdot UAC \cdot CF \cdot BR \cdot HE \cdot AF}{BW} \tag{8}$$

where
ER = Dust emission rate, in g/m^2-sec.
UAC = Unit air concentration, in g/m^3 per g/m^2-sec.
CF = Conversion factor, 10^{-3} kg/g
BR = Breathing rate, m^3/hr
HE = Hours exposed, hours/day
AF = Lung absorption factor
BW = Body weight, kg

4. Vapor Inhalation

$$\text{Vapor Inhal. ADD} = \frac{UER \cdot UAC \cdot CF \cdot BR \cdot HE \cdot AF}{BW} \tag{9}$$

where
UER = Unit vapor emission rate, in g/m^2-sec per g/kg soil
UAC = Unit air concentration, in g/m^3 per g/m^2-sec
CF = Conversion factor, 10^3 mg/g
BR = Breathing rate, m^3/hr
HE = Hours exposed, hours/day
AF = Lung absorption factor

BW = Body weight, kg

B. Derivation of Benchmarks Using USEPA CSFs

To derive benchmark soil concentrations that would yield chemical doses not exceeding a specified USEPA level of excess risk, the following general equation is used:

$$C = \frac{\textit{Excess risk level}}{(\textit{LADD of affected medium})(\textit{CSF})} \tag{10}$$

where

C = Benchmark concentration, in mg chemical per kg soil

Excess risk level = 1×10^{-4} (1 in 10,000) for workers, 1×10^{-6} (1 in 1,000,000) for off-site receptors for USEPA-designated Class A and B carcinogens, and 1×10^{-5} (1 in 100,000) for off-site receptors for USEPA-designated Class C carcinogens

LADD = Lifetime average daily dose of soil, in kg/kg/day, or of airborne chemical vapor, in mg/kg/day per mg/kg soil

CSF = Carcinogenic slope factor, or excess risk per mg/kg/day, in $(\text{mg/kg/day})^{-1}$

Route-specific CSFs are used where available, with oral CSFs generally applied to dermal as well as oral exposure. Thus,

$$C_{\textit{ingestion + dermal}} = \frac{\textit{Excess risk level}}{(\textit{LADD soil from ingestion + dermal})(\textit{CSF}_{\textit{oral}})} \tag{11}$$

$$C_{\textit{inhal}} = \frac{\textit{Excess risk level}}{(\textit{LADD soil from partic. inhal. + LADD from vapor})(\textit{CSF}_{\textit{inhal}})} \tag{12}$$

Equation (13) is used to derive a benchmark concentration across all routes of potential exposure:

(13) $$C_{all\ routes} = \frac{Excess\ risk\ level}{[(LADD\ soil_{ingestion\ +\ dermal})(CSF_{oral}) + (LADD_{inhal})(CSF_{inhal})]}$$

The following formulas are used to calculate the doses which are used in equations (10)-(13). Specific values used for the hypothetical short-term and long-term worker and off-site receptor are provided in Table 1 in the main report.

1. Soil Ingestion

(14) $$Ingestion\ LADD = \frac{IR \cdot EF \cdot ED \cdot AF}{BW \cdot LE \cdot DY}$$

where:

LADD = Lifetime average daily dose of soil, in kg/kg/day
IR = Soil ingestion rate, kg/day
EF = Exposure frequency, days/year
ED = Exposure duration, years
AF = Gastrointestinal absorption factor
BW = Body weight, kg
LE = Life expectancy, years
DY = 365 days/year

2. Dermal Contact

(15) $$Dermal\ LADD = \frac{SA \cdot SD \cdot EF \cdot ED \cdot AF}{BW \cdot LE \cdot DY}$$

where:

SA = Skin surface area exposed, in cm^2
SD = Soil deposition on skin, in kg/cm^2
EF = Exposure frequency, days/year
ED = Exposure duration, years
AF = Dermal absorption factor
BW = Body weight, kg
LE = Life expectancy, years
DY = 365 days/year

3. Particulate Inhalation

(16) $$Particulate\ Inhal.\ LADD = \frac{ER \cdot UAC \cdot CF \cdot BR \cdot HE \cdot EF \cdot ED \cdot AF}{BW \cdot LE \cdot DY}$$

where:

ER = Dust emission rate, in g/m^2-sec
UAC = Unit air concentration, in g/m^3 per g/m^2-sec
CF = Conversion factor, 10^{-3} kg/g
BR = Breathing rate, m^3/hr
HE = Hours exposed, hours/day
EF = Exposure frequency, days/year
ED = Exposure duration, years
AF = Lung absorption factor
BW = Body weight, kg
LE = Life expectancy, years
DY = 365 days/year

4. Vapor Inhalation

(17) $$Vapor\ Inhal.\ LADD = \frac{UER \cdot UAC \cdot CF \cdot BR \cdot HE \cdot EF \cdot ED \cdot AF}{BW \cdot LE \cdot DY}$$

where:

UER = Unit vapor emission rate, in g/m^2-sec per g/kg soil
UAC = Unit air concentration, in g/m^3 per g/m^2-sec
CF = Conversion factor, 10^3 mg/g
BR = Breathing rate, m^3/hr
HE = Hours exposed, hours/day
EF = Exposure frequency, days/yr
ED = Exposure duration, years
AF = Lung absorption factor
BW = Body weight, kg
LE = Life expectancy, years
DY = 365 days/year

II. GROUND WATER

Ground water benchmark concentrations are for screening purposes calculated for the off-site receptor hypothetical exposure scenario. The screening program automatically calculates benchmarks based on both ADIs and CSFs (where applicable) and selects the lower (more conservative) benchmark to use in the HSL screening procedure.

A. Derivation of Benchmarks using USEPA Methodology-Based ADIs

The following general equation is used to derive ground water benchmarks that will not exceed USEPA RfDs:

$$C = \frac{RfD}{ADD_{water}} \tag{18}$$

where

C = benchmark concentration, in mg chemical per liter water

ADD_{water} = Average daily dose of water, in L/kg/day

The equation used to calculate the ADD from ingestion is shown below. Specific values used in the equation are shown in Table 1 of the main report.

$$ADD_{water} = \frac{IR \cdot AF}{BW} \tag{19}$$

where

IR = Water ingestion rate, L/day

AF = Gastrointestinal absorption factor

BW = body weight, kg.

B. Derivation of Benchmarks using USEPA CSFs

To derive benchmark ground water concentrations yielding doses equivalent to a USEPA-specified level of excess risk (1×10^{-6}, or 1 in 1,000,000 for USEPA-designated

Class A and B carcinogens; 1 x 10^{-5} or 1 in 100,000 for USEPA-designated Class C carcinogens) (USEPA 1990b), equation (20) is used:

$$C = \frac{Excess\ risk\ level}{(LADD_{water})(CSF)} \tag{20}$$

where

C = Benchmark concentration, in mg chemical per liter water
$LADD_{water}$ = Lifetime average daily dose of water, L/kg/d
CSF = Carcinogenic slope factor, or excess risk per mg/kg/day, in $(mg/kg/day)^{-1}$

Equation (21) is used to calculate the $LADD_{water}$. Specific values used in the equation are presented in Table 1 of the main report.

$$LADD_{water} = \frac{IR \cdot EF \cdot ED \cdot AF}{BW \cdot LE \cdot DY} \tag{21}$$

where

IR = Water ingestion rate, L/day
EF = Exposure frequency, days/yr
ED = Exposure duration, years
AF = Gastrointestinal absorption factor
BW = Body weight, kg
LE = Life expectancy, years
DY = 365 days/year

APPENDIX VI

USEPA Methodology for Derivation of Subpart S Levels

I. SOIL

Subpart S soil levels are derived by the USEPA (1990b) based upon potential exposure through soil ingestion.

The formulas and exposure parameters used to derive proposed Subpart S soil levels based upon USEPA ADIs and CSFs (where applicable) are shown below in sections A and B, respectively.

A. Derivation of Subpart S Levels using USEPA ADIs

Proposed Subpart S levels are based upon hypothetical exposures involving a child exposed chronically (over a 5-year period).

$$(1) \quad \textit{Proposed Subpart S level, in mg/kg} = \frac{\textit{ADI}}{\textit{Average daily dose of soil received from ingestion}}$$

$$(2) \quad \textit{Average Daily Dose Soil Ingestion} = \frac{2 \times 10^{-4} \textit{ kg soil/d}}{16 \textit{ kg body weight}}$$

B. Derivation of Subpart S Levels using USEPA CSFs

Proposed Subpart S levels are based upon an adult hypothetically exposed over a lifetime.

$$(3) \quad \textit{Proposed Subpart S level, in mg/kg} = \frac{\textit{Excess risk level}}{\textit{(Lifetime average daily dose of soil)(CSF)}}$$

where:

Excess risk level = 1×10^{-6} for USEPA-designated Class A and B carcinogens
= 1×10^{-5} for USEPA-designated Class C carcinogens
CSF = Carcinogenic slope factor, in $(mg/kg/d)^{-1}$

(4) $$LADD_{soil} = \frac{(1 \times 10^{-4}\ kg\ soil/d)(365\ d/yr)(70\ yr.\ exposure\ period)}{(70\ kg\ body\ weight)(365\ d/yr)(70\ yr.\ lifetime)}$$

1031C:PAA011A3.W51

II. GROUND WATER

Subpart S ground water levels are derived by the USEPA (1990b) based upon potential exposure through ground water ingestion.

The formulas and exposure parameters used to derive ground water levels based upon USEPA ADIs and CSFs (where applicable) are shown below in Sections A and B, respectively.

A. Derivation of Subpart S Levels using USEPA ADIs

Proposed Subpart S levels are based upon adults with hypothetical long-term exposures via water ingestion.

(5) $$\textit{Proposed Subpart S level, in, mg/l} = \frac{\textit{ADI}}{\textit{Average daily dose of water ingested}}$$

(6) $$\textit{Average Daily Dose of water ingested} = \frac{\textit{2L water/d}}{\textit{70 kg body weight}}$$

B. Derivation of Subpart S Levels using USEPA CSFs

Proposed Subpart S levels are based upon an adult hypothetically exposed over a lifetime via water ingestion.

(7) $$\textit{Proposed Subpart S level in mg/l} = \frac{\textit{Excess risk level}}{\textit{(Lifetime average daily dose of water)(CSF)}}$$

where:

Excess risk level = 1×10^{-6} for USEPA-designated Class A and B carcinogens
= 1×10^{-5} for USEPA-designated Class C carcinogens
CSF = Carcinogenic slope factor, in $(mg/kg/d)^{-1}$

(8) $$LADD_{water} = \frac{(2L\ water/d)(365\ d/yr)(70\ yr\ exposure\ period)}{(70\ kg\ body\ weight)(365\ d/yr)(70\ yr\ lifetime)}$$

ENVIRON

Counsel in Health and Environmental Science

4350 North Fairfax Drive
Arlington, Virginia 22203
(703) 516-2300 · (800) ENVIRON

210 Carnegie Center, Suite 201
Princeton, New Jersey 08540
(609) 452-9000

Marketplace Tower
5820 Shellmound Street, Suite 700
Emeryville, California 94608
(415) 655-7400