

**RIO SALADO HABITAT RESTORATION PROJECT
RISK MANAGEMENT ASSESSMENT
AND MONITORING PROGRAM
CITY OF PHOENIX, ARIZONA**



AGRA Earth & Environmental

ENGINEERING GLOBAL SOLUTIONS

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AND MONITORING PROGRAM
CITY OF PHOENIX, ARIZONA**

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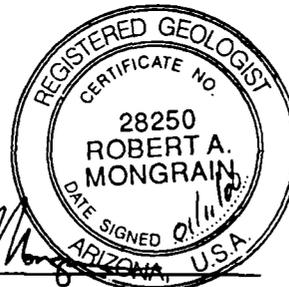
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EXECUTIVE SUMMARY

AGRA Earth & Environmental, Inc. (AGRA), on behalf of the City of Phoenix, has prepared a Risk Management Assessment and Monitoring Program (RMA) report for a portion of the Rio Salado Habitat Restoration Project. The City of Phoenix, in conjunction with the U.S. Army Corps of Engineers and other interested parties are restoring a five mile reach of the Salt River (Phoenix Reach) within the City of Phoenix. The purpose of the RMA report is to establish appropriate risk-based action levels (RBALs) which are protective of human receptors likely to be in the general vicinity during the 3-year restoration project. The basic components of the RMA are: 1) a conceptual site model; 2) data analysis; 3) an exposure assessment; 4) a toxicity assessment; and 5) calculation of action levels.

The report identified potentially impacted media, receptors (workers and general public) that could come into contact with those media, and complete exposure routes for each of those receptors. The potentially impacted media considered included sediment, air, and groundwater, either pumped or exposed to the surface. This assessment identified workers involved with restoring the habitat (trench worker), adolescents using the Phoenix Reach for recreational purposes (adolescent trespassing recreationist), nearby residents, and nearby commercial/industrial workers as those likely to be exposed to contaminated groundwater. Dermal contact, incidental ingestion and inhalation are all complete exposure routes for trench workers and adolescent trespassing recreationists exposed to groundwater and sediment. Nearby residents and commercial/industrial workers would only be exposed through inhalation of contaminants volatilized from groundwater present in trenches and excavations.

Potential constituents of concern (PCOC) were selected during data analysis by comparing groundwater data previously collected from 28 sites along the Phoenix Reach to Maximum Contaminant Levels (MCLs). The exposure assessment estimated daily intake of PCOC by a given receptor. The toxicity assessment established appropriate toxicity values for each PCOC based on the most widely accepted data.

The overall objective of risk characterization is to identify those portions of the general public that could be exposed to PCOC and then quantitatively derive an acceptable threshold exposure level or RBAL. If PCOC concentrations are below the RBAL, there is no unacceptable threat to human health at the site, and these constituents are dropped from further analysis. However, if one or more of the RBALs is exceeded, it should be considered to be one of the constituents of concern (COC) and further characterization or mitigative action may be necessary. COC were selected by preliminary screening of RBALs against existing groundwater data to estimate which PCOC may pose a health threat once they have migrated to the Phoenix Reach.

The historic groundwater data reviewed for the RMA indicates that the following PCOC have the greatest potential to be COC in the Phoenix Reach:

1,1-dichloroethene	1,2-dichloroethane
benzene	toluene
tetrachloroethene	trichloroethene
mercury	arsenic
vinyl chloride	

The results of this RMA indicate that exposure to groundwater posed the highest potential risk, as the primary source of COC, and that the on-site trench worker had the greatest risk of exposure. His/her close proximity to potentially contaminated groundwater and sediment result in exposure to COC via dermal contact, ingestion and inhalation pathways. Therefore, the trench worker had the most stringent RBALs.

This assessment has indicated that appropriate management of risk related to groundwater exposure will, in turn, address risk posed by other media. AGRA recommends that further data collection (a sampling and analysis program) be conducted to verify contaminant concentrations at specific sites in the Project Area. This will allow a more thorough evaluation of risk to the highest risk population (trench worker) at specific locations within the Phoenix Reach of the Salt River. The list of COC can then be further refined by utilizing data collected directly from daylighted groundwater and sediment in the Phoenix Reach, and comparing that data to RBALs. The direct comparison to exposed groundwater and sediment represents the most accurate and appropriate comparison; however, the preliminary screen has focused the investigation by reducing the number of PCOC which could become COC in the Project Area. The sampling and analysis program should include several locations within the Phoenix Reach where contaminants in groundwater are likely to be present (based on existing contaminant plume maps). The results of the additional data collection program should then be compared to the risk evaluation completed for this RMA report to evaluate the need for changes in construction practices as they relate to handling groundwater or sediments.

Certain options for the project exist based on the results of this RMA report. These options include: 1) no action, or moving forward with the project without further assessment or information; 2) move forward with the project and mitigate worker risks as they occur during the restoration. This will include making changes in construction practices as further data are obtained and evaluated; or 3) delay the project until site-specific data refining the potential risks are collected and evaluated. This approach will provide the highest degree of certainty in implementing monitoring and mitigation plans as the project is constructed.

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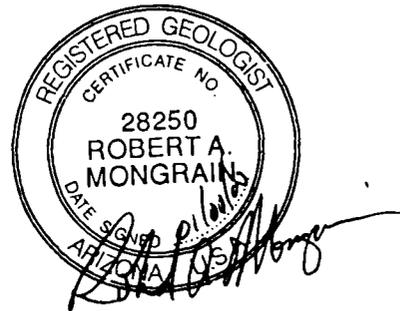
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1.0 INTRODUCTION

The City of Phoenix, in conjunction with the U.S. Army Corps of Engineers (USACE) is proposing to undertake an environmental restoration project for a five mile reach of the Salt River in Phoenix, Arizona (Phoenix Reach, depicted in Figure 1). This project is part of the overall Rio Salado Habitat Restoration project along the urban reaches of the Salt River. The restoration project includes the construction of a low flow channel, containment dikes and grade control structures in the Salt River bed. Because the area surrounding the Phoenix Reach has historically been used for gravel mining, landfills and other industrial activities, some man-made contamination is known to be present in groundwater in the area. During construction, this groundwater may be brought to the surface (daylighted groundwater) of the low flow channel and associated features and will then be discharged downstream of the construction area, either within or downstream of the Phoenix Reach.

AGRA Earth & Environmental, Inc. (AGRA) has prepared a Risk Management Assessment and Monitoring Program (RMA) report for the Phoenix Reach on behalf of the City of Phoenix. The purpose of the RMA report is to establish appropriate risk-based action levels (RBALs) to increase worker safety and ensure that public health is adequately protected during construction. It should be noted that actual risk conditions that may occur during the proposed construction are difficult to predict. However, RBALs can be identified at this time, though they are not based upon site-specific concentrations of contaminants. Rather, they are based upon general information regarding the site, anticipated exposure scenarios, and risk associated with the properties of contaminants known to be in groundwater proximal to the Phoenix Reach. The RBALs can be used to identify potential problem constituents, which can then be quantitatively assessed during future construction activities. It also should be noted that this report only addresses human health issues during the restoration period and does not assess potential issues to human health subsequent to completion of the habitat restoration, nor does it address impacts to ecological receptors during or after restoration.

1.1 BACKGROUND

Restoration of the Phoenix Reach of the Salt River is part of the overall Rio Salado Habitat Restoration Program being completed by the USACE, the Cities of Phoenix and Tempe, and other interested parties. Currently, the once perennial Phoenix Reach is a dry river bed with minimal or no vegetation and/or habitat. The overall objective of the restoration project is to enhance riparian habitat along the Phoenix Reach in order to restore local flora and fauna and to provide incidental recreational opportunities. The selected plan for the Phoenix Reach is to use shallow groundwater to create a perennial flow in the river bed.

1.2 RISK ASSESSMENT METHODOLOGY

The RMA for the Phoenix Reach has been performed in accordance with applicable guidance on risk assessment methodology issued by the United States Environmental Protection Agency (EPA). Arizona Department of Environmental Quality (ADEQ) guidance was reviewed in addition to the EPA documents to ensure that the assessment included any state specific requirements. Current toxicity information and standard default exposure assumptions were utilized for this assessment where appropriate. In certain instances, conservative but realistic, site-specific assumptions have been used for those exposure parameters where default assumptions do not accurately characterize potential exposures at the Phoenix Reach. Appropriate justification for the use of all site-specific exposure assumptions is included in this report. The following guidance documents have been the primary documents used in developing the assessment:

- *Risk Assessment Guidance for Superfund, Volume 1, Human Health Evaluation Manual/ Part A (RAGS/Part A)* (EPA, 1989b);
- *Risk Assessment Guidance for Superfund, Volume 1, Human Health Evaluation Manual/ Part B (RAGS/Part B)* (EPA, 1991b);
- *Human Health Evaluation Manual, Supplemental Guidance: Standard Default Exposure Factors* (EPA, 1991a);
- *Exposure Factors Handbook* (EPA, 1995a);
- *Air/Superfund NTGS Series: Volume IV-Procedures for Dispersion Modeling, and Air Monitoring for Superfund Air Pathways Analysis* (EPA, 1989a)
- *Standard Guide for Risk-Based Corrective Action Applied at Petroleum Release Sites* (ASTM, 1995);

The five basic phases utilized in this RMA evaluation are:

1. Conceptual Site Model - review available information to ensure that it is adequate to complete the RMA; including identified contaminant sources, potentially impacted media, receptors that could come into contact with those media, and complete exposure routes for each of those receptors;
2. Data Analysis - statistical analysis and selection of potential constituents of concern (PCOC);

3. Exposure Assessment - select appropriate equations and parameters in order to estimate average daily chemical intakes for all complete exposure pathways;
4. Toxicity Assessment - identify chemical dose-response relationships and daily intake levels at which no adverse effects or unacceptable cancer risks can reasonably be anticipated to result and select appropriate toxicity indices for each PCOC;
5. Action Level Calculation - establish target risk level, combine average daily chemical intake levels, toxicity indices and target risk levels to calculate quantitative action levels.

This protocol is consistent with EPA's paradigm stated in the *Risk Assessment Guidance for Superfund, Volume I, Human Health Evaluation Manual, Part A: Interim Final* (EPA, 1989b). The specific methodologies to be employed in each component of the risk evaluation are detailed in the following sections.

The results of this RMA will be a listing of Action Levels for each identified PCOC. It is important to note that the action levels listed for each medium (sediment, water, etc.) are derived from the associated risk each PCOC represents to human health and are not related to actual contaminant levels measured in these media. These action levels will not predict PCOC concentrations at specific locations at the site. Instead, they will represent threshold levels for remedial action in order to mitigate risk to human health at all locations where the PCOC may be encountered.

2.0 CONCEPTUAL SITE MODEL

The Conceptual Site Model (CSM) is a formal process for outlining preliminary hypotheses about risk resulting from site activities. It utilizes previously collected information such as site history, site geography, site geology and land use trends to identify complete exposure pathways. Only complete pathways provide a route of exposure where receptors may take in chemicals. Complete pathways are defined by four components. If any one of the components is missing, the pathway is not considered complete, and therefore no risk can be associated with that pathway. These components are:

1. A source and mechanism of chemical release (e.g., spills);
2. A retention or transport medium (e.g., sediment);
3. A point of potential contact with the impacted medium, referred to as the exposure point (e.g., exposed surface sediments); and

4. An exposure route (e.g., dermal contact with impacted sediments).

For the Rio Salado Habitat Restoration Project assessment, AGRA reviewed data from a report prepared by the USACE entitled, "Rio Salado Salt River, Arizona Feasibility Report and Environmental Impact Statement", dated April 10, 1998 (EIS) and a report prepared by Dames & Moore entitled "Rio Salado Habitat Restoration Project; Groundwater Quality Investigation; City of Phoenix, Arizona", dated October 3, 1997. Additionally, a site visit was conducted in early October 1999 to familiarize the project team with site conditions and evaluate potential exposure pathways.

Figure 2 presents a detailed description of the project site. Figure 3 illustrates human health exposure pathways in the Phoenix Reach and denotes which pathways are potentially complete at the subject site. Each exposure pathway deemed to be complete was considered in the risk management evaluation. The following text explains the rationale behind the selection of impacted media, receptors exposed to that media, and the route by which the receptors are exposed.

2.1 MEDIA

Shallow groundwater may be present at the surface due to excavation activities in the river bed during the Rio Salado Habitat Restoration Project. The potential sources of chemicals impacting this shallow groundwater have been identified in prior off-site investigations. The media that could be impacted by PCOC from the shallow groundwater include daylighted groundwater (groundwater that may seep into trenches or other features associated with habitat restoration. It is different from surface water in that its source is not storm water runoff or other effluent collecting in the river bed.), sediment and air. RBALs which incorporate each of these media will be developed as part of this assessment.

2.2 RECEPTORS

In order to determine if a given population is a potential receptor, it is imperative to understand the past, present and future uses of the land being considered. Currently, the Phoenix Reach experiences intermittent flow largely correlated to storm and flooding incidents. Standing bodies of pooled (non-flowing) surface water were observed at the 7th Avenue, Central Avenue, 7th Street and Interstate 10 overpasses during a site reconnaissance by AGRA in October, 1999. Active gravel mining and construction-type vehicles along established unpaved roads in dry portions of the river bed were also noted during that visit. Land use directly adjacent to the river bed in the Phoenix Reach is typically well-established commercial-industrial use. Office buildings, gravel mining facilities, landfills and other commercial-industrial businesses were observed. There is no residential land use directly adjacent to the Phoenix Reach; however, residents are located between approximately one quarter mile and one half

mile away at several locations. On the south side of the Phoenix Reach, residential housing was observed east of 7th Avenue, between 16th Street and 24th Street, and east of 24th Street. Residents east of 24th Street were the closest to the Phoenix Reach. Direct access to the Phoenix Reach was impeded by an industrial facility, but the distance was estimated to be less than one quarter mile. Only one residential area was noted on the north side of the Phoenix Reach, east of 16th Street. General land uses along the Phoenix Reach are depicted on Figure 4.

The only future land use anticipated to vary from that occurring currently will be in the river bed of the Phoenix Reach. In order to restore the environmental habitat, a low flow channel, guide dike structures and grade control structures will be constructed. The low flow channel will extend the entire five miles of the Phoenix Reach. Thirty-six guide dike structures are anticipated to be constructed, dispersed intermittently along the Phoenix Reach. Additionally, three grade control structures will be installed downstream of 16th Street, downstream of 24th Street and upstream of 24th Street, respectively.

The process of selecting receptors also utilizes spatial and temporal considerations to determine which populations will be potentially subject to the greatest risk. In general, the closer a receptor is to the source, the greater the risk. Likewise, all other things being equal, a longer duration of exposure will be associated with a greater potential risk. Potential human receptors during construction of the Phoenix Reach have been designated as construction workers, trespassing adolescent recreationists, commercial/industrial users and off-site residents (listed in sequential order from receptors closest to the source to receptors farthest away from the source). Exposure routes for each of these potential receptors is discussed below.

2.3 EXPOSURE ROUTES

There are two types of exposure routes generally considered in the risk assessment process: direct exposure routes and indirect exposure routes. A direct exposure route is complete when a receptor comes into direct contact with the impacted media (*e.g.*, dermal contact or ingestion). An indirect exposure occurs when the PCOC is transferred from the originally impacted media to another media (*e.g.*, groundwater contacting river channel sediments) and, subsequently, to a human receptor. Also, a given receptor may be exposed to one media, but not another (*e.g.*, a construction worker may be exposed to sediments, but not daylighted groundwater) and the evaluation of exposure routes should additionally be dependent on which environmental media are being considered. Therefore, identification of potentially complete exposure routes in daylighted groundwater, sediment and air for each receptor is discussed separately below.

2.3.1 Daylighted Groundwater

Direct exposure to PCOC in daylighted groundwater in the Phoenix Reach include incidental ingestion of and dermal exposure to daylighted groundwater. The receptors with the greatest potential to come into direct contact with daylighted groundwater on a regular basis are construction workers and trespassing adolescent recreationists. The reasonable maximum exposure for construction workers would likely be standing in shallow pools during work days rather than full immersion. Therefore, dermal contact to a portion of skin surface area is the most likely long-term exposure for construction workers. Because there are standing pools of water currently present within the Phoenix Reach, and other pools may form during the project, trespassing adolescent recreationists could potentially swim; thereby, incidentally ingesting some daylighted groundwater as well as receiving dermal contact to a large portion of skin surface area. Indirect exposure routes include inhalation of vapors (discussed in Section 2.3.3).

2.3.2 Sediment

Direct exposure to PCOC in sediment is likely limited to inorganic or semi-volatile constituents that could potentially precipitate from the water column. Direct dermal exposure to sediment under daylighted groundwater for construction workers and trespassing adolescent recreationists is possible. Incidental ingestion of sediment occurring after daylighted groundwater has evaporated may also occur for these receptors. Indirect exposure to PCOC in sediment may occur from inhalation of dust or outdoor air.

2.3.3 Air

Air exposure pathways are indirect pathways with either a daylighted groundwater or sediment source component. All four of the Phoenix Reach receptors (construction worker, trespassing adolescent recreationists, industrial/commercial user, and off-site residents) have the potential to be exposed to volatilized PCOC via inhalation of outdoor air. Exposure to PCOC may occur from inhalation of vapors from the daylighted groundwater source.

Likewise, inhalation of sediment dust particles that are carried in the air after affected daylighted groundwater has evaporated is a potentially complete exposure route for construction workers, trespassing adolescent recreationists, commercial/industrial workers and residents in close proximity to the river bed. PCOC adhered to dust particles would be limited to semi-volatile and inorganic constituents. Volatile constituents will likely volatilize from daylighted groundwater before settling could occur or before the daylighted groundwater evaporates. Under most circumstances inhalation of PCOC in sediment dust particles will result in a *de minimis* exposure; however, dust may be a factor during construction of the Phoenix Reach and this route is therefore evaluated as part of the RMA.

3.0 DATA ANALYSIS

Data analysis is necessary to focus a risk assessment on chemical stressors that could cause unacceptable health hazards at a given site. Identifying which chemical stressors are most likely to be PCOC for the Phoenix Reach is of particular importance because: 1) no site-specific analytical data for daylighted groundwater, sediment or air have been collected to date; and 2) the type of commercial or industrial use in close proximity to the Phoenix Reach is widely varied (*i.e.*, landfills, manufacturing, airport, service stations) which indicates the potential for multiple types of PCOC to be present (*i.e.*, metals, chlorinated solvents, petroleum constituents). Information on potential PCOC was obtained from the Dames & Moore report *Groundwater Quality Survey for the Rio Salado Habitat Restoration Project* (1997). This study compiled analytical groundwater data collected for various purposes from 28 sites along the Phoenix Reach. The analytical data include a wide variety of constituents which may be expected in an industrial area. The data analysis process includes two steps: statistical analysis of historical data and selection of PCOC.

3.1 STATISTICAL ANALYSIS

Concentrations of constituents detected in groundwater from the 28 sites identified in *Groundwater Quality Survey for the Rio Salado Habitat Restoration Project* (1997) were compiled into one database for the purposes of the assessment. The database has been analyzed statistically using SiteStat[®], a commercially available software package. The statistical analysis calculations included the total number of samples analyzed for a given constituent, the number of times that constituent was detected, minimum concentration, arithmetic mean, maximum method reporting limit (MRL), maximum concentration, standard error of the mean, the 95% upper confidence limit of the arithmetic mean concentration (95% UCL), logarithmic mean, and the 95% upper confidence limit of the logarithmic mean (Log 95% UCL).

Samples from various media at any site under investigation undergo laboratory analyses that are designed to quantify the concentrations of the various constituents in the various environmental media. As a result of the analytical procedures, a constituent may be detected and its concentration measured, detected but not able to be quantified, or not detected at all in a sample. The data set contains several constituents that were detected in some, but not all of the samples (*i.e.*, vinyl chloride was tested for in 410 groundwater samples but only detected in 19). Some options for the treatment of non-detect analytical results include: 1) assuming the PCOC is present at the MRL; and 2) assuming no PCOC were present and the concentration is zero. Assuming that the first alternative is true may be biased because the chemical may be absent altogether. Assuming a concentration of zero is also flawed, because the chemical could be present at a level below laboratory capabilities to detect and quantify the concentration. Consequently, for this assessment, when a constituent for any given

chemical analysis was not detected in a given sample, it was assumed to be present at a concentration equivalent to one-half of the MRL.

The results of the statistical analyses for groundwater samples used in the RMA are presented in Table 1.

3.2 SELECTION OF CONSTITUENTS OF CONCERN

All analytes detected at least once in groundwater were considered in the selection process for PCOC. Three factors were considered in the selection process:

- Are the analytes essential nutrients which clearly will not pose a concern (*i.e.* calcium)
- Frequency of detection
- Analyte detected at concentrations toxic to humans

Essential nutrients eliminated from further consideration are calcium, potassium, magnesium, and sodium. The next step in the process is to divide the analytes on the basis of frequency of positive detection. If the frequency of detection for an analyte is less than 5% (in a sample set of 20 or more samples), it may be a candidate for elimination. This determination is based on whether the concentrations which are detected could be toxic to selected receptors (EPA, 1989a).

The Maximum Contaminant Level (MCL) is used as the appropriate toxicity screening for groundwater, because it is the most stringent promulgated screening criteria for humans exposed to groundwater. The maximum concentration for each detected analyte within the database was compared to the MCL. If the maximum concentration in groundwater for a given analyte did not exceed the MCL, that analyte was eliminated from the assessment (Table 2). If an analyte had a concentration above the MCL and frequency of detection less than 5%, the argument could be made that it should not be considered as a PCOC; however, as a conservative measure, and for purposes of this assessment, the analyte was included as a PCOC. Table 2 presents analytes selected as PCOC based on these criteria.

One additional factor was considered in the selection of PCOC. A statistical summary of all analytical data indicated that Polynuclear Aromatic Hydrocarbons (PAHs) and methyl-tertiary butyl ether (MTBE) were not evaluated at any of the 28 sites. These are analytes commonly associated with many types of industrial processes and petroleum releases; therefore, all PAHs and MTBE were included as potential PCOC.

4.0 EXPOSURE ASSESSMENT

The overall objective of developing RBALs is to calculate a site-specific residual concentration for each PCOC in each media of concern that will not cause adverse health effects. RBALs are calculated by combining average daily intakes for each selected receptor with contaminant-specific toxicity information and acceptable risk and hazard values. The exposure assessment estimates the average daily intake by using information such as the type, magnitude, frequency, and duration of exposures to PCOC. The basic equation utilized to derive an RBAL is as follows:

$$RBAL = TR \times \frac{1}{TV} \times \left(\frac{BW \times AT}{CR \times EF \times ED} \right)$$

where:

- RBAL = Risk-Based Action Level; that is, the contaminant concentration to be estimated (in milligrams per kilogram [mg/kg]).
- TR = target risk level, most frequently, 1×10^{-6} for excess cancer risk or 1 for a non-carcinogenic hazard index.
- TV = toxicity value; for carcinogenic effects, a slope factor (SF) is used (mg/kg/day)⁻¹, for non-carcinogenic effects, a reference dose (RfD) is used (mg/kg/day)
- CR = contact rate (e.g., mg/day)
- EF = exposure frequency (days/year)
- ED = exposure duration (years)
- BW = body weight (kg)
- AT = averaging time (days); the averaging time is equal to ED × 365 days/year for non-carcinogenic effects and to a lifetime of 70 years × 365 days/year for carcinogenic effects of contaminants.

The target risk level (TR) is selected during the Calculation of Risk-Based Action Levels (Section 6) and the appropriate toxicity value (TV) for each PCOC is selected in the Toxicity Assessment (Section 5).

The remaining parameters in the equation are exposure parameters falling into two main categories: general exposure parameters or route specific parameters. Body weight (BW), averaging time (AT), exposure frequency (EF) and exposure duration (ED) are all general exposure parameters included in all exposure assessments. The contact rate (CR) is route specific and may incorporate more than one variable into the equation. For example, ingestion rate and matrix effect are combined to estimate the contact rate for the sediment ingestion exposure route. Default or site-specific data can be selected for any of these parameters. Tables 3 and 4 summarize all parameters used to calculate exposure for all receptors in daylighted groundwater and sediment, respectively. The variations applied to the general intake equation for each receptor and each pathway are presented in Tables 5 through 15 and are additionally discussed below.

4.1 GENERAL EXPOSURE PARAMETERS

Body Weight (BW), Averaging Time (AT; determined separately for carcinogenic and non-carcinogenic exposures), Exposure Frequency (EF), Exposure Duration (ED), and Exposure Time (ET) are general parameters which remain unchanged throughout all intake calculations for each specific receptor type and location.

4.1.1 Body Weight

All receptors fall into one of two general categories for body weight (BW); adolescents or adults. The BW for the adolescent trespassing recreationist was calculated to be 45 kilograms (kg) (99 lbs.) using the average weight of males and females between the ages of 6 and 18 (EPA, 1996). The EPA adult body weight default value of 70 kg (154 lbs.) (EPA, 1991) represents the most appropriate value for all adult receptors (construction worker, commercial/industrial worker and resident).

4.1.2 Averaging Time

The AT parameter represents the period over which exposure is averaged. The AT value for human health cancer risk calculations; AT_c , prorates a total cumulative dose over a lifetime. The EPA takes the position that any single exposure to a carcinogen, no matter how minute, has been associated with some risk of evoking a carcinogenic response. That is, no dose is considered to be without some level of risk, although at very low doses the risk may be infinitesimally small (EPA, 1989a). Thus, the AT_c value for each receptor is the product of a 365-day year and a 70-year life span, or 25,550 days.

The AT_n factor, used for non-carcinogenic effects, is the product of a 365-day year and the exposure duration (*i.e.*, $AT_n = 365 \text{ days/year} \times ED$). The ED for completion of environmental

restoration along the Phoenix Reach as part of the Rio Salado Restoration Project is two years (Section 4.1.4); therefore, the At_n for all receptors is 730 days (365 days/year \times 2 years).

4.1.3 Exposure Frequency (EF)

The Exposure Frequency (EF) describes the number of times per year that an event related to exposure risk is likely to occur; this factor is most often expressed in units of days/year. Variables such as weather, vacations, sick days, and institutional controls often aid in determining reasonable and realistic exposure frequencies.

EPA (1991) utilizes 250 days/year as a default value for commercial/ industrial exposure frequency. This standard default value for EF was utilized for the on-site construction worker and the off-site commercial/industrial receptors.

The river bed of the Phoenix Reach is not currently promoted as a recreational area (*i.e.*, a park); in addition, no evidence of regular use by trespassing recreationists such as bike trails, hiking paths for fishing, or rope swings in swimming areas were noted during the site reconnaissance. However, access is not limited to prohibit such activities. A conservative assumption that the site could be used for recreational purposes by the same individual every weekend of the year (104 days/year) has been selected as the appropriate EF for trespassing adolescent recreationists.

A standard default value of 350 days/year (EPA, 1991) is used for residential receptors. This represents an upper-bound estimate by assuming that a resident is at his/her home 24 hours a day and only leaves for 15 days out of an entire year.

4.1.4 Exposure Duration (ED)

The ED parameter in the intake equations represents the number of years during which an event is likely to occur. Factors affecting this parameter include variables such as age of receptor, population mobility, and occupational mobility. Exposure durations of less than seven years typically correspond to sub-chronic exposures while those greater than seven years are typically considered chronic exposures (EPA, 1989a). Based upon project logistics and a discussion with the City of Phoenix, the environmental restoration project for the Phoenix Reach is anticipated to last approximately two years. Therefore, two years was selected as a reasonable upper-bound estimate for all receptors.

4.1.5 Exposure Time (ET)

Exposure Time (ET) is expressed in hours and represents the portion of a given day (EF) which is spent on a given activity. Exposure to water or sediment for a trespassing adolescent

recreationist occurs when he/she is swimming or wading in one of the standing surface water bodies. According to EPA (EPA, 1989a) the national average time spent swimming is 2.6 hrs/day. This is the ET default value for trespassing adolescent recreationists.

The construction worker is the only other receptor which requires an estimation of ET. This assessment derives RBALs for construction workers in dermal contact with daylighted groundwater. That is, the construction worker is standing in daylighted groundwater getting wet while he/she is working. According to construction plans, the construction foreman and surveyors will be the only workers down in the trenches for short durations of time to inspect project work. While this may happen on occasion to construction foremen inspecting structures or surveyors for short durations of time, assuming that a construction worker would spend an entire 8 hour shift standing in water is a gross overestimation of risk. There are no default values available in federal guidance for this type of exposure. Therefore, a realistic yet still conservative estimate of ET for construction workers in daylighted groundwater (1 hr/day) is used as site-specific ET. In order to estimate permissible inhalation exposures, an 8-hour work day was used as the work exposure time (ETw) for both the construction worker and the construction foreman.

4.2 PARAMETERS UTILIZED IN DERMAL CONTACT EXPOSURE ROUTES

Dermal exposure to daylighted groundwater and sediment have the following route-specific parameters: skin surface area (SA), soil/sediment adherence factor (ADF), absorption factor (ABS), and dermal permeability constant (K_p). These parameters are discussed in the following sections.

4.2.1 Skin Surface Area

The only two receptors anticipated to have dermal contact exposure routes are construction workers and trespassing adolescent recreationists. The EPA default skin surface area of 20,000 square centimeters (cm^2) was used as the total skin surface area (SA_T) for the construction worker and construction foreman receptors (EPA, 1996). The SA_T for trespassing adolescent recreationists was calculated to be 16,021 cm^2 using mean measurements from EPA's *Exposure Factors Handbook* (EPA, 1996). The total skin surface area is then multiplied by a fraction of skin surface available for exposure (PS) to account for portions of the body that might be covered (SA). This fraction depends on the type of activity in which the receptor was reasonably expected to participate.

It is assumed that dermal contact with sediment for a trespassing recreationist is restricted to body areas not covered by wearing shorts and a short-sleeved shirt; *e.g.*, all but the trunk are assumed to have been exposed. According to EPA (EPA, 1996), the trunk comprises 34 percent of the total body surface area (calculated from the mean percentage of total body

surface area for males and females between the age of 6 and 18 years), thereby, allowing the remaining 66% (PS) available for exposure. The SA exposure for sediment was calculated to be 10,651 cm². In estimating SA for daylighted groundwater exposure, the assumption was made that all but the head (PS = 90%, EPA, 1996) could be completely submersed in the water at any given time; thus, SA for daylighted groundwater exposure equals 14,436 cm².

As with the trespasser, two different PS values were used for construction worker exposure to sediment and daylighted groundwater. In estimating dermal exposure to sediment, 28% (EPA, 1996) of the skin surface area is assumed to be continuously available for exposure, which is equivalent to an exposed skin surface area (SA) of 5,560 cm². The lower legs (23% of skin surface) were assumed to be available for dermal exposure to daylighted groundwater (EPA, 1996) and SA was calculated to be 4,540 cm².

4.2.2 Soil/Sediment Adherence Factor

Until recently the EPA-recommended default for soil adherence to skin ranged from 0.2 to 1.0 mg/cm² for the entire exposed surface area, without consideration for the type of activity (EPA, 1992a). However, the data from which default values were derived consisted of indirect measurements, artificial activities, and sampling for hands only. A more recent study has presented the results of direct measurement of soil/sediment loading on skin surfaces before and after normal occupational and recreational activities that might result in soil/sediment contact (Kissel and others, 1996; EPA, 1996). A range reflecting a five-order of magnitude difference among values (roughly 10⁻³ to 10² mg/cm²) was reported for observed activity-related hand loadings. This report indicated that hand loadings within the range of 0.2 to 1 mg/cm² were produced by activities in which there was vigorous soil/sediment contact (*e.g.*, rugby, farming); but for activities in which there was less soil/sediment contact (*e.g.*, soccer, professional grounds maintenance), loadings substantially less than 0.2 mg/cm² were found on hands and other body parts. Kissel and others (1996) concluded that, because non-hand loadings attributable to higher contact activities exceeded hand loadings resulting from lower contact activities, hand data from limited activities cannot be used as a conservative predictor of loadings that might occur on other body surfaces without regard to activity. Furthermore, because exposures are activity-dependent, dermal exposure to soil/sediment should be quantified using data describing human behavior (*e.g.*, type of activity, frequency, duration, including interval before bathing, clothing worn). More recent guidance documentation (EPA, 1996) has adopted this same position.

This analysis follows Kissel and others (1996), and adopts an activity-specific soil/sediment adherence factor for both the trespassing adolescent recreationist and the construction worker, exposed to sediment, which is based on data for irrigation installers.

Activity	Body Part (mg/cm ²)			
	Hands	Arms	Legs	Face
irrigation installer	0.19	0.18	0.0054	0.0063

These data provide a reasonable facsimile for the trespassing adolescent recreationist and the construction worker, as user; installation activities include both operation of machinery and manual labor.

Soil/Sediment adherence factors were calculated by normalizing each body part-specific soil/sediment adherence value with regard to the percentage of total body surface area occupied by the respective body part. Surface area percentages for hands, forearms, legs, and face are 5.2, 5.9, 12.8, and 3.9 percent, respectively (EPA, 1996). These body parts comprise 27.8 percent of the total body surface area. The normalized values for all body parts of interest were added, and the sum was divided by the total percentage of body surface area consisting of these parts. The soil/sediment adherence factor for construction workers and trespassing adolescent recreationist was calculated as follows:

$$\text{ADF (mg/cm}^2\text{)} = \frac{(0.19 \times 0.052) + (0.18 \times 0.059) + (0.0054 \times 0.128) + (0.0063 \times 0.039)}{27.8}$$

This calculation results in an ADF value of 0.077 mg/cm².

4.2.3 Absorption Factor

Another exposure factor necessary to estimate dose, and therefore risk, via dermal contact with sediments containing chemical constituents is the absorption factor (ABS) of the specific chemical from sediment. In general, the stratum corneum of the skin provides an effective barrier to environmental toxins. For example, certain hair-coloring formulations which are vigorously rubbed onto the scalp on a daily basis contain lead acetate at concentrations up to 300,000 ppm, yet lead toxicity does not appear to result. Moore and others (1980) determined that the rate of lead absorption from 203 Pb-labeled lead acetate in cosmetic preparations containing 6 mmol Pb acetate per liter (L) in male volunteers over 12 hours was 0.06% during normal use of such preparations. For most inorganic salts, percutaneous absorption is considered insignificant relative to incidental ingestion (for example, EPA Ambient Water Quality Criteria Documents, 1986). On the other hand, some drugs (e.g., nicotine) are effectively administered and absorbed into the blood stream from dermal "patches."

Most dermal bioavailability data for contaminated soil/sediments have been obtained in laboratory animals or in vitro test systems. This introduces a significant source of uncertainty

for predicting the human response. Safety factors have sometimes been applied to dermal absorption data obtained in animals to conservatively estimate the upper-bound of likely human percutaneous uptake of a certain chemical from skin exposure. This is usually unnecessary, because human skin has generally been shown for a diverse group of chemicals to be about ten-fold less permeable than the skin of typical animal species, such as rabbits and rats (Bartek and LuBedde, 1975; Shu and others, 1988).

As recently as December 1995, EPA Region III evaluated the available data concerning the dermal absorption of specific chemicals and classes of chemicals and provided several recommendations (EPA Region III Assessing Dermal Exposure from Soil, 1995). Based on pharmacokinetic properties of chemicals which were summarized in Ryan and others (1987), the EPA proposed a range of 0.1% to 1.0% for dermal absorption of inorganics (*e.g.*, metals) from soil adhering onto human skin. In this assessment, dermal absorption from the sediment is assumed to be 1% for inorganics.

For volatile organic compounds (VOCs), the risk of dermal absorption is not dependent upon dermal permeability, but rather on the rate of evaporative loss from the sediment particulates that become airborne prior to deposition on the skin surface or following the adherence on the skin surface of VOC-contaminated sediment directly contacted. Loss of chemicals from soil/sediment *in-situ* has been measured many times. The equations of Dragun (1988) suggest that the depletion rate is fairly rapid, although slower than with some other models. Solvents have much shorter half-lives on individual particles in air or on skin, due to the short diffusion distances (Howd and McKone, 1991). Howd and McKone (1991) estimated that the half-life of volatile organics from soil/sediment particles in air is on the order of 0.04 and 0.2 seconds for benzene, for example, at particle sizes of 5 mm and 25 mm, respectively. These same authors estimate the evaporative half-lives of most VOCs from soil/sediment particles on skin are about an order of magnitude less (*i.e.*, 4 to 10 milliseconds). Under conservative assumptions of exposure, Howd and McKone (1991) estimated that the uptake of carbon tetrachloride, for example, following dermal contact (1,000 mg CCl₄/kg soil/sediment at initial contact) is about 0.04 percent of the initial loading, and uptake of the solvent via ingestion of sediment on skin is 30 minutes after picking up the VOC-contaminated sediment on hands is less than 0.001 percent.

The EPA has recognized that rapid evaporative loss of VOCs from sediment adhering onto warm, air-exposed skin will preclude significant dermal absorption (Ryan and others, 1995). For volatile organics such as benzene (with a vapor pressure of about 95 millimeters of mercury (mmHg), the EPA recommends an ABS factor of 0.05% based on studies by Skowronski and others (1988) and Franz (1984); otherwise, 3% is suggested. In accordance with Region III (EPA, 1995b), 3% will be utilized as a conservative ABS for all VOCs.

For PAHs and other semi-volatile compounds, such as bis(2-ethylhexyl)phthalate, the EPA recommends a range of 1% to 10% (Exposure Factors Handbook, EPA, 1995a). For PAH compounds (viz., benzopyrene), Yang and others, (1989) reported an absorption fraction of 0.00022/hr based on in vivo and in vitro measurements of tritium-labeled benzo(a)pyrene dermal uptake from a soil matrix fortified with one percent crude oil applied to the shaved dorsal skin of rats. Conservatively assuming a 10-hour exposure period, the uptake would be 0.22%. Kao and others, (1985) reported 2.7 percent for absorption of topically applied pure benzo(a)pyrene by human skin in vitro. For the purpose of this risk assessment, an ABS of 10% is conservatively assumed for dermal absorption of semi-volatile organic compounds.

4.2.4 Dermal Permeability Constant

The dermal permeability constant (K_p) is applied in all situations where water dermal exposure routes are addressed in this assessment (*i.e.*, construction workers and trespassing adolescent recreationists). The permeability constant, K_p , accounts for the movement of a constituent dissolved in water through the skin, across the stratum corneum, and into the blood stream. K_p values for the constituents examined in this assessment were obtained from EPA guidance documentation (EPA, 1992a). For values not available in EPA (1992a), the K_p value was calculated using the equations provided in the document.

4.3 PARAMETERS UTILIZED IN INGESTION EXPOSURE ROUTES

The ingestion rate of a given media and Matrix Effect are parameters specific to the ingestion route. These parameters are incorporated into the generic intake equation listed above.

4.3.1 Ingestion Rate

The ingestion rate is necessary to adequately assess the amount of a specific impacted medium that a given receptor will potentially ingest. EPA default values were used to estimate sediment ingestion for a trespassing adolescent recreationist (100 mg/day) and construction worker (50 mg/day) (EPA, 1991). Trespassing adolescent recreationists could incidentally ingest surface water while swimming, but this is not a complete exposure route for any other receptor. The recommended default value for incidental ingestion of surface water while swimming is 0.05 L/hour (EPA, 1989).

4.3.2 Matrix Effect

Incidental ingestion incorporates the matrix effect into the general intake equation. When chemicals are administered in solid vehicles such as food and sediment, only a fraction of the ingested dose is extracted from the vehicle and subsequently absorbed through the gastrointestinal tract (EPA *Estimated Exposure to Dioxin-like Compounds*, 1992b).

Gastrointestinal absorption of contaminants sorbed onto such a medium is inhibited by physical-chemical bonding to the matrix (Hawley, 1985). This phenomenon is referred to as the gastrointestinal matrix effect (ME) of soil/sediment. Several studies referenced in the EPA's *Guidance for Data Usability in Risk Assessment Part A* (1992c) and *Estimated Exposure to Dioxin-like Compounds* (1992b) have been performed to estimate the oral absorption factors of chemicals from soil/sediment.

The bioavailability of inorganic compounds in sediment after ingestion is not well established. Gastrointestinal absorption of cadmium is only about 5 to 8 percent, 1 percent for chromium, 5 to 15 percent for lead (of which only 5 percent is retained in the body), and sparse amounts of nickel (Amdur and others, 1991). The EPA recognizes the importance of bioavailability as exemplified in its publication of two oral risk reference dose values (RfDs) for cadmium, one for cadmium in food, and one for cadmium in water. The EPA has also published two RfDs for manganese to address the bioavailability of its different forms. The separate RfDs for food and water indicate a potentially higher bioavailability of manganese dissolved in drinking water (IRIS, 1999b).

EPA *Human Health Evaluation Manual, Part B: Development of Risk-based Preliminary Remediation Goals* (1991) notes that:

For the sake of simplicity at scoping, it is assumed that the dose administered to test animals in toxicity studies on which toxicity values are based was fully absorbed. This assumption may need to be revised in cases where toxicity values based on route-to-route extrapolation are used, or there are significant differences in absorption likely between contaminants in site media and the contaminants in the vehicle used in the toxicity study.

Thus, the EPA acknowledges that matrix effects can profoundly influence chemical intake.

For semi-volatiles such as PAHs, a gastrointestinal matrix effect value of 0.29 will be utilized based on studies by Magee and others, (1996) and Yang and others (1989). Gastrointestinal absorption of inorganics and volatile organics is likely to be significant; however, data are sparse. Consistent with the EPA's recommendation for using a combination of average and upper-bound assumptions for estimating the reference ME (RME), an ME of 100 percent or an ME factor of 1.0 (*i.e.*, the maximum or worst-case assumption) is utilized for these compound classes in this RMA.

4.4 PARAMETERS UTILIZED IN INHALATION EXPOSURE ROUTES

Inhalation of PCOC associated with vapors from daylighted groundwater, vapors from sediment, and fugitive dust particles from sediment is an exposure route with several, necessarily unique parameters. The first mathematical step is to develop a volatilization factor

(VF) which converts concentrations in air to equivalent concentrations in water or sediment. Once a VF has been calculated, the following route specific parameters are added to the general intake equation: Inhalation Rate (IR_A), Retention Factor (RF), Fraction of Respirable (particles 15 microns or less in size [$PM_{1.5}$]) particles (RA), and Alveolar Factor (AF).

4.4.1 Daylighted Groundwater-to-Air Volatilization Factor for On-Site Construction Worker and Trespassing Adolescent Recreationist

For this study, daylighted groundwater-to-air volatilization assumes a relatively stationary air mass surrounding the on-site construction worker. This scenario also assumes that the receptor is within the boundary of the standing water (*i.e.* individual is standing/swimming in the exposed daylighted groundwater). There is little information available in federal or state guidance on appropriate models to use to describe a surfacewater (or in this case, daylighted groundwater) -to-air interchange for volatile constituents. Currently the EPA (1991) recommends a water to air VF of 0.5 liters per cubic meter (L/m^3) for each of the volatile constituents. This value comes from research on volatilization of organic compounds from contaminated tap water used in homes. That study reviewed emissions from water usage in showers, toilets and washing activities. In the absence of more sophisticated models, $0.5 L/m^3$ was considered to be a conservative estimate of VF as applied to the daylighted groundwater inhalation routes for the construction worker and the trespassing adolescent recreationist. The daylighted groundwater to air inhalation route is incomplete for inorganic and semi-volatile constituents because they do not volatilize. Therefore they were not included in the daylighted groundwater to air analysis.

4.4.2 Calculating Daylighted Groundwater-to-Air Volatilization Factors for Off-Site Resident and Commercial/Industrial Worker's

A different approach was used to estimate risk-based concentrations for off-site receptors than was used for on-site receptors. In this case risk-based concentrations were established for residential and commercial/industrial receptors that were some distance from the standing water.

The first step was to calculate risk-based concentrations for air (RBC_{air}) directly from exposure equations (Tables 5 & 6). Next, volatilization-to-air pathway analysis was done to evaluate source strength reduction at the receptor, due to dispersion of PCOC concentrations down wind from the daylighted groundwater source. The volatilization-to-air pathways analysis procedures involved two steps: 1) dispersion modeling was conducted to establish emission rates of PCOC from exposed daylighted groundwater necessary to achieve RBC_{air} ; and 2) these emission rates were subsequently used to establish allowable daylighted groundwater concentrations for the PCOC.

EPA's modeling protocol, SCREEN3 was used to establish allowable PCOC unitary emission rates from daylighted groundwater (See Appendix A). The model parameters input represented the most significant exposure risk. Distances from proposed sources to potential receptors were estimated and the most conservative (closest) distance was selected. Impacts were evaluated for the construction scenario that would approximate the greatest impact to off-site receptors. Therefore, the proposed grade control structure between the 16th Street and 24th Street bridges has the potential to expose the greatest amount of groundwater in the surface impoundment. In this case it was assumed that the excavation would contain daylighted groundwater for the full estimated width and length of the proposed excavation.

Unitary emission rates developed using the SCREEN3 modeling protocol were then used to establish allowable emission rates from daylighted groundwater (See Table B.1 & B.2, Appendix B). Target water concentrations for PCOC were then set using procedures to calculate emissions from quiescent surface impoundments as set forth in EPA "Air Emission Model for Water and Waste Water", EPA, 1994 (See Table B.3 & B.4, Appendix B). It was assumed for this analysis that the groundwater impounded at the excavation site is stationary and that no significant biodegradation activity takes place with respect to PCOC in the aqueous solution. Emissions were estimated using the following basic relationship describing the mass transfer of volatile constituents from an open liquid surface to air:

$$E = K C_L A$$

Where;

- E = Average PCOC emission rate from liquid surface(g/s)
- K = Overall mass transfer coefficient (m/s)
- A = Liquid surface area (m²)
- C_L = Concentration of PCOC in liquid phase (mg/L)

For the purposes of this study, C_L is the desired result. Therefore, the equation was rearranged to solve for C_L:

$$C_L = E/KA$$

4.4.3 Sediment-to-Air Conversion Factors for Non-Volatiles

EPA (1991) derived a default value for the Particulate Emission Factor (PEF) of 4.63×10^9 m³/kg which included such assumptions as mean average wind speed (4.5 m/s), percent of

bare sediment (100%), and area of contamination (2,025 m²). This default value was applied as the PEF in this evaluation of risk for all inorganic or semi-volatile inhalation exposure routes.

4.4.4 Inhalation Rate

The standard default inhalation rate of 20 m³/day was used in sediment inhalation exposure routes scenarios. This is the value used by the EPA for commercial/industrial workers and construction workers, as stated in appropriate guidance documentation (EPA, 1991). The residential default value of 15 m³/day (EPA, 1991) is used in this assessment of risk to recreational users and residents.

Site-specific inhalation rates expressed as m³/hour rather than default rates are used for the construction worker and construction foreman inhaling VOCs volatilizing from daylighted groundwater. The amount and type of activity each of these receptors is likely to perform will result in different breathing rates. The *Exposure Factors Handbook* (EPA, 1996) provides activity specific breathing rates for different age groups and different sexes. The 95% UCL inhalation rate for active individuals between 19 and 50 years is 0.675 m³/hr (EPA, 1996). This value was used for construction workers, who are more likely to be performing strenuous activities for extended periods of time. The 95% UCL inhalation rate for inactive individuals of the same age group (0.391 m³/hr) is used to estimate a construction foreman's breathing rate.

4.4.5 Retention Factor

According to the International Commission on Radiological Protection (ICRP, 1968), 75 percent of respirable dust particles (PM₁₀ or smaller), are retained when inhaled, the vast majority of which are swallowed (ICRP, 1968). This 75 percent is included in the inhalation intake equation as the retention factor parameter (RF).

4.4.6 Alveolar Factor

The alveolar absorption factor of 0.5 is utilized when inhalation RfDs, risk reference concentrations (RfCs), and inhalation cancer slope factors are based upon absorbed rather than administered doses. The EPA in many cases, has directly extrapolated an inhalation RfD from an oral RfD, derived from data obtained from orally dosed animals (*e.g.*, gavage). The amount of administered VOC that is absorbed from the gastrointestinal tract is generally relatively high (*i.e.*, approaches 100%). However, the amount of VOC absorbed from respired air is generally much less. VOCs, while efficiently absorbed from the alveolar sacs in the lung, are not absorbed well from other pulmonary tissues (*i.e.*, trachea, bronchi, *etc.*). The bronchial tree, for example, represents "dead space" in terms of gas exchange. At normal breathing rates, the fraction of tidal volume that represents alveolar ventilation is about 40 percent (Berne and

Levy, 1988). Accordingly, when inhalation RfD values are based on absorbed dose, only about half of the total respired amount of VOC vapor is absorbed, and application of an alveolar absorption factor of 0.5 is appropriate. On the other hand, if the inhalation RfD, RfC, or inhalation slope factor is based on administered doses (*e.g.*, a maintained concentration in air), the alveolar absorption factor is not applicable, and a value of one is used in the exposure algorithm.

5.0 TOXICITY ASSESSMENT

The toxicity assessment evaluates published toxicity information in order to determine the appropriate toxicity values for each PCOC. These toxicity values are derived from this dose-response relationship and can be used to estimate the potential for the occurrence of adverse effects in individuals exposed to various constituent levels.

Exposure to a chemical does not necessarily result in adverse effects. The relationship between dose and response defines the quantitative indices of toxicity required to evaluate the potential health risks associated with a given level of exposure. If the nature of the dose-response relationship is such that no effects can be demonstrated below a certain level of exposure, a threshold can be defined as an acceptable exposure level. Humans are routinely exposed to naturally-occurring non-nutritive chemicals (anutrients) and man-made chemicals at low levels (*e.g.*, typical diet, air, and water) with no apparent adverse effects. However, the potential for adverse effects may occur if the exposure level exceeds the threshold; this threshold applies primarily to chemicals which produce non-carcinogenic (systemic) effects, although there is a growing body of scientific evidence which suggests that exposure thresholds may exist for certain carcinogenic constituents as well. The EPA's current approach to assessing carcinogenic risk conservatively assumes that there is no threshold level of exposure, and that any level of exposure to a carcinogen results in some level of potential risk.

Adverse effects can be caused by acute exposure, which is a single or short-term exposure to a toxic substance, or by subchronic/chronic exposure to lower levels on a continuous or repeated basis over an extended period of time. "Acceptable" acute, subchronic or chronic levels of exposure are considered to be without any anticipated adverse effects. Such exposure levels are commonly expressed as Reference Doses (RfD). An acceptable exposure level is calculated to provide an "adequate margin of safety."

Currently, the EPA has not developed toxicity values to be utilized in dermal exposure scenarios; however, the EPA does provide the following guidance for dermal exposure:

No RfDs or slope factors are available for the dermal route of exposure. In some cases, however, non-carcinogenic or carcinogenic risks associated with dermal exposure can be evaluated using an oral RfD or oral slope factor, respectively. (EPA Risk Assessment Guidance for Superfund, Volume I, Human Health Evaluation Manual, Part A: Interim Final, 1989b).

For this study, provisional dermal toxicity values were developed and utilized in all dermal exposure pathways considered in the human health risk assessment to provide a more accurate site-specific assessment of risk.

In several cases, RfD values for oral and inhalation exposures have not been developed for certain PCOC. In these instances, a comprehensive review of pertinent literature was undertaken to determine the best available scientific dose-response toxicity information upon which provisional RfD values for this site might be based. This literature review and application was accomplished utilizing well-accepted methodologies adopted by the National Academy of Sciences and endorsed by the EPA in order to derive quantitative expressions of potential risk for selected PCOC not otherwise addressed.

RfDs are toxicity values utilized to estimate risk for non-carcinogens. The appropriate toxicity value to address carcinogens is a cancer slope factor (CSF). CSFs were used in the evaluation of risk for carcinogens which were identified as a PCOC. A number of sources of toxicity information exist for both RfDs and CSFs, and these sources vary with regard to the availability and strength of supporting evidence. EPA established the following protocol for the determination of toxicity indices; it defines a hierarchy of sources to be consulted and the methodology for determination of toxicity values. This protocol has been developed in accordance with current EPA methodology adopted and/or developed by the National Academy of Sciences. AGRA obtained toxicity values from the following hierarchy of sources:

- 1) Toxicity values are obtained from the *Integrated Risk Information System* (IRIS) (EPA, 1999b) database. This database contains the RfDs and CSFs, which have been verified by EPA's RfD and Carcinogen Risk Assessment Verification Endeavor (CRAVE) workgroups, and is, thus, the agency's preferred source for toxicity values. IRIS supersedes all other information sources.
- 2) For toxicity values which are unavailable on IRIS, the most current source of information is the Health Effects Assessment Summary Tables (HEAST) (EPA, 1999a). HEAST contains interim, as well as verified, RfDs and CSFs. Supporting toxicity information for verified values is provided in an extensive reference section of HEAST.
- 3) Toxicity values that cannot be identified in either IRIS or HEAST are derived from data in toxicological profiles for individual compounds as compiled by the Agency for Toxic

Substances and Disease Registry (ATSDR). These documents provide results from a number of toxicological studies, as well as the methodologies and assumptions used in the studies. Toxicological values for a given compound are derived from the study summarizing the best available data or the set of data which exhibits either the lowest value for Lowest-Observed-Adverse-Effect-Level (LOAEL) or the highest No-Observed-Adverse-Effect-Level (NOAEL). The LOAEL is the lowest dosage at which some effect is shown. The NOAEL is the dosage at which no observed effect or response is noted. Derivation of the acceptable daily intake will incorporate uncertainty factors for: extrapolation of data from animals to humans, calculation of the human-equivalent dose, and interspecies variability in sensitivity of the toxicant.

- 4) If a toxicological profile from ATSDR is not available, toxicity data are obtained in a literature search of EPA sources in the following order:
 - a) Health Assessment Documents
 - b) Health Effects Assessments
 - c) Health Advisories
 - d) Registry of Toxic Effects of Chemical Substances (RTECS); and,
 - e) Hazardous Substances Data Bank (HSDB).
- 5) If sufficient data cannot be gathered from the above sources, toxicity values will be obtained from EPA Region IX Preliminary Remediation Goals (May, 1998).
- 6) If sufficient data still cannot be gathered from the above sources, Toxline and other related databases and journals are searched for relevant dose-response studies upon which to derive toxicity values, using sound principles of toxicology.
- 7) If the above sources do not provide sufficient data, toxicity values are derived from Threshold Limit Values (TLVs). Acceptable intake levels can be derived from TLVs by correcting for continuous exposure and dividing by appropriate and conservative safety factors.
- 8) For chemicals which lack any toxicity information, the concept of structure-activity relationships are applied. This concept allows the derivation of an acceptable intake for a chemical by inference and analogy to closely related compounds.

The EPA has derived carcinogenic slope factors for both oral and inhalation pathways. These are utilized to quantitatively estimate risks. In the first step of EPA's evaluation, the available data are analyzed to evaluate the likelihood that the agent is a human carcinogen. The evidence is characterized separately for human studies and animal studies as sufficient, limited, inadequate, no data, or evidence of no effect. The characterizations of these two types of data are combined, and based on the extent to which the agent has been shown to be a carcinogen in experimental animals or humans, or both, the agent is given a provisional weight-of-evidence classification. EPA scientists then adjust the provisional classification upward or downward, based on other supporting evidence of carcinogenicity (see Section 7.1.3, *EPA Risk Assessment Guidance for Superfund, Volume I, Human Health Evaluation Manual, Part A: Interim Final, 1989a*).

The EPA adapted the following classification system for weight of evidence from the International Agency for Research on Cancer:

EPA WEIGHT-OF-EVIDENCE CLASSIFICATION SYSTEM FOR CARCINOGENICITY	
Group	Description
A	Human carcinogen
B1 or B2	Probable human carcinogen B1 indicates that limited human data are available B2 indicates sufficient evidence in animals and inadequate or no evidence in humans
C	Possible human carcinogen
D	Not classifiable as to human carcinogenicity
E	Evidence of non-carcinogenicity for humans

(*EPA Risk Assessment Guidance for Superfund, Volume I, Human Health Evaluation Manual, Part A: Interim Final, 1989*)

Toxicity indices were selected for PCOC in accordance with the protocol above so that RBALs could be quantitatively calculated with the objective of minimizing inherent uncertainty (Table 16). The significance of results are discussed in Section 6 (Calculation of Risk-Based Action Levels).

6.0 CALCULATION OF RISK-BASED ACTION LEVELS

The overall objective of risk characterization is to select the allowable level of risk for a given receptor and assemble the outputs of exposure and toxicity assessments to quantitatively derive the residual concentrations of PCOC which will not pose an unacceptable risk in each medium of interest for each receptor group. Residual concentrations are expressed as mass of a particular chemical in a given medium (*e.g.*, mg/L in water). For each complete exposure route, concentrations are calculated which would reduce the estimated cancer risk at a site to below one in one million (1×10^{-6}) and to reduce the hazard index estimate to below one for each constituent as elaborated in *EPA's Risk Assessment Guidance for Superfund, Human Health Evaluation Manual, Part B, Development of Risk-based Preliminary Remediation Goals (EPA, 1991)*. In the case of the Rio Salado RMA, the analysis is focused on daylighted groundwater, sediment and air, and the potential effects of human contact with these media during construction of the Rio Salado Habitat Restoration Program components. The evaluation has utilized exposure routes including dermal contact, inhalation and ingestion to evaluate risk potential. Overall, the result of this assessment has indicated that appropriately managing risk in groundwater will address risk posed by other media.

The Rio Salado Risk Management Assessment and Monitoring Program was conducted to identify allowable RBALs which will be protective of human health for receptor populations throughout the duration of construction for the Rio Salado Habitat Restoration Project. They do not predict a concentration which may be present at a given location at a given time. Actual concentrations may be subject to change over time, as affected groundwater moves through the project area. The resulting RBAL concentrations are intended to be protective of receptor populations over the entire project area, regardless of location.

In regard to residual concentrations in sediment, this assessment has not evaluated site specific sediment data to determine potential risk associated with a particular contaminant at a particular locale within the project area. The variability of geochemical conditions that may be present both spatially and temporally prohibits the estimation of a modeled concentration of a particular contaminant precipitating from daylighted groundwater with the data currently available for the project area. Direct sampling would be required to evaluate local conditions. Instead, the assessment estimates the concentration in sediment at which an unacceptable risk may be posed, given the site-specific exposures and toxicity parameters which have been developed for the life of the construction project. Site-specific data will be required to evaluate exposure potential at a given locale as the project is constructed.

6.1 DAYLIGHTED GROUNDWATER PATHWAYS

Table 17 provides a summary of the RBALs derived utilizing the site-specific parameters and algorithms for exposure in daylighted groundwater. In general, the most stringent RBALs were identified for the construction worker, which indicates that construction workers have the highest potential to be exposed to contaminant concentrations above acceptable risk levels. Of the compounds identified, maximum concentrations of 1,1-dichloroethene, 1,2-dichloroethane, benzene, toluene, tetrachloroethene, trichloroethane, vinyl chloride, arsenic and mercury were reported at levels which exceed the most stringent action level at several locations adjacent to the project area.

Consequently, these nine constituents have the greatest potential to be constituents of concern (COC). It should be noted that this list of COC is based upon the exceedance of an RBAL at a location adjacent to the site (Appendix C). Some of these exceedances were noted a considerable distance from the site, and site-specific data may indicate the concentrations of these COC are below RBALs within the project area. Additionally, the list of PAHs and MTBE are considered PCOC until sufficient data have been collected to statistically evaluate the risk associated with the presence of measurable concentrations in daylighted groundwater at the site.

6.2 SEDIMENT PATHWAYS

Sediment RBALs are summarized in Table 18. VOCs were not included in this analysis as they are likely to volatilize from daylighted groundwater and not precipitate onto sediments. Therefore, only semi-volatile organic compounds and inorganic compounds were evaluated as part of the assessment. Again, RBALs for the construction workers were the most stringent, which indicates that the threshold of allowable exposure concentrations is less for these receptors than for other receptors. As no site-specific data exist for sediments, these RBALs were created using the exposure parameters appropriate to site conditions as identified by EPA, and are generically applicable for these compounds. However, as noted above, these RBALs can not be compared to current concentrations in sediment to determine if site conditions pose an unacceptable risk to human health. Therefore, it is unknown if any of the PCOC are COC in sediments at this time.

6.3 AIR PATHWAYS

The commercial/industrial worker and the resident in the area of the Rio Salado Habitat Restoration Program are primarily at risk through exposure via PCOC in daylighted groundwater volatilizing to air. RBALs for this pathway were calculated as part of the assessment. None of the threshold values which would present a risk to the commercial/industrial worker or the resident were exceeded within the data reviewed for the RMA. The contaminant concentrations for groundwater in the project area were typically well below the threshold

values which would indicate a potential risk to one or more of these receptors and therefore, no COC were identified in this evaluation.

6.4 EXPOSURE SUMMARY

The following table presents a summary of exposure information for each of the potential receptor populations identified for the Rio Salado Habitat Restoration Project.

Receptor	Predominant Risk Pathway	Discussion
Construction Worker	Daylighted groundwater	Risk associated with dermal contact with water, or inhalation and ingestion of water, or contaminants which have volatilized from or precipitated from water, respectively. Potential risk is posed by concentrations of COC which exceed the most stringent RBALs.
Trespassing Recreationist	Daylighted groundwater	Potential risk associated with dermal contact with water, or inhalation and ingestion of water, or contaminants which have volatilized from or precipitated from water, respectively. None of the identified COC exceed RBALs for this receptor.
Commercial/Industrial Worker	Air	Potential risk associated with inhalation of identified PCOC which have volatilized from water. None of the PCOC exceed RBALs for this receptor.
Resident	Air	Potential risk associated with inhalation of identified PCOC which have volatilized from water. None of the PCOC exceed RBALs for this receptor.

The quantitative results of the RMA indicate that the construction worker is the highest risk receptor as indicated by the stringent RBALs for both the sediment and daylighted

groundwater exposure scenarios. The construction worker has the greatest risk of exposure through 1) inhalation of dust particles and vapors from sediment and daylighted groundwater; 2) ingestion of PCOC in daylighted groundwater and sediment; and 3) prolonged dermal contact with daylighted groundwater and sediment.

7.0 RECOMMENDATIONS

Based on the evaluation of potential exposures conducted during the Rio Salado RMA program, the following recommendations are made.

- ▶ A preliminary sampling and analysis program should be developed and initiated to create site-specific data and more thoroughly evaluate risks to the highest risk population (construction workers) at specific locations within the Phoenix Reach of the Salt River. The sampling and analysis program should evaluate concentrations of COC in both groundwater and sediments at various locations along the Phoenix Reach. In order to evaluate the data in a statistically significant manner, and eliminate COC from future monitoring efforts, the data collection should include at least 19 events for each medium sampled.
- ▶ The results of the preliminary sampling and analysis program should be directly compared to the risk evaluation presented within this Rio Salado RMA Report to evaluate the need for changes in construction practices as they relate to managing the water or sediments.
- ▶ The water quality database used in this assessment should be augmented with site specific data obtained from the preliminary sampling and analysis program, and then updated at least once during the duration of the construction project, to ensure that conditions have not greatly changed during the construction project.

Certain options for the project exist based on the results of this RMA report. These options include: 1) no action, or moving forward with the project without further assessment or information; 2) move forward with the project and mitigate worker risks as they occur during the restoration. This will include making changes in construction practices as further data are obtained and evaluated; or 3) delay the project until site-specific data refining the potential risks are collected and evaluated. This approach will provide the highest degree of certainty in implementing monitoring and mitigation plans as the project is constructed.

8.0 MONITORING PROGRAM

During construction activities related to the development of the proposed perennial low flow channel along the Phoenix Reach of the Salt River, construction workers and the public have

potential to come into contact with contaminated groundwater. Water quality monitoring will be performed to address potential impact to human health of those individuals that may have contact with the contaminated groundwater as a result of incidental or job-related circumstances over the approximate two-year construction period. The basic elements of a monitoring program have been developed which identify guidelines for 1) identification of COC, 2) sampling, including the establishment of sampling locations and sampling frequency, and 3) recommendations for a contingency response plan in the event that identified RBALs for COC are exceeded when groundwater is encountered. The elements of the monitoring program are based upon the results of the Risk Management Assessment.

The elements of the monitoring program also include a recommendation for the mitigation of exposure to groundwater containing concentrations of COC above the RBALs (the primary exposure pathway) for all receptor groups during the construction activities. As the quantitative results of the RMA suggest, the construction worker receptor is at the highest risk based on available data. Therefore, it is assumed for purposes of the monitoring plan, that if risk to the construction worker is mitigated, risk to lower risk groups, the trespassing recreationist, the resident, and the commercial/industrial worker will also be mitigated.

8.1 IDENTIFICATION OF COC

The preliminary list of PCOC is presented in Table 2. This list is based upon the PCOC identified during the RMA for both daylighted groundwater and sediments discussed in Section 3.2 of this report. This list has been reduced to those COC presented in Section 6.1. The COC list consists of volatile organic compounds (VOCs) and metals which are present at concentrations above RBALs. PAHs and MTBE have been included in the preliminary list of monitored PCOC for both sediment and daylighted groundwater until sufficient information regarding concentrations can be collected to establish or disregard MTBE or any PAH constituents as a COC. Additionally, daylighted groundwater should be monitored for physical parameters including turbidity, total suspended solids (TSS), total dissolved solids (TDS), pH, and specific conductance. Monitoring of these parameters will assist evaluating of changes in general conditions of the water chemistry at the Site.

8.2 SAMPLING LOCATIONS

Monitoring locations should correspond to the locations of the discharge of groundwater to the surface at the terminus of the construction zone or at intermediate discharge areas. Monitoring should also be conducted at any location where groundwater is encountered which does not correspond to planned discharge locations. The locations which correspond to the RBAL exceedances for a given COC vary throughout the Phoenix Reach as can be seen from the data presented in Appendix C. Monitoring points will be selected so that they correspond

to locations where volatilization of the contaminants in the groundwater to the air are most likely to occur; however, specific monitoring locations can not be identified at this time.

8.3 SAMPLING FREQUENCY

AGRA recommends that the City of Phoenix implement monitoring of groundwater prior to initiation of actual construction work. Monitoring of the groundwater or daylighted groundwater should be performed for a period of up to 19 events in order to collect a sufficient number of samples to determine COC concentrations in the water to a 95% confidence level. An evaluation of the data can then be performed to statistically eliminate from the monitoring program the COC that are not present above RBALs in the water derived from de-watering the active construction area. Quarterly monitoring of the remaining COC should continue until the effluent location changes.

If groundwater infiltrates excavation pits during construction activities, and data do not exist in the vicinity of the excavation, sampling should be performed immediately at that location in order to establish a baseline concentration for each preliminary COC and to identify potential exceedances of the RBALs.

8.4 CONTINGENCY RESPONSE PLAN

The results of the RMA indicated that exposure to groundwater containing concentrations of COC above the RBALs is not permissible. Therefore, a site-specific health and safety plan should be developed which includes a response plan for the contingency that groundwater exhibiting concentrations of COC above the prescribed RBALs is encountered during construction activities. The contingency plan should include establishment of an on-site safety officer; procedures for hazard communication with workers; appropriate types and use of personal protective equipment in the event that groundwater above RBALs is encountered; and construction methods to minimize contact/exposure. Periodic air monitoring of the construction area with an appropriate monitoring device (photo-ionization detector [PID], flame ionization detector [FID] or similar equipment) is recommended. Hazard communication via posted signs along the Phoenix Reach during construction should be considered to dissuade recreational users.

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Table 1
Statistical Summary of Groundwater Analytical Results

Analyte	Hits	Total # of Samples	Frequency of Detection %	Minimum mg/L	Mean mg/L	Maximum MRL mg/L	Maximum mg/L	Standard Deviation mg/L	95% UCL mg/L	Is Frequency of Detection > 5%?	MCL mg/L	Is Maximum > MCL?	Is Analyte Considered a COC?
metals													
Silver	1	169	0.59%	0.017	0.00586982	0.1	0.017	0.00602136	0.00663778	no	0.1	no	no
Arsenic	111	169	65.68%	0.004	0.01852959	1	0.092	0.06611076	0.02696125	Yes - Potential COC	0.05	Yes - Potential COC	Yes
Barium	160	169	94.67%	0.017	0.25692899	0.2	3.72	0.4878332	0.31914649	Yes - Potential COC	2	Yes - Potential COC	Yes
Beryllium	1	163	0.61%	0.003	0.0033589	0.1	0.003	0.0064071	0.00419095	no	0.004	no	no
Chromium III	21	184	11.41%	0.005	0.20436141	0.1	22.4	1.70286101	0.41250106	Yes - Potential COC	0.1	Yes - Potential COC	Yes
Mercury (Inorganic)	1	166	0.60%	1	0.00612349	0.0002	1	0.07760729	0.01611045	no	0.002	Yes - Potential COC	Yes
Nickel	46	169	27.22%	0.005	0.02572781	0.1	0.339	0.04498131	0.03146466	Yes - Potential COC	0.1	Yes - Potential COC	Yes
Lead	26	169	15.38%	0.001	0.00606154	0.5	0.017	0.0329497	0.01026389	Yes - Potential COC	0.015	Yes - Potential COC	Yes
Antimony	2	163	1.23%	0.006	0.03352147	1	0.008	0.06410296	0.04184618	no	0.006	Yes - Potential COC	Yes
Selenium	4	169	2.37%	0.002	0.02023669	2	0.009	0.13210512	0.03708517	no	0.05	no	no
Thallium	4	163	2.45%	0.001	0.09446626	10	0.004	0.67378792	0.18196744	no	0.002	Yes - Potential COC	Yes
volatiles													
1,1,1-Trichloroethane	34	410	8.29%	0.0003	0.00726707	0.1	1.3	0.07115293	0.01304759	Yes - Potential COC	0.2	Yes - Potential COC	Yes
1,1-dichloroethane	56	410	13.66%	0.0002	0.00132517	0.25	0.0293	0.00719585	0.00190977	Yes - Potential COC	NA	no	no
1,1-dichloroethene	109	410	26.59%	0.0002	0.00996622	0.25	0.42	0.04422228	0.01355887	Yes - Potential COC	0.007	Yes - Potential COC	Yes
1,2-dichloroethane	21	421	4.99%	0.0004	0.00153765	0.25	0.12	0.0094922	0.00229866	no	0.005	Yes - Potential COC	Yes
1,2-dichlorobenzene	15	410	3.66%	0.0002	0.00118239	0.25	0.0085	0.00808359	0.00183911	no	0.6	no	no
1,3-dichlorobenzene	1	410	0.24%	0.0005	0.00113598	0.25	0.0005	0.00807601	0.00179208	no	0.6	no	no
1,4-dichlorobenzene	24	410	5.85%	0.0004	0.00125415	0.25	0.012	0.00810035	0.00191223	Yes - Potential COC	0.075	no	no
Bromodichloromethane	14	410	3.41%	0.00052	0.00099893	0.25	0.0077	0.00690236	0.00155968	no	0.1	no	Yes
Benzene	116	489	23.72%	0.0004	0.28405632	0.02	20.6	1.76684243	0.41549079	Yes - Potential COC	0.005	Yes - Potential COC	Yes
Carbon tetrachloride	1	410	0.24%	0.0005	0.00089317	0.25	0.0005	0.00687205	0.00145146	no	0.005	no	no
Chlorobenzene	32	421	7.60%	0.0004	0.00107945	0.25	0.0067	0.00679286	0.00162405	Yes - Potential COC	NA	no	Yes
Chloroform	58	410	14.15%	0.0002	0.0011398	0.25	0.0091	0.00692207	0.00170216	Yes - Potential COC	0.1	no	no
cis-1,2-dichloroethane	52	389	13.37%	0.0003	0.00151149	0.25	0.055	0.00808695	0.00219131	Yes - Potential COC	0.07	no	no
chloromethane	2	410	0.49%	0.00082	0.00112615	0.25	0.0068	0.0081437	0.00178775	no	NA	no	no
Dibromochloromethane	14	410	3.41%	0.0006	0.00099793	0.25	0.0073	0.00689434	0.00155803	no	NA	no	Yes
Ethyl benzene	104	489	21.27%	0.0005	0.07178204	0.025	3.34	0.37212743	0.09946441	Yes - Potential COC	0.7	Yes - Potential COC	Yes
Tetrachloroethene	128	456	28.07%	0.0002	0.0162034	0.25	1.5	0.10315774	0.02415007	Yes - Potential COC	0.005	Yes - Potential COC	Yes
Trichloroethene	109	430	25.35%	0.0002	0.00475137	0.25	0.21	0.01904736	0.00626238	Yes - Potential COC	0.005	Yes - Potential COC	Yes
Toluene	98	489	20.04%	0.0005	0.27584818	0.25	26	1.98913586	0.42381894	Yes - Potential COC	1	Yes - Potential COC	Yes
Vinyl chloride	19	410	4.63%	0.0002	0.00128278	0.25	0.038	0.00835446	0.0019615	no	0.002	Yes - Potential COC	Yes
Xylene (mixed)	118	489	24.13%	0.0005	0.22658356	0.04	16.8	1.43684318	0.33346956	Yes - Potential COC	10	Yes - Potential COC	Yes

Table 2
Statistical Summary of Groundwater Analytical Results for Potential Constituents of Concern

Analyte	Hits	Total # of Samples	Frequency of Detection %	Minimum mg/L	Mean mg/L	Maximum MRL mg/L	Maximum mg/L	Standard Deviation mg/L	95% UCL mg/L	Is Frequency of Detection > 5%?	MCL mg/L	Is Maximum > MCL?	Is Analyte Considered a COC?
volatiles													
1,1,1-Trichloroethane	34	410	8.29%	0.0003	0.007267	0.1	1.3	0.071153	0.01304759	Yes - Potential COC	0.2	Yes - Potential COC	Yes
1,1-dichloroethene	109	410	26.59%	0.0002	0.009966	0.25	0.42	0.044222	0.01355887	Yes - Potential COC	0.007	Yes - Potential COC	Yes
1,2-dichloroethane	21	421	4.99%	0.0004	0.001538	0.25	0.12	0.009492	0.00229866	no	0.005	Yes - Potential COC	Yes
Bromodichloromethane	14	410	3.41%	0.00052	0.000999	0.25	0.0077	0.006902	0.00155968	no	0.1	no	Yes
Benzene	116	489	23.72%	0.0004	0.284056	0.02	20.6	1.766842	0.41549079	Yes - Potential COC	0.005	Yes - Potential COC	Yes
Chlorobenzene	32	421	7.60%	0.0004	0.001079	0.25	0.0067	0.006793	0.00162405	Yes - Potential COC	NA	no	Yes
Dibromochloromethane	14	410	3.41%	0.0006	0.000998	0.25	0.0073	0.006894	0.00155803	no	NA	no	Yes
Ethyl benzene	104	489	21.27%	0.0005	0.071782	0.025	3.34	0.372127	0.09946441	Yes - Potential COC	0.7	Yes - Potential COC	Yes
Tetrachloroethene	128	456	28.07%	0.0002	0.016203	0.25	1.5	0.103158	0.02415007	Yes - Potential COC	0.005	Yes - Potential COC	Yes
Trichloroethene	109	430	25.35%	0.0002	0.004751	0.25	0.21	0.019047	0.00626238	Yes - Potential COC	0.005	Yes - Potential COC	Yes
Toluene	98	489	20.04%	0.0005	0.275848	0.25	26	1.989136	0.42381894	Yes - Potential COC	1	Yes - Potential COC	Yes
Vinyl chloride	19	410	4.63%	0.0002	0.001283	0.25	0.038	0.008354	0.0019615	no	0.002	Yes - Potential COC	Yes
Xylene (mixed)	118	489	24.13%	0.0005	0.226584	0.04	16.8	1.436843	0.33346956	Yes - Potential COC	10	Yes - Potential COC	Yes
metals													
Arsenic	111	169	65.68%	0.004	0.01853	1	0.092	0.066111	0.02696125	Yes - Potential COC	0.05	Yes - Potential COC	Yes
Barium	160	169	94.67%	0.017	0.256929	0.2	3.72	0.487833	0.31914649	Yes - Potential COC	2	Yes - Potential COC	Yes
Chromium III	21	184	11.41%	0.005	0.204361	0.1	22.4	1.702861	0.41250106	Yes - Potential COC	0.1	Yes - Potential COC	Yes
Mercury (Inorganic)	1	166	0.60%	1	0.006123	0.0002	1	0.077607	0.01611045	no	0.002	Yes - Potential COC	Yes
Nickel	46	169	27.22%	0.005	0.025728	0.1	0.339	0.044981	0.03146466	Yes - Potential COC	0.1	Yes - Potential COC	Yes
Lead	26	169	15.38%	0.001	0.006062	0.5	0.017	0.03295	0.01026389	Yes - Potential COC	0.015	Yes - Potential COC	Yes
Antimony	2	163	1.23%	0.006	0.033521	1	0.008	0.064103	0.04184618	no	0.006	Yes - Potential COC	Yes
Thallium	4	163	2.45%	0.001	0.094466	10	0.004	0.673788	0.18196744	no	0.002	Yes - Potential COC	Yes
semivolatiles													
Acenaphthene													Yes
Acenaphthylene													Yes
Anthracene													Yes
Benzo(a)anthracene													Yes
Benzo(a)pyrene													Yes
Benzo(b)fluoranthene													Yes
Benzo(g,h,i)perylene													Yes
Benzo(k)fluoranthene													Yes
Chrysene													Yes
Dibenz(a,h)anthracene													Yes
Fluoranthene													Yes
Fluorene													Yes
Indeno(1,2,3-cd)pyrene													Yes
Naphthalene													Yes
Phenanthrene													Yes
Pyrene													Yes
methyltertiarybutylether													Yes

PAH's were not analyzed for at any of the 28 sites; therefore, they were automatically included as COCs.

Table 3
Parameters Utilized for Daylighted Groundwater Exposure Scenario

Parameter	Receptors:			Residential	Recreational Trespasser	Commercial/ Industrial	Construction Worker	Constructin Foreman				
	Abbreviation	Units										
Averaging time - carcinogenic	AT _C	days	25550	1	25550	1	25550	1	25550	1		
Averaging time - noncarcinogenic	AT _N	days	730	R	730	R	730	R	730	R		
Body weight	BW	kg	70	1	45	2	70	1	70	1		
Conversion factor (1000 L/1 m ³)	CF	L/cm ³	NA		1E-03		NA		NA	1E-03		
Exposure duration	ED	years	2	R	2	R	2	R	2	R		
Exposure frequency	EF	days/year	350	1	104	R	250	1	250	1		
Exposure time	ET	hrs/day	NA		2.6	3	NA		NA	1		
Exposure time (work area)	ET _w	hrs/day	NA		NA		NA		NA	8		
Ingestion rate	IR _w	L/hr	NA		0.05	3	NA		NA	NA		
Inhalation rate	IR _A	m ³ /day or m ³ /hr	15 (m ³ /day)	1	0.625 (m ³ /hr)	1	20 (m ³ /day)	1	0.675 (m ³ /hr)	1	0.391 (m ³ /hr)	2
Percent of skin surface area available for exposure	PS		NA		90%	2	NA		NA	23%	2	
Skin surface area available for exposure	SA	cm ² /day	NA		14436	C	NA		NA	4540	C	
Surface water to air volatilization factor	VF	L/m ³	NA		0.5		NA		NA	0.5		
Target cancer risk	TR		0.000001	1	0.000001	1	0.000001	1	0.000001	1	0.000001	1
Target hazard index	THI		1	1	1	1	1	1	1	1	1	1
Total skin surface area	SA _T	cm ²	NA		16021	2	NA		NA	20000	2	

- 1 EPA 1991, Risk Assessment Guidance - Superfund (RAGS) - Part B
- 2 EPA 1996, Exposure Factors Handbook
- 3 EPA 1989, Risk Assessment Guidance - Superfund (RAGS) - Part A
- C Calculated value
- R Reasonable maximum

Table 4
Parameters Utilized for Sediment Exposure Scenario

Parameter	Receptors:		Residential		Recreational Trespasser		Commercial/Industrial		Construction Worker	
	Abbreviation	Units								
Absorption - inorganics	ABS _I		NA		0.01	6	NA		0.01	6
Absorption - semivolatiles	ABS _S		NA		0.10	6	NA		0.10	6
Absorption - volatiles	ABS _V		NA		0.03	6	NA		0.03	6
Adherence factor	ADF	mg/cm ²	NA		0.63	2	NA		0.63	2
Alveolar Factor for absorbed dose	AF _D		0.5	R	0.5	R	0.5	R	0.5	R
Alveolar Factor for administered dose	AF _B		1	R	1	R	1	R	1	R
Averaging time - carcinogenic	AT _C	days	25550	1	25550	1	25550	1	25550	1
Averaging time - noncarcinogenic	AT _N	days	730	R	730	R	730	R	730	R
Body weight	BW	kg	70	1	45	2	70	1	70	1
Conversion factor (1 kg/1,000,000 mg)	CF	kg/mg	NA		0.000001		NA		0.000001	
Exposure duration	ED	years	2	R	2	R	2	R	2	R
Exposure frequency	EF	days/year	350	1	104	R	250	1	250	1
Exposure time	ET	hrs/day	NA		2.6	3	NA		NA	R
Ingestion rate for sediment	IR _S	mg/day	NA		100	3	NA		50	1
Inhalation rate	IR _A	m ³ /day or m ³ /hr	15	1	0.6 (m ³ /hr)	1	20	1	20	1
Matrix effect - non-semivolatiles	ME _N		NA		1	R	NA		1	R
Matrix effect - semivolatiles	ME _S		NA		0.29	7	NA		0.29	7
Particulate Emission Factor (for non-volatiles)	PEF	m ³ /kg	4,630,000,000	1	4,630,000,000	1	4,630,000,000	1	4,630,000,000	1
Percent of skin surface area available for exposure	PS		NA		66%	2	NA		28%	2
Respirable amount of airborne PM ₁₀	RA		0.84	4	0.84	4	0.84	4	0.84	4
Respirable amount of airborne volatiles	RA _V		1	R	1	R	1	R	1	R
Retention Factor non-volatiles	RF		0.75	5	0.75	5	0.75	5	0.75	5
Retention Factor volatiles	RF _V		1	R	1	R	1	R	1	R
Skin surface area available for exposure	SA	cm ² /day	NA		10651	C	NA		5560	C
Target cancer risk	TR		0.000001	1	0.000001	1	0.000001	1	0.000001	1
Target hazard index	THI		1	1	1	1	1	1	1	1
Total skin surface area	SA _T	cm ²	NA		16021	2	NA		20000	2

- 1 EPA 1991, Risk Assessment Guidance - Superfund (RAGS) - Part B
- 2 EPA 1996, Exposure Factors Handbook
- 3 EPA 1989, Risk Assessment Guidance - Superfund (RAGS) - Part A
- 4 Cowherd, 1985
- 5 International Commission on Radiological Protection (ICRP), 1968
- 6 EPA 1995, Region III
- 7 Magee et al., 1996

Table 5
Action Levels for PCOC in Air - Residential Scenario

Noncarcinogenic Equation	$C \text{ (mg/m}^3\text{)} =$	$(THI \cdot BW \cdot AT_N) / ((1/R_i D_i) \cdot IR \cdot EF \cdot ED)$		
Carcinogenic Equation	$C \text{ (mg/m}^3\text{)} =$	$(TR \cdot BW \cdot AT_C) / (SF_i \cdot IR \cdot EF \cdot ED)$		
Parameter	Symbol	Value	Units	Source
Concentration in air	C	chemical specific	mg/m ³	calculated
Target hazard index	THI	1		EPA 1991, RAGS-Part B
Target excess cancer risk	TR	0.000001		EPA 1991, RAGS-Part B
Body weight	BW	70	kg	EPA 1991, RAGS-Part B
Averaging time - noncarcinogenic	AT _N	730	days	Reasonable maximum
Averaging time - carcinogenic	AT _C	25550	days	EPA 1991, RAGS-Part B
Inhalation chronic reference dose	R _i D _i	chemical specific	mg/kg-day	
Inhalation slope factor	SF _i	chemical specific	(mg/kg-day) ⁻¹	
Daily inhalation rate	IR	15	m ³ /day	EPA 1991, RAGS-Part B
Exposure frequency	EF	350	days/year	EPA 1991, RAGS-Part B
Exposure duration	ED	2	years	Reasonable maximum
Analyte	Subchronic Inhalation R_iD mg/kg-day	Inhalation Slope Factor (mg/kg-day)⁻¹	Concentration in Air - Non-carcinogenic Effects (mg/m³)	Concentration in Air - Carcinogenic Effects (mg/m³)
volatiles				
1,1,1-Trichloroethane	3		14.6	
1,1-dichloroethene	0.057	0.175	0.2774	0.000973333
1,2-dichloroethane	0.056	0.091	0.272533333	0.001871795
Bromodichloromethane	0.02		0.097333333	
Benzene	0.00171	0.029	0.008322	0.005873563
Chlorobenzene	0.00571		0.027788667	
Dibromochloromethane	0.02	0.084	0.097333333	0.002027778
Ethyl benzene	0.286		1.391866667	
Tetrachloroethene	0.08	0.00203	0.389333333	0.083908046
Trichloroethene	0.53	0.006	2.579333333	0.028388889
Toluene	0.1		0.486666667	
Vinyl chloride	0.005	0.3	0.024333333	0.000567778
Xylene	0.8		3.893333333	

Table 7
Action Levels for Volatile PCOC in Daylighted Groundwater - Trespassing Recreationist Scenario

Noncarcinogenic Equation	$C \text{ (mg/L)} =$	$\frac{\text{THI} \cdot \text{BW} \cdot \text{AT}_N}{\text{EF} \cdot \text{ED} \cdot \text{ET} \cdot \left(\left(\frac{1}{R_D} \right) \cdot \text{CF} \cdot \text{SA} \cdot \text{K}_P + \left(\frac{1}{R_D} \right) \cdot \text{IR}_W + \left(\frac{1}{R_D} \right) \cdot \text{IR}_A \cdot \text{VF} \right)}$			
Carcinogenic Equation	$C \text{ (mg/L)} =$	$\frac{\text{TR} \cdot \text{BW} \cdot \text{AT}_C}{\text{EF} \cdot \text{ED} \cdot \text{ET} \cdot \left(\text{SF}_O \cdot \text{CF} \cdot \text{SA} \cdot \text{K}_P + \text{SF}_O \cdot \text{IR}_W + \text{SF}_I \cdot \text{IR}_A \cdot \text{VF} \right)}$			
Parameter	Symbol	Value	Units	Source	
Concentration in water	C	chemical specific	mg/L		
Target hazard index	THI	1		EPA 1991, RAGS-Part B	
Target cancer risk	TR	0.000001		EPA 1991, RAGS-Part B	
Body weight of a child age 6-18	BW	45	kg	EPA 1996, Exposure Factors Handbook	
Averaging time - noncarcinogenic	AT_N	730	days	Reasonable maximum	
Averaging time - carcinogenic	AT_C	25550	days	EPA 1991, RAGS-Part B	
Exposure frequency	EF	104	days/year	Reasonable maximum	
Exposure duration	ED	2	years	Reasonable maximum	
Dermal chronic reference dose	R_{D_D}	chemical specific	mg/kg-day		
Oral chronic reference dose	R_{D_O}	chemical specific	mg/kg-day		
Inhalation chronic reference dose	R_{D_I}	chemical specific	mg/kg-day		
Oral cancer slope factor	SF_O	chemical specific	$(\text{mg/kg-day})^{-1}$		
Inhalation slope factor	SF_I	chemical specific	$(\text{mg/kg-day})^{-1}$		
Conversion factor (1000L/1 m ³)	CF	0.001	L/cm ³	calculated	
Child skin surface area available for exposure	SA	14436	cm ²	$\text{SA}_T \cdot \text{PS}$	
Total skin surface area of a child age 6-18	SA_T	16021	cm ²	EPA 1996, Exposure Factors Handbook	
Percent of skin surface area available for exposure	PS	90%		EPA 1996, Exposure Factors Handbook	
Permeability coefficient	K_P	chemical specific	cm/hr		
Exposure time	ET	2.6	hrs/day	EPA 1989, RAGS-Part A	
Ingestion rate	IR_W	0.05	L/hr	EPA 1989, RAGS-Part A	
Inhalation rate	IR_A	0.625	m ³ /hr	EPA 1991, RAGS-Part B	
Daylighted groundwater to air volatilization factor	VF	0.5	L/m ³	EPA 1991, RAGS-Part B	

Analyte	K_P (cm/hr)	Subchronic Dermal R_{D_D} mg/kg-day	Subchronic Oral R_{D_O} mg/kg-day	Subchronic Inhalation R_{D_I} mg/kg-day	Oral Slope Factor $(\text{mg/kg-day})^{-1}$	Inhalation Slope Factor $(\text{mg/kg-day})^{-1}$	Concentration in	Concentration in
							Daylighted Groundwater - Non-carcinogenic Effects (mg/l)	Daylighted Groundwater - Carcinogenic Effects (mg/l)
volatiles								
1,1,1-Trichloroethane	0.017	0.855	0.9	3			135.9040572	
1,1-dichloroethene	0.016	0.00855	0.009	0.057	0.6	0.175	1.595563628	0.00951771
1,2-dichloroethane	0.0053	0.1805	0.19	0.056	0.091	0.091	9.687637089	0.053193153
Bromodichloromethane	0.0058	0.019	0.02	0.02	0.062		2.694688939	0.256302128
Benzene	0.111	0.006745	0.0071	0.00171	0.029	0.029	0.142072076	0.037293215
Chlorobenzene	0.041	0.19	0.2	0.00571			1.045144412	
Dibromochloromethane	0.0039	0.19	0.2	0.02	0.084	0.084	3.754568849	0.06040686
Ethyl benzene	1	0.95	1	0.286			3.716102584	
Tetrachloroethene	0.4	0.095	0.1	0.08	0.052	0.00203	0.931368206	0.007001689
Trichloroethene	0.2	0.01638	0.018	0.53	0.011	0.006	0.337999806	0.062164307
Toluene	1	1.9	2	0.1			5.649067678	
Vinyl chloride	0.0073	0.247	0.26	0.005	1.9	0.3	0.961935053	0.005463179
Xylene (mixed)	0.000339	3.48	4	0.8			150.0903235	

Table 8
Action Levels for Non-volatile PCOC in Daylighted Groundwater - Trespassing Recreationist Scenario

Noncarcinogenic Equation	$C \text{ (mg/L)} = \frac{THI \cdot BW \cdot AT_N}{EF \cdot ED \cdot ET \cdot ((1/R_d D_o) \cdot CF \cdot SA \cdot K_p) + ((1/R_d D_o) \cdot IR_w)}$
Carcinogenic Equation	$C \text{ (mg/L)} = \frac{TR \cdot BW \cdot AT_C}{EF \cdot ED \cdot ET \cdot ((SF_o \cdot CF \cdot SA \cdot K_p) + (SF_o \cdot IR_w))}$

Parameter	Symbol	Value	Units	Source
Concentration in water	C	chemical specific	mg/L	
Target hazard index	THI	1		EPA 1991, RAGS-Part B
Target cancer risk	TR	0.000001		EPA 1991, RAGS-Part B
Body weight of a child age 6-18	BW	45	kg	EPA 1996, Exposure Factors Handbook
Averaging time - noncarcinogenic	AT _N	730	days	Reasonable maximum
Averaging time - carcinogenic	AT _C	25550	days	EPA 1991, RAGS-Part B
Exposure frequency	EF	104	days/year	EPA 1989, RAGS-Part A
Exposure duration	ED	2	years	Reasonable maximum
Dermal chronic reference dose	R _d D _o	chemical specific	mg/kg-day	
Oral chronic reference dose	R _o D _o	chemical specific	mg/kg-day	
Oral cancer slope factor	SF _o	chemical specific	(mg/kg-day) ⁻¹	
Conversion factor (1000L/1 m ³)	CF	0.001	L/cm ³	calculated
Child skin surface area available for exposure	SA	14436	cm ²	SA _T * PS
Total skin surface area of a child age 6-18	SA _T	16021	cm ²	EPA 1996, Exposure Factors Handbook
Percent of skin surface area available for exposure	PS	90%		EPA 1996, Exposure Factors Handbook
Permeability coefficient	K _p	chemical specific	cm/hr	
Exposure time	ET	2.6	hrs/day	EPA 1989, RAGS-Part A
Ingestion rate	IR _w	0.05	L/hr	EPA 1989, RAGS-Part A

Analyte	K _p (cm/hr)	Subchronic Dermal R _d D mg/kg-day	Subchronic Oral R _o D mg/kg-day	Oral Slope Factor (mg/kg-day) ⁻¹	Concentration in Daylighted Groundwater - Non-carcinogenic Effects (mg/l)	Concentration in Daylighted Groundwater - Carcinogenic Effects (mg/l)
metals						
Arsenic	0.000479145	0.000285	0.0003	1.5	0.31799143	0.024890863
Barium	0.001	0.007	0.07		21.86709319	
Chromium	0.000741964	0.1	1		386.4532288	
Mercury	0.001	0.000021	0.0003		0.071087481	
Nickel	0.000673471	0.00086	0.02		4.398104251	
Lead	0.00008030	0.0003052	0.0028		2.803748703	
Antimony	0.001	0.000004	0.0004		0.016260125	
Thallium	0.00008248	0.00064	0.0008		0.943380464	
semivolatiles						
Acenaphthene	0.310119978	0.42	0.6		5.651823344	
Acenaphthylene	0.44262035	0.238	0.34		2.249180325	
Anthracene	0.674454745	2.1	3		13.04845761	
Benzo(a)anthracene	0.81	0.0035	0.005	0.73	0.018119079	0.00024789
Benzo(a)pyrene	1.2	0.0084	0.012	7.3	0.029381404	0.00001676
Benzo(b)fluoranthene	1.2	0.00161	0.0023	0.73	0.005631436	0.000167557
Benzo(g,h,i)perylene	73.94600794	0.0084	0.012		0.000477751	
Benzo(k)fluoranthene	44.77125551	0.00161	0.0023	0.073	0.000151236	0.00004504
Chrysene	0.81	0.0224	0.032	0.0073	0.115962103	0.024788952
Dibenz(a,h)anthracene	2.7	0.0035	0.005	7.3	0.005447102	0.00000746
Fluoranthene	0.36	0.28	0.4		3.24931333	
Fluorene	0.451401491	0.28	0.4		2.594894848	
Indeno(1,2,3-cd)pyrene	1.9	0.0084	0.012	0.73	0.018570471	0.000105938
Naphthalene	0.069	0.028	0.04		1.648777945	
Phenanthrene	0.23	0.049	0.07		0.886676741	
Pyrene	2.316783636	0.21	0.3		0.380829541	

Table 9
Action Levels for Volatile PCOC in Daylighted Groundwater - Construction Worker Scenario

Noncarcinogenic Equation	$C \text{ (mg/L)} = \frac{THI \cdot BW \cdot AT_N}{EF \cdot ED \cdot (1/R_i D_i) \cdot IR_A \cdot VF \cdot ET_W}$				
Carcinogenic Equation	$C \text{ (mg/L)} = \frac{TR \cdot BW \cdot AT_C}{EF \cdot ED \cdot SF_i \cdot IR_A \cdot VF \cdot ET_W}$				
Parameter	Symbol	Value	Units	Source	
Concentration in water	C	chemical specific	mg/L		
Target hazard index	THI	1		EPA 1991, RAGS-Part B	
Target cancer risk	TR	0.000001		EPA 1991, RAGS-Part B	
Body weight	BW	70	kg	EPA 1991, RAGS-Part B	
Averaging time - noncarcinogenic	AT _N	730	days	Reasonable maximum	
Averaging time - carcinogenic	AT _C	25550	days	EPA 1991, RAGS-Part B	
Exposure frequency	EF	250	days/year	EPA 1991, RAGS-Part B	
Exposure duration	ED	2	years	Reasonable maximum	
Inhalation chronic reference dose	R _i D _i	chemical specific	mg/kg-day		
Inhalation slope factor	SF _i	chemical specific	(mg/kg-day) ⁻¹		
Exposure time (work area)	ET _W	8	hrs/day	EPA 1991, RAGS-Part B	
Inhalation rate (inactive)	IR _A	0.675	m ³ /hr	EPA 1996, Exposure Factors Handbook	
Daylighted groundwater to air volatilization	VF	0.5	L/m ³	EPA 1991, RAGS-Part B	
Analyte		Subchronic Inhalation R_iD mg/kg-day	Inhalation Slope Factor (mg/kg-day)⁻¹	Concentration in Daylighted Groundwater - Non-carcinogenic Effects (mg/l)	Concentration in Daylighted Groundwater - Carcinogenic Effects (mg/l)
volatiles					
1,1,1-Trichloroethane		3		113.6096204	
1,1-dichloroethene		0.057	0.175	2.158582788	0.007573975
1,2-dichloroethane		0.056	0.091	2.120712914	0.014565336
Bromodichloromethane		0.02		0.757397469	
Benzene		0.00171	0.029	0.064757484	0.04570502
Chlorobenzene		0.00571		0.216236978	
Dibromochloromethane		0.02	0.084	0.757397469	0.015779114
Ethyl benzene		0.286		10.83078381	
Tetrachloroethene		0.08	0.00203	3.029589878	0.652928853
Trichloroethene		0.53	0.006	20.07103294	0.220907595
Toluene		0.1		3.786987347	
Vinyl chloride		0.005	0.3	0.189349367	0.004418152
Xylene (mixed)		0.8		30.29589878	

Table 10
Action Levels for Volatile PCOC in Daylighted Groundwater - Construction Foreman Scenario

Noncarcinogenic Equation	$C \text{ (mg/L)} = \frac{\text{THI} \cdot \text{BW} \cdot \text{AT}_N}{\text{EF} \cdot \text{ED} \cdot ((1/R_i D_D) \cdot \text{CF} \cdot \text{SA} \cdot \text{K}_p \cdot \text{ET}) + ((1/R_i D_i) \cdot \text{IR}_A \cdot \text{VF} \cdot \text{ET})}$						
Carcinogenic Equation	$C \text{ (mg/L)} = \frac{\text{TR} \cdot \text{BW} \cdot \text{AT}_C}{\text{EF} \cdot \text{ED} \cdot ((\text{SF}_O \cdot \text{CF} \cdot \text{SA} \cdot \text{K}_p \cdot \text{ET}) + (\text{SF}_I \cdot \text{IR}_A \cdot \text{VF} \cdot \text{ET}))}$						
Parameter	Symbol	Value	Units	Source			
Concentration in water	C	chemical specific	mg/L				
Target hazard index	THI	1		EPA 1991, RAGS-Part B			
Target cancer risk	TR	0.000001		EPA 1991, RAGS-Part B			
Body weight	BW	70	kg	EPA 1991, RAGS-Part B			
Averaging time - noncarcinogenic	AT _N	730	days	Reasonable maximum			
Averaging time - carcinogenic	AT _C	25550	days	EPA 1991, RAGS-Part B			
Exposure frequency	EF	250	days/year	EPA 1991, RAGS-Part B			
Exposure duration	ED	2	years	Reasonable maximum			
Dermal chronic reference dose	R _i D _D	chemical specific	mg/kg-day				
Inhalation chronic reference dose	R _i D _i	chemical specific	mg/kg-day				
Oral cancer slope factor	SF _O	chemical specific	(mg/kg-day) ⁻¹				
Inhalation slope factor	SF _I	chemical specific	(mg/kg-day) ⁻¹				
Conversion factor (1000L/1 m ³)	CF	0.001	L/cm ³	calculated			
Skin surface area available for exposure	SA	4540	cm ²	SA _T * PS			
Total skin surface area of adult	SA _T	20000	cm ²	EPA 1996, Exposure Factors Handbook			
Percent of skin surface area available for exposure	PS	23%		EPA 1996, Exposure Factors Handbook			
Permeability coefficient	K _p	chemical specific	cm/hr				
Exposure time (daylighted groundwater)	ET	1	hrs/day	Reasonable maximum			
Exposure time (work area)	ET _w	8	hrs/day	EPA 1991, RAGS-Part B			
Inhalation rate (inactive)	IR _A	0.391	m ³ /hr	EPA 1996, Exposure Factors Handbook			
Daylighted groundwater to air volatilization factor	VF	0.5	L/m ³	EPA 1991, RAGS-Part B			
Analyte	K_p (cm/hr)	Subchronic Dermal R_iD mg/kg-day	Subchronic Inhalation R_iD mg/kg-day	Oral Slope Factor (mg/kg-day) ⁻¹	Inhalation Slope Factor (mg/kg-day) ⁻¹	Concentration in Daylighted Groundwater - Non-carcinogenic Effects (mg/l)	Concentration in Daylighted Groundwater - Carcinogenic Effects (mg/l)
volatiles							
1,1,1-Trichloroethane	0.017	0.855	3			167.1573585	
1,1-dichloroethene	0.016	0.00855	0.057	0.6	0.175	2.844906604	0.011277588
1,2-dichloroethane	0.0053	0.1805	0.056	0.091	0.091	3.643359142	0.024761456
Bromodichloromethane	0.0058	0.019	0.02	0.062		1.284637191	2.19100518
Benzene	0.111	0.006745	0.00171	0.029	0.029	0.10333901	0.05966375
Chlorobenzene	0.041	0.19	0.00571			0.371935566	
Dibromochloromethane	0.0039	0.19	0.02	0.084	0.084	1.305856168	0.026932746
Ethyl benzene	1	0.95	0.286			9.975251388	
Tetrachloroethene	0.4	0.095	0.08	0.052	0.00203	2.643682341	0.036647455
Trichloroethene	0.2	0.01638	0.53	0.011	0.006	1.750501974	0.184682677
Toluene	1	1.9	0.1			5.670405653	
Vinyl chloride	0.0073	0.247	0.005	1.9	0.3	0.326713034	0.00672384
Xylene (mixed)	0.0003392	3.48	0.8			52.2846787	

Table 11
Action Levels for Non-volatile PCOC in Daylighted Groundwater - Construction Foreman Scenario

Noncarcinogenic Equation	$C \text{ (mg/L)} = \frac{THI \cdot BW \cdot AT_N}{(1/R_f D_D) \cdot EF \cdot ED \cdot CF \cdot SA \cdot K_p \cdot ET}$			
Carcinogenic Equation	$C \text{ (mg/L)} = \frac{TR \cdot BW \cdot AT_C}{SF_o \cdot EF \cdot ED \cdot CF \cdot SA \cdot K_p \cdot ET}$			
Parameter	Symbol	Value	Units	Source
Concentration in water	C	chemical specific	mg/L	
Target hazard index	THI	1		EPA 1991, RAGS-Part B
Target cancer risk	TR	0.000001		EPA 1991, RAGS-Part B
Body weight	BW	70	kg	EPA 1991, RAGS-Part B
Averaging time - noncarcinogenic	AT _N	730	days	Reasonable maximum
Averaging time - carcinogenic	AT _C	25550	days	EPA 1991, RAGS-Part B
Exposure frequency	EF	250	days/year	EPA 1991, RAGS-Part B
Exposure duration	ED	2	years	Reasonable maximum
Dermal chronic reference dose	R _f D _D	chemical specific	mg/kg-day	
Oral cancer slope factor	SF _O	chemical specific	(mg/kg-day) ⁻¹	
Conversion factor (1000L/1 m ³)	CF	0.001	L/cm ³	calculated
Skin surface area available for exposure	SA	4540	cm ²	SA _T * PS
Total skin surface area of adult	SA _T	20000	cm ²	EPA 1996, Exposure Factors Handbook
Percent of skin surface area available for exposure	PS	23%		EPA 1996, Exposure Factors Handbook
Permeability coefficient	K _p	chemical specific	cm/hr	
Exposure time	ET	1	hrs/day	Reasonable maximum

Analyte	K _p (cm/hr)	Subchronic Dermal R _f D mg/kg-day	Oral Slope Factor (mg/kg-day) ⁻¹	Concentration in Daylighted Groundwater Non-carcinogenic Effects (mg/l)	Concentration in Daylighted Groundwater - Carcinogenic Effects (mg/l)
metals					
Arsenic	0.000479145	0.000285	1.5	13.38976505	1.096238074
Barium	0.001	0.007		157.5770925	
Chromium	0.000741964	0.1		3033.978319	
Mercury	0.001	0.000021		0.472731278	
Nickel	0.000673471	0.00086		28.74580916	
Lead	8.03001E-05	0.0003052		85.5585393	
Antimony	0.001	0.000004		0.090044053	
Thallium	8.24769E-05	0.00064		174.6798278	
semivolatiles					
Acenaphthene	0.310119978	0.42		30.48699286	
Acenaphthylene	0.44262035	0.238		12.10432631	
Anthracene	0.674454745	2.1		70.0908817	
Benzo(a)anthracene	0.81	0.0035	0.73	0.09726981	0.001332463
Benzo(a)pyrene	1.2	0.0084	7.3	0.157577093	0.0000899
Benzo(b)fluoranthene	1.2	0.00161	0.73	0.030202276	0.000899413
Benzo(g,h,i)perylene	73.94600794	0.0084		0.00255717	
Benzo(k)fluoranthene	44.77125551	0.00161	0.073	0.000809509	0.000241069
Chrysene	0.81	0.0224	0.0073	0.622526785	0.133246315
Dibenz(a,h)anthracene	2.7	0.0035	7.3	0.029180943	0.00003997
Fluoranthene	0.36	0.28		17.50856583	
Fluorene	0.451401491	0.28		13.96336481	
Indeno(1,2,3-cd)pyrene	1.9	0.0084	0.73	0.099522374	0.00056805
Naphthalene	0.069	0.028		9.134903914	
Phenanthrene	0.23	0.049		4.795824555	
Pyrene	2.316783636	0.21		2.040463642	

Table 12
Action Levels for PCOC in Sediment - Residential Scenario

Noncarcinogenic Equation	$C \text{ (mg/kg)} = \frac{THI \cdot BW \cdot AT_N}{(1/R_{fD_i}) \cdot EF \cdot ED \cdot IR_A \cdot RA \cdot AF \cdot (1/PEF)}$			
Carcinogenic Equation	$C \text{ (mg/kg)} = \frac{TR \cdot BW \cdot AT_C}{SF_1 \cdot EF \cdot ED \cdot IR_A \cdot RF \cdot AF \cdot (1/PEF)}$			
Parameter	Symbol	Value	Units	Source
Concentration in sediment	C	chemical specific	mg/kg	
Target hazard index	THI	1		EPA 1991, RAGS-Part B
Target cancer risk	TR	0.000001		EPA 1991, RAGS-Part B
Body weight	BW	70	kg	EPA 1991, RAGS-Part B
Averaging time - noncarcinogenic	AT _N	730	days	Reasonable maximum
Averaging time - carcinogenic	AT _C	25550	days	EPA 1991, RAGS-Part B
Exposure frequency	EF	350	days/year	EPA 1991, RAGS-Part B
Exposure duration	ED	2	years	Reasonable maximum
Inhalation chronic reference dose	R _{fD_i}	chemical specific	mg/kg-day	
Inhalation slope factor	SF ₁	chemical specific	(mg/kg-day) ⁻¹	
Inhalation rate	IR _A	15	m ³ /day	EPA 1991, RAGS-Part B
Retention Factor non-volatiles	RF	0.75		ICRP, 1968
Alveolar Factor for administered dose	AF _B	1		Reasonable maximum
Alveolar Factor for absorbed dose	AF _D	0.5		Reasonable maximum
Sediment to air volatilization factor	VF	chemical specific	m ³ /kg	calculated
Particulate Emission Factor	PEF	4,630,000,000	m ³ /kg	RAGS-Part B, EPA 1991
Analyte	Subchronic Inhalation RfD mg/kg-day	Inhalation Slope Factor (mg/kg-day) ⁻¹	Concentration in Sediment - Noncarc. Effects mg/kg	Concentration in Sediment - Carcinogenic Effects mg/kg
metals				
Arsenic	0.0001	1.5	3,004,356	701,016
Barium	0.001		30,043,556	
Chromium	0.0019		57,082,756	
Mercury	0.000086		2,583,746	
Nickel	0.00017	0.84	5,107,404	1,251,815
Lead	0.000429		12,888,685	
Antimony	0.0026		78,113,244	
Thallium	0.0002		6,008,711	
semivolatiles				
Acenaphthene	0.6		36,052,266,667	
Acenaphthylene	0.34		20,429,617,778	
Anthracene	3		180,261,333,333	
Benzo(a)anthracene	0.005	0.73	300,435,556	2,880,889
Benzo(a)pyrene	0.012	5.8	721,045,333	181,297
Benzo(b)fluoranthene	0.0023	0.73	138,200,356	2,880,889
Benzo(g,h,i)perylene	0.012		721,045,333	
Benzo(k)fluoranthene	0.0023	0.073	138,200,356	28,808,889
Chrysene	0.032	0.0073	1,922,787,556	288,088,889
Dibenz(a,h)anthracene	0.005	7.3	300,435,556	288,089
Fluoranthene	0.4		24,034,844,444	
Fluorene	0.4		24,034,844,444	
Indeno(1,2,3-cd)pyrene	0.012	0.73	721,045,333	2,880,889
Naphthalene	0.053		3,184,616,889	
Phenanthrene	0.07		4,206,097,778	
Pyrene	0.3		18,026,133,333	

Table 13
Action Levels for PCOC in Sediment - Commercial/Industrial Worker Scenario

Noncarcinogenic Equation	$C \text{ (mg/kg)} = \frac{\text{THI} \cdot \text{BW} \cdot \text{AT}_N}{(1/R_{D_i}) \cdot \text{EF} \cdot \text{ED} \cdot \text{IR}_A \cdot \text{RF} \cdot \text{AF} \cdot (1/\text{PEF})}$			
Carcinogenic Equation	$C \text{ (mg/kg)} = \frac{\text{TR} \cdot \text{BW} \cdot \text{AT}_C}{\text{SF}_i \cdot \text{EF} \cdot \text{ED} \cdot \text{IR}_A \cdot \text{RF} \cdot \text{AF} \cdot (1/\text{PEF})}$			
Parameter	Symbol	Value	Units	Source
Concentration in sediment	C	chemical specific	mg/kg	
Target hazard index	THI	1		EPA 1991, RAGS-Part B
Target cancer risk	TR	0.000001		EPA 1991, RAGS-Part B
Body weight	BW	70	kg	EPA 1991, RAGS-Part B
Averaging time - noncarcinogenic	AT _N	1095	days	Reasonable maximum
Averaging time - carcinogenic	AT _C	25550	days	EPA 1991, RAGS-Part B
Exposure frequency	EF	250	days/year	EPA 1991, RAGS-Part B
Exposure duration	ED	2	years	Reasonable maximum
Inhalation chronic reference dose	R _{D_i}	chemical specific	mg/kg-day	
Inhalation slope factor	SF _i	chemical specific	(mg/kg-day) ⁻¹	
Inhalation rate	IR _A	20	m ³ /day	EPA 1991, RAGS-Part B
Retention Factor non-volatiles	RF	0.75		ICRP, 1968
Alveolar Factor for administered dose	AF _B	1		Reasonable maximum
Alveolar Factor for absorbed dose	AF _D	0.5		Reasonable maximum
Particulate Emission Factor	PEF	4,630,000,000	m ³ /kg	RAGS-Part B, EPA 1991
Analyte	Subchronic Inhalation RfD mg/kg-day	Inhalation Slope Factor (mg/kg-day)⁻¹	Concentration in Sediment - Noncarc. Effects mg/kg	Concentration in Sediment - Carcinogenic Effects mg/kg
metals				
Arsenic	0.0001	1.5	4,731,860	736,067
Barium	0.001		47,318,600	
Chromium	0.0019		89,905,340	
Mercury	0.000086		4,069,400	
Nickel	0.00017	0.84	8,044,162	1,314,406
Lead	0.000429		20,299,679	
Antimony	0.0026		123,028,360	
Thallium	0.0002		9,463,720	
semivolatiles				
Acenaphthene	0.6		56,782,320,000	
Acenaphthylene	0.34		32,176,648,000	
Anthracene	3		283,911,600,000	
Benzo(a)anthracene	0.005	0.73	473,186,000	3,024,933
Benzo(a)pyrene	0.012	5.8	1,135,646,400	190,362
Benzo(b)fluoranthene	0.0023	0.73	217,665,560	3,024,933
Benzo(g,h,i)perylene	0.012		1,135,646,400	
Benzo(k)fluoranthene	0.0023	0.073	217,665,560	30,249,333
Chrysene	0.032	0.0073	3,028,390,400	302,493,333
Dibenz(a,h)anthracene	0.005	7.3	473,186,000	302,493
Fluoranthene	0.4		37,854,880,000	
Fluorene	0.4		37,854,880,000	
Indeno(1,2,3-cd)pyrene	0.012	0.73	1,135,646,400	3,024,933
Naphthalene	0.053		5,015,771,600	
Phenanthrene	0.07		6,624,604,000	
Pyrene	0.3		28,391,160,000	

Table 14
Action Levels for PCOC in Sediment - Trespassing Recreationist Scenario

Noncarcinogenic Equation	$C \text{ (mg/kg)} = \frac{THI \cdot BW \cdot AT_N}{EF \cdot ED \cdot ((1/R_{D0}) \cdot CF \cdot SA \cdot ADF \cdot ABS) + ((1/R_{D0}) \cdot CF \cdot IR_S \cdot ME) + ((1/R_{D1}) \cdot IR_A \cdot ET \cdot RF \cdot AF \cdot (1/PEF))}$						
Carcinogenic Equation	$C \text{ (mg/kg)} = \frac{TR \cdot BW \cdot AT_C}{EF \cdot ED \cdot ((SF_0 \cdot CF \cdot SA \cdot ADF \cdot ABS) + (SF_0 \cdot CF \cdot IR_S \cdot ME) + (SF_1 \cdot IR_A \cdot ET \cdot RF \cdot AF \cdot (1/PEF)))}$						
Parameter	Symbol	Value	Units	Source			
Concentration in sediment	C	chemical specific	mg/kg				
Target hazard index	THI	1		EPA 1991, RAGS-Part B			
Target cancer risk	TR	0.000001		EPA 1991, RAGS-Part B			
Body weight of a child age 6-18	BW	45	kg	EPA 1996, Exposure Factors Handbook			
Averaging time - noncarcinogenic	AT _N	730	days	Reasonable maximum			
Averaging time - carcinogenic	AT _C	25550	days	EPA 1991, RAGS-Part B			
Exposure frequency	EF	104	days/year	Reasonable maximum			
Exposure duration	ED	2	years	Reasonable maximum			
Dermal chronic reference dose	R _{D0}	chemical specific	mg/kg-day				
Oral chronic reference dose	R _{D0}	chemical specific	mg/kg-day				
Inhalation chronic reference dose	R _{D1}	chemical specific	mg/kg-day				
Oral cancer slope factor	SF ₀	chemical specific	(mg/kg-day) ⁻¹				
Inhalation slope factor	SF ₁	chemical specific	(mg/kg-day) ⁻¹				
Conversion factor (1 kg/1,000,000 mg)	CF	1.00E-06	kg/mg				
Child skin surface area available for exposure	SA	10651	cm ² /day	SA _T * PS			
Total skin surface area of a child age 6-18	SA _T	16021	cm ²	EPA 1996, Exposure Factors Handbook			
Percent of skin surface area available for exposure	PS	66%		EPA 1996, Exposure Factors Handbook			
Adherence factor	ADF	0.077	mg/cm ²	EPA 1996, Exposure Factors Handbook			
Absorption - volatiles	ABS _V	0.03		EPA 1995, Region III			
Absorption - semivolatiles	ABS _S	0.10		EPA 1995, Region III			
Absorption - inorganics	ABS _I	0.01		EPA 1995, Region III			
Ingestion rate for sediment	IR _S	100	mg/day	EPA 1989, RAGS-Part A			
Exposure time	ET	2.6	hrs/day	EPA 1989, RAGS-Part A			
Matrix effect - semivolatiles	ME _S	0.29		Magee et al., 1996			
Matrix effect - non-semivolatiles	ME _N	1		Reasonable maximum			
Inhalation rate	IR _A	0.625	m ³ /hr	EPA 1991, RAGS-Part B			
Retention Factor non-volatiles	RF	0.75		ICRP, 1968			
Alveolar Factor for administered dose	AF _B	1		Reasonable maximum			
Alveolar Factor for absorbed dose	AF _D	0.5		Reasonable maximum			
Particulate Emission Factor	PEF	4,630,000,000	m ³ /kg	RAGS-Part B, EPA 1991			
Analyte	Subchronic Dermal R_D mg/kg-day	Subchronic Oral R_D mg/kg-day	Subchronic Inhalation R_D mg/kg-day	Oral Slope Factor (mg/kg-day) ⁻¹	Inhalation Slope Factor (mg/kg-day) ⁻¹	Concentration in Sediment - Noncarc. Effects mg/kg	Concentration in Sediment - Carcinogenic Effects mg/kg
metals							
Arsenic	0.000285	0.0003	0.0001	1.5	1.5	436	34
Barium	0.007	0.07	0.001			60,705	
Chromium	0.1	1	0.0019			866,645	
Mercury	0.000021	0.0003	0.000086			218	
Nickel	0.00086	0.02	0.00017		0.84	10,858	24,988,150
Lead	0.0003052	0.0028	0.000429			2,522	
Antimony	0.000004	0.0004	0.0026			69	
Thallium	0.00064	0.0008	0.0002			1,145	
semivolatiles							
Acenaphthene	0.42	0.6	0.6			648,020	
Acenaphthylene	0.238	0.34	0.34			367,212	
Anthracene	2.1	3	3			3,240,102	
Benzo(a)anthracene	0.0035	0.005	0.005	0.73	0.73	5,400	68
Benzo(a)pyrene	0.0084	0.012	0.012	7.3	5.8	12,960	7
Benzo(b)fluoranthene	0.00161	0.0023	0.0023	0.73	0.73	2,484	68
Benzo(g,h,i)perylene	0.0084	0.012	0.012			12,960	
Benzo(k)fluoranthene	0.00161	0.0023	0.0023	0.073	0.073	2,484	682
Chrysene	0.0224	0.032	0.032	0.0073	0.0073	34,561	6,818
Dibenz(a,h)anthracene	0.0035	0.005	0.005	7.3	7.3	5,400	7
Fluoranthene	0.28	0.4	0.4			432,014	
Fluorene	0.28	0.4	0.4			432,014	
Indeno(1,2,3-cd)pyrene	0.0084	0.012	0.012	0.73	0.73	12,960	68
Naphthalene	0.028	0.04	0.053			43,201	
Phenanthrene	0.049	0.07	0.07			75,602	
Pyrene	0.21	0.3	0.3			324,010	

Table 15
Action Levels for PCOC in Sediment - Construction Worker Scenario

Noncarcinogenic Equation $C \text{ (mg/kg)} = \frac{THI \cdot BW \cdot AT_N}{EF \cdot ED \cdot ((1/R_{D_o}) \cdot CF \cdot SA \cdot ADF \cdot ABS) + ((1/R_{D_o}) \cdot CF \cdot IR_s \cdot ME) + ((1/R_{D_i}) \cdot IR_A \cdot RF \cdot AF \cdot (1/PEF))}$

Carcinogenic Equation $C \text{ (mg/kg)} = \frac{TR \cdot BW \cdot AT_C}{EF \cdot ED \cdot ((SF_o \cdot CF \cdot SA \cdot ADF \cdot ABS) + (SF_o \cdot CF \cdot IR_s \cdot ME) + (SF_i \cdot IR_A \cdot RF \cdot AF \cdot (1/PEF)))}$

Parameter	Symbol	Value	Units	Source
Concentration in sediment	C	chemical specific	mg/kg	
Target hazard index	THI	1		EPA 1991, RAGS-Part B
Target cancer risk	TR	0.000001		EPA 1991, RAGS-Part B
Body weight	BW	70	kg	EPA 1991, RAGS-Part B
Averaging time - noncarcinogenic	AT _N	730	days	Reasonable maximum
Averaging time - carcinogenic	AT _C	25550	days	EPA 1991, RAGS-Part B
Exposure frequency	EF	250	days/year	EPA 1991, RAGS-Part B
Exposure duration	ED	2	years	Reasonable maximum
Dermal chronic reference dose	R _D _o	chemical specific	mg/kg-day	
Oral chronic reference dose	R _D _o	chemical specific	mg/kg-day	
Inhalation chronic reference dose	R _D _i	chemical specific	mg/kg-day	
Oral cancer slope factor	SF _o	chemical specific	(mg/kg-day) ⁻¹	
Inhalation slope factor	SF _i	chemical specific	(mg/kg-day) ⁻¹	
Conversion factor (1 kg/1,000,000 mg)	CF	0.000001	kg/mg	
Child skin surface area available for exposure	SA	5560	cm ² /day	SA ₇ ·PS
Total skin surface area of a child age 6-18	SA ₇	20000	cm ²	EPA 1996, Exposure Factors Handbook
Percent of skin surface area available for exposure	PS	28%		EPA 1996, Exposure Factors Handbook
Adherence factor	ADF	0.077	mg/cm ²	EPA 1996, Exposure Factors Handbook
Absorption - volatiles	ABS _v	0.03		EPA 1995, Region III
Absorption - semivolatiles	ABS _s	0.10		EPA 1995, Region III
Absorption - inorganics	ABS _i	0.01		EPA 1995, Region III
Ingestion rate for sediment	IR _s	50	mg/day	EPA 1991, RAGS-Part B
Matrix effect - semivolatiles	ME _s	0.29		Magee et al., 1996
Matrix effect - non-semivolatiles	ME _N	1		Reasonable maximum
Inhalation rate	IR _A	20	m ³ /day	EPA 1991, RAGS-Part B
Retention Factor non-volatiles	RF	0.75		ICRP, 1968
Alveolar Factor for administered dose	AF _a	1		Reasonable maximum
Alveolar Factor for absorbed dose	AF _D	0.5		Reasonable maximum
Particulate Emission Factor (for non-volatiles)	PEF	4,630,000,000	m ³ /kg	RAGS-Part B, EPA 1991

Analyte	Subchronic			Oral Slope Factor (mg/kg-day) ⁻¹	Inhalation Slope Factor (mg/kg-day) ⁻¹	Concentration in Sediment - Noncarc. Effects	Concentration in Sediment - Carcinogenic Effects
	Dermal R _D mg/kg-day	Oral R _D mg/kg-day	Inhalation R _D mg/kg-day			mg/kg	mg/kg
metals							
Arsenic	0.000285	0.0003	0.0001	1.5	1.5	562	44
Barium	0.007	0.07	0.001			76,893	
Chromium	0.1	1	0.0019			1,081,286	
Mercury	0.000021	0.0003	0.000086			276	
Nickel	0.00086	0.02	0.00017		0.84	13,632	1,314,406
Lead	0.0003052	0.0028	0.000429			3,205	
Antimony	0.000004	0.0004	0.0026			86	
Thallium	0.00064	0.0008	0.0002			1,477	

Table 15
Action Levels for PCOC in Sediment - Construction Worker Scenario

Noncarcinogenic Equation	C (mg/kg) =	$\frac{THI \cdot BW \cdot AT_N}{EF \cdot ED \cdot ((1/R_{D_O}) \cdot CF \cdot SA \cdot ADF \cdot ABS) + ((1/R_{D_O}) \cdot CF \cdot IR_S \cdot ME) + ((1/R_{D_I}) \cdot IR_A \cdot RF \cdot AF \cdot (1/PEF))}$
Carcinogenic Equation	C (mg/kg) =	$\frac{TR \cdot BW \cdot AT_C}{EF \cdot ED \cdot ((SF_O \cdot CF \cdot SA \cdot ADF \cdot ABS) + (SF_O \cdot CF \cdot IR_S \cdot ME) + (SF_I \cdot IR_A \cdot RF \cdot AF \cdot (1/PEF)))}$

Parameter	Symbol	Value	Units	Source
Concentration in sediment	C	chemical specific	mg/kg	
Target hazard index	THI	1		EPA 1991, RAGS-Part B
Target cancer risk	TR	0.000001		EPA 1991, RAGS-Part B
Body weight	BW	70	kg	EPA 1991, RAGS-Part B
Averaging time - noncarcinogenic	AT _N	730	days	Reasonable maximum
Averaging time - carcinogenic	AT _C	25550	days	EPA 1991, RAGS-Part B
Exposure frequency	EF	250	days/year	EPA 1991, RAGS-Part B
Exposure duration	ED	2	years	Reasonable maximum
Dermal chronic reference dose	R _D O	chemical specific	mg/kg-day	
Oral chronic reference dose	R _D O	chemical specific	mg/kg-day	
Inhalation chronic reference dose	R _D I	chemical specific	mg/kg-day	
Oral cancer slope factor	SF _O	chemical specific	(mg/kg-day) ⁻¹	
Inhalation slope factor	SF _I	chemical specific	(mg/kg-day) ⁻¹	
Conversion factor (1 kg/1,000,000 mg)	CF	0.000001	kg/mg	
Child skin surface area available for exposure	SA	5560	cm ² /day	SA _T ·PS
Total skin surface area of a child age 6-18	SA _T	20000	cm ²	EPA 1996, Exposure Factors Handbook
Percent of skin surface area available for exposure	PS	28%		EPA 1996, Exposure Factors Handbook
Adherence factor	ADF	0.077	mg/cm ²	EPA 1996, Exposure Factors Handbook
Absorption - volatiles	ABS _V	0.03		EPA 1995, Region III
Absorption - semivolatiles	ABS _S	0.10		EPA 1995, Region III
Absorption - inorganics	ABS _I	0.01		EPA 1995, Region III
Ingestion rate for sediment	IR _S	50	mg/day	EPA 1991, RAGS-Part B
Matrix effect - semivolatiles	ME _S	0.29		Magee et al., 1996
Matrix effect - non-semivolatiles	ME _N	1		Reasonable maximum
Inhalation rate	IR _A	20	m ³ /day	EPA 1991, RAGS-Part B
Retention Factor non-volatiles	RF	0.75		ICRP, 1968
Alveolar Factor for administered dose	AF _B	1		Reasonable maximum
Alveolar Factor for absorbed dose	AF _D	0.5		Reasonable maximum
Particulate Emission Factor (for non-volatiles)	PEF	4,630,000,000	m ³ /kg	RAGS-Part B, EPA 1991

Analyte							Concentration in Sediment - Noncarc. Effects	Concentration in Sediment - Carcinogenic Effects
	Subchronic Dermal R _D	Subchronic Oral R _D	Subchronic Inhalation R _D	Oral Slope Factor	Inhalation Slope Factor	mg/kg	mg/kg	
	mg/kg-day	mg/kg-day	mg/kg-day	(mg/kg-day) ⁻¹	(mg/kg-day) ⁻¹			
semivolatiles								
Acenaphthene	0.42	0.6	0.6			810,451		
Acenaphthylene	0.238	0.34	0.34			459,255		
Anthracene	2.1	3	3			4,052,253		
Benzo(a)anthracene	0.0035	0.005	0.005	0.73	0.73	6,754	85	
Benzo(a)pyrene	0.0084	0.012	0.012	7.3	5.8	16,209	9	
Benzo(b)fluoranthene	0.00161	0.0023	0.0023	0.73	0.73	3,107	85	
Benzo(g,h,i)perylene	0.0084	0.012	0.012			16,209		
Benzo(k)fluoranthene	0.00161	0.0023	0.0023	0.073	0.073	3,107	855	
Chrysene	0.0224	0.032	0.032	0.0073	0.0073	43,224	8,549	
Dibenz(a,h)anthracene	0.0035	0.005	0.005	7.3	7.3	6,754	9	
Fluoranthene	0.28	0.4	0.4			540,300		
Fluorene	0.28	0.4	0.4			540,300		
Indeno(1,2,3-cd)pyrene	0.0084	0.012	0.012	0.73	0.73	16,209	85	
Naphthalene	0.028	0.04	0.053			54,030		
Phenanthrene	0.049	0.07	0.07			94,553		
Pyrene	0.21	0.3	0.3			405,225		

Table 16
Summary of Toxicity Data for Potential Constituents of Concern

Chemical	Cas #	Oral Chronic RfD (mg/kg-day)	Source	Inhalation Chronic RfD (mg/kg-day)	Source	Range of Absorption by G.I. Tract	Source	Dermal Chronic RfD (mg/kg-day)	Oral Subchronic RfD (mg/kg-day)	Source	Inhalation Subchronic RfD (mg/kg-day)	Source
volatiles												
1,1,1-Trichloroethane	71556	0.02	E	0.286	W	0.95		0.0855	0.9	Pa	3	Pa
1,1-dichloroethene	75354	0.009	IRIS	0.0057	Pa	0.95		0.00855	0.009	H	0.057	Pa
1,2-dichloroethane	107062	0.019	Pa	0.00286	E	0.95		0.01805	0.19	Pa	0.056	Pa
Bromodichloromethane	75274	0.02	IRIS	0.02	Region IX EPA	0.95		0.019	0.02	H	0.02	Region IX EPA
Benzene	71432	0.00071	Pa	0.00171	E	0.95		0.0006745	0.0071	Pa	0.0071	Ps
Chlorobenzene	108907	0.02	IRIS	0.00571	H2	0.95		0.019	0.2	Pa	0.05	Pa
Dibromochloromethane	124481	0.02	IRIS	0.02	Region IX EPA	0.95		0.019	0.2	H	0.02	Region IX EPA
Ethyl benzene	100414	0.1	IRIS	0.286	IRIS	0.95		0.095	1	Pa	0.29	Pa
Tetrachloroethene	127184	0.01	IRIS	0.008	Pa	0.95		0.0095	0.1	H	0.08	Pa
Trichloroethene	79016	0.006	E	0.053	Pa	0.91		0.006734	0.018	Pa	0.53	Pa
Toluene	108883	0.2	IRIS	0.114	IRIS	0.95		0.19	2	H	0.1	Pa
Vinyl chloride	75014	0.0013	Pa	0.005	Pa	0.95		0.001235	0.26	Pa	0.005	Pa
Xylene (mixed)	1330207	2	IRIS	0.8	Pa	0.87		1.74	4	Pa	0.8	Pa
metals												
Arsenic	7440382	0.0003	IRIS	0.0001	Pa	0.95	ATSDR	0.000285	0.0003	H	0.0001	Pa
Barium	7440393	0.07	IRIS	0.000143	H2	0.1	Pa	0.007	0.07	H	0.001	H2
Chromium III		1	IRIS	0.00000571	W	0.1	Pa	0.1	1	H	0.0019	Pa
Mercury (Inorganic)	7439976	0.0003	H	0.0000857	H	0.07	ATSDR	0.000021	0.0003	H	0.000086	HE
Nickel	7440020	0.02	IRIS	0.000017	Pa	0.043	ATSDR	0.00086	0.02	H	0.00017	Pa
Lead	743-9921	0.0028	Pa	0.000429	NAAQS	0.109	ATSDR	0.0003052	0.0028	Pa	0.000429	NAAQS
Antimony	7440360	0.0004	IRIS	0.00026	Pa	0.01	ATSDR	0.000004	0.0004	H	0.0026	Pa
Thallium	7440280	0.00008	Pa	0.0002	Pa	0.8		0.000064	0.0008	Pa	0.0002	Pa

Table 16
Summary of Toxicity Data for Potential Constituents of Concern

Chemical	Cas #	Oral	Source	Inhalation	Source	Range of	Source	Dermal	Oral	Source	Inhalation	Source
		Chronic		Chronic		Absorption		Chronic	Subchronic		Subchronic	
		RfD		RfD		by G.I.		RfD	RfD		RfD	
		(mg/kg-day)		(mg/kg-day)		Tract		(mg/kg-day)	(mg/kg-day)		(mg/kg-day)	
semivolatiles												
Acenaphthene	208968	0.06	IRIS	0.06	Ps	0.7	ATSDR1	0.042	0.6	H	0.6	Ps
Acenaphthylene	83329	0.034	Pa	0.034	Ps	0.7	ATSDR1	0.0238	0.34	Pa	0.34	Ps
Anthracene	120127	0.3	IRIS	0.3	Ps	0.7	ATSDR1	0.21	3	H	3	Ps
Benzo(a)anthracene	56553	0.0005	Pa	0.0005	Ps	0.7	ATSDR1	0.00035	0.005	Pa	0.005	Ps
Benzo(a)pyrene	50328	0.0012	Pa	0.0012	Ps	0.7	ATSDR1	0.00084	0.012	Pa	0.012	Ps
Benzo(b)fluoranthene	205992	0.00023	Pa	0.00023	Ps	0.7	ATSDR1	0.000161	0.0023	Pa	0.0023	Ps
Benzo(g,h,i)perylene	191242	0.0012	Pa	0.0012	Ps	0.7	ATSDR1	0.00084	0.012	Pa	0.012	Ps
Benzo(k)fluoranthene	207089	0.00023	Pa	0.00023	Ps	0.7	ATSDR1	0.000161	0.0023	Pa	0.0023	Ps
Chrysene	218019	0.0032	Pa	0.0032	Ps	0.7	ATSDR1	0.00224	0.032	Pa	0.032	Ps
Dibenz(a,h)anthracene	53703	0.0005	Pa	0.0005	Ps	0.7	ATSDR1	0.00035	0.005	Pa	0.005	Ps
Fluoranthene	206440	0.04	IRIS	0.04	Ps	0.7	ATSDR1	0.028	0.4	H	0.4	Ps
Fluorene	86737	0.04	IRIS	0.04	Ps	0.7	ATSDR1	0.028	0.4	H	0.4	Ps
Indeno(1,2,3-cd)pyrene	193395	0.0012	Pa	0.0012	Ps	0.7	ATSDR1	0.00084	0.012	Pa	0.012	Ps
Naphthalene	91203	0.04	W	0.0053	Ps	0.7	ATSDR1	0.028	0.04	Pa	0.053	Ps
Phenanthrene	85018	0.007	Pa	0.007	Ps	0.7	ATSDR1	0.0049	0.07	Pa	0.07	Ps
Pyrene	129000	0.03	IRIS	0.03	Ps	0.7	ATSDR1	0.021	0.3	H	0.3	Ps

Table 16
Summary of Toxicity Data for Potential Constituents of Concern

Chemical	Dermal Subchronic RfD (mg/kg-day)	Oral CSF (mg/kg-day) ⁻¹	Source	Inhalation CSF (mg/kg-day) ⁻¹	Source	Henry's Law Const. atm (m ³ /mol)	Diffusion Coeff. in Air cm ² /sec	Source	Diffusion Coeff. in Water cm ² /sec	Source	K _p Average (cm/hr)	K _p Qualifier (G & B if blank)
volatiles												
1,1,1-Trichloroethane	0.855					0.014	0.08182758	Lyman	1.00355E-05	Lyman	0.017	derm 92
1,1-dichloroethene	0.00855	0.6	IRIS	0.175	IRIS	0.034	0.09369152	Lyman	1.18621E-05	Lyman	0.016	derm 92
1,2-dichloroethane	0.1805	0.091	IRIS	0.091	IRIS	0.00098	0.09155459	Lyman	1.13004E-05	Lyman	0.0053	derm 92
Bromodichloromethane	0.019	0.062	IRIS			0.32	0.0996355	Lyman	1.12229E-05	Lyman	0.0058	derm 92
Benzene	0.006745	0.029	IRIS	0.029	IRIS	0.0056	0.0894	Lyman	0.0000111	Lyman	0.111	derm 92
Chlorobenzene	0.19					0.0037	0.07390994	Lyman	9.91359E-06	Lyman	0.041	derm 92
Dibromochloromethane	0.19	0.084	IRIS	0.084	Region IX	0.001	0.24062119	Lyman	7.5771E-05	Lyman	0.0039	derm 92
Ethyl benzene	0.95					0.00788	0.15372522	Lyman	2.65147E-05	Lyman	1	derm 92
Tetrachloroethene	0.095	0.052	E	0.00203	E	0.026	0.07607358	Lyman	9.25382E-06	Lyman	0.4	derm 92
Trichloroethene	0.01638	0.011	(1)	0.006	E	0.0091	0.08337418	Lyman	1.0343E-05	Lyman	0.2	derm 92
Toluene	1.9					0.00664	0.08037532	Lyman	9.94167E-06	Lyman	1	derm 92
Vinyl chloride	0.247	1.9	H	0.3	H	0.025	0.11043979	Lyman	1.41964E-05	Lyman	0.0073	derm 92
Xylene (mixed)	3.48					0.007	0.0738	PCGEMS	0.00000822	PCGEMS	0.000339	
metals												
Arsenic	0.000285	1.5	IRIS	1.5	H						0.000479	
Barium	0.007										0.001	
Chromium III	0.1										0.000742	
Mercury (Inorganic)	0.000021										0.001	
Nickel	0.00086			0.84	IRIS						0	
Lead	0.0003052										0	
Antimony	0.000004										0.001	
Thallium	0.00064										0	

Table 16
Summary of Toxicity Data for Potential Constituents of Concern

Chemical	Dermal Subchronic RfD (mg/kg-day)	Oral CSF (mg/kg-day) ⁻¹	Inhalation CSF (mg/kg-day) ⁻¹	Henry's Law Const. atm (m ³ /mol)	Diffusion Coeff. in Air cm ² /sec	Diffusion Coeff. in Water cm ² /sec	K _p Average (cm/hr)	K _p Qualifier (G & B if blank)		
semivolatiles										
Acenaphthene	0.42			0.000092	0.06226263	Lyman 7.12116E-06	Lyman 0.31012			
Acenaphthylene	0.238			0.0015	0.06296203	Lyman 6.90338E-06	Lyman 0.44262			
Anthracene	2.1			0.000086	0.05968933	Lyman 7.04057E-06	Lyman 0.674455			
Benzo(a)anthracene	0.0035	0.73	Pa	0.73	Ps	0.0000012	0.05282969	Lyman 5.94025E-06	Lyman 0.81	derm 92
Benzo(a)pyrene	0.0084	7.3	IRIS	5.8	Ohio EPA	0.0000015	0.05129084	Lyman 5.6972E-06	Lyman 1.2	derm 92
Benzo(b)fluoranthene	0.00161	0.73	Pa	0.73	Ps	0.000012	0.04947816	Lyman 5.65833E-06	Lyman 1.2	derm 92
Benzo(g,h,i)perylene	0.0084					0.00000014	0.04989506	Lyman 5.50462E-06	Lyman 73.94601	
Benzo(k)fluoranthene	0.00161	0.073	Pa	0.073	Ps	0.000039	0.04856981	Lyman 5.5355E-06	Lyman 44.77126	
Chrysene	0.0224	0.0073	Pa	0.0073	Ps	0.00000095	0.08516571	Lyman 9.93865E-06	Lyman 0.81	derm 92
Dibenz(a,h)anthracene	0.0035	7.3	Pa	7.3	Ps	2.6E-09	0.04787586	Lyman 5.31095E-06	Lyman 2.7	derm 92
Fluoranthene	0.28					0.00001	0.05746547	Lyman 6.41915E-06	Lyman 0.36	derm 92
Fluorene	0.28					0.000064	0.06249359	Lyman 7.0208E-06	Lyman 0.451401	
Indeno(1,2,3-cd)pyrene	0.0084	0.73	Pa	0.73	Ps	0.000000069	0.04989506	Lyman 5.46918E-06	Lyman 1.9	derm 92
Naphthalene	0.028					0.00046	0.07016191	Lyman 7.89673E-06	Lyman 0.069	derm 92
Phenanthrene	0.049					0.00016	0.05968933	Lyman 6.77676E-06	Lyman 0.23	derm 92
Pyrene	0.21					0.000005	0.05746547	Lyman 6.4739E-06	Lyman 2.316784	

Table 17

Summary of Action Level Calculations for Daylighted Groundwater Exposure Scenario

Constituent	Residential	Commercial/Industrial	Trespassing Recreationalist		Construction Foreman		Construction Worker		Most Stringent Action Level (mg/L)
	Action Level at Grade Control Structures (mg/L)	Action Level at Grade Control Structures (mg/L)	Non-carcinogenic Action Level (mg/L)	Carcinogenic Action Level (mg/L)	Non-carcinogenic Action Level (mg/L)	Carcinogenic Action Level (mg/L)	Non-carcinogenic Action Level (mg/L)	Carcinogenic Action Level (mg/L)	
volatiles									
1,1,1-Trichloroethane	40,260	42,273	135.9040572		167.1573585		113.6096204		113.61
1,1-dichloroethane	2	3	1.595563628	0.00951771	2.844906604	0.011277588	2.158582788	0.007573975	0.0076
1,2-dichloroethane	5	5	9.687637089	0.053193153	3.643359142	0.024761456	2.120712914	0.014565336	0.0146
Bromodichloromethane	254	266	2.694688939	0.256302128	1.284637191	2.19100518	0.757397469		0.26
Benzene	15	16	0.142072076	0.037293215	0.10333901	0.05966375	0.064757484	0.04570502	0.037
Chlorobenzene	77	81	1.045144412		0.371935566		0.216236978		0.22
Dibromochloromethane	1	2	3.754568849	0.06040686	1.305856168	0.026932746	0.757397469	0.015779114	0.02
Ethyl benzene	2,008	2,108	3.716102584		9.975251388		10.83078381		3.72
Tetrachloroethene	244	257	0.931368206	0.007001689	2.643682341	0.036647455	3.029589878	0.652928853	0.007
Trichloroethene	77	81	0.337999806	0.062164307	1.750501974	0.184682677	20.07103294	0.220907595	0.062
Toluene	1,350	1,417	5.649067678		5.670405653		3.786987347		3.79
Vinyl chloride	1	1	0.961935053	0.005463179	0.326713034	0.00672384	0.189349367	0.004418152	0.00
Xylene	12,258	12,871	150.0903235		52.2846787		30.29589878		30.30
metals									
Arsenic	NA	NA	0.31799143	0.024890863	13.38976505	1.096238074	NA	NA	0.025
Barium	NA	NA	21.86709319		157.5770925		NA	NA	21.87
Chromium	NA	NA	386.4532288		3033.978319		NA	NA	386.45
Mercury	NA	NA	0.071087481		0.472731278		NA	NA	0.071
Nickel	NA	NA	4.398104251		28.74580916		NA	NA	4.40
Lead	NA	NA	2.803748703		85.5585393		NA	NA	2.80
Antimony	NA	NA	0.016260125		0.090044053		NA	NA	0.02
Thallium	NA	NA	0.943380464		174.6798278		NA	NA	0.94
semivolatiles									
Acenaphthene	NA	NA	5.651823344		30.48699286		NA	NA	5.65
Acenaphthylene	NA	NA	2.249180325		12.10432631		NA	NA	2.25
Anthracene	NA	NA	13.04845761		70.0908817		NA	NA	13.05
Benzo(a)anthracene	NA	NA	0.018119079	0.00024789	0.09726981	0.001332463	NA	NA	0.00
Benzo(a)pyrene	NA	NA	0.029381404	0.000017	0.157577093	8.99413E-05	NA	NA	0.00
Benzo(b)fluoranthene	NA	NA	0.005631436	0.000167557	0.030202276	0.000899413	NA	NA	0.00
Benzo(g,h,i)perylene	NA	NA	0.000477751		0.00255717		NA	NA	0.00
Benzo(k)fluoranthene	NA	NA	0.000151236	0.0000450	0.000809509	0.000241069	NA	NA	0.00
Chrysene	NA	NA	0.115962103	0.0247890	0.622526785	0.133246315	NA	NA	0.02
Dibenz(a,h)anthracene	NA	NA	0.005447102	0.0000075	0.029180943	3.99739E-05	NA	NA	0.00
Fluoranthene	NA	NA	3.24931333		17.50856583		NA	NA	3.25
Fluorene	NA	NA	2.594894848		13.96336481		NA	NA	2.59
Indeno(1,2,3-cd)pyrene	NA	NA	0.018570471	0.000105938	0.099522374	0.00056805	NA	NA	0.00
Naphthalene	NA	NA	1.648777945		9.134903914		NA	NA	1.65
Phenanthrene	NA	NA	0.886676741		4.795824555		NA	NA	0.89
Pyrene	NA	NA	0.380829541		2.040463642		NA	NA	0.38

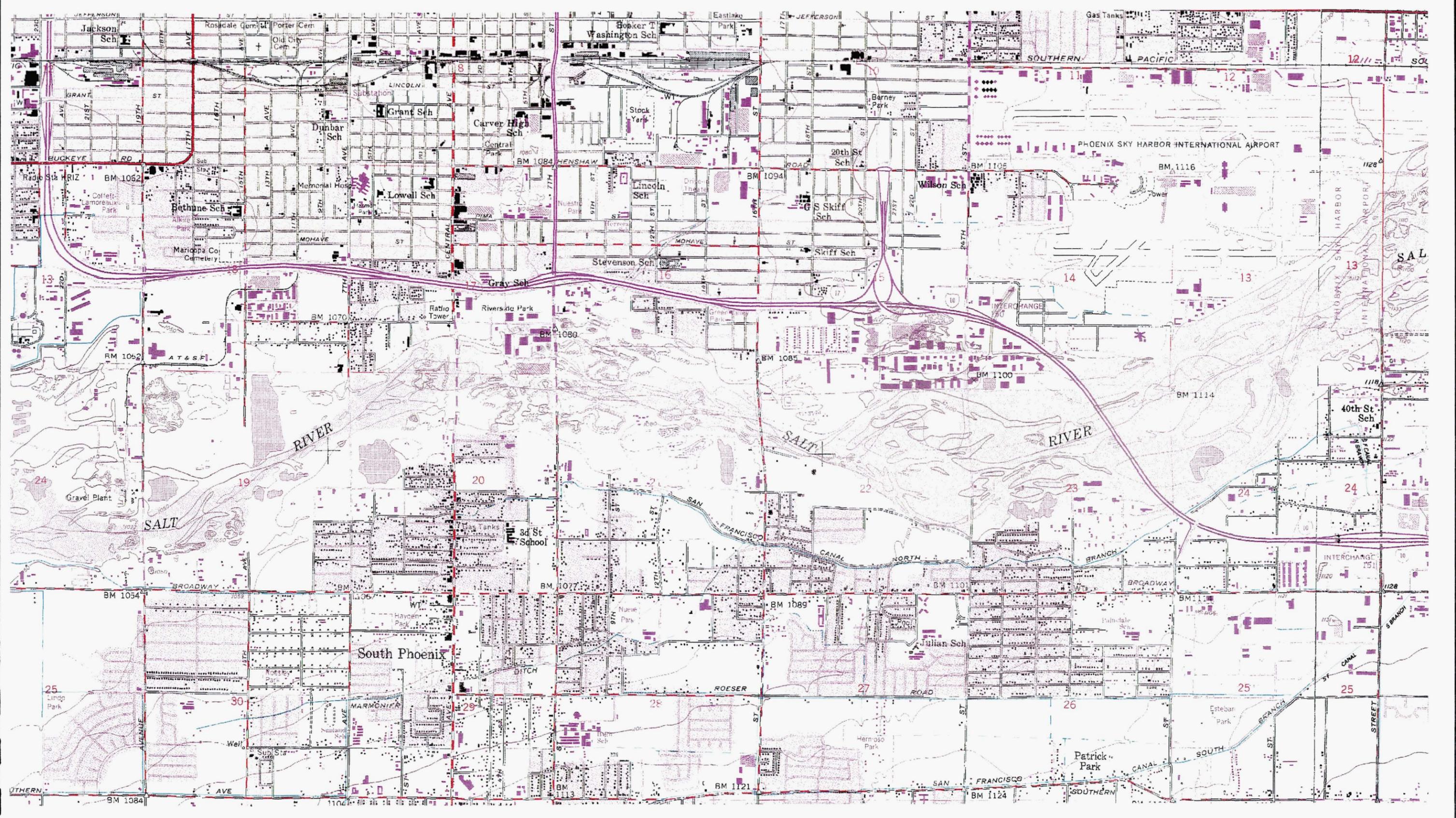
NA - Not applicable because inhalation is the only exposure route for these receptors: Metals and semi-volatile constituents do not volatilize from water.

Table 18
Summary of Action Level Calculations for Sediment Exposure Scenario

Constituent	Residential		Commercial/Industrial		Trespassing Recreationalist		Construction Worker		Most Stringent Action Level (mg/kg)
	Non-carcinogenic Action Level (mg/kg)	Carcinogenic Action Level (mg/kg)	Non-carcinogenic Action Level (mg/kg)	Carcinogenic Action Level (mg/kg)	Non-carcinogenic Action Level (mg/kg)	Carcinogenic Action Level (mg/kg)	Non-carcinogenic Action Level (mg/kg)	Carcinogenic Action Level (mg/kg)	
metals									
Arsenic	3,004,356	701,016	4,731,860	736,067	436	34	562	44	34
Barium	30,043,556		47,318,600		60,705		76,893		60,705
Chromium	57,082,756		89,905,340		866,645		1,081,286		866,645
Mercury	2,583,746		4,069,400		218		276		218
Nickel	5,107,404	1,251,815	8,044,162	1,314,406	10,858	24,988,150	13,632	1,314,406	10,858
Lead	12,888,685		20,299,679		2,522		3,205		2,522
Antimony	78,113,244		123,028,360		69		86		69
Thallium	6,008,711		9,463,720		1,145		1,477		1,145
semivolatiles									
Acenaphthene	36,052,266,667		56,782,320,000		648,020		810,451		648,020
Acenaphthylene	20,429,617,778		32,176,648,000		367,212		459,255		367,212
Anthracene	180,261,333,333		283,911,600,000		3,240,102		4,052,253		3,240,102
Benzo(a)anthracene	300,435,556	2,880,889	473,186,000	3,024,933	5,400	68	6,754	85	68
Benzo(a)pyrene	721,045,333	181,297	1,135,646,400	190,362	12,960	7	16,209	9	7
Benzo(b)fluoranthene	138,200,356	2,880,889	217,665,560	3,024,933	2,484	68	3,107	85	68
Benzo(g,h,i)perylene	721,045,333		1,135,646,400		12,960		16,209		12,960
Benzo(k)fluoranthene	138,200,356	28,808,889	217,665,560	30,249,333	2,484	682	3,107	855	682
Chrysene	1,922,787,556	288,088,889	3,028,390,400	302,493,333	34,561	6,818	43,224	8,549	6,818
Dibenz(a,h)anthracene	300,435,556	288,089	473,186,000	302,493	5,400	7	6,754	9	7
Fluoranthene	24,034,844,444		37,854,880,000		432,014		540,300		432,014
Fluorene	24,034,844,444		37,854,880,000		432,014		540,300		432,014
Indeno(1,2,3-cd)pyrene	721,045,333	2,880,889	1,135,646,400	3,024,933	12,960	68	16,209	85	68
Naphthalene	3,184,616,889		5,015,771,600		43,201		54,030		43,201
Phenanthrene	4,206,097,778		6,624,604,000		75,602		94,553		75,602
Pyrene	18,026,133,333		28,391,160,000		324,010		405,225		324,010

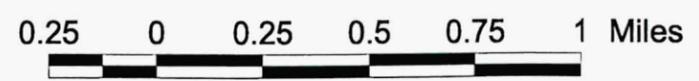
FIGURES

- FIGURE 1 VICINITY MAP**
- FIGURE 2 PROJECT LOCATION MAP**
- FIGURE 3 CONCEPTUAL SITE MODEL OF COMPLETE HUMAN HEALTH
EXPOSURE PATHWAYS**
- FIGURE 4 GENERALIZED LAND USE MAP**



ROAD CLASSIFICATION

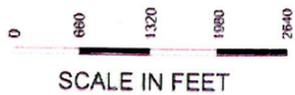
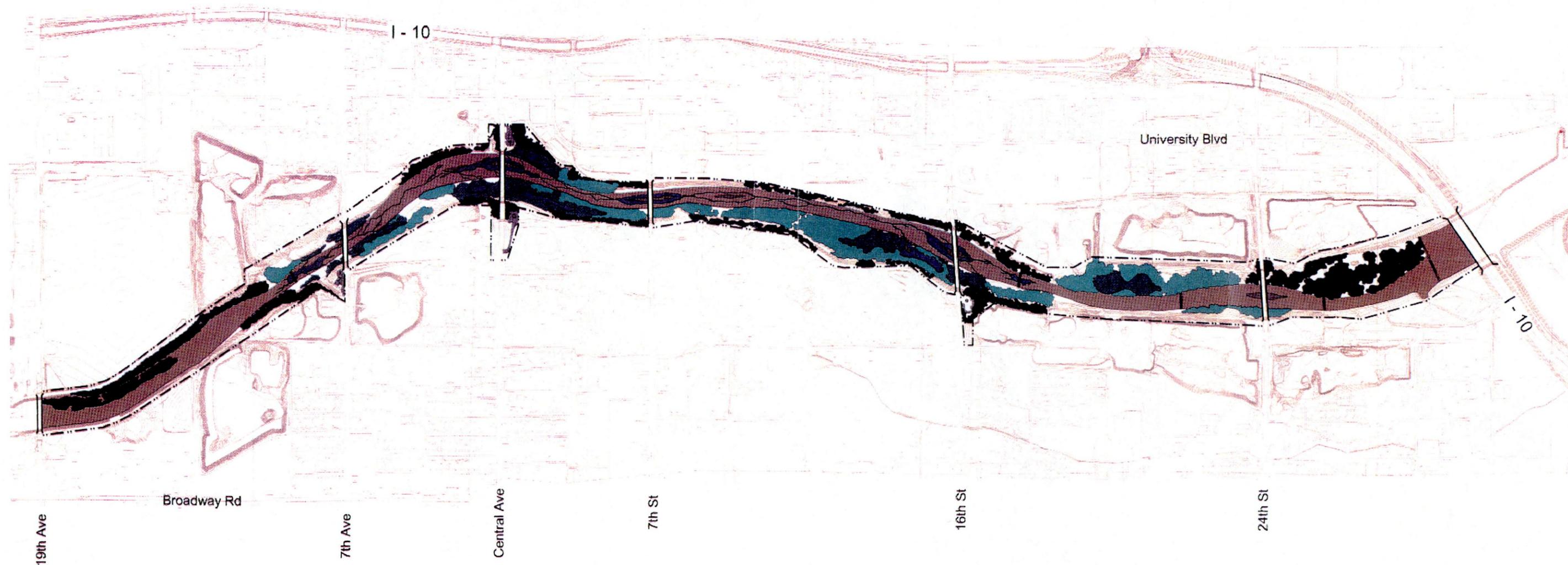
Heavy-duty	Light-duty
Medium-duty	Unimproved dirt
○ Interstate Route	○ U. S. Route
	○ State Route



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 Phoenix, Arizona 85009-1502
 Tel: (602)772-6848
 Fax: (602)772-7238

JOB NO.	9-114-002237
DESIGN	TOI
DRAWN	EMP
DATE	10/99
SCALE	GRAPHIC

FIGURE 1 - VICINITY MAP
RIO SALADO HABITAT RESTORATION PROJECT
RISK MANAGEMENT ASSESSMENT
AND MONITORING PROGRAM
CITY OF PHOENIX, ARIZONA



- - - - - Project Boundary
- ▨ Low Flow Channel
- ▬ Channel Drop Structure
- ▨ Channel Island
- ▨ Open Water
- ▨ Wetland Habitat
- ▨ Braided Stream
- ▨ Cottonwood / Willow Zone
- ▨ Mesquite Zone



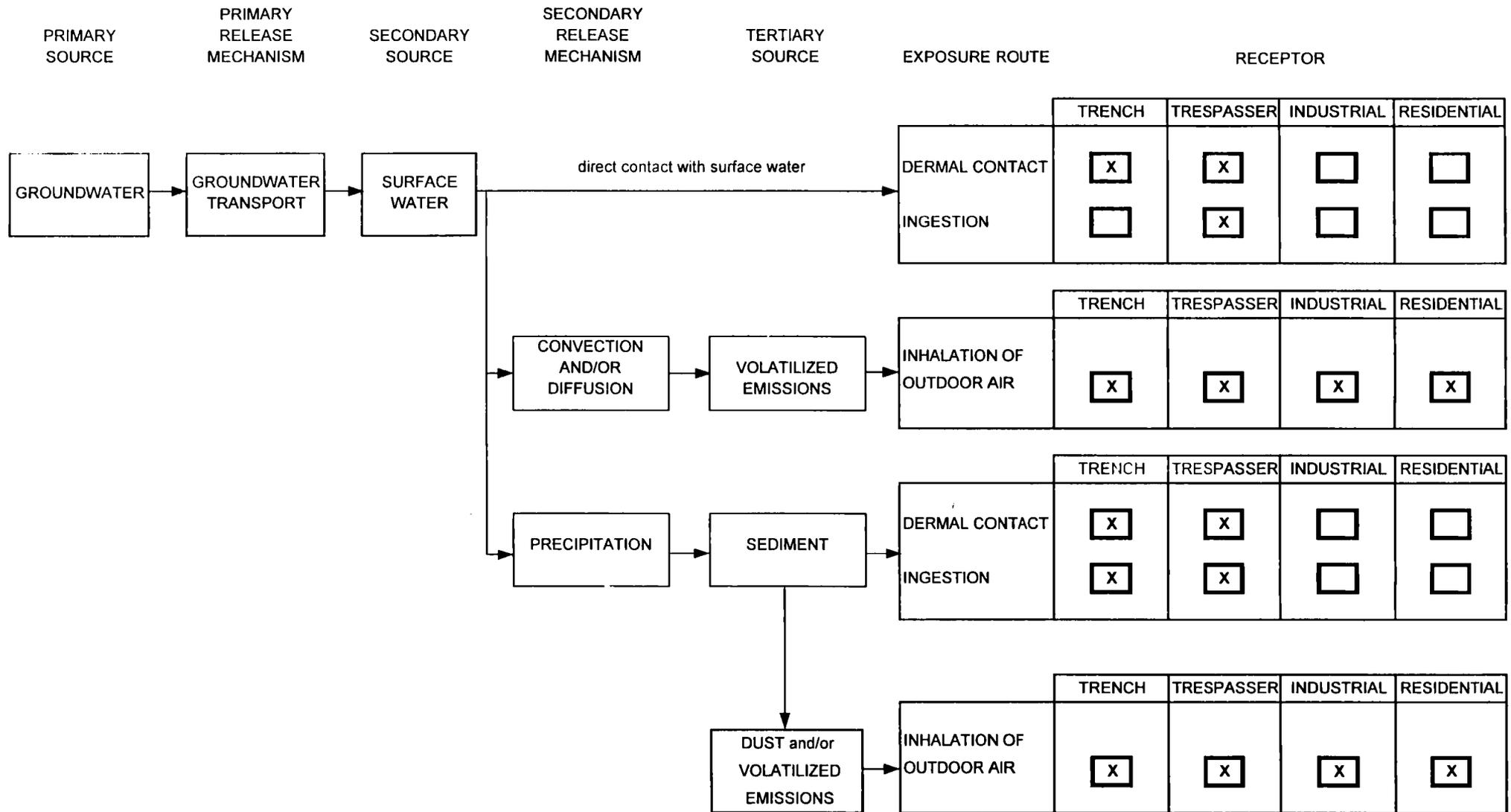
Adapted from: City of Phoenix, Planning Department August 1997

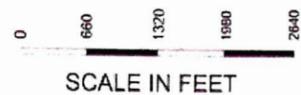
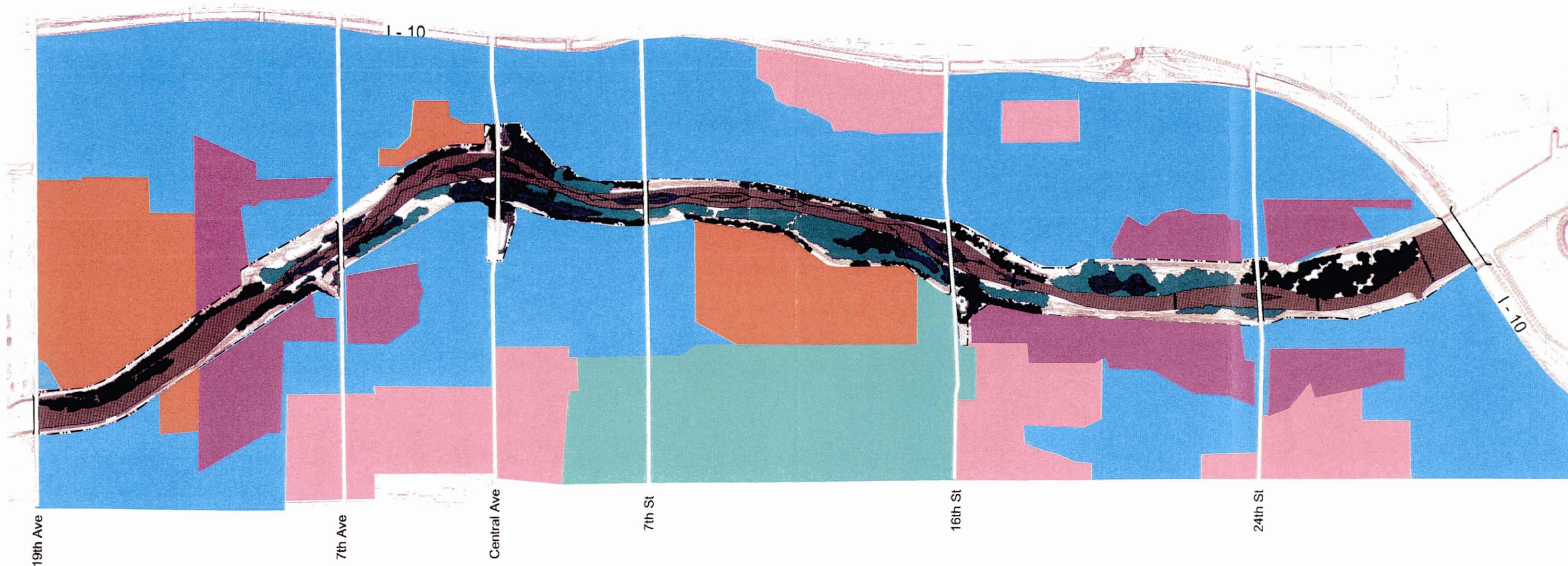
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FIGURE 2 - PROJECT LOCATION MAP
RIO SALADO HABITAT RESTORATION PROJECT
RISK MANAGEMENT ASSESSMENT
AND MONITORING PROGRAM
CITY OF PHOENIX, ARIZONA

FIGURE 3
Conceptual Site Model of Complete Human Health Exposure Pathways





- | | | |
|--------------------------------|------------------------|--------------------------|
| Sand & Gravel Pits | Project Boundary | Wetland Habitat |
| Landfills | Low Flow Channel | Braided Stream |
| Residential | Channel Drop Structure | Cottonwood / Willow Zone |
| Light Industrial | Channel Island | Mesquite Zone |
| Mixed Residential & Commercial | Open Water | |



Adapted from: City of Phoenix, Planning Department August 1997

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FIGURE 4 - GENERALIZED LAND USE MAP
RIO SALADO HABITAT RESTORATION PROJECT
RISK MANAGEMENT ASSESSMENT
AND MONITORING PROGRAM
CITY OF PHOENIX, ARIZONA

APPENDIX B

Table B1
Allowable Emission Rates for Offsite Residential

COC	Unitary Emission Concentration ($\mu\text{g}/\text{m}^3$)	Concentration in Air - Non-carcinogenic Effects ($\mu\text{g}/\text{m}^3$)	Concentration in Air - Carcinogenic Effects ($\mu\text{g}/\text{m}^3$)	Allowable Emission Rate ($\text{g}/\text{s}\cdot\text{m}^2$)	Surface area (m^2)	Allowable emission rate (g/s)
1, 1, 1-Trichloroethane	1.17E+05	1.39E+03		1.19E-02	4,633	5.52E+01
1, 1-Dichloroethene	1.17E+05	2.77E+01	6.49E-01	5.56E-06	4,633	2.57E-02
1, 2-Dichloroethane	1.17E+05	1.39E+01	1.25E+00	1.07E-05	4,633	4.95E-02
Bromodichloromethane	1.17E+05	9.73E+01		8.33E-04	4,633	3.86E+00
Benzene	1.17E+05	8.32E+00	3.92E+00	3.35E-05	4,633	1.55E-01
Chlorobenzene	1.17E+05	2.78E+01		2.38E-04	4,633	1.10E+00
Dibromochloromethane	1.17E+05	9.73E+01	7.95E-03	6.80E-08	4,633	3.15E-04
Ethyl Benzene	1.17E+05	1.39E+03		1.19E-02	4,633	5.52E+01
Tetrachloroethene	1.17E+05	3.89E+01	5.68E+01	4.86E-04	4,633	2.25E+00
Trichloroethene	1.17E+05	2.58E+02	1.89E+01	1.62E-04	4,633	7.51E-01
Toluene	1.17E+05	5.55E+02		4.75E-03	4,633	2.20E+01
Vinyl Chloride	1.17E+05	2.43E+01	3.79E-01	3.24E-06	4,633	1.50E-02
Xylene	1.17E+05	3.89E+03		3.33E-02	4,633	1.54E+02

APPENDIX B

Table B2
Allowable Emissions Rates
for Offsite Commercial/Industrial

	Unitary Emission Concentration (ug/m3)	Concentration in Air - Non-carcinogenic Effects (ug/m3)	Concentration in Air Carcinogenic Effects (ug/m3)	Allowable Emission Rate (g/s*m2)	Surface area (m2)	Allowable emission rate (g/s)
1, 1, 1-Trichloroethane	1.17E+05	1.53E+04		1.31E-01	4,633	6.08E+02
1, 1-Dichloroethene	1.17E+05	2.91E+02	6.82E-01	5.83E-06	4,633	2.70E-02
1, 2-Dichloroethane	1.17E+05	2.86E+02	1.31E+00	1.12E-05	4,633	5.20E-02
Bromodichloromethane	1.17E+05	1.02E+02		8.74E-04	4,633	4.05E+00
Benzene	1.17E+05	8.74E+00	4.11E+00	3.52E-05	4,633	1.63E-01
Chlorobenzene	1.17E+05	2.92E+01		2.50E-04	4,633	1.16E+00
Dibromochloromethane	1.17E+05	1.02E+02	8.34E-03	7.14E-08	4,633	3.31E-04
Ethyl Benzene	1.17E+05	1.46E+03		1.25E-02	4,633	5.79E+01
Tetrachloroethene	1.17E+05	4.09E+02	5.88E+01	5.03E-04	4,633	2.33E+00
Trichloroethene	1.17E+05	2.71E+03	1.99E+01	1.70E-04	4,633	7.88E-01
Toluene	1.17E+05	5.11E+02		4.37E-03	4,633	2.03E+01
Vinyl Chloride	1.17E+05	2.56E+01	3.98E-01	3.40E-06	4,633	1.58E-02
Xylene	1.17E+05	4.09E+03		3.50E-02	4,633	1.62E+02

APPENDIX B

Table B3
Estimated Action Level Calculations
for Liquid Concentrations (C_L) for Offsite Residential

COC	Liquid Concentration ¹ C _L (mg/L)	Air Emissions E (g/s)	Liquid Surface Area A (m ²)	Mass Transfer Coefficients				Gas Constant R (atm m ³)/(g mol K)	Temp T (K)	Wind Velocity U (m/s)	Schmidt No. ⁵ S _{cG} (μ _g)/(ρ _G (D _a))	Air Viscosity μ _a (g/cm s)	Air Density ρ _a (g/cm ³)	Contaminant Diffusivities			Henry's Constant H (atm m ³)/(g mol)	d _a (m)
				K (m/s)	Liquid ³ k _L (m/s)	Gas ⁴ k _G (m/s)	Equilibrium ² K _{eq} (m/s)							in air D _a (cm ² /s)	in water D _w (cm ² /s)	D _{other} (cm ² /s)		
1, 1, 1-Trichloroethane	3,838.2	5.52E+01	4,633	3.10E-06	3.11E-06	1.98E-03	5.72E-01	8.21E-05	298.15	1.0	1.84E+00	1.81E-04	1.20E-03	8.18E-02	1.00E-05	8.50E-06	1.40E-02	76.80
1, 1-Dichloroethene	1.6	2.57E-02	4,633	3.46E-06	3.47E-06	2.17E-03	1.39E+00	8.21E-05	298.15	1.0	1.61E+00	1.81E-04	1.20E-03	9.37E-02	1.19E-05	8.50E-06	3.40E-02	76.80
1, 2-Dichloroethane	3.2	4.95E-02	4,633	3.36E-06	3.36E-06	2.14E-03	4.00E-02	8.21E-05	298.15	1.0	1.65E+00	1.81E-04	1.20E-03	9.16E-02	1.13E-05	8.50E-06	9.80E-04	76.80
Bromodichloromethane	253.7	3.86E+00	4,633	3.28E-06	3.35E-06	2.26E-03	1.31E+01	8.21E-05	298.15	1.0	1.51E+00	1.81E-04	1.20E-03	9.96E-02	1.12E-05	8.50E-06	3.20E-01	76.80
Benzene	10.1	1.55E-01	4,633	3.32E-06	3.32E-06	2.11E-03	2.29E-01	8.21E-05	298.15	1.0	1.69E+00	1.81E-04	1.20E-03	8.94E-02	1.11E-05	8.50E-06	5.60E-03	76.80
Chlorobenzene	77.2	1.10E+00	4,633	3.08E-06	3.08E-06	1.85E-03	1.51E-01	8.21E-05	298.15	1.0	2.04E+00	1.81E-04	1.20E-03	7.39E-02	9.91E-06	8.50E-06	3.70E-03	76.80
Dibromochloromethane	0.0	3.15E-04	4,633	1.20E-05	1.20E-05	4.09E-03	4.09E-02	8.21E-05	298.15	1.0	6.27E-01	1.81E-04	1.20E-03	2.41E-01	7.58E-05	8.50E-06	1.00E-03	76.80
Ethyl Benzene	2,007.7	5.52E+01	4,633	5.93E-06	5.94E-06	3.03E-03	3.22E-01	8.21E-05	298.15	1.0	9.81E-01	1.81E-04	1.20E-03	1.54E-01	2.65E-05	8.50E-06	7.88E-03	76.80
Tetrachloroethene	165.5	2.25E+00	4,633	2.94E-06	2.94E-06	1.89E-03	1.06E+00	8.21E-05	298.15	1.0	1.98E+00	1.81E-04	1.20E-03	7.61E-02	9.25E-06	8.50E-06	2.60E-02	76.80
Trichloroethene	51.2	7.51E-01	4,633	3.17E-06	3.17E-06	2.01E-03	3.72E-01	8.21E-05	298.15	1.0	1.81E+00	1.81E-04	1.20E-03	8.34E-02	1.03E-05	8.50E-06	9.10E-03	76.80
Toluene	1,538.8	2.20E+01	4,633	3.08E-06	3.09E-06	1.96E-03	2.71E-01	8.21E-05	298.15	1.0	1.88E+00	1.81E-04	1.20E-03	8.04E-02	9.94E-06	8.50E-06	6.64E-03	76.80
Vinyl Chloride	0.8	1.50E-02	4,633	3.91E-06	3.91E-06	2.43E-03	1.02E+00	8.21E-05	298.15	1.0	1.37E+00	1.81E-04	1.20E-03	1.10E-01	1.42E-05	8.50E-06	2.50E-02	76.80
Xylene	12,257.9	1.54E+02	4,633	2.72E-06	2.72E-06	1.85E-03	2.86E-01	8.21E-05	298.15	1.0	2.04E+00	1.81E-04	1.20E-03	7.38E-02	8.22E-06	8.50E-06	7.00E-03	76.80

Notes:

1. $C_L = E / (K \cdot A)$
 $1/K = (1/k_L) + (1/(k_G K_{eq}))$
2. $K_{eq} = H / RT$
3. $k_L = (2.78 \times 10^{-6}) \cdot (ABS(D_w / D_{ether}))^{2/3}$
4. $k_G = (4.832 \times 10^{-3}) \cdot (U \cdot 0.78) \cdot (Sc_G - 0.67) \cdot (de - 0.11)$
5. $Sc_G = (mg) / (rG)(Da)$
6. $d_a = (ABS(4A/p))^{0.5}$

APPENDIX B

**Table B4
Estimated Action Level Calculations
for Liquid Concentrations (C_L) for Offsite Commercial/Industrial**

	Mass Transfer Coefficients										Contaminant Diffusivity							
	Concentration C _i (mg/L)	Emissions E (g/s)	Liq. Sur. Area A (m ²)	K (s/m)	Liquid K _l (m/s)	Gas K _g (m/s)	Equilibrium K _{eq} (m/s)	Gas Constant R (atm m ³)/(g mol K)	Temp T (K)	Wind Velocit U (m/s)	Schmidt No. Sc _G (μg/(ρD _a))	Air Viscosity μ _a (g/cm s)	Air Density ρ _a (g/cm ³)	in air D _a (cm ² /s)	in water D _w (cm ² /s)	D _{ether} (cm ² /s)	Henrys Constant H (atm m ³)/(g mol)	De (m)
1, 1, 1-Trichlorethane	42273.36	607.67	4633	3.10E-06	3.11E-06	1.98E-03	5.72E-01	8.21E-05	298.15	1	1.84E+00	1.81E-04	1.20E-03	8.18E-02	1.00E-05	8.50E-06	1.40E-02	76.80
1, 1-Dichloroethene	1.68	0.03	4633	3.46E-06	3.47E-06	2.17E-03	1.39E+00	8.21E-05	298.15	1	1.61E+00	1.81E-04	1.20E-03	9.37E-02	1.19E-05	8.50E-06	3.40E-02	76.80
1, 2-Dichloroethane	3.34	0.05	4633	3.36E-06	3.36E-06	2.14E-03	4.00E-02	8.21E-05	298.15	1	1.65E+00	1.81E-04	1.20E-03	9.16E-02	1.13E-05	8.50E-06	9.80E-04	76.80
Bromodichloromethane	266.39	4.05	4633	3.28E-06	3.35E-06	2.26E-03	1.31E+01	8.21E-05	298.15	1	1.51E+00	1.81E-04	1.20E-03	9.96E-02	1.12E-05	8.50E-06	3.20E-01	76.80
Benzene	10.60	0.16	4633	3.32E-06	3.32E-06	2.11E-03	2.29E-01	8.21E-05	298.15	1	1.69E+00	1.81E-04	1.20E-03	8.94E-02	1.11E-05	8.50E-06	5.60E-03	76.80
Chlorobenzene	81.07	1.16	4633	3.08E-06	3.08E-06	1.85E-03	1.51E-01	8.21E-05	298.15	1	2.04E+00	1.81E-04	1.20E-03	7.39E-02	9.91E-06	8.50E-06	3.70E-03	76.80
Dibromochloromethan	0.01	3.31E-04	4633	1.20E-05	1.20E-05	4.09E-03	4.09E-02	8.21E-05	298.15	1	6.27E-01	1.81E-04	1.20E-03	2.41E-01	7.58E-05	8.50E-06	1.00E-03	76.80
Ethyl Benzene	2108.13	57.93	4633	5.93E-06	5.94E-06	3.03E-03	3.22E-01	8.21E-05	298.15	1	9.81E-01	1.81E-04	1.20E-03	1.54E-01	2.65E-05	8.50E-06	7.88E-03	76.80
Tetrachloroethene	171.21	2.33	4633	2.94E-06	2.94E-06	1.89E-03	1.06E+00	8.21E-05	298.15	1	1.98E+00	1.81E-04	1.20E-03	7.61E-02	9.25E-06	8.50E-06	2.60E-02	76.80
Trichloroethene	53.73	0.79	4633	3.17E-06	3.17E-06	2.01E-03	3.72E-01	8.21E-05	298.15	1	1.81E+00	1.81E-04	1.20E-03	8.34E-02	1.03E-05	8.50E-06	9.10E-03	76.80
Toluene	1417.30	20.26	4633	3.08E-06	3.09E-06	1.96E-03	2.71E-01	8.21E-05	298.15	1	1.88E+00	1.81E-04	1.20E-03	8.04E-02	9.94E-06	8.50E-06	6.64E-03	76.80
Vinyl Chloride	0.87	0.02	4633	3.91E-06	3.91E-06	2.43E-03	1.02E+00	8.21E-05	298.15	1	1.37E+00	1.81E-04	1.20E-03	1.10E-01	1.42E-05	8.50E-06	2.50E-02	76.80
Xylene	12870.82	162.04	4633	2.72E-06	2.72E-06	1.85E-03	2.86E-01	8.21E-05	298.15	1	2.04E+00	1.81E-04	1.20E-03	7.38E-02	8.22E-06	8.50E-06	7.00E-03	76.80

Notes:

1. C_L=E/(K*A)
1/K=(1/k_L)+(1/(k_GK_{eq}))
2. K_{eq}=H/RT
3. k_L=(2.78X10⁻⁶)(ABS(Dw/Dether)^{2/3})
4. k_G=(4.832X10⁻³)(U^{0.78})(Sc_G^{-0.67})(de^{-0.11})
5. Sc_G=(mg)/(rG)(Da)
6. d_e=(ABS(4A/ρ))^{0.5}

APPENDIX A
SCREEN3 MODEL RUN

10/22/99
09:24:00

*** SCREEN3 MODEL RUN ***
*** VERSION DATED 96043 ***

Rio Salado Risk Analysis - Grade Control Structure Unitary Rate

SIMPLE TERRAIN INPUTS:

SOURCE TYPE = AREA
EMISSION RATE (G/(S-M**2)) = 1.00000
SOURCE HEIGHT (M) = .0000
LENGTH OF LARGER SIDE (M) = 200.0000
LENGTH OF SMALLER SIDE (M) = 23.0000
RECEPTOR HEIGHT (M) = 2.0000
URBAN/RURAL OPTION = URBAN

THE REGULATORY (DEFAULT) MIXING HEIGHT OPTION WAS SELECTED.
THE REGULATORY (DEFAULT) ANEMOMETER HEIGHT OF 10.0 METERS WAS ENTERED.

MODEL ESTIMATES DIRECTION TO MAX CONCENTRATION

BUOY. FLUX = .000 M**4/S**3; MOM. FLUX = .000 M**4/S**2.

*** FULL METEOROLOGY ***

*** SCREEN AUTOMATED DISTANCES ***

*** TERRAIN HEIGHT OF 0. M ABOVE STACK BASE USED FOR FOLLOWING DISTANCES

DIST (M)	CONC (UG/M**3)	STAB	U10M (M/S)	USTK (M/S)	MIX HT (M)	PLUME HT (M)	MAX DIR (DEG)
400.	.1466E+07	6	1.0	1.0	10000.0	.00	0.
500.	.9843E+06	6	1.0	1.0	10000.0	.00	0.
600.	.7190E+06	6	1.0	1.0	10000.0	.00	0.
700.	.5549E+06	6	1.0	1.0	10000.0	.00	0.
800.	.4455E+06	6	1.0	1.0	10000.0	.00	0.
900.	.3686E+06	6	1.0	1.0	10000.0	.00	0.
1000.	.3120E+06	6	1.0	1.0	10000.0	.00	0.

MAXIMUM 1-HR CONCENTRATION AT OR BEYOND 400. M:
400. .1466E+07 6 1.0 1.0 10000.0 .00 0.

*** SUMMARY OF SCREEN MODEL RESULTS ***

CALCULATION PROCEDURE	MAX CONC (UG/M**3)	DIST TO MAX (M)	TERRAIN HT (M)
SIMPLE TERRAIN	.1466E+07	400.	0.

** REMEMBER TO INCLUDE BACKGROUND CONCENTRATIONS **

APPENDIX B

ACTION LEVEL CALCULATION FOR DAYLIGHTED GROUNDWATER EMISSIONS

APPENDIX C

LOCATION INFORMATION OF DISCRETE SAMPLES WHICH EXCEEDED RBALS

APPENDIX C

SITE	LOCATION	ANALYTE	CAS#	RESULT	QUALIFIER	UNITS	GROUP	DATE
GARRETT	GGMW63Q90	11dce	75-35-4	420		UG/L	VOC-H20	8/21/90
GARRETT	GGMW13Q90	11dce	75-35-4	400		UG/L	VOC-H20	8/21/90
GARRETT	GGMW81Q91	11dce	75-35-4	305		UG/L	VOC-H20	2/11/91
GARRETT	GGMW83Q90	11dce	75-35-4	290		UG/L	VOC-H20	8/21/90
GARRETT	GGMW41Q91	11dce	75-35-4	274		UG/L	VOC-H20	2/11/91
GARRETT	GGMW11Q91	11dce	75-35-4	250		UG/L	VOC-H20	2/11/91
161ARG	AGS043Q94	11dce	75-35-4	250	U	UG/L	VOC-H20	7/1/94
GARRETT	GGMW33Q90	11dce	75-35-4	220		UG/L	VOC-H20	8/21/90
GARRETT	GGMW53Q90	11dce	75-35-4	180		UG/L	VOC-H20	8/21/90
GARRETT	GGMW51Q91	11dce	75-35-4	156		UG/L	VOC-H20	2/11/91
GARRETT	GGMW73Q90	11dce	75-35-4	130		UG/L	VOC-H20	8/21/90
GARRETT	GGMW31Q91	11dce	75-35-4	117		UG/L	VOC-H20	2/11/91
GARRETT	GGMW43Q90	11dce	75-35-4	110		UG/L	VOC-H20	8/21/90
EXXON	EXMW33Q96	11dce	75-35-4	100	U	UG/L	VOC-H20	9/3/96
GARRETT	GGMW71Q91	11dce	75-35-4	72.1		UG/L	VOC-H20	2/11/91
GARRETT	GGMW23Q90	11dce	75-35-4	51		UG/L	VOC-H20	8/21/90
161ARG	AGS043Q93	11dce	75-35-4	50	U	UG/L	VOC-H20	9/8/93
19thAve	DM5S1Q94	11dce	75-35-4	44.4		UG/L	VOC-H20	1/28/94
GARRETT	GGMW21Q91	11dce	75-35-4	43.6		UG/L	VOC-H20	2/11/91
GARRETT	GGMW61Q91	11dce	75-35-4	42.1		UG/L	VOC-H20	2/11/91
161ARG	AGS041Q94	11dce	75-35-4	40	U	UG/L	VOC-H20	2/1/94
19thAve	DM5S1Q93	11dce	75-35-4	32		UG/L	VOC-H20	1/20/93
161ARG	AGW3013Q94	11dce	75-35-4	25	U	UG/L	VOC-H20	7/1/94
GARRETT	GGMW14Q92	11dce	75-35-4	24		UG/L	VOC-H20	12/11/92
19thAve	DM5S1Q97	11dce	75-35-4	23		UG/L	VOC-H20	1/13/97
19thAve	DM5S1Q95	11dce	75-35-4	23		UG/L	VOC-H20	1/17/95
Del Rio	1661Q94	11dce	75-35-4	22.5		UG/L	VOC-H20	2/3/94
Del Rio	1664Q92	11dce	75-35-4	21.7		UG/L	VOC-H20	10/26/92
Del Rio	1661Q95	11dce	75-35-4	20		UG/L	VOC-H20	1/24/95
19thAve	DM8D1Q97	11dce	75-35-4	20		UG/L	VOC-H20	1/13/97
161ARG	AGS042Q94	11dce	75-35-4	20	U	UG/L	VOC-H20	4/1/94
WVB WQAR	WVB42Q95	11dce	75-35-4	20	U	UG/L	VOC-H20	5/3/95
19thAve	DM8D1Q94	11dce	75-35-4	18.4		UG/L	VOC-H20	1/26/94
19thAve	DM5S1Q96	11dce	75-35-4	17.5		UG/L	VOC-H20	1/8/96
Del Rio	1661Q96	11dce	75-35-4	14.6		UG/L	VOC-H20	1/12/96
19thAve	DM8D1Q96	11dce	75-35-4	14.2		UG/L	VOC-H20	1/8/96
19thAve	DM3I1Q97	11dce	75-35-4	14		UG/L	VOC-H20	1/20/95
Del Rio	1634Q92	11dce	75-35-4	13.8		UG/L	VOC-H20	10/30/92
Del Rio	1661Q97	11dce	75-35-4	13.6		UG/L	VOC-H20	1/21/97
19thAve	DM3I1Q94	11dce	75-35-4	13.3		UG/L	VOC-H20	2/1/94
19thAve	DM8S1Q97	11dce	75-35-4	13		UG/L	VOC-H20	1/13/97
19thAve	DM8D1Q95	11dce	75-35-4	13		UG/L	VOC-H20	1/17/95
19thAve	DM7D1Q94	11dce	75-35-4	12.5		UG/L	VOC-H20	1/31/94
WVB WQAR	WVB42Q96	11dce	75-35-4	12.5	U	UG/L	VOC-H20	4/17/96
19thAve	DM3I1Q96	11dce	75-35-4	12.3		UG/L	VOC-H20	1/11/96
19thAve	DM3I1Q97	11dce	75-35-4	12		UG/L	VOC-H20	1/16/97
19thAve	DM3I1Q93	11dce	75-35-4	11		UG/L	VOC-H20	1/25/93
19thAve	DM7D1Q97	11dce	75-35-4	10		UG/L	VOC-H20	1/14/97

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SRP WELLS	14E1N3Q93	11dce	75-35-4	10		UG/L	VOC-H2O	9/3/93
19thAve	DM5D1Q97	11dce	75-35-4	9.4		UG/L	VOC-H2O	1/13/97
Del Rio	1631Q97	11dce	75-35-4	8.7		UG/L	VOC-H2O	1/22/97
19thAve	DM7D1Q95	11dce	75-35-4	8.5		UG/L	VOC-H2O	1/19/95
19thAve	DM7D1Q96	11dce	75-35-4	7.9		UG/L	VOC-H2O	1/10/96
EW WQARF	EW11W74Q96	11dce	75-35-4	7.9		UG/L	VOC-H2O	10/8/96
19thAve	DM3P1Q93	11dce	75-35-4	7.8		UG/L	VOC-H2O	1/25/93

Number of 1,1-dce samples over RBAL = 55

161ARG	AGS043Q94	12dca	107-06-2	250	U	UG/L	VOC-H2O	7/1/94
BFI	BFIMW32Q93	12dca	107-06-2	120		UG/L	VOC-H2O	5/27/93
EXXON	EXMW33Q96	12dca	107-06-2	100	U	UG/L	VOC-H2O	9/3/96
161ARG	AGS043Q93	12dca	107-06-2	50	U	UG/L	VOC-H2O	9/8/93
PSHIA SE	CPGW11Q97	12dca	107-06-2	43		UG/L	VOC-H2O	2/22/97
161ARG	AGS041Q94	12dca	107-06-2	40	U	UG/L	VOC-H2O	2/1/94
PSHIA SE	CPGW14Q96	12dca	107-06-2	40		UG/L	VOC-H2O	12/10/96
GARRETT	GGMW13Q90	12dca	107-06-2	31		UG/L	VOC-H2O	8/21/90
161ARG	AGW3013Q94	12dca	107-06-2	25	U	UG/L	VOC-H2O	7/1/94
161ARG	AGS042Q94	12dca	107-06-2	20	U	UG/L	VOC-H2O	4/1/94
WVB WQAR	WVB42Q95	12dca	107-06-2	20	U	UG/L	VOC-H2O	5/3/95
GREENFIEL	GRMW12Q93	12dca	107-06-2	15		UG/L	VOC-H2O	4/1/93

Number of 1,2 dca samples over RBAL = 12

161ARG	AGS042Q92	benz	71-43-2	20600		UG/L	VOCs-H2O	5/13/92
161ARG	AGS041Q94	benz	71-43-2	17000		UG/L	VOCs-H2O	2/1/94
161ARG	AGS043Q93	benz	71-43-2	15000		UG/L	VOCs-H2O	9/8/93
161ARG	AGS043Q94	benz	71-43-2	15000		UG/L	VOCs-H2O	7/1/94
BFI	BFIMW32Q93	benz	71-43-2	10000		UG/L	VOCs-H2O	5/27/93
BFI	BFIMW32Q95	benz	71-43-2	9700		UG/L	VOCs-H2O	5/26/95
161ARG	AGS042Q94	benz	71-43-2	7000		UG/L	VOCs-H2O	4/1/94
BFI	BFIMW52Q95	benz	71-43-2	5800		UG/L	VOCs-H2O	5/26/95
EXXON	EXMW62Q97	benz	71-43-2	5500		UG/L	VOCs-H2O	6/12/97
BFI	BFIMW33Q94	benz	71-43-2	5400		UG/L	VOCs-H2O	8/19/94
EXXON	EXMW34Q96	benz	71-43-2	4200		UG/L	VOCs-H2O	12/2/96
EXXON	EXMW31Q97	benz	71-43-2	3800		UG/L	VOCs-H2O	3/12/97
EXXON	EXMW32Q97	benz	71-43-2	3500		UG/L	VOCs-H2O	6/12/97
EXXON	EXMW33Q96	benz	71-43-2	2700		UG/L	VOCs-H2O	9/3/96
EXXON	EXMW61Q97	benz	71-43-2	2000		UG/L	VOCs-H2O	4/14/97
BFI	BFIMW31Q96	benz	71-43-2	1400		UG/L	VOCs-H2O	3/7/96
BFI	BFIMW13Q94	benz	71-43-2	1000		UG/L	VOCs-H2O	8/19/94
161ARG	AGW3013Q94	benz	71-43-2	990		UG/L	VOCs-H2O	7/1/94
AFCO	KLMW14Q92	benz	71-43-2	980		UG/L	VOCs-H2O	11/25/92
AFCO	AFMW34Q95	benz	71-43-2	700		UG/L	VOCs-H2O	10/12/95
BFI	BFIMW32Q96	benz	71-43-2	690		UG/L	VOCs-H2O	5/6/96
AFCO	KLMW12Q93	benz	71-43-2	650		UG/L	VOCs-H2O	5/26/93
BFI	BFIMW34Q96	benz	71-43-2	610		UG/L	VOCs-H2O	12/18/96
Hertz	HP2Q92MW8	benz	71-43-2	490		UG/L	VOCs-H2O	5/27/92
PSHIA SE	CPGW11Q97	benz	71-43-2	370		UG/L	VOCs-H2O	2/22/97
AFCO	KLMW32Q93	benz	71-43-2	300		UG/L	VOCs-H2O	5/26/93
AFCO	KLMW11Q94	benz	71-43-2	300		UG/L	VOCs-H2O	2/3/94
161ARG	AGW3012Q92	benz	71-43-2	287		UG/L	VOCs-H2O	5/13/92

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AFCO	AFMW33Q95	benz	71-43-2	280	UG/L	VOCs-H20	7/25/95
Hertz	HP2Q92MW5	benz	71-43-2	280	UG/L	VOCs-H20	5/27/92
PSHIA SE	CPGW14Q96	benz	71-43-2	270	UG/L	VOCs-H20	12/10/96
BFI	BFIMW43Q94	benz	71-43-2	190	UG/L	VOCs-H20	8/19/94
AFCO	AFMW24Q95	benz	71-43-2	180	UG/L	VOCs-H20	10/12/95
AFCO	KLMW34Q92	benz	71-43-2	170	UG/L	VOCs-H20	11/25/92
AFCO	AFMW32Q96	benz	71-43-2	160	UG/L	VOCs-H20	5/10/96
AFCO	KLMW31Q94	benz	71-43-2	160	UG/L	VOCs-H20	2/3/94
AFCO	AFMW22Q96	benz	71-43-2	110	UG/L	VOCs-H20	5/10/96
AFCO	KLMW24Q92	benz	71-43-2	100	UG/L	VOCs-H20	11/25/92
AFCO	AFMW23Q95	benz	71-43-2	94	UG/L	VOCs-H20	7/25/95
161ARG	AGS011Q94	benz	71-43-2	91	UG/L	VOCs-H20	2/1/94
AFCO	KLMW22Q93	benz	71-43-2	74	UG/L	VOCs-H20	5/26/93
PPG	PPG54Q94	benz	71-43-2	73	UG/L	VOCs-H20	12/20/94
Hertz	HP2Q96MW1	benz	71-43-2	51	UG/L	VOCs-H20	3/26/96
AFCO	KLMW21Q94	benz	71-43-2	50	UG/L	VOCs-H20	2/3/94
161ARG	AGW3012Q94	benz	71-43-2	43	UG/L	VOCs-H20	4/1/94
PPG	PPG54Q95	benz	71-43-2	40	UG/L	VOCs-H20	12/21/95

Number of Benzene samples over RBAL = 46

19thAve	DM3P1Q95	Hg	7487-94-7	1	MG/L	METALS-H2	1/20/95
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Number of Hg samples over RBAL = 1

WVB WQAR	WVB42Q96	pce	127-18-4	1500	UG/L	VOCs-H20	4/17/96	
WVB WQAR	WVB43Q92	pce	127-18-4	1300	UG/L	VOCs-H20	9/24/92	
TALLOW	PTBC13Q93	pce	127-18-4	560	UG/L	VOCs-H20	7/7/93	
WVB WQAR	IWMW12Q97	pce	127-18-4	456	UG/L	VOCs-H20	5/14/97	
WVB WQAR	IWMW12Q96	pce	127-18-4	410	UG/L	VOCs-H20	4/17/96	
161ARG	AGS043Q94	pce	127-18-4	250	U	UG/L	VOCs-H20	7/1/94
PPG	PPG34Q96	pce	127-18-4	200	UG/L	VOCs-H20	12/19/96	
PPG	PPG54Q96	pce	127-18-4	200	UG/L	VOCs-H20	12/19/96	
PPG	PPG34Q95	pce	127-18-4	170	UG/L	VOCs-H20	12/21/95	
PPG	PPG24Q96	pce	127-18-4	170	UG/L	VOCs-H20	12/19/96	
PPG	PPG44Q96	pce	127-18-4	170	UG/L	VOCs-H20	12/19/96	
PPG	PPG44Q95	pce	127-18-4	140	UG/L	VOCs-H20	12/21/95	
PPG	PPG42Q96	pce	127-18-4	140	UG/L	VOCs-H20	6/18/96	
PPG	PPG44Q94	pce	127-18-4	120	UG/L	VOCs-H20	12/20/94	
PPG	PPG32Q95	pce	127-18-4	110	UG/L	VOCs-H20	6/23/95	
PPG	PPG42Q95	pce	127-18-4	100	UG/L	VOCs-H20	6/23/95	
PPG	PPG32Q96	pce	127-18-4	100	UG/L	VOCs-H20	6/18/96	
EXXON	EXMW33Q96	pce	127-18-4	100	U	UG/L	VOCs-H20	9/3/96
PPG	PPG22Q96	pce	127-18-4	82	UG/L	VOCs-H20	6/18/96	
PPG	PPG24Q95	pce	127-18-4	80	UG/L	VOCs-H20	12/21/95	
PPG	PPG52Q96	pce	127-18-4	79	UG/L	VOCs-H20	6/18/96	
PPG	PPG54Q94	pce	127-18-4	77	UG/L	VOCs-H20	12/20/94	
PPG	PPG24Q94	pce	127-18-4	76	UG/L	VOCs-H20	12/20/94	
WVB WQAR	WVB42Q97	pce	127-18-4	64.6	UG/L	VOCs-H20	5/14/97	
PPG	PPG22Q95	pce	127-18-4	64	UG/L	VOCs-H20	6/23/95	
EW WQARF	EW942Q92	pce	127-18-4	62.7	UG/L	VOCs-H20	6/26/92	
WVB WQAR	IWMW14Q94	pce	127-18-4	58	UG/L	VOCs-H20	10/12/94	
PPG	PPG52Q95	pce	127-18-4	56	UG/L	VOCs-H20	6/23/95	

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161ARG	AGS043Q93	pce	127-18-4	50	U	UG/L	VOCs-H20	9/8/93
PPG	PPG54Q95	pce	127-18-4	46		UG/L	VOCs-H20	12/21/95
TALLOW	PTBC12Q93	pce	127-18-4	42		UG/L	VOCs-H20	5/24/93
161ARG	AGS041Q94	pce	127-18-4	40	U	UG/L	VOCs-H20	2/1/94
EW WQARF	EW89W12Q95	pce	127-18-4	34		UG/L	VOCs-H20	4/25/95
WVB WQAR	WVBDW32Q9	pce	127-18-4	34		UG/L	VOCs-H20	4/25/95
AMERON	AMUMW13Q9	pce	127-18-4	29		UG/L	VOCs-H20	8/5/96
GREENFIEL	GRMW12Q93	pce	127-18-4	28		UG/L	VOCs-H20	4/1/93
161ARG	AGW3013Q94	pce	127-18-4	25	U	UG/L	VOCs-H20	7/1/94
TALLOW	PTBC22Q93	pce	127-18-4	22		UG/L	VOCs-H20	5/24/93
161ARG	AGS042Q94	pce	127-18-4	20	U	UG/L	VOCs-H20	4/1/94
WVB WQAR	WVB42Q95	pce	127-18-4	20	U	UG/L	VOCs-H20	5/3/95
PPG	PPG34Q94	pce	127-18-4	19		UG/L	VOCs-H20	12/20/94
WVB WQAR	IWMW12Q95	pce	127-18-4	14		UG/L	VOCs-H20	5/3/95
UNOCAL	UCMW11Q97	pce	127-18-4	14		UG/L	VOCs-H20	3/5/97
EW WQARF	EW94W14Q95	pce	127-18-4	13		UG/L	VOCs-H20	12/8/95
AMERON	AMUMW13Q9	pce	127-18-4	11		UG/L	VOCs-H20	8/1/95
UNOCAL	UCMW12Q97	pce	127-18-4	11		UG/L	VOCs-H20	6/5/97
GARRETT	GGMW11Q91	pce	127-18-4	9.7		UG/L	VOCs-H20	2/11/91
EW WQARF	EW94W12Q96	pce	127-18-4	8.1		UG/L	VOCs-H20	4/3/96

Number of PCE samples over RBAL = 48

161ARG	AGS043Q94	tce	79-01-6	250	U	UG/L	VOCs-H20	7/1/94
GARRETT	GGMW13Q90	tce	79-01-6	210		UG/L	VOCs-H20	8/21/90
GARRETT	GGMW83Q90	tce	79-01-6	172		UG/L	VOCs-H20	8/21/90
GARRETT	GGMW11Q91	tce	79-01-6	131		UG/L	VOCs-H20	2/11/91
EXXON	EXMW33Q96	tce	79-01-6	100	U	UG/L	VOCs-H20	9/3/96
GARRETT	GGMW53Q90	tce	79-01-6	96		UG/L	VOCs-H20	8/21/90
GARRETT	GGMW81Q91	tce	79-01-6	89.9		UG/L	VOCs-H20	2/11/91
GARRETT	GGMW63Q90	tce	79-01-6	73		UG/L	VOCs-H20	8/21/90
GARRETT	GGMW41Q91	tce	79-01-6	66.6		UG/L	VOCs-H20	2/11/91
GARRETT	GGMW73Q90	tce	79-01-6	63		UG/L	VOCs-H20	8/21/90
GARRETT	GGMW51Q91	tce	79-01-6	63		UG/L	VOCs-H20	2/11/91
GARRETT	GGMW31Q91	tce	79-01-6	62.3		UG/L	VOCs-H20	2/11/91

Number of TCE samples over RBAL = 12

BFI	BFIMW22Q96	As	7440-38-2	1	U	MG/L	METALS-H2	5/6/96
BFI	BFIMW32Q96	As	7440-38-2	1	U	MG/L	METALS-H2	5/6/96
BFI	BFIMW32Q96	As	7440-38-2	1	U	MG/L	METALS-H2	5/6/96
19thAve	I51Q96	As	7440-38-2	0.092		MG/L	METALS-H2	1/9/96
ESTES	ESEW12Q95	As	7440-38-2	0.066		MG/L	METALS-H2	6/23/95
19thAve	I41Q94	As	7440-38-2	0.066		MG/L	METALS-H2	1/26/94
19thAve	I41Q95	As	7440-38-2	0.045		MG/L	METALS-H2	1/19/95
19thAve	I81Q94	As	7440-38-2	0.044		MG/L	METALS-H2	1/27/94
19thAve	I41Q96	As	7440-38-2	0.043		MG/L	METALS-H2	1/8/96
19thAve	I81Q93	As	7440-38-2	0.042		MG/L	METALS-H2	1/22/93
19thAve	I31Q96	As	7440-38-2	0.04		MG/L	METALS-H2	1/8/96
19thAve	I81Q96	As	7440-38-2	0.035		MG/L	METALS-H2	1/9/96
19thAve	I81Q95	As	7440-38-2	0.034		MG/L	METALS-H2	1/19/95
19thAve	I31Q93	As	7440-38-2	0.034		MG/L	METALS-H2	1/19/93
19thAve	I31Q97	As	7440-38-2	0.033		MG/L	METALS-H2	1/14/97

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19thAve	I31Q94	As	7440-38-2	0.032		MG/L	METALS-H2	1/28/94
19thAve	I31Q95	As	7440-38-2	0.028		MG/L	METALS-H2	1/18/95

Number of arsenic samples over RBAL = 17

EXXON	EXMW62Q97	toluene	108-88-3	26000		UG/L	VOCs-H20	6/12/97
BFI	BFIMW32Q93	toluene	108-88-3	20000		UG/L	VOCs-H20	5/27/93
EXXON	EXMW61Q97	toluene	108-88-3	18000		UG/L	VOCs-H20	4/14/97
BFI	BFIMW32Q95	toluene	108-88-3	13000		UG/L	VOCs-H20	5/26/95
EXXON	EXMW32Q97	toluene	108-88-3	9600		UG/L	VOCs-H20	6/12/97
EXXON	EXMW31Q97	toluene	108-88-3	9500		UG/L	VOCs-H20	3/12/97
EXXON	EXMW34Q96	toluene	108-88-3	8800		UG/L	VOCs-H20	12/2/96
BFI	BFIMW52Q95	toluene	108-88-3	7500		UG/L	VOCs-H20	5/26/95
BFI	BFIMW33Q94	toluene	108-88-3	6000		UG/L	VOCs-H20	8/19/94
EXXON	EXMW33Q96	toluene	108-88-3	5900		UG/L	VOCs-H20	9/3/96

Number of toluene samples over RBAL = 10

161ARG	AGS043Q94	vc	75-01-4	250	U	UG/L	VOCs-H20	7/1/94
EXXON	EXMW33Q96	vc	75-01-4	200	U	UG/L	VOCs-H20	9/3/96
161ARG	AGS043Q93	vc	75-01-4	50	U	UG/L	VOCs-H20	9/8/93
161ARG	AGS041Q94	vc	75-01-4	40	U	UG/L	VOCs-H20	2/1/94
WVB WQAR	WVB42Q95	vc	75-01-4	40	U	UG/L	VOCs-H20	5/3/95
ESTES	ESEW141Q93	vc	75-01-4	38		UG/L	VOCs-H20	3/2/93
161ARG	AGW3013Q94	vc	75-01-4	25	U	UG/L	VOCs-H20	7/1/94
WVB WQAR	WVB42Q96	vc	75-01-4	25	U	UG/L	VOCs-H20	4/17/96
161ARG	AGS042Q94	vc	75-01-4	20	U	UG/L	VOCs-H20	4/1/94
WVB WQAR	IWMW12Q96	vc	75-01-4	10	U	UG/L	VOCs-H20	4/17/96
ESTES	ESEW141Q94	vc	75-01-4	7.5		UG/L	VOCs-H20	3/16/94
19thAve	DM7S1Q93	vc	75-01-4	7.5		UG/L	VOCs-H20	1/26/93
ESTES	ESEW142Q95	vc	75-01-4	7		UG/L	VOCs-H20	6/21/95
COP EF ARE	CPEF13Q93	vc	75-01-4	5	U	UG/L	VOCs-H20	8/2/93
COP EF ARE	CPEF23Q93	vc	75-01-4	5	U	UG/L	VOCs-H20	8/2/93
COP EF ARE	CPEF33Q93	vc	75-01-4	5	U	UG/L	VOCs-H20	8/2/93
COP EF ARE	CPEF14Q93	vc	75-01-4	5	U	UG/L	VOCs-H20	11/2/93
COP EF ARE	CPEF24Q93	vc	75-01-4	5	U	UG/L	VOCs-H20	11/2/93
COP EF ARE	CPEF34Q93	vc	75-01-4	5	U	UG/L	VOCs-H20	11/2/93
COP EF ARE	CPEF11Q94	vc	75-01-4	5	U	UG/L	VOCs-H20	2/17/94
COP EF ARE	CPEF21Q94	vc	75-01-4	5	U	UG/L	VOCs-H20	2/17/94
COP EF ARE	CPEF31Q94	vc	75-01-4	5	U	UG/L	VOCs-H20	2/17/94
AFCO	AFMW33Q95	vc	75-01-4	5	U	UG/L	VOCs-H20	7/25/95
EXXON	EXMW44Q96	vc	75-01-4	5	U	UG/L	VOCs-H20	12/2/96
WVB WQAR	WVB43Q92	vc	75-01-4	5	U	UG/L	VOCs-H20	9/24/92

Number of vc samples over RBAL = 25