REMEDIATION GUIDELINES FOR PETROLEUM CONTAMINATED SITES IN MAINE

MAINE DEPARTMENT OF ENVIRONMENTAL PROTECTION
BUREAU OF REMEDIATION & WASTE MANAGEMENT

Effective Date: December 1, 2009
Amendment Date: May 23, 2014

Approved: _____

Melanie Loyzim, Director, Bureau of Remediation & Waste Management

Table of Contents

List of Tables

List of Appendices

Glossary of Terms

The following definitions are provided to assist in understanding how terms are used in these guidelines. Terms used in this document are defined in Maine oil pollution prevention statutes, 38 MRSA, §541 and §562-A, and Department rules, 06-096 CMR chapters 600 and 691unless otherwise indicated or defined in these guidelines. Those definitions should be consulted in determining the legal rights and duties of persons who have suffered or caused an oil discharge. Appendix F lists some of the laws bearing on responsibility for and clean-up of oil discharges.

1. Ambient ground water quality. Ambient ground water quality is the prevailing chemical and physical water quality properties of ground water surrounding or underlying an oil discharge or oil contamination. Ambient ground water may or may not be utilized as a drinking water supply source.

2. Background contaminants. Background contaminants mean those contaminants whose presence or concentration is not due to a discharge of oil. Background contaminants may be naturally occurring or man-made. Naturally occurring iron, manganese, arsenic and other metals mobilized from bedrock due to changes in ground water chemistry resulting from an oil discharge are not considered background contaminants.

3. Chapter 600. Chapter 600 is the Department Oil Discharge Prevention and Pollution Control Rules for Marine Oil Terminals, Transportation, Pipelines, and Vessels, 06-096 CMR 600.

4. Chapter 691. Chapter 691 is the Department Rules for Underground Oil Storage Facilities, 06-096 CMR 691.

5. Community public drinking water supply or well. As defined in Title 22 MRSA, §2601 and Chapter 691, this is a water supply or well which serves at least 15 year round service connections or regularly serves at least 25 year-round residents. Common examples include town and water district wells, or a communal well serving a mobile home park or other housing development.

6. Contamination. Contamination, as used in this guidance document in reference to oil pollution of ground water and soil, includes any one of the following conditions:
   a) The presence of free product or an oil sheen;
   b) The presence of oil constituents at concentrations exceeding primary drinking water standards adopted by the Maine Department of Health and Human Service's under 22 MRSA, section 2611;
   c) The presence of oil constituents at concentrations exceeding maximum exposure guidelines (MEGs) developed and recommended by the Maine Department of Human Service's Center for Disease Control and Prevention;
   d) A statistically significant increase in the concentration of measured parameters at on-site or down-gradient locations by comparison with

representative background values, as demonstrated by statistical methods and procedures using a 95% level of confidence, approved by the commissioner and consistent with the provisions of 40 CFR subsection 264.97 (except that where the "Regional Administrator" is referred to, the "Commissioner" is meant);

e) Soil and water where VPH or EPH petroleum hydrocarbon fractions or target compounds are documented above the laboratory method practical quantitation limit (PQL); or
f) Soils visibly stained or discolored by heavy oil.

7. Discharge. Discharge means any spilling, leaking, pumping, pouring, emitting, escaping, emptying, or dumping of oil (38 MRSA, §562-A).

8. Eligible Clean-up Costs. Eligible clean-up costs are defined in State law (38 MRSA, §562-A) to mean those costs that:
   a) Are necessary to clean up discharges of oil to the satisfaction of the Commissioner;
   b) Are cost effective and technologically feasible and reliable;
   c) Effectively mitigate or minimize damages; and
   d) Provide adequate protection of the public health and welfare and the environment.

9. Free product. Free product means light non-aqueous phase liquid (LNAPL) oil or petroleum.

10. Fund Insurance Program. The Fund Insurance Program is the State program established under 38 MRSA, §568-A and 569-A to cover costs associated with the clean-up of discharges from oil storage facilities. The program uses public funds from the Maine Ground Water Oil Clean Up Fund to cover the eligible clean-up costs.

11. Hazard Index. Hazard index (HI) for the purpose of these guidelines is the method used to calculate whether an adverse health risk, other than cancer, may occur to an individual exposed to contaminants. Specifically, the HI applies to non-carcinogenic effects and means the sum of hazard quotients for substances that affect the same organ system.

12. Hazardous substance. Hazardous substance has the same meaning as in Maine statute (38 MRSA, §1362) and the Department's *Maine Remedial Action Guidelines for Sites Contaminated with Hazardous Substances*.

13. Heavy oils. Heavy oils are those oils that must be heated during storage, including, but not limited to #5 and #6 oil.

14. Incremental lifetime cancer risk. Incremental life time cancer risk (ILCR) is the method used to calculate the increased risk of cancer that may occur to an individual exposed to contaminants. Specifically, ILCR means the incremental probability of an individual developing cancer over a lifetime as a result of exposure to a contaminant.

15. Oil. Oil, as defined in statute (38 MRSA, §562-A) means oil, oil additives, petroleum products and their by-products of any kind and in any form including, but not limited to, petroleum, fuel oil, sludge, oil refuse, oil mixed with other non-hazardous waste, crude oils and other liquid hydrocarbons regardless of specific gravity.

16. Oil saturated soils. Oil saturated soils, or saturated soils, are used in these guidelines to describe soils which contain mobile product.

17. Oil storage facility. Oil storage facility is defined as in Maine statute (38 MRSA, §562-A) and means tanks together with associated piping, transfer and dispensing facilities, used to store or supply oil at a fixed location for more than 4 consecutive months per year. If less than 10% of the facility capacity is beneath the surface of the ground, the facility is an above ground oil storage facility, or AST. All other oil storage facilities are underground storage tank (UST) facilities, including facilities with tanks located wholly above the ground surface if associated underground piping contains 10% or more of the facility's total capacity.

18. Non-transient, Non-community well or water system. This refers to a public drinking water supply which is neither a community nor transient well or system. Such a water system serves the same 25 or more persons for six (6) months or more per year. Examples include schools, day care centers, factories, industrial or office parks or other large places of employment with their own well.

19. Private drinking water well. This is defined in statute (38 MRSA, §1392) as a well that is used to supply water for human consumption and is not a public water supply well. Individual household wells are the most prevalent example. A well used exclusively for livestock, animals or plants does not meet this definition.

20. Public drinking water supply or well. A public drinking water supply or well is any well or other source of drinking water that furnishes water for human consumption for 15 service connections, regularly serves an average of at least 25 individuals daily at least 60 days out of the year, or supplies bottled water for sale (22 MRSA, §2601).

21. Residual contamination. In the context of these guidelines, residual contamination is any oil contaminated soil or ground water remaining following completion of remediation to the Department's satisfaction.

22. Transient public water well or water system. These water systems are also referred to as a "transient non-community water system". This is a well or water system which serves at least 25 persons, but not necessarily the same individuals, for at least 60 days per year (22 MRSA, §2601). Common examples include restaurants, motels and hotels, campgrounds, golf courses highway rest

areas and some convenience stores.[1] A bottled water company well is considered a transient public water supply.

23. Urban ground water non-attainment area. These are aquifers or portions of an aquifer that because of current and historical land use and pollution have little potential for use as a public or private drinking supply source. *For the purpose of these guidelines only*, these are densely developed industrial, commercial or residential areas, including portions of mapped sand and gravel aquifers or other ground water aquifers where any one of the following conditions are documented or found to exist:
    a) The aquifer or ground water beyond the property on which the discharge occurred was polluted with one or more man-made contaminants in concentrations exceeding federal maximum contaminant levels (MCL) or a State MCL or maximum exposure guideline (MEG) prior to the discharge, AND the aquifer's ground water has not been and is not now the subject of a Department supervised or approved remediation effort with the eventual goal of restoring or protecting ground water to ensure its potability; OR,
    b) Dense commercial or residential development where most lots are ½ acre or less with subsurface waste water disposal, with public drinking water service, and no active, potable water supply wells within 1000 ft.; OR
    c) Where institutional controls or a municipal ordinance prohibits the withdrawal of ground water for human use within 1000 ft. of the discharge location; OR
    d) Other documentation demonstrating to the Department's satisfaction that the aquifer is unsuitable or unavailable as a future public or private drinking water resource.

23. Waste oil. Waste oil refers to a petroleum or synthetic oil that, through use or handling, has become unsuitable for its original purpose due to the presence of hazardous substances or other impurities, or loss of its original properties (38 MRSA, §1303-C).

[1] A convenience store with its own well should be considered a transient public water system for the purpose of these guidelines if it serves food and beverages to the public prepared with water from its drinking water supply well.

1. Introduction

Maine law prohibits the unlicensed discharge of oil to land or waters and requires any person discharging or suffering a discharge of oil to immediately remove that discharge to the satisfaction of the Commissioner of the Department of Environmental Protection (Department). The Commissioner is authorized by Maine law to also undertake the removal or clean up using the most cost effective alternative that is technically feasible and reliable, and which effectively mitigates or minimizes damages to, and provides adequate protection of the public health, welfare and the environment.

This document provides technical guidance for making risk based remediation decisions at oil discharge sites in Maine to ensure public health is adequately protected. The guidelines were developed for use by Department staff charged with overseeing the investigation and remediation of a discharge, and may be useful to responsible parties and their technical representatives carrying out their obligation to clean up discharges of oil "to the Commissioner's satisfaction" as required under 38 M.R.S.A. §548.

These guidelines are not rules or regulations. They are not intended to have the force of law and do not create or affect the legal rights of any person under Maine law. In the event of a conflict between these guidelines and any Maine statute or rule, the statute or rule is controlling.

The guidelines are intended to be applied based on site specific conditions. The Department recognizes that each clean-up project is unique and that the appropriate remediation actions will depend on the specific circumstances of the discharge, including, but not limited to, the type and amount of oil discharged, the proximity of the discharge to sensitive receptors and geological conditions of the site. The Department further recognizes that site specific factors may make it necessary or appropriate to deviate from this guidance.

1.1. Purpose. The purposes of this oil remediation guidance document are threefold:

1.1.1. To ensure that oil remediation decisions are based on the public health risks from exposure to petroleum and its chemical constituents resulting from oil discharges and pollution;

1.1.2. To inform the public and regulated community about how the Department exercises its discretion regarding the removal and clean-up of oil discharges; and

1.1.3. To promote consistency in the level of clean up required statewide, while providing adequate flexibility to accommodate greatly varying site specific conditions that influence the public health threat from any given discharge.

1.2. Applicability.

1.2.1. Department staff should, and others may, use these guidelines to make decisions regarding the initiation, implementation and termination of remediation of discharges from oil storage facilities, and other discharges of oil.

1.2.2. These guidelines can be used for both State funded remediation projects as well as those undertaken by responsible parties or other persons without State funding. In the case of remediation projects eligible for coverage under the Fund Insurance Program, the Department may use the guidelines to assess the need for expenses for which coverage is sought.[2]

1.2.3. These guidelines apply to the remediation of oil discharges and contamination, including gasoline, aviation fuels, methyl tertiary butyl ether (MTBE), kerosene, #2 heating oil, other heating oils including heavy oils, diesel fuel, or other comparable petroleum hydrocarbons. The guidelines apply to discharges of gasoline-ethanol blends with 15% ethanol or less.

1.2.4. The guidelines should be applied to new and historical oil discharges discovered and reported after the guidelines' effective date. The guidelines should not be applied retro-actively to remediation of sites or discharges whose completion and closure were approved by the Department, unless a site is reopened because of new information regarding the extent of contamination or risks associated with existing contamination, changes in land use and receptors, or unanticipated changes in the fate and transport of oil pollution. [3]

1.2.5. The guidelines do not apply to the types of oil discharges and circumstances listed below, where remediation decisions will be made by the Department on a case by case basis.

1.2.5.1. Waste oil discharges. [4]

1.2.5.2. Oil discharges resulting from transportation accidents, including ship, truck, rail and pipeline discharges, that are discovered upon occurrence and promptly reported to the Department, and do not reach a drinking water supply well, a significant sand and gravel aquifer mapped by the Maine Geological Survey, or a bedrock aquifer.

1.2.5.3. Discharges at Department licensed marine oil terminals.

1.2.5.4. Oil discharges from electrical transformers.

1.2.5.5. A site or a portion of a site where hazardous substances contamination are co-mingled with oil contamination.

1.2.5.6. Discharges of denatured ethanol (3-5% gasoline, 95%+ alcohol.

---

[2] In cases where a voluntary clean-up is undertaken and the associated costs are not eligible for reimbursement from the Maine Ground Water Oil Clean-up Fund, these guidelines do not prohibit remediation to concentrations lower than those specified in this document.

[3] Because of the encroachment of development and receptors onto petroleum discharge sites, and the difficulty predicting future surrounding land uses, the completion of remediation to the satisfaction of the Department under these guidelines may not be sufficient to obtain a waiver of future liability under 38 MRSA, §343-E for applicants to the Voluntary Response Action Program (VRAP) program without additional remediation.

[4] Since waste oil may contain materials that make it a hazardous waste, clean-up criteria and analyses other than those included in these guidelines often need to be considered. These may include the Department's hazardous waste regulations as well as the Department's Remedial Action Guidelines for Sites Contaminated with Hazardous Substances.

1.2.6. The guidance does not address ecological risks. Discharges of oil transported to surface water bodies by ground water benefit when oil contaminated soil and ground water are remediated in accordance with this guidance. However, the guidance is not intended to adequately remediate oil discharges reaching surface waters so as to protect or restore that water body's biological community.

1.3. Overview of Guidance. This document contains remediation guidelines for home heating oil response actions, drinking and ground water, and soil. Department guidelines to protect indoor air quality from intrusion of petroleum vapors are incorporated by reference. Statewide health risk-based guidelines suitable for most sites are provided for carcinogenic and non-carcinogenic target chemicals. Similar numeric health risk-based guidelines are also provided for petroleum hydrocarbon fractions to assess non-carcinogenic health risks posed by public exposure to petroleum resulting from oil pollution. These apply to ground water, drinking water, soils and indoor air. Drinking and ground water protection guidelines include soil guidelines based on leaching to ground water modeling. Soil guidelines are commensurate with the potential and degree of human exposure using common exposure scenarios, including residential, park/recreation users, outdoor commercial/industrial workers, and excavation/construction workers. Flexibility is provided in the guidelines to allow for the development of site specific clean-up guidelines based on a site specific risk assessment for those sites where that may be more cost effective. Such alternate guidelines require written Department approval. To allow for the development of public health risk-based guidelines, the guidelines are based on the Massachusetts Department of Environmental Protection's petroleum hydrocarbon fractions analytical methods. Qualitative clean-up guidelines are provided for free petroleum product and oil saturated soils remediation.

1.4. How to Use the Guidelines. Use of Section 3 is specific to the clean up of recent home heating oil tank system discharges. All applicable guidelines found in Sections 2, 4, 5 and 6 should be used to guide other remediation decisions. When multiple soil remediation guidelines apply, the most conservative guideline value for a specific compound or petroleum fraction should be used.

2. Free Product and Oil Saturated Soil Remediation

2.1. Free product remediation. Free petroleum product contamination, the light non-aqueous phase liquid (LNAPL) oil or petroleum found on the ground water table, should be removed or remediated at all locations where found to the Department's satisfaction. This represents the Department's historic baseline remediation guideline to prevent or mitigate fire and explosion threats in buildings, underground utilities and during construction; indoor air pollution; petroleum exposure to outdoor workers; and threats to Maine's

surface water bodies.

2.2. Oil saturated soils. Oil saturated soils should be remediated at all locations found to the Department's satisfaction to prevent or mitigate free product contamination of ground water, vapor problems in indoor air and utilities, and petroleum exposure to outdoor workers, including excavation and construction workers. Oil saturated soil remediation is also needed to mitigate the risk of or the discharge of oil to the State's surface water bodies.

.

2.2.1. For gasoline, diesel fuel, and fuel oil discharges, or sites with mixed petroleum discharges, saturated soils may be identified by field testing using an oleophilic dye shake test in accordance with the Department's *Compendium of Field Testing of Soil Samples for Gasoline and Fuel Oil Standard Operating Procedure, Standard Operating Procedure (TS004)* for field testing of soil samples for fuel oils found online. (http://www.maine.gov/dep/spills/petroleum/documents/sop/ts004.pdf)[5]

2.2.2. Other field methods for determining if soil is saturated with oil may be used if approved in advance by the Department.

3. Home Heating Oil Tank Discharge Response

3.1. Applicability. This remediation guideline only applies to discharges of 600 gallons or less of kerosene, #1 or #2 home heating oil from an above ground oil storage tank or piping, and associated overfills. It also only applies when responding within 30 days of the approximate date of the discharge.

3.2. Soil clean-up.

3.2.1. Remove free product, and oil saturated and visibly stained soils.

3.2.2. Determine areal extent and depth of excavation/soil removal using visual observations and an oleophilic dye shake test conducted in accordance with the Department's *Standard Operating Procedure TS004* for field testing of soil samples for fuel oils, or another field method approved by the Department. Periodically collect samples for field analysis from the excavation bottom and sidewalls. Cease removal when field testing results are negative or indicate contamination concentrations start to decline significantly. At very recent discharges, photoionization device (PID) screening may be a useful means to determine when to collect soil samples for field analysis by the oleophilic dye shake test.

3.2.3. Document residual soil contamination left in place following soil removal. When the discharge is 5 or more gallons take a minimum of two (2) soil grab samples at the completion of soil removal for laboratory EPH and VPH analysis. The samples should be representative of the range of residual soil contamination being left. One sample is to be collected from the location of

[5] Compendium of Field Testing of Soil Samples for Gasoline and Fuel Oil, Standard Operating Procedure, Standard Operating Procedure TS004, Maine Dept. of Environmental Protection, 2011.

the highest field reading and a second from the lowest. Proceed with backfilling upon sample collection.

3.3. Other applicable guidelines. Whenever any one of the following conditions exists, remediation decisions are also governed by the other sections of this document. These circumstances include:

3.3.1. A private or public drinking water supply well has been contaminated;

3.3.2. The discharge is within 1000 ft. or within the source water protection area of a community or non-community non-transient public drinking water supply well (i.e. all public wells other than transient public wells – restaurants, convenience stores, motels, etc.);

3.3.3. Contaminated soils extend to bedrock;

3.3.4. Free product is under a building;

3.3.5. Basement sump or building drainage system contain contaminated water;

3.3.6. Strong persistent indoor petroleum odors, not resolved by temporary venting or removal of saturated soils; or

3.3.7. High PID readings where basement wall and floor meet or where utilities enter building

4. Drinking Water/Ground Water Protection & Remediation Guidelines

4.1. Applicability. If a discharge location meets any ONE of the following criteria, the remediation goal for the site and surrounding area should include the protection and remediation of drinking water and ground water, and this section applies to the remediation decisions for the site:

4.1.1. A private or public drinking water supply well is contaminated that is actively used for human consumption of the water.

4.1.2. A discharge is located in a source water protection area of a public drinking water supply as mapped by the Maine Drinking Water Program in the Department of Health and Human Services (http://www.maine.gov/dep/gis/datamaps/DWP_Wells/index.html).

4.1.3. A discharge is located within 1000 ft. of an active community (e.g. town, water district, or mobile home park wells) or non-community non-transient (e.g. school, business with more than 25 year round employees) public drinking water supply well (http://www.maine.gov/dep/gis/datamaps/DWP_Wells/index.html) .

4.1.4. A gasoline discharge is within 1000 ft. of a private well or transient (e.g. restaurant, motel, convenience store, etc.) public drinking water supply well in active use for human consumption

4.1.5. A discharge of petroleum products other than gasoline is located within 500 ft. of an active private or transient public drinking water supply well used for human consumption

4.1.6. A discharge is located on a significant sand and gravel aquifer as mapped by the Maine Geological Survey in the Maine Department of Conservation (http://www.maine.gov/dacf/mgs/pubs/online/aquifers/aquifers.htm) ; OR

4.1.7. Where there is a high probability of future residential development and use of the ground water for private drinking water wells. This is limited to entire parcels, and portions thereof, within 1000 ft. of a gasoline discharge, or

within 500 ft. of another petroleum product discharge; that are currently zoned by the municipality or the Maine Land Use Planning Commission (plantations and unorganized townships) to expressly allow residential development as a permitted use; public drinking water service is not available within 1000 ft. of the discharge location; AND ground water at the property boundary of the parcel with the discharge is contaminated by oil above the remediation guidelines in Table 1, or a State or federal drinking water standard.

4.2. Exception for Urban Ground Water Non-attainment Areas. This section does not apply to a site where only 4.1.6 or 4.1.7 above applies, and the discharge location meets the criteria of an urban ground water non-attainment area.

4.3. Exception for work place safety. These guidelines are not intended or appropriate for use to protect construction, excavation or remediation workers against exposure to oil contaminated ground water encountered during construction or remediation activities.[6]

4.4. Tier 1 – General Statewide Guidelines

4.4.1. General application of guidelines. The purpose of the guidelines for ground water or drinking water is two-fold. The first is to guide when, and when not to require, undertake, or fund (with State monies) the monitoring, treatment and remediation of dissolved phase contaminated groundwater and drinking water supplies. The second purpose is to provide guidance when ground water contamination and remediation sites should be closed and public remediation expenditures would cease.

4.4.2. Drinking water remediation guidelines. Remediation guidelines for private and public drinking water supplies contaminated with petroleum constituents are based on Maine Center for Disease Control and Prevention (MCDC) Maximum Exposure Guidelines (MEGs), and in the specific case of MTBE, the MCDC's regulatory Maximum Contaminant Level (MCL). These are presented in Table 1. When two or more petroleum compounds are found present in a drinking water supply, but none exceed a Table 1 guideline, the cumulative health affect should also be evaluated to ensure that the increased lifetime cancer risk (ILCR) and hazard index (HI) for humans consuming that water is not greater than $1x10^{-5,}$ or 1.0, respectively. A risk calculation spreadsheet developed by the Maine CDC to determine the ILCR and HI of multiple contaminants is available for use on the Department's website (http://www.maine.gov/dep/spills/publications/guidance/index.html).[7]

4.4.3. Ground water remediation guidelines. Table 1 guidelines also serve as ground water remediation guidelines for petroleum constituents, in addition to drinking water. These guidelines should be used to establish the

[6] Applicable work place safety regulations such as OSHA regulations 40 CFR 1910.120 and 1925.55 should be consulted.

[7] Because all petroleum products are made up of hundreds of compounds and drinking water affected by oil contamination is almost always contaminated with more than 1 of these compounds, consideration of the cumulative health risk of consuming multiple contaminants is recommended. Despite no one contaminant concentration exceeding a MEG or MCL, the cumulative health risk may still be unacceptable.

remediation objectives for sites where ground water is contaminated by dissolved phase petroleum constituents.[8]

4.4.4. Use of other drinking water or ground water remediation guidelines.

4.4.4.1. In those cases involving leaded gasoline discharges where lead scavenger compounds may be of concern in drinking water, applicable Maine MEGs or federal MCLs may be used to supplement the Table 1 guidelines (e.g. ethylene dibromide or 1,2 dichloroethane).

4.4.4.2. Other ground water remediation guidelines may be developed and used in accordance with section 4.6 (Tier 3).

4.4.5. Sampling, monitoring and treatment of contaminated or at risk private and public drinking water wells.

4.4.5.1. For newly reported oil discharge sites, all water supplies found by the Department to be contaminated or at significant risk of contamination should be sampled.

4.4.5.2. Private and public drinking water supply wells, verified by a minimum of two rounds of sample collection and analyses to be contaminated by oil compounds should be provided temporary treatment and quarterly monitoring satisfactory to the Department when the concentration of any one contaminant meets or exceeds an action level concentration listed in Table 2, or 75% of a federal or State of Maine drinking water standard[9] (rounded to one significant figure).

4.4.5.3. When private wells are contaminated with arsenic mobilized due to changes in ground water chemistry resulting from an oil discharge such that the drinking water standard for arsenic is exceeded, appropriate treatment and quarterly monitoring is to be provided.[10]

4.4.5.4. If quarterly monitoring reveals that contaminant concentrations remain below the guidelines in Table 1 and other applicable drinking water standards, or no longer present an unacceptable health risk due to multiple contaminants for four (4) sequential quarters, treatment should be discontinued. The cumulative health risk of multiple contaminants may be determined using a ILCR/HI calculator provided on the Department's website (http://www.maine.gov/dep/spills/publications/guidance/index.html). The health risk is considered unacceptable when the ILCR or HI of the multiple contaminants present exceed $1x10^{-5}$ or 1.0, respectively.

4.4.5.5. Private drinking water supply wells determined by the Department to be at significant risk of contamination should be sampled and monitored on a quarterly basis. Identification of "at risk" wells should be governed by site specific circumstances. If contamination is likely, given the site's geology and the circumstances of the discharge, the

---

[8] The health effects of the presence of multiple petroleum contaminants below MEGs should only be considered in remediation decisions regarding contaminated drinking water supplies or ground water to which section 4 of these guidelines apply.

[9] Drinking water standards include the U.S. Environmental Protection Agency maximum contaminant levels (MCL), State of Maine MCL, or a maximum exposure guideline (MEG) published by the Maine Center for Disease Control and Prevention in the Department of Health and Human Services.

[10] In cases where ground water chemistry indicates that oil contamination of ground water is liberating and increasing arsenic (As) concentrations greater than the MCL, point-of-use (POU) treatment of private well water will generally be the most cost effective treatment option to protect public health..

well should be placed on quarterly monitoring for four quarters to allow time to assess contamination trends. If the well becomes contaminated, it is to be managed in a manner consistent with the preceding paragraphs, guided by the concentration levels and trends.

4.4.5.6. Quarterly monitoring may be continued as determined appropriate by the Department based on site specific geology or other unique circumstances, or if additional data are needed as part of the overall site monitoring plan.

4.4.6. Replacement, long-term treatment and remediation of contaminated private drinking water supply wells. Concentration levels should guide decisions concerning long-term solutions to contaminated water supplies. The replacement of contaminated private drinking water supplies or provision of long term treatment for these water supplies should be provided or required where prevailing contaminant concentrations are at or above those of Table 1 or State and federal drinking water standards, and are likely to remain so. Other remediation measures may also be considered such as the installation of Jaswell seals where technically feasible. Well replacement, long-term treatment or remediation should also be provided when the ILCR is likely to remain equal to or greater than $1x10^{-5}$, or the HI will remain equal to or greater than 1.0 from the cumulative effect of multiple petroleum contaminants. The cancer and non-cancer risks can be assessed using an online risk calculator on the Department's website (http://www.maine.gov/dep/spills/publications/guidance/index.html) . Because of greater reliability as a long-term solution, the Department prefers replacement wells over long-term treatment systems and other remediation measures when replacement is technically feasible and cost effective.

4.4.7. Remediation of contaminated public drinking water supplies. The Maine Drinking Water Program in the Department of Health and Human Services is to be notified when any public drinking water supply is found to be contaminated or at significant risk of contamination. These guidelines, State maximum exposure guidelines (MEGs) and federal drinking water regulatory standards should be applied in making decisions for the monitoring, treatment and remediation of the contaminated public drinking water supplies. Transient non-community public water supplies (e.g. motels, restaurants, churches, town meeting halls) should be handled in the same manner as private residential drinking water supply wells as specified in paragraphs 4.4.4 and 4.4.5 above. Decisions to treat and monitor non-transient, non-community public water supplies (e.g. schools, larger places of employment, food processing facilities, etc) should also be governed by the same criteria as private wells, however, monitoring and treatment should be coordinated with the Maine Drinking Water Program. Decisions on whether to monitor, treat or remediate a community public drinking water supply contaminated or at significant risk of contamination by oil should be made jointly with the Maine Drinking Water Program.

4.4.8. Persistent petroleum odor and taste problems in drinking water. Oil contaminated private and public drinking water supply wells not exceeding the remediation guidelines may still pose a nuisance due to documented and persistent petroleum odors or taste problems. Such nuisance problems

when caused by oil contamination should be evaluated and addressed on a site specific basis to the Department's satisfaction.

4.4.9. Investigation and remediation of ambient ground water quality contamination.

4.4.9.1. This guidance should be used in conjunction with the investigation and corrective action requirements of the Department's Rules for Underground Oil Storage Facilities (Section 12 of Chapter 691) regardless of the source. Like Chapter 691, the decision to require an initial hydrogeological investigation is at the Department's discretion. However, this guidance addresses whether to investigate a site further or to pursue groundwater remediation based on the findings of an initial hydrogeological investigation.

4.4.9.2. Investigation beyond an initial hydrogeologic investigation or remediation of ambient groundwater contamination may be required by the Department when prevailing concentrations of dissolved phase oil contamination equal or exceed the guidelines in Table 1. When prevailing concentrations are below applicable guidelines for 12 consecutive months, groundwater remediation may be terminated and the project considered for closure after an additional 12 months of confirmation monitoring. If concentrations increase again above the guidelines, further investigation, remediation or monitoring should be considered.

4.4.9.3. Use of an environmental covenant or deed notice should be considered to prevent or notify the public of the potential of future exposures to unsafe drinking water via a future well prior to closing a site, when:

4.4.9.3.1. Ground water remediation to these guidelines is not technically feasible; or

4.4.9.3.2. Multiple petroleum contaminants remain in ground water (and not currently used as a drinking water supply) at concentrations below Table 1 guidelines, but water quality poses a health risk if consumed because the ILCR equals or exceeds $1x10^{-5}$ or the HI is equal to or is above 1.0. The health risk from multiple contaminants may be evaluated using the cumulative risk calculator provided on the Department's website (http://www.maine.gov/dep/spills/publications/guidance/index.html).

4.4.10. Investigation of potential oil discharge sources. When a private or public water supply well is found contaminated, the source is to be investigated (if not known) and preventative measures taken to eliminate or mitigate the source as required by Department regulation and statute, regardless of the concentration of oil parameters (including below action levels). Once the source of the contamination is known, a more informed decision can be made regarding the risk to the well and on the most cost effective and technically feasible remediation approach.

TABLE 1
Tier 1 Statewide Ground Water & Drinking Water Remediation Guidelines for Petroleum Related Compounds (ug/L)[11]

CAS Number	Chemical	Guideline[12]
Petroleum Target Compounds		
91-57-6	2-Methylnaphthalene	**30**
83-32-9	Acenaphthene	**400**
208-96-8	Acenaphthylene	**400**
120-12-7	Anthracene	**2000**
71-43-2	Benzene	**4.0**
56-55-3	Benzo(a)anthracene	**0.5**
50-32-8	Benzo(a)pyrene	**0.05**
205-99-2	Benzo(b)fluoranthene	**0.5**
191-24-2	Benzo(g,h,i)perylene	**200**
207-08-9	Benzo(k)fluoranthene	**5.0**
218-01-9	Chrysene	**50**
53-70-3	Dibenz(a,h)anthracene	**0.05**
100-41-4	Ethylbenzene	**30**
206-44-0	Fluoranthene	**300**
86-73-7	Fluorene	**300**
193-39-5	Indeno(1,2,3-cd)pyrene	**0.5**
7439-92-1	Lead	**10**
1634-04-4	Methyl tert-butyl ether[13]	**35**
91-20-3	Naphthalene	**10**
85-01-8	Phenanthrene	**200**
129-00-0	Pyrene	**200**
108-88-3	Toluene	**600**
1330-20-7	Xylene	**1000**
Petroleum Hydrocarbon Fractions	C5-C8 Aliphatics	**300**
	C9-C12 Aliphatics	**700**
	C9-C18 Aliphatics	**700**
	C19-C36 Aliphatics	**10,000**
	C9-C10 Aromatics	**200**
	C11-C22 Aromatics	**200**

[11] Shading indicates that guideline value may be lower than the Practical Quantitation Limit (PQL) of the lab method. If so use the PQL as the guideline for this contaminant. MEG for acenaphthene used for acenaphthylene; MEG for pyrene used for benzo(g,h,i)perylene and phenanthrene; MEG for n-hexane used for C5-C8 aliphatics; MEG for C9-C17 aliphatic mixture used for C9-C12 aliphatics and C9-C18 aliphatics; MEG for C15-C45 aliphatics used for C18-C36 aliphatics; MEG for pyrene used for C9-C10 aromatics and C11-C22 aromatics..

[12] Guidelines are rounded to nearest single significant figure to be consistent with MCDC MEGs.

[13] The guideline for MTBE is based on the State MCL established in Chapter 231 of the Maine Department of Health and Human Services regulations, Rules for Drinking Water, and approved by the Maine Legislature in 1997.

TABLE 2
Action Level Concentrations in Drinking Water Supply Wells for Temporary Treatment[14]

Chemical/Petroleum Hydrocarbon Fraction	Action Level (µg/l)
2-Methylnaphthalene	**20**
Acenaphthene	**300**
Acenaphthylene	**300**
Anthracene	**2000**
Benzene	**3.0**
Benzo(a)anthracene	**0.4**
Benzo(a)pyrene	**0.04**
Benzo(b)fluoranthene	**0.4**
Benzo(g,h,i)perylene	**200**
Benzo(k)fluoranthene	**4.0**
Chrysene	**40**
Dibenz(a,h)anthracene	**0.03**
Ethylbenzene	**20**
Fluoranthene	**200**
Fluorene	**200**
Indeno(1,2,3-cd)pyrene	**0.4**
Lead	**8**
Methyl tert-butyl ether	**30**
Naphthalene	**8**
Phenanthrene	**200**
Pyrene	**200**
Toluene	**400**
Xylene	**800**
C5-C8 Aliphatics	**200**
C9-C12 Aliphatics	**500**
C9-C18 Aliphatics	**500**
C19-C36 Aliphatics	**8,000**
C9-C10 Aromatics	**200**
C11-C22 Aromatics	**200**

Guideline value may be below Practical Quantification Limit (PQL) of lab method. If so, use the PQL as an action level concentration.

[14] Action concentrations set at 75% of ground water/drinking water guidelines in Table 1. Action levels are rounded to one significant figure.

4.4.11. Leaching to ground water soil remediation guidelines. General statewide Tier 1 soil clean-up guidelines to prevent oil contaminated soils from acting as a continuing source of ground water contamination exceeding Maine drinking water standards and ground water guidelines are presented in Table 3. The basis for their development is provided in Appendix D. The Department reserves authority to require more site specific, Tier 2 or 3, leaching to ground water soil remediation guidelines when the risk of ground and drinking water contamination or site conditions merit. This includes, but is not limited to, when soil contamination extends to the bedrock surface before encountering the ground water table, where shallow bedrock is present (<20 ft.) or when till overburden is highly fractured.

4.5. Tier 2 – Incorporation of Site Specific Modeling Variables for Determining Leaching to Ground Water Soil Remediation Guidelines

4.5.1. For sites where the surficial geology to ground water or bedrock has been adequately characterized and found to consist of either sand and gravel, or till, more soil specific guidelines may be found in Appendix B and may be used with Department approval. For the purpose of using Appendix B, tills are surficial materials where 20% or more passes a #200 U.S. Standard Sieve Mesh (0.074 mm). Soils with less than 20% passing through a #200 sieve will be considered sand and gravel.

4.5.2. Using the same models used by the Department to develop the guidelines in Table 3, but using more site specific input data is an option with prior Department approval. The SESOIL leaching to ground water model and AT123D model of contaminant dispersion and advection are to be used. Measures specific to the site for such model variables as meteorological data, biodegradation, and soil properties may be substituted.

4.5.3. For sites with a shallow bedrock aquifer (<20 ft.), changes to the SESOIL model and the conceptual geological site model upon which it is based to ensure the quality of bedrock ground and drinking water is recommended and may be made with prior Department approval.

4.6. Tier 3 – Site Specific Ground Water Protection Remediation Guidelines

4.6.1. With prior Department approval, the development and use of site specific ground water and leaching to ground water soil remediation guidelines are an option under these guidelines on a case by case basis, when the Department finds that public health and the environment are adequately protected. For recent discharges, site specific guidelines require a sound understanding of site geology, contaminant fate and transport in the soil and ground water, and potential receptors. For very old discharges, water quality in nearby drinking water wells or appropriately located ground water monitoring wells may be considered in evaluating the need for or the extent of contaminated soil remediation. Human exposure via ingestion of drinking water not meeting state and federal drinking water standards will not be considered by the Department.

TABLE 3
Tier 1 Soil Remediation Guidelines
Based on Petroleum Leaching to Ground Water[15]

Petroleum Target Compounds	Concentration (mg/kg) [16]
2-Methylnaphthalene	3.6
Acenaphthene	170
Acenaphthylene	68
Anthracene	2400
Benzene	0.51
Benzo(a)anthracene	10,000
Benzo(a)pyrene	10,000
Benzo(b)fluoranthene	10,000
Benzo(g,h,i)perylene	10,000
Benzo(k)fluoranthene	10,000
Chrysene	10,000
Dibenz(a,h)anthracene	10,000
Ethylbenzene	0.81
Fluoranthene	10,000
Fluorene	120
Indeno(1,2,3-cd)pyrene	10,000
Lead	10,000
Methyl tert-butyl ether	0.19
Naphthalene	1.7
Phenanthrene	97
Pyrene	10,000
Toluene	8.1
Xylene	26
Petroleum Hydrocarbon Fractions	
C5-C8 Aliphatics	1600
C9-C12 Aliphatics	10,000
C9-C18 Aliphatics	10,000
C19-C36 Aliphatics	10,000
C9-C10 Aromatics	75
C11-C22 Aromatics	460

[15] Guidelines present the lower of soil concentrations derived for sand and gravel or sandy till soils using SESOIL leaching and AT123D dispersion/advection models, and Maine meteorological and geology data. The basis for the guidelines is presented in Appendix D.

[16] Shading indicates Department modeling predicted ground water exceedance of MEG unlikely in 1000 years regardless of soil concentration. Guideline therefore set at ceiling level of 10,000 mg/kg.

5. Soil Exposure Guidelines

This section addresses the health risks to the public from direct exposure to petroleum contaminated soils by way of dermal contact, ingestion, and inhalation of soil particles or vapors. Three options for the remediation of oil contaminated soils are provided in this section of the guidelines. The first option or tier (Tier 1) is for use at smaller soil contamination sites and is less site specific than Tier 2 or 3 guidelines. Tier 2 is statewide guidelines derived by the MCDC and the Department based on a common set of exposure and toxicological factors. Under Tier 2, numeric guidelines have been derived for common exposure scenarios. These are residential areas and their inhabitants, recreational areas and their users, commercial areas and commercial/industrial workers, and excavation/construction workers. To provide further flexibility, under Tier 3, site specific clean up guidelines may be derived and used upon prior approval by the Department and the MCDC. These direct contact soil guidelines should be used in conjunction with other soil remediation guidelines for oil saturated soil and prevention of leaching to ground water in Sections 2 and 4, where they apply.

5.1. Tier 1 – Direct Contact Soil Remediation Guidelines for Small Remediation Sites. The Tier 1 soil guidelines presented in Table 4 are intended to provide simpler guidelines for smaller soil contamination sites statewide. They should be used to address direct contact routes of exposure to contaminated soil at those sites where 200 cubic yards or less of contaminated soil is found, and without the need to consider the types of receptors on the contaminated land parcel, the depth of contamination, background concentrations of PAHs or future changes in land use. They are well suited for use remediating smaller petroleum discharges that are discovered and reported promptly at underground and above ground oil storage facilities, including, but not limited to, tank or truck overfills, piping leaks, dispenser discharges and smaller underground storage tank removals. They may also be used to guide the clean-up of small volumes of recently discovered historical oil contamination. Tier 1 is not appropriate for the remediation of sites with larger volumes (>200 cy) of oil contaminated soil. Larger sites should use the more site specific guidelines in Tier 2 or Tier 3 to ensure remediation decisions are more risk based and cost effective.

Table 4
Tier 1 Direct Contact Soil Remediation Guidelines for Smaller Petroleum Contamination Sites[17]

Chemical/Petroleum Fraction	Concentration (mg/kg)
2-Methylnaphthalene	100
Acenaphthene	1,500
Acenaphthylene	1,500
Anthracene	760
Benzene	17
Benzo(a)anthracene	0.26
Benzo(a)pyrene	0.026
Benzo(b)fluoranthene	0.26
Benzo(g,h,i)perylene	750
Benzo(k)fluoranthene	2.6
Chrysene	26
Dibenz(a,h)anthracene	0.026
Ethylbenzene	130
Fluoranthene	1,000
Fluorene	1,000
Indeno(1,2,3-cd)pyrene	0.26
Lead	170
Methyl tert-butyl ether	790
Naphthalene	500
Phenanthrene	750
Pyrene	750
Toluene	2,700
Xylene	6,800
C5-C8 Aliphatics	1,400
C9-C12 Aliphatics	2,700
C9-C18 Aliphatics	2,700
C19-C36 Aliphatics	10,000
C9-C10- Aromatics	750
C11-C22 Aromatics	750

Value is greater than ceiling value of 10,000 mg/kg. The ceiling value is used as the guideline for this compound or fraction.

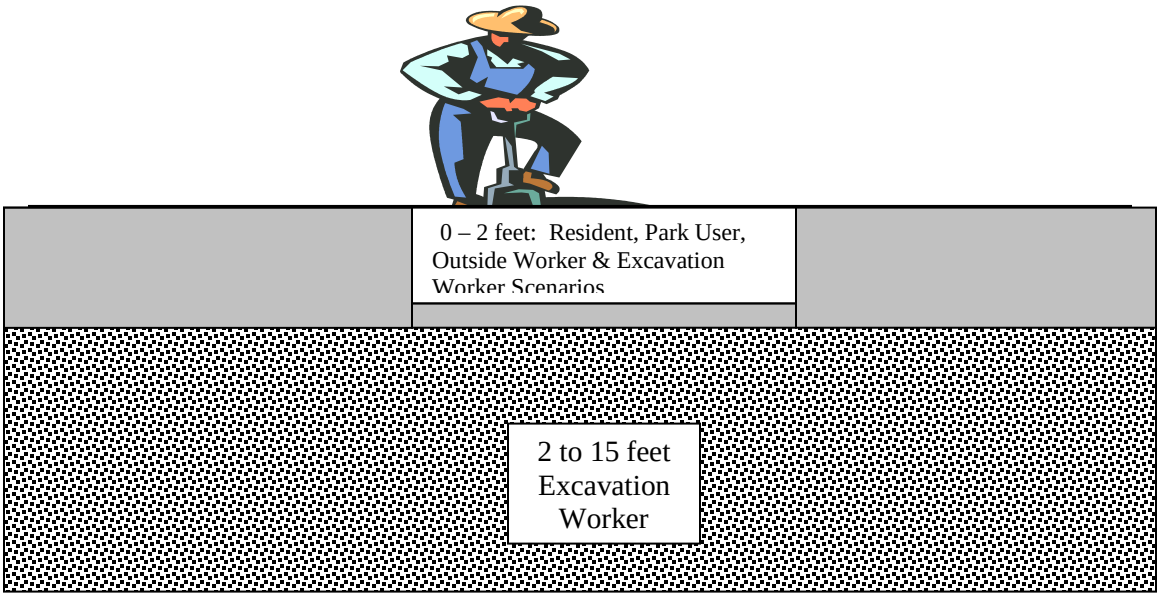
Value may be less than the lab method's Practical Quantification Limit (PQL). If so, use the PQL as the guideline for this compound.

[17] These guidelines are the lowest of those presented in Table 5 for each compound, and represents the most conservative value for each of the common human exposure scenarios addressed in these guidelines.

5.2. Tier 2 – Soil Guidelines for Common Human Exposure Scenarios.

5.2.1. Exposure scenarios. Applicable human exposure scenarios should be selected from amongst the options below. Often multiple scenarios may apply to the same site. The accessibility of contaminated soils affects the likelihood of human exposure under different land use scenarios. The residential, recreational/park user, and outdoor commercial/industrial worker scenarios apply to contamination in soil to which residents, users and workers are most likely exposed, the upper two (2) feet. The construction/excavation worker scenario applies to contamination to a depth of 15 ft. below the surface. Contaminated soils located at a depth greater than 15 ft., or covered completely by a building or other permanent structure without an earthen floor are considered sufficiently isolated from human exposure.

Figure 1
Applicability of Contaminated Soil Exposure Scenarios



5.2.2. Residential. This scenario applies to areas where petroleum contaminated soils are documented and where people live (either year-round or seasonally), including single and multiple family dwellings and their associated yards. [18] The residential scenario assumes continuous exposure

[18] Since soil exposures were assumed in the development of the guidelines to occur during the time of year when the ground is not frozen or snow covered, seasonal residential homes are also included.

to children and adults over a thirty-year duration as the population passes through childhood and into adulthood. Exposures to soil by incidental ingestion, dermal contact, and inhalation of contaminants in both fugitive dust and ambient air are assumed to occur with a high frequency and high intensity when the ground is not frozen or snow covered, as children and adults play and work in a residential yard and engage in activities that disturb and displace soil (e.g. lawn mowing, gardening, playing outdoor games or sports, etc.). Because of the similarities in the degree of exposure of children, this scenario should be applied to day-care facilities. It may be applicable to some elder care and medical care facilities on a case by case basis where likely exposure is comparable to that of a residential yard. This scenario does not apply to urban areas, where all contaminated soils are paved and inaccessible to humans other than through construction and heavy equipment excavation activities.

5.2.3. Recreational/park user. This scenario applies to areas of oil contaminated soils underlying parks, play grounds, athletic fields, school yards, and other outdoor recreational areas. The recreational/park user scenario is similar to the residential scenario in that it assumes continuous exposure to children and adults over thirty-year duration. However, the frequency of exposure of recreational activities at a park or other open space is reasonably anticipated to be less than that occurring in a residential yard. Soil exposures are assumed to occur by incidental ingestion, dermal contact, and inhalation of contaminants in fugitive dust and ambient air when the ground is not frozen or snow covered.

5.2.4. Outdoor commercial/industrial worker. This scenario applies to oil contaminated soils underlying outdoor areas of commercial and industrial facilities where people work. The outdoor worker scenario includes full-time industrial and commercial workers whose jobs require that they be outdoors for a portion of the work day such as groundskeepers, loading dock workers, parking lot attendants, and wood yard workers. Other common examples of this worker exposure scenario include a bulk oil storage plant, railroad yard, auto recycling facility, junkyard or a gas station. This scenario can also be used to conservatively evaluate indoor workers who may be exposed to soil briefly during work breaks and outdoor lunches on a routine basis. Exposures to soil by incidental ingestion, dermal contact, and inhalation of contaminants in fugitive dust and ambient air are assumed to occur over a period of 25 years for the work days of the year when the ground is not frozen or snow covered. Contact with soil is assumed to be of lower intensity than assumed for a residential scenario since these workers are unlikely to be displacing soil (i.e. digging).

5.2.5. Construction/excavation worker.

5.2.5.1. The construction/excavation worker scenario assumes exposures to soil during high intensity soil disturbance activities such as digging, grading, and back-filling. Exposures to soil by incidental ingestion, dermal contact and inhalation of contaminants on fugitive dust and in ambient air are assumed to occur at a greater intensity than that assumed for the outdoor commercial worker due to the degree of soil disturbance and displacement anticipated.

5.2.5.2. The excavation/construction worker scenario guidelines in Table 5 are for a construction project period of 6 months or shorter. This scenario can be used to conservatively evaluate a utility worker or landscaper whose exposure may be as intense as a construction/excavation worker, but is expected to be of a lesser duration.

5.2.5.3. For construction projects in or over contaminated soil of duration greater than 6 months, site specific guidelines should be developed based on a risk assessment or another means satisfactory to the Department.

5.2.5.4. Exceptions. This scenario is not intended to protect workers undertaking excavation or construction work in a location where it is reasonable to expect for their employer or the workers themselves to anticipate encountering oil contaminated soil and therefore are able to take appropriate work place safety measures to avoid unhealthy exposures. The excavation/construction worker scenario is not intended to be a substitute for required work place safety measures such as OSHA regulations (29 CFR, 1910.120 or 1925.55). It does not apply to the following:

5.2.5.5. Remediation or other workers required to have the proper level of SARA/hazardous materials safety training in accordance with 29 CFR 1910.120 of OSHA regulations;

5.2.5.5.1. An active commercial oil storage facility;

5.2.5.5.2. The parcel of property upon which the oil discharge occurred and the landowner has or should have knowledge of the discharge[19];

5.2.5.5.3. A former commercial oil storage facility where documentation of past petroleum discharges or contamination is public information and available by conducting a search of public records; or

5.2.5.5.4. Where a deed notice or an environmental covenant has been attached to the property deed.

5.2.6. Soil guidelines by exposure scenario. Oil contaminated soil remediation guidelines are provided in Table 5 for petroleum hydrocarbon fractions and target chemicals for each of the human exposure scenarios described above. Select all scenarios which apply to the current and likely future human uses of the area impacted by oil contaminated soils and implement the lowest and more conservative of the guidelines from Table 5. Remediation of soils to address likely future land uses and exposure scenarios is limited to that specified in 5.2.4.

5.2.7. Consideration of background concentrations of polycyclic aromatic hydrocarbons (PAHs). Additional guidelines for select PAHs are provided in Table 6 for use at those sites where a background concentration exceeds health risk based remediation concentrations in Table 5. Table 6's guidelines are based on 90 percent of the upper predictive limit of

[19] The owner of the property upon which the discharge occurred is responsible for informing excavation/construction workers of the possibility of encountering oil contaminated soil or ground water so they and their employer can implement appropriate work place safety measures as required by OSHA regulations (e.g. 29 CFR 1910.120 or 1925.55).

background PAH concentrations in urban and rural areas in Maine.[20] Background concentrations are provided for urban soils, urban fill, and rural soil. Urban areas are defined as locations within a mapped Maine Department of Transportation Urban Compact Zone. Rural areas are all other parts of Maine. Urban fill guidelines apply only to urban areas where the contaminated media is not native soil, but man-placed materials originating from a location other than the oil discharge site and consisting in substantive part of materials which may contain PAHs, including but not limited to brick, cement, wood, wood ash, coal, coal ash, boiler ash, clinkers, asphalt, glass, plastic, metals, demolition debris and roadside ditch material. Clean sand, gravel or other soil fill are not considered urban fill for the specific application of the background PAH guidelines. When encountering fill in rural areas consisting of substantial amounts of coal or wood ash, boiler ash, clinkers, asphalt or roadside ditch material, development of a site specific PAH background concentrations may be appropriate in accordance with Tier 3 guidelines below (section 5.3).

5.2.8. Consideration of changes in future land use and exposure scenarios. Use of direct contact soil guidelines are primarily intended to protect current land uses from unhealthy exposure. Application to protect future land uses should be limited to those circumstances where the future land use and exposure scenario can be reasonably predicted. The guidelines should be applied to sites where the soil remediation is part of the redevelopment of a site or other imminent construction activity, including utility construction, is planned and expected to follow a site's remediation.

5.2.9. Tier 2 guidelines may be used with prior Department approval for exposure scenarios other than those described in 5.2.1, but where the health risks (carcinogenic, non-carcinogen), exposure routes and duration of human exposure are very similar to that for a resident, park user, outdoor commercial worker or excavation construction worker.

5.3. Tier 3 – Development of Site Specific Soil Remediation Guidelines

5.3.1. For sites where cost effective, the Department will consider for approval site specific soil remediation guidelines based on a sound understanding of the soil contamination, potential exposure pathways and a site specific risk assessment completed in accordance with the State of Maine's risk assessment guidelines - http://www.maine.gov/dep/spills/publications/guidance/index.html

5.3.2. Risk assessments require prior Department and MCDC review and approval.

5.3.3. Site specific soil remediation guidelines need to minimize risk of exposure to potential receptors and adequately protect public health.

5.3.4. Site specific guidelines should be based on the Massachusetts DEP petroleum hydrocarbon fractions and analytical methods as described in Section 9 of the guidance.

[20] Summary Report for Evaluation of Concentrations of Polycyclic Aromatic Hydrocarbons (PAHs) in Background Soils in Maine by AMEC Environmental & Infrastructure Inc., for the Maine Department of Environmental Protection, November 16, 2012.

5.3.5. Establishment of site specific background PAH concentrations should be based on a soil sampling and statistical data analysis plan, or another proposed methodology reviewed and approved in advance by the Department.

TABLE 5
Tier 2 Soil Remediation Guidelines for Petroleum Target Compounds and Hydrocarbon Fractions (mg/kg)[21]

Chemical/Fraction	Resident	Park User	OutdoorCommercialWorker	ExcvtnConstructnWrkr
2-Methylnaphthalene	94	160	730	120
Acenaphthene	1,500	2,500	10,000	2,000
Acenaphthylene	1,500	2,500	10,000	10,000
Anthracene	7,000	10,000	10,000	760
Benzene	17	28	86	30
Benzo(a)anthracene*	0.26	0.44	3.5	43
Benzo(a)pyrene*	0.026	0.044	0.35	4.3
Benzo(b)fluoranthene*	0.26	0.44	3.5	43
Benzo(g,h,i)perylene	750	1,200	5,500	10,000
Benzo(k)fluoranthene*	2.6	4.4	35	430
Chrysene	26	44	350	4,300
Dibenz(a,h)anthracene*	0.026	0.044	0.35	4.3
Ethylbenzene	130	220	430	3,900
Fluoranthene	1,000	1,700	7,300	10,000
Fluorene	1,000	1,700	7,300	10,000
Indeno(1,2,3-cd)pyrene*	0.26	0.44	3.5	43
Lead	170	280	560	950
Methyl tert-butyl ether	790	1,300	2,600	10,000
Naphthalene	500	830	3,700	10,000
Phenanthrene	750	1,200	5,400	1,800
Pyrene	750	1,200	5,500	10,000
Toluene	2,700	4,500	10,000	10,000
Xylene [(b)]	6,800	10,000	10,000	10,000
C5-C8 Aliphatics	1,400	2,300	10,000	10,000
C9-C12 Aliphatics	2,700	4,400	10,000	10,000
C9-C18 Aliphatics	2,700	4,400	10,000	10,000
C19-C36 Aliphatics	10,000	10,000	10,000	10,000
C9-C10 Aromatics	750	1,200	5,500	10,000
C11-C22 Aromatics	750	1,200	5,500	10,000

Value is greater than ceiling value of 10,000 mg/kg. The ceiling value is used as the cumulative risk-based guideline for this compound.

[21] Guidelines are based either on the health risk of cumulative exposures, the ceiling concentration where the health risk based value is greater than 10,000 mg/kg. Cumulative risk-based guidelines consider combined exposure by ingestion, dermal contact, and inhalation of outdoor dust and vapors. The technical basis for these guidelines is provided in Appendix C. PAHs where typical Maine background concentrations may be greater than the guidelines are indicated by an asterisk (*). These are available in Table 6.

Table 6
Tier 2 Soil Remediation Guidelines for Select Target Polycyclic Aromatics (PAHs) Where Background Concentrations Exceed Health Risk Based Concentrations (mg/kg)[22]

PAH	Urban Soil	Rural Soil	Urban Fill
Benzo(a)anthracene	1.6	0.86	27
Benzo(a)pyrene	1.7	1.5	5.2
Benzo(b)fluoranthene	1.9	1.3	6.8
Benzo(k)fluoranthene	0.76	0.69	12
Dibenz(a,h)anthracene	0.28	0.32	4.5
Indeno(1,2,3-cd) pyrene	0.74	0.4	3.3

Note: Use MDOT urban compact zone mapping to distinguish between "urban" and all other ("rural") areas of Maine to implement these guidelines. MDOT urban compact mapping is available on the Department website (http://www.maine.gov/dep/gis/datamaps/statewide_layers/state_urban_compact_areas.kmz) Urban fill consists of man-placed materials originating from a location other than the oil discharge site that may contain PAHs, including brick, cement, wood, wood ash, coal, coal ash, boiler ash, clinkers, asphalt, glass, plastic, metal, demolition debris and roadside ditching material.

6. Indoor Air Pollution & Petroleum Vapor Intrusion Evaluation

6.1. Explosion Hazards. Explosion hazard assessment is outside the scope of this guidance. However, when encountered or suspected due to indoor petroleum vapors, advise the occupants to immediately evacuate and contact the local fire department and the Department's Division of Response Services.

6.2. Soil gas & indoor air sampling. Soil gas, indoor air sampling and other site evaluation methods recommended in this section should be conducted in accordance with the Department's vapor intrusion (VI) guidance. (http://www.maine.gov/dep/spills/petroleum/index.html)

[22] Unless stated otherwise, guidelines based on 90 percent of the Upper Prediction Limit (UPL) background PAH concentrations rounded to one significant figure from the Summary Report for Evaluation of Concentrations of Polycyclic Aromatic Hydrocarbons (PAHs) in Background Soils in Maine by AMEC for the Department of Environmental Protection, November 16, 2012. Locations within a designated Maine Dept. of Transportation Urban Compact Zone are defined as "Urban" for the purpose of using this table; all other locations are "Rural".

6.3. Evaluation and Remediation of Obvious Human Exposure to Petroleum Vapors.

6.3.1. When vapor exposure is obvious in a routinely occupied building, indoor air quality sampling and remediation should be considered with the objective of mitigating the exposure of building occupants to unhealthy concentrations of petroleum constituents as evaluated by health risk based Indoor Air Targets (IATs) developed by the Maine CDC . Remediation measures should be approved by the Department prior to implementation and undertaken as soon as practical.

6.3.2. Indicators of obvious petroleum vapor exposure include, but are not limited to, oil contamination in or immediately under the building; free product or contaminated water in a basement drainage sump or system; strong petroleum odors present within the building; or high PID readings indicative of petroleum vapors where underground utilities enter a building or along where the basement walls and floor meet.[23] Occupant complaints of chronic headaches, stinging eyes or sore throats following an oil discharge on the premises may suggest petroleum vapor exposure. Many indoor home heating oil tank and piping discharges and some exterior home heating oil tank discharges will result in an obvious human exposure.

6.3.3. A sudden, catastrophic gasoline discharge of 100 gallons or more that reaches the subsurface should be treated as a potential obvious source of vapor exposure by way of preferential pathways and ground water to occupants of nearby buildings.[24] Direct discharges of smaller volumes of gasoline into a stormdrain or sanitary sewer should also be considered an obvious source of vapor exposure. Nearby utility access ways and connections to nearby buildings should be screened for LNAPL (free product) and vapor migration.[25]

6.4. Vapor Intrusion Evaluation and Remediation Associated with Gasoline Discharges.

6.4.1. When it is not obvious that occupants of a routinely occupied building are being exposed to gasoline vapors, the potential for a complete vapor intrusion pathway to receptors should be investigated in accordance with the Department's petroleum VI guidance when any one of the following conditions (http://www.maine.gov/dep/spills/petroleum/index.html) are found to exist:

6.4.1.1. Gasoline saturated soils are found within 30 feet laterally of a foundation

6.4.1.2. LNAPL or grossly contaminated ground water is documented within 30 feet laterally of a foundation and less than15 feet vertically below the elevation of the lowest point of the building. Grossly contaminated ground water is characterized as containing 5,000 ppb or more benzene, or 30,000 ppb or more of total VPH.

[23] A PID able to detect VOCs in the parts per billion range is recommended for this purpose.

[24] Maine Dept. of Environmental Protection of Environmental Protection review of complete vapor intrusion pathways at recent gasoline spills in southern Maine, Sept. 30, 2009.

[25] Proper safety precautions should be followed in screening such confined spaces possibly containing vapors in the explosive range, including the use of intrinsically safe equipment.

6.4.1.3. Gasoline contaminated ground water above the practical quantitation limit (PQL) for VPH fractions or target compounds is found less than 6 feet vertically below the building's lowest point (e.g. basement floor, crawl space floor or foundation slab).

6.4.2. Potential exposure of oil storage facility employees to petroleum vapors are a work place safety issue and the responsibility of the facility owner and operator to assess and remediate. OSHA regulations rather these Department guidelines apply.

6.4.3. Where a vapor intrusion evaluation concludes there is a complete vapor intrusion pathway, indoor air quality monitoring and remediation should be considered and implemented as soon as practical with the Department's approval and evaluated with the health risk based Indoor Air Targets developed by the Maine CDC and found on the Department's website.

6.5. Indoor Air and VI References. Guides and studies related to indoor air quality and vapor intrusion are available at DEP's website - http://www.maine.gov/dep/spills/publications/guidance/index.html.

7. Exposure Controls and Alternative Site Specific Remediation Guidelines

7.1. Consideration of alternative site specific guidelines. Alternative site specific ground water, soil and indoor air remediation guidelines may be considered by the Department for approval when based on the ability to cost effectively protect receptors by alternate means to only remediating contaminated soil, ground water or vapors. The goal remains the same, remediation of human exposure to petroleum to health-protective guidelines. In some cases, implementation of such mitigation measures as replacement public water, installation of sub-slab vapor ventilation or institutional controls (e.g. environmental covenants) may adequately and more cost effectively mitigate human exposure with less remediation of soil and ground water than specified in previous sections of these guidelines.

7.2. Use of environmental covenants. When the Department determines further remedial action is not technically feasible or cost effective, the Department will consider for approval the use of environmental covenants as part of a comprehensive site remediation plan to prevent human exposure to contaminants. Environmental covenants proposed as part of a Department approved oil remediation plan need to meet the requirements of the Maine Uniform Environmental Covenants Act (UECA), 38 MRSA. §3001 et seq. A model template is available online at the Department's website(http://www.maine.gov/dep/spills/vrap/index.html) .

8. Documentation of Residual Contamination & Remediation Performance

8.1. Residual soil contamination. Residual soil contamination that is being left unremediated in conformance with these guidelines, or otherwise approved by the Department, should be documented. Exceptions are limited to gasoline discharges of 1 gallon or less and discharges of other types of oil that are 5 or less gallons. Adequate documentation of whether these remediation guidelines have been met and the degree of residual contamination left following remediation should consist of soil sampling conducted in accordance with Department standard operating procedures (Compendium of Field Testing of Soil Samples for Gasoline and Fuel Oil, Standard Operating Procedure TS004 (http://www.maine.gov/dep/spills/petroleum/documents/sop/ts004.pdf) , or another method of comparable accuracy approved by the Department. The soil samples collected should be representative of the range of residual soil contamination being left and the types of products discharged at the site. In the event that oil saturated soils are left unremediated with Department approval, documentation of the extent of the residual contamination is adequate without laboratory analyses.

8.2. Residual ground water contamination. Ground water quality at the time a decision is made that ground water remediation is not feasible or is to be terminated, should be documented with samples collected from four (4) consecutive quarters from each previously contaminated drinking or monitoring well, and analyzed in accordance with a Department approved ground water sampling plan. If section 4 of these guidelines apply such that ground water is likely to be used in the future for a private or public drinking water supply well and multiple petroleum contaminants remain present, the post-remediation ground water quality should be evaluated using the multiple contaminant cumulative risk calculator to determine if the increased lifetime cancer risk ($\leq$1x10-5) and hazard index ($\leq$ 1.0) are acceptable. This calculator is available online at the Department's website (http://www.maine.gov/dep/spills/publications/guidance/index.html). If future consumption of ground water is determined to pose a health risk, an environmental covenant or deed notice should be considered.

9. Analytical Methods & Sampling for Water and Soil

9.1. Massachusetts Department of Environmental Protection Petroleum Hydrocarbon Fractions Analytical Methods. To allow the development of remediation guidelines with a toxicological basis, these guidelines are based on the Massachusetts Department of Environmental Protection's (MassDEP) petroleum hydrocarbon fraction analytical methods for Volatile Petroleum Hydrocarbons (VPH) and Extractable Petroleum Hydrocarbons (EPH). These analytical methods should be used when collecting data to support remediation decisions covered by this guidance. The petroleum hydrocarbon fractions measure and evaluate the non-cancer risks posed by human

exposure to petroleum, while the target compounds identified and quantified by the methods evaluate both the cancer and non-cancer hazard.

9.2. EPH and VPH petroleum hydrocarbon fractions. EPH and VPH methods measure the collective concentrations of aliphatic and aromatic hydrocarbons needed to assess toxicological risk as illustrated in the Table 7 below.[26]

TABLE 7
EPH/VPH Defined Hydrocarbon Fractions

Analytical Method	Analytical Defined Hydrocarbon Fraction
C5-C8 aliphatics	VPH
C9-C12 aliphatics	VPH
C9-C18 aliphatics	EPH
C19-C36 aliphatics	EPH
C9-C10 aromatics	VPH
C11-C22 aromatics	EPH

9.3. Target chemicals. Target chemicals of interest and for which guidelines have been developed are identified in the guidelines and include poly aromatic hydrocarbons (PAHs), benzene, toluene, ethyl benzene, xylene, methyl tert-butyl ether (MTBE), and lead.

9.4. Sampling and Analytical Guidelines.

9.4.1. All private and public drinking water supply wells suspected of being contaminated by oil should be initially sampled and analyzed for VPH and EPH, regardless of the product discharged or the age of the discharge. Based on initial results, a VPH/EPH drinking water monitoring plan may be developed to reflect site specific chemicals of concern for Department approval.

9.4.2. Samples of soil and ambient ground water should initially be analyzed by VPH and/or EPH in accordance with Table 8. Based on initial results, a sampling plan may be developed to reflect site specific chemicals of concern for Department approval.

9.4.3. When collecting soil or water samples as part of an investigation of a discharge of an aviation gasoline or a racing vehicle gasoline, lead analyses should be conducted. Samples should also be analyzed for lead when investigating other gasoline discharges that are believed to have occurred before 1987.[27]

[26] Massachusetts Dept. Environmental Protection, Characterizing Risks Posed by Petroleum Contaminated Sites: Implementation of the MADEP VPH/EPH Approach, October 31,2002

[27] In accordance with the federal Clean Air Act the phase out of lead in most motor vehicle gasoline was completed by the end of 1986.

9.5. VPH Laboratory Method. VPH analyses should be conducted in accordance with the Massachusetts Department of Environmental Protection's Method for the Determination of Volatile Petroleum Hydrocarbons (VPH) http://www.mass.gov/eea/agencies/massdep/cleanup/regulations/iv-petroleum-hydrocarbon-methods.html

9.6. EPH Laboratory Method. EPH analyses should be conducted in accordance with the Massachusetts Department of Environmental Protection's Method for the Determination of Extractable Petroleum Hydrocarbons (EPH) . http://www.mass.gov/eea/agencies/massdep/cleanup/regulations/iv-petroleum-hydrocarbon-methods.html

9.7. Lead Laboratory Methods. Lead may be analyzed in soil and water by a variety of U.S. Environmental Protection Agency laboratory methods, including SW846. 6010C, 6020A, or 7010. In water, lead may also be analyzed by EPA methods 200.7, 200.8 or 200.9.

9.8. PAH Laboratory Methods. When PAHs with remediation guidelines below the PQL of the EPH method are chemicals of concern for a particular site, a single ion monitoring (SIMs) analysis should be specifically requested in advance from the laboratory in order to decrease the lab method's detection limit. These PAHs may be chemicals of concern at sites where there has been a heavy heating oil (#4, #5 or #6) or waste oil discharge, or where justified by the site's conceptual model and required by the Department.[28]

TABLE 8
Recommendations for EPH and VPH Testing[29]

Petroleum Product	VPH	EPH
Gasoline	X	
Fresh diesel/#2 fuel oil	X	X
Weathered diesel/#2 fuel oil		X
#3 - #6 fuel oils		X
Waste oil	X	X
Jet fuels/kerosene	X	X
Unknown oils or sources	X	X

[28] SIMs analyses are not generally recommended at sites where only gasoline has been discharged.

[29] Massachusetts Department of Environmental Protection - VPH/EPH Spring Training 1997, http://www.mass.gov/dep/cleanup/tphtrain.pdf.

9.9. Performance & quality assurance standards.

9.9.1. Only VPH and EPH analytical data from laboratories certified by the State of Maine Department of Health and Human Resources (DHHS) can be accepted by the Department.

9.9.2. Modifications to the VPH and EPH laboratory methods should be approved by the Department in writing and before the submission or use of data in remediation decision making to ensure their acceptance by the Department.

9.9.3. Field sampling quality control must follow guidance in the Leaking Underground Storage Tanks Quality Assurance Plan [LUST QAP] Standard Operating Procedure [SOP] Field Quality Control Guidance (http://www.maine.gov/dep/spills/petroleum/lustqaplan.html) or Department approved site specific work plan. Special attention should be given to following the sampling SOPs in Appendix B of the Quality Assurance Plan, including those for properly sampling drinking water supplies, soil, and field screening soil using a PID or oleophilic dye shake test.

9.9.4. Laboratory analytical quality control must follow guidance in the laboratory method or a Department approved site specific work plan.

9.10. Approval of other analytical methods. The Department may approve as part of a site specific monitoring and sampling plan reduced or alternate analytical regimes to those described above. Examples include operational monitoring of an active remediation system, need for comparison to historical analytical data, or data to support a site specific model or risk assessment. Use of other analytical methods should be approved by the Department prior to use. Such approval requires assurances of adequate field and laboratory quality assurance controls. By statute, the Department does not accept data from a laboratory which is not certified by the State of Maine.

9.11. Required other sampling and analytical methods. The Department may require other sampling regimes or use of other laboratory methods to address site specific conditions and hazards. This may include, but is not limited to the following. EPA Method 524 for drinking water may be needed when evaluating public water supply water quality. Arsenic sampling in ground and drinking water may be required along with other ground water parameters when natural arsenic liberation from bedrock due to alterations to the ground water chemistry by the presence of oil is suspected.

9.12. Indoor air quality testing. Indoor air quality sampling and analyses should be conducted in accordance with the Department's "Vapor Intrusion Evaluation Guidance"(http://www.maine.gov/dep/spills/publications/guidance/index.html#vi).

10. Disclaimer.

While this document provides the Department's expectations for the removal and remediation of discharges to the Commissioner's satisfaction as required under Maine law (see Appendix F), the Department retains the discretion to adopt approaches on a case-by-case basis that differ from this guidance where appropriate. The guidance does not create or confer any rights or obligations on any persons made responsible under Maine law for removing an oil discharge, or on any other persons. As indicated throughout the guidelines, alternate approaches may be considered by the Department, but require prior written approval to ensure they result in a clean-up to the Commissioner's satisfaction. Such alternative approaches should be discussed with the Department staff responsible for overseeing oil remediation.

11. Referenced Documents and Publications

11.1. AMEC for the Maine Department of Environmental Protection, Summary Report for Evaluation of Concentrations of Polycyclic Aromatic Hydrocarbons (PAHs) in Background Soils in Maine, November 16, 2012.

11.2. Maine Department of Environmental Protection, Chapter 691: Rules for Underground Oil Storage Facilities, April 3, 2007.

11.3. Massachusetts Department of Environmental Protection, Characterizing Risks Posed by Petroleum Contaminated Sites: Implementation of the MADEP VPH/EPH Approach Final Policy, October 31, 2002.

11.4. Massachusetts Department of Environmental Protection, Division of Environmental Analysis; Method for the Determination of Extractable Petroleum Hydrocarbons (EPH), Version 1.1; July 2004.

11.5. Massachusetts Department of Environmental Protection, Division of Environmental Analysis; Method for the Determination of Volatile Petroleum Hydrocarbons (VPH), Version 1.1; July 2004.

11.6. Massachusetts Department of Environmental Protection - VPH/EPH Spring Training 1997,
Site Cleanup Policies & Guidance

11.7. Massachusetts Department of Environmental Protection, Office of Research and Standards; Technical Update: Background Levels of Polycyclic Aromatic Hydrocarbons and Metals in Soil; May 2002.

APPENDIX A

CAS NUMBER for TARGET COMPOUNDS

CAS Number	Chemical
Petroleum Target Compounds	
91-57-6	2-Methylnaphthalene
83-32-9	Acenaphthene
208-96-8	Acenaphthylene
120-12-7	Anthracene
71-43-2	Benzene
56-55-3	Benzo(a)anthracene
50-32-8	Benzo(a)pyrene
205-99-2	Benzo(b)fluoranthene
191-24-2	Benzo(g,h,i)perylene
207-08-9	Benzo(k)fluoranthene
218-01-9	Chrysene
53-70-3	Dibenz(a,h)anthracene
100-41-4	Ethylbenzene
206-44-0	Fluoranthene
86-73-7	Fluorene
193-39-5	Indeno(1,2,3-cd)pyrene
7439-92-1	Lead
1634-04-4	Methyl tert-butyl ether
91-20-3	Naphthalene
85-01-8	Phenanthrene
129-00-0	Pyrene
108-88-3	Toluene
1330-20-7	Xylene

APPENDIX B

Soil Remediation Guideline Concentrations (mg/kg)
Based on Petroleum Leaching to Ground Water for Sand & Gravel and Sandy Till Surficial Geology[30]

Petroleum Target Compounds	Sand & Gravel[31]	Till[32]
2-Methylnaphthalene	3.9	3.6
Acenaphthene	170	230
Acenaphthylene	68	71
Anthracene	2,400	10,000
Benzene	0.51	14
Benzo(a)anthracene	10,000	10,000
Benzo(a)pyrene	10,000	10,000
Benzo(b)fluoranthene	10,000	10,000
Benzo(g,h,i)perylene	10,000	10,000
Benzo(k)fluoranthene	10,000	10,000
Chrysene	10,000	10,000
Dibenz(a,h)anthracene	10,000	10,000
Ethylbenzene	2.3	0.81
Fluoranthene	10,000	10,000
Fluorene	120	190
Indeno(1,2,3-cd)pyrene	10,000	10,000
Lead	10,000	10,000
Methyl tert-butyl ether	0.32	0.19
Naphthalene	1.9	1.7
Phenanthrene	97	160
Pyrene	NA	NA
Toluene	24	8.1
Xylene	58	26
Petroleum Hydrocarbon Fractions		
C5-C8 Aliphatics	10,000	1,600
C9-C12 Aliphatics	NA	NA
C9-C18 Aliphatics	NA	NA
C19-C36 Aliphatics	NA	NA
C9-C10 Aromatics	75	81
C11-C22 Aromatics	460	1,600

Value is greater than ceiling value of 10,000 mg/kg. The ceiling value is to be used as the remediation guideline.

[30] Where Department modeling predicted ground water exceedance of MEG unlikely in 1000 years regardless of soil concentration, guideline established at the ceiling value.

[31] Surficial materials with less than 20% passing through a #200 sieve will be considered sand and gravel.

[32] Surficial materials where 20% or more passes a #200 sieve are to be considered a till.

APPENDIX C

TECHNICAL BASIS AND BACKGROUND

FOR THE

MAINE PETROLEUM SOIL GUIDELINES[33]

Revision of May 18, 2011

[33] **User note:** Tables 1-4 presented as part of this appendix differ from the final guidelines presented in Tables 5 and 6 in the body of the petroleum guidelines in that they consider and incorporate background PAH concentrations and therefore are not entirely health risk based as are the values presented in this appendix.

Prepared by Diane Silverman of the Maine Center for Disease Control and Prevention, Department of Health and Human Services, with assistance from the Maine Department of Environmental Protection

Table of Contents

TECHNICAL BASIS AND BACKGROUND FOR THE MAINE PETROLEUM SOIL GUIDELINES

Revision of May 18, 2011

OVERVIEW

This basis statement documents the methodology used to calculate direct contact soil guidelines for the six petroleum hydrocarbon fractions defined by the Massachusetts Department of Environmental Protection (MassDEP): C5-C8 aliphatics, C9-C12 aliphatics, C9-C18 aliphatics, C19-C36 aliphatics, C9-C10 aromatics, and C11-C22 aromatics. The Maine Remedial Action Guidelines (MERAGs) are used as soil cleanup levels for petroleum-related target compounds (i.e. benzene, toluene, ethylbenzene, xylenes, carcinogenic and non-carcinogenic polycyclic aromatic hydrocarbons, methyl tert butyl ether and lead). For the petroleum fractions, MassDEP does not consider potential carcinogenicity but rather evaluates the carcinogenicity of petroleum releases through an evaluation of the target compounds. Therefore, MERAGs for potential carcinogens and non-carcinogens found in petroleum products should also be used to assess petroleum releases. Because this document does not discuss the development of the MERAGs for the petroleum-related target compounds, the reader is referred to the MERAGs Basis Statement (http://www.maine.gov/dep/spills/publications/guidance/rags/final_5-8-2013/2%20ME-RAGS_Final_5-8-2013%20Corrected%20Copy.pdf) for information regarding their calculation.

The purpose of the direct contact soil guidelines for petroleum fractions is to identify levels that prevent adverse human health effects from occurring as a result of long-term exposure to soils. A quantitative health risk assessment approach based on Maine's 2011 *Guidance Manual for Human Health Risk Assessments at Hazardous Substance Sites* (http://www.maine.gov/dep/spills/publications/guidance/index.html) was utilized. Conservative default exposure factors were selected to ensure protectiveness. Exposure to soil was evaluated for residential land use and non-residential scenarios including outdoor commercial, excavation/construction, and recreational/park use. Petroleum fraction soil guidelines based on the transfer of contaminants from soil to groundwater, and subsequent use of groundwater as drinking water, were also derived (see Appendix D).

For each petroleum fraction, the level (Exposure Point Concentration) which represents the acceptable level (Hazard Quotient of 0.2) for the individual fraction has been calculated. The target Hazard Quotient is 20% of Maine’s total non-cancer risk limit of 1 for compounds acting on the same target organ. The lower target risk level for individual fractions allows the total site risk to remain below the acceptable level even though

multiple chemicals are present at a site. As stated in the Risk Assessment Manual, the total risk from the site must be acceptable for DEP to consider the site "clean".

GENERAL METHODS

DOSE RESPONSE ASSESSMENT

Soil guideline development was based on the use of chronic and sub-chronic oral reference doses (RfDs) and inhalation reference concentrations (RfCs) developed by MassDEP in November 2003, except for the C5-C8 aliphatic fraction where RfCs were based on provisional peer-reviewed toxicity values (PPRTVs) developed by the United States Environmental Protection Agency (USEPA) in September 2009. The MassDEP fraction-specific RfDs and MassDEP and USEPA PPRTV RfCs are shown below:

Non-Carcinogenic Toxicity Values for Petroleum Fractions

Petroleum Fraction	Chronic RfD (mg/kg-day)	Sub-chronic RfD (mg/kg-day)	Chronic RfC (mg/m^3)	Subchronic RfC (mg/m^3)
C5-C8 aliphatics	0.04	0.4	0.6	2
C9-C12 aliphatics	0.1	1	0.2	0.6
C9-C18 aliphatics	0.1	1	0.2	0.6
C19-C36 aliphatics	2	6	NA	NA
C9-C10 aromatics	0.03	0.3	0.05	0.5
C11-C22 aromatics	0.03	0.3	0.05	0.5

Massachusetts Department of Environmental Protections (MassDEP), 2003. Updated Petroleum Hydrocarbon Fraction Toxicity Values for the VPH/EPH/APH Methodology. Massachusetts Department of Environmental Protection, Boston, MA. November 2003. United States Environmental Protection Agency (USEPA), 2009. Provisional Peer-Reviewed Toxicity Values for Complex Mixtures of Aliphatic and Aromatic Hydrocarbons. Superfund Health Risk Technical Support Center. Office of Research and Development. September 2009.

Data sources for chronic and sub-chronic reference doses (RfDs) and reference concentrations (RfCs) and carcinogenic slope factors (SFs) and unit risks (URs) for petroleum-related target compounds were developed using the hierarchy described in the Risk Assessment Manual. The toxicity values and their sources are provided on Table 1 in the MERAGs Basis Statement (http://www.maine.gov/dep/spills/publications/guidance/index.html). Remedial action guidelines for lead have been developed using biokinetic modeling developed by EPA. The methodology used to develop the soil lead guidelines is discussed on Section IV of the MERAGs Basis Statement.

EXPOSURE ASSESSMENT

Figure 1 of the Risk Assessment Manual lists the potential exposure pathways for the residential and non-residential scenarios. In formulating the direct contact soil guidelines, DEP considered the exposures to petroleum fractions resulting from incidental ingestion of contaminated soil, inhalation of fugitive dusts and volatile compounds released from contaminated soil into ambient air, and dermal contact with contaminated soil. The guidelines were derived using conservative default exposure factors because all potential pathways were not considered, or in the case of dermal contact, cannot be quantified for some chemicals. It is DEP's expectation that in order to employ less conservative exposure assumptions, the site must be adequately characterized and a full risk assessment conducted using the procedures in the Risk Assessment Manual.

In general, soil guidelines for the residential scenario are the lowest values with the guidelines progressing in an increasing manner for residential and recreational land use, commercial land use, and finally for construction workers.

The guidelines do not include an evaluation of volatile fractions released from soil and subsequent inhalation of impacted air in an occupied building. Should volatile fractions be present in soil either beneath or in close proximity to an existing building, the indoor air pathway is most accurately evaluated through the collection of soil gas or indoor air data. Maine has developed Vapor Intrusion Guidance that should be followed to evaluate this potential exposure pathway (http://www.maine.gov/dep/spills/publications/guidance/index.html#vi) . Impacts to future buildings should be considered as a part of redevelopment options for the site (e.g. the use of passive/active venting and/or subslab vapor barriers).

The following text describes the general methodology used to develop the soil petroleum fraction guidelines for the oral, dermal and inhalation routes of exposure. Because the soil guidelines are based on cumulative exposures across all exposure pathways, the soil guidelines are derived from the oral, dermal and inhalation EPCs according to the following equation:

$$EPC_{soil} = \frac{1}{}$$

$$\frac{1}{EPC_{oral}} + \frac{1}{EPC_{dermal}} + \frac{1}{EPC_{inhalation}}$$

Because oral and dermal exposures are expressed as a dose in units of milligrams of chemical per day adjusted for the body weight of the exposed person (mg chemical /kg BW · day), the Average Daily Dose (ADD) over the time period of exposure is estimated as follows:

$$ADD = \frac{EPC * CR * ET * EF * ED}{BW * AP * DPY}$$

Where:

ADD =	Average Daily Dose, in these guidelines always expressed as units of mg chemical/kg BW · day
EPC =	Exposure Point Concentration, in these guidelines always expressed as mg chemical/kg soil
CR =	Contact Rate, for example, 200 mg soil/day ingested for young children
ET =	Exposure Time, appropriate only when the contact rate is not a daily rate
EF =	Exposure Frequency; days per year
BW =	Body Weight, in the guidelines always expressed as kg BW
ED =	Exposure Duration; years
AP =	Averaging Period; years
DPY =	365 days per year

The units for ADD are mg chemical/kg BW · day. The ADD represents either a chronic or sub-chronic exposure period. Sub-chronic exposures are applicable for excavation/construction workers; all other scenarios are evaluated using a chronic exposure period. The Exposure Duration is set equal to the Averaging Period.

The Hazard Quotient (HQ) is the ADD divided by the reference dose:

$$HQ = \frac{ADD}{RfD}$$

If a chronic Average Daily Dose is calculated, a chronic reference dose is used to calculate the HQ. Likewise, a sub-chronic reference dose is used to calculate the HQ for sub-chronic Average Daily Doses. By substitution, the HQ can also be expressed as follows:

$$HQ = \frac{EPC * CR * ET * EF * ED}{BW * AP * DPY * RfD}$$

The maximum acceptable HQ value for each fraction is 0.2, assuring that the total site risk will be below a Hazard Index of 1. Therefore, by inserting a value of 0.2 for the HQ and rearranging the formula, the maximum acceptable EPC for the pathway (e.g. the oral pathway) can be obtained, as follows:

$$EPC_{oral} = \frac{0.2 * RfD * BW * AP * DPY}{CR * ET * EF * ED}$$

It should be noted that unit conversion factors are often necessary. This will be made explicit in the sections that follow.

Though similar equations are used for the dermal exposure pathway, the toxicity values selected for use would be adjusted for applicability to the dermal route of exposure.

The fugitive dust and volatile chemical inhalation exposure pathways are evaluated using an Average Daily Exposure (ADE) approach in which the soil concentration is modeled to estimate an airborne chemical concentration. An Average Daily Exposure is in units of airborne concentration (e.g. mg/m^3) and evaluated for hazard through the use of inhalation toxicity values (RfCs) rather than oral or dermal RfDs. It should be noted that conversion factors for hours per day are often necessary. This will be made explicit in the sections that follow.

DEFAULT EXPOSURE FACTORS AND FORMULAS

The Risk Assessment Manual contains standard default exposure assumptions applicable to Maine. A combination of average and upper percentile exposure assumptions were selected such that overall, the assumptions are representative of a reasonable maximum (95^{th} percentile) exposure. Exposure assumptions used in the development of the soil petroleum fraction guidelines are those presented in Risk Assessment Manual Table 1.

SOIL INGESTION

The most sensitive residential and park user receptor for effects based on ingestion of petroleum fractions in soil is the young child, from 1 to <6 years of age. $ADD_{chronic}$ was determined for the residential 1 to <6 age group, using conservative default exposure factors presented in Risk Assessment Manual Table 1. For generic cleanup guidelines,

DEP considers it appropriate to use the conservative simplifying assumption that all of the soil ingested is contaminated.

The formula for $ADD_{chronic}$ for young child (age 1 to <6) ingestion of soil is:

$$ADD_{chronic} = \frac{EPC_{oral} * IR * FC * UC * EF * ED}{BW * AP * DPY}$$

Where:

EPC_{oral}	=	Exposure Point Concentration; mg chemical/kg soil
IR	=	Soil Ingestion Rate; mg soil/day
FC	=	Fraction Contaminated; 1.0, dimensionless
BW	=	Body Weight; kg
UC	=	Unit Conversion; 10^{-6} kg soil/mg soil
EF	=	Exposure Frequency; days per year
ED	=	Exposure Duration; years
AP	=	Averaging Period; years
DPY	=	365 days per year

To estimate the chronic Hazard Quotient:

$$HQ = \frac{ADD_{chronic}}{RfD_{chronic}}$$

To solve for the acceptable soil level, HQ = 0.2 was substituted along with the default exposure assumptions, and the equation rearranged to solve for the residential EPC as follows:

$$EPC_{oral} \text{ (mg chemical/kg soil)} = 3.4\ E{+}04\ \frac{\text{kg BW} \cdot \text{ day}}{\text{kg soil}} * RfD_{chronic}\ \frac{\text{mg chemical}}{\text{kg BW} \cdot \text{ day}}$$

For non-residential exposure scenarios, DEP evaluated exposures for three populations: park users, outdoor commercial workers, and construction/excavation workers. A chronic ADD was calculated for each scenario, except for the excavation/construction worker for which a sub-chronic ADD was calculated. Again, to ensure protectiveness, conservative default exposure factors were selected as presented in Table 1 of the Risk Assessment Manual.

The following presents the equations used to calculate the soil level protective of each of the land use scenarios for incidental ingestion of petroleum fractions in soil (based on a HQ = 0.2).

Park Use (young child age 1 to <6):

EPC_{oral} (mg chemical/kg soil) = 5.68 E+04 $\frac{\text{kg BW} \cdot \text{day}}{\text{kg soil}}$ * $RfD_{chronic}$ $\frac{\text{mg chemical}}{\text{kg BW} \cdot \text{day}}$

Outdoor Commercial:

EPC_{oral} (mg chemical/kg soil) = 3.4 E+05 $\frac{\text{kg BW} \cdot \text{day}}{\text{kg soil}}$ * $RfD_{chronic}$ $\frac{\text{mg chemical}}{\text{kg BW} \cdot \text{day}}$

Excavation/Construction:

EPC_{oral} (mg chemical/kg soil) = 1.24 E+05 $\frac{\text{kg BW} \cdot \text{day}}{\text{kg soil}}$ * $RfD_{subchronic}$ $\frac{\text{mg chemical}}{\text{kg BW} \cdot \text{day}}$

Tables 1 through 4 list guidelines based on incidental ingestion of soil contaminated by petroleum fractions and target compounds for the residential, park user, outdoor commercial worker, and excavation/construction worker scenarios, respectively, based on a HQ of 0.2 and an ILCR of 1E-06. The MERAGs Basis Statement should be referred to for details concerning the calculation of the ingestion guidelines for the petroleum-related target compounds.

INHALATION OF FUGITIVE DUSTS AND VOLATILE CHEMICALS

The Risk Assessment Manual recommends the evaluation of fugitive dusts and volatile chemicals in outdoor air using a Particulate Emission Factor (PEF) and a Volatilization Factor (VF). These factors represent an estimate of the relationship between soil contaminant concentrations and concentrations of these contaminants in air as a consequence of particle suspension and volatile chemical release from impacted soil. The PEF and VF are used to model an estimated concentration of chemical in air as follows:

$$EPC_{air}\ \frac{\text{mg chemical}}{\text{m}^3\ \text{air}} = EPC_{soil}\ \frac{\text{mg chemical}}{\text{kg soil}} * FC * [1/PEF\ (\text{m}^3/\text{kg}) + 1/VF\ (\text{m}^3/\text{kg})]$$

where:

EPC_{air}	=	Exposure Point Concentration of Chemical in Air, mg chemical/m^3 air
EPC_{soil}	=	Exposure Point Concentration of chemical in soil, mg chemical/kg soil
FC	=	fraction contaminated, assumed to be 1.0, dimensionless
PEF	=	1.36 x 10^9 m^3/kg

The PEF used is a default value recommended by the Risk Assessment Manual applicable to a 0.5-acre source size and using conservative default assumptions for the

fraction of vegetative cover, mean annual wind speed, and percent soil moisture. The VFs used are chemical-specific values modeled by DEP. The documentation of the calculation of the fraction-specific VFs are provided in Appendix E. The VFs for the volatile petroleum fractions, calculated using the methodology and assumptions provided in Appendix E are presented in the following table.

Volatilization Factors (m^3/kg) for Petroleum Fractions

Petroleum Fraction	Construction Worker	Outdoor Commercial Worker	Resident / Park User
C5-C8 aliphatics	6.05E+05	8.66E+07	9.91E+07
C9-C12 aliphatics	2.95E+05	1.57E+07	1.88E+07
C9-C18 aliphatics	2.32E+05	1.10E+07	1.33E+07
C19-C36 aliphatics	NV	NV	NV
C9-C10 aromatics	2.73E+05	1.38E+07	1.66E+07
C11-C22 aromatics	5.81E+05	1.96E+07	2.36E+07

NV – Not volatile

Because the VFs are dependent on averaging time (i.e. the length of time off-gassing is assumed to occurs), scenario-specific VFs are presented since each scenario is associated with a defined averaging period (30 years for the resident and park user, 25 years for the outdoor commercial worker, and 6 months for the construction worker). For non-volatile chemicals, the VF term is removed from the equation. Because the Risk Assessment Manual bases the EPC for fugitive dusts and volatiles on the concentration of chemical in air, inhalation toxicity values (i.e. RfCs) are used to estimate hazards associated with the inhalation of fugitive dusts.

As previously described, the fugitive dust and volatile pathway is evaluated using an Average Daily Exposure (ADE) in units of mg chemical per m^3 air. The modeled EPC_{air} is used to calculate the $ADE_{chronic}$ for this exposure pathway using the following formula, assuming FC = 1, as follows:

$$ADE_{chronic} = \frac{EPC_{inhalation}(\text{mg chemical/m}^3\text{ soil}) * [1/PEF + 1/VF] * ET * EF * ED}{AP * DPY * HPD}$$

Where:

$EPC_{inhalation}$	=	Exposure Point Concentration, mg chemical/m^3 soil
PEF	=	Particulate Emission Factor; 1.36 x 10^9 m^3/kg
VF	=	Volatilization factor; m^3/kg (chemical-specific)
ET	=	Exposure Time; hours per day
EF	=	Exposure Frequency; days per year
ED	=	Exposure Duration; years
AP	=	Averaging Period; years

DPY = 365 days per year
HPD = 24 hours per day

$ADE_{chronic}$ was determined for the residential and park user 1 to <6 age group, using conservative default exposure factors presented in Risk Assessment Manual Table 1. For the two worker exposure scenarios, the ADE was calculated for the adult. Again, to ensure protectiveness, conservative default exposure factors were selected as presented in Risk Assessment Manual Table 1.

For each scenario:

$$HQ = \frac{ADE_{chronic}}{RfC_{chronic}}$$

For the excavation/construction worker, a sub-chronic ADE is calculated and a sub-chronic RfC is used to derive the HQ. To solve for an acceptable soil level for the residential child, HQ = 0.2 was substituted into the above formulas and the equations rearranged as follows:

$EPC_{inhalation}$ (mg chemical /kg soil) = 5.84 / [1/$RfC_{chronic}$ (mg chemical/m^3 air)*(1/PEF + 1/VF) (m^3/kg)]

The following presents the equations used to calculate the soil level protective of each of the land use scenarios for inhalation of fugitive dusts and volatiles in outdoor air for petroleum fractions in soil (based on a HQ = 0.2).

Park Use (young child age 1 to <6):

$EPC_{inhalation}$ (mg chemical/kg soil) = 9.74 / [1/$RfC_{chronic}$ (mg chemical/m^3 air)*(1/PEF + 1/VF) (m^3/kg)]

Outdoor Commercial:

$EPC_{inhalation}$ (mg chemical/kg soil) = 5.84 / [1/$RfC_{chronic}$ (mg chemical/m^3 air)*(1/PEF + 1/VF) (m^3/kg)]

Excavation/Construction:

$EPC_{inhalation}$ (mg chemical/kg soil) = 0.88 / [1/$RfC_{chronic}$ (mg chemical/m^3 air)*(1/PEF + 1/VF) (m^3/kg)]

Tables 1 through 4 list guidelines based on the inhalation of fugitive dust and volatiles in outdoor air by petroleum fractions and target compounds for the residential, park user, outdoor commercial worker, and excavation/construction worker scenarios, respectively, based on a HQ of 0.2 and an ILCR of 1E-06. The MERAGs Basis Statement should be referred to for details concerning the calculation of the inhalation guidelines for the petroleum-related target compounds.

DERMAL CONTACT PATHWAY

Quantitative estimates of risk due to dermal contact with soil are based on the fraction of the chemical absorbed through the skin. Currently, dermal absorption factors (DAFs) are only available for a substances presented in Exhibit 3-4 of EPA's Dermal Guidance document (http://www.epa.gov/oswer/riskassessment/ragse/index.htm). The EPA default value for semi-volatile organic compounds (0.1) has been applied to the aliphatic petroleum fractions except for the C5-C8 aliphatic fraction which, as a volatile fraction, was not evaluated for dermal exposures. For the aromatic fractions, the dermal absorption factor for polycyclic aromatic hydrocarbons (0.13) was used. Risk Assessment Manual Table 1 presents the receptor-specific exposure assumptions for the resident, park user, outdoor commercial worker, and excavation/construction workers. Because hazard is evaluated from the internal amount of chemical, toxicity factors generated from potential doses may be adjusted based on gastrointestinal absorption efficiencies and recommendations for adjustment of toxicity values provided by EPA. However, because the gastrointestinal absorption efficiency of each of the petroleum fractions is expected to greater than 50%, no adjustment of the oral RfD values has been made, consistent with EPA guidance for the dermal exposure route.

As with oral exposures, the young child (ages 1 to <6) is the most sensitive receptor for effects for the resident and park user scenarios. For non-carcinogenic effects based on the dermal exposure pathway, $ADD_{chronic}$ is calculated as follows:

$$ADD_{chronic}\ (\text{mg chemical/ kg BW} \cdot \text{day}) = \frac{EPC_{dermal} * FC * AF * SA * EF * ED * UC * DAF}{BW * AP * DPY}$$

Where:

EPC_{dermal}	=	Exposure Point Concentration; mg chemical/kg soil
AF	=	Skin:Soil Adherence Factor; mg soil/cm^2 skin · day
FC	=	Fraction Contaminated; assumed to equal 1, dimensionless
DAF	=	Dermal Absorption Fraction; chemical-specific, dimensionless
SA	=	Exposed Skin Surface Area; cm^2
EF	=	Exposure Frequency; days per year
ED	=	Exposure Duration; years
AP	=	Averaging Period; years
BW	=	Body Weight; kg
DPY	=	365 days per year
UC	=	Unit Conversion; 10^{-6} kg/mg

By substituting the exposure assumptions for the young child resident and assuming a HQ = 0.2:

$$EPC_{dermal}\ (\text{mg chemical/kg soil}) = 1.22E{+}4\ \frac{\text{kg BW} \cdot \text{day}}{} * RfD_{chronic}\ \frac{\text{mg chemical}}{} * 1/DAF$$

kg soil kg BW · day

For the additional receptors, the equations are:

Park Use (young child age 1 to <6):

$$EPC_{dermal}\ (\text{mg chemical/kg soil}) = 2E{+}4\ \frac{\text{kg BW}\cdot\text{ day}}{\text{kg soil}} * RfD_{chronic}\ \frac{\text{mg chemical}}{\text{kg BW}\cdot\text{day}} * 1/DAF$$

Outdoor Commercial:

$$EPC_{dermal}\ (\text{mg chemical/kg soil}) = 5.2E{+}4\ \frac{\text{kg BW}\cdot\text{ day}}{\text{kg soil}} * RfD_{chronic}\ \frac{\text{mg chemical}}{\text{kg BW}\cdot\text{day}} * 1/DAF$$

Excavation/Construction:

$$EPC_{dermal}\ (\text{mg chemical/kg soil}) = 4.2E{+}4\ \frac{\text{kg BW}\cdot\text{ day}}{\text{kg soil}} * RfD_{subchronic}\ \frac{\text{mg chemical}}{\text{kg BW}\cdot\text{day}} * 1/DAF$$

Tables 1 through 4 list guidelines based on dermal contact with soil contaminated by petroleum fractions and target compounds for the residential, park user, outdoor commercial worker, and excavation/construction worker scenarios, respectively, based on a HQ of 0.2 and an ILCR of 1E-06. The MERAGs Basis Statement should be referred to for details concerning the calculation of the dermal guidelines for the petroleum-related target compounds.

DERIVATION OF SOIL BACKGROUND CONCENTRATIONS

In site-specific circumstances, statistically valid sampling may demonstrate that a local background concentration of a contaminant is higher than a soil guideline that is based strictly on the above risk-based calculations. By DEP policy, if site contaminants are due to background contamination, then site contamination levels must exceed background levels before DEP requires remedial action. To assist with determining site-specific clean-up goals at Maine sites, DEP added background concentrations for select metals to the MERAG appendices. The information presented in the MERAG appendices should be consulted to determine whether site-specific lead levels are consistent with background.

Table 1 - Summary of Toxicity Values and Volatilization Factors Used for Remedial Action Guidelines - 5/17/2011

CAS Number	Chemical	Chronic RfD (mg/kg-day)	Basis	Subchronic RfD (mg/kg-day)	Basis	Chronic RfC (mg/m^3)	Basis	Subchronic RfC (mg/m^3)	Basis	Oral Slope Factor $(mg/kg\text{-}day)^{-1}$	Basis	Inhalation Unit Risk $(ug/m^3)^{-1}$	Basis	Volatilization Factors (m^3/kg)		
														Construction Worker	Outdoor Commercial Worker	Resident / Park User
630-20-6	1,1,1,2-Tetrachloroethane	0.03	IRIS	0.03	HEAST	ND		ND		0.026	IRIS	0.0000074	IRIS	10000000000	104000000	125000000
79-34-5	1,1,2,2-Tetrachloroethane	0.02	IRIS	0.05	IRIS	ND		ND		0.2	IRIS	ND		10000000000	374000000	466000000
71-55-6	1,1,1-Trichloroethane	2	IRIS	7	IRIS	5	IRIS	5	IRIS	ND		ND		323000	6950000	8270000
79-00-5	1,1,2-Trichloroethane	0.004	IRIS	0.04	ATSDR	ND		ND		0.057	IRIS	0.000016	IRIS****	49600	1260000	1510000
92-52-4	1,1-Biphenyl	0.05	IRIS	0.05	HEAST	ND		ND		ND		ND		10000000000	10000000000	1E+10
75-34-3	1,1-Dichloroethane	0.2	PPRTV	2	PPRTV	0.5	HEAST****	5	HEAST	0.0057	CA-OEHHA	0.0000016	CA-OEHHA****	677000	13800000	16800000
75-35-4	1,1-Dichloroethene	0.05	IRIS	0.05	IRIS	0.2	IRIS	0.2	IRIS	ND		ND		1580000	19000000	22500000
87-61-6	1,2,3-Trichlorobenzene	0.01	IRIS*	0.01	HEAST*	0.002	PPRTV*	0.002	PPRTV*	ND		ND		55700	1790000	2150000
120-82-1	1,2,4-Trichlorobenzene	0.01	IRIS	0.01	HEAST	0.002	PPRTV	0.002	PPRTV	0.029	PPRTV	ND		57200	1850000	2210000
96-12-8	1,2-Dibromo-3-chloropropane	0.0002	PPRTV	0.002	ATSDR	0.0002	IRIS	0.002	ATSDR	0.8	PPRTV	0.006	PPRTV	89200	2850000	3420000
95-50-1	1,2-Dichlorobenzene	0.03	ATSDR**	0.6	ATSDR	0.2	HEAST****	2	HEAST	ND		ND		82100	2640000	3170000
107-06-2	1,2-Dichloroethane	0.02	PPRTV	0.2	ATSDR	2.4	ATSDR	2.4	ATSDR	0.091	IRIS	0.000026	IRIS****	70300	2270000	2730000
156-59-2	1,2-Dichloroethene (cis)	0.002	IRIS	0.02	IRIS	0.06	PPRTV*	0.8	ATSDR*	ND		ND		437000	10000000	12000000
156-60-5	1,2-Dichloroethene (trans)	0.02	IRIS	0.2	ATSDR	0.06	PPRTV	0.8	ATSDR	ND		ND		427000	10000000	12100000
78-87-5	1,2-Dichloropropane	0.09	ATSDR	0.07	ATSDR	0.004	IRIS	0.03	ATSDR	0.036	CA-OEHHA	0.00001	CA-OEHHA	52100	877000	1050000
528-29-0	1,2-Dinitrobenzene	0.0001	PPRTV	0.001	PPRTV	ND		ND		ND		ND		NV	NV	NV
106-99-0	1,3-Butadiene	ND		ND		0.002	IRIS	0.002	IRIS	3.4	CA-OEHHA	0.00003	IRIS	10000000000	10000000000	1E+10
541-73-1	1,3-Dichlorobenzene	0.0002	ATSDR**	0.02	ATSDR	ND		ND		ND		ND		95100	3020000	3630000
142-28-9	1,3-Dichloropropane	0.02	PPRTV	0.2	PPRTV	ND		ND		ND		ND		28500	488000	586000
542-75-6	1,3-Dichloropropene	0.03	IRIS	0.04	ATSDR	0.02	IRIS	0.04	ATSDR	0.1	IRIS	0.000004	IRIS	10000000000	10000000000	1E+10
99-65-0	1,3-Dinitrobenzene	0.0001	IRIS	0.0005	ATSDR	ND		ND		ND		ND		NV	NV	NV
106-46-7	1,4-Dichlorobenzene	0.07	ATSDR	0.07	ATSDR	0.06	ATSDR	1.2	ATSDR	0.0054	CA-OEHHA	0.000011	CA-OEHHA****	83200	2670000	3210000
100-25-4	1,4-Dinitrobenzene	0.0001	PPRTV	0.001	PPRTV	ND		ND		ND		ND		NV	NV	NV
123-91-1	1,4-Dioxane	0.03	IRIS	0.03	IRIS	3	CA-OEHHA	3	CA-OEHHA	0.1	IRIS	ND		NV	NV	NV
93-76-5	2,4,5-T	0.01	IRIS	0.1	HEAST	ND		ND		ND		ND		NV	NV	NV
93-72-1	2,4,5-TP	0.008	IRIS	0.008	HEAST	ND		ND		ND		ND		NV	NV	NV
95-95-4	2,4,5-Trichlorophenol	0.1	IRIS	1	HEAST	ND		ND		ND		ND		NV	NV	NV
88-06-2	2,4,6-Trichlorophenol	0.001	PPRTV	0.001	PPRTV	ND		ND		0.011	IRIS	0.0000031	IRIS	NV	NV	NV
118-96-7	2,4,6-Trinitrotoluene	0.0005	IRIS	0.0005	ATSDR	ND		ND		0.03	IRIS	ND		NV	NV	NV
120-83-2	2,4-Dichlorophenol	0.003	IRIS	0.003	ATSDR	ND		ND		ND		ND		NV	NV	NV
105-67-9	2,4-Dimethylphenol	0.02	IRIS	0.05	PPRTV	ND		ND		ND		ND		NV	NV	NV
51-28-5	2,4-Dinitrophenol	0.002	IRIS	0.02	PPRTV	ND		ND		ND		ND		NV	NV	NV
121-14-2	2,4-Dinitrotoluene	0.002	IRIS	0.002	HEAST	ND		ND		0.31	CA-OEHHA	0.000089	CA-OEHHA	NV	NV	NV

576-26-1	2,6-Dimethylphenol	0.0006	IRIS	0.006	HEAST	ND		ND		ND		ND		NV	NV	NV
606-20-2	2,6-Dinitrotoluene	0.001	PPRTV	0.004	ATSDR	ND		ND		0.68	IRIS	0.000089	CA-OEHHA	NV	NV	NV
95-57-8	2-Chlorophenol	0.005	IRIS	0.008	PPRTV	ND		ND		ND		ND		196000	5520000	6620000
95-48-7	2-Cresol	0.05	IRIS	0.1	ATSDR	0.6	CA-OEHHA	1.8	CA-OEHHA***	ND		ND		NV	NV	NV
91-57-6	2-Methylnaphthalene	0.004	IRIS	0.004	IRIS	0.003	IRIS*	0.003	IRIS*	ND		ND		143000	4680000	5610000
91-94-1	3,3-Dichlorobenzidine	ND		ND		ND		ND		0.45	IRIS	0.00034	CA-OEHHA	NV	NV	NV
108-39-4	3-Cresol	0.05	IRIS	0.1	ATSDR	0.6	CA-OEHHA	1.8	CA-OEHHA***	ND		ND		NV	NV	NV
106-47-8	4-Chloroaniline	0.0005	PPRTV	0.0005	PPRTV	ND		ND		0.2	PPRTV	ND		NV	NV	NV
106-44-5	4-Cresol	0.005	HEAST	0.1	ATSDR	0.6	CA-OEHHA	1.8	CA-OEHHA***	ND		ND		NV	NV	NV
83-32-9	Acenaphthene	0.06	IRIS	0.6	ATSDR	0.003	IRIS*	0.003	IRIS*	ND		ND		806000	29100000	35000000
208-96-8	Acenaphthylene	0.06	IRIS*	0.6	ATSDR*	0.003	IRIS*	0.003	IRIS*	ND		ND		9720000	321000000	387000000
67-64-1	Acetone	0.9	IRIS	2	ATSDR	31	ATSDR	31	ATSDR	ND		ND		10000000000	10000000000	1E+10
107-02-8	Acrolein	0.0005	IRIS	0.004	ATSDR	0.00035	CA-OEHHA	0.0035	CA-OEHHA***	ND		ND		10000000000	10000000000	1E+10
107-13-1	Acrylonitrile	0.001	HEAST	0.01	ATSDR	0.002	IRIS	0.002	IRIS	0.54	IRIS	0.000068	IRIS	10000000000	10000000000	1E+10
15972-60-8	Alachlor	0.01	IRIS	0.01	HEAST	ND		ND		0.056	CA-OEHHA	ND		NV	NV	NV
309-00-2	Aldrin	0.00003	IRIS	0.00004	PPRTV	ND		ND		17	IRIS	0.0049	IRIS	NV	NV	NV
107-05-1	Allyl chloride	ND		ND		0.001	IRIS	0.01	HEAST	0.021	CA-OEHHA	0.000006	CA-OEHHA****	238000	4950000	5890000
7429-90-5	Aluminum	1	ATSDR	1	ATSDR	0.005	PPRTV	0.005	PPRTV	ND		ND		NV	NV	NV
120-12-7	Anthracene	0.3	IRIS	10	ATSDR	0.003	IRIS*	0.003	IRIS*	ND		ND		291000	4680000	5610000
7440-36-0	Antimony	0.0004	IRIS	0.0004	PPRTV	ND		ND		ND		ND		NV	NV	NV
12674-11-2	Aroclor 1016	0.00007	IRIS	0.00021	IRIS***	ND		ND		2	IRIS	0.00057	IRIS	NV	NV	NV
7440-38-2	Arsenic	0.0003	IRIS	0.0003	HEAST	0.000015	CA-OEHHA	0.000015	CA-OEHHA	9.45	CA-OEHHA	0.0033	CA-OEHHA	NV	NV	NV
1912-24-9	Atrazine	0.001	ATSDR**	0.003	ATSDR	ND		ND		0.23	CA-OEHHA	ND		NV	NV	NV
7440-39-3	Barium	0.2	IRIS	0.2	ATSDR	ND		ND		ND		ND		NV	NV	NV
71-43-2	Benzene	0.0005	ATSDR	0.0005	ATSDR	0.01	ATSDR	0.02	ATSDR	0.055	IRIS	0.0000078	IRIS	10000000000	10000000000	1E+10
56-55-3	Benzo(a)anthracene	ND		ND		ND		ND		0.73	IRIS	0.00011	CA-OEHHA	NV	NV	NV
50-32-8	Benzo(a)pyrene	ND		ND		ND		ND		7.3	IRIS	0.0011	CA-OEHHA	NV	NV	NV
205-99-2	Benzo(b)fluoranthene	ND		ND		ND		ND		0.73	IRIS	0.00011	CA-OEHHA	NV	NV	NV
191-24-2	Benzo(g,h,i)perylene	0.03	IRIS*	0.3	HEAST*	ND		ND		ND		ND		NV	NV	NV
207-08-9	Benzo(k)fluoranthene	ND		ND		ND		ND		0.073	IRIS	0.00011	CA-OEHHA	NV	NV	NV
100-44-7	Benzyl chloride	0.002	PPRTV	0.002	PPRTV	0.001	PPRTV	0.001	PPRTV	0.17	IRIS	0.000049	CA-OEHHA****	10000000000	10000000000	1E+10
7440-41-7	Beryllium	0.002	IRIS	0.002	IRIS	0.00002	IRIS	0.00002	IRIS	ND		0.0024	IRIS	NV	NV	NV
117-81-7	bis(2-Ethylhexyl)phthalate	0.06	ATSDR	0.1	ATSDR	ND		ND		0.014	IRIS	0.0000024	CA-OEHHA	NV	NV	NV
75-27-4	Bromodichloromethane	0.02	IRIS	0.02	HEAST	ND		ND		0.062	IRIS	0.000037	CA-OEHHA	121000	3760000	4510000
75-25-2	Bromoform	0.02	IRIS	0.2	ATSDR	ND		ND		0.0079	IRIS	0.0000011	IRIS****	NV	NV	NV
74-83-9	Bromomethane	0.0014	IRIS	0.003	ATSDR	0.005	IRIS	0.2	ATSDR	ND		ND		10200000	128000000	154000000
85-68-7	Butyl benzyl phthalate	0.2	IRIS	2	HEAST	ND		ND		0.0019	PPRTV	ND		NV	NV	NV
7440-43-9	Cadmium	0.00007	ATSDR**	0.00007	ATSDR	0.00002	CA-OEHHA	0.00005	CA-OEHHA***	ND		0.0018	IRIS	NV	NV	NV
75-15-0	Carbon disulfide	0.1	IRIS	0.1	HEAST	0.7	IRIS	2.1	IRIS***	ND		ND		379000	6940000	8290000
56-23-5	Carbon tetrachloride	0.004	IRIS	0.01	IRIS	0.1	IRIS	0.1	IRIS	0.07	IRIS	0.000006	IRIS	58200	1470000	1760000
57-74-9	Chlordane	0.0005	IRIS	0.0006	ATSDR	0.0007	IRIS	0.007	IRIS***	0.35	IRIS	0.0001	IRIS	NV	NV	NV

108-90-7	Chlorobenzene	0.02	IRIS	0.4	ATSDR	1	CA-OEHHA	1	CA-OEHHA	ND		ND		214000	6550000	7860000
67-66-3	Chloroform	0.01	IRIS	0.1	ATSDR	0.002	ATSDR**	0.25	ATSDR	0.031	CA-OEHHA	0.000023	IRIS****	409000	9760000	11700000
16065-83-1	Chromium (+3)	1.5	IRIS	1.5	IRIS	ND		ND		ND		ND		NV	NV	NV
18540-29-9	Chromium (+6)	0.003	IRIS	0.009	IRIS***	0.0001	IRIS	0.001	ATSDR	ND		0.012	IRIS	NV	NV	NV
218-01-9	Chrysene	ND		ND		ND		ND		0.0073	IRIS	0.000011	CA-OEHHA	NV	NV	NV
7440-48-4	Cobalt	0.0003	PPRTV	0.003	PPRTV	0.000006	PPRTV	0.00002	PPRTV	ND		0.009	PPRTV	NV	NV	NV
7440-50-8	Copper	0.014	ATSDR	0.014	ATSDR	0.001	RIVM	0.001	RIVM	ND		ND		NV	NV	NV
57-12-5	Cyanide	0.0006	IRIS	0.006	IRIS	0.0008	IRIS	0.002	IRIS	ND		ND		NV	NV	NV
72-54-8	DDD	ND		ND		ND		ND		0.24	IRIS	0.000069	CA-OEHHA	NV	NV	NV
72-55-9	DDE	ND		ND		ND		ND		0.34	IRIS	0.000097	CA-OEHHA	NV	NV	NV
50-29-3	DDT	0.0005	IRIS	0.0005	ATSDR	ND		ND		0.34	IRIS	0.000097	IRIS	NV	NV	NV
53-70-3	Dibenz(a,h)anthracene	ND		ND		ND		ND		7.3	IRIS	0.0012	CA-OEHHA	NV	NV	NV
124-48-1	Dibromochloromethane	0.02	IRIS	0.2	HEAST	ND		ND		0.084	IRIS	0.000027	CA-OEHHA	108000	3390000	4070000
84-74-2	Dibutyl phthalate	0.1	IRIS	0.1	IRIS	ND		ND		ND		ND		NV	NV	NV
75-71-8	Dichlorodifluoromethane	0.2	IRIS	0.2	IRIS	0.2	HEAST****	2	HEAST	ND		ND		3790000	22500000	27500000
84-66-2	Diethyl phthalate	0.8	IRIS	6	ATSDR	ND		ND		ND		ND		NV	NV	NV
60-57-1	Dieldrin	0.00005	IRIS	0.0001	ATSDR	ND		ND		16	IRIS	0.0046	IRIS	NV	NV	NV
88-85-7	Dinoseb	0.001	IRIS	0.001	HEAST	ND		ND		ND		ND		NV	NV	NV
1746-01-6	Dioxin-Like Compounds - TEQ	0.000000001	ATSDR	0.00000002	ATSDR	0.00000004	CA-OEHHA	0.00000004	CA-OEHHA	130000	CA-OEHHA	38	CA-OEHHA	NV	NV	NV
115-29-7	Endosulfan	0.006	IRIS	0.006	HEAST	ND		ND		ND		ND		NV	NV	NV
72-20-8	Endrin	0.0003	IRIS	0.002	ATSDR	ND		ND		ND		ND		NV	NV	NV
100-41-4	Ethylbenzene	0.1	IRIS	0.4	ATSDR	0.1	ATSDR**	8.7	ATSDR	0.011	CA-OEHHA	0.0000025	CA-OEHHA	1230000	39200000	47100000
106-93-4	Ethylene dibromide	0.009	IRIS	0.009	IRIS	0.009	IRIS	0.009	IRIS	2	IRIS	0.0006	IRIS	55000	1700000	2040000
75-00-3	Ethyl chloride	0.01	PPRTV**	0.1	PPRTV	10	IRIS	10	HEAST	ND		ND		10000000000	10000000000	2840000000
206-44-0	Fluoranthene	0.04	IRIS	0.4	ATSDR	ND		ND		ND		ND		NV	NV	NV
86-73-7	Fluorene	0.04	IRIS	0.4	ATSDR	0.003	IRIS*	0.003	IRIS*	ND		ND		10000000000	497000000	600000000
76-44-8	Heptachlor	0.00001	ATSDR**	0.0001	ATSDR	ND		ND		4.5	IRIS	0.0013	IRIS	NV	NV	NV
1024-57-3	Heptachlor epoxide	0.000013	IRIS	0.000013	HEAST	ND		ND		9.1	IRIS	0.0026	IRIS	NV	NV	NV
118-74-1	Hexachlorobenzene	0.0008	IRIS	0.0001	ATSDR	ND		ND		1.6	IRIS	0.00046	IRIS	NV	NV	NV
87-68-3	Hexachlorobutadiene	0.001	PPRTV	0.001	PPRTV	ND		ND		0.078	IRIS	0.000022	IRIS****	NV	NV	NV
319-84-6	Hexachlorocyclohexane, alpha (alpha-BHC)	0.008	ATSDR	0.008	ATSDR	ND		ND		6.3	IRIS	0.0018	IRIS	NV	NV	NV
319-85-7	Hexachlorocyclohexane, beta (beta-BHC)	0.00006	ATSDR**	0.0006	ATSDR	ND		ND		1.8	IRIS	0.00053	IRIS	NV	NV	NV
58-89-9	Hexachlorocyclohexane, gamma (Lindane)	0.000004	ATSDR**	0.00001	ATSDR	ND		ND		1.1	CA-OEHHA	0.00031	CA-OEHHA	NV	NV	NV
67-72-1	Hexachloroethane	0.001	IRIS	0.01	ATSDR	ND		ND		0.014	IRIS	0.000004	IRIS****	NV	NV	NV
121-82-4	Hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX)	0.003	IRIS	0.03	ATSDR	ND		ND		0.11	IRIS	ND		NV	NV	NV
193-39-5	Indeno(1,2,3-cd)pyrene	ND		ND		ND		ND		0.73	IRIS	0.00011	CA-OEHHA	NV	NV	NV
7439-89-6	Iron	0.7	PPRTV	0.7	PPRTV	ND		ND		ND		ND		NV	NV	NV
7439-92-1	Lead	ND		ND		ND		ND		0.0085	CA-OEHHA	0.000012	CA-OEHHA	NV	NV	NV

121-75-5	Malathion	0.02	ATSDR	0.02	ATSDR	0.002	ATSDR**	0.02	ATSDR	ND		ND		NV	NV	NV
7439-96-5	Manganese	0.024	IRIS	0.024	HEAST	0.00005	IRIS	0.00015	IRIS***	ND		ND		NV	NV	NV
7487-94-7	Mercuric chloride & other inorganic mercury compounds	0.0003	IRIS	0.003	HEAST	ND		ND		ND		ND		NV	NV	NV
72-43-5	Methoxychlor	0.005	IRIS	0.005	HEAST	ND		ND		ND		ND		NV	NV	NV
78-93-3	Methyl ethyl ketone	0.6	IRIS	0.6	IRIS	5	IRIS	5	IRIS	ND		ND		10000000000	10000000000	1E+10
108-10-1	Methyl isobutyl ketone	0.08	HEAST	0.8	HEAST	3	IRIS	3	IRIS	ND		ND		10000000000	10000000000	1E+10
80-62-6	Methyl methacrylate	1.4	IRIS	1.4	IRIS	0.7	IRIS	0.7	IRIS	ND		ND		10000000000	10000000000	1E+10
1634-04-4	Methyl tert-butyl ether	0.03	ATSDR**	0.3	ATSDR	3	IRIS	3	ATSDR	0.0018	CA-OEHHA	0.00000026	CA-OEHHA	10000000000	10000000000	1E+10
75-09-2	Methylene chloride	0.06	ATSDR	0.06	HEAST	1.1	ATSDR	1.1	ATSDR	0.0075	IRIS	0.00000047	IRIS	10000000000	10000000000	1E+10
7439-98-7	Molybdenum	0.005	IRIS	0.005	HEAST	0.012	RIVM	0.012	RIVM	ND		ND		NV	NV	NV
106-94-5	n-Propyl bromide	0.0014	IRIS*	0.003	ATSDR*	0.005	IRIS*	0.2	ATSDR*	ND		ND		1030000	15900000	19200000
91-20-3	Naphthalene	0.02	IRIS	0.6	ATSDR	0.003	IRIS	0.003	IRIS	ND		0.000034	CA-OEHHA	47400000	260000000	298000000
7440-2-0	Nickel	0.003	ITER**	0.003	ITER	0.00009	ATSDR	0.0002	ATSDR	ND		0.00026	CA-OEHHA	NV	NV	NV
2691-41-0	Octahydro-1,3,5,7-tetranitro-1,3,5,7-tetra (HMX)	0.05	IRIS	0.05	ATSDR	ND		ND		ND		ND		NV	NV	NV
56-38-2	Parathion	0.006	HEAST	0.006	HEAST	ND		ND		ND		ND		NV	NV	NV
1336-36-3	PCBs	0.00002	IRIS	0.00003	ATSDR	ND		ND		2	IRIS	0.00057	IRIS	NV	NV	NV
87-86-5	Pentachlorophenol	0.005	IRIS	0.005	IRIS	ND		ND		0.4	IRIS	ND		NV	NV	NV
14797-73-0	Perchlorate	0.00012	MeCDC	0.00012	MeCDC	ND		ND		ND		ND		NV	NV	NV
85-01-8	Phenanthrene	0.03	IRIS*	0.3	HEAST*	0.003	IRIS*	0.003	IRIS*	ND		ND		780000	20800000	25000000
108-95-2	Phenol	0.3	IRIS	0.3	IRIS	0.2	CA-OEHHA	0.6	CA-OEHHA***	ND		ND		NV	NV	NV
129-00-0	Pyrene	0.03	IRIS	0.3	HEAST	ND		ND		ND		ND		680000	4310000	5130000
7782-49-2	Selenium	0.005	ATSDR	0.005	HEAST	0.02	CA-OEHHA	0.02	CA-OEHHA	ND		ND		NV	NV	NV
7440-22-4	Silver	0.005	IRIS	0.005	HEAST	ND		ND		ND		ND		NV	NV	NV
100-42-5	Styrene	0.2	IRIS	2	IRIS***	0.3	ATSDR**	0.9	CA-OEHHA	ND		ND		10000000000	10000000000	1E+10
127-18-4	Tetrachloroethene	0.01	IRIS	0.1	HEAST	0.27	ATSDR	0.27	ATSDR	0.54	CA-OEHHA	0.0000059	CA-OEHHA	170000	3760000	4520000
298-2-2	Thimet (Phorate)	0.0002	HEAST	0.0002	HEAST	ND		ND		ND		ND		NV	NV	NV
108-88-3	Toluene	0.08	IRIS	0.8	IRIS***	5	IRIS	5	IRIS	ND		ND		10000000000	10000000000	1E+10
79-1-6	Trichloroethene	ND		ND		0.6	CA-OEHHA	0.6	ATSDR	0.0059	CA-OEHHA	0.000002	CA-OEHHA	131000	3040000	3660000
75-69-4	Trichlorofluoromethane	0.3	IRIS	0.3	IRIS	0.7	HEAST****	7	HEAST	ND		ND		334000	6290000	7600000
7440-62-2	Vanadium	0.007	HEAST	0.007	HEAST	ND		ND		ND		ND		NV	NV	NV
108-05-4	Vinyl acetate	1	HEAST	1	HEAST	0.2	IRIS	0.2	HEAST	ND		ND		10000000000	10000000000	1E+10
75-1-4	Vinyl chloride	0.003	IRIS	0.003	IRIS	0.01	ATSDR**	0.08	ATSDR	0.72	IRIS	0.0000044	IRIS	2990000	22400000	26000000
1330-20-7	Xylene	0.2	IRIS	0.4	ATSDR	0.1	IRIS	0.3	IRIS***	ND		ND		10000000000	10000000000	9470000000
7440-66-6	Zinc	0.3	IRIS	0.3	ATSDR	ND		ND		ND		ND		NV	NV	NV

NOTES:
IRIS - Integrated Risk Information System; May 2011
CA-OEHHA - California Office of Environmental Health Hazard Assessment; May 2011
ATSDR - Agency for Toxic Substances and Disease Registry; December 2010
PPRTV - Provisional Peer-Reviewed Toxicity Values (developed by Superfund Technical

Support Center); May 2011

HEAST - Health Effects Assessment Summary
Tables; July 1997

ITER - International Toxicity Estimates for Risk; May 2011
RIVM - Dutch National Institute for Public Health and the
Environment; May 2011

* - Surrogate toxicity value used for this compound
** - Adjusted by MeCDC to account for additional uncertainty in the value provided
by the original source
*** - Adjusted by MeCDC to remove subchronic-to-chronic
uncertainty factor
**** - This value is based on oral data, increasing the uncertainty
associated with its value
NV - Not volatile, therefore, no volatilization factor needed

Table 2 (A) - Remedial Action Guidelines for Residential Scenario (mg/kg) - 5/17/2011 (ILCR=1E-05; HQ=1)

CAS Number	Chemical	Soil Ingestion - Noncarcinogenic	Soil Ingestion - Carcinogenic	**Soil Ingestion - RAGs**	Soil Dermal - Noncarcinogenic	Soil Dermal - Carcinogenic	**Soil Dermal - RAGS**	Soil Inhalation – Non-carcinogenic	Soil Inhalation - Carcinogenic	**Soil Inhalation - RAGs**	Soil Cumulative Noncarcinogenic	Soil Cumulative - Carcinogenic
630-20-6	1,1,1,2-Tetrachloroethane	5.1E+03	5.5E+02	**5.5E+02**					1.1E+07	**1.1E+07**	5.1E+03	5.5E+02
79-34-5	1,1,2,2-Tetrachloroethane	3.4E+03	7.1E+01	**7.1E+01**							3.4E+03	7.1E+01
71-55-6	1,1,1-Trichloroethane	3.4E+05		**3.4E+05**				1.2E+09		**1.2E+09**	3.4E+05	
79-00-5	1,1,2-Trichloroethane	6.8E+02	2.5E+02	**2.5E+02**					6.4E+04	**6.4E+04**	6.8E+02	2.5E+02
92-52-4	1,1-Biphenyl	8.5E+03		**8.5E+03**							8.5E+03	
75-34-3	1,1-Dichloroethane	3.4E+04	2.5E+03	**2.5E+03**				2.4E+08	7.1E+06	**7.1E+06**	3.4E+04	2.5E+03
75-35-4	1,1-Dichloroethene	8.5E+03		**8.5E+03**				1.3E+08		**1.3E+08**	8.5E+03	
87-61-6	1,2,3-Trichlorobenzene	1.7E+03		**1.7E+03**				1.3E+05		**1.3E+05**	1.7E+03	
120-82-1	1,2,4-Trichlorobenzene	1.7E+03	4.9E+02	**4.9E+02**				1.3E+05		**1.3E+05**	1.7E+03	4.9E+02
96-12-8	1,2-Dibromo-3-chloropropane	3.4E+01	3.3E+00	**3.3E+00**				2.0E+04	6.1E+04	**2.0E+04**	3.4E+01	3.3E+00
95-50-1	1,2-Dichlorobenzene	5.1E+03		**5.1E+03**				1.8E+07		**1.8E+07**	5.1E+03	
107-06-2	1,2-Dichloroethane	3.4E+03	1.6E+02	**1.6E+02**				1.9E+08	7.1E+04	**7.1E+04**	3.4E+03	1.6E+02
156-59-2	1,2-Dichloroethene (cis)	3.4E+02		**3.4E+02**				2.1E+07		**2.1E+07**	3.4E+02	
156-60-5	1,2-Dichloroethene (trans)	3.4E+03		**3.4E+03**				2.1E+07		**2.1E+07**	3.4E+03	
78-87-5	1,2-Dichloropropane	1.5E+04	3.9E+02	**3.9E+02**				1.2E+05	7.1E+04	**7.1E+04**	1.4E+04	3.9E+02
528-29-0	1,2-Dinitrobenzene	1.7E+01		**1.7E+01**	6.1E+01		**6.1E+01**				1.3E+01	
106-99-0	1,3-Butadiene		4.2E+00	**4.2E+00**				7.0E+07	2.7E+07	**2.7E+07**	7.0E+07	4.2E+00
541-73-1	1,3-Dichlorobenzene	3.4E+01		**3.4E+01**							3.4E+01	
142-28-9	1,3-Dichloropropane	3.4E+03		**3.4E+03**							3.4E+03	
542-75-6	1,3-Dichloropropene	5.1E+03	1.4E+02	**1.4E+02**				7.0E+08	2.0E+08	**2.0E+08**	5.1E+03	1.4E+02
99-65-0	1,3-Dinitrobenzene	1.7E+01		**1.7E+01**	6.1E+01		**6.1E+01**				1.3E+01	
106-46-7	1,4-Dichlorobenzene	1.2E+04	2.6E+03	**2.6E+03**				5.6E+06	2.0E+05	**2.0E+05**	1.2E+04	2.6E+03
100-25-4	1,4-Dinitrobenzene	1.7E+01		**1.7E+01**	6.1E+01		**6.1E+01**				1.3E+01	
123-91-1	1,4-Dioxane	5.1E+03	1.4E+02	**1.4E+02**	1.8E+04	4.5E+02	**4.5E+02**	1.2E+11		**1.2E+11**	4.0E+03	1.1E+02
93-76-5	2,4,5-T	1.7E+03		**1.7E+03**	6.1E+03		**6.1E+03**				1.3E+03	
93-72-1	2,4,5-TP	1.4E+03		**1.4E+03**	4.9E+03		**4.9E+03**				1.1E+03	
95-95-4	2,4,5-Trichlorophenol	1.7E+04		**1.7E+04**	6.1E+04		**6.1E+04**				1.3E+04	
88-06-2	2,4,6-Trichlorophenol	1.7E+02	1.3E+03	**1.7E+02**	6.1E+02	4.1E+03	**6.1E+02**		3.0E+08	**3.0E+08**	1.3E+02	9.8E+02
118-96-7	2,4,6-Trinitrotoluene	8.5E+01	4.7E+02	**8.5E+01**	3.0E+02	1.5E+03	**3.0E+02**				6.7E+01	3.6E+02
120-83-2	2,4-Dichlorophenol	5.1E+02		**5.1E+02**	1.8E+03		**1.8E+03**				4.0E+02	

105-67-9	2,4-Dimethylphenol	3.4E+03		**3.4E+03**	1.2E+04		**1.2E+04**				2.7E+03	
51-28-5	2,4-Dinitrophenol	3.4E+02		**3.4E+02**	1.2E+03		**1.2E+03**				2.7E+02	
121-14-2	2,4-Dinitrotoluene	3.4E+02	4.6E+01	**4.6E+01**	1.2E+03	1.5E+02	**1.5E+02**		1.0E+07	**1.0E+07**	2.7E+02	3.5E+01
576-26-1	2,6-Dimethylphenol	1.0E+02		**1.0E+02**	3.7E+02		**3.7E+02**				8.0E+01	
606-20-2	2,6-Dinitrotoluene	1.7E+02	2.1E+01	**2.1E+01**	6.1E+02	6.6E+01	**6.6E+01**		1.0E+07	**1.0E+07**	1.3E+02	1.6E+01
95-57-8	2-Chlorophenol	8.5E+02		**8.5E+02**							8.5E+02	
95-48-7	2-Cresol	8.5E+03		**8.5E+03**	3.0E+04		**3.0E+04**	2.4E+10		**2.4E+10**	6.7E+03	
91-57-6	2-Methylnaphthalene	6.8E+02		**6.8E+02**	1.9E+03		**1.9E+03**	4.9E+05		**4.9E+05**	5.0E+02	
91-94-1	3,3-Dichlorobenzidine		3.2E+01	**3.2E+01**		1.0E+02	**1.0E+02**		2.7E+06	**2.7E+06**		2.4E+01
108-39-4	3-Cresol	8.5E+03		**8.5E+03**	3.0E+04		**3.0E+04**	2.4E+10		**2.4E+10**	6.7E+03	
106-47-8	4-Chloroaniline	8.5E+01	7.1E+01	**7.1E+01**	3.0E+02	2.3E+02	**2.3E+02**				6.7E+01	5.4E+01
106-44-5	4-Cresol	8.5E+02		**8.5E+02**	3.0E+03		**3.0E+03**	2.4E+10		**2.4E+10**	6.7E+02	
83-32-9	Acenaphthene	1.0E+04		**1.0E+04**	2.8E+04		**2.8E+04**	3.0E+06		**3.0E+06**	7.5E+03	
208-96-8	Acenaphthylene	1.0E+04		**1.0E+04**	2.8E+04		**2.8E+04**	2.6E+07		**2.6E+07**	7.5E+03	
67-64-1	Acetone	1.5E+05		**1.5E+05**				1.1E+12		**1.1E+12**	1.5E+05	
107-02-8	Acrolein	8.5E+01		**8.5E+01**				1.2E+07		**1.2E+07**	8.5E+01	
107-13-1	Acrylonitrile	1.7E+02	2.6E+01	**2.6E+01**				7.0E+07	1.2E+07	**1.2E+07**	1.7E+02	2.6E+01
15972-60-8	Alachlor	1.7E+03	2.5E+02	**2.5E+02**	6.1E+03	8.1E+02	**8.1E+02**				1.3E+03	1.9E+02
309-00-2	Aldrin	5.1E+00	8.3E-01	**8.3E-01**	1.8E+01	2.7E+00	**2.7E+00**		1.9E+05	**1.9E+05**	4.0E+00	6.4E-01
107-05-1	Allyl chloride		6.8E+02	**6.8E+02**				1.7E+05	6.7E+05	**1.7E+05**	1.7E+05	6.8E+02
7429-90-5	Aluminum	1.7E+05		**1.7E+05**				2.0E+08		**2.0E+08**	1.7E+05	
120-12-7	Anthracene	5.1E+04		**5.1E+04**	1.4E+05		**1.4E+05**	4.9E+05		**4.9E+05**	3.5E+04	
7440-36-0	Antimony	6.8E+01		**6.8E+01**							6.8E+01	
12674-11-2	Aroclor 1016	1.2E+01	7.1E+00	**7.1E+00**	3.0E+01	1.6E+01	**1.6E+01**		1.6E+06	**1.6E+06**	8.6E+00	4.9E+00
7440-38-2	Arsenic	5.1E+01	1.5E+00	**1.5E+00**	6.1E+02	1.6E+01	**1.6E+01**	6.0E+05	2.8E+05	**2.8E+05**	4.7E+01	1.4E+00
1912-24-9	Atrazine	1.7E+02	6.2E+01	**6.2E+01**	6.1E+02	2.0E+02	**2.0E+02**				1.3E+02	4.7E+01
7440-39-3	Barium	3.4E+04		**3.4E+04**							3.4E+04	
71-43-2	Benzene	8.5E+01	2.6E+02	**8.5E+01**				3.5E+08	1.0E+08	**1.0E+08**	8.5E+01	2.6E+02
56-55-3	Benzo(a)anthracene		3.6E+00	**3.6E+00**		9.9E+00	**9.9E+00**		3.3E+06	**3.3E+06**		2.6E+00
50-32-8	Benzo(a)pyrene		3.6E-01	**3.6E-01**		9.9E-01	**9.9E-01**		3.3E+05	**3.3E+05**		2.6E-01
205-99-2	Benzo(b)fluoranthene		3.6E+00	**3.6E+00**		9.9E+00	**9.9E+00**		3.3E+06	**3.3E+06**		2.6E+00
191-24-2	Benzo(g,h,i)perylene	5.1E+03		**5.1E+03**	1.4E+04		**1.4E+04**				3.7E+03	
207-08-9	Benzo(k)fluoranthene		3.6E+01	**3.6E+01**		9.9E+01	**9.9E+01**		3.3E+06	**3.3E+06**		2.6E+01
100-44-7	Benzyl chloride	3.4E+02	8.3E+01	**8.3E+01**				3.5E+07	1.7E+07	**1.7E+07**	3.4E+02	8.3E+01
7440-41-7	Beryllium	3.4E+02		**3.4E+02**				7.9E+05	3.9E+05	**3.9E+05**	3.4E+02	3.9E+05
117-81-7	bis(2-Ethylhexyl)phthalate	1.0E+04	1.0E+03	**1.0E+03**	3.7E+04	3.2E+03	**3.2E+03**		3.9E+08	**3.9E+08**	8.0E+03	7.7E+02
75-27-4	Bromodichloromethane	3.4E+03	2.3E+02	**2.3E+02**					8.3E+04	**8.3E+04**	3.4E+03	2.3E+02
75-25-2	Bromoform	3.4E+03	1.8E+03	**1.8E+03**	1.2E+04	5.7E+03	**5.7E+03**		8.4E+08	**8.4E+08**	2.7E+03	1.4E+03

74-83-9	Bromomethane	2.4E+02		**2.4E+02**				2.0E+07		**2.0E+07**	2.4E+02	
85-68-7	Butyl benzyl phthalate	3.4E+04	7.5E+03	**7.5E+03**	1.2E+05	2.4E+04	**2.4E+04**				2.7E+04	5.7E+03
7440-43-9	Cadmium	1.2E+01		**1.2E+01**	1.1E+02		**1.1E+02**	7.9E+05	5.1E+05	**5.1E+05**	1.1E+01	5.1E+05
75-15-0	Carbon disulfide	1.7E+04		**1.7E+04**				1.7E+08		**1.7E+08**	1.7E+04	
56-23-5	Carbon tetrachloride	6.8E+02	2.0E+02	**2.0E+02**				5.1E+06	2.0E+05	**2.0E+05**	6.8E+02	2.0E+02
57-74-9	Chlordane	8.5E+01	4.1E+01	**4.1E+01**	7.6E+02	3.2E+02	**3.2E+02**	2.8E+07	9.3E+06	**9.3E+06**	7.7E+01	3.6E+01
108-90-7	Chlorobenzene	3.4E+03		**3.4E+03**				2.3E+08		**2.3E+08**	3.4E+03	
67-66-3	Chloroform	1.7E+03	4.6E+02	**4.6E+02**				6.8E+05	3.4E+05	**3.4E+05**	1.7E+03	4.6E+02
16065-83-1	Chromium (+3)	2.6E+05		**2.6E+05**							2.6E+05	
18540-29-9	Chromium (+6)	5.1E+02		**5.1E+02**				4.0E+06	3.0E+04	**3.0E+04**	5.1E+02	3.0E+04
218-01-9	Chrysene		3.6E+02	**3.6E+02**		9.9E+02	**9.9E+02**		3.3E+07	**3.3E+07**		2.6E+02
7440-48-4	Cobalt	5.1E+01		**5.1E+01**				2.4E+05	1.0E+05	**1.0E+05**	5.1E+01	1.0E+05
7440-50-8	Copper	2.4E+03		**2.4E+03**				4.0E+07		**4.0E+07**	2.4E+03	
57-12-5	Cyanide	1.0E+02		**1.0E+02**				3.2E+07		**3.2E+07**	1.0E+02	
72-54-8	DDD		5.9E+01	**5.9E+01**		1.9E+02	**1.9E+02**		1.3E+07	**1.3E+07**		4.5E+01
72-55-9	DDE		4.2E+01	**4.2E+01**		1.3E+02	**1.3E+02**		9.6E+06	**9.6E+06**		3.2E+01
50-29-3	DDT	8.5E+01	4.2E+01	**4.2E+01**	1.0E+03	4.4E+02	**4.4E+02**		9.6E+06	**9.6E+06**	7.9E+01	3.8E+01
53-70-3	Dibenz(a,h)anthracene		3.6E-01	**3.6E-01**		9.9E-01	**9.9E-01**		3.0E+05	**3.0E+05**		2.6E-01
124-48-1	Dibromochloromethane	3.4E+03	1.7E+02	**1.7E+02**					1.0E+05	**1.0E+05**	3.4E+03	1.7E+02
84-74-2	Dibutyl phthalate	1.7E+04		**1.7E+04**	6.1E+04		**6.1E+04**				1.3E+04	
75-71-8	Dichlorodifluoromethane	3.4E+04		**3.4E+04**				1.6E+08		**1.6E+08**	3.4E+04	
84-66-2	Diethyl phthalate	1.4E+05		**1.4E+05**	4.9E+05		**4.9E+05**				1.1E+05	
60-57-1	Dieldrin	8.5E+00	8.9E-01	**8.9E-01**	3.0E+01	2.8E+00	**2.8E+00**		2.0E+05	**2.0E+05**	6.7E+00	6.8E-01
88-85-7	Dinoseb	1.7E+02		**1.7E+02**	6.1E+02		**6.1E+02**				1.3E+02	
1746-01-6	Dioxin-Like Compounds - TEQ	1.7E-04	1.1E-04	**1.1E-04**	2.0E-03	1.2E-03	**1.2E-03**	1.6E+03	2.4E+01	**2.4E+01**	1.6E-04	1.0E-04
115-29-7	Endosulfan	1.0E+03		**1.0E+03**	3.7E+03		**3.7E+03**				8.0E+02	
72-20-8	Endrin	5.1E+01		**5.1E+01**	1.8E+02		**1.8E+02**				4.0E+01	
100-41-4	Ethylbenzene	1.7E+04	1.3E+03	**1.3E+03**				1.3E+08	1.2E+07	**1.2E+07**	1.7E+04	1.3E+03
106-93-4	Ethylene dibromide	1.5E+03	7.1E+00	**7.1E+00**				5.4E+05	2.3E+03	**2.3E+03**	1.5E+03	7.1E+00
75-00-3	Ethyl chloride	1.7E+03		**1.7E+03**				2.7E+11		**2.7E+11**	1.7E+03	
206-44-0	Fluoranthene	6.8E+03		**6.8E+03**	1.9E+04		**1.9E+04**				5.0E+03	
86-73-7	Fluorene	6.8E+03		**6.8E+03**	1.9E+04		**1.9E+04**	3.6E+07		**3.6E+07**	5.0E+03	
76-44-8	Heptachlor	1.7E+00	3.2E+00	**1.7E+00**	6.1E+00	1.0E+01	**6.1E+00**		7.1E+05	**7.1E+05**	1.3E+00	2.4E+00
1024-57-3	Heptachlor epoxide	2.2E+00	1.6E+00	**1.6E+00**	7.9E+00	5.0E+00	**5.0E+00**		3.6E+05	**3.6E+05**	1.7E+00	1.2E+00
118-74-1	Hexachlorobenzene	1.4E+02	8.9E+00	**8.9E+00**	4.9E+02	2.8E+01	**2.8E+01**		2.0E+06	**2.0E+06**	1.1E+02	6.8E+00
87-68-3	Hexachlorobutadiene	1.7E+02	1.8E+02	**1.7E+02**	6.1E+02	5.8E+02	**5.8E+02**		4.2E+07	**4.2E+07**	1.3E+02	1.4E+02
319-84-6	Hexachlorocyclohexane, alpha (alpha-BHC)	1.4E+03	2.3E+00	**2.3E+00**	4.9E+03	7.2E+00	**7.2E+00**		5.1E+05	**5.1E+05**	1.1E+03	1.7E+00
319-85-7	Hexachlorocyclohexane, beta (beta-BHC)	1.0E+01	7.9E+00	**7.9E+00**	3.7E+01	2.5E+01	**2.5E+01**		1.7E+06	**1.7E+06**	8.0E+00	6.0E+00

58-89-9	Hexachlorocyclohexane, gamma (Lindane)	6.8E-01	1.3E+01	**6.8E-01**	6.1E+00	1.0E+02	**6.1E+00**		3.0E+06	**3.0E+06**	6.1E-01	1.1E+01
67-72-1	Hexachloroethane	1.7E+02	1.0E+03	**1.7E+02**	6.1E+02	3.2E+03	**6.1E+02**		2.3E+08	**2.3E+08**	1.3E+02	7.7E+02
121-82-4	Hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX)	5.1E+02	1.3E+02	**1.3E+02**	1.8E+03	4.1E+02	**4.1E+02**				4.0E+02	9.8E+01
193-39-5	Indeno(1,2,3-cd)pyrene		3.6E+00	**3.6E+00**		9.9E+00	**9.9E+00**		3.3E+06	**3.3E+06**		2.6E+00
7439-89-6	Iron	1.2E+05		**1.2E+05**							1.2E+05	
7439-92-1	Lead		1.7E+03	**1.7E+03**					7.7E+07	**7.7E+07**	3.4E+02	1.7E+03
121-75-5	Malathion	3.4E+03		**3.4E+03**	1.2E+04		**1.2E+04**	7.9E+07		**7.9E+07**	2.7E+03	
7439-96-5	Manganese	4.1E+03		**4.1E+03**				2.0E+06		**2.0E+06**	4.1E+03	
7487-94-7	Mercuric chloride & other inorganic mercury compounds	5.1E+01		**5.1E+01**							5.1E+01	
72-43-5	Methoxychlor	8.5E+02		**8.5E+02**	3.0E+03		**3.0E+03**				6.7E+02	
78-93-3	Methyl ethyl ketone	1.0E+05		**1.0E+05**				1.7E+11		**1.7E+11**	1.0E+05	
108-10-1	Methyl isobutyl ketone	1.4E+04		**1.4E+04**				1.0E+11		**1.0E+11**	1.4E+04	
80-62-6	Methyl methacrylate	2.4E+05		**2.4E+05**				2.4E+10		**2.4E+10**	2.4E+05	
1634-04-4	Methyl tert-butyl ether	5.1E+03	7.9E+03	**5.1E+03**				1.0E+11	3.1E+09	**3.1E+09**	5.1E+03	7.9E+03
75-09-2	Methylene chloride	1.0E+04	1.9E+03	**1.9E+03**				3.8E+10	1.7E+09	**1.7E+09**	1.0E+04	1.9E+03
7439-98-7	Molybdenum	8.5E+02		**8.5E+02**				4.8E+08		**4.8E+08**	8.5E+02	
106-94-5	n-Propyl bromide	2.4E+02		**2.4E+02**				2.8E+06		**2.8E+06**	2.4E+02	
91-20-3	Naphthalene	3.4E+03		**3.4E+03**	9.4E+03		**9.4E+03**	2.1E+07	4.9E+06	**4.9E+06**	2.5E+03	4.9E+06
7440-2-0	Nickel	5.1E+02		**5.1E+02**				3.6E+06	3.6E+06	**3.6E+06**	5.1E+02	3.6E+06
2691-41-0	Octahydro-1,3,5,7-tetranitro-1,3,5,7-tetra (HMX)	8.5E+03		**8.5E+03**	3.0E+04		**3.0E+04**				6.7E+03	
56-38-2	Parathion	1.0E+03		**1.0E+03**	3.7E+03		**3.7E+03**				8.0E+02	
1336-36-3	PCBs	3.4E+00	7.1E+00	**3.4E+00**	8.7E+00	1.6E+01	**8.7E+00**		1.6E+06	**1.6E+06**	2.4E+00	4.9E+00
87-86-5	Pentachlorophenol	8.5E+02	3.5E+01	**3.5E+01**	1.2E+03	4.5E+01	**4.5E+01**				5.0E+02	2.0E+01
14797-73-0	Perchlorate	2.0E+01		**2.0E+01**							2.0E+01	
85-01-8	Phenanthrene	5.1E+03		**5.1E+03**	1.4E+04		**1.4E+04**	2.2E+06		**2.2E+06**	3.7E+03	
108-95-2	Phenol	5.1E+04		**5.1E+04**	1.8E+05		**1.8E+05**	7.9E+09		**7.9E+09**	4.0E+04	
129-00-0	Pyrene	5.1E+03		**5.1E+03**	1.4E+04		**1.4E+04**				3.7E+03	
7782-49-2	Selenium	8.5E+02		**8.5E+02**				7.9E+08		**7.9E+08**	8.5E+02	
7440-22-4	Silver	8.5E+02		**8.5E+02**							8.5E+02	
100-42-5	Styrene	3.4E+04		**3.4E+04**				1.0E+10		**1.0E+10**	3.4E+04	
127-18-4	Tetrachloroethene	1.7E+03	2.6E+01	**2.6E+01**				3.6E+07	5.2E+05	**5.2E+05**	1.7E+03	2.6E+01
298-2-2	Thimet (Phorate)	3.4E+01		**3.4E+01**	1.2E+02		**1.2E+02**				2.7E+01	
108-88-3	Toluene	1.4E+04		**1.4E+04**				1.7E+11		**1.7E+11**	1.4E+04	
79-1-6	Trichloroethene		2.4E+03	**2.4E+03**				6.4E+07	1.2E+06	**1.2E+06**	6.4E+07	2.4E+03
75-69-4	Trichlorofluoromethane	5.1E+04		**5.1E+04**				1.5E+08		**1.5E+08**	5.1E+04	
7440-62-2	Vanadium	1.2E+03		**1.2E+03**							1.2E+03	
108-05-4	Vinyl acetate	1.7E+05		**1.7E+05**				7.0E+09		**7.0E+09**	1.7E+05	

75-1-4	Vinyl chloride	5.1E+02	9.3E-01	**9.3E-01**				7.4E+06	5.7E+04	**5.7E+04**	5.1E+02	9.3E-01
1330-20-7	Xylene	3.4E+04		**3.4E+04**				3.5E+09		**3.5E+09**	3.4E+04	
7440-66-6	Zinc	5.1E+04		**5.1E+04**							5.1E+04	

Value is greater than the ceiling value of 10,000 mg/kg. The ceiling value should be used as the cumulative soil guideline for this compound.

Table 3 (A) - Remedial Action Guidelines for Park User/Recreational Scenario (mg/kg) - 5/17/2011 (ILCR=1E-05; HQ=1)

CAS Number	Chemical	Soil Ingestion – Non-carcinogenic	Soil Ingestion - Carcinogenic	**Soil Ingestion - RAGs**	Soil Dermal Non-carcinogenic	Soil Dermal - Carcinogenic	**Soil Dermal - RAGS**	Soil Inhalation - Noncarcinogenic	Soil Inhalation - Carcinogenic	**Soil Inhalation - RAGs**	Soil Cumulative Noncarcinogenic	Soil Cumulative - Carcinogenic
630-20-6	1,1,1,2-Tetrachloroethane	8.5E+03	9.1E+02	**9.1E+02**					1.8E+07	**1.8E+07**	8.5E+03	9.1E+02
79-34-5	1,1,2,2-Tetrachloroethane	5.7E+03	1.2E+02	**1.2E+02**							5.7E+03	1.2E+02
71-55-6	1,1,1-Trichloroethane	5.7E+05		**5.7E+05**				2.0E+09		**2.0E+09**	5.7E+05	
79-00-5	1,1,2-Trichloroethane	1.1E+03	4.2E+02	**4.2E+02**					1.1E+05	**1.1E+05**	1.1E+03	4.1E+02
92-52-4	1,1-Biphenyl	1.4E+04		**1.4E+04**							1.4E+04	
75-34-3	1,1-Dichloroethane	5.7E+04	4.2E+03	**4.2E+03**				4.0E+08	1.2E+07	**1.2E+07**	5.7E+04	4.1E+03
75-35-4	1,1-Dichloroethene	1.4E+04		**1.4E+04**				2.2E+08		**2.2E+08**	1.4E+04	
87-61-6	1,2,3-Trichlorobenzene	2.8E+03		**2.8E+03**				2.1E+05		**2.1E+05**	2.8E+03	
120-82-1	1,2,4-Trichlorobenzene	2.8E+03	8.2E+02	**8.2E+02**				2.1E+05		**2.1E+05**	2.8E+03	8.2E+02
96-12-8	1,2-Dibromo-3-chloropropane	5.7E+01	5.4E+00	**5.4E+00**				3.3E+04	1.0E+05	**3.3E+04**	5.7E+01	5.4E+00
95-50-1	1,2-Dichlorobenzene	8.5E+03		**8.5E+03**				3.1E+07		**3.1E+07**	8.5E+03	
107-06-2	1,2-Dichloroethane	5.7E+03	2.6E+02	**2.6E+02**				3.2E+08	1.2E+05	**1.2E+05**	5.7E+03	2.6E+02
156-59-2	1,2-Dichloroethene (cis)	5.7E+02		**5.7E+02**				3.5E+07		**3.5E+07**	5.7E+02	
156-60-5	1,2-Dichloroethene (trans)	5.7E+03		**5.7E+03**				3.5E+07		**3.5E+07**	5.7E+03	
78-87-5	1,2-Dichloropropane	2.6E+04	6.6E+02	**6.6E+02**				2.0E+05	1.2E+05	**1.2E+05**	2.3E+04	6.5E+02
528-29-0	1,2-Dinitrobenzene	2.8E+01		**2.8E+01**	1.0E+02		**1.0E+02**				2.2E+01	
106-99-0	1,3-Butadiene		7.0E+00	**7.0E+00**				1.2E+08	4.5E+07	**4.5E+07**	1.2E+08	7.0E+00
541-73-1	1,3-Dichlorobenzene	5.7E+01		**5.7E+01**							5.7E+01	
142-28-9	1,3-Dichloropropane	5.7E+03		**5.7E+03**							5.7E+03	
542-75-6	1,3-Dichloropropene	8.5E+03	2.4E+02	**2.4E+02**				1.2E+09	3.4E+08	**3.4E+08**	8.5E+03	2.4E+02
99-65-0	1,3-Dinitrobenzene	2.8E+01		**2.8E+01**	1.0E+02		**1.0E+02**				2.2E+01	
106-46-7	1,4-Dichlorobenzene	2.0E+04	4.4E+03	**4.4E+03**				9.4E+06	3.3E+05	**3.3E+05**	2.0E+04	4.3E+03
100-25-4	1,4-Dinitrobenzene	2.8E+01		**2.8E+01**	1.0E+02		**1.0E+02**				2.2E+01	
123-91-1	1,4-Dioxane	8.5E+03	2.4E+02	**2.4E+02**	3.0E+04	7.5E+02	**7.5E+02**	2.0E+11		**2.0E+11**	6.7E+03	1.8E+02
93-76-5	2,4,5-T	2.8E+03		**2.8E+03**	1.0E+04		**1.0E+04**				2.2E+03	
93-72-1	2,4,5-TP	2.3E+03		**2.3E+03**	8.1E+03		**8.1E+03**				1.8E+03	
95-95-4	2,4,5-Trichlorophenol	2.8E+04		**2.8E+04**	1.0E+05		**1.0E+05**				2.2E+04	
88-06-2	2,4,6-Trichlorophenol	2.8E+02	2.2E+03	**2.8E+02**	1.0E+03	6.8E+03	**1.0E+03**		5.0E+08	**5.0E+08**	2.2E+02	1.6E+03
118-96-7	2,4,6-Trinitrotoluene	1.4E+02	7.9E+02	**1.4E+02**	5.1E+02	2.5E+03	**5.1E+02**				1.1E+02	6.0E+02
120-83-2	2,4-Dichlorophenol	8.5E+02		**8.5E+02**	3.0E+03		**3.0E+03**				6.7E+02	
105-67-9	2,4-Dimethylphenol	5.7E+03		**5.7E+03**	2.0E+04		**2.0E+04**				4.4E+03	
51-28-5	2,4-Dinitrophenol	5.7E+02		**5.7E+02**	2.0E+03		**2.0E+03**				4.4E+02	
121-14-2	2,4-Dinitrotoluene	5.7E+02	7.6E+01	**7.6E+01**	2.0E+03	2.4E+02	**2.4E+02**		1.7E+07	**1.7E+07**	4.4E+02	5.8E+01

576-26-1	2,6-Dimethylphenol	1.7E+02		**1.7E+02**	6.1E+02		**6.1E+02**				1.3E+02	
606-20-2	2,6-Dinitrotoluene	2.8E+02	3.5E+01	**3.5E+01**	1.0E+03	1.1E+02	**1.1E+02**		1.7E+07	**1.7E+07**	2.2E+02	2.6E+01
95-57-8	2-Chlorophenol	1.4E+03		**1.4E+03**							1.4E+03	
95-48-7	2-Cresol	1.4E+04		**1.4E+04**	5.1E+04		**5.1E+04**	4.0E+10		**4.0E+10**	1.1E+04	
91-57-6	2-Methylnaphthalene	1.1E+03		**1.1E+03**	3.1E+03		**3.1E+03**	8.2E+05		**8.2E+05**	8.3E+02	
91-94-1	3,3-Dichlorobenzidine		5.3E+01	**5.3E+01**		1.7E+02	**1.7E+02**		4.5E+06	**4.5E+06**		4.0E+01
108-39-4	3-Cresol	1.4E+04		**1.4E+04**	5.1E+04		**5.1E+04**	4.0E+10		**4.0E+10**	1.1E+04	
106-47-8	4-Chloroaniline	1.4E+02	1.2E+02	**1.2E+02**	5.1E+02	3.8E+02	**3.8E+02**				1.1E+02	9.0E+01
106-44-5	4-Cresol	1.4E+03		**1.4E+03**	5.1E+03		**5.1E+03**	4.0E+10		**4.0E+10**	1.1E+03	
83-32-9	Acenaphthene	1.7E+04		**1.7E+04**	4.7E+04		**4.7E+04**	5.0E+06		**5.0E+06**	1.2E+04	
208-96-8	Acenaphthylene	1.7E+04		**1.7E+04**	4.7E+04		**4.7E+04**	4.4E+07		**4.4E+07**	1.2E+04	
67-64-1	Acetone	2.6E+05		**2.6E+05**				1.8E+12		**1.8E+12**	2.6E+05	
107-02-8	Acrolein	1.4E+02		**1.4E+02**				2.0E+07		**2.0E+07**	1.4E+02	
107-13-1	Acrylonitrile	2.8E+02	4.4E+01	**4.4E+01**				1.2E+08	2.0E+07	**2.0E+07**	2.8E+02	4.4E+01
15972-60-8	Alachlor	2.8E+03	4.2E+02	**4.2E+02**	1.0E+04	1.3E+03	**1.3E+03**				2.2E+03	3.2E+02
309-00-2	Aldrin	8.5E+00	1.4E+00	**1.4E+00**	3.0E+01	4.4E+00	**4.4E+00**		3.2E+05	**3.2E+05**	6.7E+00	1.1E+00
107-05-1	Allyl chloride		1.1E+03	**1.1E+03**				2.9E+05	1.1E+06	**2.9E+05**	2.9E+05	1.1E+03
7429-90-5	Aluminum	2.8E+05		**2.8E+05**				3.3E+08		**3.3E+08**	2.8E+05	
120-12-7	Anthracene	8.5E+04		**8.5E+04**	2.3E+05		**2.3E+05**	8.2E+05		**8.2E+05**	5.8E+04	
7440-36-0	Antimony	1.1E+02		**1.1E+02**							1.1E+02	
12674-11-2	Aroclor 1016	2.0E+01	1.2E+01	**1.2E+01**	5.1E+01	2.7E+01	**2.7E+01**		2.7E+06	**2.7E+06**	1.4E+01	8.2E+00
7440-38-2	Arsenic	8.5E+01	2.5E+00	**2.5E+00**	1.0E+03	2.7E+01	**2.7E+01**	9.9E+05	4.7E+05	**4.7E+05**	7.9E+01	2.3E+00
1912-24-9	Atrazine	2.8E+02	1.0E+02	**1.0E+02**	1.0E+03	3.3E+02	**3.3E+02**				2.2E+02	7.8E+01
7440-39-3	Barium	5.7E+04		**5.7E+04**							5.7E+04	
71-43-2	Benzene	1.4E+02	4.3E+02	**1.4E+02**				5.8E+08	1.7E+08	**1.7E+08**	1.4E+02	4.3E+02
56-55-3	Benzo(a)anthracene		5.9E+00	**5.9E+00**		1.6E+01	**1.6E+01**		5.5E+06	**5.5E+06**		4.4E+00
50-32-8	Benzo(a)pyrene		5.9E-01	**5.9E-01**		1.6E+00	**1.6E+00**		5.5E+05	**5.5E+05**		4.4E-01
205-99-2	Benzo(b)fluoranthene		5.9E+00	**5.9E+00**		1.6E+01	**1.6E+01**		5.5E+06	**5.5E+06**		4.4E+00
191-24-2	Benzo(g,h,i)perylene	8.5E+03		**8.5E+03**	2.3E+04		**2.3E+04**				6.2E+03	
207-08-9	Benzo(k)fluoranthene		5.9E+01	**5.9E+01**		1.6E+02	**1.6E+02**		5.5E+06	**5.5E+06**		4.4E+01
100-44-7	Benzyl chloride	5.7E+02	1.4E+02	**1.4E+02**				5.8E+07	2.8E+07	**2.8E+07**	5.7E+02	1.4E+02
7440-41-7	Beryllium	5.7E+02		**5.7E+02**				1.3E+06	6.4E+05	**6.4E+05**	5.7E+02	6.4E+05
117-81-7	bis(2-Ethylhexyl)phthalate	1.7E+04	1.7E+03	**1.7E+03**	6.1E+04	5.4E+03	**5.4E+03**		6.4E+08	**6.4E+08**	1.3E+04	1.3E+03
75-27-4	Bromodichloromethane	5.7E+03	3.8E+02	**3.8E+02**					1.4E+05	**1.4E+05**	5.7E+03	3.8E+02
75-25-2	Bromoform	5.7E+03	3.0E+03	**3.0E+03**	2.0E+04	9.5E+03	**9.5E+03**		1.4E+09	**1.4E+09**	4.4E+03	2.3E+03
74-83-9	Bromomethane	4.0E+02		**4.0E+02**				3.4E+07		**3.4E+07**	4.0E+02	
85-68-7	Butyl benzyl phthalate	5.7E+04	1.2E+04	**1.2E+04**	2.0E+05	4.0E+04	**4.0E+04**				4.4E+04	9.5E+03
7440-43-9	Cadmium	2.0E+01		**2.0E+01**	1.8E+02		**1.8E+02**	1.3E+06	8.6E+05	**8.6E+05**	1.8E+01	8.6E+05

75-15-0	Carbon disulfide	2.8E+04		**2.8E+04**				2.8E+08		**2.8E+08**	2.8E+04	
56-23-5	Carbon tetrachloride	1.1E+03	3.4E+02	**3.4E+02**				8.6E+06	3.3E+05	**3.3E+05**	1.1E+03	3.4E+02
57-74-9	Chlordane	1.4E+02	6.8E+01	**6.8E+01**	1.3E+03	5.4E+02	**5.4E+02**	4.6E+07	1.5E+07	**1.5E+07**	1.3E+02	6.0E+01
108-90-7	Chlorobenzene	5.7E+03		**5.7E+03**				3.8E+08		**3.8E+08**	5.7E+03	
67-66-3	Chloroform	2.8E+03	7.6E+02	**7.6E+02**				1.1E+06	5.7E+05	**5.7E+05**	2.8E+03	7.6E+02
16065-83-1	Chromium (+3)	4.3E+05		**4.3E+05**							4.3E+05	
18540-29-9	Chromium (+6)	8.5E+02		**8.5E+02**				6.6E+06	5.1E+04	**5.1E+04**	8.5E+02	5.1E+04
218-01-9	Chrysene		5.9E+02	**5.9E+02**		1.6E+03	**1.6E+03**		5.5E+07	**5.5E+07**		4.4E+02
7440-48-4	Cobalt	8.5E+01		**8.5E+01**				4.0E+05	1.7E+05	**1.7E+05**	8.5E+01	1.7E+05
7440-50-8	Copper	4.0E+03		**4.0E+03**				6.6E+07		**6.6E+07**	4.0E+03	
57-12-5	Cyanide	1.7E+02		**1.7E+02**				5.3E+07		**5.3E+07**	1.7E+02	
72-54-8	DDD		9.9E+01	**9.9E+01**		3.1E+02	**3.1E+02**		2.2E+07	**2.2E+07**		7.5E+01
72-55-9	DDE		7.0E+01	**7.0E+01**		2.2E+02	**2.2E+02**		1.6E+07	**1.6E+07**		5.3E+01
50-29-3	DDT	1.4E+02	7.0E+01	**7.0E+01**	1.7E+03	7.4E+02	**7.4E+02**		1.6E+07	**1.6E+07**	1.3E+02	6.4E+01
53-70-3	Dibenz(a,h)anthracene		5.9E-01	**5.9E-01**		1.6E+00	**1.6E+00**		5.1E+05	**5.1E+05**		4.4E-01
124-48-1	Dibromochloromethane	5.7E+03	2.8E+02	**2.8E+02**					1.7E+05	**1.7E+05**	5.7E+03	2.8E+02
84-74-2	Dibutyl phthalate	2.8E+04		**2.8E+04**	1.0E+05		**1.0E+05**				2.2E+04	
75-71-8	Dichlorodifluoromethane	5.7E+04		**5.7E+04**				2.6E+08		**2.6E+08**	5.7E+04	
84-66-2	Diethyl phthalate	2.3E+05		**2.3E+05**	8.1E+05		**8.1E+05**				1.8E+05	
60-57-1	Dieldrin	1.4E+01	1.5E+00	**1.5E+00**	5.1E+01	4.7E+00	**4.7E+00**		3.4E+05	**3.4E+05**	1.1E+01	1.1E+00
88-85-7	Dinoseb	2.8E+02		**2.8E+02**	1.0E+03		**1.0E+03**				2.2E+02	
1746-01-6	Dioxin-Like Compounds - TEQ	2.8E-04	1.8E-04	**1.8E-04**	3.4E-03	1.9E-03	**1.9E-03**	2.6E+03	4.1E+01	**4.1E+01**	2.6E-04	1.7E-04
115-29-7	Endosulfan	1.7E+03		**1.7E+03**	6.1E+03		**6.1E+03**				1.3E+03	
72-20-8	Endrin	8.5E+01		**8.5E+01**	3.0E+02		**3.0E+02**				6.7E+01	
100-41-4	Ethylbenzene	2.8E+04	2.2E+03	**2.2E+03**				2.2E+08	2.1E+07	**2.1E+07**	2.8E+04	2.2E+03
106-93-4	Ethylene dibromide	2.6E+03	1.2E+01	**1.2E+01**				8.9E+05	3.9E+03	**3.9E+03**	2.5E+03	1.2E+01
75-00-3	Ethyl chloride	2.8E+03		**2.8E+03**				4.5E+11		**4.5E+11**	2.8E+03	
206-44-0	Fluoranthene	1.1E+04		**1.1E+04**	3.1E+04		**3.1E+04**				8.3E+03	
86-73-7	Fluorene	1.1E+04		**1.1E+04**	3.1E+04		**3.1E+04**	6.1E+07		**6.1E+07**	8.3E+03	
76-44-8	Heptachlor	2.8E+00	5.3E+00	**2.8E+00**	1.0E+01	1.7E+01	**1.0E+01**		1.2E+06	**1.2E+06**	2.2E+00	4.0E+00
1024-57-3	Heptachlor epoxide	3.7E+00	2.6E+00	**2.6E+00**	1.3E+01	8.3E+00	**8.3E+00**		5.9E+05	**5.9E+05**	2.9E+00	2.0E+00
118-74-1	Hexachlorobenzene	2.3E+02	1.5E+01	**1.5E+01**	8.1E+02	4.7E+01	**4.7E+01**		3.4E+06	**3.4E+06**	1.8E+02	1.1E+01
87-68-3	Hexachlorobutadiene	2.8E+02	3.0E+02	**2.8E+02**	1.0E+03	9.7E+02	**9.7E+02**		7.0E+07	**7.0E+07**	2.2E+02	2.3E+02
319-84-6	Hexachlorocyclohexane, alpha (alpha-BHC)	2.3E+03	3.8E+00	**3.8E+00**	8.1E+03	1.2E+01	**1.2E+01**		8.6E+05	**8.6E+05**	1.8E+03	2.9E+00
319-85-7	Hexachlorocyclohexane, beta (beta-BHC)	1.7E+01	1.3E+01	**1.3E+01**	6.1E+01	4.2E+01	**4.2E+01**		2.9E+06	**2.9E+06**	1.3E+01	1.0E+01
58-89-9	Hexachlorocyclohexane, gamma (Lindane)	1.1E+00	2.2E+01	**1.1E+00**	1.0E+01	1.7E+02	**1.0E+01**		5.0E+06	**5.0E+06**	1.0E+00	1.9E+01
67-72-1	Hexachloroethane	2.8E+02	1.7E+03	**2.8E+02**	1.0E+03	5.4E+03	**1.0E+03**		3.9E+08	**3.9E+08**	2.2E+02	1.3E+03
121-82-4	Hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX)	8.5E+02	2.2E+02	**2.2E+02**	3.0E+03	6.8E+02	**6.8E+02**				6.7E+02	1.6E+02

193-39-5	Indeno(1,2,3-cd)pyrene		5.9E+00	**5.9E+00**		1.6E+01	**1.6E+01**		5.5E+06	**5.5E+06**		4.4E+00
7439-89-6	Iron	2.0E+05		**2.0E+05**							2.0E+05	
7439-92-1	Lead		2.8E+03	**2.8E+03**					1.3E+08	**1.3E+08**	5.3E+02	2.8E+03
121-75-5	Malathion	5.7E+03		**5.7E+03**	2.0E+04		**2.0E+04**	1.3E+08		**1.3E+08**	4.4E+03	
7439-96-5	Manganese	6.8E+03		**6.8E+03**				3.3E+06		**3.3E+06**	6.8E+03	
7487-94-7	Mercuric chloride & other inorganic mercury compounds	8.5E+01		**8.5E+01**							8.5E+01	
72-43-5	Methoxychlor	1.4E+03		**1.4E+03**	5.1E+03		**5.1E+03**				1.1E+03	
78-93-3	Methyl ethyl ketone	1.7E+05		**1.7E+05**				2.9E+11		**2.9E+11**	1.7E+05	
108-10-1	Methyl isobutyl ketone	2.3E+04		**2.3E+04**				1.7E+11		**1.7E+11**	2.3E+04	
80-62-6	Methyl methacrylate	4.0E+05		**4.0E+05**				4.1E+10		**4.1E+10**	4.0E+05	
1634-04-4	Methyl tert-butyl ether	8.5E+03	1.3E+04	**8.5E+03**				1.7E+11	5.2E+09	**5.2E+09**	8.5E+03	1.3E+04
75-09-2	Methylene chloride	1.7E+04	3.2E+03	**3.2E+03**				6.4E+10	2.9E+09	**2.9E+09**	1.7E+04	3.2E+03
7439-98-7	Molybdenum	1.4E+03		**1.4E+03**				7.9E+08		**7.9E+08**	1.4E+03	
106-94-5	n-Propyl bromide	4.0E+02		**4.0E+02**				4.6E+06		**4.6E+06**	4.0E+02	
91-20-3	Naphthalene	5.7E+03		**5.7E+03**	1.6E+04		**1.6E+04**	3.6E+07	8.2E+06	**8.2E+06**	4.2E+03	8.2E+06
7440-2-0	Nickel	8.5E+02		**8.5E+02**				6.0E+06	5.9E+06	**5.9E+06**	8.5E+02	5.9E+06
2691-41-0	Octahydro-1,3,5,7-tetranitro-1,3,5,7-tetra (HMX)	1.4E+04		**1.4E+04**	5.1E+04		**5.1E+04**				1.1E+04	
56-38-2	Parathion	1.7E+03		**1.7E+03**	6.1E+03		**6.1E+03**				1.3E+03	
1336-36-3	PCBs	5.7E+00	1.2E+01	**5.7E+00**	1.4E+01	2.7E+01	**1.4E+01**		2.7E+06	**2.7E+06**	4.1E+00	8.2E+00
87-86-5	Pentachlorophenol	1.4E+03	5.9E+01	**5.9E+01**	2.0E+03	7.5E+01	**7.5E+01**				8.3E+02	3.3E+01
14797-73-0	Perchlorate	3.4E+01		**3.4E+01**							3.4E+01	
85-01-8	Phenanthrene	8.5E+03		**8.5E+03**	2.3E+04		**2.3E+04**	3.6E+06		**3.6E+06**	6.2E+03	
108-95-2	Phenol	8.5E+04		**8.5E+04**	3.0E+05		**3.0E+05**	1.3E+10		**1.3E+10**	6.7E+04	
129-00-0	Pyrene	8.5E+03		**8.5E+03**	2.3E+04		**2.3E+04**				6.2E+03	
7782-49-2	Selenium	1.4E+03		**1.4E+03**				1.3E+09		**1.3E+09**	1.4E+03	
7440-22-4	Silver	1.4E+03		**1.4E+03**							1.4E+03	
100-42-5	Styrene	5.7E+04		**5.7E+04**				1.7E+10		**1.7E+10**	5.7E+04	
127-18-4	Tetrachloroethene	2.8E+03	4.4E+01	**4.4E+01**				5.9E+07	8.7E+05	**8.7E+05**	2.8E+03	4.4E+01
298-2-2	Thimet (Phorate)	5.7E+01		**5.7E+01**	2.0E+02		**2.0E+02**				4.4E+01	
108-88-3	Toluene	2.3E+04		**2.3E+04**				2.9E+11		**2.9E+11**	2.3E+04	
79-1-6	Trichloroethene		4.0E+03	**4.0E+03**				1.1E+08	2.1E+06	**2.1E+06**	1.1E+08	4.0E+03
75-69-4	Trichlorofluoromethane	8.5E+04		**8.5E+04**				2.6E+08		**2.6E+08**	8.5E+04	
7440-62-2	Vanadium	2.0E+03		**2.0E+03**							2.0E+03	
108-05-4	Vinyl acetate	2.8E+05		**2.8E+05**				1.2E+10		**1.2E+10**	2.8E+05	
75-1-4	Vinyl chloride	8.5E+02	9.4E-01	**9.4E-01**				1.2E+07	5.7E+04	**5.7E+04**	8.5E+02	9.4E-01
1330-20-7	Xylene	5.7E+04		**5.7E+04**				5.8E+09		**5.8E+09**	5.7E+04	
7440-66-6	Zinc	8.5E+04		**8.5E+04**							8.5E+04	

Value is greater than the ceiling value of 10,000 mg/kg. The ceiling value should be used as the cumulative soil guideline for this compound.

Table 4 (A) - Remedial Action Guidelines for Outdoor Commercial Worker Scenario (mg/kg) - 5/17/2011 (ILCR=1E-05; HQ=1)

CAS Number	Chemical	Soil Ingestion - Noncarcinogenic	Soil Ingestion - Carcinogenic	**Soil Ingestion - RAGs**	Soil Dermal - Noncarcinogenic	Soil Dermal - Carcinogenic	**Soil Dermal - RAGS**	Soil Inhalation - Noncarcinogenic	Soil Inhalation - Carcinogenic	**Soil Inhalation - RAGs**	Soil Cumulative - Noncarcinogenic	Soil Cumulative - Carcinogenic
630-20-6	1,1,1,2-Tetrachloroethane	5.1E+04	1.8E+03	**1.8E+03**					1.1E+07	**1.1E+07**	5.1E+04	1.8E+03
79-34-5	1,1,2,2-Tetrachloroethane	3.4E+04	2.4E+02	**2.4E+02**							3.4E+04	2.4E+02
71-55-6	1,1,1-Trichloroethane	3.4E+06		**3.4E+06**				1.0E+09		**1.0E+09**	3.4E+06	
79-00-5	1,1,2-Trichloroethane	6.8E+03	8.4E+02	**8.4E+02**					6.4E+04	**6.4E+04**	6.8E+03	8.3E+02
92-52-4	1,1-Biphenyl	8.5E+04		**8.5E+04**							8.5E+04	
75-34-3	1,1-Dichloroethane	3.4E+05	8.4E+03	**8.4E+03**				2.0E+08	7.0E+06	**7.0E+06**	3.4E+05	8.4E+03
75-35-4	1,1-Dichloroethene	8.5E+04		**8.5E+04**				1.1E+08		**1.1E+08**	8.5E+04	
87-61-6	1,2,3-Trichlorobenzene	1.7E+04		**1.7E+04**				1.0E+05		**1.0E+05**	1.5E+04	
120-82-1	1,2,4-Trichlorobenzene	1.7E+04	1.6E+03	**1.6E+03**				1.1E+05		**1.1E+05**	1.5E+04	1.6E+03
96-12-8	1,2-Dibromo-3-chloropropane	3.4E+02	6.0E+01	**6.0E+01**				1.7E+04	3.9E+02	**3.9E+02**	3.3E+02	5.2E+01
95-50-1	1,2-Dichlorobenzene	5.1E+04		**5.1E+04**				1.5E+07		**1.5E+07**	5.1E+04	
107-06-2	1,2-Dichloroethane	3.4E+04	5.2E+02	**5.2E+02**				1.6E+08	7.1E+04	**7.1E+04**	3.4E+04	5.2E+02
156-59-2	1,2-Dichloroethene (cis)	3.4E+03		**3.4E+03**				1.7E+07		**1.7E+07**	3.4E+03	
156-60-5	1,2-Dichloroethene (trans)	3.4E+04		**3.4E+04**				1.7E+07		**1.7E+07**	3.4E+04	
78-87-5	1,2-Dichloropropane	1.5E+05	1.3E+03	**1.3E+03**				1.0E+05	7.2E+04	**7.2E+04**	6.1E+04	1.3E+03
528-29-0	1,2-Dinitrobenzene	1.7E+02		**1.7E+02**	2.6E+02		**2.6E+02**				1.0E+02	
106-99-0	1,3-Butadiene		1.4E+01	**1.4E+01**				7.0E+07	3.3E+07	**3.3E+07**	7.0E+07	1.4E+01
541-73-1	1,3-Dichlorobenzene	3.4E+02		**3.4E+02**							3.4E+02	
142-28-9	1,3-Dichloropropane	3.4E+04		**3.4E+04**							3.4E+04	
542-75-6	1,3-Dichloropropene	5.1E+04	4.8E+02	**4.8E+02**				7.0E+08	2.4E+08	**2.4E+08**	5.1E+04	4.8E+02
99-65-0	1,3-Dinitrobenzene	1.7E+02		**1.7E+02**	2.6E+02		**2.6E+02**				1.0E+02	
106-46-7	1,4-Dichlorobenzene	1.2E+05	8.8E+03	**8.8E+03**				4.7E+06	2.0E+05	**2.0E+05**	1.2E+05	8.5E+03
100-25-4	1,4-Dinitrobenzene	1.7E+02		**1.7E+02**	2.6E+02		**2.6E+02**				1.0E+02	
123-91-1	1,4-Dioxane	5.1E+04	4.8E+02	**4.8E+02**	7.7E+04	7.2E+02	**7.2E+02**	1.2E+11		**1.2E+11**	3.1E+04	2.9E+02
93-76-5	2,4,5-T	1.7E+04		**1.7E+04**	2.6E+04		**2.6E+04**				1.0E+04	
93-72-1	2,4,5-TP	1.4E+04		**1.4E+04**	2.1E+04		**2.1E+04**				8.2E+03	
95-95-4	2,4,5-Trichlorophenol	1.7E+05		**1.7E+05**	2.6E+05		**2.6E+05**				1.0E+05	
88-06-2	2,4,6-Trichlorophenol	1.7E+03	4.3E+03	**1.7E+03**	2.6E+03	6.6E+03	**2.6E+03**		3.6E+08	**3.6E+08**	1.0E+03	2.6E+03
118-96-7	2,4,6-Trinitrotoluene	8.5E+02	1.6E+03	**8.5E+02**	1.3E+03	2.4E+03	**1.3E+03**				5.1E+02	9.6E+02
120-83-2	2,4-Dichlorophenol	5.1E+03		**5.1E+03**	7.7E+03		**7.7E+03**				3.1E+03	
105-67-9	2,4-Dimethylphenol	3.4E+04		**3.4E+04**	5.2E+04		**5.2E+04**				2.1E+04	
51-28-5	2,4-Dinitrophenol	3.4E+03		**3.4E+03**	5.2E+03		**5.2E+03**				2.1E+03	
121-14-2	2,4-Dinitrotoluene	3.4E+03	1.5E+02	**1.5E+02**	5.2E+03	2.3E+02	**2.3E+02**		1.2E+07	**1.2E+07**	2.1E+03	9.3E+01

576-26-1	2,6-Dimethylphenol	1.0E+03		**1.0E+03**	1.5E+03		**1.5E+03**				6.2E+02	
606-20-2	2,6-Dinitrotoluene	1.7E+03	7.0E+01	**7.0E+01**	2.6E+03	1.1E+02	**1.1E+02**		1.2E+07	**1.2E+07**	1.0E+03	4.2E+01
95-57-8	2-Chlorophenol	8.5E+03		**8.5E+03**							8.5E+03	
95-48-7	2-Cresol	8.5E+04		**8.5E+04**	1.3E+05		**1.3E+05**	2.4E+10		**2.4E+10**	5.1E+04	
91-57-6	2-Methylnaphthalene	6.8E+03		**6.8E+03**	7.9E+03		**7.9E+03**	4.1E+05		**4.1E+05**	3.6E+03	
91-94-1	3,3-Dichlorobenzidine		1.1E+02	**1.1E+02**		1.6E+02	**1.6E+02**		3.3E+06	**3.3E+06**		6.4E+01
108-39-4	3-Cresol	8.5E+04		**8.5E+04**	1.3E+05		**1.3E+05**	2.4E+10		**2.4E+10**	5.1E+04	
106-47-8	4-Chloroaniline	8.5E+02	2.4E+02	**2.4E+02**	1.3E+03	3.6E+02	**3.6E+02**				5.1E+02	1.4E+02
106-44-5	4-Cresol	8.5E+03		**8.5E+03**	1.3E+04		**1.3E+04**	2.4E+10		**2.4E+10**	5.1E+03	
83-32-9	Acenaphthene	1.0E+05		**1.0E+05**	1.2E+05		**1.2E+05**	2.5E+06		**2.5E+06**	5.4E+04	
208-96-8	Acenaphthylene	1.0E+05		**1.0E+05**	1.2E+05		**1.2E+05**	2.3E+07		**2.3E+07**	5.5E+04	
67-64-1	Acetone	1.5E+06		**1.5E+06**				1.1E+12		**1.1E+12**	1.5E+06	
107-02-8	Acrolein	8.5E+02		**8.5E+02**				1.2E+07		**1.2E+07**	8.5E+02	
107-13-1	Acrylonitrile	1.7E+03	8.8E+01	**8.8E+01**				7.0E+07	1.4E+07	**1.4E+07**	1.7E+03	8.8E+01
15972-60-8	Alachlor	1.7E+04	8.5E+02	**8.5E+02**	2.6E+04	1.3E+03	**1.3E+03**				1.0E+04	5.1E+02
309-00-2	Aldrin	5.1E+01	2.8E+00	**2.8E+00**	7.7E+01	4.3E+00	**4.3E+00**		2.3E+05	**2.3E+05**	3.1E+01	1.7E+00
107-05-1	Allyl chloride		2.3E+03	**2.3E+03**				1.4E+05	6.7E+05	**1.4E+05**	1.4E+05	2.3E+03
7429-90-5	Aluminum	1.7E+06		**1.7E+06**				2.0E+08		**2.0E+08**	1.7E+06	
120-12-7	Anthracene	5.1E+05		**5.1E+05**	6.0E+05		**6.0E+05**	4.1E+05		**4.1E+05**	1.6E+05	
7440-36-0	Antimony	6.8E+02		**6.8E+02**							6.8E+02	
12674-11-2	Aroclor 1016	1.2E+02	2.4E+01	**2.4E+01**	1.3E+02	2.6E+01	**2.6E+01**		2.0E+06	**2.0E+06**	6.2E+01	1.2E+01
7440-38-2	Arsenic	5.1E+02	5.0E+00	**5.0E+00**	2.6E+03	2.5E+01	**2.5E+01**	6.0E+05	3.4E+05	**3.4E+05**	4.3E+02	4.2E+00
1912-24-9	Atrazine	1.7E+03	2.1E+02	**2.1E+02**	2.6E+03	3.1E+02	**3.1E+02**				1.0E+03	1.2E+02
7440-39-3	Barium	3.4E+05		**3.4E+05**							3.4E+05	
71-43-2	Benzene	8.5E+02	8.7E+02	**8.5E+02**				3.5E+08	1.3E+08	**1.3E+08**	8.5E+02	8.7E+02
56-55-3	Benzo(a)anthracene		6.5E+01	**6.5E+01**		7.6E+01	**7.6E+01**		1.0E+07	**1.0E+07**		3.5E+01
50-32-8	Benzo(a)pyrene		6.5E+00	**6.5E+00**		7.6E+00	**7.6E+00**		1.0E+06	**1.0E+06**		3.5E+00
205-99-2	Benzo(b)fluoranthene		6.5E+01	**6.5E+01**		7.6E+01	**7.6E+01**		1.0E+07	**1.0E+07**		3.5E+01
191-24-2	Benzo(g,h,i)perylene	5.1E+04		**5.1E+04**	6.0E+04		**6.0E+04**				2.8E+04	
207-08-9	Benzo(k)fluoranthene		6.5E+02	**6.5E+02**		7.6E+02	**7.6E+02**		1.0E+07	**1.0E+07**		3.5E+02
100-44-7	Benzyl chloride	3.4E+03	2.8E+02	**2.8E+02**				3.5E+07	2.0E+07	**2.0E+07**	3.4E+03	2.8E+02
7440-41-7	Beryllium	3.4E+03		**3.4E+03**				7.9E+05	4.6E+05	**4.6E+05**	3.4E+03	4.6E+05
117-81-7	bis(2-Ethylhexyl)phthalate	1.0E+05	3.4E+03	**3.4E+03**	1.5E+05	5.2E+03	**5.2E+03**		4.6E+08	**4.6E+08**	6.2E+04	2.1E+03
75-27-4	Bromodichloromethane	3.4E+04	7.7E+02	**7.7E+02**					8.3E+04	**8.3E+04**	3.4E+04	7.6E+02
75-25-2	Bromoform	3.4E+04	6.0E+03	**6.0E+03**	5.2E+04	9.1E+03	**9.1E+03**		1.0E+09	**1.0E+09**	2.1E+04	3.6E+03
74-83-9	Bromomethane	2.4E+03		**2.4E+03**				1.7E+07		**1.7E+07**	2.4E+03	
85-68-7	Butyl benzyl phthalate	3.4E+05	2.5E+04	**2.5E+04**	5.2E+05	3.8E+04	**3.8E+04**				2.1E+05	1.5E+04

7440-43-9	Cadmium	1.2E+02		**1.2E+02**	4.5E+02		**4.5E+02**	7.9E+05	6.2E+05	**6.2E+05**	9.4E+01	6.2E+05
75-15-0	Carbon disulfide	1.7E+05		**1.7E+05**				1.4E+08		**1.4E+08**	1.7E+05	
56-23-5	Carbon tetrachloride	6.8E+03	6.8E+02	**6.8E+02**				4.3E+06	2.0E+05	**2.0E+05**	6.8E+03	6.8E+02
57-74-9	Chlordane	8.5E+02	1.4E+02	**1.4E+02**	3.2E+03	5.2E+02	**5.2E+02**	2.8E+07	1.1E+07	**1.1E+07**	6.7E+02	1.1E+02
108-90-7	Chlorobenzene	3.4E+04		**3.4E+04**				1.9E+08		**1.9E+08**	3.4E+04	
67-66-3	Chloroform	1.7E+04	1.5E+03	**1.5E+03**				5.7E+05	3.4E+05	**3.4E+05**	1.7E+04	1.5E+03
16065-83-1	Chromium (+3)	2.6E+06		**2.6E+06**							2.6E+06	
18540-29-9	Chromium (+6)	5.1E+03		**5.1E+03**				4.0E+06	9.3E+04	**9.3E+04**	5.1E+03	9.3E+04
218-01-9	Chrysene		6.5E+03	**6.5E+03**		7.6E+03	**7.6E+03**		1.0E+08	**1.0E+08**		3.5E+03
7440-48-4	Cobalt	5.1E+02		**5.1E+02**				2.4E+05	1.2E+05	**1.2E+05**	5.1E+02	1.2E+05
7440-50-8	Copper	2.4E+04		**2.4E+04**				4.0E+07		**4.0E+07**	2.4E+04	
57-12-5	Cyanide	1.0E+03		**1.0E+03**				3.2E+07		**3.2E+07**	1.0E+03	
72-54-8	DDD		2.0E+02	**2.0E+02**		3.0E+02	**3.0E+02**		1.6E+07	**1.6E+07**		1.2E+02
72-55-9	DDE		1.4E+02	**1.4E+02**		2.1E+02	**2.1E+02**		1.1E+07	**1.1E+07**		8.5E+01
50-29-3	DDT	8.5E+02	1.4E+02	**1.4E+02**	4.3E+03	7.1E+02	**7.1E+02**		1.1E+07	**1.1E+07**	7.1E+02	1.2E+02
53-70-3	Dibenz(a,h)anthracene		6.5E+00	**6.5E+00**		7.6E+00	**7.6E+00**		9.3E+05	**9.3E+05**		3.5E+00
124-48-1	Dibromochloromethane	3.4E+04	5.7E+02	**5.7E+02**					1.0E+05	**1.0E+05**	3.4E+04	5.6E+02
84-74-2	Dibutyl phthalate	1.7E+05		**1.7E+05**	2.6E+05		**2.6E+05**				1.0E+05	
75-71-8	Dichlorodifluoromethane	3.4E+05		**3.4E+05**				1.3E+08		**1.3E+08**	3.4E+05	
84-66-2	Diethyl phthalate	1.4E+06		**1.4E+06**	2.1E+06		**2.1E+06**				8.2E+05	
60-57-1	Dieldrin	8.5E+01	3.0E+00	**3.0E+00**	1.3E+02	4.5E+00	**4.5E+00**		2.4E+05	**2.4E+05**	5.1E+01	1.8E+00
88-85-7	Dinoseb	1.7E+03		**1.7E+03**	2.6E+03		**2.6E+03**				1.0E+03	
1746-01-6	Dioxin-Like Compounds - TEQ	1.7E-03	3.7E-04	**3.7E-04**	8.6E-03	1.9E-03	**1.9E-03**	1.6E+03	2.9E+01	**2.9E+01**	1.4E-03	3.1E-04
115-29-7	Endosulfan	1.0E+04		**1.0E+04**	1.5E+04		**1.5E+04**				6.2E+03	
72-20-8	Endrin	5.1E+02		**5.1E+02**	7.7E+02		**7.7E+02**				3.1E+02	
100-41-4	Ethylbenzene	1.7E+05	4.3E+03	**4.3E+03**				1.1E+08	1.2E+07	**1.2E+07**	1.7E+05	4.3E+03
106-93-4	Ethylene dibromide	1.5E+04	2.4E+01	**2.4E+01**				4.5E+05	2.3E+03	**2.3E+03**	1.5E+04	2.4E+01
75-00-3	Ethyl chloride	1.7E+04		**1.7E+04**				3.5E+11		**3.5E+11**	1.7E+04	
206-44-0	Fluoranthene	6.8E+04		**6.8E+04**	7.9E+04		**7.9E+04**				3.7E+04	
86-73-7	Fluorene	6.8E+04		**6.8E+04**	7.9E+04		**7.9E+04**	3.2E+07		**3.2E+07**	3.7E+04	
76-44-8	Heptachlor	1.7E+01	1.1E+01	**1.1E+01**	2.6E+01	1.6E+01	**1.6E+01**		8.6E+05	**8.6E+05**	1.0E+01	6.4E+00
1024-57-3	Heptachlor epoxide	2.2E+01	5.2E+00	**5.2E+00**	3.4E+01	7.9E+00	**7.9E+00**		4.3E+05	**4.3E+05**	1.3E+01	3.2E+00
118-74-1	Hexachlorobenzene	1.4E+03	3.0E+01	**3.0E+01**	2.1E+03	4.5E+01	**4.5E+01**		2.4E+06	**2.4E+06**	8.2E+02	1.8E+01
87-68-3	Hexachlorobutadiene	1.7E+03	6.1E+02	**6.1E+02**	2.6E+03	9.3E+02	**9.3E+02**		5.1E+07	**5.1E+07**	1.0E+03	3.7E+02
319-84-6	Hexachlorocyclohexane, alpha (alpha-BHC)	1.4E+04	7.6E+00	**7.6E+00**	2.1E+04	1.1E+01	**1.1E+01**		6.2E+05	**6.2E+05**	8.2E+03	4.6E+00
319-85-7	Hexachlorocyclohexane, beta (beta-BHC)	1.0E+02	2.6E+01	**2.6E+01**	1.5E+02	4.0E+01	**4.0E+01**		2.1E+06	**2.1E+06**	6.2E+01	1.6E+01
58-89-9	Hexachlorocyclohexane, gamma (Lindane)	6.8E+00	4.3E+01	**6.8E+00**	2.6E+01	1.6E+02	**2.6E+01**		3.6E+06	**3.6E+06**	5.4E+00	3.4E+01

67-72-1	Hexachloroethane	1.7E+03	3.4E+03	**1.7E+03**	2.6E+03	5.2E+03	**2.6E+03**		2.8E+08	**2.8E+08**	1.0E+03	2.1E+03
121-82-4	Hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX)	5.1E+03	4.3E+02	**4.3E+02**	7.7E+03	6.6E+02	**6.6E+02**				3.1E+03	2.6E+02
193-39-5	Indeno(1,2,3-cd)pyrene		6.5E+01	**6.5E+01**		7.6E+01	**7.6E+01**		1.0E+07	**1.0E+07**		3.5E+01
7439-89-6	Iron	1.2E+06		**1.2E+06**							1.2E+06	
7439-92-1	Lead		5.6E+03	**5.6E+03**					9.3E+07	**9.3E+07**	1.1E+03	5.6E+03
121-75-5	Malathion	3.4E+04		**3.4E+04**	5.2E+04		**5.2E+04**	7.9E+07		**7.9E+07**	2.1E+04	
7439-96-5	Manganese	4.1E+04		**4.1E+04**				2.0E+06		**2.0E+06**	4.0E+04	
7487-94-7	Mercuric chloride & other inorganic mercury compounds	5.1E+02		**5.1E+02**							5.1E+02	
72-43-5	Methoxychlor	8.5E+03		**8.5E+03**	1.3E+04		**1.3E+04**				5.1E+03	
78-93-3	Methyl ethyl ketone	1.0E+06		**1.0E+06**				1.7E+11		**1.7E+11**	1.0E+06	
108-10-1	Methyl isobutyl ketone	1.4E+05		**1.4E+05**				1.0E+11		**1.0E+11**	1.4E+05	
80-62-6	Methyl methacrylate	2.4E+06		**2.4E+06**				2.4E+10		**2.4E+10**	2.4E+06	
1634-04-4	Methyl tert-butyl ether	5.1E+04	2.6E+04	**2.6E+04**				1.0E+11	3.8E+09	**3.8E+09**	5.1E+04	2.6E+04
75-09-2	Methylene chloride	1.0E+05	6.4E+03	**6.4E+03**				3.8E+10	2.1E+09	**2.1E+09**	1.0E+05	6.4E+03
7439-98-7	Molybdenum	8.5E+03		**8.5E+03**				4.8E+08		**4.8E+08**	8.5E+03	
106-94-5	n-Propyl bromide	2.4E+03		**2.4E+03**				2.3E+06		**2.3E+06**	2.4E+03	
91-20-3	Naphthalene	3.4E+04		**3.4E+04**	4.0E+04		**4.0E+04**	1.9E+07	5.2E+06	**5.2E+06**	1.8E+04	5.2E+06
7440-2-0	Nickel	5.1E+03		**5.1E+03**				3.6E+06	4.3E+06	**3.6E+06**	5.1E+03	4.3E+06
2691-41-0	Octahydro-1,3,5,7-tetranitro-1,3,5,7-tetra (HMX)	8.5E+04		**8.5E+04**	1.3E+05		**1.3E+05**				5.1E+04	
56-38-2	Parathion	1.0E+04		**1.0E+04**	1.5E+04		**1.5E+04**				6.2E+03	
1336-36-3	PCBs	3.4E+01	2.4E+01	**2.4E+01**	3.7E+01	2.6E+01	**2.6E+01**		2.0E+06	**2.0E+06**	1.8E+01	1.2E+01
87-86-5	Pentachlorophenol	8.5E+03	1.2E+02	**1.2E+02**	5.2E+03	7.2E+01	**7.2E+01**				3.2E+03	4.5E+01
14797-73-0	Perchlorate	2.0E+02		**2.0E+02**							2.0E+02	
85-01-8	Phenanthrene	5.1E+04		**5.1E+04**	6.0E+04		**6.0E+04**	1.8E+06		**1.8E+06**	2.7E+04	
108-95-2	Phenol	5.1E+05		**5.1E+05**	7.7E+05		**7.7E+05**	7.9E+09		**7.9E+09**	3.1E+05	
129-00-0	Pyrene	5.1E+04		**5.1E+04**	6.0E+04		**6.0E+04**				2.8E+04	
7782-49-2	Selenium	8.5E+03		**8.5E+03**				7.9E+08		**7.9E+08**	8.5E+03	
7440-22-4	Silver	8.5E+03		**8.5E+03**							8.5E+03	
100-42-5	Styrene	3.4E+05		**3.4E+05**				1.0E+10		**1.0E+10**	3.4E+05	
127-18-4	Tetrachloroethene	1.7E+04	8.8E+01	**8.8E+01**				3.0E+07	5.2E+05	**5.2E+05**	1.7E+04	8.8E+01
298-2-2	Thimet (Phorate)	3.4E+02		**3.4E+02**	5.2E+02		**5.2E+02**				2.1E+02	
108-88-3	Toluene	1.4E+05		**1.4E+05**				1.7E+11		**1.7E+11**	1.4E+05	
79-1-6	Trichloroethene		8.1E+03	**8.1E+03**				5.3E+07	1.2E+06	**1.2E+06**	5.3E+07	8.0E+03
75-69-4	Trichlorofluoromethane	5.1E+05		**5.1E+05**				1.3E+08		**1.3E+08**	5.1E+05	
7440-62-2	Vanadium	1.2E+04		**1.2E+04**							1.2E+04	
108-05-4	Vinyl acetate	1.7E+06		**1.7E+06**				7.0E+09		**7.0E+09**	1.7E+06	

75-1-4	Vinyl chloride	5.1E+03	6.6E+01	**6.6E+01**				6.4E+06	4.1E+06	**4.1E+06**	5.1E+03	6.6E+01
1330-20-7	Xylene	3.4E+05		**3.4E+05**				3.5E+09		**3.5E+09**	3.4E+05	
7440-66-6	Zinc	5.1E+05		**5.1E+05**							5.1E+05	

Value is greater than the ceiling value of 10,000 mg/kg. The ceiling value should be used as the cumulative soil guideline for this compound.

Table 5 (A) - Remedial Action Guidelines for Excavation/Construction Worker Scenario (mg/kg) - 5/17/2011 (ILCR=1E-05; HQ=1)

CAS Number	Chemical	Soil Ingestion - Noncarcinogenic	Soil Ingestion - Carcinogenic	**Soil Ingestion - RAGs**	Soil Dermal - Noncarcinogenic	Soil Dermal - Carcinogenic	**Soil Dermal - RAGS**	Soil Inhalation - Noncarcinogenic	Soil Inhalation - Carcinogenic	**Soil Inhalation - RAGs**	Soil Cumulative - Noncarcinogenic	Soil Cumulative - Carcinogenic
630-20-6	1,1,1,2-Tetrachloroethane	9.3E+03	1.7E+04	**9.3E+03**					9.9E+08	**9.9E+08**	9.3E+03	1.7E+04
79-34-5	1,1,2,2-Tetrachloroethane	1.5E+04	2.2E+03	**2.2E+03**							1.5E+04	2.2E+03
71-55-6	1,1,1-Trichloroethane	2.2E+06		**2.2E+06**				7.1E+06		**7.1E+06**	1.7E+06	
79-00-5	1,1,2-Trichloroethane	1.2E+04	7.6E+03	**7.6E+03**					1.9E+04	**1.9E+04**	1.2E+04	5.4E+03
92-52-4	1,1-Biphenyl	1.5E+04		**1.5E+04**							1.5E+04	
75-34-3	1,1-Dichloroethane	6.2E+05	7.6E+04	**7.6E+04**				1.5E+07	2.6E+06	**2.6E+06**	5.9E+05	7.4E+04
75-35-4	1,1-Dichloroethene	1.5E+04		**1.5E+04**				1.4E+06		**1.4E+06**	1.5E+04	
87-61-6	1,2,3-Trichlorobenzene	3.1E+03		**3.1E+03**				4.9E+02		**4.9E+02**	4.2E+02	
120-82-1	1,2,4-Trichlorobenzene	3.1E+03	1.5E+04	**3.1E+03**				5.0E+02		**5.0E+02**	4.3E+02	1.5E+04
96-12-8	1,2-Dibromo-3-chloropropane	6.2E+02	5.4E+02	**5.4E+02**				7.8E+02	9.1E+01	**9.1E+01**	3.5E+02	7.8E+01
95-50-1	1,2-Dichlorobenzene	1.9E+05		**1.9E+05**				7.2E+05		**7.2E+05**	1.5E+05	
107-06-2	1,2-Dichloroethane	6.2E+04	4.8E+03	**4.8E+03**				7.4E+05	1.7E+04	**1.7E+04**	5.7E+04	3.7E+03
156-59-2	1,2-Dichloroethene (cis)	6.2E+03		**6.2E+03**				1.5E+06		**1.5E+06**	6.2E+03	
156-60-5	1,2-Dichloroethene (trans)	6.2E+04		**6.2E+04**				1.5E+06		**1.5E+06**	5.9E+04	
78-87-5	1,2-Dichloropropane	2.2E+04	1.2E+04	**1.2E+04**				6.8E+03	3.2E+04	**6.8E+03**	5.2E+03	8.7E+03
528-29-0	1,2-Dinitrobenzene	3.1E+02		**3.1E+02**	1.0E+03		**1.0E+03**				2.4E+02	
106-99-0	1,3-Butadiene		1.3E+02	**1.3E+02**				1.0E+07	2.4E+08	**1.0E+07**	1.0E+07	1.3E+02
541-73-1	1,3-Dichlorobenzene	6.2E+03		**6.2E+03**							6.2E+03	
142-28-9	1,3-Dichloropropane	6.2E+04		**6.2E+04**							6.2E+04	
542-75-6	1,3-Dichloropropene	1.2E+04	4.3E+03	**4.3E+03**				2.1E+08	1.8E+09	**2.1E+08**	1.2E+04	4.3E+03
99-65-0	1,3-Dinitrobenzene	1.5E+02		**1.5E+02**	5.2E+02		**5.2E+02**				1.2E+02	
106-46-7	1,4-Dichlorobenzene	2.2E+04	8.0E+04	**2.2E+04**				4.4E+05	4.6E+04	**4.6E+04**	2.1E+04	2.9E+04
100-25-4	1,4-Dinitrobenzene	3.1E+02		**3.1E+02**	1.0E+03		**1.0E+03**				2.4E+02	
123-91-1	1,4-Dioxane	9.3E+03	4.3E+03	**4.3E+03**	3.1E+04	1.4E+04	**1.4E+04**	1.8E+10		**1.8E+10**	7.1E+03	3.3E+03
93-76-5	2,4,5-T	3.1E+04		**3.1E+04**	1.0E+05		**1.0E+05**				2.4E+04	
93-72-1	2,4,5-TP	2.5E+03		**2.5E+03**	8.3E+03		**8.3E+03**				1.9E+03	
95-95-4	2,4,5-Trichlorophenol	3.1E+05		**3.1E+05**	1.0E+06		**1.0E+06**				2.4E+05	
88-06-2	2,4,6-Trichlorophenol	3.1E+02	3.9E+04	**3.1E+02**	1.0E+03	1.3E+05	**1.0E+03**		2.7E+09	**2.7E+09**	2.4E+02	3.0E+04
118-96-7	2,4,6-Trinitrotoluene	1.5E+02	1.4E+04	**1.5E+02**	5.2E+02	4.8E+04	**5.2E+02**				1.2E+02	1.1E+04
120-83-2	2,4-Dichlorophenol	9.3E+02		**9.3E+02**	3.1E+03		**3.1E+03**				7.1E+02	
105-67-9	2,4-Dimethylphenol	1.5E+04		**1.5E+04**	5.2E+04		**5.2E+04**				1.2E+04	
51-28-5	2,4-Dinitrophenol	6.2E+03		**6.2E+03**	2.1E+04		**2.1E+04**				4.8E+03	
121-14-2	2,4-Dinitrotoluene	6.2E+02	1.4E+03	**6.2E+02**	2.1E+03	4.7E+03	**2.1E+03**		9.4E+07	**9.4E+07**	4.8E+02	1.1E+03

576-26-1	2,6-Dimethylphenol	1.9E+03		**1.9E+03**	6.2E+03		**6.2E+03**				1.4E+03	
606-20-2	2,6-Dinitrotoluene	1.2E+03	6.4E+02	**6.4E+02**	4.1E+03	2.1E+03	**2.1E+03**		9.4E+07	**9.4E+07**	9.5E+02	4.9E+02
95-57-8	2-Chlorophenol	2.5E+03		**2.5E+03**							2.5E+03	
95-48-7	2-Cresol	3.1E+04		**3.1E+04**	1.0E+05		**1.0E+05**	1.1E+10		**1.1E+10**	2.4E+04	
91-57-6	2-Methylnaphthalene	1.2E+03		**1.2E+03**	3.2E+03		**3.2E+03**	1.9E+03		**1.9E+03**	6.0E+02	
91-94-1	3,3-Dichlorobenzidine		9.6E+02	**9.6E+02**		3.2E+03	**3.2E+03**		2.5E+07	**2.5E+07**		7.4E+02
108-39-4	3-Cresol	3.1E+04		**3.1E+04**	1.0E+05		**1.0E+05**	1.1E+10		**1.1E+10**	2.4E+04	
106-47-8	4-Chloroaniline	1.5E+02	2.2E+03	**1.5E+02**	5.2E+02	7.2E+03	**5.2E+02**				1.2E+02	1.7E+03
106-44-5	4-Cresol	3.1E+04		**3.1E+04**	1.0E+05		**1.0E+05**	1.1E+10		**1.1E+10**	2.4E+04	
83-32-9	Acenaphthene	1.9E+05		**1.9E+05**	4.8E+05		**4.8E+05**	1.1E+04		**1.1E+04**	9.8E+03	
208-96-8	Acenaphthylene	1.9E+05		**1.9E+05**	4.8E+05		**4.8E+05**	1.3E+05		**1.3E+05**	6.5E+04	
67-64-1	Acetone	6.2E+05		**6.2E+05**				1.6E+11		**1.6E+11**	6.2E+05	
107-02-8	Acrolein	1.2E+03		**1.2E+03**				1.8E+07		**1.8E+07**	1.2E+03	
107-13-1	Acrylonitrile	3.1E+03	8.0E+02	**8.0E+02**				1.0E+07	1.1E+08	**1.0E+07**	3.1E+03	8.0E+02
15972-60-8	Alachlor	3.1E+03	7.7E+03	**3.1E+03**	1.0E+04	2.6E+04	**1.0E+04**				2.4E+03	6.0E+03
309-00-2	Aldrin	1.2E+01	2.6E+01	**1.2E+01**	4.1E+01	8.5E+01	**4.1E+01**		1.7E+06	**1.7E+06**	9.5E+00	2.0E+01
107-05-1	Allyl chloride		2.1E+04	**2.1E+04**				1.0E+04	2.4E+05	**1.0E+04**	1.0E+04	1.9E+04
7429-90-5	Aluminum	3.1E+05		**3.1E+05**				3.0E+07		**3.0E+07**	3.1E+05	
120-12-7	Anthracene	3.1E+06		**3.1E+06**	7.9E+06		**7.9E+06**	3.8E+03		**3.8E+03**	3.8E+03	
7440-36-0	Antimony	1.2E+02		**1.2E+02**							1.2E+02	
12674-11-2	Aroclor 1016	6.5E+01	2.2E+02	**6.5E+01**	1.5E+02	5.2E+02	**1.5E+02**		1.5E+07	**1.5E+07**	4.6E+01	1.5E+02
7440-38-2	Arsenic	9.3E+01	4.6E+01	**4.6E+01**	1.0E+03	5.1E+02	**5.1E+02**	8.9E+04	2.5E+06	**8.9E+04**	8.5E+01	4.2E+01
1912-24-9	Atrazine	9.3E+02	1.9E+03	**9.3E+02**	3.1E+03	6.3E+03	**3.1E+03**				7.1E+02	1.5E+03
7440-39-3	Barium	6.2E+04		**6.2E+04**							6.2E+04	
71-43-2	Benzene	1.5E+02	7.9E+03	**1.5E+02**				1.0E+08	9.4E+08	**1.0E+08**	1.5E+02	7.9E+03
56-55-3	Benzo(a)anthracene		5.9E+02	**5.9E+02**		1.5E+03	**1.5E+03**		7.6E+07	**7.6E+07**		4.3E+02
50-32-8	Benzo(a)pyrene		5.9E+01	**5.9E+01**		1.5E+02	**1.5E+02**		7.6E+06	**7.6E+06**		4.3E+01
205-99-2	Benzo(b)fluoranthene		5.9E+02	**5.9E+02**		1.5E+03	**1.5E+03**		7.6E+07	**7.6E+07**		4.3E+02
191-24-2	Benzo(g,h,i)perylene	9.3E+04		**9.3E+04**	2.4E+05		**2.4E+05**				6.7E+04	
207-08-9	Benzo(k)fluoranthene		5.9E+03	**5.9E+03**		1.5E+04	**1.5E+04**		7.6E+07	**7.6E+07**		4.3E+03
100-44-7	Benzyl chloride	6.2E+02	2.6E+03	**6.2E+02**				5.2E+06	1.5E+08	**5.2E+06**	6.2E+02	2.6E+03
7440-41-7	Beryllium	6.2E+02		**6.2E+02**				1.2E+05	3.5E+06	**1.2E+05**	6.2E+02	3.5E+06
117-81-7	bis(2-Ethylhexyl)phthalate	3.1E+04	3.1E+04	**3.1E+04**	1.0E+05	1.0E+05	**1.0E+05**		3.5E+09	**3.5E+09**	2.4E+04	2.4E+04
75-27-4	Bromodichloromethane	6.2E+03	7.0E+03	**6.2E+03**					2.0E+04	**2.0E+04**	6.2E+03	5.2E+03
75-25-2	Bromoform	6.2E+04	5.5E+04	**5.5E+04**	2.1E+05	1.8E+05	**1.8E+05**		7.6E+09	**7.6E+09**	4.8E+04	4.2E+04
74-83-9	Bromomethane	9.3E+02		**9.3E+02**				8.9E+06		**8.9E+06**	9.3E+02	
85-68-7	Butyl benzyl phthalate	6.2E+05	2.3E+05	**2.3E+05**	2.1E+06	7.6E+05	**7.6E+05**				4.8E+05	1.8E+05

7440-43-9	Cadmium	2.2E+01		**2.2E+01**	1.8E+02		**1.8E+02**	3.0E+05	4.6E+06	**3.0E+05**	1.9E+01	4.6E+06	
75-15-0	Carbon disulfide	3.1E+04		**3.1E+04**				3.5E+06		**3.5E+06**	3.1E+04		
56-23-5	Carbon tetrachloride	3.1E+03	6.2E+03	**3.1E+03**				2.5E+04	5.9E+04	**2.5E+04**	2.8E+03	5.6E+03	
57-74-9	Chlordane	1.9E+02	1.2E+03	**1.9E+02**	1.5E+03	1.0E+04	**1.5E+03**	4.2E+07	8.3E+07	**4.2E+07**	1.7E+02	1.1E+03	
108-90-7	Chlorobenzene	1.2E+05		**1.2E+05**				9.4E+05		**9.4E+05**	1.1E+05		
67-66-3	Chloroform	3.1E+04	1.4E+04	**1.4E+04**				4.5E+05	1.1E+05	**1.1E+05**	2.9E+04	1.2E+04	
16065-83-1	Chromium (+3)	4.6E+05		**4.6E+05**							4.6E+05		
18540-29-9	Chromium (+6)	2.8E+03		**2.8E+03**				6.0E+06	6.9E+05	**6.9E+05**	2.8E+03	6.9E+05	
218-01-9	Chrysene		5.9E+04	**5.9E+04**		1.5E+05	**1.5E+05**		7.6E+08	**7.6E+08**		4.3E+04	
7440-48-4	Cobalt	9.3E+02		**9.3E+02**				1.2E+05	9.3E+05	**1.2E+05**	9.2E+02	9.3E+05	
7440-50-8	Copper	4.3E+03		**4.3E+03**				6.0E+06		**6.0E+06**	4.3E+03		
57-12-5	Cyanide	1.9E+03		**1.9E+03**				1.2E+07		**1.2E+07**	1.9E+03		
72-54-8	DDD		1.8E+03	**1.8E+03**		6.0E+03	**6.0E+03**		1.2E+08	**1.2E+08**		1.4E+03	
72-55-9	DDE		1.3E+03	**1.3E+03**		4.3E+03	**4.3E+03**		8.6E+07	**8.6E+07**		9.8E+02	
50-29-3	DDT	1.5E+02	1.3E+03	**1.5E+02**	1.7E+03	1.4E+04	**1.7E+03**		8.6E+07	**8.6E+07**	1.4E+02	1.2E+03	
53-70-3	Dibenz(a,h)anthracene		5.9E+01	**5.9E+01**		1.5E+02	**1.5E+02**		6.9E+06	**6.9E+06**		4.3E+01	
124-48-1	Dibromochloromethane	6.2E+04	5.2E+03	**5.2E+03**					2.5E+04	**2.5E+04**	6.2E+04	4.3E+03	
84-74-2	Dibutyl phthalate	3.1E+04		**3.1E+04**	1.0E+05		**1.0E+05**				2.4E+04		
75-71-8	Dichlorodifluoromethane	6.2E+04		**6.2E+04**				3.3E+07		**3.3E+07**	6.2E+04		
84-66-2	Diethyl phthalate	1.9E+06		**1.9E+06**	6.2E+06		**6.2E+06**				1.4E+06		
60-57-1	Dieldrin	3.1E+01	2.7E+01	**2.7E+01**	1.0E+02	9.0E+01	**9.0E+01**		1.8E+06	**1.8E+06**	2.4E+01	2.1E+01	
88-85-7	Dinoseb	3.1E+02		**3.1E+02**	1.0E+03		**1.0E+03**				2.4E+02		
1746-01-6	Dioxin-Like Compounds - TEQ	6.2E-03	3.3E-03	**3.3E-03**	6.9E-02	3.7E-02	**3.7E-02**	2.4E+02	2.2E+02	**2.2E+02**	5.7E-03	3.1E-03	
115-29-7	Endosulfan	1.9E+03		**1.9E+03**	6.2E+03		**6.2E+03**				1.4E+03		
72-20-8	Endrin	6.2E+02		**6.2E+02**	2.1E+03		**2.1E+03**				4.8E+02		
100-41-4	Ethylbenzene	1.2E+05	3.9E+04	**3.9E+04**				4.7E+07	3.0E+06	**3.0E+06**	1.2E+05	3.9E+04	
106-93-4	Ethylene dibromide	2.8E+03	2.2E+02	**2.2E+02**				2.2E+03	5.6E+02	**5.6E+02**	1.2E+03	1.6E+02	
75-00-3	Ethyl chloride	3.1E+04		**3.1E+04**				5.2E+10		**5.2E+10**	3.1E+04		
206-44-0	Fluoranthene	1.2E+05		**1.2E+05**	3.2E+05		**3.2E+05**				8.9E+04		
86-73-7	Fluorene	1.2E+05		**1.2E+05**	3.2E+05		**3.2E+05**	1.6E+07		**1.6E+07**	8.9E+04		
76-44-8	Heptachlor	3.1E+01	9.6E+01	**3.1E+01**	1.0E+02	3.2E+02	**1.0E+02**		6.4E+06	**6.4E+06**	2.4E+01	7.4E+01	
1024-57-3	Heptachlor epoxide	4.0E+00	4.8E+01	**4.0E+00**	1.3E+01	1.6E+02	**1.3E+01**		3.2E+06	**3.2E+06**	3.1E+00	3.7E+01	
118-74-1	Hexachlorobenzene	3.1E+01	2.7E+02	**3.1E+01**	1.0E+02	9.0E+02	**1.0E+02**		1.8E+07	**1.8E+07**	2.4E+01	2.1E+02	
87-68-3	Hexachlorobutadiene	3.1E+02	5.6E+03	**3.1E+02**	1.0E+03	1.9E+04	**1.0E+03**		3.8E+08	**3.8E+08**	2.4E+02	4.3E+03	
319-84-6	Hexachlorocyclohexane, alpha (alpha-BHC)	2.5E+03	6.9E+01	**6.9E+01**	8.3E+03	2.3E+02	**2.3E+02**		4.6E+06	**4.6E+06**	1.9E+03	5.3E+01	
319-85-7	Hexachlorocyclohexane, beta (beta-BHC)	1.9E+02	2.4E+02	**1.9E+02**	6.2E+02	8.0E+02	**6.2E+02**		1.6E+07	**1.6E+07**	1.4E+02	1.9E+02	
58-89-9	Hexachlorocyclohexane, gamma (Lindane)	3.1E+00	3.9E+02	**3.1E+00**	2.6E+01	3.3E+03	**2.6E+01**		2.7E+07	**2.7E+07**	2.8E+00	3.5E+02	

67-72-1	Hexachloroethane	3.1E+03	3.1E+04	**3.1E+03**	1.0E+04	1.0E+05	**1.0E+04**		2.1E+09	**2.1E+09**	2.4E+03	2.4E+04
121-82-4	Hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX)	9.3E+03	3.9E+03	**3.9E+03**	3.1E+04	1.3E+04	**1.3E+04**				7.1E+03	3.0E+03
193-39-5	Indeno(1,2,3-cd)pyrene		5.9E+02	**5.9E+02**		1.5E+03	**1.5E+03**		7.6E+07	**7.6E+07**		4.3E+02
7439-89-6	Iron	2.2E+05		**2.2E+05**							2.2E+05	
7439-92-1	Lead		5.1E+04	**5.1E+04**					6.9E+08	**6.9E+08**	9.5E+02	5.1E+04
121-75-5	Malathion	6.2E+03		**6.2E+03**	2.1E+04		**2.1E+04**	1.2E+08		**1.2E+08**	4.8E+03	
7439-96-5	Manganese	7.4E+03		**7.4E+03**				8.9E+05		**8.9E+05**	7.4E+03	
7487-94-7	Mercuric chloride & other inorganic mercury compounds	9.3E+02		**9.3E+02**							9.3E+02	
72-43-5	Methoxychlor	1.5E+03		**1.5E+03**	5.2E+03		**5.2E+03**				1.2E+03	
78-93-3	Methyl ethyl ketone	1.9E+05		**1.9E+05**				2.6E+10		**2.6E+10**	1.9E+05	
108-10-1	Methyl isobutyl ketone	2.5E+05		**2.5E+05**				1.6E+10		**1.6E+10**	2.5E+05	
80-62-6	Methyl methacrylate	4.3E+05		**4.3E+05**				3.7E+09		**3.7E+09**	4.3E+05	
1634-04-4	Methyl tert-butyl ether	9.3E+04	2.4E+05	**9.3E+04**				1.6E+10	2.8E+10	**1.6E+10**	9.3E+04	2.4E+05
75-09-2	Methylene chloride	1.9E+04	5.8E+04	**1.9E+04**				5.8E+09	1.6E+10	**5.8E+09**	1.9E+04	5.8E+04
7439-98-7	Molybdenum	1.5E+03		**1.5E+03**				7.1E+07		**7.1E+07**	1.5E+03	
106-94-5	n-Propyl bromide	9.3E+02		**9.3E+02**				9.0E+05		**9.0E+05**	9.3E+02	
91-20-3	Naphthalene	1.9E+05		**1.9E+05**	4.8E+05		**4.8E+05**	6.0E+05	8.3E+06	**6.0E+05**	1.1E+05	8.3E+06
7440-2-0	Nickel	9.3E+02		**9.3E+02**				1.2E+06	3.2E+07	**1.2E+06**	9.3E+02	3.2E+07
2691-41-0	Octahydro-1,3,5,7-tetranitro-1,3,5,7-tetra (HMX)	1.5E+04		**1.5E+04**	5.2E+04		**5.2E+04**				1.2E+04	
56-38-2	Parathion	1.9E+03		**1.9E+03**	6.2E+03		**6.2E+03**				1.4E+03	
1336-36-3	PCBs	9.3E+00	2.2E+02	**9.3E+00**	2.2E+01	5.2E+02	**2.2E+01**		1.5E+07	**1.5E+07**	6.5E+00	1.5E+02
87-86-5	Pentachlorophenol	1.5E+03	1.1E+03	**1.1E+03**	2.1E+03	1.4E+03	**1.4E+03**				8.8E+02	6.2E+02
14797-73-0	Perchlorate	3.7E+01		**3.7E+01**							3.7E+01	
85-01-8	Phenanthrene	9.3E+04		**9.3E+04**	2.4E+05		**2.4E+05**	1.0E+04		**1.0E+04**	8.9E+03	
108-95-2	Phenol	9.3E+04		**9.3E+04**	3.1E+05		**3.1E+05**	3.6E+09		**3.6E+09**	7.1E+04	
129-00-0	Pyrene	9.3E+04		**9.3E+04**	2.4E+05		**2.4E+05**				6.7E+04	
7782-49-2	Selenium	1.5E+03		**1.5E+03**				1.2E+08		**1.2E+08**	1.5E+03	
7440-22-4	Silver	1.5E+03		**1.5E+03**							1.5E+03	
100-42-5	Styrene	6.2E+05		**6.2E+05**				4.7E+09		**4.7E+09**	6.2E+05	
127-18-4	Tetrachloroethene	3.1E+04	8.0E+02	**8.0E+02**				2.0E+05	1.8E+05	**1.8E+05**	2.7E+04	8.0E+02
298-2-2	Thimet (Phorate)	6.2E+01		**6.2E+01**	2.1E+02		**2.1E+02**				4.8E+01	
108-88-3	Toluene	2.5E+05		**2.5E+05**				2.6E+10		**2.6E+10**	2.5E+05	
79-1-6	Trichloroethene		7.3E+04	**7.3E+04**				3.4E+05	4.0E+05	**3.4E+05**	3.4E+05	6.2E+04
75-69-4	Trichlorofluoromethane	9.3E+04		**9.3E+04**				1.0E+07		**1.0E+07**	9.2E+04	
7440-62-2	Vanadium	2.2E+03		**2.2E+03**							2.2E+03	
108-05-4	Vinyl acetate	3.1E+05		**3.1E+05**				1.0E+09		**1.0E+09**	3.1E+05	

75-1-4	Vinyl chloride	9.3E+02	6.0E+02	**6.0E+02**				1.0E+06	4.2E+06	**1.0E+06**	9.3E+02	6.0E+02
1330-20-7	Xylene	1.2E+05		**1.2E+05**				1.6E+09		**1.6E+09**	1.2E+05	
7440-66-6	Zinc	9.3E+04		**9.3E+04**							9.3E+04	

Value is greater than the ceiling value of 10,000 mg/kg. The ceiling value should be used as the cumulative soil guideline for this compound.

Appendix D

Development of Leaching Based Soil Guidelines.

Overview

The leaching based soil guidelines are designed to protect drinking water consumed from a well. The guideline marks the point above which leaching of the soil by rainwater will cause groundwater to be contaminated above the drinking water guidelines at the well. If the concentration in the soil is below the guideline, the soil may be left in place because leaching by rainwater will not contaminate the well above the drinking water remediation guidelines.

The leaching scenario was modeled using the SESOIL and AT123D models. SESOIL models downward transport in the soil zone above the water table and AT123D models the groundwater transport to the well which is the receptor or compliance point. A conservative approach was used in the creation of the scenario and selection of model parameters.

The guidelines developed from the models are generic and to be used for Tier 1 remediation decisions. The models may be used to develop more precise cleanup standards using site specific data at Tier 2 or Tier 3 decision making levels.

Model Selection

The model needed to be robust and relatively easy to use to develop the leaching based soil standards. SESOIL is a one dimensional compartmental model used to replicate the movement of water through the soil column and the transport of contaminants in the soil to the water table. It was created for EPA in 1984 by Bonazountas and Wagner[1.] and improved by Hetrick[2.] in 1989. It enables the user to apply site specific climate, soil and chemical release data. This gives it a great degree of versatility as it can be applied to sites with different soils and all regions of the state. Other states, including Oregon, California, Colorado, Wisconsin, New Hampshire and Massachusetts have used these models to establish leaching based soil standards. AT123D is a three dimensional semi analytical fate and transport groundwater flow model that is user friendly to set up and easy to link to SESOIL. It was developed by Yeh[3.] in 1981 at the Oak Ridge National Laboratory.

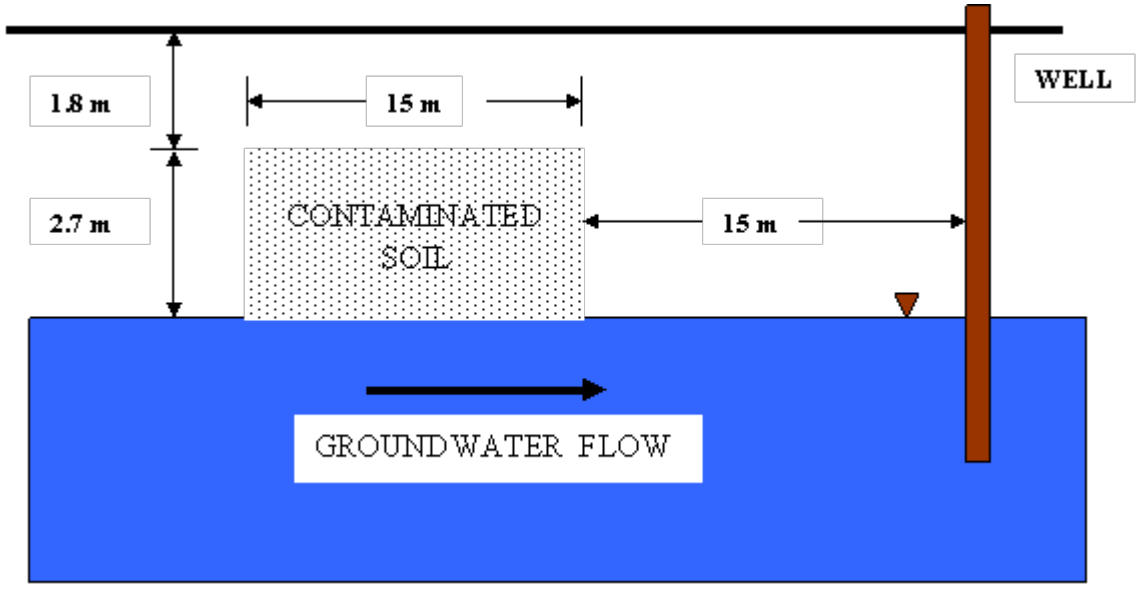
1. Bonazountas M. and J.M. Wagner, 1984, "SESOIL" A Seasonal Soil Compartment Model, Arthur D. Little, Inc. for U.S. Environmental Protection Agency, Office of Toxic Substances, Washington, DC. 555 pp.
2. Hetrick, D.M., C.C. Travis, S.K. Leonard and R.S. Kinerson, Qualitative Validation of Pollutant Transport Components of an Unsaturated Soil Zone Model (SESOIL). ORNL/TM-10672, Oak Ridge National Laboratory, Oak Ridge, TN, 42 pp.
3. Yeh, G.T., 1981, AT123D: Analytical Transient One-,Two-, and Three-Dimensional Simulation of Waste Transport in the Aquifer System. ORNL-5602, Oak Ridge National Laboratory, Oak Ridge, TN,

The models are programmed in FORTRAN, but recent interfaces have made them more user friendly. The SEVIEW interface developed by Robert Schneiker[4.] in 1993 is a helpful for tracking the results when you have a large number of runs to be made. It makes it easy to set up the scenarios and interpret the model results. The output is summarized in a series of reports that are easy to read and can be saved for future reference. SEVIEW version 6.3 was used to develop the guidelines.

Soil Leaching Scenario Conceptual Model

The conceptual model is based on a site where the groundwater table is located at a depth of 4.5 m (15 ft). Soil is contaminated from 1.8 m (6 ft) to the groundwater table. The cross-sectional area of contaminated soil is 750,000 cm^2 in a rectangular shape 15 m by 5 m. The receptor well is placed 15 m (50 ft) from the down flow edge of the contaminated soil.[5.] See Figure 1.

Fig. 1. Conceptual Site Model, Leaching Scenario.



The purpose of the model is to determine the ratio of soil contamination (C_s) to water contamination (C_w) at the receptor. A soil concentration is calculated from the drinking water standard (MEG) at the receptor to create a soil standard above which leaching of the soil would cause water contamination to exceed the MEG at the receptor. This becomes the cleanup standard. It does not matter what soil concentration is entered into

4. Schneiker, R., 2006, SEVIEW, Integrated Contaminant Transport and Fate Modeling System, Version 6.3, Madison, Wisconsin, 269 pp.
5. The model is scaled in meters. References to distances in feet are rounded to help the reader conceptualize the model

the model to determine the ratio (C_s/C_w), this ratio is not dependent on the magnitude of concentration.

The model is designed to develop a generic standard to be used at all sites where the bedrock is deeper than 20 ft. The conceptual model represents a worst case scenario. Hence contaminated soil is placed on the water table, the depth of contamination is based on an underground tank leak (not a surface spill) and the area of contamination is based on the cross-sectional area for a 15,000 gallon tank. The tank size was selected because 93% of the registered underground storage tanks in Maine are equal to or less than this size. The horizontal cross section of the tank is 8.98 m x 3.05 m which is rounded to 10 m x 3 m which has been enlarged by approximately 1.5 times to account for dispersion of the oil around the tank and smearing from seasonal changes in groundwater level. The final dimensions are 15 m x 5 m.

Soil Parameters

Soil parameters were selected to calibrate the hydrologic cycle in SESOIL to carefully estimated recharge rates at two sites in Maine (Gerber and Hebson[6].). One site is in a sand and gravel aquifer and the other in till. Two soil scenarios were modeled; one in sand and gravel, the other in till. The following section on the SESOIL vadose zone modeling explains this calibration in more detail.

The intrinsic permeability selected is based on values for hydraulic conductivity reported by Gerber and Hebson. Effective porosity was selected based on characteristic porosities for sand and gravel and till. The disconnectedness index was varied (within limits) to calibrate the model. It was limited to the range listed as default values by Bonazountas and Wagner (1984). This technique was used because intrinsic permeability and porosity are variables that can be measured in the field, but the disconnectedness index is not. Minor adjustments to intrinsic permeability and effective porosity had to be made to fine tune the calibration. Final values were within the variance of default values recommended for the model (Bonazountas and Wagner, 1984). Parameter values are shown in Table 1.

SESOIL – Vadose Zone model

Contaminants migrate from soil to the groundwater through the process of rainfall percolating through the soil, dissolving the contaminant mixed in the soil and transporting it to the water table. The SESOIL model replicates this process in two modules, the hydrologic cycle and the pollutant Fate cycle.

---

6. Gerber, R.G and C.S. Hebson, 1996, Ground Water Recharge Rates for Maine Soils and Bedrock, p. 23-52 in M. Loiselle, T.K.Weddle, C. White, Selected Papers on the Hydrogeology of Maine, Geological Society of Maine, Bulletin 4.

The hydrologic cycle is based on the work of Peter Eagleson [7.] who in 1978 published a series of papers that applied the concepts of soil physics to the problem of modeling the flow of water and air through the vadose zone (the soil zone above the water table). Precipitation has three outcomes. It flows off the surface as runoff, down through the soil to recharge groundwater or upward in the soil to be discharged to the atmosphere through evapotranspiration. These outcomes are controlled by the climate and the soil properties. Climate files put into the model, on a monthly basis, temperature, precipitation, amount and length of storms, cloud cover, albedo and humidity. Soil properties consist of density, intrinsic permeability, porosity, organic carbon content and soil pore disconnected index. The soil pore disconnectedness index is an exponent in the equation that calculates relative permeability of the soil/water/air flow system as a function of the soil type and the water saturation in the soil pores. Soil type is described by the soil pore disconnectedness index in the equation. Soils where pores are well connected have low values of the disconnectedness index and soils that have poorly connected pores have high values of the index. Sand and gravel aquifers are characterized by low values of the index and till aquifers have high values.

The hydrologic cycle is calibrated to recharge rates estimated from precipitation and flow date available for the aquifer to be modeled. Values of parameters that are measurable such as intrinsic permeability and effective porosity are selected for input and the soil pore disconnectedness index is varied until the groundwater recharge from the model matches the estimated recharge rate as closely as possible. It is important to do this calibration correctly because the fate of the pollutants in the soil is closely linked to flow characteristics of the water in the soil.

Two soil types are modeled for setting the leaching based standards: a sand and gravel soil and a till soil. Recharge rates used for the sand and gravel soil were estimated by Gerber and Hebson (1996)[.] from the Branch Brook aquifer in Kennebunk and Wells. Average recharge rate for this aquifer averaged 55% of precipitation. The estimated recharge rate for the till aquifer is 20% of precipitation, reported by Gerber and Hebson (1996) for a till in the little Androscoggin River north of South Paris from a study by Morrissey (1983)[8.]. Climate files from Sanford and Farmington developed from National Weather Service data were used. These locations are in the same weather zone as the sites where recharge estimates were made and in relatively close proximity.

The pollutant cycle models the movement and dilution of the chemicals in the soil based on advection, adsorption and volatilization of the chemical. Physical properties of the chemicals used are: solubility, Henry's law constant, organic carbon adsorption coefficient, molecular weight, air diffusion coefficient and water diffusion coefficient. Biodegradation rate was used where it was readily available.

---

7. Eagleson, P.S, 1978, Climate, Soil and Vegetation. Water Resources Research Vol. 14, No. 5, p. 705-778.
8. Morrissey, D.J., 1983, Hydrology of the Little Androscoggin River Valley Aquifer, Oxford County, Maine, U.S. Geological Survey Water-Resources Investigations 83-4018, Augusta, Maine

AT123D – Groundwater Segment

Aquifer parameters in AT123D are derived from the parameters used for the SESOIL model with the exception of gradient and dispersivities. A gradient of 0.005 has been used to represent an average of typical gradients in Maine. Dispersivity values are summarized in the table of parameters input to the model below. Hydraulic conductivity (cm/sec) has been converted from intrinsic permeability (cm^2)

Table 1. Model Parameters

Parameter	Sand & Gravel Scenario	Till Scenario
Soil Bulk Density	1.5 gm/cm^3	1.5 gm/cm^3
Effective Porosity	37 %	20%
Soil Pore Disconnectedness Index	5.5	11.0
Organic Carbon Content	0.002	0.002
Release Area	750,000 cm^2	750,000 cm^2
Volatilization Factor	1.00	1.00
Intrinsic Permeability	1×10^{-8} cm^2	3×10^{-10} cm^2
Hydraulic Conductivity	1×10^{-3} cm/sec	3×10^{-5} cm/sec
Gradient	0.005	0.005
Dispersivities	20/2/2	20/2/2

APPENDIX E

Assumptions and Technical Background for Modeling of Contaminant Volatilization from Soil

One of the human exposure routes considered in the derivation of soil remediation standards is the volatilization and transfer of volatile chemicals from contaminated soil to the atmosphere and breathing zone. The ***Volatilization Factor*** (VF), which relates a substance's concentration in soil to its concentration in the breathing zone, was one input to the Maine Center for Disease Control and Prevention's estimate of appropriate risk-based soil guidelines. This appendix describes the methodology and assumptions used to estimate the VF for the chemicals 0f concern in these remediation guidelines.

The concentration in air resulting from soil at a contaminated site depends upon 1) the rate at which a contaminant volatilizes from the surface; and 2) the degree to which it is dispersed between the surface and a receptor. These factors depend upon chemical-physical characteristics of the contaminant, soil characteristics, and site size, terrain, and meteorology. Contaminant concentration may also vary over time, as the source is depleted by biodegradation, leaching to groundwater, and volatilization. Contaminant concentration is estimated by modeling the volatilization and dispersion components separately and combining their effects.

Volatilization Rate

Volatilization rate was estimated using EMSOFT (Exposure Model for Soil-Organic Fate and Transport), developed in the late 1980's for the US Environmental Protection Agency (EPA) and based on the work of Jury, et.al. EMSOFT is an analytical model which calculates a contaminant ***flux rate*** (mass per unit area per unit time) through a thin stagnant air layer overlying a source. Mass transport is driven by diffusion only; that is, the concentration gradient through the contaminated soil depth, and then through the stagnant air layer. The contaminant diffuses through the soil's air- and water-filled pore spaces. Diffusion is retarded by the contaminant's tendency to partition into soil pore water and to sorb to the surfaces of soil particles. Contaminant characteristics which affect flux rate include its diffusivities in air and water, its Henry's Law constant, and its organic carbon partition coefficient. If a contaminant degradation rate in soil is available, this may be input as well. A more thorough discussion of EMSOFT can be found in the EMSOFT User's Guide (September, 2002), published by the EPA Office of Research and Development.

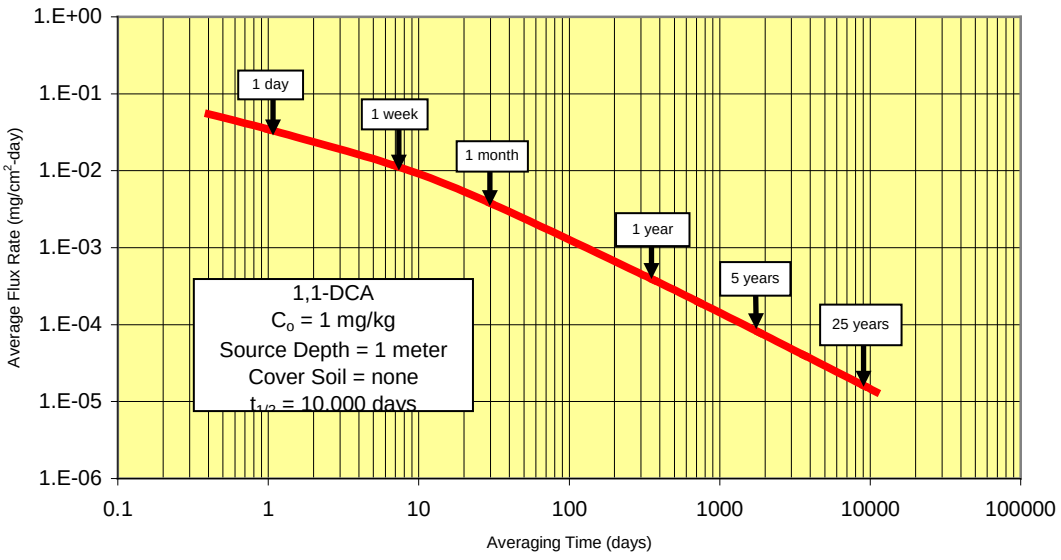
EMSOFT can calculate the flux rate from a source comprised of multiple soil layers. Soil layers may have different characteristics but each layer is assumed homogeneous in bulk density, air- and water-filled porosity, and organic carbon content. A contaminant concentration for each layer must be specified. No soil concentration can be modeled which would cause the pore water concentration to exceed the contaminant's solubility;

that is, no separate-phase contaminant (NAPL) can be present. EMSOFT will model the effect, if desired, of a single layer of clean soil of specified thickness overlying the source. Also, a net pore water flux – either upward into the source area or downward – can be specified. EMSOFT postulates a source that is depleted over time as contaminants volatilize from the soil, are leached to groundwater, or are biodegraded in place. This differs from previous modeling efforts, in which an “infinite source” – where contaminant concentration in soil and flux rate to the atmosphere remained constant over time – was assumed.

EMSOFT can calculate flux rates over user-specified averaging periods from less than a day to 250 years. EMSOFT outputs include the average flux rate over the entire period, and 100 instantaneous flux rates spread evenly across the selected period. EMSOFT can also produce the average contaminant concentration in each layer at the end of the averaging period, its average concentration at each 1/100th “time-step” of the period, and the final contaminant concentrations at each of fifty depths within the source.

Average flux rate varies with the duration of the averaging period. A high initial flux rate gradually decreases as contaminant is depleted from the shallow soils and is replaced at a slower rate by diffusion from deeper in the source. Figure 1 depicts the effect of averaging time upon average flux rate for a typical volatile organic compound (VOC).

Figure 1 - Flux Rate vs Averaging Time



In determining volatilization rates for the inhalation pathway, the following assumptions were made:

- Source Depth was assumed to be 1 meter. While contaminated soil is often found at greater depths, particularly at UST sites, long-term flux rates were not found to be significantly higher with deeper sources

- A Source Concentration of 1 mg/kg was used to facilitate later calculations.

- Soil Properties used were consistent with those in modeling contaminant leaching to groundwater. Air- and water-filled porosities used were 0.27 and 0.10, respectively. Soil bulk density was 1.5 gm/cm^3. A fractional organic carbon content of 0.006 was assumed.

- Clean Cover Soil. Flux rates were modeled assuming no clean cover soil present.

- Stagnant Air Layer. A 2 cm. stagnant air layer was assumed, based upon recommendation of the EMSOFT User Manual.

- A Net Porewater Flux Rate of zero was chosen. This is conservative, in that none of the contaminant mass is lost to groundwater.

- Contaminant Biodegradation Half-Life in soil was set at the high end of the literature range

- Henry's Law Constants were maintained at the 25^{o}C reference value, rather than adjusted to the 10^{o}C temperature characteristic of most soils. Since this constant decreases with decreasing temperature, using the reference temperature increases contaminant volatility and is a conservative assumption.

Finally, it was assumed that exposure would begin one year after the spill and would continue for an averaging period consistent with the exposure scenario: six months for the Excavation or Construction Worker, twenty-five years for the Outdoor Commercial Work or Recreational User, and thirty years for the Residential User. The one-year delay reflects the fact that invasive use of a site in many cases begins years following a spill, after off-gassing, leaching, and biodegradation have greatly reduced the high initial flux rate . Where exposure is known to begin immediately following the spill, the published RAGs values should not be relied upon without separately evaluating the risk due to inhalation, absent the delay.

Using these assumptions, the average flux rates for sixty-four priority pollutants and the six petroleum hydrocarbon VPH/EPH ranges were modeled over the averaging periods of one, twenty-five, and thirty years used, respectively, in the construction worker, recreational, and residential use exposure scenarios.

Contaminant Dispersion

Estimates of contaminant dispersion from an areal source were developed by EPA in the 1990s. Using the Industrial Source Complex 3-Dimensional – Short Term (ISC3-ST) protocol, EPA determined maximum contaminant concentrations in air resulting from unit contaminant concentrations in soil for sources between one-half and thirty acres in size. Separate estimates were made for twenty-nine metropolitan areas spread across the continental US, using meteorological and terrain data specific to each city. The data

were then reduced by regression analysis to equations relating concentration in air to source size for each city. A more detailed discussion of EPA's modeling approach can be found in "Soil Screening Guidance: User's Manual," (EPA/540-R-96/018; April, 1996), Appendix D and also EPA's "Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites," (OSWER 9355.4-24; December, 2002), Appendix D.

Portland, Maine was among the cities for which dispersion was modeled. EPA's modeling determined that for a setting having Portland, Maine meteorological conditions, a contaminant flux rate of 74.32 grams per square meter per second would be needed to produce a maximum concentration of 1 kilogram per cubic meter at the center of a half-acre source. The 74.32 gm/M^2-sec per kg/M^3 is the so-called ***dispersion factor*** for a half-acre site in Portland. It is a measure of how readily a site's meteorological setting disperses a volatilized substance. The larger the dispersion factor, the larger the flux rate required to produce the same concentration at a receptor. A large source area has a smaller dispersion factor because contaminant is volatilizing from more surface area in all directions from a "centered" receptor; thus a lower flux rate is needed to produce the same effect. Dispersion factors for sites of various sizes with Portland meteorology are as follows:

Source Area Size (acres)	Dispersion Factor (gm/M^2-sec per kg/M^3)
0.5	74.32
1	65.67
5	50.04
10	44.81
30	37.93

The one-half acre site size on which the volatilization factor was based reflects the area of soil contamination typical of many petroleum remediation projects. It is also consistent with the source size used by EPA in determining the particulate inhalation factor (PEF) for contaminants sorbed to airborne soil particles. Risk from inhalation of particulates was also evaluated but found to be trivial compared with the volatilization pathway.

Volatilization Factor

The **volatilization rate** (rate at which a contaminant is transferred from soil into the overlying air) and **dispersion factor** (rate at which vapor-phase contaminant is diluted before reaching a receptor) are finally combined to produce the ***volatilization factor,*** (VF). Simplified, the VF is the ratio of a contaminant concentration in soil (milligrams per kilogram) to its concentration in air at a receptor directly over the source area (milligrams per cubic meter). Higher VFs therefore indicate that higher contaminant concentrations in soil are needed to produce the same concentration in inhaled air. The Volatilization Factor is typically expressed in cubic meters per kilograms (M^3/kg).

The VF is combined with contaminant toxicity information, exposure duration and frequency, and receptor characteristics to produce the inhalation-based Remedial Action Goal (RAG) for a given contaminant. Risk assessment methodology for the inhalation pathway is presented in detail in Appendix C of the Remediation Guidelines.

APPENDIX F

Excerpts from Maine law regarding removal and clean up of oil discharges

Prohibition on oil discharges [38, Maine Revised Statutes, section 543]

The discharge of oil into or upon any coastal waters, estuaries, tidal flats, beaches and lands adjoining the seacoast of the State, or into or upon any lake, pond, river, stream, sewer, surface water drainage, ground water or other waters of the State or any public or private water supply or onto lands adjacent to, on, or over such waters of the State is prohibited.

Removal of discharges required [38, Maine Revised Statues, section 548]

Any person discharging or suffering the discharge of oil in the manner prohibited by section 543 shall immediately undertake to remove that discharge to the commissioner's satisfaction. Notwithstanding the above requirement, the commissioner may undertake the removal or cleanup of that discharge and may retain agents and contractors for those purposes who shall operate under the direction of the commissioner. The commissioner may implement remedies to restore or replace water supplies contaminated by a discharge of oil prohibited by section 543, including all discharges from interstate pipelines, using the most cost-effective alternative that is technologically feasible and reliable and that effectively mitigates or minimizes damages to, and provides adequate protection of, the public health, welfare and the environment. The commissioner may investigate and sample sites where an oil discharge has or may have occurred to identify the source and extent of the discharge. During the course of the investigation, the commissioner may require submission of information or documents that relate or may relate to the discharge under investigation from any person who the commissioner has reason to believe may be a responsible party...

Any unexplained discharge of oil within state jurisdiction or discharge of oil occurring in waters beyond state jurisdiction that for any reason penetrates within state jurisdiction must be removed by or under the direction of the commissioner...

Enforcement; penalties [38 Maine Revised Statutes, section 550]

Any person who causes or is responsible for a discharge in violation of section 543 is not subject to any fines or civil penalties if that person:

1. **Report and remove.** Reports within 2 hours and promptly removes the discharge in accordance with the rules and orders of the board or commissioner; and

2. **Reimburse.** Reimburses the department for any disbursement made from the fund in connection with the discharge pursuant to section 551, subsection 5, paragraph B within 30 days of demand.