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**N.J.A.C. 7:26D**

**REMEDIATION STANDARDS**

Statutory authority:

N.J.S.A. 13:1D-1 et seq., 58:10-23.11a et seq., 58:10A-1 et seq., and 58:10B-1 et seq.

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## **SUBCHAPTER 1 GENERAL INFORMATION**

### **7:26D-1.1 Purpose**

(a) This chapter implements the provisions of the Brownfield and Contaminated Site Remediation Act, N.J.S.A. 58:10B-1.1 et seq., and other statutes, by establishing minimum standards for the remediation of contaminated ground water and surface water, and by establishing the minimum residential direct contact and non-residential direct contact soil remediation standards.

(b) This chapter does not establish the minimum impact to ground water soil remediation standards; these standards shall be developed on a site-by-site basis, pursuant to the Department's authority under N.J.S.A. 58:10B-12a. 12a and the Department's Soil Remediation Standards Guidance for Impact to Ground Water available at [www.nj.gov/dep/srp/srra/regs/guidance.htm](http://www.nj.gov/dep/srp/srra/regs/guidance.htm).

(c) This chapter supplements the requirements in the Technical Requirements for Site Remediation rules, N.J.A.C. 7:26E.

### **7:26D-1.2 Scope**

(a) Except as provided in N.J.A.C. 7:26D-1.1(b) and unless otherwise provided by rule or statute, this chapter shall constitute the rules of the Department concerning minimum standards for the remediation of ground water, surface water and soil.

(b) Remediating ground water, surface water, or soil to any applicable standard set forth in this chapter shall not relieve any person from:

1. Complying with more stringent requirements or provisions imposed under any other Federal, State, or local applicable statutes or regulations; and
2. Complying with any impact to ground water soil remediation standard established by the Department as provided in N.J.A.C. 7:26D-1.1(b); and
3. Obtaining any and all permits required by Federal, State or local statutes or regulations.

(c) No provision of this chapter shall be construed to limit the Department's authority to require additional remediation based upon site-specific conditions in order to protect human health, safety and the environment.

(d) Nothing in this chapter shall be construed to limit the authority of the Department to establish discharge limits for pollutants, or to prescribe penalties for violations of those limits pursuant to any statutory authority, or to require the complete removal of any illegally discharged hazardous substances, hazardous waste, or pollutants pursuant to law.

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(e) The person responsible for conducting the remediation shall not be required to remediate to a level or concentration that is lower than the regional natural background level.

### **7:26D-1.3 Construction and severability**

(a) This chapter shall be liberally construed to permit the Department to effectuate the purposes of the statutes listed in N.J.A.C. 7:26D-1.4(a).

(b) If any subchapter, section, subsection, provision, clause, or portion of this chapter, or the application thereof to any person, is adjudged unconstitutional or invalid by a court of competent jurisdiction, such judgment shall be confined in its operation to the subchapter, section, subsection, provision, clause, portion, or application directly involved in the controversy in which such judgment shall have been rendered and it shall not affect or impair the remainder of this chapter or the application thereof to other persons.

### **7:26D-1.4 Applicability**

(a) Except as provided in N.J.A.C. 7:26D-1.1(b), this chapter establishes the minimum remediation standards for ground water, surface water and soil for any contaminated site in New Jersey including, without limitation, those sites subject to:

1. The Industrial Site Recovery Act (ISRA), N.J.S.A. 13:1K-6 et seq.;
2. The New Jersey Underground Storage of Hazardous Substances Act (UST), N.J.S.A. 58:10A-21 et seq.;
3. The Spill Compensation and Control Act, N.J.S.A. 58:10-23.11a et seq.;
4. The Solid Waste Management Act, N.J.S.A. 13:E-1 et seq.;
5. The Water Pollution Control Act, N.J.S.A. 58:10A-1 et seq.;
6. The Brownfield and Contaminated Site Remediation Act, N.J.S.A. 58:10B-1 et seq.;
7. The Comprehensive Regulated Medical Waste Management Act, N.J.S.A. 13:1E-48.1 et seq.;
8. The Major Hazardous Waste Facilities Siting Act, N.J.S.A. 13:1E-49 et seq.;
9. The Sanitary Landfill Facility Closure and Contingency Fund Act, N.J.S.A. 13:1E-100 et seq.; and
10. The Regional Low-Level Radioactive Waste Disposal Facility Siting Act, N.J.S.A. 13:1E-177 et seq.

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(b) The requirements of this chapter shall be applied pursuant to N.J.A.C. 7:26E-1.3(c) regardless of whether remediation is conducted with Department oversight pursuant to N.J.A.C. 7:26C.

(c) Notwithstanding any other provision of this chapter, all applicable remediation standards and remedial actions that involve real property located in the Pinelands area shall be consistent with the provisions of the Pinelands Protection Act, N.J.S.A. 13:18A-1 et seq., and any rules promulgated pursuant thereto, and with Section 502 of the National Parks and Recreation Act of 1978, 16 U.S.C. §4711.

### **7:26D-1.5 Definitions**

The following words and terms, when used in this chapter, shall have the following meanings unless the context clearly indicates otherwise:

“Alternative remediation standard” or “ARS” means a residential use or non-residential use soil remediation standard that is established using site specific factors following the procedures set forth in N.J.A.C. 7:26D-7 Appendices 5 and 6, pursuant to this chapter.

“Carcinogen” means a contaminant capable of inducing a cancer response, including Group A (Human Carcinogen), Group B (Probable Human Carcinogen) and Group C (Possible Human Carcinogen) categorized in accordance with the USEPA Guidelines for Carcinogen Risk Assessment, 51 Fed. Reg. 33932 (1986), as amended and supplemented.

“Contaminated site” means a contaminated site as defined pursuant to the Technical Requirements for Site Remediation rules at N.J.A.C. 7:26E-1.8.

“Contamination” or “contaminant” means contamination or a contaminant as defined pursuant to the Technical Requirements for Site Remediation rules at N.J.A.C. 7:26E-1.8.

“Department” means the New Jersey Department of Environmental Protection.

“Discharge” means a discharge as defined pursuant to the Technical Requirements for Site Remediation rules at N.J.A.C. 7:26E-1.8.

“Exposure pathways” means the methods by which humans can come into contact with contamination including, but not limited to, the ingestion-dermal exposure pathway and the inhalation exposure pathway.

“Ground water” means ground water as defined pursuant to the Ground Water Quality Standards at N.J.A.C. 7:9C-1.6, which includes Class I, Class II and Class III ground water.

“Ground water quality criteria” means any human health-based ground water quality criteria as defined pursuant to the Ground Water Quality Standards at N.J.A.C. 7:9C-1.6.

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“Impact to ground water remediation standard” means a vadose zone soil remediation standard established or developed by the Department pursuant to its authority under N.J.S.A. 58:10B-12a that is designed to limit the amount of contaminant that leaches from the vadose zone to ground water such that the resulting ground water concentration will not exceed the applicable ground water remediation standard.

“Ingestion-dermal exposure pathway” means the process by which humans can come into contact with contamination through the direct ingestion of contamination and the absorption of contamination through the skin.

“Inhalation exposure pathway” means the process by which humans can come into contact with contamination through the inhalation of contamination.

“Non-residential use” means an exposure assumption based on exposure of adult outdoor workers to contaminated media during an eight-hour work day, 225 days a year, for 25 years.

“Non-residential direct contact soil remediation standard” means a soil remediation standard for the ingestion-dermal and inhalation exposure pathways established or developed pursuant to this chapter that is designed to protect human health at non-residential use sites.

“Oversight document” means any document defined as an oversight document pursuant to the Department Oversight of the Remediation of Contaminated Sites rules at N.J.A.C. 7:26C-1.3.

“Person responsible for conducting the remediation” means the person responsible for conducting the remediation as defined pursuant to the Technical Requirements for Site Remediation rules at N.J.A.C. 7:26E-1.8.

“Person responsible for conducting the remediation” means any person defined as such pursuant to the Administrative Requirements for the Remediation of Contaminated Sites rules at N.J.A.C. 7:26C-1.3.

“Pollutant” means any substance defined as such pursuant to the Water Pollution Control Act, N.J.S.A. 58:10A-1 et seq.

“Practical quantitation level” or “PQL” means a practical quantitation level or PQL as defined pursuant to Technical Requirements for Site Remediation rules at N.J.A.C. 7:26E-1.8.

“Regional natural background level” means the concentration of a contaminant consistently present in the environment in the region of the site and which has not been influenced by localized human activities.

“Remediation” or “remediate” means remediation or remediate as defined pursuant to the Technical Requirements for Site Remediation rules at N.J.A.C. 7:26E-1.8.

“Remediation standards” means the combination of numeric standards that establish a level or concentration, and narrative standards, to which contaminants must be treated, removed or

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otherwise cleaned for soil, ground water or surface water, as established by the Department pursuant to the Brownfield and Contaminated Sites Remediation Act at N.J.S.A. 58:10B-12 and this chapter.

“Residential direct contact soil remediation standard” means a soil remediation standard for the ingestion-dermal and inhalation exposure pathways established or developed pursuant to this chapter that is designed to protect human health at residential use sites, schools (pre-K-12) and childcare centers.

“Residential use” means a land use scenario based on exposure to contaminated media for 24 hours a day, 350 days a year for 30 years by children and adults living on a site.

“Surface water” means “surface water” as defined pursuant to the Surface Water Quality Standards, N.J.A.C. 7:9B.

“USEPA” means the United States Environmental Protection Agency.

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## **SUBCHAPTER 2. MINIMUM GROUND WATER REMEDIATION STANDARDS**

### **7:26D-2.1 Purpose**

This subchapter establishes the minimum remediation standards for ground water.

### **7:26D-2.2 Minimum ground water remediation standards**

(a) The minimum remediation standards to which ground water shall be remediated are:

1. For Class II ground water, the Ground Water Quality Standards developed pursuant to N.J.A.C. 7:9C-1.7(c) and (d);

2. For Class I-A and Class I-PL, Ground Water Quality Standards developed pursuant to N.J.A.C. 7:9C-1.7(a) and (b);

3. For Class III-A and Class III-B, Ground Water Quality Standards developed pursuant to N.J.A.C. 7:9C-1.7(e) and (f); and

4. For all ground water, regardless of classification, each of the following narrative ground water remediation standards, as applicable:

- i. The general ground water quality policies in N.J.A.C. 7:9C-1.2;
- ii. The narrative ground water quality criteria in N.J.A.C. 7:9C-1.7;
- iii. The ground water quality antidegradation policy in N.J.A.C. 7:9C-1.8;
- iv. The remediation requirements in N.J.A.C. 7:26E-1 through 8 in order to both:
  - (1) Address the adverse impact of the contamination on the ground water itself; and
  - (2) Limit additional risks posed by the contamination to the human health and safety and to the environment;
- v. The free and residual product removal, treatment, or containment requirements of N.J.A.C. 7:26E-6.1(d);
- vi. The contaminants have not migrated to the ground surface, structures, or air in concentrations that pose a threat to human health; and
- vii. The following factors, as applicable on a site-specific basis, for selecting an appropriate ground water remedial action:
  - (1) The location of the contaminated site relative to ground water use;
  - (2) The potential human and environmental exposure to the ground water contamination;

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- (3) The present, projected, and potential ground water use at the site and in the area surrounding the site over the 25 years after the selection of the ground water remedy;
  - (4) The ambient ground water quality at the site and in the area surrounding the site resulting from both human activities and natural conditions;
  - (5) The physical and chemical characteristics of the contaminants of concern; and
  - (6) The criteria in N.J.A.C. 7:26E-6.3(d)1i, used to determine when natural remediation is appropriate as a remedial action for ground water contamination.
- (b) The Department shall not approve an alternative ground water remediation standard that is based on a site-specific risk assessment.

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### **SUBCHAPTER 3. MINIMUM SURFACE WATER REMEDIATION STANDARDS**

#### **7:26D-3.1 Purpose**

This subchapter establishes the minimum remediation standards for surface water.

#### **7:26D-3.2 Minimum surface water remediation standards**

(a) The minimum remediation standards for surface water are:

1. The numeric New Jersey Surface Water Quality Standards, N.J.A.C. 7:9B-1.14(c) and (d); and

2. The following narrative surface water remediation standards:

- i. The general surface water quality policies in N.J.A.C. 7:9B-1.5;
- ii. The narrative surface water quality criteria in N.J.A.C. 7:9B-1.14;
- iii. The remediation requirements in N.J.A.C. 7:26E-1 through 8 in order to both:
  - (1) Address the adverse impact of the contamination on the surface water itself; and
  - (2) Limit additional risks posed by the contamination to the public health and safety and to the environment;
- iv. The free and residual product removal, treatment, or containment requirements of N.J.A.C. 7:26E-6.1(d); and
- v. The following narrative criteria, as applicable on a site-specific basis, for selecting an appropriate surface water remedial action:
  - (1) The location of the contaminated site relative to surface water use;
  - (2) The potential human and environmental exposure to the surface water contamination;
  - (3) The present and projected surface water use at the site and in the area surrounding the site;
  - (4) The ambient ground water quality at the site and in the area surrounding the site resulting from both human activities and natural conditions; and
  - (5) The physical and chemical characteristics of the contaminants of concern.

(b) The Department shall not approve an alternative surface water remediation standard that is based on a site-specific risk assessment.

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## **SUBCHAPTER 4 MINIMUM SOIL REMEDIATION STANDARDS**

### **7:26D-4.1 Purpose**

- (a) This subchapter establishes minimum soil remediation standards, including:
1. Residential direct contact soil remediation standards; and
  2. Non-residential direct contact soil remediation standards.

### **7:26D-4.2 Residential direct contact soil remediation standards**

(a) The Department developed the residential direct contact human health-based criteria in chapter Appendix 1, Table 1A, incorporated herein by reference, as follows:

1. The residential human health-based criteria for the ingestion-dermal exposure pathway, based on the equations, data sources, and conventions provided in chapter Appendix 2 incorporated herein by reference; and
2. The residential human health-based criteria for the inhalation exposure pathway, based on the equations, data sources, and conventions provided in chapter Appendix 3, incorporated herein by reference.

(b) The residential direct contact soil remediation standard for each contaminant listed in Appendix Table 1A is the more stringent of either the ingestion-dermal human health-based criterion or the inhalation human health-based criterion, or the PQL if the PQL is less stringent than the corresponding human health-based criterion.

### **7:26D-4.3 Non-residential direct contact soil remediation standards**

(a) The Department developed the non-residential direct contact human health-based criteria in Appendix 1, Table 1B, incorporated herein by reference, as follows:

1. The non-residential human health-based criteria for the ingestion-dermal exposure pathway, based on the equations, data sources, and conventions provided in Appendix 2; and
2. The non-residential human health-based criteria for the inhalation exposure pathway, based on the equations, data sources, and conventions provided in Appendix 3.

(b) The non-residential direct contact soil remediation standard for each contaminant listed in Table 1B is the more stringent of either the ingestion-dermal human health-based criterion or the inhalation human health-based criterion, or the PQL if the PQL is less stringent than the corresponding human health-based criterion.

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## **SUBCHAPTER 5 INTERIM SOIL REMEDIATION STANDARDS**

### **7:26D-5.1 Purpose**

Except as provided at N.J.A.C. 7:26D-1.1(b), this subchapter sets forth the procedures that the Department will use to establish interim soil remediation standards.

### **7:26D-5.2 Development of an interim soil remediation standard**

(a) The Department may establish an interim remediation standard for soil when a contaminant is not listed in Appendix 1, Tables 1A, or 1B of this chapter.

(b) An interim remediation standard shall be developed for soil as follows:

1. For the ingestion-dermal pathway, using the procedures set forth in Appendix 2; and
2. For the inhalation pathway, using the procedures set forth in Appendix 3.

(c) For the two pathways listed in (b)1 above, the person responsible for conducting a remediation may request that the Department develop an interim soil remediation standard under this section.

### **7:26D-5.3 Publication of interim soil remediation standards; promulgation**

(a) The Department shall publish on its web site a listing of all interim soil remediation standards developed pursuant to this chapter and the technical basis used in their derivation.

(b) Interim soil remediation standards developed pursuant to this chapter shall be replaced with duly promulgated soil remediation standards as soon as reasonably possible.

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## **SUBCHAPTER 6 UPDATING SOIL REMEDIATION STANDARDS**

### **7:26D-6.1 Purpose**

This subchapter sets forth the procedures that the Department will use to update remediation standards for soil developed pursuant to this chapter.

### **7:26D-6.2 Notice of administrative change to update promulgated soil remediation standards**

(a) The Department shall post on its web site and publish in the New Jersey Register a notice of administrative change to modify a soil remediation standard in Appendix 1, Tables 1A, 1B when the USEPA revises the carcinogenic slope factor or reference dose data contained in the Integrated Risk Information System (IRIS) database on which a remediation standard in Table 1A or 1B is based.

(b) The notice of administrative change shall identify the contaminant, the basis for the administrative change, and the revised criterion to be listed in Appendix 1, Table 1A and 1B.

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## **SUBCHAPTER 7 ALTERNATIVE SOIL REMEDIATION STANDARDS**

### **7:26D-7.1 Purpose**

Except as provided at N.J.A.C. 7:26D-1.1(b), this subchapter sets forth the circumstances in which the Department may require the person responsible for conducting the remediation to develop an alternative soil remediation standard, the procedures that the person responsible for conducting the remediation shall use to apply for permission to use an alternative soil remediation standard, the procedures for the person to develop an alternative remediation standard without the Department's prior approval, and the procedures the Department shall use to evaluate an application for the use of an alternative soil remediation standard that is proposed by the person responsible for conducting the remediation.

### **7:26D-7.2 Applicability**

An alternative soil remediation standard developed pursuant to this chapter may only be numeric and may only be used at the site for which it is approved and is not applicable at any other site.

### **7:26D-7.3 Basis for an alternative soil remediation standard**

(a) Except as provided in N.J.A.C. 7:26D-7.5, the person responsible for conducting the remediation may propose, in accordance with N.J.A.C. 7:26D-7.4, an alternative soil remediation standard based on the following:

1. For the ingestion-dermal exposure pathway, the procedures set forth in chapter Appendix 4, incorporated herein by reference; and
2. For the inhalation pathway, the procedures set forth in chapter Appendix 5, incorporated herein by reference.

(b) The basis for the request for an alternative remediation standard may include, but is not limited to, the following:

1. New chemical toxicity data;
2. New risk assessment methodology or models;
3. Alternative land use planned for the site; or
4. Site-specific conditions that support the modification of input parameters for models used to develop alternative soil remediation standards pursuant to Appendices 4 and 5.

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(c) The Department may require the person responsible for conducting the remediation to develop an alternative soil remediation standard that is more stringent than the minimum standards established by this chapter where necessary to ensure adequate protection of human health, based upon a review of the following:

1. The number or magnitude of the discharge(s) being investigated;
2. The nature of the contaminants;
3. Distance to and sensitivity of people at risk of exposure; and
4. Any other site-specific conditions the Department identifies that necessitate the need for an alternative soil remediation standard in order to protect human health.

#### **7:26D-7.4 Alternative soil remediation standards application and approval process**

(a) The person responsible for conducting the remediation may seek Department approval for an alternative soil remediation standard based on the criteria in N.J.A.C. 7:26D-7.3(a) and (b) above by completing the application in chapter Appendix 6, incorporated herein by reference, and submitting the completed application on an Alternative Soil Remediation Standard Application form provided by the Department in accordance with (b) below.

(b) The Department will review the application to develop an alternative remediation standard and send the person responsible for conducting the remediation the following, as applicable:

1. If the Department determines that the application is complete and that the proposed alternative soil remediation standard is protective of human health and safety and the environment, the Department will provide the person responsible for conducting the remediation with a written approval of the alternative soil remediation standard for that site or area of concern;
2. If the Department determines that the application is deficient, the Department will provide written comments to the person responsible for conducting the remediation describing the deficiencies in the application, in which case the person may submit a revised application addressing the deficiencies to the Department; or
3. If the Department determines that the proposed alternative soil remediation is not protective of human health, the Department will provide the person responsible for conducting the remediation with written notification of the denial of the application. The person shall not apply the denied alternative remediation standard to the contaminated site or area of concern.

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**7:26D-7.5 Procedures for the development of alternative soil remediation standards without prior approval from the Department**

(a) The person responsible for conducting the remediation is not required to obtain the Department's prior approval for alternative inhalation soil remediation standards that are developed using N.J.A.C. 7:26D-Appendix 5 and modification of the following site-specific input parameters:

1. Depth range of contamination;
2. Organic carbon concentration;
3. Vegetative cover; and
4. The average number of vehicle trips.

(b) The person responsible for conducting the remediation that chooses to develop an alternative remediation standard pursuant to (a) above shall provide the following, with the applicable remedial phase report that is submitted to the Department:

1. Documentation that the appropriate methods were used to develop the alternative remediation standard;
2. How the input parameters were selected, including all related laboratory results; and
3. A description how the standards were used in the remediation of the site or area of concern.

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**APPENDIX 1  
SOIL REMEDIATION STANDARDS TABLES**

**Table 1A – Residential Direct Contact Health Based Criteria and  
Soil Remediation Standards (mg/kg)**

<b>Contaminant</b>	<b>CAS No.</b>	<b>Ingestion-Dermal Health Based Criterion</b>	<b>Inhalation Health Based Criterion</b>	<b>Soil PQL</b>	<b>Residential Direct Contact Soil Remediation Standard</b>
Acenaphthene	83-32-9	3,400	NA	0.2	3,400
Acenaphthylene	208-96-8	NA	NA	0.2	NA
Acetone (2-Propanone)	67-64-1	70,000	NA	0.01	70,000
Acetophenone	98-86-2	6,100	2	0.2	2
Acrolein	107-02-8	39	0.5	0.5	0.5
Acrylonitrile	107-13-1	1	0.9	0.5	0.9
Aldrin	309-00-2	0.04	5	0.002	0.04
Aluminum	7429-90-5	78,000	NA	20	78,000
Anthracene	120-12-7	17,000	380,000	0.2	17,000
Antimony	7440-36-0	31	360,000	6	31
Arsenic	7440-38-2	0.4	980	1	19*
Atrazine	1912-24-9	210	NA	0.2	210
Barium	7440-39-3	16,000	910,000	20	16,000
Benzaldehyde	100-52-7	6,100	NA	0.2	6100
Benzene	71-43-2	3	2	0.005	2
Benzidine	92-87-5	0.002	0.004	0.7	0.7
Benzo(a)anthracene (1,2-Benzanthracene)	56-55-3	0.6	38,000	0.2	0.6
Benzo(a)pyrene	50-32-8	0.06	3,800	0.2	0.2
Benzo(b)fluoranthene (3,4-Benzofluoranthene)	205-99-2	0.6	38,000	0.2	0.6
Benzo(ghi)perylene	191-24-2	NA	380,000	0.2	380,000
Benzo(k)fluoranthene	207-08-9	6	38,000	0.2	6
Beryllium	7440-41-7	16	1,800	0.5	16
1,1'-Biphenyl	92-52-4	3,100	NA	0.2	3,100
Bis(2-chloroethyl)ether	111-44-4	0.4	0.6	0.2	0.4
Bis(2-chloroisopropyl)ether	108-60-1	2,400	23	0.2	23
Bis(2-ethylhexyl) phthalate	117-81-7	35	NA	0.2	35
Bromodichloromethane (Dichlorobromomethane)	75-27-4	10	1	0.005	1
Bromoform	75-25-2	81	98	0.005	81
Bromomethane (Methyl bromide)	74-83-9	110	25	0.005	25
2-Butanone (Methyl ethyl ketone) (MEK)	78-93-3	3,100	NA	0.01	3,100
Butyl benzyl phthalate	85-68-7	1,200	NA	0.2	1,200
Cadmium	7440-43-9	78	1,000	0.5	78
Caprolactam	105-60-2	31,000	NA	0.2	31,000
Carbazole	86-74-8	24	740,000	0.2	24

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<b>Contaminant</b>	<b>CAS No.</b>	<b>Ingestion-Dermal Health Based Criterion</b>	<b>Inhalation Health Based Criterion</b>	<b>Soil PQL</b>	<b>Residential Direct Contact Soil Remediation Standard</b>
Carbon disulfide	75-15-0	7,800	NA	0.5	7,800
Carbon tetrachloride	56-23-5	7	0.6	0.005	0.6
Chlordane (alpha and gamma)	57-74-9	0.2	42,000	0.002	0.2
Chlorobenzene	108-90-7	510	NA	0.005	510
Chloroethane (Ethyl chloride)	75-00-3	220	NA	0.005	220
Chloroform	67-66-3	780	0.6	0.005	0.6
Chloromethane (Methyl chloride)	74-87-3	NA	4	0.005	4
2-Chlorophenol (o-Chlorophenol)	95-57-8	310	910	0.2	310
Chrysene	218-01-9	62	380,000	0.2	62
Cobalt	7440-48-4	1,600	9,100	5	1,600
Copper	7440-50-8	3,100	NA	3	3,100
Cyanide	57-12-5	1,600	NA	3	1,600
4,4'-DDD	72-54-8	3	61,000	0.003	3
4,4'-DDE	72-55-9	2	670	0.003	2
4,4'-DDT	50-29-3	2	44,000	0.003	2
Dibenz(a,h)anthracene	53-70-3	0.06	3,500	0.2	0.2
Dibromochloromethane (Chlorodibromomethane)	124-48-1	8	3	0.005	3
1,2-Dibromo-3-chloropropane	96-12-8	0.3	0.08	0.005	0.08
1,2-Dibromoethane	106-93-4	0.008	0.1	0.005	0.008
1,2-Dichlorobenzene (o-Dichlorobenzene)	95-50-1	5,300	NA	0.005	5,300
1,3-Dichlorobenzene (m-Dichlorobenzene)	541-73-1	5,300	NA	0.005	5,300
1,4-Dichlorobenzene (p-Dichlorobenzene)	106-46-7	610	5	0.005	5
3,3'-Dichlorobenzidine	91-94-1	1	3	0.2	1
Dichlorodifluoromethane	75-71-8	16,000	490	0.005	490
1,1-Dichloroethane	75-34-3	510	8	0.005	8
1,2-Dichloroethane	107-06-2	5	0.9	0.005	0.9
1,1-Dichloroethene	75-35-4	11	61	0.005	11
1,2-Dichloroethene (cis) (c-1,2-Dichloroethylene)	156-59-2	780	230	0.005	230
1,2-Dichloroethene (trans) (t-1,2-Dichloroethylene)	156-60-5	1,300	300	0.005	300
2,4-Dichlorophenol	120-83-2	180	NA	0.2	180
1,2-Dichloropropane	78-87-5	9	2	0.005	2
1,3-Dichloropropene (cis and trans)	542-75-6	6	2	0.005	2
Dieldrin	60-57-1	0.04	1	0.003	0.04
Diethyl phthalate	84-66-2	49,000	NA	0.2	49,000
2,4-Dimethyl phenol	105-67-9	1,200	NA	0.2	1,200
Di-n-butyl phthalate	84-74-2	6,100	NA	0.2	6,100
4,6-Dinitro-2-methylphenol (4,6-Dinitro-o-cresol)	534-52-1	6	730,000	0.3	6
2,4-Dinitrophenol	51-28-5	120	NA	0.3	120

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<b>Contaminant</b>	<b>CAS No.</b>	<b>Ingestion-Dermal Health Based Criterion</b>	<b>Inhalation Health Based Criterion</b>	<b>Soil PQL</b>	<b>Residential Direct Contact Soil Remediation Standard</b>
2,4-Dinitrotoluene	121-14-2	0.7	6	0.2	0.7
2,6-Dinitrotoluene	606-20-2	0.7	2	0.2	0.7
2,4-Dinitrotoluene/2,6-Dinitrotoluene (mixture)	25321-14-6	0.7	NA	0.2	0.7
Di-n-octyl phthalate	117-84-0	2,400	NA	0.2	2,400
1,2-Diphenylhydrazine	122-66-7	0.6	5	0.7	0.7
Endosulfan I and Endosulfan II (alpha and beta)	115-29-7	470	NA	0.003	470
Endosulfan sulfate	1031-07-8	470	NA	0.003	470
Endrin	72-20-8	23	NA	0.003	23
Ethyl benzene	100-41-4	7,800	NA	0.005	7,800
Fluoranthene	206-44-0	2,300	NA	0.2	2,300
Fluorene	86-73-7	2,300	NA	0.2	2,300
alpha-HCH (alpha-BHC)	319-84-6	0.1	0.7	0.002	0.1
beta-HCH (beta-BHC)	319-85-7	0.4	8,000	0.002	0.4
Heptachlor	76-44-8	0.1	6	0.002	0.1
Heptachlor epoxide	1024-57-3	0.07	5	0.002	0.07
Hexachlorobenzene	118-74-1	0.3	1	0.2	0.3
Hexachloro-1,3-butadiene	87-68-3	6	12	0.2	6
Hexachlorocyclopentadiene	77-47-4	370	45	0.2	45
Hexachloroethane	67-72-1	35	83	0.2	35
Indeno(1,2,3-cd)pyrene	193-39-5	0.6	38,000	0.2	0.6
Isophorone	78-59-1	510	NA	0.2	510
Lead	7439-92-1	400	44,000	1	400
Lindane (gamma-HCH) (gamma-BHC)	58-89-9	0.4	3	0.002	0.4
Manganese	7439-96-5	11,000	91,000	2	11,000
Mercury	7439-97-6	23	27	0.1	23
Methoxychlor	72-43-5	390	NA	0.02	390
Methyl acetate	79-20-9	78,000	NA	0.005	78,000
Methylene chloride (Dichloromethane)	75-09-2	46	34	0.005	34
2-Methylnaphthalene	91-57-6	230	NA	0.17	230
2-Methylphenol (o-Creosol)	95-48-7	310	NA	0.2	310
4-Methylphenol (p-Creosol)	106-44-5	31	NA	0.2	31
Methyl tert-butyl ether (MTBE)	1634-04-4	780	110	0.005	110
Naphthalene	91-20-3	2,400	6	0.2	6
Nickel (Soluble salts)	7440-02-0	1,600	360,000	4	1,600
2-Nitroaniline	88-74-4	NA	39	0.3	39
Nitrobenzene	98-95-3	31	160	0.2	31
N-Nitrosodimethylamine	62-75-9	0.01	0.02	0.7	0.7
N-Nitrosodi-n-propylamine	621-64-7	0.07	0.2	0.2	0.2
N-Nitrosodiphenylamine	86-30-6	99	NA	0.2	99
Pentachlorophenol	87-86-5	3	590	0.3	3
Phenanthrene	85-01-8	NA	NA	0.2	NA

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<b>Contaminant</b>	<b>CAS No.</b>	<b>Ingestion-Dermal Health Based Criterion</b>	<b>Inhalation Health Based Criterion</b>	<b>Soil PQL</b>	<b>Residential Direct Contact Soil Remediation Standard</b>
Phenol	108-95-2	18,000	NA	0.2	18,000
Polychlorinated biphenyls (PCBs)	1336-36-3	0.2	20	0.03	0.2
Pyrene	129-00-0	1,700	NA	0.2	1,700
Selenium	7782-49-2	390	NA	4	390
Silver	7440-22-4	390	NA	1	390
Styrene	100-42-5	16,000	90	0.005	90
Tertiary butyl alcohol (TBA)	75-65-0	1,400	4,800	0.1	1,400
1,1,2,2-Tetrachloroethane	79-34-5	10	1	0.005	1
Tetrachloroethene (PCE) (Tetrachloroethylene)	127-18-4	8	2	0.005	2
Thallium	7440-28-0	5	360,000	3	5
Toluene	108-88-3	6,300	NA	0.005	6,300
Toxaphene	8001-35-2	0.6	70	0.2	0.6
1,2,4-Trichlorobenzene	120-82-1	73	NA	0.005	73
1,1,1-Trichloroethane	71-55-6	290	NA	0.005	290
1,1,2-Trichloroethane	79-00-5	31	2	0.005	2
Trichloroethene (TCE) (Trichloroethylene)	79-01-6	21	7	0.005	7
Trichlorofluoromethane	75-69-4	23,000	NA	0.005	23,000
2,4,5-Trichlorophenol	95-95-4	6,100	NA	0.2	6,100
2,4,6-Trichlorophenol	88-06-2	19	340	0.2	19
Vanadium	7440-62-2	78	NA	5	78
Vinyl chloride	75-01-4	2	0.7	0.005	0.7
Xylenes	1330-20-7	12,000	NA	0.005	12,000
Zinc	7440-66-6	23,000	NA	6	23,000

NA = Standard not available

\* The direct contact standard for arsenic is based on natural background

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**Table 1B – Non-Residential Direct Contact Health Based Criteria and Soil Remediation Standards (mg/kg)**

Contaminant	CAS No.	Ingestion-Dermal Health Based Criterion	Inhalation Health Based Criterion	Soil PQL	Non-Residential Direct Contact Soil Remediation Standard
Acenaphthene	83-32-9	37,000	300,000	0.2	37,000
Acenaphthylene	208-96-8	NA	300,000	0.2	300,000
Acetone (2-Propanone)	67-64-1	NA	NA	0.01	NA
Acetophenone	98-86-2	68,000	5	0.2	5
Acrolein	107-02-8	570	1	0.5	1
Acrylonitrile	107-13-1	6	3	0.5	3
Aldrin	309-00-2	0.2	14	0.002	0.2
Aluminum	7429-90-5	NA	NA	20	NA
Anthracene	120-12-7	180,000	30,000	0.2	30,000
Antimony	7440-36-0	450	23,000	6	450
Arsenic	7440-38-2	2	76	1	19*
Atrazine	1912-24-9	2,400	NA	0.2	2,400
Barium	7440-39-3	230,000	59,000	20	59,000
Benzaldehyde	100-52-7	68,000	NA	0.2	68,000
Benzene	71-43-2	14	5	0.005	5
Benzidine	92-87-5	0.008	0.01	0.7	0.7
Benzo(a)anthracene (1,2-Benzanthracene)	56-55-3	2	3,000	0.2	2
Benzo(a)pyrene	50-32-8	0.2	300	0.2	0.2
Benzo(b)fluoranthene (3,4-Benzofluoranthene)	205-99-2	2	3,000	0.2	2
Benzo(ghi)perylene	191-24-2	NA	30,000	0.2	30,000
Benzo(k)fluoranthene	207-08-9	23	3,000	0.2	23
Beryllium	7440-41-7	230	140	0.5	140
1,1'-Biphenyl	92-52-4	34,000	NA	0.2	34,000
Bis(2-chloroethyl)ether	111-44-4	2	2	0.2	2
Bis(2-chloroisopropyl)ether	108-60-1	27,000	67	0.2	67
Bis(2-ethylhexyl) phthalate	117-81-7	140	140,000	0.2	140
Bromodichloromethane (Dichlorobromomethane)	75-27-4	51	3	0.005	3
Bromoform	75-25-2	400	280	0.005	280

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<b>Contaminant</b>	<b>CAS No.</b>	<b>Ingestion-Dermal Health Based Criterion</b>	<b>Inhalation Health Based Criterion</b>	<b>Soil PQL</b>	<b>Non-Residential Direct Contact Soil Remediation Standard</b>
Bromomethane (Methyl bromide)	74-83-9	1,600	59	0.005	59
2-Butanone (Methyl ethyl ketone) (MEK)	78-93-3	44,000	NA	0.01	44,000
Butyl benzyl phthalate	85-68-7	14,000	NA	0.2	14,000
Cadmium	7440-43-9	1,100	78	0.5	78
Caprolactam	105-60-2	340,000	NA	0.2	340,000
Carbazole	86-74-8	96	58,000	0.2	96
Carbon disulfide	75-15-0	110,000	NA	0.5	110,000
Carbon tetrachloride	56-23-5	35	2	0.005	2
Chlordane (alpha and gamma)	57-74-9	1	3,300	0.002	1
Chlorobenzene	108-90-7	7,400	NA	0.005	7,400
Chloroethane (Ethyl chloride)	75-00-3	1,100	NA	0.005	1,100
Chloroform	67-66-3	11,000	2	0.005	2
Chloromethane (Methyl chloride)	74-87-3	NA	12	0.005	12
2-Chlorophenol (o-Chlorophenol)	95-57-8	3,400	2,200	0.2	2,200
Chrysene	218-01-9	230	30,000	0.2	230
Cobalt	7440-48-4	23,000	590	5	590
Copper	7440-50-8	45,000	280,000	3	45,000
Cyanide	57-12-5	23,000	NA	3	23,000
4,4'-DDD	72-54-8	13	4,800	0.003	13
4,4'-DDE	72-55-9	9	3,400	0.003	9
4,4'-DDT	50-29-3	8	3,400	0.003	8
Dibenz(a,h)anthracene	53-70-3	0.2	270	0.2	0.2
Dibromochloromethane (Chlorodibromomethane)	124-48-1	38	8	0.005	8
1,2-Dibromo-3-chloropropane	96-12-8	1	0.2	0.005	0.2
1,2-Dibromoethane	106-93-4	0.04	0.3	0.005	0.04
1,2-Dichlorobenzene (o-Dichlorobenzene)	95-50-1	59,000	NA	0.005	59,000

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Contaminant	CAS No.	Ingestion-Dermal Health Based Criterion	Inhalation Health Based Criterion	Soil PQL	Non-Residential Direct Contact Soil Remediation Standard
1,3-Dichlorobenzene (m-Dichlorobenzene)	541-73-1	59,000	NA	0.005	59,000
1,4-Dichlorobenzene (p-Dichlorobenzene)	106-46-7	6,800	13	0.005	13
3,3'-Dichlorobenzidine	91-94-1	4	960	0.2	4
Dichlorodifluoromethane	75-71-8	230,000	NA	0.005	230,000
1,1-Dichloroethane	75-34-3	7,400	24	0.005	24
1,2-Dichloroethane	107-06-2	26	3	0.005	3
1,1-Dichloroethene	75-35-4	160	150	0.005	150
1,2-Dichloroethene (cis) (c-1,2-Dichloroethylene)	156-59-2	11,000	560	0.005	560
1,2-Dichloroethene (trans) (t-1,2-Dichloroethylene)	156-60-5	19,000	720	0.005	720
2,4-Dichlorophenol	120-83-2	2,100	NA	0.2	2,100
1,2-Dichloropropane	78-87-5	47	5	0.005	5
1,3-Dichloropropene (cis and trans)	542-75-6	32	7	0.005	7
Dieldrin	60-57-1	0.2	3	0.003	0.2
Diethyl phthalate	84-66-2	550,000	NA	0.2	550,000
2,4-Dimethyl phenol	105-67-9	14,000	NA	0.2	14,000
Di-n-butyl phthalate	84-74-2	68,000	NA	0.2	68,000
4,6-Dinitro-2-methylphenol (4,6-Dinitro-o-cresol)	534-52-1	68	47,000	0.3	68
2,4-Dinitrophenol	51-28-5	1,400	820,000	0.3	1,400
2,4-Dinitrotoluene	121-14-2	3	16	0.2	3
2,6-Dinitrotoluene	606-20-2	3	7	0.2	3
2,4-Dinitrotoluene/2,6-Dinitrotoluene (mixture)	25321-14-6	3	NA	0.2	3
Di-n-octyl phthalate	117-84-0	27,000	NA	0.2	27,000
1,2-Diphenylhydrazine	122-66-7	2	13	0.7	2
Endosulfan I and Endosulfan II (alpha and beta)	115-29-7	6,800	NA	0.003	6,800
Endosulfan sulfate	1031-07-8	6,800	NA	0.003	6,800
Endrin	72-20-8	340	120,000	0.003	340
Ethyl benzene	100-41-4	110,000	NA	0.005	110,000

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Contaminant	CAS No.	Ingestion-Dermal Health Based Criterion	Inhalation Health Based Criterion	Soil PQL	Non-Residential Direct Contact Soil Remediation Standard
Fluoranthene	206-44-0	24,000	300,000	0.2	24,000
Fluorene	86-73-7	24,000	300,000	0.2	24,000
alpha-HCH (alpha-BHC)	319-84-6	0.5	2	0.002	0.5
beta-HCH (beta-BHC)	319-85-7	2	620	0.002	2
Heptachlor	76-44-8	0.7	18	0.002	0.7
Heptachlor epoxide	1024-57-3	0.3	13	0.002	0.3
Hexachlorobenzene	118-74-1	1	4	0.2	1
Hexachloro-1,3-butadiene	87-68-3	25	35	0.2	25
Hexachlorocyclopentadiene	77-47-4	4,100	110	0.2	110
Hexachloroethane	67-72-1	140	82,000	0.2	140
Indeno(1,2,3-cd)pyrene	193-39-5	2	3,000	0.2	2
Isophorone	78-59-1	2,000	NA	0.2	2,000
Lead	7439-92-1	800	12,000	1	800
Lindane (gamma-HCH) (gamma-BHC)	58-89-9	2	10	0.002	2
Manganese	7439-96-5	160,000	5,900	2	5,900
Mercury	7439-97-6	340	65	0.1	65
Methoxychlor	72-43-5	5,700	NA	0.02	5,700
Methyl acetate	79-20-9	NA	NA	0.005	NA
Methylene chloride (Dichloromethane)	75-09-2	230	97	0.005	97
2-Methylnaphthalene	91-57-6	2400	300,000	0.17	2400
2-Methylphenol (o-Creosol)	95-48-7	3,400	NA	0.2	3,400
4-Methylphenol (p-Creosol)	106-44-5	340	NA	0.2	340
Methyl tert-butyl ether (MTBE)	1634-04-4	11,000	320	0.005	320
Naphthalene	91-20-3	25,000	17	0.2	17
Nickel (Soluble salts)	7440-02-0	23,000	23,000	4	23,000
2-Nitroaniline	88-74-4	NA	23,000	0.3	23,000
Nitrobenzene	98-95-3	340	390	0.2	340
N-Nitrosodimethylamine	62-75-9	0.06	0.05	0.7	0.7
N-Nitrosodi-n-propylamine	621-64-7	0.3	0.05	0.2	0.3

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N-Nitrosodiphenylamine	86-30-6	390	130,000	0.2	390
Pentachlorophenol	87-86-5	10	1,700	0.3	10
Phenanthrene	85-01-8	NA	300,000	0.2	300,000
Phenol	108-95-2	210,000	NA	0.2	210,000
Polychlorinated biphenyls (PCBs)	1336-36-3	1	57	0.03	1
Pyrene	129-00-0	18,000	300,000	0.2	18,000
Selenium	7782-49-2	5,700	NA	4	5,700
Silver	7440-22-4	5,700	NA	1	5,700
Styrene	100-42-5	230,000	260	0.005	260
Tertiary butyl alcohol (TBA)	75-65-0	20,000	11,000	0.1	11,000
1,1,2,2-Tetrachloroethane	79-34-5	150	3	0.005	3
Tetrachloroethene (PCE) (Tetrachloroethylene)	127-18-4	39	5	0.005	5
Thallium	7440-28-0	79	23,000	3	79
Toluene	108-88-3	91,000	NA	0.005	91,000
Toxaphene	8001-35-2	3	200	0.2	3
1,2,4-Trichlorobenzene	120-82-1	820	NA	0.005	820
1,1,1-Trichloroethane	71-55-6	4,200	NA	0.005	4,200
1,1,2-Trichloroethane	79-00-5	440	6	0.005	6
Trichloroethene (TCE) (Trichloroethylene)	79-01-6	100	20	0.005	20
Trichlorofluoromethane	75-69-4	340,000	NA	0.005	340,000
2,4,5-Trichlorophenol	95-95-4	68,000	NA	0.2	68,000
2,4,6-Trichlorophenol	88-06-2	74	960	0.2	74
Vanadium	7440-62-2	1,100	470,000	5	1,100
Vinyl chloride	75-01-4	8	2	0.005	2
Xylenes	1330-20-7	170,000	NA	0.005	170,000
Zinc	7440-66-6	340,000	110,000	6	110,000

NA = Standard not available \* The direct contact standard for arsenic is based on natural background

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**APPENDIX 2**  
**Methods for the Development of**  
**Ingestion-Dermal Soil Remediation Standards for**  
**Residential and Non-residential Exposure (Equations 1 through 4)**

**Equation 1**  
**Combined Ingestion and Dermal Absorption Exposure to**  
**Carcinogenic Contaminants in Soil**  
**Residential Scenario**

Source: USEPA. 2002. Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites, Final.

$$\text{Remediation Standard (mg/kg)} = \frac{TR * AT * 365d / yr}{(EF * 10^{-6} \text{ kg / mg}) \left[ (SF_o * IF_{soil / adj}) + (SF_{ABS} * SFS * ABS_d * EV) \right]}$$

<b>Parameter</b>	<b>Definition</b>	<b>Units</b>	<b>Default</b>
TR	Target cancer risk	Unitless	10 <sup>-6</sup>
AT	Averaging time	Years	70
EF	Exposure frequency	Days/year	350
SF <sub>ABS</sub>	Dermally adjusted cancer slope factor	(mg/kg-d) <sup>-1</sup>	Chemical-specific
SFS	Age-adjusted dermal factor	mg-yr/kg-event	360
ABS <sub>d</sub>	Dermal absorption fraction	Unitless	Chemical-specific
EV	Event frequency	Events/day	1
SF <sub>o</sub>	Oral cancer slope factor	(mg/kg-d) <sup>-1</sup>	Chemical-specific
IF <sub>soil/adj</sub>	Age-adjusted soil ingestion factor	mg-yr/kg-d	114

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**Equation 2**  
**Combined Ingestion and Dermal Absorption Exposure to**  
**Non-Carcinogenic Contaminants in Soil**  
**Residential Sites**

Source: USEPA. 2002. Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites, Final.

$$\text{Remediation Standard (mg/kg)} = \frac{THQ * BW * AT * 365 \text{ l/yr}}{(EF * ED * 10^6 \text{ kg/mg}) \left[ \left( \frac{1}{RfD_o} * IR \right) + \left( \frac{1}{RfD_{ABS}} * AF * ABS_d * EV * SA \right) \right]}$$

<b>Parameter</b>	<b>Definition</b>	<b>Units</b>	<b>Default</b>
THQ	Target hazard quotient	Unitless	1
BW	Body weight	kg	15
AT	Averaging time	Years	6
EF	Exposure frequency	Days/year	350
ED	Exposure duration	Years	6
RfD <sub>o</sub>	Oral reference dose	mg/kg-day	Chemical-specific
IR	Soil ingestion rate	mg/day	200
RfD <sub>ABS</sub>	Dermally adjusted reference dose	mg/kg-day	Chemical-specific
AF	Skin-soil adherence factor	mg/cm <sup>2</sup> -event	0.2
ABS <sub>d</sub>	Dermal absorption factor	Unitless	Chemical-specific
EV	Event frequency	Events/day	1
SA	Skin surface area exposed-child	cm <sup>2</sup>	2,800

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**Equation 3**  
**Combined Ingestion and Dermal Absorption Exposure to**  
**Carcinogenic Contaminants in Soil**  
**Non-Residential Outdoor Worker Site**

Source: USEPA. 2002. Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites, Final.

$$\text{Remediation Standard (mg/kg)} = \frac{TR * BW * AT * 365 \text{ d/yr}}{(EF * ED * 10^{-6} \text{ kg/mg}) * ((SF_o * IR) * (SF_{ABS} * AF * ABS_d * SA * EV))}$$

<b>Parameter</b>	<b>Definition</b>	<b>Units</b>	<b>Default</b>
TR	Target cancer risk	Unitless	10 <sup>-6</sup>
BW	Body weight	kg	70
AT	Averaging time	Years	70
EF	Exposure frequency	Days/year	225
ED	Exposure duration	Years	25
SF <sub>O</sub>	Oral cancer slope factor	(mg/kg-d) <sup>-1</sup>	Chemical-specific
IR	Soil ingestion rate	mg/d	100
SF <sub>ABS</sub>	Dermally adjusted cancer slope factor	(mg/kg-d) <sup>-1</sup>	Chemical-specific
AF	Soil-skin adherence factor	mg/cm <sup>2</sup> -event	0.2
ABS <sub>d</sub>	Dermal absorption factor	Unitless	Chemical-specific
SA	Skin surface exposed	cm <sup>2</sup>	3,300
EV	Event frequency	Events/day	1

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**Equation 4**  
**Combined Ingestion and Dermal Absorption Exposure to**  
**Non-Carcinogenic Contaminants in Soil**  
**Non-Residential Outdoor Worker Site**

Source: USEPA. 2002. Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites, Final.

$$\text{Remediation Standard (mg/kg)} = \frac{THQ * BW * AT * 365d / yr}{(EF * ED * 10^{-6} \text{ kg/mg}) \left[ \left( \frac{1}{RfD_o} * IR \right) + \left( \frac{1}{RfD_{ABS}} * AF * ABS_d * SA * EV \right) \right]}$$

<b>Parameter</b>	<b>Definition</b>	<b>Units</b>	<b>Default</b>
THQ	Target hazard quotient	Unitless	1
BW	Body weight	kg	70
AT	Averaging time	Years	25
EF	Exposure frequency	Days/years	225
ED	Exposure duration	Years	25
RfD <sub>o</sub>	Oral reference dose	mg/kg-d	Chemical-specific
IR	Soil ingestion rate	mg/d	100
RfD <sub>ABS</sub>	Dermally adjusted reference dose	mg/kg-d	Chemical-specific
AF	Skin-soil adherence factor	mg/cm <sup>2</sup> -event	0.2
ABS <sub>d</sub>	Dermal absorption fraction	Unitless	Chemical-specific
SA	Skin surface exposed	cm <sup>2</sup>	3,300
EV	Event frequency	Events/day	1

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**APPENDIX 3**  
**Methods for the Development of Inhalation Remediation Standards**  
**Residential and Non-residential Use (Equations 1 through 25)**

**I. Methods for the Development of Inhalation Standards**  
**for Volatile Contaminants (Equations 1 through 8)**

**Equation 1**  
**Inhalation Soil Remediation Standards for Carcinogenic**  
**Volatile Organic Contaminants**

Source: Soil Screening Guidance: Technical Background Document EPA/540/R-95/128 (May 1996); Equation 4

$$Inh_v SRS_c = \frac{TR * AT * 365 \text{ days/year}}{URF * 1000 \frac{\mu\text{g}}{\text{mg}} * EF * ED * \left(\frac{1}{VF}\right)}$$

<b>Parameter</b>	<b>Definition</b>	<b>Units</b>	<b>Default</b>
$Inh_v SRS_c$	Inhalation soil remediation standard for volatile carcinogens	mg/kg	Chemical-specific
TR	Target cancer risk	unitless	$1 \times 10^{-6}$
AT	Averaging time	years	70
URF	Inhalation unit risk factor	$(\mu\text{g}/\text{m}^3)^{-1}$	Chemical-specific
EF	Exposure frequency	day/year	350 (Residential) 225 (Non-residential)
ED	Exposure duration	years	30 (Residential) 25 (Non-residential)
VF	Soil-to-air volatilization factor	$\text{m}^3/\text{kg}$	Chemical-specific

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**Equation 2**  
**Inhalation Soil Remediation Standards for Non-carcinogenic**  
**Volatile Organic Contaminants**

Source: Soil Screening Guidance: Technical Background Document EPA/540/R-95/128 (May 1996); Equation 5

$$Inh_vSRS_n = \frac{THQ * AT * 365 \frac{days}{year}}{EF * ED * \left(\frac{1}{RfC}\right) * \left(\frac{1}{VF}\right)}$$

<b>Parameter</b>	<b>Definition</b>	<b>Units</b>	<b>Default</b>
Inh <sub>v</sub> SRS <sub>n</sub>	Inhalation soil remediation standard for volatile noncarcinogens	mg/kg	Chemical-specific
THQ	Target hazard quotient	unitless	1
AT	Averaging time	years	30 (Residential) 25 (Non-residential)
EF	Exposure frequency	day/year	350 (Residential) 225 (Non-residential)
ED	Exposure duration	years	30 (Residential) 25 (Non-residential)
RfC	Inhalation reference concentration	mg/m <sup>3</sup>	Chemical-specific
VF	Soil-to-air volatilization factor	m <sup>3</sup> /kg	Chemical-specific

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**Equation 3**  
**Volatilization Factor (VF)**

Source: Soil Screening Guidance: Technical Background Document EPA/540/R-95/128 (May 1996); Equation 6

$$VF = \left( \frac{Q}{C_{vol}} \right) * \frac{(3.14 * D_A * T)^{1/2}}{2 * \rho_b * D_A} * 10^{-4} \frac{m^2}{cm^2}$$

<b>Parameter</b>	<b>Definition</b>	<b>Units</b>	<b>Default</b>
VF	Soil-to-air volatilization factor	m <sup>3</sup> /kg	Chemical-specific
Q/C <sub>vol</sub>	Inverse concentration at center of (specific to volume)	(g/m <sup>2</sup> -s)/(kg/m <sup>3</sup> )	90.4 (Residential) 138.7 (Non-residential)
D <sub>A</sub>	Apparent diffusivity	cm <sup>2</sup> /s	Chemical-specific
T	Exposure interval	seconds	9.5x10 <sup>8</sup> (Residential) 7.9x10 <sup>8</sup> (Non-residential)
ρ <sub>b</sub>	Dry soil bulk density	g/cm <sup>3</sup>	1.5

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**Equation 4**  
**Apparent Diffusivity (DA)**

Source: Soil Screening Guidance: Technical Background Document EPA/540/R-95/128 (May 1996); Equation 57

$$D_A = \frac{\left[ (\theta_a^{10/3} * D_i * H') + (\theta_w^{10/3} * D_w) \right] / n^2}{(\rho_b * K_d) + \theta_w + (\theta_a * H')}$$

<b>Parameter</b>	<b>Definition</b>	<b>Units</b>	<b>Default</b>
D <sub>A</sub>	Apparent diffusivity	cm <sup>2</sup> /s	Chemical-specific
θ <sub>a</sub>	Air-filled soil porosity	L <sub>air</sub> /L <sub>soil</sub>	0.18
D <sub>i</sub>	Diffusivity in air	cm <sup>2</sup> /s	Chemical-specific
H'	Henry's Law Constant	unitless	Chemical-specific
θ <sub>w</sub>	Water-filled soil porosity	L <sub>water</sub> /L <sub>soil</sub>	0.23
D <sub>w</sub>	Diffusivity in water	cm <sup>2</sup> /s	Chemical-specific
n	Total soil porosity	L <sub>pore</sub> /L <sub>soil</sub>	0.41
ρ <sub>b</sub>	Dry soil bulk density	g/cm <sup>3</sup>	1.5
K <sub>d</sub>	Soil-water partition coefficient	cm <sup>3</sup> /g	Chemical-specific

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**Equation 5**  
**Soil-Water Partition Coefficient ( $K_d$ )**

Source: Soil Screening Guidance: Technical Background Document EPA/540/R-95/128 (May 1996); Equation 74

$$K_d = K_{oc} * f_{oc}$$

<b>Parameter</b>	<b>Definition</b>	<b>Units</b>	<b>Default</b>
$K_d$	Soil-water partition coefficient	$\text{cm}^3/\text{g}$	Chemical-specific
$K_{oc}$	Soil organic carbon-water partition coefficient	$\text{cm}^3/\text{g}$	Chemical-specific
$f_{oc}$	Organic carbon content of soil	$\text{g}/\text{g}$	0.002

**Equation 6**  
**Air-Filled Soil Porosity ( $\theta_a$ )**

Source: Soil Screening Guidance: Technical Background Document EPA/540/R-95/128 (May 1996); Equation 7

$$\theta_a = n - \theta_w$$

<b>Parameter</b>	<b>Definition</b>	<b>Units</b>	<b>Default</b>
$\theta_a$	Air-filled soil porosity	$L_{\text{air}}/L_{\text{soil}}$	0.18
$\theta_w$	Water-filled soil porosity	$L_{\text{water}}/L_{\text{soil}}$	0.23
$n$	Total soil porosity	$L_{\text{pore}}/L_{\text{soil}}$	0.41

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**Equation 7**  
**Soil Moisture Content**

Source: Soil Screening Guidance: Technical Background Document EPA/540/R-95/128 (May 1996); Attachment A - "Conceptual Site Model"

$$\theta_w = n(I / K_s)^{1/(2b+3)}$$

<b>Parameter</b>	<b>Definition</b>	<b>Units</b>	<b>Default</b>
$\theta_w$	Water-filled soil porosity	$L_{\text{water}}/L_{\text{soil}}$	0.23
n	Total soil porosity	$L_{\text{pore}}/L_{\text{soil}}$	0.41
I	Soil moisture infiltration rate	m/yr	0.28
$K_s$	Saturated hydraulic conductivity of the soil	m/yr	387
$1/(2b+3)$	Determined by soil type (Soil Screening Guidance: Technical Background Document EPA/540/R-95/128 (May 1996); Attachment A - "Conceptual Site Model," Table A-2)	Unitless	0.080

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**Equation 8**  
**Soil Saturation Limit ( $C_{sat}$ )**

Source: Soil Screening Guidance: Technical Background Document EPA/540/R-95/128 (May 1996); Equation 9

$$C_{sat} = \frac{S}{\rho_b} \left[ (K_d * \rho_b) + \theta_w + (H' * \theta_a) \right]$$

<b>Parameter</b>	<b>Definition</b>	<b>Units</b>	<b>Default</b>
$C_{sat}$	Soil saturation concentration	mg/kg	Chemical-specific
S	Solubility in water	mg/L <sub>water</sub>	Chemical-specific
$\rho_b$	Dry soil bulk density	g/cm <sup>3</sup>	1.5
$K_d$	Soil-Water partition coefficient	cm <sup>3</sup> /g	Chemical-specific
$\theta_w$	Water-filled soil porosity	L <sub>water</sub> /L <sub>soil</sub>	0.23
H'	Henry's Law Constant	Unitless	Chemical-specific
$\theta_a$	Air-filled soil porosity	L <sub>air</sub> /L <sub>soil</sub>	0.18

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## II. Methods for the Development of Inhalation Standards for Particulate Contaminants for Exposure Scenarios for Residential Sites (Equations 9 through 13)

### Equation 9 Inhalation Soil Remediation Standards for Carcinogenic Particulate Contamination for Residential Sites

Source: Soil Screening Guidance: Technical Background Document EPA/540/R-95/128 (May 1996); Equation 4

$$Inh_pSRS_c = \frac{TR * AT \times 365 \text{ days/year}}{URF * 1,000 \mu\text{g/mg} * EF * ED * \left( \frac{1}{PEF} \right)}$$

Parameter	Definition	Units	Default
Inh <sub>p</sub> SRS <sub>c</sub>	Inhalation Soil Remediation Standard for carcinogens	mg/kg	Chemical-specific
TR	Target cancer risk	unitless	1x10 <sup>-6</sup>
AT	Averaging time	years	70
URF	Inhalation unit risk factor	(μg/m <sup>3</sup> ) <sup>-1</sup>	Chemical-specific
EF	Exposure frequency	days/year	350 (Residential)
ED	Exposure duration	years	30 (Residential)
PEF	Particulate emission factor	m <sup>3</sup> /kg	1,739,586,603

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**Equation 10**  
**Inhalation Soil Remediation Standards for Noncarcinogenic**  
**Particulate Contamination for Residential Sites**

Source: Soil Screening Guidance: Technical Background Document EPA/540/R-95/128 (May 1996); Equation 5

$$Inh_pSRS_n = \frac{THQ * AT * 365 \text{ days/year}}{EF * ED * \left(\frac{1}{RfC}\right) * 1,000 \mu\text{g/mg} * \left(\frac{1}{PEF}\right)}$$

<b>Parameter</b>	<b>Definition</b>	<b>Units</b>	<b>Default</b>
Inh <sub>p</sub> SRS <sub>n</sub>	Inhalation Soil Standard for noncarcinogens	mg/kg	Chemical-specific
THQ	Target hazard quotient	unitless	1
AT	Averaging time	years	30 (Residential)
EF	Exposure frequency	days/year	350 (Residential)
ED	Exposure duration	years	30 (Residential)
RfC	Inhalation reference concentration	μg/m <sup>3</sup>	Chemical-specific
PEF	Particulate emission factor	m <sup>3</sup> /kg	1,739,586,603

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**Equation 11**  
**Particulate Emission Factor (PEF)**

Source: Soil Screening Guidance: Technical Background Document EPA/540/R-95/128 (May 1996); Equation 10

$$PEF = \frac{Q}{C} * \left[ \frac{3,600 \text{ sec/ hr}}{0.036 * (1 - V) * \left(\frac{U_m}{U_t}\right)^3 * F(x)} \right]$$

<b>Parameter</b>	<b>Definition</b>	<b>Units</b>	<b>Default</b>
PEF	Particulate emission factor	m <sup>3</sup> /kg	1,739,586,603 (Residential)
Q/C	Inverse concentration at center of source	(g/m <sup>2</sup> -s)/(kg/m <sup>3</sup> )	90.4 (Residential)
V	Fraction of vegetative cover	unitless	0.5
U <sub>m</sub>	Mean annual wind speed	m/s	4.56
U <sub>t</sub>	Equivalent threshold value of wind speed at seven miles per hr	m/s	11.32
F(x)	Function dependent on U <sub>m</sub> /U <sub>t</sub> derived using Cowherd et al. (1985)	unitless	0.159

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**Equation 12**  
**Inverse Concentration Factor for Dispersion (Q/C)**

Source: Soil Screening Guidance: Technical Background Document EPA/540/R-95/128 (May 1996); Equation 59

$$Q/C = \frac{J_{s^{ave}}}{C_{air} * 10^{-9} \text{ kg} / \mu\text{g}}$$

<b>Parameter</b>	<b>Definition</b>	<b>Units</b>	<b>Default</b>
Q/C	Inverse concentration at center of source	(g/m <sup>2</sup> -s)/(kg/m <sup>3</sup> )	90.4 (Residential)
J <sub>s</sub> <sup>ave</sup>	Average rate of contaminant flux	g/m <sup>2</sup> -s	0.000494315 (Residential)
C <sub>air</sub>	Maximum contaminant concentration	μg/m <sup>3</sup>	5,468 (Residential)

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**Equation 13**  
**Average Rate Of Contaminant Flux ( $J_s^{ave}$ )**

Source: Soil Screening Guidance: Technical Background Document EPA/540/R-95/128 (May 1996); Equation 59

$$J_{s^{ave}} = \frac{ER}{A}$$

<b>Parameter</b>	<b>Definition</b>	<b>Units</b>	<b>Default</b>
$J_s^{ave}$	Average rate of contaminant flux	$g/m^2-s$	0.000494315 (Residential)
ER	Emission rate (normalized)	g/s	1
A	Area	$m^2$	1/2 acre = 2,023 $m^2$ (Residential)

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### III. Methods for the Development of Inhalation Standards for Particulate Contaminants for Exposure Scenarios for Non-Residential Sites (Equations 14 through 21)

#### Equation 14 Inhalation Soil Remediation Standards for Non-Residential Sites for Carcinogenic Particulate Contaminants

Source: Derived from Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites, Peer Review Draft, OSWER 9355.4-24 (March 2001), Equation 4-3

$$Inh_pSRS_c = \frac{TR}{CSF * DOSE} * \frac{10^6 mg}{kg}$$

<b>Parameter</b>	<b>Definition</b>	<b>Units</b>	<b>Default</b>
Inh <sub>p</sub> SRS <sub>c</sub>	Health-based soil cleanup level for carcinogens	mg/kg	Chemical-specific
TR	Target cancer risk	unitless	1x10 <sup>-6</sup>
CSF	Cancer slope factor	(mg/kg-day) <sup>-1</sup>	Chemical-specific
DOSE	Exposure dose calculation	mg/kg-day	0.000871

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**Equation 15**  
**Inhalation Soil Remediation Standards for Non-Residential Sites**  
**for Non-Carcinogenic Particulate Contaminants**

Source: Derived from Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites, Peer Review Draft, OSWER 9355.4-24 (March 2001), Equation 4-4

$$Inh_pSRS_n = \frac{1}{DOSE / RfD} * \frac{10^6 mg}{kg}$$

<b>Parameter</b>	<b>Definition</b>	<b>Units</b>	<b>Default</b>
Inh <sub>p</sub> SRS <sub>n</sub>	Health-based soil cleanup level for noncarcinogens	mg/kg	Chemical-specific
DOSE	Exposure dose calculation	mg/kg-day	0.00244
RfD	Reference dose	mg/kg-day	Chemical-specific

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**Equation 16**  
**Converting Unit Risk Factor to Cancer Slope Factor**

Source: Derived from footnote equation Table A-1, NJDEP Technical Manual 1003 - Guidance on Preparing a Risk Assessment for Air Contaminant Emissions, December 1994

$$CSF = \frac{URF * BW}{DIR} * \frac{10^3 \mu g}{mg}$$

<b>Parameter</b>	<b>Definition</b>	<b>Units</b>	<b>Default</b>
CSF	Cancer Slope Factor	(mg/kg-day) <sup>-1</sup>	Chemical-specific
URF	Unit Risk Factor	(μg/m <sup>3</sup> ) <sup>-1</sup>	Chemical-specific
BW	Body weight	kg	70
DIR	Daily inhalation rate	m <sup>3</sup> /day	20

**Equation 17**  
**Converting Reference Concentration to Reference Dose**

Source: Users Guide and Background Technical Document for USEPA Region IX Preliminary Remediation Goals Table, USEPA (2004)

$$RfD = RfC * DIR * \left( \frac{1}{BW} \right) * \left( \frac{mg}{10^3 \mu g} \right)$$

<b>Parameter</b>	<b>Definition</b>	<b>Units</b>	<b>Default</b>
RfD	Reference dose	(mg/kg-day)	Chemical-specific
RfC	Reference concentration	(μg/m <sup>3</sup> )	Chemical-specific
DIR	Daily inhalation rate	m <sup>3</sup> /day	20
BW	Body weight	kg	70

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**Equation 18**  
**Exposure Dose**

Source: Derived from Guidelines for Exposure Assessment, EPA/600/2-92/001 (May 1992);  
Equation 2-5

$$DOSE = \frac{PEF_s * IR * EF * ED}{BW * AT}$$

<b>Parameter</b>	<b>Definition</b>	<b>Units</b>	<b>Default</b>
DOSE	Exposure dose calculation	mg/kg-day	0.000871 (Carcinogenic) 0.00244 (Non-carcinogenic)
PEF <sub>s</sub>	Particulate emission factor from site activity; differs from "PEF" noted in Equations 10 and 11	mg/m <sup>3</sup>	0.0139
IR	Inhalation rate	m <sup>3</sup> /day	20
EF	Exposure frequency	days at site per year	225
ED	Exposure duration	Years	25
BW	Body weight	kg	70
AT	Averaging time	days	25,550 (Carcinogenic) 9,125 (Non-carcinogenic)

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**Equation 19**  
**Particulate Emission Factor From Site Activity (PEF<sub>s</sub>)**

Source: Derived from Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites, Peer Review Draft, OSWER 9355.4-24 (March 2001), Equation 5-9

$$PEF_s = CF * \left[ (D_{isc} * ER_{wind}) + (D_{isc} * ER_{traffic}) * \left( \frac{A_{traf}}{A_s} \right) \right]$$

<b>Parameter</b>	<b>Definition</b>	<b>Units</b>	<b>Default</b>
PEF <sub>s</sub>	Particulate emission factor from site activity	mg/m <sup>3</sup>	0.0139
CF	Conversion factor	mg/μg	10 <sup>-3</sup>
D <sub>isc</sub>	Air dispersion factor for unit emission rate of one g/s	(μg-sec)/(m <sup>3</sup> -g)	170
ER <sub>wind</sub>	Wind generated particulate emission rate per year	g/s	0.0528
ER <sub>traffic</sub>	Particulate emission rate for site traffic	g/s	0.0286
A <sub>traf</sub>	Area of traffic	m <sup>2</sup>	8,093.65
A <sub>s</sub>	Site area	m <sup>2</sup>	8,093.65

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**Equation 20**  
**Particulate Emission Rate (ER<sub>traffic</sub>)**

Source: Derived from Equation 21, below - conversion of units in Equation 21 from g/VKT to g/s

$$ER_{traffic} = \frac{E_{10} * TC * D * TF}{(28,800 \text{ seconds}/8\text{-hr day}) * EF}$$

<b>Parameter</b>	<b>Definition</b>	<b>Units</b>	<b>Default</b>
ER <sub>traffic</sub>	Particulate emission rate for site traffic	g/s	0.0286
E <sub>10</sub>	Particulate emission factor	g/VKT	277.8
TC	Daily traffic count for the unpaved area	vehicles/day	33
D	Average distance a vehicle travels through the unpaved area	km	0.09
TF	Traffic frequency	days with traffic/year	225
EF	Exposure frequency	days at site/year	225

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**Equation 21**

**Particulate Emission Factor from vehicles per kilometer traveled (from USEPA 2003c)**

Source: AP-42, Chapter 13.2.2.2; Equations 1a and 2

$$E_{10} = (281.9 \text{ g/VKT}) * \left[ k(s/12)^{0.9} * (W/3)^{0.45} \right] * \left[ \frac{(365 - p)}{365 \text{ days}} \right]$$

<b>Parameter</b>	<b>Definition</b>	<b>Units</b>	<b>Default</b>
E <sub>10</sub>	Particulate emission factor per kilometer traveled	g/VKT (grams per vehicle-kilometer-traveled)	277.8
k	Particle size multiplier	unitless	1.5 for PM10
s	Silt content of unpaved surface	%	11
W	Mean vehicle weight	tons	3.1
p	days with at least 0.254 mm (0.01 in) precipitation per year	days	121.3

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**IV. Equations for Industrial Wind Erosion listed in Section 13.2.5 of U.S. EPA's AP-42, Compilation of Air Pollutant Emission Factors, Volume I: Stationary, Point, and Area Source (listed with several New Jersey-specific values for convenience; Equations 22 through 25)**

**Equation 22  
Particulate Emission Rate from Wind Erosion ( $ER_{wind}$ )**

Source: Derived from AP-42, Chapter 13.2.5.3; Equation 2

$$ER_{wind} = \frac{k * N * P * SA}{31,536,000 \text{ sec/ year}}$$

<b>Parameter</b>	<b>Definition</b>	<b>Units</b>	<b>Default</b>
$ER_{wind}$	Wind generated particulate emission rate per year	g/s	0.0528
k	Particle size multiplier	unitless	0.5 for PM10
N	Number of disturbances per year	(year) <sup>-1</sup>	225
P	Erosion Potential	g/m <sup>2</sup>	1.83
SA	Surface area of the site	m <sup>2</sup>	8,093.65

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**Equation 23**  
**Erosion Potential for a Dry Exposed Surface**

Source: Derived from AP-42, Chapter 13.2.5.3; Equation 3

$$P = 58*(u^* - u^t)^2 + 25*(u^* - u^t)$$

<b>Parameter</b>	<b>Definition</b>	<b>Units</b>	<b>Default</b>
P	Erosion potential	g/m <sup>2</sup>	1.83
u*	Friction velocity	m/s	1.39376
u <sup>t</sup>	Threshold Friction Velocity	m/s	1.33

A threshold friction velocity of 1.33 m/s for roadbed material is assumed. This value is taken from Table 13.2.5-2 of AP-42 (USEPA 1998a).

**Equation 24**  
**Friction Velocity (u\*)**

Source: Derived from AP-42, Chapter 13.2.5.3; Equation 4

$$u^* = 0.053 * u_{10}^+$$

<b>Parameter</b>	<b>Definition</b>	<b>Units</b>	<b>Default</b>
u*	Friction velocity	m/s	1.39376
u <sup>+</sup> <sub>10</sub>	Fastest Mile Wind at 10 meters	m/s	26.297

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**Equation 25**  
**Correct the Fastest Wind Mile ( $u^{6.1}$ ) to a Reference Height of 10 meters**

Source: Derived from AP-42, Chapter 13.2.5.3; Equation 5

$$u_{10}^+ = u^{6.1} * \frac{\ln(10m/0.005)}{\ln(z/0.005)}$$

<b>Parameter Definition</b>	<b>Units</b>	<b>Default</b>
$u_{10}^+$ Fastest Mile Wind at 10 meters	m/s	26.297
$u^{6.1}$ Fastest Mile Wind at standard anemometer height	m/s	24.587
$z$ Anemometer height	m	6.1

Fastest Mile Wind Speed of 55 miles per hour (24.58 m/s) found in "Local Climatological Data Annual Summary for Newark, New Jersey" (NOAA 2002b). Value is fastest mile wind speed among climatological records for stations at Allentown and Philadelphia, Pennsylvania, Wilmington, Delaware, Atlantic City, New Jersey, and Central Park, New York.

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## **APPENDIX 4**

### **Methods for the Development of Alternative Ingestion-Dermal Soil Remediation Standards**

Pursuant to N.J.A.C. 7:26D-7, the person responsible for conducting the remediation may propose, for the Department's approval, an alternative soil remediation standard (ARS) for the Ingestion-Dermal exposure pathway for a site or an area of concern based on one of the options provided in this Appendix.

#### **A. General Requirements**

The ingestion-dermal exposure pathway has limited ARS options. Soil remediation standards developed for this exposure pathway are based on established risk assessment methods that do not employ site-specific factors. In addition, the default input parameters for these factors are generally accepted and used by EPA and other state agencies. The Department does not believe it is practicable to develop site-specific ARS through the modifications of these standard default input parameters. Therefore, ARS options for the ingestion-dermal pathway are limited to the two options listed below.

Alternative remediation standards calculated pursuant to this Appendix are applicable to ingestion-dermal remediation standards only. The person responsible for conducting the remediation is required to evaluate an ingestion-dermal ARS to determine if such an ARS impacts 1) human health via the inhalation exposure pathway, 2) ground water quality and 3) ecological receptors.

#### **B. Alternative Remediation Standard Options**

##### **Option I– Site Specific Default Values (Lead Site Contamination)**

The ingestion-dermal pathway uses EPA recommended default exposure parameters for residential and non-residential scenarios for all standards, except lead. These default parameters are generic and reflect a reasonable maximum exposure (RME) that may not be adjusted.

For lead, other risk assessment tools have been developed that use models to predict appropriate blood lead levels. The Department may accept an application for an ARS for residential exposure based on input parameters identified by the Integrated Exposure Uptake Biokinetic Model for Lead in Children (IEUBK) (USEPA, 1994)<sup>1</sup> using site-specific data for soil and dust lead concentrations. Site data may be used to refine estimates for other exposure-related model parameters such as bioavailability. However, except for lead, the Department will not accept applications for alternative remediation standards based on changes to bioavailability assumptions.

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<sup>1</sup> U.S. Environmental Protection Agency (USEPA). 1994. Guidance Manual for the Integrated Exposure Uptake Biokinetic Model for Lead in Children. Office of Solid Waste and Emergency Response, Washington, DC. OSWER 9285.7-15-1.

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The Department may accept an application for alternative remediation standard for lead for non-residential site use based on input parameters identified in the document Recommendations of the Technical Review Workgroup (TRW) for Lead for an Interim Approach to Assessing Risk Associated with Adult Exposures to Lead in Soil (USEPA, 1996)<sup>2</sup>.

The Department may accept an application for an alternative remediation standard for a recreational land use at a lead site based on the assessment of non-continuous exposure for all ages identified in the EPA guidance, Assessing Intermittent or Variable Exposures at Lead Sites (USEPA, 2003)<sup>3</sup>.

More information on the development of an alternative remediation standard for lead is provided in the ingestion dermal basis and background document which is available on the Department's web site at [www.state.nj.us/dep/srp](http://www.state.nj.us/dep/srp).

The Department does not require the remediation of a discharge to levels that are lower than natural background levels. See N.J.S.A. 58:10B-12(g)(4). The person responsible for conducting the remediation may conduct a site investigation to determine background levels in soil, pursuant to N.J.A.C. 7:26E-3.10 on a site specific basis.

### **Option II- Recreational Land Use Scenario**

An alternative remediation standard may be based on use of the site for recreational purposes. Recreational purposes are site-specific uses that do not reflect either a residential or non-residential land use scenario. Alternative standards may be based on site-specific land use scenarios that effect the amount time that people are likely to spend at a site that is designated for recreational use. There are two basic types of recreational land use, active and passive, that may be considered. Examples of active recreational land use are sports playing fields and playgrounds. Examples of passive recreational land use are walking or bike trails. The approval of an alternative remediation standard for recreational land use will be contingent on the use of proper institutional controls to ensure the continued use of the site for the proposed recreational purpose.

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<sup>2</sup> U.S. Environmental Protection Agency (USEPA). 1996b. Recommendations of the Technical Review Workgroup for Lead for an Interim Approach to Assessing Risks Associated with Adult Exposures to Lead in Soil, USEPA Technical Workgroup for Lead. December, 1996.

<sup>3</sup> U.S. Environmental Protection Agency (USEPA). 2003b. Assessing Intermittent or Variable Exposures at Lead Sites, Office of Solid Waste and Emergency Response, OSWER 9285.7-76.

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## **APPENDIX 5**

### **Methods for the Development of Alternative Inhalation Soil Remediation Standards**

Pursuant to N.J.A.C. 7:26D-7.2, the person responsible for conducting the remediation may propose, for the Department's approval, an alternative soil remediation standard (ARS) for the inhalation exposure pathway for a site or an area of concern based on one of the options provided in this Appendix.

#### **A. General Requirements**

The inhalation exposure pathway has several ARS options. The soil remediation standards developed for this exposure pathway are based on established risk assessment methods that employ some factors that are not site-specific. In addition, the default input parameters for these factors are generally accepted and used by EPA and other state agencies. The Department does not believe it is practicable to develop a site-specific ARS through the modification of these standard default input parameters. Therefore, ARS options for the inhalation pathway are limited to the options listed below.

If the concentration of any alternative remediation standard derived pursuant to this Appendix exceeds the contaminant's  $C_{\text{sat}}$  value (Table 1), the contaminant is not regulated as a volatile phase contaminant by the inhalation exposure pathway. However, the contaminant may be regulated as a particulate if appropriate.

Alternative remediation standards calculated pursuant to this Appendix are applicable to inhalation remediation standards only. The person responsible for conducting the remediation is required to evaluate an inhalation ARS to determine if such an ARS impacts 1) human health via the ingestion-dermal exposure pathway, 2) ground water quality and/or 3) ecological receptors.

Multiple site-specific conditions may be used to calculate an ARS for a given contaminant. If an ARS is developed using a given site-specific physical and/or operational condition(s), that (those) condition(s) must be applied consistently.

#### **B. Alternative Remediation Standard Options**

##### **Option I. Volatile Phase Contaminants**

1. For volatile phase contaminants, three parameters can be varied to develop an ARS. These parameters are depth range of contamination, organic carbon content of the soil, and site size. These parameters are applicable to residential and non-residential scenarios as well as carcinogenic and noncarcinogenic health endpoints.
  - i. Depth Range of Contamination
    - (1) Determine the actual depth range of contamination by conducting sampling pursuant to the Technical Requirements for Site Remediation, N.J.A.C. 7:26E-4.

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(2) Use the actual depth range of contamination in the Jury Model that is included in the EMSOFT software package to derive a site-specific volatilization factor (VF) following the methodology in Appendix I of the Inhalation Pathway Basis and Background.

(3) Substitute the derived site-specific volatilization factor into Equations 1 and 2 N.J.A.C. 7:26D, Appendix 2, to calculate an alternative inhalation remediation standard. Using a finite depth range reduces the mass of contaminant in the soil, which will reduce the average volatilization flux.

(4) The Department will not require the use of an institutional control pursuant to N.J.A.C. 7:26E-8 for an ARS based on depth range of contamination when the depth range of contamination begins at the ground surface. The Department will require the use of an institutional control pursuant to N.J.A.C. 7:26E-8 when an ARS is based on depth range of contamination that begins below the ground surface.

ii. Soil organic carbon content ( $f_{oc}$ ):

(1) Collect a minimum of three samples from different locations at the site that are representative of each area of concern including soil type(s) and sample depth equivalent to the location of contamination. Samples may not be collected from areas with high levels of organic contamination (greater than 1,000 ppm).

(2) Analyze samples for soil organic carbon content using the Lloyd Kahn Method<sup>4</sup>.

(3) Use the average soil organic carbon content as  $f_{oc}$  in the Soil-Water Partition Coefficient Equation (Appendix 2, Equation 5) to develop a site-specific  $K_d$  value. If  $f_{oc}$  values at a given area of concern vary by more than an order of magnitude, they may not be averaged to calculate a site-specific  $K_d$  value. In this case, the lowest  $f_{oc}$  value must be used to determine the  $K_d$  value for the soil in the area of concern.

(4) Use the site-specific  $K_d$  value in Equation 4, Appendix 2 to calculate a site-specific value for apparent diffusivity,  $DA$ .

(5) Use the site-specific value for apparent diffusivity,  $DA$ , in Equation 3, Appendix 2, to calculate a site-specific volatilization factor, VF.

(6) Substitute the site-specific volatilization factor into Equations 1 and 2, Appendix 2, to calculate an alternative inhalation remediation standard.

(7) The Department will not require the use of an institutional control pursuant to N.J.A.C. 7:26E-8 for an ARS based on soil organic carbon content.

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<sup>4</sup> Determination of Total Organic Carbon in Sediment (Lloyd Khan Method). U.S. Environmental Protection Agency, Region II, Edison, New Jersey, 1988. (<http://www.epa.gov/region02/qa/documents.htm>)

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## **Option II. Particulate Phase Contaminants**

### **1. For Residential Exposure**

#### **i. Vegetative Cover:**

(1) Measure the actual amount of vegetative cover to determine the fraction of vegetative cover ( $V$ ) on the site. An example of an acceptable vegetative cover would be areas of continuous grass where there is no bare ground.

(2) Use the measured fraction of vegetative cover ( $V$ ) in Equation 11, Appendix 2 to calculate the particulate emission factor (PEF).

(3) Use the calculated particulate emission factor (PEF) in Equation 9 or 10 of Appendix 2 to calculate the volatile contaminant carcinogenic ( $\text{Inh}_v\text{SRS}_c$ ) or noncarcinogenic ( $\text{Inh}_v\text{SRS}_n$ ) soil remediation standard for the inhalation pathway, respectively.

(4) The Department will require the use of an institutional control pursuant to N.J.A.C. 7:26E-8 for an ARS based on an actual amount of vegetative cover to ensure that the basis for the ARS is maintained.

### **2. For Non-residential Scenario**

#### **i. Vehicle Trips Per Day ARS for nonresidential sites of two or more acres**

(1) Determine the daily traffic count for an unpaved area (TC) (For future use, the entire site is assumed to be unpaved). The number of vehicle trips per day will be calculated by dividing the weekly total by the number of days of site operation for that week.

(2) Use the measured daily traffic count for an unpaved area (TC) in Equation 20, Appendix 2 to calculate the particulate emission rate for site traffic ( $\text{ER}_{\text{traffic}}$ ).

(3) Use the calculated particulate soil remediation standards ( $\text{ER}_{\text{traffic}}$ ) in Equation 19 to calculate the particulate emission factor from site activity ( $\text{PEF}_s$ ).

(4) Use the calculated particulate emission factor from site activity ( $\text{PEF}_s$ ) in Equation 18, Appendix 2 to calculate the exposure dose calculation (DOSE).

(5) Use the calculated exposure dose calculation (DOSE) in Equation 14 or 15 of Appendix 2 to calculate the particulate contaminant carcinogenic ( $\text{Inh}_p\text{SRS}_c$ ) or the particulate contaminant noncarcinogenic ( $\text{Inh}_p\text{SRS}_n$ ) soil remediation standard for the inhalation pathway, respectively.

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(6) The Department will require the use of an institutional control pursuant to N.J.A.C. 7:26E-8 for an ARS based on actual vehicle activity to ensure that the basis for the ARS is maintained.

### **Option III. Recreational Land Use Scenario**

An alternative remediation standard may be based on use of the site for recreational purposes. Recreational purposes are site-specific uses that do not reflect either a residential or non-residential land use scenario. Alternative standards may be based on site-specific land use scenarios that effect the amount time that people are likely to spend at a site that is designated for recreational use. There are two basic types of recreational land use, active and passive, that may be considered. Examples of active recreational land use are sports playing fields and playgrounds. Examples of passive recreational land use are walking or bike trails. The approval of an alternative remediation standard for recreational land use will be contingent on the use of proper institutional controls to ensure the continued use of the site for the proposed recreational purpose.