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ARARS

PENNSYLVANIA
DER

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF ENVIRONMENTAL RESOURCES
200 Pine Street
Williamsport, PA 17701-6510

August 4, 1994

Northcentral Regional Office

Mr. Frank Klanchar, RPM
US EPA Region III
3HW21
841 Chestnut Building
Philadelphia, PA 19107

RE: State ARARs
Centre County Kepone Site
Ruetgers-Nease Corporation
College Township, Centre County

Dear Mr. Klanchar:

This letter is in response to your request for state ARARs for the above site. The following list of ARARs were based on the site information available at this time. Additional evaluation of the ARARs will be required during subsequent phases of the remediation.

Enclosed is a copy of "ARARs For Cleanup Response and Remedial Actions in Pennsylvania" dated June 1993, which identifies State ARARs. Additionally the State ARARs include, but are not limited to, the following to which we particularly direct your attention:

The Pennsylvania Constitution, Article 1, Section 27.

Hazardous Waste Management Regulations, Article VII, Chapters 260-270 (25 Pa. Code 260.1-270.1 et seq.), and the Solid Waste Management Act, Act of July 7, 1980, P.L. 380, No. 97, as amended, 35 P.S. Sections 6018.101 et seq.

Article VII applies to the identification and listing, generation, transportation, storage, treatment and disposal of hazardous waste, and, contains the requirements under the federal RCRA program for the state to implement an approved hazardous waste program.

✓ The Pennsylvania ARAR for groundwater for hazardous substances is that all groundwater be remediated to "background" quality as specified by 25 Pa. Code Sections 264.90-264.100 and in particular by Pa. Code Sections 264.97(i), (j), and 264.100(a)(6) and (9). The Commonwealth also maintains that the requirement to remediate to background is also found in other legal authorities.

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The Department's "Groundwater Quality Protection Strategy", dated February 1992, is a "to be considered" (TBC) requirement setting out the background quality requirement as a remediation goal and provides for protective levels above background when the background groundwater quality goal cannot feasibly be achieved. Also, see 25 Pa. Code Chapter 16,, Water Quality Toxics Strategy, for water quality guidance.

Spent carbon generated as part of the pump and treat system must be managed as a hazardous waste according to 25 Pa. Code Section 261.6(b) & (c), and must meet the requirements of 25 Pa. Code Chapters 260-270.

Source and migration control wells may require well drillings and any waters extracted during the construction/test stage to be managed according to 25 Pa. Code Chapters 260-270.

Stream sediments removed in the future as a result of a (post-feasibility study) ecological assessment, and determined to be hazardous, must be managed according to Chapter 260-270.

Residual Waste Management Regulations, Chapters 281-299 (25 Pa. Code 287.1-299.101 et seq.), and the Solid Waste Management Act, Act of July 7, 1980, P.L. 380, No. 97, as amended, 35 P.S. Sections 6018.101 et seq.

The Department's "Cleanup Standards for Contaminated Soils," dated December 1993, is a "to be considered" (TBC) requirement that establishes soil cleanup standards deemed to be acceptable under the residual waste regulations.

See additional reference under municipal waste regulations.

Municipal Waste Management Regulations, Chapters 271-285 (25 Pa. Code 271.1 et seq.), and the Solid Waste Management Act, Act of July 7, 1980, P.L. 380, No. 97, as amended, 35 P.S. Sections 6018.101 et seq.

Contains provisions generally applicable to all municipal waste activities. If removal of non-hazardous contaminated stream sediments occurs, the dredged sediment is defined as a construction/ demolition waste at 25 Pa. Code Section 271.1 and shall meet the provisions of Chapters 271-285 as stated in 25 Pa. Code Section 287.2(b)(1).

Air Quality Control Regulations, Chapters 123, 127 and 131 (25 Pa. Code 123.1, 127.1 and 131.1 et seq.), and the Air Pollution Control Act, Act of January 8, 1960, P.L. 2119, 35 P.S. Sections 4001, et seq.

These regulations set forth standards for fugitive emissions, federal and state "Ambient Air Quality Standards" and provides for the "Best Available Technology" for control of new sources through construction, modification and reactivation.

Volatization must meet the requirements of 25 Pa. Code Chapters 123, 127 and 131.

Emissions Reduction from Stripper/Carbon Absorption. To the extent that new point source air emissions result from the implementation of the Remedial Alternative, 25 Pa. Code Section 127.12(a)(5) is applicable, requiring that emissions be reduced to the minimum obtainable levels through the use of Best Available Technology (BAT) as defined in 25 Pa. Code Section 121.1.

The guidance manual, "Air Quality Permitting Criteria for Remediation Projects Involving Air Strippers and Soil Decontamination Units", provides a permit exemption policy for remediation projects involving the Bureau of Air Quality Control regulations.

Water Quality Management Regulations, Chapters 92, 93, 95, 97, 101 and 102, and the Clean Streams Law, Act of June 22, 1937, P.L. 1987, as amended, 35 P.S. Sections 691.1 et seq.

Discharge of treated water must meet the effluent standards and monitoring requirements of Chapter 92, 25 Pa. Code Chapter 92.1 et seq. (NPDES program).

25 Pa. Code Chapter 93 provides specific water quality criteria and designates water use protection requirements for surface waters in Pennsylvania.

25 Pa. Code Chapter 95 sets forth waste treatment requirements for all dischargers.

25 Pa. Code Chapter 97 sets forth provisions for industrial waste dischargers.

25 Pa. Code Chapter 101 contains provisions for incidences which would endanger downstream users of Pennsylvania waters, and specifies actions to be taken.

25 Pa. Code Chapter 102 sets forth requirements for earth moving activities leading to accelerated erosion and sedimentation control.

25 Pa. Code Chapter 16, Water Qualilty Toxics Strategy, for water quality guidance.

Guidance "Toxics Management Strategy", as a TBC.

Dams, Waterways and Wetlands.

The Storm Water Management Act, Act of October 4, 1978, P.L. 864, No. 167, as amended, 32 P.S. Sections 680.1-680.17. This act addresses control of stormwater runoff during actions that disturb land, such as, grading or excavation. These activities must meet construction criteria consistent with the county watershed managment plan.

Dams, Waterways and Wetlands, Chapter 105, 25 Pa. Code Sections 105.1 et seq. These regulations address the restoration of wetland areas. See guidance document "Pennsylvania Wetlands Protection Program Regulations, Policy and Procedure and Ecological Considerations", as a TBC.

The Fish and Boat Code, Act of October 16, 1980, P.L. 996, as amended, 30 Pa. C.S. Sections 101 et seq. and Chapter 25, Section 2504 - Pollution of Waters.

Chapter 25 addresses protection of property and waters.

Topographic and Geologic Survey, The Water Well Drillers License Act, Act of May 29, 1956, P.L. 1840, 32 P.S. Section 645.1 et seq.

25 Pa. Code Sections 107.1 et seq. sets forth requirements for the licensing of water well drillers, prevention of pollution of underground waters, submittal of well construction records and well abandonment notification.

Water Supply and Community Health, Chapter 109, 25 Pa. Code Secdtions 109 et seq., and the Pennsylvania Safe Drinking Water Act, Act of May 1, 1984, P.L. 206, 35 P.S. Sections 721.1 et seq.

In-home well water treatment requirements.

Pennsylvania Hazardous Substance Transportation Regulations, Pa. Code Titles 13 & 15, and the Pennsylvania Department of Transportation, Act of June 1, 1945 (P.L. 1242, No. 428) (36 P.S. Sections 670-411, 670-420, 670-421 and 670-702).

Addresses transportation requirements for contaminated media shipped off-site for analysis, treatment or disposal and for treatment supplies brought on-site.

If you have any questions concerning our state ARARs, please feel free to contact me at (717) 327-3633.

Sincerely,

Douglas L. Overdorff

Douglas L. Overdorff
Project Officer
HSCP
Environmental Cleanup

Enclosure: June 1993 "ARARs for Cleanup
Response and Remedial Actions
in Pennsylvania"

cc: L. Newcomer
D. Overdorff
D. Brems - Central Office
P. Zaepfel - OCC, HSSE
File

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INTERIM

Frank, I highlighted the soil cleanup 20 levels.

Cleanup Standards for Contaminated Soils

Pennsylvania Department of Environmental Resources

December 1993

INTERIM

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INTRODUCTION

One of the touchstones or key elements of any environmental cleanup is the need to determine how much of the contamination must be removed, treated or otherwise isolated from the environment, i.e., "How clean is clean?". The "science" of developing cleanup standards often involves the synergism of many disciplines, such as toxicology, statistics, chemistry, geology, soil science, law, etc. Cleanup standards are often established through modeling and are either generic or site-specific.

This guidance document contains a listing of generic soil cleanup standards and generally describes the methods and assumptions used to arrive at the standards. These standards are intended to guide remediations at both voluntary and enforcement-related sites. Based upon current scientific knowledge, these generic soil cleanup standards are designed to protect public health and the environment, including protection of ground water in accordance with applicable laws and as described by the Commonwealth's Ground Water Quality Protection Strategy. This guidance is a living document and will be revised as appropriate, such as when new toxicological information becomes available and warrants a change. Additions and modifications to the list of generic soil cleanup standards will occur periodically.

Guidance is not a substitute for nor does it supersede applicable law or regulations including, but not limited to, those requirements set forth in the Department's Hazardous Waste Management or Residual Waste Regulations. For instance, cleaning up hazardous waste to levels stated in the tables does not relieve persons from obligations to comply with the hazardous waste management regualtions. This guidance does, however, replace the document entitled "Interim Guidance - Protective Levels for the Excavation, Treatment, Cleanup and Disposal of Virgin Fuel Contaminated Soils" previously issued by the Department.

These soil cleanup standards are deemed to be acceptable under the residual waste regulations provided that the remediation plans are developed and implemented in association with achieving the cleanup standards. As a minimum, in the course of achieving the standards, the responsible party shall develop and implement remediation plans that address relevant provisions of Section 287.117 (relating to closure plans), Section 287.123 (relating to site access), Section 287.132 (relating to chemical analysis), Section 287.341(g)(4) (relating to releases), Sections 287.342(d),(g), and (h) (relating to final closure), and other pertinent provisions of the residual waste regulations.

Any questions concerning the values contained in this guidance or requests for including additional soil cleanup standards should be directed to the Bureau of Waste Management, Division of Remediation at (717) 783-9475.

I. Implementation of Generic Soil Standards

The following procedure is to be used to implement the generic soil cleanup standards.

1. For the specific organic contaminant of interest in Table 1A, use, as the generic standard, the lowest of the direct contact non-cancer standard, the $1x10^{-6}$ CRL value for carcinogens, or the applicable ground water protection level. For example, benzene has a non-cancer standard of 1000 mg/kg, a $1x10^{-6}$ CRL value of approximately 100 mg/kg (1000/6.5 rounded down to one significant figure), and ground water protection levels of 0.2 mg/kg and 0.8 mg/kg. The value which should be used as the generic standard is one of the ground water protection values (depending on the residence time of benzene in the soil).

   As another example, p,p'-DDT has a non-cancer standard of 30 mg/kg, a $1x10^{-6}$ CRL value of approximately 10 mg/kg (30/2.3 rounded down to one significant figure), and ground water protection levels of 500 mg/kg (for both). The value which should be used as the generic standard is 10 mg/kg based on the $1x10^{-6}$ CRL.

2. For specific inorganic contaminants of interest in Table 1B, use, as the generic standard, the level listed as the cleanup standard. It is assumed that these levels also protect ecological receptors, direct contact, and ground water concerns. If that is not true at the site, levels must be used that protect these concerns.

3. For cleanups involving carcinogens, a $1x10^{-6}$ (one in one million) excess cancer risk level must be achieved, if feasible, at all soil remediation projects by:

   (a) utilizing treatment and/or removal technologies that directly meet the cancer risk level of $1x10^{-6}$, or

   (b) utilizing treatment and/or removal technologies that <u>at least</u> achieve a $1x10^{-4}$ excess cancer risk level and are supplemented by engineering and institutional controls which increase the overall level of protectiveness to $1x10^{-6}$.

   The responsible party has the choice of achieving the $1x10^{-6}$ level of protectiveness through either option (a) or (b). Regardless of the manner in which the required protectiveness level is achieved, the responsible party will generally not be expected to perform additional remediation, unless one of the following circumstances occur: 1) falsification of data, 2) changes in toxicological information, 3) new information about the site, or 4) the remedy fails or does not achieve the performance it was designed to meet.

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If it is not feasible to meet at least the $1x10^{-4}$ excess cancer risk level through the utilization of treatment and/or removal technologies, engineering and institutional controls must be employed to increase the overall protectiveness to $1x10^{-6}$. In such cases the responsible party will generally not be expected to perform additional remediation, unless one of the following circumstances occur: 1) falsification of data, 2) changes in toxicological information, 3) new information about the site, 4) the remedyfails or does not achieve the performance it was designed to meet, or 5) technology is developed which is significantly more feasible and is capable of achieving at least a $1x10^{-4}$ excess cancer risk level.

Screening of remedies should be conducted to ensure that the application of the most effective feasible technology, to treat or remove contaminated soil, is evaluated against any remaining need to implement institutional or engineering controls, so that the use of controls is minimized.

The $1x10^{-6}$ protectiveness level in soil is applicable regardless of the land use. However, two exposure assumptions will be used in the application of site-specific models and direct contact generic soil standards that consider the historic and reasonably expected future use of the property. The cleanup level for unrestricted uses, such as residential and agricultural activities, will be based upon conservative assumptions for body weight (child), exposure frequency, duration, averaging time, etc. For restricted uses, such as industrial and manufacturing activities, exposure assumptions will again be directly related to the use and be based upon appropriate body weight (adult), exposure frequency, duration, averaging time, etc. Ecological receptors will be considered on a site-by-site basis and their protection will be factored into the overall remediation decision.

Deed restrictions will be required whenever the $1x10^{-6}$ level has not been met through treatment or removal. Should there be a proposal to change land use from restricted use to an unrestricted use, further remediation to provide protectiveness for the new land use may be necessary.

4. The cleanup standards that are to be applied should be evaluated to ensure that ecological receptors are not adversely affected at the level of the cleanup standards. This evaluation should consider effects on all trophic levels within the food chain at the site to include plants as well as animals. Particular consideration should be given to (1) rare, threatened, or endangered species, (2) species of special concern as identified by the Pennsylvania Game Commission, the Pennsylvania Fish and Boat Commission, or the DER, (3) protection of populations (herds, flocks, etc.) of ecological receptors, and (4) protection of important habitats.

The attached Tables 1A and 1B contain generic soil standards for each of the compounds/contaminants listed. Table 1A includes only organic compounds, and Table 1B includes only metals and other inorganic contaminants. The general format for each compound/contaminant in Table 1A includes: the CASRN (Chemical Abstract Services Registry Number); the direct contact non-cancer standard; the cancer risk level (CRL) as applicable; and the ground water protection standards levels 1 and 2. The general format for each contaminant in Table 1B includes: the CASRN and the generic soil standard. The following is a brief explanation of each of these:

CASRN (Chemical Abstract Services Registry Number)

It is not uncommon for compounds to be referred to by various names. The CASRN noted in Tables 1A and 1B is a number unique to a specific compound or contaminant irrespective of the common name(s) for the compound. The CASRN can be used to find any compound or contaminant on a list provided that the contaminant has a CASRN. For example, 2-methylphenol cannot be found in Table 1A under that name. The CASRN for 2-methylphenol is 95-48-7 which is in Table 1A as o-cresol. o-cresol and 2-methylphenol are different names for the same compound.

Direct Contact Non-Cancer Standard

The direct contact non-cancer standard in Table 1A is the generic soil cleanup standard for each compound based on non-cancer effects. The direct contact non-cancer standard is estimated by applying residential exposure assumptions to an oral reference dose obtained from EPA's Integrated Risk Information System (IRIS), EPA Health Effects Assessment Summary Tables (HEAST), or derived from small mammal bioassay data (in the absence of IRIS and HEAST data). The assumptions used to estimate the direct contact non-cancer standards in Table 1A are contained in Table 2 of this document.

[CRL] (Cancer Risk Level)

[CRL] is the estimated cancer risk level associated with the direct contact non-cancer standard in Table 1A for each compound which is a carcinogen and for which a cancer potency factor has been established. This value is useful in estimating a contaminant concentration in soil for a desired cancer risk level which differs from the [CRL] value. For example, if you want to know the concentration of benzene in soil which is equivalent to a $1x10^{-6}$ cancer risk level, you simply multiply the direct contact non-cancer standard in Table 1A by the ratio of the desired cancer risk level to the [CRL]. The $1x10^{-6}$ cancer risk level for benzene is then calculated as $1000(1x10^{-6}/6.5x10^{-6})$ or 154 mg/kg. The desired cancer risk level should never exceed the value within brackets

[CRL]. This would yield a value in excess of the direct contact non-cancer standard meaning that the resulting level would no longer be protective based on non-cancer effects. The assumptions used to estimate these cancer risk levels are contained in Table 2 of this document.

Ground Water Protection Levels

The generic soil standards contained in this portion of Table 1A are based on the potential of a contaminant or compound to migrate to ground water. These standards are based on the concepts of desorption non-equilibrium and are designed to actually be protective of soil pore water. Two different standards are provided for each organic compound on the list depending on how recently the soil has become contaminated. Level 1 is applicable to soils that have been contaminated as a result of recent or continuing spills, leaks, or discharges. Level 2 applies to soils that have been contaminated by spills, leaks, or discharges which occurred, in total, more than one year ago. All releases will be assumed to be Level 1 unless clear and convincing evidence supports the use of Level 2. In order to be eligible to use Level 2, the responsible party must demonstrate by clear and convincing evidence that the release has been in the soil for more than one year and that the responsible party acted in good faith (for example, by not delaying remediation to take advantage of the Level 2 standard). It is incumbent upon the responsible party to respond to spills and releases in compliance with all applicable laws and regulations.

The general assumptions and rationale used to estimate the generic soil standards for ground water protection are contained in Table 3 of this document.

II. Land Use and the Use of Institutional and Engineering Controls

Remedies which continue to protect human health, all uses of water, all ecological receptors, and which protect the current and reasonably expected future uses of land are the goal. Where remediations meet this goal, responsible parties will have no ongoing obligation to augment the initial remedy as long as land use remains the same.

In those situations where it is not feasible to remove or treat contamination to an acceptable level, the use of institutional or engineering controls is necessary to ensure that the overall protectiveness level of the remedy meets an acceptable level. Any control of this type will eliminate uses or limit the use of the property. These controls include, but are not limited to, caps, fences, land use restrictions, and water use restrictions. Cleanup plans which include land use restrictions should incorporate appropriate deed restrictions.

In order for remedies to be as permanent as practicable, engineering and institutional controls should be used in a manner which protects or restores as many uses as possible. For instance, it may be possible to remove contamination to a level that is safe for worker protection instead of simply capping the contamination and eliminating all uses. Or, it may be possible to treat or remove the top layers of soil to address a direct contact threat, with restrictions for excavation below that point.

Also, unless the land use is only temporarily lost or restricted, active engineering controls are preferred instead of or in addition to passive institutional controls.

The reliance on engineering or institutional controls to make a remedy protective of human health and safety and the environment will carry ongoing obligations for the responsible party. Controls must be maintained in order for the remedy to remain protective. Therefore, fences must be repaired, deed restrictions must be adhered to, and caps must be inspected and, if necessary, repaired. Short term or permanent loss or restriction of uses of natural resources also may subject responsible parties to natural resource damage claims.

III. Explanatory Notes for Tables 1A and 1B

1. The lists in Tables 1A and 1B are not meant to be exhaustive but represent the more common compounds/contaminants that are encountered in soil.

2. Direct contact non-cancer standards and [CRL] values in Table 1A may change as toxicological data change. Similarly, the values in Table 1B may change as toxicological data change for metals and other inorganics. The values in Tables 1A and 1B will be updated periodically to reflect changes and additions.

3. For soils with multiple organic contaminants, the sum of the concentrations of specific compounds should never exceed 500 mg/kg when attempting to meet the generic ground water protection standards. The reason for this has to do with the desorption non-equilibrium equations upon which the ground water protection standards are based. For example, suppose soil contains 150 mg/kg endrin; 50 mg/kg aldrin; and 350 mg/kg chlordane. Even though the generic ground water protection standard for each individual compound has been met, the sum of their concentrations exceeds 500 mg/kg; therefore, the sum of their concentrations would have to be reduced by 50 mg/kg to ensure that they are protective of ground water.

4. In addition to the generic standards in Table 1A, an unsaturated zone contaminant migration model also has been developed and is a component of the Criteria Estimation Modeling System (CREST). The model in CREST (or other models approved by the Department) may be used to demonstrate that soil contaminant levels which exceed the generic soil standard for ground water protection are still protective of ground water based on site-specific conditions. This model is based on desorption non-equilibrium and is applicable to organic compounds in soil. Another model which exists in CREST and which is based on equilibrium partitioning could be used to model migration of inorganics in conjunction with site-specific leachate data.

5. The generic cleanup standards listed in Table 1B are based either on the exposure assumptions listed in Table 2 of this document or the maximum cumulative metal loading applied to soil through the land application of biosolids as set forth in 40 CFR Part 503 (Standards for the Use or Disposal of Sewage Sludge), whichever is more protective. The loading rates in 40 CFR Part 503 are based on the methodology and assumptions set forth in the Technical Support Document for Land Application of Sewage Sludge (EPA 822/R-93-001a and b - November 1992).

6. Standards based on ground water protection have not been included for the inorganics in Table 1B because the desorption non-equilibrium equations used in that methodology apply only to organics. In order to determine standards for metals and other inorganics that are protective of ground water, leachate data should be used either directly or indirectly.

Table 1A

Generic Soil Standards for Organic Compounds*

Compound/Contaminant CASRN	Direct Contact Non-Cancer (mg/kg) [CRL]	1×10^{-6} Excess Cancer Risk Level mg/kg	Ground Water Protection Level 1 mg/kg	Ground Water Protection Level 2 mg/kg
Acenaphthene 83-32-9	4000	NA	7	30
Aldrin 309-00-2	2 [6.5×10^{-6}]	0.3	100	500
Anthracene 120-12-7	20,000	NA	20	70
Benzene 71-43-2	1000 [6.5×10^{-6}]	100	0.2	0.[illegible]
Benzo[a]pyrene 50-32-8	10 [1.6×10^{-5}]	0.6	500	500
Chlordane 57-74-9	4 [1.2×10^{-6}]	3	400	500
Chlorobenzene 108-90-7	1000	NA	0.6	3
Chloroform 67-66-3	700 [9.6×10^{-7}]	--	0.1	0.5
Cresol, o- 95-48-7	3000	NA	0.1	0.5
Cresol, p- 106-44-5	300	NA	0.1	0.4
D, 2,4- 94-75-7	700	NA	0.6	2
DDD, p,p'- 72-54-8	40 [2.1×10^{-6}]	20	400	500
DDE 72-55-9	300 [2.3×10^{-5}]	10	200	500
DDT, p,p'- 50-29-3	30 [2.3×10^{-6}]	10	500	500

Table 1A (continued)

Generic Soil Standards for Organic Compounds*

Compound/Contaminant CASRN	Direct Contact Non-Cancer (mg/kg)[CRL]	$1x10^{-6}$ Excess Cancer Risk Level mg/kg	Ground Water Protection Level 1 mg/kg	Ground Water Protection Level 2 mg/kg
Dichlorobenzene, 1,2- 95-50-1	7000	NA	2	7
Dichlorobenzene, 1,4- 106-46-7	100 [$5.4x10^{-7}$]	--	2	7
Dichloroethane, 1,1- 75-34-3	7000	NA	0.1	0.5
Dichloroethane, 1,2- 107-06-2	300 [$6.1x10^{-6}$]	50	0.07	0.3
Dichloroethylene, 1,1- 5-35-4	700	NA	0.2	1
Dichloroethylene, 1,2- (trans) 156-60-5	1000	NA	0.2	0.6
Dieldrin 60-57-1	3 [$1.1x10^{-5}$]	0.3	20	90
Endrin 72-20-8	20	NA	200	500
Ethylbenzene 100-41-4	7000	NA	1	5
Fluoranthene 206-44-0	3000	NA	100	400
Fluorene 86-73-7	3000	NA	10	40
Heptachlor 76-44-8	30 [$3.0x10^{-5}$]	1	90	400
Lindane 58-89-9	20 [$5.8x10^{-6}$]	3	3	10
Methoxychlor 72-43-5	300	NA	60	200

Table 1A (continued)

Generic Soil Standards for Organic Compounds*

Compound/Contaminant CASRN	Direct Contact Non-Cancer (mg/kg) [CRL]	$1x10^{-6}$ Excess Cancer Risk Level mg/kg	Ground Water Protection Level	
			1 mg/kg	2 mg/kg
Methylene chloride 75-09-2	4000 [$6.7x10^{-6}$]	600	0.05	0.2
Methyl ethyl ketone 78 93-3	40,000	NA	0.01	0.05
Methylnaphthalene, 1- 90-12-0	1000	NA	5	20
Methylnaphthalene, 2- 91-57-6	1000	NA	5	20
Naphthalene 91-20-3	600	NA	2	8
Pentachlorophenol 87-86-5	2000 [$5.4x10^{-5}$]	40	50	200
Petroleum Hydrocarbons (PHC)** (for fuel-contaminated soil only)			200**	500
Phenanthrene 85-01-8	200	NA	20	80
Phenol 108-95-2	40,000	NA	0.05	0.2
Polychlorinated Biphenyls*** (PCBs) 1336-36-3	5 [$1x10^{-6}$]***			
Pyrene 129-00-0	2000	NA	80	300
TP, 2,4,5- (Silvex) 93-72-1	600	NA	0.6	3
Tetrachloroethane, 1,1,1,2- 630-20-6	2000	NA	1	4

Table 1A (continued)

Generic Soil Standards for Organic Compounds*

Compound/Contaminant CASRN	Direct Contact Non-Cancer (mg/kg) [CRL]	$1x10^{-6}$ Excess Cancer Risk Level mg/kg	Ground Water Protection Level	
			1 mg/kg	2 mg/kg
Tetrachloroethylene 127-18-4	700	NA	0.6	2
Toluene 108-88-3	10,000	NA	0.5	2
Toxaphene 8001-35-2	30 [$7.4x10^{-6}$]	4	5	20
Trichloroethane, 1,1,1- 71-55-6	7000	NA	0.3	1
Trichloroethane, 1,1,2- 79-00-5	300	NA	0.2	0.8
Trichloroethylene 79-01-6	1000 [$2.5x10^{-6}$]	400	0.4	2
Xylenes, total 1330-20-7	100,000	NA		
Xylene, o- 95-47-6			0.7	3
Xylene, m- 108-38-3			1	5
Xylene, p- 106-42-3			1	5

* All generic soil standards listed in this table are on a dry weight basis.

** This standard applies only to soils contaminated with virgin fuels which are defined for this document as unused distillate and residual petroleum fuels including, but not limited to, heating or fuel oils, diesel fuels, aviation fuels, kerosene, or gasoline. Virgin fuels do not include blended fuels containing used oil or other waste materials.

The analytical methodology to be used to make this PHC determination is gas chromatography using a flame ionization detector (GC-FID) developed for the American Petroleum Institute (API, 1992). Other recognized methods may be used if approved by the Department. Fuels that contain substantial amounts of PHCs above C28 may require alternative analytical methodologies for quantitation. The Department should be contacted for specific guidance on analytical methodologies when dealing with these types of fuels.

(See: American Petroleum Institute (API). February 1992. Methods for the Measurement of Petroleum Hydrocarbons: Gasoline Range/Diesel Range, as updated.)

*** This standard is based directly on a CRL of $1x10^{-6}$ and is not based on non-cancer effects.

-- The $1x10^{-6}$ excess cancer risk level exceeds the direct contact non-cancer standard (see text).

Table 1B

Generic Soil Standards for Metals and Other Inorganic Contaminants[1]

Contaminant	CASRN	Cleanup Standard (mg/kg)
Arsenic	7440-38-2	20[2]
Barium	7440-39-3	5000[2]
Cadmium	7440-43-9	20[3]
Chromium (hexavalent)	18540-29-9	300[2]
Chromium (total)	7440-47-3	1000[3]
Copper	7440-50-8	700[3]
Cyanide	57-12-5	1000[3]
Mercury	7439-97-6	20[2]
Nickel	7440-02-0	200[3]
Selenium	7782-49-2	60[3]
Zinc	7440-66-6	1000[3]

[1] All cleanup standards listed in this table are on a dry weight basis and have been rounded to one significant figure.

[2] These cleanup standards are based on the assumptions set forth in Table 2 of this document.

[3] These cleanup standards are based on the 40 CFR Part 503 cumulative metals loading rates which have been converted to concentrations in soil by assuming a six-inch plow zone depth. Loading rates that are based on a human direct contact exposure (as described in the Technical Support Document for Land Application of Sewage Sludge - November 1992) have not been used to estimate cleanup standards.

Table 2

Exposure Assumptions Used in Development of Direct Contact Generic Soil Standards and Estimation of Cancer Risk Levels

Assumptions for Non-Carcinogenic Effects

Incidental soil ingestion rate, child	200 mg/day*
Body weight, child	15 kg
Exposure frequency	350 days/yr**
Exposure duration, child	6 years
Averaging time, child	6 years
Oral absorption fraction	1

Assumptions for Carcinogens

Incidental soil ingestion rate, child	100 mg/day*
Incidental soil ingestion rate, adult	50 mg/day*
Body weight, child	15 kg
Body weight, adult	70 kg
Exposure frequency, child	100 days/yr**
Exposure frequency, adult	100 days/yr**
Exposure duration, child	6 years
Exposure duration, adult	24 years
Averaging time	70 years
Oral absorption fraction	1

* The use of different soil ingestion rates for carcinogens versus non-carcinogenic effects is from the Proposed RCRA Corrective Action Regulations. 200 mg/day represents an upper bound value: 100 mg/day and 50 mg/day represent "average" or median values.

** The 350 day/yr exposure frequency is from CERCLA guidance directives: the 100 day/yr exposure frequency is based on the number of frost free days in Pennsylvania.

Table 3

General Assumptions/Rationale Used in Development of Ground Water Protection Generic Soil Standards

- Equations based on non-equilibrium desorption of organic compounds from soil are appropriate in estimating generic soil standards.

- Standard equilibrium partitioning equations (such as the Freundlich Equation) do not adequately address desorption of organic compounds from unsaturated zone soil.

- Analytical data for unsaturated zone soils do not support the use of standard equilibrium partitioning equations.

- Non-equilibrium desorption of organics from soil (as presented in numerous research papers) is supported by analytical data for unsaturated zone soils.

- As organic compounds remain in unsaturated zone soil for longer and longer periods of time, their tendency to desorb from the soil decreases.

- In the determination of the generic soil standards, no dilution/attenuation of the contaminant is assumed to occur between contaminated soil and the aquifer.

8/1/94

ORIGINAL (Red)

From time to time, I receive requests for generic cleanup standards for soils contaminated with compounds/constituents that are not included in the interim December 1993 document. The following lists have been developed (and will be updated to include additional contaminants/constituents as requested) for your use. The "rules" used to develop these levels are the same ones that are specified and discussed in Chapter 2 of the CREST user's manual (with a few minor exceptions). The format used in Tables 1A and 1B of the standards document is also used here.

It is intended that these contaminants/constituents will be included in future revisions of the standards document (if and when such revisions occur).

Table 1A Additions

Generic Soil Standards for Organic Compounds

Compound/Contaminant CASRN	Direct Contact Non-Cancer (mg/kg) [CRL]	1x10-6 Excess Cancer Risk Level mg/kg	Ground Water Protection Level 1 mg/kg	Ground Water Protection Level 2 mg/kg
Acetone 67-64-1	8000	NA	0.006	0.03
Aniline 62-53-3	100 [1.3x10-7]	800	0.03	0.1
Atrazine 1912-24-9	3000	NA	2	6
Benz[a]anthracene 56-55-3	NA	6	200	500
Benzo[b]fluoranthene 205-99-2	NA	6	500	500
Benzo[k]fluoranthene 207-08-9	NA	60	500	500
Benzo[ghi]perylene 191-24-2	Toxicological data unavailable.		500	500
Bis(2-ethylhexyl) phthalate 117-81-7	1000 [3.1x10-6]	300	100	400
Carbon disulfide 75-15-0	7000	NA	0.2	0.8
Chrysene 218-01-9	NA	600	300	500

Cumene 98-82-8	3000	NA	3	10
Dibutyl phthalate 84-74-2	7000	NA	70	300
1,3-Dichlorobenzene 541-73-1	7000	NA	2	7
1,2-Dichloropropane 78-87-5	NA	60	0.2	0.9
Freon 11 (trichlorofluoromethane) 75-69-4	20,000	NA	0.4	2
Freon 12 (dichlorodifluoromethane) 75-71-8	10,000	NA	0.3	1
Hexachlorobenzene 118-74-1	60 [2.1x10-5]	3	100	500
Indeno(1,2,3-cd)- pyrene 193-39-5	NA	6	500	500
Kepone 143-50-0	NA	0.2	90	400
Mirex 2385-85-5	20 [6.3x10-6]	2	60	200
MTBE (Methyl tert-butyl ether) 1634-04-4	1000	NA	0.05	0.2
Styrene 100-42-5	10,000	NA	1	4
2,3,7,8-TCDD 1746-01-6	NA	0.00003	500	500
1,1,2,2-Tetrachloro- ethane 79-34-5	NA	20	0.3	1
Tetrahydrofuran 109-99-9	Toxicological data unavailable.		0.02	0.07
1,2,4-Trichlorobenzene 120-82-1	800	NA	6	20

Trifluralin 1582-09-8	600	NA	9	40
1,2,4-Trimethylbenzene 95-63-6	40	NA	3	10
Vinyl chloride 75-01-4	NA	2	3	10

Table 1B Additions

Generic Soil Standards for Metals and Other Inorganic Contaminants

Contaminant	CASRN	Cleanup Standard (mg/kg)
Antimony	7440-36-0	30
Beryllium	7440-41-7	1
Silver	7440-22-4	400
Thallium	7440-28-0	6

Criteria Estimation Modeling System

(INTERIM)

Technical Support Software for
Estimation of Protective Contaminant Levels in Soil

November 1993

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ORIGINAL (Red)

USER'S MANUAL
FOR
CRITERIA ESTIMATION (CREST) MODELING SYSTEM
(INTERIM)

by

Donald L. Killian

Scientific Services Section
Division of Remediation
Bureau of Waste Management

PENNSYLVANIA DEPARTMENT OF ENVIRONMENTAL RESOURCES

November 1993

November 1993

PREFACE

This manual and the software which it supports have been developed for the purpose of estimating criteria for contaminants in soil which are protective of human health and the environment and also for estimating whether contaminants existing in soils at specific sites pose a threat to ground water. This modeling system has been used to estimate the Department's "Cleanup Standards for Contaminated Soils". The assumptions, rationale and methodology which have been used to estimate those standards are provided in this document.

This manual describes in detail two spreadsheets which can be used to estimate the potential vertical migration of contaminants from contaminated unsaturated zone soil. One spreadsheet pertains to organic compounds and is based on nonequilibrium desorption: the other spreadsheet pertains to inorganics and requires data from leachate analysis prior to its use. It should be noted that the concepts embodied in these two spreadsheets (particularly the spreadsheet developed for organic compounds) represent a departure from the way desorption of contaminants from unsaturated zone soils is generally perceived.

Models and equations that have historically been used to estimate potential migration of contaminants in unsaturated zone soils often are not supported by analytical data for contaminants in unsaturated zone soil. These models and equations are based primarily on the use of equilibrium partitioning of organic contaminants and are founded on data from sorption experiments in saturated systems. Their use in saturated systems would seem to be well justified; however, the same application to unsaturated systems does not appear to be valid.

The spreadsheets described in this document have been developed simply to offer an approach which is supported qualitatively by a great deal of analytical data in unsaturated zone soils. The algorithms presented in the text of this document are relatively simple. As more research is conducted in the area of non-equilibrium desorption and as more data become available, other modeling systems based on more refined equations may be developed.

The inherent nature of the environment (whether unsaturated zone soils, air, ground water, etc.) does not lend itself to exactitude when it comes to predicting the fate and transport of contaminants among environmental media. Non-equilibrium desorption algorithms seem to "fit" the data better for unsaturated zone soils than do equilibrium partitioning equations; however, neither approach is exact.

Other modeling systems currently exist for estimating potential vertical migration of contaminants through soil. Therefore, the CREST modeling system should not be viewed as advocating or endorsing its use to the exclusion of any other existing models or equations. Instead CREST is provided as a tool to aid in making informed remediation decisions and to aid in estimating potential contaminant migration in unsaturated zone soils.

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CHAPTER ONE

INTRODUCTION

Remediation of contaminated environmental media has become an extremely important issue in recent years. Although there is general agreement that remediation of environmental contamination is necessary, considerable disagreement exists not only on specific remedial actions that should be implemented at a given site but also on the basis for such remedial actions. Two general concepts are usually considered as the basis for determining remediation of environmental contamination. These concepts are protectiveness and feasibility. Feasibility comprises a number of subcomponents including cost- effectiveness of the remedial action as well as effectiveness, implementability, and permanence resulting from the action. Remedial actions based on protectiveness usually are directed toward protection of human health and the environment including ecological receptors.

This document and the supporting computer software are directed toward protectiveness. More specifically, the focus is on a relatively simple and easy-to-use methodology which has been used to determine "protective" cleanup standards for contaminated soil in the absence of any type of engineering/institutional controls which may be implemented at a site (i.e., capping, surface water diversion, deed notices/restrictions, fencing, replacing drinking water sources, subsurface slurry walls, etc.).

One major problem in determining "protective" levels in soil is first deciding what is meant by the word "protective". Different individuals have different opinions on this matter. For soils, some individuals prefer to apply the concept of protectiveness to a human receptor by comparing a contaminant level in soil to a health-based standard. Others prefer to apply protectiveness to the ground water by ensuring that a contaminant level in soil will not contaminate ground water.

The methodology presented in this document is not meant to advance one level of protectiveness over another, i.e., protection of human health versus protection of ground water. This methodology embraces both concepts of protectiveness by allowing the user to estimate cleanup criteria based on protection of human health and protection of ground water. This system has been developed to allow a high degree of flexibility to the individual(s) who must ultimately decide what remedial action to take at a contaminated site. This is especially important since the complexity of contaminated sites can vary from those that are very small where the contaminant has not migrated appreciably to those that are extremely large where contaminants have migrated significant distances both vertically and laterally.

In order to apply protective numeric cleanup criteria as efficiently as possible to a given site, generic cleanup levels are extremely useful. Use of generic criteria at some sites is much more efficient and timely than determining numeric criteria based on site-specific conditions. Generic cleanup standards ensure protectiveness because they are based on the use of relatively conservative generic assumptions in the areas of environmental fate and transport modeling, exposure assessment, toxicological evaluation and/or risk assessment.

This system has been designed to provide the user with the capability to easily estimate, for a given organic contaminant, soil cleanup criteria for protection of ground water (based on some limited site-specific information). This procedure, its basis and the supporting equations are provided in Chapter 2 of this document. The rationale for the soil cleanup standards which are based on groundwater protection are provided in Chapter 2 also as well as the equations and exposure assumptions which have been used to estimate the human health-based soil cleanup standards.

The modeling system is not designed to provide groundwater protection criteria for metals and other inorganics in soil. Leachate and total analysis data from site soils would be needed to estimate such criteria for inorganics on a site-specific basis.

In addition, this system provides an additional site-specific approach to determine whether contaminant levels existing in soil at a specific site are protective of ground water by estimating potential migration of contaminants from contaminated soil vertically toward ground wat Chapter 3 describes the site-specific model which applies to organic compounds. Chapter 4 describes the site-specific model which applies to inorganics. The model for inorganics requires the use of leachate and total analytical data for contaminated soils.

These site-specific models are not amenable to developing criteria because they are based on combinations of soil contaminant concentrations, depth of contaminated soil, depth to ground water and time; however, they are useful for the purpose of illustrating potential migration of contaminants from soil vertically toward ground water.

The soil cleanup standards and criteria discussed above are based on either migration of contaminants from soil to ground water or direct human contact with contaminated soil. These are generally the scenarios which result in the greatest human health risk; however, there are instances where exposure of other receptors to contaminants may be important. Potential exposure and subsequent adverse effects on aquatic and terrestrial ecological receptors should also be considered on a site-specific basis.

In summary, Chapter 2 of this document explains how the soil cleanup standards have been developed and how some limited site-specific criteria (based on protection of ground water) can be developed. Chapter 3 discusses the site-specific migration model for organic contaminants, and Chapter 4 describes the site-specific migration model for inorganics. Chapter 5 explains how to access the software for the two sitespecific migration models and what the system requirements are to use the software. Chapter 6 includes a discussion of the input variables in the system and how values for the variables can be obtained.

Appendix A provides a list of log K_{OW} values and aqueous solubilities f[illegible] some of the more common organic contaminants frequently detected in soils. Appendix B is a list of log K_{OC} values which can be used in the unsaturated zone migration model for organic compounds discussed in Chapter 3. Appendix C provides a list of references upon which the components of this modeling system are based.

CHAPTER TWO

GENERIC CLEANUP STANDARDS FOR SOIL

This chapter describes in detail the basis of the cleanup standards for contaminated soil and the methodology and assumptions used in their estimation. Each of the following is discussed separately in this chapter: (1) the estimation of the non-cancer direct contact standard; (2) the estimation of the cancer risk level for the non-cancer direct contact standard; (3) the estimation of the cleanup standards for some metals based on 40 CFR Part 503; (4) the estimation of the soil cleanup standards for organics based on groundwater protection, and; (5) the estimation of organic contaminant levels in soil which would be protective of ground water on a limited site-specific basis.

<u>Non-Cancer Direct Contact Soil Cleanup Standard</u>: This standard is based exclusively on the protection of human health from non-carcinogenic effects. More specifically this standard is based on an exposure scenario in which children directly contact contaminated soil and sustain an exposure to the contaminant(s) via incidental ingestion of soil.

The development of the non-cancer direct contact soil cleanup standard requires the application of some generic exposure assumptions to toxicological data. For non-carcinogenic effects, the exposure assumptions for residential incidental ingestion of soil which are presented in the United States Environmental Protection Agency OSWER Directive 9285.6-03 (EPA, 1991) have been used in conjunction with those presented for residential exposure to chemicals in soil in EPAs "Risk Assessment Guidance for Superfund Human Health Evaluation Manual Part A" (EPA, 1989). These exposure assumptions are listed in the following table.

Exposure Assumptions for
Residential Exposure to Chemicals in Soil
(Non-Carcinogenic Effects)

Incidental soil ingestion rate, child (IRc)	200 mg/day
Body weight, child (BWc)	15 kilograms
Exposure frequency (EF)	350 days/year
Exposure duration, child (EDc)	6 years
Averaging time, non-carcinogens, child (ATncc)	6 years
Oral absorption fraction (AF)	1

To ensure consistency, the primary source of toxicological data is EPAs Integrated Risk Information System (IRIS), and the secondary source is the most recent EPA Health Effects Assessment Summary Tables (HEAST). The toxicological data which are used to develop non-cancer direct contact cleanup standards are chronic oral reference doses (oRfD). In the absence of such data in IRIS or HEAST, oRfDs are derived from oral LD_{50}s in small rodent bioassays according to a method in Layton et al (1987). This method is simply to multiply an oral LD_{50} value (expressed in mg/kg of body weight) by $5x10^{-6}$. According to Layton et al (1987), "It is emphasized that these interim ADI [RfD] values are no substitute for toxicity testing, but that such testing would most likely result in higher ADI [RfD] estimates."

While this is not a rigorous method for deriving oRfDs, it is conservative and provides a method for estimating non-cancer cleanup standards for contaminants that may otherwise be ignored or overloo but which may exhibit significant toxicity. In many cases, carcinogens which have an oral cancer slope factor do not have oRfDs. This does not mean that such carcinogens have no non-cancer effects. A cleanup level which is estimated from the oral cancer slope factor may not be protective with respect to non-carcinogenic effects. Therefore, it is imperative to have some non-cancer goal even though that goal is not based on toxicological data of the highest quality.

For contaminants with non-carcinogenic effects, the exposure dose should not exceed the chronic oral reference dose. The non-cancer direct contact cleanup standards have been estimated using the following equation:

$$\text{Standard} = \frac{(365)(BWc)(ATncc)(oRfD)}{(EF)(EDc)(IRc)(AF)(10^{-6})}$$

where; Standard = non-cancer direct contact cleanup standard (mg/kg)

BWc = body weight of a child (kg)

ATncc = averaging time for non-carcinogenic effects for a child (years)

EF = exposure frequency (days/year)

EDc = exposure duration for a child (years)

IRc = incidental soil ingestion rate for a child (mg/day)

AF = absorption factor

oRfD = chronic oral reference dose (mg/kg/day)

This equation uses child exposure assumptions instead of those for an adult because, in all cases, the child exposure assumptions will yield a lower non-cancer standard than adult exposure assumptions. The specific reason for this is that the incidental soil ingestion rate for a child exceeds that for an adult, and the child body weight is lower than that for an adult. Both of these differences have the effect of lowering the non-cancer standard for a child relative to the non-cancer standard for an adult.

Substituting exposure assumptions from the table;

$$\text{Standard} = \frac{(365\ \text{days/yr})(15\ \text{kg})(6\ \text{yrs})(\text{oRfD})}{(350\ \text{days/yr})(6\ \text{yrs})(200\ \text{mg/day})(1)(10^{-6}\ \text{kg/mg})}$$

$$\boxed{\text{Non-Cancer Direct Contact Cleanup Standard} = (78200\ \text{kg body weight-days/kg soil})(\text{oRfD})}$$

Cancer Risk Level (CRL) Estimation: In the "Cleanup Standards for Contaminated Soils", the CRL associated with the non-cancer direct contact cleanup standard is provided for contaminants which are carcinogens. In order to estimate the associated CRL, an exposure scenario must again be used in conjunction with appropriate toxicological data. The exposure scenario which has been used is a residential one in which individuals directly contact contaminated soil via incidental ingestion of soil according to the exposure assumptions contained in the following table:

Exposure Assumptions for
Residential Exposure to Chemicals in Soil
(Carcinogenic Effects)

Incidental soil ingestion rate, child (IRc)	100 mg/day
Incidental soil ingestion rate, adult (IRa)	50 mg/day
Body weight, child (BWc)	15 kilograms
Body weight, adult (BWa)	70 kilograms
Exposure frequency, child (EFc)	100 days/year
Exposure frequency, adult (EFa)	100 days/year
Exposure duration, child (EDc)	6 years

Exposure duration, adult (EDa)	24 years
Averaging time	70 years
Oral absorption fraction (AF)	1

The use of different soil ingestion rates for carcinogens versus non-carcinogenic effects is from the Proposed RCRA Corrective Action Regulations. 200 mg/day represents an upper bound value: 100 mg/day and 50 mg/day represent "average" or median values.

The exposure frequency for carcinogens (100 days/year) is based on the number of frost free days in Pennsylvania, i.e., 3 days of exposure for every frost free week per year.

Again, to ensure consistency, the primary source of toxicological da[illegible] is EPAs Integrated Risk Information System (IRIS), and the secondary source is the most recent EPA Health Effects Assessment Summary Tables (HEAST). The toxicological data which are used to estimate CRLs are oral cancer slope factors (oCSF).

For carcinogens, a contaminant level in soil associated with a given CRL can be estimated using the following equation:

$$C_{soil} = \frac{(365)(ATc)(CRL)}{(AF)(EF)(1x10^{-6})(oCSF)\left[\frac{(IRc)(EDc)}{(BWc)} + \frac{(IRa)(EDa)}{(BWa)}\right]}$$

where; C_{soil} = concentration of contaminant in soil associated wit[illegible] given CRL (mg/kg)

ATc = averaging time for carcinogens (years)

CRL = cancer risk level associated with C_{soil}

oCSF = oral cancer slope factor $(mg/kg/day)^{-1}$

IRa = incidental soil ingestion rate for an adult (mg/day)

IRc = incidental soil ingestion rate for a child (mg/day)

BWa = body weight for an adult (kg)

BWc = body weight for a child (kg)

EDa = exposure duration for an adult (years)

EDc = exposure duration for a child (years)

EF = exposure frequency (days/year)

AF = oral absorption fraction

This equation separates the 30 years of exposure into two parts - one for childhood (six years from age 1 to 6) and one for the following 24 years of exposure.

Substituting exposure assumptions from the table;

$$C_{soil} = \frac{(365\ \text{d/y})(70\ \text{y})(1\text{x}10^{-6})}{(1)(100\ \text{d/y})(1\text{x}10^{-6}\ \text{kg/mg})(\text{oCSF})\left[\dfrac{(100\ \text{mg/d})(6\ \text{y})}{(15\ \text{kg})} + \dfrac{(50\ \text{mg/d})(24\ \text{y})}{(70\ \text{kg})}\right]}$$

$$\boxed{C_{soil} = \frac{[(4471250)(\text{CRL})\ \text{kg body weight-days/kg soil}]}{\text{oCSF}}}$$

In order to determine the CRL associated with the non-cancer direct contact cleanup standard (NCDCCS) for a contaminant, the NCDCCS is substituted for C_{soil} in the above equation which is then solved for t[illegible] CRL, or;

$$\boxed{\text{CRL} = (2.23\text{x}10^{-7})(\text{oCSF})(\text{non-cancer direct contact cleanup standard})}$$

Example of estimation of non-cancer direct contact standard and the associated CRL:

contaminant: pentachlorophenol

oRfD = $3\text{x}10^{-2}$ mg/kg/day

oCSF = $1.2\text{x}10^{-1}$ $(\text{mg/kg/day})^{-1}$

Standard = (78200 kg bw-days/kg soil)(oRfD) = (78200)(0.03)

Standard = 2000 mg/kg (rounded to one significant digit)

$$\text{CRL} = (2.23\text{x}10^{-7})(\text{oCSF})(\text{non-cancer standard})$$

$$= (2.23\text{x}10^{-7})(0.12)(2000)$$

$$\text{CRL} = 5.4\text{x}10^{-5}$$

<u>Estimation of Cleanup Standards for Some Metals (40 CFR Part 503)</u>: In order to ensure that soil cleanup standards are protective of human health under conditions which differ from a direct contact exposure scenario but which could plausibly occur at a site, the maximum cumulative metal loading rates set forth in 40 CFR Part 503 (<u>Standards for the Use or Disposal of Sewage Sludge</u>) have been considered. By applying the assumptions provided below, loading rates have been converted to metal concentrations in soil. The resulting concentrations which are lower than the concentrations estimated using a dir[illegible] contact exposure scenario have been used as the cleanup standard in lieu of the levels estimated from the direct contact scenario. In instances where the cumulative metal loading rate is based solely on a human direct contact exposure scenario, the soil cleanup standard has been estimated according to the direct contact exposure assumptions set forth in this chapter. This has been done for consistency and to ensure that cleanup standards are protective of human health.

The loading rates in 40 CFR Part 503 are based on the methodology and assumptions set forth in EPA (1992). Some of the resulting metal concentrations are lower than those estimated using only a direct contact scenario primarily because other exposure pathways and effects have been considered in the development of those regulations, i.e., potential uptake of metals by crops and subsequent ingestion of the crops by humans, potential livestock toxicity, and plant toxicity. These are plausible scenarios because land use at many sites could conceivably change to agricultural in the future.

Conversion assumptions:

plow zone depth = 6 inches (0.152 meters)

bulk density of soil = 1.5 g/cc or 1500 kg/m^3

Conversion procedure:

$$\begin{array}{c}\text{loading rate}\\\text{kg/hectare}\end{array} \text{ x } \frac{1\text{ hectare}}{10000\text{ m}^2} \text{ x } \frac{1\text{ m}^3}{1500\text{ kg}} \text{ x } \frac{10^6\text{ mg}}{\text{kg}} \text{ x } \frac{1}{0.152\text{ m}} = \begin{array}{c}\text{metal level}\\\text{in soil}\\\text{in mg/kg}\end{array}$$

$$\text{Metal level in soil (mg/kg)} = \frac{\text{metal loading rate in kg/hectare}}{2.28}$$

The following sludge cumulative metal loading rates are from 40 CFR Part 503 and have been used in the estimation of soil cleanup standards for the metals listed.

Metal Contaminant	Cumulative Metal Loading Rate kilograms/hectare	Basis for Loading Rate
C[illegible]ium	53	Uptake by biota and subsequent ingestion by ecological receptors
Chromium (total)	3000	Plant toxicity
Copper	1500	Plant toxicity
Nickel	420	Plant toxicity
Selenium	130	Livestock toxicity
Zinc	2800	Plant toxicity

Groundwater Protection Soil Cleanup Standards for Organic Compounds: The method used to develop these cleanup standards is based primarily o[illegible]he concepts of non-equilibrium desorption. These standards are de[illegible]gned to be protective of soil pore water (and therefore ground water). In this method, equations based on non-equilibrium desorption of organic compounds from soil are used to estimate levels of organic compounds in soil which will result in non-detectable levels in the soil pore water, i.e., the contaminant is sorbed in and/or on the solid matrix of the soil.

In determining remediation levels for contaminants in soil based on the potential for such contaminants to migrate from the soil into underlying ground water, the Bureau of Waste Management of the Pennsylvania Department of Environmental Resources, the U. S. Environmental Protection Agency and numerous consultants and contractors have historically applied the same general methodology, i.e., equilibrium partitioning. This methodology consists of calculating a soil/water adsorption partition coefficent (K_p) by multiplying a measured or estimated organic carbon fraction in soil (OC) by another partition coefficient (K_{OC}) values for which can either be found in the literature or estimated from other parameters.

K_{OC} values are based on saturated systems. According to Lyman et al (1982);

$$K_{OC} = \frac{\text{ug adsorbed/g organic carbon}}{\text{ug/ml solution}}$$

and

$$K_p = \frac{x/m}{C^{1/n}}$$

where; x/m = ug adsorbed/g of soil

C = ug/ml of solution

n = parameter with value generally ranging from 0.9 to 1.4

The latter equation is often referred to as the Freundlich equation.

From the above discussion;

$$K_p = (K_{OC})(OC)$$

Therefore;

$$(K_{OC})(OC) = \frac{x/m}{C^{1/n}}$$

Generally, in attempting to estimate a "protective" contaminant concentration in soil, the Freundlich equation is modified by assuming $n = 1$ and by assuming that x/m is equivalent to a contaminant concentration in soil minus the product of the effective porosity and contaminant concentration in water. This yields the following basic equation:

$$(K_{OC})(OC) = \frac{C_{soil} - P(C_{water})}{C_{water}}$$

where; C_{soil} = contaminant concentration in soil (mg/kg)

C_{water} = contaminant concentration in water associated with that soil, i.e., pore water (mg/l)

P = effective porosity of soil

By setting C_{water} equal to a protective level (MCL or other health-based level) and assuming an effective soil porosity, a protective level in soil is often estimated.

On the face of it, this seems rather straightforward and rational; however, contaminated unsaturated zone soil data do not seem to support this approach. In fact, data for unsaturated zone soil which has been contaminated for lengthy periods of time do not correlate well with what would be predicted by this method. Simply put, relatively low concentrations of contaminants in soil seem to linger for several years in the soil and are not depleted rapidly as this approach implies. This means that the aqueous concentrations of contaminants which are presumed to desorb from contaminated soil using this approach are very likely to be gross overestimates. This is crucial from a soil remediation perspective because, as the estimated "acceptable" contaminant level in soil becomes lower, the amount of soil requiring remediation rises.

The point being made here is best illustrated in an example. Suppose a [illegible]o inch depth of surface soil is contaminated with TCE. The following data apply:

TCE concentration in soil = 100 mg/kg (dry weight)
K_{oc} for TCE = 126
Soil organic carbon content = 0.001
Recharge rate = 13 inches/yr
Effective porosity of soil = 0.25
Detection limit for TCE in water = 0.1 ug/l
MCL for TCE = 5 ug/l
Soil bulk density = 1.5 g/cc

Using the previously described approach;

$$K_p = (0.001)(126) = 0.126$$

and

$$C_{water} = (100\ \text{mg/kg})/(0.126 + 0.25) = 266\ \text{mg/l}$$

A one liter volume of this soil (prior to leaching) contains 150 mg of TCE or 150 mg/l. One pore volume of water contains (0.25 l)(266 mg/l) or 66.5 mg of TCE. This means that after one pore volume of water has infiltrated through the liter of soil, there remains 83.5 mg TCE/l in soil or 56 mg/kg soil.

If this same process is repeated iteratively, approximately 24 pore volumes later there should be no detectable TCE remaining in the soil. Based on the given values for recharge and effective porosity (which are reasonable for Pennsylvania), approximatley 26 pore volumes of water will infiltrate the two inches of soil in slightly over one year. This means that in approximately one year all of the TCE in the two inches of soil should be virtually gone. If partitioning from soil into air were also considered, it would take considerably less than one year for the TCE (a volatile compound) to be depleted from the soil. Intuitively, this sounds unreasonable. Obviously, TCE does not migrate from the soil this rapidly.

Using the MCL in the same procedure to determine a protective TCE concentration in soil yields a protective level of 1.9 ug/kg. This would then logically be depleted from soil in a matter of days (under this same scenario). If this partitioning method actually approaches the reality of how volatile organic contaminants migrate in the environment, there should virtually be no contaminant remaining in soil by the time remedial actions are performed at many sites (often years after the sampling upon which the RI/FS is based). Yet contaminants are presumed to remain in the soil for years until the remedial action is taken. Clearly, this partitioning method is inadequate for predicting desorption of contaminants from soil into pore water or volatilization into the atmosphere.

The inadequacy of the partitioning approach presented above to accurately predict desorption of organic compounds from soil has been cited extensively in the literature. (See "List of References Regarding Soil Desorption Kinetics" at the end of this chapter.) According to Peterson et al (1988), the use of partition coefficients based on saturated conditions to predict volatile contaminant transport under unsaturated conditions should be avoided. They found that partition coefficients for TCE under unsaturated conditions were one to four orders of magnitude greater than those measured under saturated conditions. Smith et al (1990) also makes this observation for TCE in vadose zone soil. Steinberg et al (1987) found that 1,2-dibromoethane (EDB), which is a volatile organic with appreciable aqueous solubility, persisted in surface soil for up to 19 years after its last known application. The authors cite the high resistance of EDB in soil to migrate to air or to desorb to water. The actual partition coefficients were between two and three orders of magnit[illegible] greater than those predicted using the method described above. Th[illegible]e authors performed additional work with EDB in soils (Sawhney et al, 1988) which yielded results consistent with their initial findings. McCall and Agin (1985) found that over time picloram in soil becomes increasingly resistant to leaching implying that methods currently used to predict chemical migration will overestimate mobility.

Recently, there has been considerable interest in the desorption kinetics of organic contaminants from soil matrices. New theories which identify non-equilibrium desorption of organics from soil based on mass diffusion from soil matrices are emerging. Some of the desorption work which has been accomplished recently can be used to develop a more cogent method for estimating desorption of organic compounds from soil and more accurately predict migration of organic compounds in unsaturated zone soil.

According to Brusseau et al (1990), the partitioning approach described above has "failed to adequately represent experimental data." The authors state that sorption of organics occurs in two stages: an initial stage in which organic compounds are rapidly taken up or released (occuring within minutes to hours) followed by a much longer period of time (days or months) in which uptake and release of organics is much slower. This system of sorption/desorption is conceptualized by the following bicontinuum as presented in Brusseau et al (1990):

$$\begin{tikzcd} C_g \arrow[r, leftrightarrow, "H"] & C_w \arrow[r, leftrightarrow, "K_p"] & S_1 \arrow[r, shift left, "k_1"] & S_2 \arrow[l, shift left, "k_2"] \end{tikzcd}$$

where; C_g = solute concentration in gas phase

C_w = solute concentration in water phase

S_1 = sorbed phase concentration in equilibrium domain

S_2 = sorbed phase concentration in mass-transfer-constrained domain

K_p = equilibrium sorption constant

H = Henry's constant

k_1 = forward first-order mass-transfer rate constant

k_2 = reverse first-order mass-transfer rate constant

In this bicontinuum conceptualization, K_p is essentially the same K_p described in the previous methodology and is associated with the rapid sorption/desorption stage described above. After the initial rapid stage of the bicontinuum has occurred, there exists a relationship between S_2 and C_w which would seem to be, at least in part, a function of time. The ratio of S_2 to C_w is termed, for purposes here, the "apparent" partition coefficient although it is not equivalent to the equilibrium partitioning coefficient used to describe partitioning in saturated systems. This implies that the "apparent" partition coefficient might not remain constant but rather may change through time.

In work performed by Pavlostathis and Mathavan (1992), it appears as though the apparent partition coefficient of a contaminant in soil is directly related to the residence time of the contaminant in the soil, i.e., the longer the contaminant is in soil the larger is its apparent partition coefficient. It seems that, as time goes on, the contaminant becomes more entrained into the matrix of the soil.

In this same work, desorption could not be correlated with soil properties such as soil organic carbon, cation exchange capacity or specific surface area. Such properties did not appear to have an effect on the desorption of the resistant fraction. In addition, this work could not correlate aqueous solubility or organic carbon partition coefficients with desorption. The reason for this may be that the work was not designed to detect such a correlation.

Partition coefficients were calculated from data for four different compounds (TCE, PCE, xylenes and toluene) in four different soils. The partition coefficient represented the relatively quick initial desorption of the labile fraction - not the resistant fraction. These soils were obtained from various sites which had been contaminated [illegible] the past. These values were then plotted against the aqueous solubilities of each compound. The partition coefficients for PCE were much lower (relative to those of the other three compounds) than one would expect. The reason for this could be related to the relative residence times of each of the contaminants. If the residence time of PCE in the soil was short (relative to the other compounds), the labile fraction (non-resistant to desorption) would be larger resulting in a relatively higher aqueous concentration and therefore a lower apparent partition coefficient. Without knowing the residence times of each of these compounds (i.e., when the soil became contaminated with each contaminant), it is impossible to correlate partition coefficients with each other or with aqueous solubilities.

Generally, with respect to the labile fraction of organic compounds in soil, it has been shown that, as aqueous solubility increases, partition coefficients decrease. In fact, K_{OC} values can be estimated from aqueous solubilities.

Although Pavlostathis and Mathavan (1992) conclude that "More studies are needed to correlate the soil partition coefficient to the field residence time.", data from their work can be used to at least begin development of an approach to determine to what extent organic contaminants will desorb from long-contaminated unsaturated zone soils. The approach which is currently widely used (application of rapid desorption of the entire fraction of organic contaminant from soil) is obviously incorrect. If it were correct, soils which were contaminated from a few months to years ago would be depleted of contaminants due to water infiltration and volatilization. In other words, the contaminants would be undetectable in soil because they would be gone. This is not the case. The following approach is offered with the understanding that, as time goes on, it will be modified and refined based on future work in the area of desorption kinetics.

Pavlostathis and Mathavan (1992) evaluated the effect of residence time of TCE in soil on its desorption from the soil. Soil samples were amended with neat TCE and stored at 4°C in the dark. Samples were subjected to desorption by washing with deionized water at intervals of 2.5, 5.5, and 15.5 months. TCE concentrations in the solid versus aqueous phases were measured during these intervals. As such, apparent partition coefficients can be estimated for each time interval. The following table contains data extracted from Figure 6 of Pavlostathis and Mathavan (1992).

Aqueous TCE Concentration	TCE Sorbate Concentration mg/kg		
mg/l	2.5 months	5.5 months	15.5 months
0	0.31	0.47	0.94
0.1	0.375	0.52	1.125
0.2	0.4	0.56	1.25

Since the data in Figure 6 appear to be linear, the equation for each can be determined from the slope-intercept method. The following three equations result:

$$C_{sorb} = 0.45C_{aq} + 0.31 \qquad (t = 2.5 \text{ months}) \quad [1]$$

$$C_{sorb} = 0.45C_{aq} + 0.47 \qquad (t = 5.5 \text{ months}) \quad [2]$$

$$C_{sorb} = 1.55C_{aq} + 0.94 \qquad (t = 15.5 \text{ months}) \quad [3]$$

where; C_{sorb} = sorbate concentration in mg/kg

C_{aq} = aqueous concentration in mg/l

t = time in months

In order to incorporate the variable of time mathematically into these desorption equations, one can consider the change of the slopes and intercepts through time. The first and third equations are used since the slope of the second line could not be differentiated adequately from the first line from Figure 6 (probably because the time difference between the two (3 months) is not sufficiently large to make a detectable difference).

The change in slope per time is calculated as:

$$d[\text{slope}]/t = (1.55 - 0.45)/(15.5 - 2.5)$$

$$d[\text{slope}]/t = 0.0846 \; \frac{(\text{mg/kg})/(\text{mg/l})}{\text{month}}$$

The change in intercept per time is calculated as:

$$d[\text{intercept}]/t = (0.94 - 0.31)/(15.5 - 2.5)$$

$$d[\text{intercept}]/t = 0.0485 \text{ (mg/kg)/month}$$

Equation [1] or [3] can then be used to incorporate time as a variable. Using equation [1]:

$$C_{sorb} = [0.45 + 0.0846(t-2.5)]C_{aq} + 0.31 + 0.0485(t-2.5) \quad [4]$$

$$C_{sorb} = (0.2385 + 0.0846t)C_{aq} + 0.0485t + 0.18875 \quad [5]$$

From Feenstra et al (1991), the following relationship exists (assuming there is no air-filled porosity in the soil):

$$C_{soil} = \frac{(C_{sorb})(B) + (C_{aq})(P_w)}{B} \quad [6]$$

where; C_{soil} = total contaminant concentration in soil (mg/kg dry wt)

B = dry bulk density of soil (g/cc)

P_w = water-filled porosity of soil

Rearranging [6] yields:

$$C_{sorb} = \frac{(B)(C_{soil}) - (P_w)(C_{aq})}{B} \quad [7]$$

Substituting [7] into [5] and solving for C_{aq} yields:

$$C_{aq} = \frac{C_{soil} - 0.0485t - 0.18875}{0.2385 + 0.0846t + (P_w/B)} \quad [8]$$

Equation [8] is very useful for TCE-contaminated soil.

This same type of equation can be derived for other organic compounds if one assumes that K_{OC} values for different compounds are appropriate indicators of desorption relative to each other. In other words, if one compound has a K_{OC} value twice that of another, it will have an apparent partition coefficient twice that of the other (under identical conditions). This seems to be reasonable based on many desorption studies of labile fractions (although this could not be determined by Pavlostathis and Mathavan (1992) for the reasons discussed above).

This can be accomplished by multiplying the change in slope per time value and the intercept per time value for TCE by the ratio of the non-TCE compound K_{OC} to the K_{OC} for TCE. The K_{OC} for TCE is 126 ml/g. Equation [4] can be modified in the following manner for other compounds:

$$C_{sorb} = (K_{OC}/126)\{[0.45 + 0.0846(t-2.5)]C_{aq} + 0.31 + 0.0485(t-2.5)\}$$

$$C_{sorb} = 0.00794K_{OC}C_{aq}[0.45 + 0.0846(t-2.5)] + 0.00246K_{OC} + 0.000385(t-2.5)K_{OC}$$

$$C_{sorb} = (0.00189K_{OC} + 0.000671K_{OC}t)C_{aq} + 0.000385K_{OC}t + 0.001498K_{OC}$$

Substituting equation [7] and solving for C_{aq} yields:

$$C_{aq} = \frac{C_{soil} - 0.000385K_{OC}t - 0.001498K_{OC}}{0.00189K_{OC} + 0.000671K_{OC}t + (P_w/B)} \qquad [9]$$

With this equation, a spreadsheet can easily be constructed which will estimate aqueous contaminant concentrations which could result from soil with a known contaminant concentration and with a known contaminant residence time.

This equation has been used in a similar fashion to estimate the groundwater soil cleanup standards for organic compounds. In the estimation of these standards, the equation has been used conservatively by assuming a residence time of 0 months and setting the aqueous concentration in soil pore water at 0. The equation is then solved for C_{soil} which is the soil cleanup standard.

This estimation methodology assumes that there is at least 0.1% naturally occurring organic carbon in the soil which is approximately the organic carbon content of the soil from which the data from Pavlostathis and Mathavan (1992) have been taken. Assuming that it is the naturally occurring organic carbon content of the soil that is primarily responsible for the sorption of organic contaminants in soil, a maximum limit of 500 mg/kg (0.05%) for all organic compounds has been conservatively set to ensure that the organic contaminant concentrations do not exceed the sorption capacity of the naturally occurring organic carbon in the soil.

In estimating the groundwater soil cleanup standards, values from the EPAs Risk Reduction Engineering Laboratory Treatability Database for aqueous solubility and log octanol-water partition coefficient (log K_{OW}) have been used in conjunction with regression equations from Lyman et al (1982) and the equations derived from data in Pavlostathis and Mathavan (1992). In order to enhance consistency, data from the RREL Treatability Database is used as a "first choice".

In instances where only a log K_{OW} value or only an aqueous solubility value or neither value are available in the RREL Treatability Database, the unavailable value(s) is obtained from an alternate source. If an alternate source cannot be found, only the applicable regression equations from Lyman et al (1982) are used to estimate log K_{OC} values.

These values are then used in nine regression equations (for each compound) to estimate nine log K_{OC} values for each compound. (These equations follow and can be found in Lyman et al (1982).)

$$\log K_{OC} = -0.55(\log S) + 3.64 \quad [S \text{ in mg/l}]$$

$$\log K_{OC} = -0.54(\log S) + 0.44 \quad [S \text{ in mole fraction}]$$

$$\log K_{OC} = -0.557(\log S) + 4.277 \quad [S \text{ in micromoles/l}]$$

$$\log K_{OC} = 0.544(\log K_{OW}) + 1.377$$

$$\log K_{OC} = 0.937(\log K_{OW}) - 0.006$$

$$\log K_{OC} = 1.00(\log K_{OW}) - 0.21$$

$$\log K_{OC} = 0.94(\log K_{OW}) + 0.02$$

$$\log K_{OC} = 1.029(\log K_{OW}) - 0.18$$

$$\log K_{OC} = 0.524(\log K_{OW}) + 0.855$$

Each of these nine (or less) log K_{OC} values are then used in a modification of equation [9]. This equation is:

$$C_{soil} = C_{aq}[0.00189(K_{OC}) + 0.000671(K_{OC})(t) + (P_W/B)] + 0.000385(K_{OC})(t) + 0.001498(K_{OC})$$

where; C_{soil} = concentration of constituent in soil in mg/kg

C_{aq} = concentration of constituent in soil pore water in mg/l

t = residence time of constituent in soil in months

B = dry bulk density of soil in g/cc

P_W = water-filled porosity of soil

K_{OC} = organic carbon partition coefficient

Since the protectiveness goal is "non detect" in ground water, ground water would be protected when the constituent is not detectable in soil pore water. In the context of the above equation, this is equivalent to a level where $C_{aq} = 0$. Substituting 0 for C_{aq} yields the following equation:

$$C_{soil} = K_{OC}(0.000385t + 0.001498) \qquad [10]$$

The protective soil concentration is then dependent upon the K_{OC} of the constituent and the residence time of the constituent in soil.

O[illegible] cleanup standard has been estimated for each organic compound. It is assumed that the residence time for the contaminant in soil is 0 months, i.e., t = 0 months. (Levels for soil contaminated for longer periods can also be estimated using this methodology within certain limitations [i.e., t cannot exceed 15.5 months based on the data from which the equations have been derived.]; however, a conservative approach has been used to estimate generic cleanup standards. As t increases, estimated cleanup levels also increase. Estimation of cleanup levels that are somewhat more site-specific is discussed in the following section of this chapter.)

The estimation of each groundwater soil cleanup standard has been made in the following manner. For each of the organic compounds, the nine K_{OC} values (estimated from solubility and log K_{OW} data) have been substituted into the above equation for t = 0. This results in nine C_{soil} values. The mean of these values is then estimated as the groundwater soil cleanup standard for that compound.

<u>Estimation of Site-Specific Groundwater Soil Cleanup Levels</u>: The groundwater soil cleanup standards estimated according to the previous discussion are relatively conservative for at least four major reasons:

(1) A short residence time has been used to represent the amount of time the contaminant has been in the soil matrix. As residence time increases, desorption decreases resulting in a potentially higher contaminant concentration being protective of ground water.

(2) No dilution has been considered between the contaminant in soil pore water of the unsaturated zone and the ground water. As the dilution factor between the unsaturated zone and the ground water increases, potentially higher contaminant concentrations in soil would be protective of ground water.

(3) No attenuative capacity of uncontaminated soil which may exist between the contaminated soil and ground water has been considered. The contaminated soil is assumed to be virtually in direct contact with ground water.

(4) No consideration is given to processes such as volatilization or biological or chemical degradation which could reduce the mass of contaminant in the soil making it less available to migrate to ground water.

Consideration of any of these four factors requires some site-specific analysis. Mechanisms of potential contaminant loss such as degradation and volatilization are extremely difficult to predict and require considerable site-specific analysis. Estimation of dilution factors between the unsaturated zone and ground water is less difficult but also requires site-specific information. Several relatively simple and not so simple groundwater models exist which could estimate such dilution; however, where to apply the compliance point in ground water is often extremely problematic. Modeling migration of organic contaminants through uncontaminated unsaturated zone soils can be accomplished with a variety of models one of which is discussed in Chapter 3 of this document; however, such models assume homogeneous conditions in soil which rarely (if ever) actually exist. This creates significant uncertainty in such modeling results.

The simplest of these factors to consider in estimating alternate groundwater soil cleanup levels is the one which applies to residence time. In some instances, it may be quite easy to determine the residence time of an organic contaminant in soil. In such cases, equation [10] could be used to estimate a cleanup level by substituting the residence time and K_{OC} value for the contaminant. However, a residence time of 15.5 months should not be exceeded bas on the limitations of the data from which the equation has been derived.

As an example, benzene has a K_{OC} of approximately 158 (based on the RREL Treatability Database values for solubility and log K_{OW}). The cleanup standard for benzene is 0.2 mg/kg (t = 0 months). An equally protective level of benzene in soil where t = 15 months is 0.9 mg/kg (based on the mean of the nine values estimated from equation [10]).

November 1993

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CHAPTER THREE

UNSATURATED ZONE POTENTIAL MIGRATION MODEL FOR ORGANICS

Spreadsheet name: NEQPART.WK1

General Description: The primary purpose of this model is to estimate the movement of organic compounds vertically through unsaturated zone soils toward bedrock/ground water. This spreadsheet is based on the concept that organic contaminants in soil desorb from the soil matrix into soil pore water at a rate that is dependent on the residence time of the contaminant in the soil. In other words, the longer a soil is contaminated with an organic compound the slower is the desorption of that compound from the soil matrix to the pore water. T[illegible] is explained in greater detail in Chapter 2 of this manual. This explains (at least in part) the phenomenon of surface soils which have been contaminated with VOCs for several years remaining contaminated even though currently applied fate and transport modeling (existing in the Department's Risk Assessment/Fate and Transport Modeling System [RAFT] and virtually all other modeling systems) would predict that the VOC should have been depleted from the soil years earlier (due to volatilization into the atmosphere and leaching by infiltrating precipitation).

The "migration" component of this model is based on contaminant depletion (mass balance) as infiltrating water moves through the contaminated soil and underlying uncontaminated soil.

Application: This spreadsheet enables the user to estimate vertical migration of organic contaminants from soil to underlying soil through time. As such, its most useful application would probably be in determining whether or not a contaminant in soil may reach ground water, what the concentration will be in soil pore water at the ground water/vadose zone interface (if it does migrate to ground water), and how long it will take for the contaminant to get there.

This spreadsheet could also be a useful component in making "what if" determinations with respect to remediation options. For example, if the uppermost 5 feet of soil is contaminated at a site, this spreadsheet could aid in determining whether removal of a 1-foot or 2-foot depth of soil would result in protection of ground water or whether any soil needs to be removed at all to protect ground water.

Required input: The major portion of this spreadsheet is output. The input ranges are B6 to B10 and B18 to C47. Following is a brief description of the needed input.

cell B6 = recharge rate for the unsaturated zone soil in cm/yr. [As a cautionary note, if this value becomes unrealistically high (> 100 cm/yr), the output becomes very erratic. This is due to the computational formulas in the spreadsheet. These formulas could be modified with logic statements to prevent this problem; however, this would require much more memory resulting in a much more limited capability in terms of the number of time increments which could be modeled.]

cell B7 = soil bulk density in g/cc

cell B8 = water-filled porosity of soil

cell B9 = K_{OC} of compound in ml/g

cell B10 = depth increment in feet or thickness of soil layers bein[illegible] considered in feet [This is determined essentially from the contaminant concentrations in soil at varying depths obtained from on-site sampling.]

cells C18 to C47 = contaminant concentration in soil in mg/kg dry weight at each soil depth

cells B18 to B47 = residence time of contaminant in soil in months at each depth

Input variable values that are needed to use this spreadsheet are discussed in greater detail in Chapter 6 of this manual.

The input cells and ranges of cells in this spreadsheet are unprotected. The remaining cells of the spreadsheet are protected and are either labels (text), estimated values (from user input), [illegible] blank cells. It should be noted that disabling the protection of protected cells which contain mathematical formulas and making any changes could result in the loss of those formulas and could therefore destroy the capabilities of the spreadsheet. <u>To avoid this, formulas in protected cells should not be changed</u>.

<u>Spreadsheet assumptions and equations</u>: The following assumptions apply to this spreadsheet:

1. Homogeneous and isotropic conditions exist in the unsaturated zone soils.

2. Flow of water infiltrating vertically through the unsaturated zone is uniform.

3. Contaminant movement is only in the vertical direction - not lateral.

4. Contaminant concentrations are not so high as to affect the flow of water in the unsaturated zone.

5. Multiple contaminants act independently of each other.

6. Contaminant loss processes such as volatilization and degradation do not exist in the unsaturated zone.

7. Non-equilibrium desorption (as discussed in Chapter 2 of this manual) is the major process controlling the concentration gradient between the contaminant in the soil matrix and infiltrating water.

8. For any organic compound in soil, the relationship between the concentration sorbed and the aqueous concentration remains linear as residence time in the soil increases to values exceeding 15 months.

9. The naturally occurring organic carbon content of the soil is at least 0.1%.

10. Non-equilibrium desorption for organic compounds in soil at concentrations which exceed half of the naturally occurring organic carbon content of the soil (500 mg/kg) does not apply and therefore this model should not be used.

The equations upon which this model is based are actually located in the range of D18 to IO155 and are ordered according to time increments. Equations pertinent to time increments 1 through 28 are located in range D18 to IO47. Equations pertinent to time increments 29 through 55 are located in range G54 to IO83. Equations pertinent to time increments 56 through 82 are located in range G90 to IO119. Equations pertinent to time increments 83 through 109 are located in range G126 to IO155.

The first time increment (range D18 to F47) contains, for each of the 30 depth increments, an aqueous and sorbate contaminant concentration based on the dry weight concentrations in soil and contaminant residence times supplied by the user. The equations from which these concentrations are estimated are equations [9] and [7], respectively, from Chapter 2 in this manual.

The second and all subsequent time increments contain for each of the 30 depth increments nine different estimated values (except for the first depth increment which contains only four values). These include a contaminant concentration in soil, the fraction of that mass in soil which is new (residence time = 0 months), the fraction of that mass in soil which is not new (residence time > 0 months), the aqueous concentration resulting from the new mass, the aqueous concentration resulting from the mass that is not new, the total aqueous concentration, and the sorbate concentration. (The reason that fewer values are estimated for the first depth increment is that it is not receiving any "new" mass of contaminant because it is the uppermost contaminated layer of soil.)

The soil concentration in the first depth increment is estimated by subtracting the mass lost from soil in the previous time increment by desorption into infiltrating water (the mass lost having migrated to the second depth increment). The aqueous concentration in the first depth increment is estimated with the use of equation [9] in Chapter 2. The sorbate concentration in the first depth increment is estimated with the use of equation [7] in Chapter 2.

The contaminant concentrations and other values estimated in the subsequent depth increments are based simply on balancing the mass contaminant as it desorbs from soil in one depth increment into infiltrating water and migrates vertically into the next depth increment. The original mass of contaminant remains constant; the location of the contaminant changes with time. Residence time is incorporated into the equations with each time increment at each depth increment.

The value of the time increment in cell B12 is simply the amount of time for infiltrating water to pass through the given depth increment based on the recharge rate and water-filled porosity of the soil.

<u>Spreadsheet output</u>: The most significant output includes cell B12 and the range B201 to DF230. Cell B12 is the time increment value in months which is estimated from the input values for the depth increment, recharge rate, and water-filled porosity of soil.

Range B201 to DF230 contains the estimated pore water contaminant concentrations at various depths at various times. Column B is for the first time increment. Column C is for the second time increment, etc. Column DF is for the 109th (and last) time increment. In order to assign a time value to each of these increments, it is necessary to multiply by the value in B12.

Similarly, row 201 (beginning at column B) pertains to soil pore water in the first depth increment. Row 202 (beginning at column B) pertains to the second depth increment, etc. Row 230 pertains to the 30th (and last) depth increment. In order to assign a depth value to each of these increments, it is necessary to multiply by the value entered in cell B10.

As already discussed, the calculations and additional estimates upon which the values in range B201 to DF230 are based are included in the ranges D18 to IO155. They have been placed in range B201 to DF230 so that the migration trend of the contaminant through time can be easily discerned and so that the trend can be displayed graphically.

Example 1: A soil with the following properties is contaminated with TCE [K_{OC} = 126 ml/g] at a dry weight concentration of 10 mg/kg.

Bulk density = 1.5 g/cc
Water-filled porosity = 0.25

Recharge rate = 33 cm/year [13 inches/year]
Depth increment = 1 foot
Residence time of TCE in soil = 0 months

The results of these inputs show that, after 16 time increments (44 months), the TCE concentration in soil pore water at the initially contaminated one-foot layer is 0 [cell Q201] (although the soil itself is still contaminated - the contaminant being sorbed to/in the soil matrix). The greatest distance the TCE migrates is to the 6th depth increment [row 206] or 5 to 6 feet from the surface. It arrives there in the 7th time increment [cell H206] or at 19 months. By the 21st time increment [cell V206], the TCE concentration in pore water is 0 at the 5 to 6 foot depth. Therefore, if the distance to groundwater exceeds 6 feet, TCE will not migrate to groundwater according to these estimates.

Example 2: Suppose this scenario is the same as that of Scenario 1 except that the residence time of TCE in the soil is 1 year (12 months).

The results of these inputs show that, after 29 time increments (80 months), the TCE concentration in soil pore water at the initially contaminated one-foot layer is 0 (although the soil itself is still contaminated - the contaminant being sorbed to/in the soil matrix). The greatest distance the TCE migrates is to the 5th depth increment or 4 to 5 feet from the surface. It arrives there in the 8th time increment or at 22 months and increases to a maximum concentration in pore water of 0.0264 mg/l in the 10th time increment or at 28 months. By the 33rd time increment, the TCE concentration in pore water is 0 at the 4 to 5 foot depth. Therefore, if the distance to groundwater exceeds 5 feet, TCE will not migrate to groundwater according to these estimates.

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CHAPTER FOUR

UNSATURATED ZONE POTENTIAL MIGRATION MODEL FOR INORGANICS

Spreadsheet name: EQPART.WK1

General Description: The primary purpose of this model is to estimate the movement of inorganic species vertically through unsaturated zone soils toward bedrock/ground water. This spreadsheet is based on concepts that are substantially different from those concepts upon which the migration model for organics is based. The reason for this is simply that, unlike most organic compounds commonly found as contaminants in soil, inorganic species in soil exist in a variety of compounds which can have widely varying properties and which can also be differently affected by the properties of the environment in which they exist. One of these properties is aqueous solubility.

For example, the aqueous solubility of lead chloride results in a lead concentration in water of tens of parts per million; however, lead sulfide results in a lead concentration in water of a few parts per quadrillion (a relative difference in solubility of about ten orders of magnitude). From a groundwater protection perspective, soil contaminated with lead chloride would be more of a concern than soil contaminated with lead sulfide.

Other factors which can greatly affect the mobility of inorganic species in soil include: the oxidation state of the species; the physical state of the species; the pH of the soil and surrounding environment; the cation exchange capacity of the soil; the presence of other contaminants in the soil and their form; the availability of water in the soil and surrounding environment; the availability of oxygen in the soil; and the physical properties of the soil.

Metal speciation models do exist which take these factors into consideration. These models generally require a great deal of information concerning the specific compounds existing in soil as well as specific properties of the soil. This information is not commonly available unless the user has specific knowledge concerning the materials or wastes which were released to the soil. If this information is available, the use of such models still requires a significant level of expertise on the part of the user.

The spreadsheet which this chapter describes is not a metal speciation model and is not based directly on the factors discussed above. Therefore, it does not require a detailed knowledge of the specific compounds existing in soil or soil properties. In addition, this spreadsheet is comparatively simple to use.

This spreadsheet relies on a relatively simple, straightforward methodology which allows the user to at least discern a trend of potential migration of inorganic species vertically through soil at a site. This is accomplished by first estimating an "apparent" partition coefficient by mathematically comparing total and leachate analysis data for soils on-site. With this "apparent" partition coefficient, the spreadsheet can then make estimates of potential migration of inorganic species in much the same way that it is done in the spreadsheet for estimating potential migration of organics.

Again, the "migration" component of this model is based on contaminant depletion (mass balance) as infiltrating water moves through the contaminated soil and underlying uncontaminated soil.

While this method of estimating migration of inorganic species may seem somewhat oversimplified, it offers the user an easy-to-use option to the metal speciation models which currently exist. In addition, if the results of modeling potential migration of inorganics with this spreadsheet indicate that a significant potential exists for groundwater to be degraded, a more rigorous modeling approach (such as the use of a metal speciation model) may be in order.

Application: This spreadsheet enables the user to estimate vertical migration of inorganic species from contaminated soil to underlying soil through time. As such, its most useful application would probably be in determining whether or not an inorganic contaminant in soil may reach ground water, and to a lesser extent, what the concentration will be in soil pore water at the ground water/vadose zone interface (if it does migrate to ground water), and how long it will take for the contaminant to get there.

This spreadsheet could also be a useful component in making "what i[illegible] determinations with respect to remediation options. For example, if the uppermost 5 feet of soil is contaminated at a site, this spreadsheet could aid in determining what potential effect removal of a 1-foot or 2-foot depth of soil would have on subsequent vertical migration of the contaminant.

Required input: The major portion of this spreadsheet is output. The input ranges are B6 to B10 and C18 to C67. Following is a brief description of the needed input.

cell B6 = recharge rate for the unsaturated zone soil in cm/yr. [As a cautionary note, if this value becomes unrealistically high (> 100 cm/yr), the output becomes very erratic. This is due to the computational formulas in the spreadsheet. These formulas could be modified with logic statements to prevent this problem; however, this would require much more memory resulting in a much more limited capability in terms of the number of time increments which could be modeled.]

cell B7 = soil bulk density in g/cc

cell B8 = water-filled porosity of soil

cell B9 = "apparent" partition coefficient of inorganic species in ml/g

cell B10 = depth increment in feet or thickness of soil layers being considered in feet [This is determined essentially from the contaminant concentrations in soil at varying depths obtained from on-site sampling.]

cells C18 to C67 = contaminant concentration in soil in mg/kg dry weight at each soil depth

I[illegible]t variable values that are needed to use this spreadsheet are discussed in greater detail in Chapter 6 of this manual.

The input cells and ranges of cells in this spreadsheet are unprotected. The remaining cells of the spreadsheet are protected and are either labels (text), estimated values (from user input), or blank cells. It should be noted that disabling the protection of protected cells which contain mathematical formulas and making any changes could result in the loss of those formulas and could therefore destroy the capabilities of the spreadsheet. To avoid this, formulas in protected cells should not be changed.

Spreadsheet assumptions and equations: The following assumptions apply to this spreadsheet:

1. Homogeneous and isotropic conditions exist in the unsaturated zone soils.
2. Flow of water infiltrating vertically through the unsaturated zone is uniform.
3. Contaminant movement is only in the vertical direction - not lateral.
4. Contaminant concentrations are not so high as to affect the flow of water in the unsaturated zone.
5. Multiple contaminants act independently of each other.
6. For any inorganic species in soil, the relationship between the concentration "sorbed" and the aqueous concentration remains linear irrespective of concentration.

The equations upon which this model is based are actually located in the range of D18 to IT156 and are ordered according to time increments. Equations pertinent to time increments 1 through 62 are located in range D18 to IP67. Equations pertinent to time increments 63 through 124 are located in range G107 to IT156.

The first time increment (range D18 to F67) contains, for each of the 50 depth increments, an aqueous and "sorbate" contaminant concentration based on the dry weight concentrations in soil and "apparent" partition coefficient supplied by the user. The equations from which these concentrations are estimated are:

$$C_{aq} = \frac{(B)(C_{soil})}{(B)(K_{app}) + (P_w)} \qquad [1]$$

$$C_{sorb} = (K_{app})(C_{aq}) \qquad [2]$$

where; C_{soil} = total contaminant concentration in soil (mg/kg dry wt)

C_{aq} = aqueous concentration of contaminant in mg/l

C_{sorb} = "sorbate" concentration of contaminant in mg/kg (more properly the concentration that is not aqueous)

K_{app} = "apparent" partition coefficient in ml/g (mathematically the ratio of C_{sorb} to C_{aq})

P_w = water-filled porosity of soil

B = dry bulk density of soil in g/cc

The second and all subsequent time increments contain for each of the 50 depth increments four different estimated values. These include a contaminant concentration in soil, the total aqueous concentration, and the sorbate concentration.

The soil concentration in the first depth increment is estimated by subtracting the mass lost from soil in the previous time increment by solubilization into infiltrating water (the mass lost having migrated to the second depth increment). The aqueous concentration in the first depth increment is estimated with the use of equation [1] above. The sorbate concentration in the first depth increment is estimated with the use of equation [2] above.

The contaminant concentrations and other values estimated in the subsequent depth increments are based simply on balancing the mass of contaminant as it solubilizes from soil in one depth increment into infiltrating water and migrates vertically into the next depth increment. The original mass of contaminant remains constant; the location of the contaminant changes with time.

The value of the time increment in cell B12 is simply the amount of time for infiltrating water to pass through the given depth increment based on the recharge rate and water-filled porosity of the soil.

Apparent partition coefficient (Kapp): K_{app} can be most easily estimated from a plot of total dry weight concentration of an inorganic species in soil (C_{soil}) versus the concentration in leachate (C_{aq}) where both variables are defined as above. A regression equation of the the following form is then developed based on the plot:

$$C_{soil} = (m)(C_{aq}) + b$$

where; b = the y-intercept in mg/kg

m = the slope = $[C_{soil}/C_{aq}]$

from equation [1] above:

$$C_{aq} = \frac{(B)(C_{soil})}{(B)(K_{app}) + (P_w)}$$

rearranging;

$$\frac{C_{soil}}{C_{aq}} = \frac{(B)(K_{app}) + P_w}{B} = K_{app} + P_w/B$$

substituting;

$$m = K_{app} + P_w/B$$

and;

$$K_{app} = m - P_w/B$$

One point to be made about this equation has to do with the leachate procedure used. Most leachate procedures incorporate a 20:1 dilution of the material being leached, i.e., the amount of leachate is 20 times that of the material being leached. In such cases, m will have a value of at least 20 which makes the effect of P_w/B relatively minor. In some cases, this 20:1 dilution could remove some of the conservativeness of the potential migration estimate; however, the aggressive leachate procedure itself often adds conservativeness. Ideally, data from column studies would be more meaningful than leachate analyses.

Spreadsheet output: The most significant output includes cell B12 and the range C203 to DV252. Cell B12 is the time increment value in months which is estimated from the input values for the depth increment, recharge rate, and water-filled porosity of soil.

Range C203 to DV252 contains the estimated pore water contaminant concentrations at various depths at various times. Column C is for the first time increment. Column D is for the second time increment, etc. Column DV is for the 124th (and last) time increment. In order to assign a time value to each of these increments, it is necessary to multiply by the value in B12.

Similarly, row 203 (beginning at column C) pertains to soil pore water in the first depth increment. Row 204 (beginning at column C) pertains to the second depth increment, etc. Row 252 pertains to the 50th (and last) depth increment. In order to assign a depth value to each of these increments, it is necessary to multiply by the value entered in cell B10.

As already discussed, the calculations and additional estimates upon which the values in range C203 to DV252 are based are included in the ranges D18 to IT156. They have been placed in range C203 to DV252 so that the migration trend of the contaminant through time can be easily discerned and so that the trend can be displayed graphically.

Example 1: A soil with the following properties is contaminated with lead at a dry weight concentration of 5000 mg/kg.

Bulk density = 1.5 g/cc
Water-filled porosity = 0.25

Recharge rate = 33 cm/year [13 inches/year]
Depth increment = 1 foot

The "apparent" partition coefficient is 50 (calculated from on-site soil data), and the approximate method detection limit for lead is 0.001 mg/l.

The results of these inputs show that after 124 time increments (343 months or approximately 29 years) the greatest depth that lead has migrated beyond the initially contaminated one foot depth increment at a detectable level in soil pore water is about five feet. Approximately 66% of the lead remains in the initially contaminated one foot depth increment with 33% existing in the two feet below this increment.

Example 2: Suppose this scenario is the same as that of Scenario 1 except that the initial lead concentration in soil is 600 mg/kg.

The results of these inputs show that after 124 time increments (343 months or approximately 29 years) the greatest depth that lead has migrated beyond the initially contaminated one foot depth increment at a detectable level in soil pore water is about four feet. Again, approximately 66% of the lead remains in the initially contaminated one foot depth increment with 33% existing in the two feet below this increment.

CHAPTER FIVE

ACCESSING THE SYSTEM PROGRAMS

General Discussion: This system is comprised of two separate LOTUS 1-2-3 spreadsheets. Any user of these spreadsheets should have a working knowledge of LOTUS 1-2-3 spreadsheet software. One of the spreadsheets estimates potential migration of organic contaminants from contaminated soil vertically through the unsaturated zone. This spreadsheet is named NEQPART.WK1 and is described in detail in Chapter 3 of this manual.

The second spreadsheet estimates potential migration of inorganic contaminants from contaminated soil vertically through the unsaturated zone. This spreadsheet is named EQPART.WK1 and is described in detail in Chapter 4 of this manual.

If information concerning equations and rationale is needed, the user should consult the appropriate chapter(s).

This chapter (Chapter 5) explains how to load and access NEQPART.WK1 and EQPART.WK1. It also describes what the user must do upon entering either of the programs so that the programs are easily usable.

How to Load and Access the Programs: Both of these spreadsheets are very large (NEQPART.WK1 = 2.4 megabytes and EQPART.WK1 = 1.5 megabytes). Because of this, sufficient disk space is needed to load them onto a hard drive (at least 3.9 megabytes). Also, in order to access them, a rather large amount of memory is required. At least four megabytes of expanded memory is recommended.

Since both NEQPART.WK1 and EQPART.WK1 are LOTUS 1-2-3 spreadsheets, they can be loaded from diskettes to a hard drive in the same manner as any other LOTUS 1-2-3 spreadsheet. Because of their size, they are provided on three 3.5-inch 1.44 MByte diskettes. Loading them onto a hard disk can be done simply in an MS-DOS environment by doing the following:

1. Put backup diskette number 1 in the A drive.
2. At the C:\> prompt, type RESTORE A: C:\123*.* /s
3. Press <enter>. The files on the diskette will be restored to the hard disk.
4. Put backup diskette numbers 2 and 3 into the A drive when prompted.

After backup diskette number 3 is restored, the C:\> prompt again appears. The spreadsheet files will be restored into a directory with the name "123" and into a subdirectory of 123 named "sorption". If these directories did not exist on the hard disk prior to restoring the files, the restore command will automatically make them.

NEQPART.WK1 and EQPART.WK1 can both be accessed from the hard disk in exactly the same manner that any other LOTUS 1-2-3 file is accessed - by choosing file retrieval from the top line menu, i.e., type \fr. Once either NEQPART.WK1 or EQPART.WK1 is accessed, the user needs to go to the appropriate input cells and enter the appropriate values. The input cell locations and values needed are described in greater detail in Chapter 3 (for NEQPART.WK1) and Chapter 4 (for EQPART.WK1).

These spreadsheets are not menu-driven. This provides the user with maximum flexibility. It is possible for the user to go to any portion of either of these spreadsheets and view values as well as formulas from which those values are estimated. This makes the spreadsheets a bit more difficult to use and requires that the user have a relatively greater knowledge of the structure of the spreadsheets as well as the rationale upon which the spreadsheet formulas are based. It is recommended that the user read Chapters 3 and 4 of this manual before using these spreadsheets for the first time.

CHAPTER SIX

INPUT VARIABLE VALUES

NEQPART.WK1 and EQPART.WK1 require input variable values of two general types: (1) site-specific and (2) contaminant-specific. The following table lists all of the input variables for which values may be needed to use either NEQPART.WK1 or EQPART.WK1.

Input Variables

Dry bulk density of unsaturated zone soil

Volumetric flux in unsaturated zone (approximated as recharge)

Water-filled porosity of unsaturated zone soil (volumetric water content)

Concentration of contaminant in unsaturated zone soils and the depth at which that concentration exists

Amount of time that contaminant has existed in the unsaturated zone soil - residence time (organics only)

"Apparent" partition coefficient of inorganic contaminant

Organic carbon partition coefficient for organic contaminants

Following is a discussion of each of the input variables listed and the sources from which values for each can be obtained. For variables which require calculation, the method or methods which can be used to accomplish those calculations are given. EPA (1983) has been consulted as a source for the discussion concerning dry bulk density, volumetric flux and water-filled porosity. Other references were also consulted as cited in the text.

It must be understood that the use of actual site-specific information is preferable when it is available. This reduces the amount of uncertainty in modeling results which may otherwise be created when estimates of input data are substituted for actual information. It is realized that such information is often not available. The following discussions are offered so that informed estimates can be made in the absence of such data. In addition, these discussions do not necessarily represent the best or only way to estimate values for these variables. Users of these spreadsheets may know of better estimation methods which are more technically or scientifically sound. Such methods should be used if they are, in fact, more technically sound. Whatever methods are used, it is important that they are documented so that they are not presumed, at some point, to be arbitrary.

Dry Bulk Density of Unsaturated Zone Soil

Bulk density is the mass of a unit volume of dry soil, as measured in the field, usually expressed in g/cc or lb/ft^3. The entire volume is taken into consideration including both soils and pore spaces. Thus, loose porous soils will have low values of bulk density while more compact soils will have higher values. Bulk density values normally range from 1.0 to 2.0 g/cc, and soils with high organic matter content will generally have low bulk density values.

Brady (1974) has presented the following ranges of bulk density for selected surface soil types commonly found in agricultural areas:

	Bulk Density (g/cc)
well-decomposed organic soil	0.2 - 0.3
cultivated surface mineral soils	1.25 -1.45
clay, clay loam, silt loam	1.00 - 1.60
sands and sandy loam	1.20 - 1.80

Ritter and Paquette (1967) have listed the following bulk density ranges for material classes encountered in road and airfield construction:

	Bulk Density (g/cc)
silts and clays	1.3 - 2.0
sands and sandy soils	1.6 - 2.2
gravel and gravelly soils	1.8 - 2.3

Subsoils will generally be more compact than surface soils and will thus have higher bulk densities. Very compact subsoils regardless of texture can have bulk densities of 2.0 g/cc or greater; values of 2.3 to 2.5 g/cc should be considered as upper limits. If no data are available, a value of 1.5 g/cc can be used with reasonable accuracy for many soils.

Bulk densities of 1.5 g/cc for unsaturated zone surface soils and 2.0 g/cc for deeper soils (including saturated zone soils) are typically used in modeling efforts.

Volumetric Flux in Unsaturated Zone

Volumetric flux is approximately equivalent to percolation and recharge. To estimate percolation and recharge values for a specific site, the conventional water balance equation can be written in the following form:

$$PER = P - ET - DR$$

where PER = percolation and recharge, cm/yr
P = precipitation, cm/yr
ET = evapotranspiration, cm/yr
DR = direct surface runoff, cm/yr

For simplification, the equation ignores any man-made water additions (e.g. irrigation) and any change in soil moisture storage. PER includes both percolation and recharge to the groundwater systems of concern. PER is used to assess contaminant movement through the unsaturated zone; however, this value may need to be reduced to estimate recharge to deep aquifers or where impermeable strata exist.

A variety of local meteorologic and hydrologic data sources can be contacted to estimate percolation and recharge values for a specific site based on the water balance components of the above equation. Local sources of this information should be used whenever possible.

Lacking any local data, estimates of mean annual percolation can be made based on the U. S. Soil Conservation Service hydrologic soil classifications defined in the following table. The second table which follows (from Jarrett undated) lists the U.S. SCS hydrologic soil classifications for several of the soils in Pennsylvania. The isopleths of mean annual percolation in Figure A which follows these tables were derived from application of the U.S. Soil Conservation Curve Number procedure (U.S. SCS, 1964) for estimating potential direct runoff and are taken from Stewart <u>et al</u>, 1976.

Hydrologic Soil Classifications (U.S. SCS, 1964)

Group/Runoff Potential	Description
Group A. Low Runoff Potential	Soils having high infiltration rates even when thoroughly wetted and consisting chiefly of deep, well to excessively-drained sands or gravels. These soils have a high rate of water transmission.
Group B. Moderately Low Runoff Potential	Soils having moderate infiltration rates when thoroughly wetted and consisting chiefly of moderately deep to deep, moderately well to well-drained soils with moderately fine to moderately coarse textures. These soils have a moderate rate of water transmission.
Group C. Moderately High Runoff Potential	Soils having slow infiltration rates when thoroughly wetted and consisting chiefly of soils with a layer that impedes downward movement of water, or soils with moderately fine to fine texture. These soils have a slow rate of water transmission.
Group D. High Runoff Potential	Soils having very slow infiltration rates when thoroughly wetted and consisting chiefly of clay soils with a high swelling potential, soils with a permanent high water table, soils with a claypan or clay layer at or near the surface, and shallow soils over nearly impervious material. These soils have a very slow rate of water transmission.

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Hydrologic Soil Classiifcations for Pennsylvania Soils

Soil Series	Group	Soil Series	Group	Soil Series	Group
Abbottstown	C	Braceville	C	Conowingo	C
Albia	C	Brandywine	C	Conyngham	
Albrights	C	Brecknock	B	Cookport	C
Alden	D	Brinkerton	D	Corydon	C
Aldino	C	Brooke	C	Cossayuna	C
Allegheny	B	Buchanan	C	Croton	D
Allenwood	B	Bucks	B	Culvers	C
Allis	D	Burgin	D	Dalton	C
Altavista	C	Butlertown	C	Dannemora	D
Alton	B	Calvert	D	Dekalb	C
Alvira	C	Calvin	C	Dilldown	
Amaranth		Cambridge	C	Doylestown	D
Andover	D	Canadice	D	Drab	
Arendtsville	B	Caneadea	D	Drifton	C
Ariel		Canfield	C	Duffield	B
Armagh	D	Captina		Duncannon	B
Armenia		Cardiff	B	Dunning	D
Arnot	C/D	Catoctin	C	Edgemont	B
Ashton	B	Cattaraugus	C	Edom	C
Atherton	B/D	Cavode	C	Elioak	C
Athol	B	Chagrin	B	Elk	B
Atkins		Chalfont	C	Elkins	D
Baile	D	Chambersburg		Elkinsville	B
Barbour	B	Chavies	B	Ellery	D
Bartle	D	Chanango	A	Elliber	A
Basner	B	Chester	B	Elsinboro	B
Bath	C	Chewacla	C	Empeyville	C
Bedford	C	Chili	B	Erie	C
Bedington	B	Chillisquaque		Ernest	C
Belmont	B	Chilo	B/D	Evendale	
Beltsville	C	Chippewa	B/D	Fallsington	D
Benson	C/D	Christiana	B	Fleetwood	
Berks	C	Chrome	C	Fogelsville	B
Bermudian	B	Clarksburg	C	Frankstown	B
Berrien		Clymer	B	Fredon	C
Birdsall	D	Codorus	C	Frenchtown	D
Birdsboro	B	Collamer	C	Ganoga	
Blago	D	Comly	C	Gatesburg	A
Blairton	C	Conestoga	B	Germania	
Bowmansville	C	Congaree	B	Gilpin	C
Boynton		Conotton	B	Ginat	D

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Hydrologic Soil Classifications for Pennsylvania Soils

Soil Series	Group
Glenelg	B
Glenville	C
Gresham	C
Guernsey	C
Guthrie	D
Hagerstown	C
Halsey	D
Hanover	C
Hartleton	B
Hartsells	B
Hatboro	D
Hazleton	B
Highfield	B
Hollinger	B
Holly	D
Holston	B
Hornell	D
Howard	B
Howell	C
Hublersburg	C
Huntington	B
Imler	
Iva	C
Kedron	C
Kerrtown	
Keyport	C
Klinesville	C/D
Kreamer	
Lackawanna	C
Laidig	C
Lakin	A
Lamington	D
Landisburg	C
Langford	C
Lansdale	B
Lansdowne	
Lawrence	C
Lawrenceville	C
Leadvale	C
Leck Kill	B
Leetonia	C
Legore	B
Lehew	C
Lehigh	C
Leonardtown	D
Letort	
Lewisberry	B
Library	D
Lickdale	D
Lindside	C
Litz	C
Lobdell	C
Lorain	C/D
Lordstown	C
Loudenville	C
Loysville	D
Luray	C/D
Lyles	B
Mahoning	D
Manlius	C
Manor	B
Mardin	C
Markes	D
Mazeppa	B
Meckesville	C
Mehoopany	
Melvin	D
Mertz	
Middlebury	B
Millheim	(C)
Miner	D
Minora	C
Monongahela	C
Montalto	C
Montevallo	D
Montgomery	D
Morris	C
Morrison	B
Mount Lucas	C
Murrill	B
Myersville	B
Natalie	C
Neshaminy	B
Newark	C
Nolo	B
Northumberland	C/D
Norton	C
Norwich	D
Opequon	C/D
Oquaga	C
Othello	D
Ottawa	
Papakating	D
Pekin	C
Penn	C
Pequea	C
Phelps	B
Philo	B
Plainfield	A
Platea	C
Pope	B
Purdy	D
Quakertown	B
Rainsboro	C
Ramsey	D
Raritan	C
Ravenna	C
Rayne	B
Readington	C
Reaville	C
Red Hook	C
Rimer	C
Robertsville	D
Rohrersville	C
Rowland	C
Rushtown	A
Ryder	C
Sassafras	B
Scio	B
Sciotoville	C
Sedan	
Sequatchie	B
Sheffield	D

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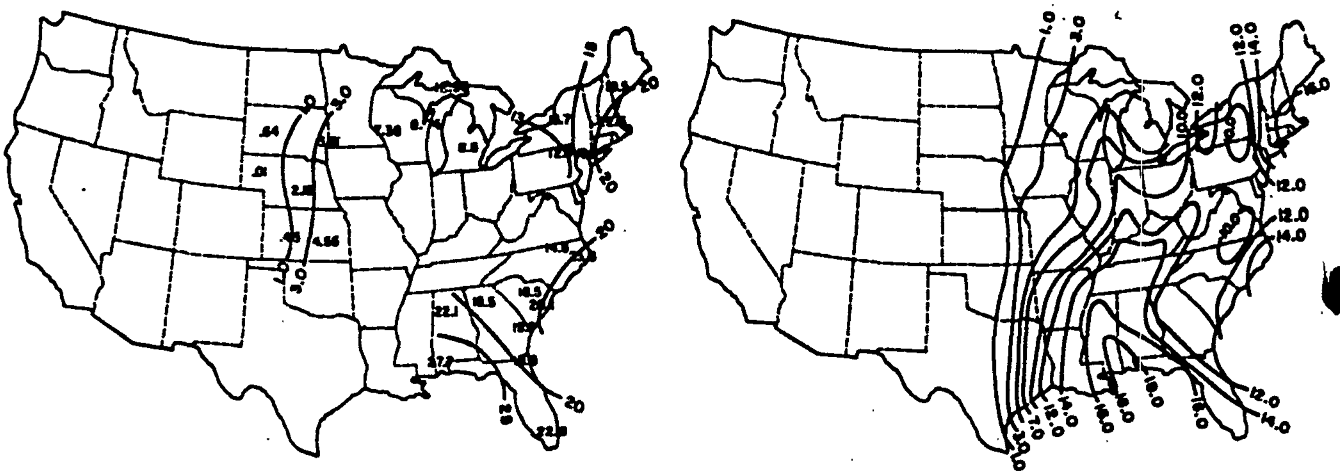
Hydrologic Soil Classifications for Pennsylvania Soils

Soil Series	Group	Soil Series	Group	Soil Series	Group
Shelmadine	D	Upshur	C	Westmoreland	B
Shelocta	B	Vandergrift	C	Wharton	C
Sloan	D	Vanderlip	A	Wheeling	B
Steinsburg	C	Venango	C	Whiteford	B
Swartswood	C	Volusia	C	Whitwell	C
Sweden	B	Vrooman	B	Wickham	B
Thorndale	D	Wallington	C	Williamson	C
Tilsit	C	Wallkill	C/D	Wiltshire	C
Tioga	B	Warners	A/D	Woodglenn	D
Titusville	C	Washington	B	Woodstown	C
Trexler	C	Watchung	D	Wooster	C
Troy	C	Watson	C	Woostern	B
Trumbull	D	Wauseon	B/D	Worsham	D
Tughill	D	Wayland	C/D	Worth	C
Tunkhannock	A	Weeksville	B/D	Wurtsboro	C
Tygart	D	Wenadkee	D	Wyalusing	D
Tyler	D	Weikert	C/D	Zipp	C/D
Unadilla	B	Wellsboro	C	Zoar	C
Ungers	B	Wellston	B		

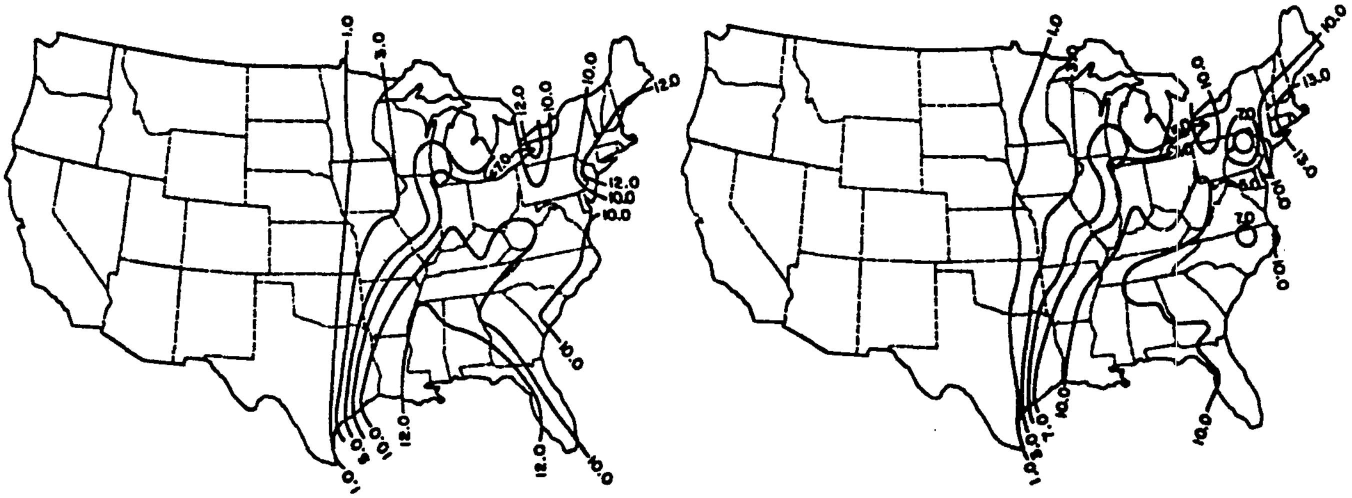
Figure A

Mean Annual Percolation Below a 4-Foot Root Zone
(inches)
(Stewart *et al*, 1976)



Hydrologic Soil Group A
4 inches available water
holding capacity

Hydrologic Soil Group B
8 inches available water
holding capacity



Hydrologic Soil Group C
8 inches available water
holding capacity

Hydrologic Soil Group D
6 inches available water
holding capacity

A volumetric flux of 0.0905 cm/day has frequently been used for modeling. This is based on a conservative assumption that the soil is in Group A which is "low runoff potential" implying high infiltration into the subsurface. This value is based directly on a percolation rate of 13 inches per year (from Figure A).

Water-filled Porosity of Unsaturated Zone Soil (Volumetric Water Content)

The volumetric water content is the percent of the total soil volume which is filled with water. Under saturated conditions, the volumetric water content equals the total porosity of soil and is considerably less than porosity under unsaturated conditions. Conceptually, under steady flow conditions, water (i.e. volumetric flux or percolation) is flowing through the pore spaces occupied by the volumetric water content. Thus, the flux and moisture content are directly related with higher flux values requiring higher moisture content, and vice versa.

Volumetric water content values will range from 5% to 10% at the low end to less than the total porosity at the higher end. For most soils this results in a range of 5% to 50%. If no other local information is available, a value within this range should be selected. For high percolation values water content values of 30% to 50% should be used. For low percolation values water content values of 10% to 20% should be used. Alternately, the user may assume that the volumetric water content is equal to the field capacity for the particular soil type. Field capacity is the moisture retained by soil after free drainage. Representative value ranges of field capacity are contained in the following table.

	Field Capacity
Sandy soils	0.05 - 0.15
Silt/loam soils	0.13 - 0.30
Clay soils	0.26 - 0.45

Typically, a value of 0.25 for volumetric water content in the unsaturated zone has been used in modeling.

Contaminant Concentration in Unsaturated Zone Soil
Depth of Contaminated Soil in Unsaturated Zone

Values for these parameters are based on actual site data, i.e., they must be measured.

Residence Time of Organic Contaminant in Soil

The value for residence time is based strictly on site-specific knowledge of the amount of time a contaminant has been in unsaturated zone soil. In cases where a reasonable estimate cannot be made, a value of zero is recommended.

Organic Carbon Partition Coefficient (K_{OC})

Values for log K_{OC} exist in a variety of sources and publications in the literature. Appendix B provides log K_{OC} data for several contaminants encountered in environmental media. In addition, log K_{OC} data for other compounds exist in the literature. Literature searches for log K_{OC} values for specific compounds may be useful. Journals which may be particularly useful include Chemosphere, Environmental Science and Technology, and Environmental Chemistry and Toxicology. ATSDR profiles also contain K_{OC} values.

If values cannot be found in the literature, it is also possible to estimate values for log K_{OC} based on the aqueous solubility or log K_{OW} of the specific compound of interest. Estimation procedures (using regression equations) are presented in Chapter 2 of this manual and have been taken from Lyman et al, 1982.

Apparent Partition Coefficient (K_{app})

The apparent partition coefficient and the procedure from which to estimate it are discussed in detail in Chapter 4 of this manual.

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APPENDIX A

SOLUBILITY AND LOG KOW DATA FOR SOME COMMON ORGANIC CONTAMINANTS

Constituent	Aqueous Solubility (mg/l)	Source of Solubility	Log Kow	Source of Log Kow
Acenaphthene	3.42	RREL	3.92	RREL
Aldrin	0.017	RREL	5.11	RREL
Anthracene	1.29	RREL	4.45	RREL
Benzene	1780	RREL	2.13	RREL
Benzo[a]pyrene	0.0038	RREL	5.98	RREL
Chlordane	0.056	RREL	6	RAFT
Chlorobenzene	488	RREL	2.84	RREL
Chloroform	9300	RREL	1.97	RREL
Cresol, o-	31000	RREL	1.95	RREL
Cresol, p-	24000	RREL	1.9	RAFT
D, 2,4-	890	RREL	2.81	RREL
DDD, p,p'-	0.16	RREL	5.99	RREL
DDE	0.04	RREL	5.69	RREL
DDT, p,p'-	0.0031	RREL	6.19	RREL
Dichlorobenzene, 1,2-	145	RREL	3.38	RREL
Dichlorobenzene, 1,4-	79	RREL	3.39	RREL
Dichloroethane, 1,1-	5500	RREL	1.79	RREL
Dichloroethane, 1,2-	8690	RREL	1.45	RREL
Dichloroethylene, 1,1-	210	RREL	1.48	RREL
Dichloroethylene, 1,2- (trans)	600	RREL	1.48	RREL
Dieldrin	0.186	RREL	4.09	RREL

APPENDIX A (continued)

SOLUBILITY AND LOG KOW DATA FOR SOME COMMON ORGANIC CONTAMINANTS

Constituent	Aqueous Solubility (mg/l)	Source of Solubility	Log Kow	Source of Log Kow
Ethylbenzene	152	RREL	3.15	RREL
Fluoranthene	0.265	RREL	5.33	RREL
Fluorene	1.9	RREL	4.18	RREL
Heptachlor	0.056	RREL	5.1	RAFT
Lindane	7	RREL	3.24	RREL
Methoxychlor	0.04	RREL	4.68	RREL
Methylene chloride	16700	RREL	1.25	RREL
Methyl ethyl ketone	275000	RREL	0.26	RREL
Methylnaphthalene, 1-	27	RREL	3.87	RREL
Methylnaphthalene, 2-	26	RREL	3.86	RREL
Naphthalene	30	RREL	3.37	RREL
Pentachlorophenol	14	RREL	5.01	RREL
Phenanthrene	0.816	RREL	4.46	RREL
Phenol	80000	RREL	1.46	RREL
Pyrene	0.16	RREL	5.18	RREL
TP, 2,4,5- (Silvex)	140	RREL	2.44	RREL
Tetrachloroethane, 1,1,1,2-	200	RREL	3.04	RREL
Tetrachloroethylene	150	RREL	2.53	RREL
Toluene	515	RREL	2.69	RREL
Toxaphene	3	RREL	3.3	RREL
Trichloroethane, 1,1,1-	4400	RREL	2.47	RREL

APPENDIX A (continued)

SOLUBILITY AND LOG KOW DATA FOR SOME COMMON ORGANIC CONTAMINANTS

Constituent	Aqueous Solubility (mg/l)	Source of Solubility	Log Kow	Source of Log Kow
Trichloroethylene	1100	RREL	2.53	RREL
Xylene, o-	175	RREL	2.77	RREL
Xylene, m-	200	RREL	3.2	RREL
Xylene, p-	198	RREL	3.15	RREL

RREL denotes EPAs Risk Reduction Engineering Laboratory Database.

RAFT denotes the user's manual of the Department's Risk Assessment/Fate and Transport Modeling System which further cites source of data.

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APPENDIX B

LOG KOC VALUES FOR SOME CONTAMINANTS

Contaminant	Log Koc
Acenaphthene 83-32-9	3.8 (est by 1)
Acenaphthylene 208-96-8	3.68 (3)
Acetanilide 103-84-4	1.19 (4)
Acetone 67-64-1	-0.43 (3)
Acetophenone 98-86-2	1.63 (1,4,5) 1.73 (6)
Acridine 260-94-6	4.22 (4) 4.11 (5)
Acrolein 107-02-8	-0.28 (3)
Acrylonitrile 107-13-1	-1.13 (3)
Aldrin 309-00-2	2.61 (3)
Ametryn 834-12-8	2.59 (4)
Aminoanthracene, 2- 613-13-8	4.45 (4)
Aminochrysene, 6- 2642-98-0	5.21 (4,5)
Aminonitrobenzene, 3- 626-01-7	1.49 (4)
Aminonitrobenzene, 4- 100-01-6	1.64 (4) 1.88 (5)

APPENDIX B (continued)

LOG KOC VALUES FOR SOME CONTAMINANTS

Contaminant	Log Koc
Aniline 62-53-3	1.17 (4)
Anisole 100-66-3	1.30 (4) 1.54 (5)
Anthracene 120-12-7	4.42 (5) 4.38 (6) 4.27,4.41 (3) 4.205 (3)
Anthracene-9-carboxylic acid	2.71 (4,5)
Aroclor 1016 12674-11-2	4.70 (3) 4.25 (2)
Aroclor 1221 11104-28-2	2.44 (3) 3.62 (2)
Aroclor 1232 11141-16-5	2.83 (3) 3.85 (2)
Aroclor 1242 53469-21-9	3.71 (3) 4.09 (2)
Aroclor 1248 12672-29-6	5.64 (3) 4.74 (2)
Aroclor 1254 11097-69-1	5.61 (3) 4.81 (2)
Aroclor 1260 11096-82-5	6.42 (3) 5.54 (2)
Atrazine 1912-24-9	2.17 (4,5) 1.92 (6) 2.20 (1)
BHC, a- 319-84-6	3.279 (3)
BHC, b- 319-85-7	3.462,3.322 (3) 3.553 (3)

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APPENDIX B (continued)

LOG KOC VALUES FOR SOME CONTAMINANTS

Contaminant	Log Koc
BHC, d- 319-86-8	3.279 (3)
Benefin 1861-40-1	4.03 (4)
Benzene 71-43-2	1.69,1.92 (3) 1.96,2.00 (3) 1.92 (1)
Benzidine 92-87-5	1.60 (3)
Benzo[a]anthracene 56-55-3	6.14 (1,3)
Benzo[a]pyrene 50-32-8	5.60-6.29 (3)
Benzo[b]fluoranthene 205-99-2	5.74 (3)
Benzo[ghi]perylene 191-24-2	6.89 (3)
Benzo[k]fluoranthene 207-08-9	6.64 (3)
Benzoic acid 65-85-0	1.48-2.70 (3) 2.26 (3)
Benzyl alcohol 100-51-6	1.98 (3)
Benzyl butyl phthalate 85-68-7	1.83-2.54 (3)
Bis(2-chloroethoxy)methane 111-91-1	2.06 (3)
Bis(2-chloroethyl)ether 111-44-4	1.15 (3)

APPENDIX B (continued)

LOG KOC VALUES FOR SOME CONTAMINANTS

Contaminant	Log Koc
Bis(2-chloroisopropyl)ether 108-60-1	1.79 (3)
Bis(2-ethylhexyl)phthalate 117-81-7	5.0 (3)
Bromacil 314-40-9	1.86 (4,5)
Bromoacetanilide, 3-	1.77 (4)
Bromoacetanilide, 4- 103-88-8	1.71 (4)
Bromoaniline, 4- 106-40-1	1.72 (4)
Bromobenzene 108-86-1	2.65 (6)
Bromodichloromethane 75-27-4	1.79 (3)
Bromoform 75-25-2	2.45,2.06 (3)
Bromonitrobenzene, 4- 586-78-7	2.18 (4) 2.42 (5)
Bromophenol, 4- 106-41-2	2.17 (4) 2.41 (5)
Bromophenyl phenyl ether, 4- 101-55-3	4.94 (3)
Bumeton, sec-	2.54 (4)
Butralin	3.91 (4,5)
Butylbenzene, n- 104-51-8	3.39 (4,5) 3.51 (6)

APPENDIX B (continued)

LOG KOC VALUES FOR SOME CONTAMINANTS

Contaminant	Log Koc
Butyranilide 1129-50-6	1.47 (4)
Carbamate, ethyl-N-phenyl	1.58 (4)
Carbamate, isopropyl-N-phenyl	1.71 (4)
Carbamate, methyl-N-(3-chlorophenyl)	1.91 (4)
Carbamate, methyl-N-phenyl	1.49 (4) 1.73 (5)
Carbamate, n-butyl-N-phenyl	2.02 (4) 2.26 (5)
Carbamate, n-pentyl-N-phenyl	2.37 (4)
Carbamate, n-propyl-N-phenyl	1.82 (4) 2.06 (5)
Carbaryl 63-25-2	2.47 (4) 2.02 (5) 2.30 (6) 2.36 (1)
[illegible]arbofuran 1563-66-2	1.46 (1)
Carbon disulfide 75-15-0	2.38-2.55 (3)
Carbon tetrachloride 56-23-5	1.85 (5) 2.35,2.64 (3) 2.62 (3)
Carbophenothion	4.66 (4)
Chloramben 133-90-4	1.32 (4)
Chloramben, methyl ester	2.71 (4)

APPENDIX B (continued)

LOG KOC VALUES FOR SOME CONTAMINANTS

Contaminant	Log Koc
Chlordane 57-74-9	5.15,5.57 (3)
Chlordane, cis- 5103-74-2	6.00,5.40 (3) 5.57 (3)
Chlordane, trans- 5103-71-9	6.00,5.48 (3)
Chlorfenvinphos	2.23 (4)
Chloro-4-bromonitrobenzene, 3-	2.36 (4)
Chloro-4-methoxyacetanilide, 3-	1.68 (4)
Chloro-4-methoxyaniline, 3-	1.69 (4)
Chloro-4-methoxyaniline, 3-	1.93 (5)
Chloro-m-cresol, p- 59-50-7	2.89 (3)
Chloroacetanilide, 2- 533-17-5	1.34 (4) 1.58 (5)
Chloroacetanilide, 3- 588-07-8	1.62 (4) 1.86 (5)
Chloroaniline, 4- 106-47-8	2.08 (6) 2.42,1.98 (3) 2.05,3.10 (3) 3.18,2.75 (3)
Chlorobenzene 108-90-7	2.41 (5) 1.68,2.52 (3)
Chloroethane 75-00-3	0.51 (3)
Chloroethyl vinyl ether, 2- 110-75-8	0.82 (3)

APPENDIX B (continued)

LOG KOC VALUES FOR SOME CONTAMINANTS

Contaminant	Log Koc
Chloroform 67-66-3	1.65 (5) 1.64 (3)
Chloronaphthalene, 2- 91-58-7	3.93 (3)
Chlorooxuron	3.51 (4)
Chlorophenol, 2- 95-57-8	2.56 (3)
Chlorophenyl phenyl ether, 4- 7005-72-3	3.60 (3)
Chloropicolinic acid, 6-	0.95 (4)
Chlorpyrifos 2921-88-2	4.13 (4)
Chlorthiamide	2.03 (4) 1.99 (1)
Chrysene 218-01-9	5.39 (3)
[illegible]rotoxyphos	2.23 (4)
Cyanazine 21725-46-2	2.30 (4,5)
Cycloate	2.54 (4)
D, 2,4- 94-75-7	1.61 (4) 1.30 (1,5) 2.59 (6)
DDD, p,p'- 72-54-8	4.64 (3)
DDE, p,p'- 72-55-9	6.00,5.386 (3)

APPENDIX B (continued)

LOG KOC VALUES FOR SOME CONTAMINANTS

Contaminant	Log Koc
DDT 50-29-3	5.38 (1,5) 5.63 (6) 5.38,5.146 (3) 5.18,6.26 (3)
Di-n-butylphthalate 84-74-2	3.14 (3)
Di-n-octyl phthalate 117-84-0	8.99 (3)
Diallate	3.28 (1,4,5)
Diazinon 333-41-5	2.12 (4)
Dibenzanthracene, 1,2,5,6- 53-70-3	6.31 (4,5) 6.22 (3)
Dibenzocarbazole, 1,2,7,8- 239-64-5	6.14 (4) 6.11 (5)
Dibenzofuran 132-64-9	3.91-4.10 (3)
Dibenzothiophene 132-65-0	4.05 (1,4) 4.00 (5)
Dibromo-3-chloropropane, 1,2- 96-12-8	2.11 (5)
Dibromochloromethane 124-48-1	1.92 (3)
Dibromoethane, 1,2- 106-93-4	1.64 (1,5) 2.08 (6)
Dicamba 1918-00-9	0.34 (1)
Dichlobenil	2.37 (4,5)

APPENDIX B (continued)

LOG KOC VALUES FOR SOME CONTAMINANTS

Contaminant	Log Koc
Dichloroacetanilide, 3,4-	2.10 (4) 2.34 (5)
Dichloroaniline, 3,4- 95-76-1	2.05 (4)
Dichlorobenzene, 1,2- 95-50-1	2.50 (5) 2.27,3.23 (3) 2.255 (3)
Dichlorobenzene, 1,3- 541-73-1	2.47 (5) 2.23,3.23 (3)
Dichlorobenzene, 1,4- 106-46-7	2.44 (5) 2.20 (3)
Dichlorobenzidine, 3,3'- 91-94-1	3.30 (3)
Dichlorodifluoromethane 75-71-8	2.56 (3)
Dichloroethane, 1,1- 75-34-3	1.48 (3)
Dichloroethane, 1,2- 107-06-2	1.15,1.279 (3)
Dichloroethylene, (trans), 1,2- 156-60-5	1.77 (3)
Dichloroethylene, 1,1- 75-35-4	1.81 (3)
Dichloronitrobenzene, 3,4- 99-54-7	2.29 (4) 2.53 (5)
Dichlorophenol, 2,3- 576-24-9	2.65 (4)
Dichlorophenol, 2,4- 120-83-2	2.75 (4,5) 2.94 (3)

APPENDIX B (continued)

LOG KOC VALUES FOR SOME CONTAMINANTS

Contaminant	Log Koc
Dichloropicolinic acid, 3,6-	0.30 (4)
Dichloropropane, 1,2- 78-87-5	1.71,1.431 (3)
Dichloropropylene, (cis), 1,3- 10061-01-5	1.68,1.36 (3)
Dichloropropylene, (trans), 1,3- 10061-02-6	1.68,1.415 (3)
Dieldrin 60-57-1	4.55,4.08 (3)
Diethyl phthalate 84-66-2	1.84 (3)
Diflubenzuron 35367-38-5	3.83 (4)
Dimethoate 60-51-5	0.72 (4)
Dimethyl phthalate 131-11-3	1.63(pH7.4) (3) 0.88(pH5.6) (3) 1.84(pH4.2) (3) 2.28 (3)
Dimethylbenzanthracene, 7,12- 57-97-6	5.37 (4,5) 5.68 (1)
Dimethylphenol, 2,4- 105-67-9	2.07 (3)
Dinitramine	3.60 (4)
Dinitro-o-cresol, 4,6- 534-52-1	2.64 (3)
Dinitrophenol, 2,4- 51-28-5	1.25 (3)

APPENDIX B (continued)

LOG KOC VALUES FOR SOME CONTAMINANTS

Contaminant	Log Koc
Dinitrotoluene, 2,4- 121-14-2	1.79 (3)
Dinitrotoluene, 2,6- 606-20-2	1.79 (3)
Dinoseb 88-85-7	2.09 (4,5) 3.82 (6)
Diphenylamine 122-39-4	2.54 (4) 2.78 (5)
Diphenylhydrazine,1,2- 122-66-7	2.82 (3)
Dipropetryn	3.07 (4)
Disulfoton 298-04-4	3.25 (4) 3.20 (1)
EPTC	2.38 (4)
Endosulfan sulfate 1031-07-8	3.37 (3)
[illegible]ndosulfan, a- 959-98-8	3.31 (3)
Endosulfan, b- 33213-65-9	3.37 (3)
Endrin 72-20-8	3.92 (3)
Endrin aldehyde 7421-93-4	4.43 (3)
Ethion 563-12-2	4.19 (4)
Ethylbenzene 100-41-4	2.38 (6) 1.98,2.41 (3)

APPENDIX B (continued)

LOG KOC VALUES FOR SOME CONTAMINANTS

Contaminant	Log Koc
Ethylnaphthalene, 1-	3.89 (6)
Fenamiphos 22224-92-6	2.28 (4)
Fluchloralin	3.56 (4,5)
Fluometuron 2164-17-2	2.24 (1)
Fluoranthene 206-44-0	4.62 (3)
Fluorene 86-73-7	3.70 (3)
Fluoroacetanilide, 3-	1.33 (4)
Fluoroacetanilide, 4-	1.24 (4)
Heptachlor 76-44-8	4.34 (3)
Heptachlor epoxide 1024-57-3	4.32 (3)
Hexachlorobenzene 118-74-1	3.59 (1,3,5) 4.77 (6) 4.01,2.56 (3) 2.70,4.32 (3)
Hexachlorobutadiene 87-68-3	3.67 (3)
Hexachlorocyclopentadiene 77-47-4	3.63 (3)
Hexachloroethane 67-72-1	3.34 (3)
Hexanone, 2- 591-78-6	2.13 (3)

APPENDIX B (continued)

LOG KOC VALUES FOR SOME CONTAMINANTS

Contaminant	Log Koc
Indeno[1,2,3-cd]pyrene 193-39-5	7.49 (3)
Isocil	2.11 (4,5)
Isophorone 78-59-1	1.49 (3)
Leptophos	3.97 (4)
Lindane 58-89-9	2.96 (3,5) 3.03,2.87 (3) 3.11,3.52 (3) 2.93,3.42 (3)
Linuron 330-55-2	2.93 (1)
Malathion 121-75-5	3.26 (1)
Methazole	3.42 (4)
Methiocarb	2.08 (4)
[illegible]ethomyl 16752-77-5	2.20 (4)
Methoxyacetanilide, 4- 51-66-1	1.16 (4) 1.40 (5)
Methoxychlor 72-43-5	4.99 (6) 4.90,4.95 (3) 4.90 (1)
Methyl bromide 74-83-9	1.92 (3)
Methyl chloride 74-87-3	1.40 (3)
Methyl chloropyrifos	3.52 (4)

APPENDIX B (continued)

LOG KOC VALUES FOR SOME CONTAMINANTS

Contaminant	Log Koc
Methyl ethyl ketone 78-93-3	0.09 (3)
Methyl parathion 298-00-0	3.99 (4)
Methyl-2-pentanone, 4- 108-10-1	0.79 (3)
Methyl-4-bromoaniline, 3-	2.02 (4) 2.26 (5)
Methylacetanilide, 3- 537-92-8	1.21 (4) 1.45 (5)
Methylaniline, 3- 108-44-1	1.66 (4) 1.65 (5)
Methylaniline, 4- 106-49-0	1.66 (4)
Methylcholanthrene, 3- 56-49-5	6.25 (4,5)
Methylene chloride 75-09-2	1.44 (5) 0.94 (3)
Methylnaphthalene, 2- 91-57-6	3.93 (3,5) 3.87 (3)
Methylphenol, 2- 95-48-7	1.34 (3)
Methylphenol, 4- 106-44-5	1.69 (3) <2.7 (1)
Metribuzin 21087-64-9	1.98 (4,5)
Mirex 2385-85-5	7.38 (1)

APPENDIX B (continued)

LOG KOC VALUES FOR SOME CONTAMINANTS

Contaminant	Log Koc
Naphthalene 91-20-3	3.11 (3,5) 2.74,3.52 (3) 2.96,3.04 (3) 3.16,3.21 (3)
Naphthol, 1- 90-15-3	3.33 (4) 2.64 (5)
Neburon	3.49 (1)
Nitralin	2.98 (1)
Nitrapyrin 1929-82-4	2.31 (4)
Nitroacetanilide, 3- 122-28-1	1.70 (4)
Nitroaniline, 2- 88-74-4	1.23-1.62 (3)
Nitroaniline, 3- 99-09-2	1.26 (3)
Nitroaniline, 4- 100-01-6	1.08 (3)
Nitrobenzene 98-95-3	1.70 (4) 1.94 (5) 2.36 (3) 1.95 (pH7.4)(3)
Nitrophenol, 2- 88-75-5	1.57 (3)
Nitrophenol, 4- 98-95-3	2.18 (6) 2.33,1.74 (3)
Nitrosodi-n-propylamine, N- 621-64-7	1.01 (3)
Nitrosodimethylamine, N- 62-75-9	1.41 (3)

APPENDIX B (continued)

LOG KOC VALUES FOR SOME CONTAMINANTS

Contaminant	Log Koc
Nitrosodiphenylamine, N- 86-30-6	2.76 (3)
Norflurazon 27314-13-2	3.28 (4)
Parathion 56-38-2	3.68 (4) 4.03 (1)
Pebulate	2.80 (4,5)
Pentachlorobenzene 608-93-5	3.50 (5)
Pentachlorophenol 87-86-5	3.73 (4) 2.95 (3,5) 4.04 (6) 2.96 (3)
Phenanthrene 85-1-8	4.36 (3,5) 3.72,4.59 (3)
Phenol 108-95-2	1.43 (3,5) 1.35 (6) 1.24 (3)
Phorate	2.58 (4)
Picloram 1918-02-1	1.23 (4,5) 1.41 (1)
Profluralin	3.93 (4)
Prometon 1610-18-0	2.54 (4)
Prometryn 7287-19-6	2.91 (4)
Pronamide 23950-58-5	2.30 (4)

APPENDIX B (continued)

LOG KOC VALUES FOR SOME CONTAMINANTS

Contaminant	Log Koc
Propachlor 1918-16-7	2.42 (4)
Propazine 139-40-2	2.20 (4)
Pyrene 129-00-0	4.92 (3,5) 4.66,4.88 (3) 4.80,4.81 (3) 5.13,4.67 (3)
Quinoline 91-22-5	2.76 (1)
Simazine 122-34-9	2.13 (4) 2.15 (1)
Styrene 100-42-5	2.87 (3)
T, 2,4,5- 93-76-5	1.72 (4,5)
TCDD, 2,3,7,8- 1746-01-6	6.66 (3)
Terbacil 5902-51-2	1.71 (4)
Tetracene	5.81 (5)
Tetrachlorobenzene, 1,2,3,4- 634-66-2	3.83 (4) 3.84 (5)
Tetrachlorobenzene, 1,2,3,5- 634-90-2	3.20 (5)
Tetrachlorobenzene, 1,2,4,5- 95-94-3	3.86 (4)
Tetrachloroethane, 1,1,2,2- 79-34-5	1.90 (5) 2.07,1.663 (3)

APPENDIX B (continued)

LOG KOC VALUES FOR SOME CONTAMINANTS

Contaminant	Log Koc
Tetrachloroethylene 127-18-4	2.42,2.56 (3) 2.322 (3)
Tetrachloroguaiacol	2.85 (5)
Tetrachlorophenol, 2,3,4,5- 4901-51-3	4.12 (4)
Tetrachlorophenol, 2,3,4,6- 58-90-2	3.35 (4) 2.66 (5)
Tetramethylbenzene, 1,2,4,5- 95-93-2	3.12 (4)
Thiabendazole	3.24 (4)
Toluene 108-88-3	2.39 (4) 2.06,2.18 (3)
Toxaphene 8001-35-2	3.18 (3)
Triallate 2303-17-5	3.35 (4)
Trichloro-2-pyridinol, 3,5,6-	2.11 (4)
Trichlorobenzene, 1,2,3- 87-61-6	3.37 (4)
Trichlorobenzene, 1,2,4- 120-82-1	2.94 (5) 2.70,3.09 (3) 3.16 (3)
Trichlorobenzene, 1,3,5- 108-70-3	2.85 (4,5)
Trichloroethane, 1,1,1- 71-55-6	2.26 (5) 2.18,2.017 (3)
Trichloroethane, 1,1,2- 79-00-5	1.87 (4) 1.89 (5) 1.75 (3)

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APPENDIX B (continued)

LOG KOC VALUES FOR SOME CONTAMINANTS

Contaminant	Log Koc
Trichloroethylene 79-01-6	2.00 (4,5) 1.81,2.10 (3) 2.025 (3)
Trichlorofluoromethane 75-69-4	2.20,2.13 (3)
Trichloromethyl)aniline, 3-(	2.12 (4)
Trichlorophenol, 2,4,5- 95-95-4	3.36 (4) 2.85,3.51 (3)
Trichlorophenol, 2,4,6- 88-06-2	3.02 (4) 2.52 (5) 3.03 (3)
Trichlorophenol, 3,4,5- 609-19-8	3.56 (4)
Triclopyr	1.43 (4)
Trietazine	2.78 (4,5)
Trifluoromethyl)acetanilide, 3-(	1.51 (4)
[illegible]rifluoromethyl)aniline, 3-(98-16-8	2.36 (5)
Trifluralin 1582-09-8	4.14 (1,4) 5.13 (6)
Trimethylbenzene, 1,2,3- 526-73-8	2.80 (4,5)
Trimethylbenzene, 1,3,5- 108-67-8	2.82 (4,5)
Urea, (2-chlorophenyl)	1.37 (4)
Urea, (2-fluorophenyl)	1.08 (4)
Urea, (3,4-dichlorophenyl)	2.25 (4)

APPENDIX B (continued)

LOG KOC VALUES FOR SOME CONTAMINANTS

Contaminant	Log Koc
Urea, (3-bromophenyl)	1.82 (4)
Urea, (3-chloro-4-methoxyphenyl)	1.76 (4)
Urea, (3-chlorophenyl)	1.77 (4)
Urea, (3-fluorophenyl)	1.53 (4)
Urea, (3-methyl-4-bromophenyl)	2.13 (4)
Urea, (3-methyl-4-fluorophenyl)	1.54 (4)
Urea, (3-methylphenyl)	1.32 (4)
Urea, (4-bromophenyl)	1.88 (4)
Urea, (4-fluorophenyl)	1.28 (4)
Urea, (4-phenoxyphenyl)	2.32 (4)
Urea, 3-(3,4-dichlorophenyl)-1,1-dimethyl	1.97 (4)
Urea, 3-(3,4-dichlorophenyl)-1-methyl	2.22 (4) 2.46 (5)
Urea, 3-(3,4-dichlorophenyl)-1-methyl-1-methoxy	2.19 (4)
Urea, 3-(3,5-dimethyl-4-bromophenyl)-1,1-dimethyl	2.29 (4)
Urea, 3-(3,5-dimethylphenyl)-1,1-dimethyl	1.49 (4)
Urea, 3-(3-chloro-4-methoxyphenyl)-1,1-dimethyl	1.50 (4)
Urea, 3-(3-chloro-4-methoxyphenyl)-1-methyl	1.60 (4)
Urea, 3-(3-chloro-4-methylphenyl)-1,1-dimethyl	1.78 (4)
Urea, 3-(3-chloro-4-methylphenyl)-1-methyl	1.86 (4)
Urea, 3-(3-chlorophenyl)-1,1-dimethyl	1.55 (4) 1.79 (5)

APPENDIX B (continued)

LOG KOC VALUES FOR SOME CONTAMINANTS

Contaminant	Log Koc
Urea, 3-(3-chlorophenyl)-1-methyl	1.69 (4) 1.93 (5)
Urea, 3-(3-fluorophenyl)-1,1-dimethyl	1.49 (4)
Urea, 3-(3-methoxyphenyl)-1,1-dimethyl	1.48 (4)
Urea, 3-(4-bromophenyl)-1-methyl-1-methoxy	1.78 (4) 2.02 (5)
Urea, 3-(4-chlorophenyl)-1,1-dimethyl	1.46 (4)
Urea, 3-(4-chlorophenyl)-1-methyl-1-methoxy	1.95 (4) 1.84 (5)
Urea, 3-(4-fluorophenyl)-1,1-dimethyl	1.19 (4)
Urea, 3-(4-methoxyphenyl)-1,1-dimethyl	1.16 (4)
Urea, 3-(4-methylphenyl)-1,1-dimethyl	1.27 (4) 1.51 (5)
Urea, 3-[3-(trifluoromethyl)phenyl]-1,1-dimethyl	2.24 (4)
Urea, 3-phenyl-1,1-dimethyl	1.43 (4)
Urea, 3-phenyl-1-cycloheptyl	2.13 (4)
Urea, 3-phenyl-1-cyclohexyl	1.83 (4) 2.07 (5)
Urea, 3-phenyl-1-cyclopentyl	1.69 (4) 1.93 (5)
Urea, 3-phenyl-1-cyclopropyl	1.48 (4)
Urea, 3-phenyl-1-methyl	1.05 (4)
Urea, [3-(trifluoromethyl)phenyl]	1.72 (4)
Urea, phenyl 64-10-8	1.11 (4) 1.35 (5)

APPENDIX B (continued)

LOG KOC VALUES FOR SOME CONTAMINANTS

Contaminant	Log Koc
Urea,3-(3-chloro-4-bromophenyl)-1-methyl-1-methoxy	2.34 (4)
Vinyl acetate 108-05-4	0.45 (3)
Vinyl chloride 75-01-4	0.39 (3)
Xylene, m- 108-38-3	2.26 (4) 3.20 (3)
Xylene, o- 95-47-6	2.73 (6) 2.11 (3)
Xylene, p- 106-42-3	2.52 (4,5) 2.31 (3)

(1) Lyman <u>et al</u>, 1982.
(2) CRC Press, 1986.
(3) Montgomery and Welkom, 1990.
(4) Sabljic, 1987.
(5) Bahnick and Doucette, 1988.
(6) Hodson and Williams, 1988.

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PENNSYLVANIA'S SURFACE WATER QUALITY MONITORING NETWORK
(WQN)

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF ENVIRONMENTAL RESOURCES
BUREAU OF WATER QUALITY MANAGEMENT

Robert P. Casey
Governor

Arthur A. Davis
Secretary

PUBLICATION NUMBER 33
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Section II

Fish Tissue

FISH TISSUE SAMPLING METHODS

Samples for determination of fish tissue contaminants may be collected as part of the Water Quality Network, during special studies, or in response to an environmental emergency. When needed, the following procedures should be employed to obtain fish tissue samples.

1. Collect fish (electrofishing, seine, gill net, rotenone, angling, other) taking care not to contaminate specimens with gasoline, motor oil, sediment, or soil. Record method used on Field Data Sheet (copy attached).

2. Measure the total length of each specimen in the sample to the nearest millimeter. Weigh each specimen in the sample to the nearest gram. Record both on Field Data Sheet.

3. Note general condition, tumors, lesions, etc. on Field Data Sheet.

4. Prepare sample:

   A. Whole Fish - Wrap composite sample (or individual fish if necessary for specific study) in clean, commercial (restaurant) grade aluminum foil allowing only the dull foil surface to contact fish tissue. Indicate sample type on Field Data Sheet.

   B. Fillets - Rinse clean fillet knife with purified hexane **labeled as suitable for pesticide residue analysis.**

      (1) Samples of fish with scales will be scaled, skin-on fillets (FDA Standard Fillet, Figure 1). Each sample will normally consist of the fillets from both sides of five fish (10 fillets). All individuals in the composite should be of similar size and, if possible, be of a size normally taken by anglers.

      In trout streams, fish should be wild or holdovers of seven inches or more. In warm water streams, samples should be of a representative, important sport species. A suggested ranking of warm water fish, in descending order of desirability, is bass, crappie, rock bass, redbreast sunfish, bluegill, pumpkinseed. If recreationally important, channel catfish can be collected from warm water locations.

      (2) For the catfish family (channel catfish and bullheads), the composite sample will contain skinless fillets. This is the FDA protocol and reflects the common consumption practice for catfish.

      (3) Samples of American eels will consist of five, one-inch cross sections from five skinned and gutted eels. The sections should be evenly spaced throughout each individual.

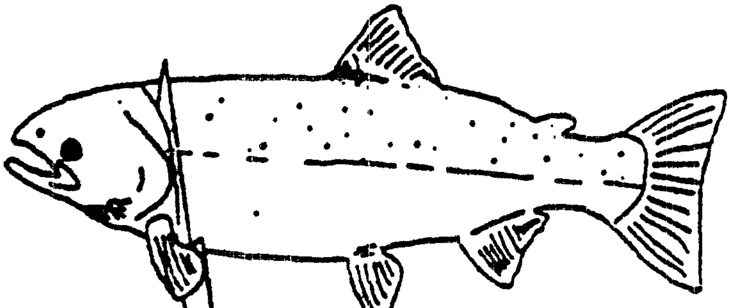
5. Clearly label each sample with the station number or water body name and location, date, time, and collector number (if necessary).

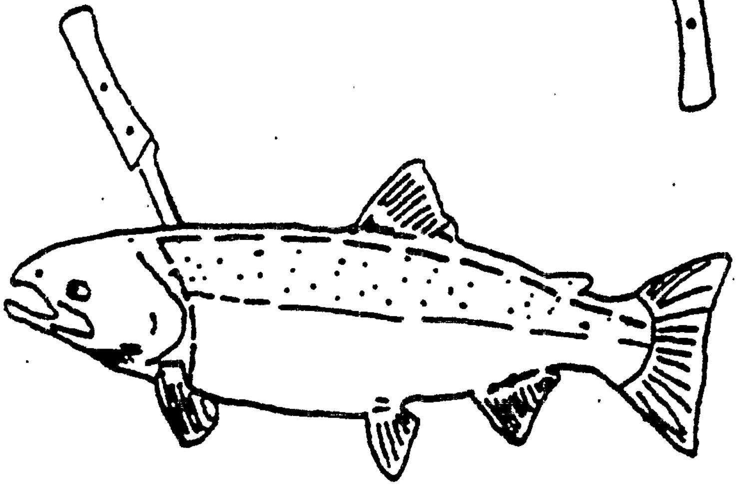
6. Place foil wrapped sample in a food grade protective plastic bag and freeze sample immediately (on dry ice if possible).

7. Be sure Field Data Sheet and request(s) for analysis have been completed.

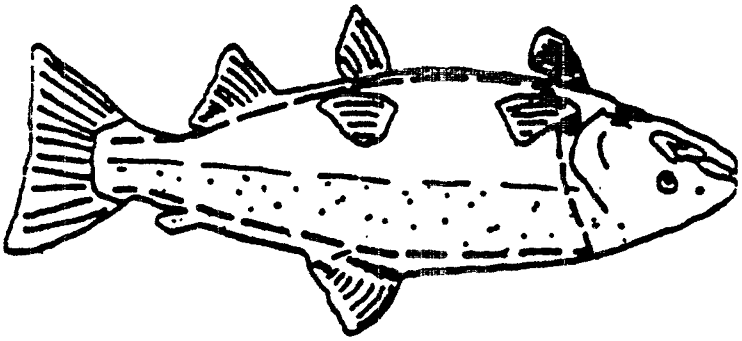
Figure 1. Procedure for the preparation of "standard fillets" as adapted from a procedure developed by New York State Department of Environmental Conservation.

1. **Make a cut behind the entire length of the operculum (gill cover) cutting through the skin and flesh to the spinal column.**



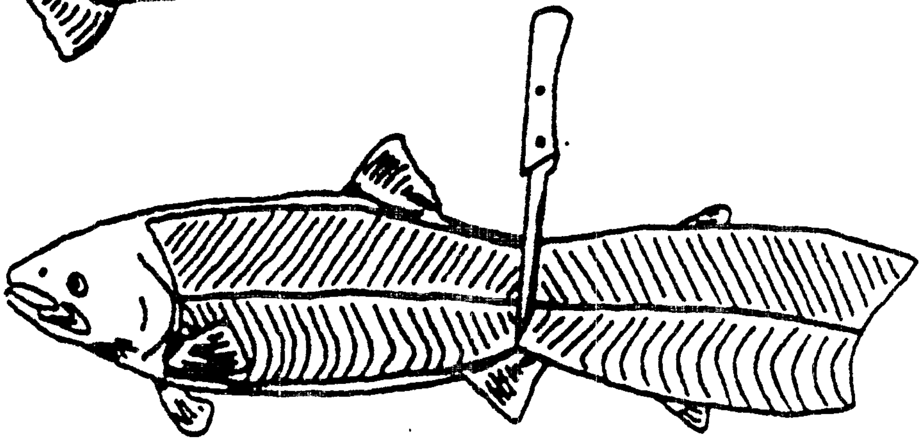


2. **Make a shallow cut through the skin (on either side of the dorsal fin) from the base of head to the posterior end of the caudal peduncle.**



3. **Make a cut along the belly from the base of the pectoral fin to the posterior end of the caudal peduncle. This cut is made on both sides of the anus and the anal fin.**

4. Remove the fillet.



FIELD DATA SHEET
Tissue Sampling - Commonwealth of Pennsylvania

Station #______ Water Body:____________________________ Date:________

Location:____

____

County:________________ Municipality:________________________________

Collector:_________________ Agency:______________ Coll.#_____________

Method: Electrofishing ( ) Seine ( ) Gill Net ( ) Rotenone ( )
Angling ( ) Other ( ):_________________________________

Reason:____

	SPECIES	TL-MM	WT-G	*CONDITION
1.				
2.				
3.				
4.				
5.				
6.				
7.				
8.				
9.				
10.				

*Note tumors, lesions, & general condition (if needed).

Tissue Type: Whole Fish ( ) Skinless Fillet ( ) Skin-on Fillet ( )
Scaled (Y or N) ( )
Blood ( ) Organ ( ):_____________________________________
Other ( ):____

Comments (water/weather conditions,man-hours expended,problems etc.)

APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS (ARARs)
FOR
CLEANUP RESPONSE AND REMEDIAL ACTIONS IN PENNSYLVANIA

DEPARTMENT OF ENVIRONMENTAL RESOURCES
BUREAU OF WASTE MANAGEMENT
DIVISION OF REMEDIATION

Final

June 1993

Original (Red)

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APPENDICES:

Federal and State Statute/Regulation Guide

ARAR Matrices

A. Chemical Specific Matrix
    Table 1, Water Quality Criteria for Toxic Substances
    Table 2, Pennsylvania Maximum Contaminant Levels - January 1993

B. Location Specific Matrix

C. Action Specific Matrix

INTRODUCTION

This document contains a list of state standards and requirements for cleanup related activities at waste sites in the Commonwealth of Pennsylvania. The purpose of this document is to identify, in a general fashion, state standards and requirements that will serve as a starting point for the determination of site specific cleanup related criteria.

The development and specific identification of cleanup criteria is a dynamic process. Some standards and requirements can be readily identified (i.e., ambient water quality criteria and promulgated drinking water standards.) Most, however, can only be derived after submittal and review of detailed information regarding site location, system design, and development of contaminant-specific discharge limits.

It should be noted that this document is a comprehensive list of environmental cleanup standards and requirements, however, the document is not inclusive. Additionally, regulatory standards and requirements are subject to change. Therefore, further consultation with and analysis by the appropriate Department and other Commonwealth personnel will be required.

Finally, this document is advisory and does not represent any determination made by the Department of Environmental Resources. This document shall in no way be construed or understood to create any duty or obligation upon the Department of Environmental Resources or the Commonwealth of Pennsylvania.

DEFINITION OF ARARs

Background

Section 121(d) the Comprehensive Environmental Response Compensation and Liability Act (CERCLA), (as amended by the Superfund Amendments and Reauthorization Act of 1986 (SARA)) and the Hazardous Sites Cleanup Act (HSCA or Act 108) Section 504, requires that Fund-financed, enforcement, and Federal facility remedial cleanup actions comply with requirements or standards under Federal and State environmental laws. The requirements that must be complied with are those that are applicable, or relevant and appropriate, to the hazardous substances, pollutants, or contaminants at a site or to the circumstances of the release. Compliance is required at the completion of the remedial action for hazardous substances, pollutants, or contaminants that remain on-site.

Section 504 of the Pennsylvania Hazardous Sites Cleanup Act (HSCA) provides that final remedial action under HSCA shall meet applicable and relevant and appropriate cleanup standards. Furthermore, cleanup standards promulgated under HSCA shall be consistent with State standards permitted under 121 (d) of the federal Superfund Act. HSCA further provides that DER may promulgate, by rulemaking, cleanup standards that are generally applicable to remedial responses to the releases of hazardous substances or contaminants.

Applicable requirements means that those cleanup standards, standards of control, and other substantive environmental protection requirements, criteria, or limitations **promulgated** under Federal or State law that specifically address a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance at a CERCLA or HSCA site. "Applicability" implies that the remedial action or the circumstances at the site satisfy all of the jurisdictional prerequisites of a requirement.

Relevant and appropriate requirements means those cleanup standards, standards of control, and other substantive environmental protection requirements, criteria, or limitations promulgated under Federal or State law that, while not 'applicable' to a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance at a CERCLA or HSCA site, address problems or situations sufficiently similar to those encountered, and that their use is well suited to the particular site.

The relevance and appropriateness of a requirement can be judged by comparing a number of factors, including the characteristics of the remedial action, the hazardous substances in question, or the physical circumstances of the site, with those addressed in the requirement. It is also helpful to look at the objective and origin of the requirement. For example, while RCRA regulations may not be applicable to closing undisturbed hazardous waste in place, the RCRA regulation for closure by capping may be deemed relevant and appropriate.

A requirement that is judged to be relevant and appropriate must be complied with to the same degree as if it were applicable. However, there is more discretion in this determination: it is possible for only part of a requirement to be considered relevant and appropriate, the rest being dismissed if judged not to be relevant and appropriate in a given case.

Non-promulgated or non-regulatory documents (health advisories, guidances, proposed regulations) issued by the State or Federal government are not considered potential ARARs and are referred to as "to be considered" requirements or TBCs. TBCs are evaluated along with ARARs and are considered appropriate in the absence of a specific ARAR or where ARARs are not sufficiently protective in developing cleanup goals.

Types of ARARs

There are several different types of requirements that Cleanup actions may have to comply with. The classification of ARARs are listed below with specific matrices attached as appendices to this document:

Chemical-specific requirements set legal (background), health or risk-based concentration limits, or ranges in various environmental media for specific hazardous substances, pollutants, or contaminants. Examples: Maximum Contaminant Levels, national Ambient Air Quality Standards.

These requirements may set protective cleanup levels for the chemical of concern in the designated media, or else indicate an acceptable level of discharge (e.g., air emission or wastewater discharge taking into account water quality standards) where one occurs in a remedial activity. If a chemical has more than one such requirement, the more stringent ARAR should be complied with.

In accordance with, among others, Article 1, Section 27 of the Pennsylvania Constitution, Sections 301, 307, 401 and 402 of the Pennsylvania Clean Streams Law, and the Solid Waste Management Act, the legal liability of any responsible party for groundwater contamination is to remediate any contamination to background water quality. Nothing in this document or the accompanying materials should be deemed to constitute any modification to a responsible party's legal liability to restore contaminated waters to background.

Action-specific requirements or design specifications set controls or restrictions on particular kinds of activities related to management of hazardous substances, pollutants, or contaminants. Examples: RCRA regulations for closure of hazardous waste storage or disposal units; RCRA incineration standards; Clean Water Act pretreatment standards for discharges to POTWs.

These requirements are triggered not by the specific chemicals present at a site but rather by the particular remedial activities that are selected to accomplish a remedy. Since there are usually several alternative actions for any remedial site, very different requirements can come into play. These action-specific requirements may specify particular performance levels, actions, or technologies, as well as specific levels (or a methodology for setting specific levels) for discharged or residual chemicals.

Location specific requirements set restrictions on activities depending on the characteristics of a site. Examples: Federal and State siting laws for hazardous waste facilities; sites on National Register of Historic Places.

These requirements function like action-specific requirements. Alternative remedial actions may be restricted or precluded depending on the location or characteristics of the site and the requirements that apply to it.

Specific Standards, Special Standard, and Modifications

A. **Chemical, Location and Action Specific Matrices** - The Specific Matrices attached to this document and referenced above represent identifications of ARARs at the time this document was prepared. This information shall not be construed as establishing a complete or final list of Pennsylvania ARARs. In addition to the numbers or description of ARARs contained in the Matrices, other ARARs may exist which are derived from Pennsylvania statutes and regulations which may not be identifiable except in the context of a specific case. The Department reserves the right to identify additional ARARs at any time.

B. **Special Standards** - Section 504 of HSCA allows the Department to establish additional standards, without rulemaking, on a case-by-case basis where any of the following apply:

1. The circumstances at the site are such that the applicable general standards, as applied, would not provide the degree of protection to public health or the environment intended by the general standards.

2. The degree of additional environmental protection provided by the special standard is significant in relation to the cost of implementing it.

C. **Modification of ARARs - The Department may modify an ARAR if any of the following apply:**

1. Compliance with a requirement at a site will result in greater risk to the public health and safety of the environment than alternative options.

2. Compliance with a requirement at a site is technically infeasible from an engineering perspective.

3. The remedial actions selected will attain a standard of performance that is equivalent to that required under the otherwise applicable requirement through use of another method or approach.

4. The remedial action selected will not provide for cost-effective response.

D. **Fund Money Modification** - The Department may modify an ARAR where the site is being remediated through the use of fund money where the Department determines that such a modification is in the public interest.

E. **Effect of modification under C and D** - Where the Department allows a modification to any ARAR, such modification shall not be construed to constitute a modification of any responsible person's legal liability unless a waiver of liability is expressly stated in writing by the Department. Such a modification shall therefore only constitute an authorization by the Department to proceed with a cleanup plan in accordance with the modification and such conditions as the Department may proscribe.

DER's Bureau of Waste Management

A. Statutory Authority:

The Department's major source of standards and requirements governing waste sites are found under the Solid Waste Management Act 97 (35 P.S. §§6018.101 - 6018.1003).

The Hazardous Sites Cleanup Act 108 (35 P.S. §6020.101). Removal and remediation program independent from the Federal Superfund program. Provides means for funding, enforcement, cleanup standards and hazardous waste facilities siting.

B. Regulations:

Numerous requirements are promulgated under the Solid Waste Management Act; these regulations are found in the Pennsylvania Bulletin, and are also codified in Title 25 of the Pennsylvania Code. Relevant chapters are as follows:

1. Article VII, Chapters 260-270, Hazardous Waste Management Regulations

   (a) 25 Pa. Code, Chapters 260-266 and 270) - applies to the identification and listing, generation, transportation, storage, treatment and disposal of hazardous waste; contains the requirements under the federal Resource, Conservation and Recovery Act for a state to implement a federally-approved hazardous waste program.

   (b) Chapter 267 (25 Pa. Code §§267.1 - 267.62) - sets forth the minimum requirements for demonstrating sufficient financial responsibility to operate a hazardous waste storage, treatment or disposal facility by providing bond guarantees for the operation, closure, and post-closure requirements of a hazardous waste storage, treatment or disposal facility, and by providing insurance protection for personal injury and property damage arising out of operation of a hazardous waste storage, treatment or disposal facility.

   (c) Chapter 269 (25 Pa. Code §§269.1 - 269.50) - sets forth requirements that apply to siting of hazardous waste treatment and disposal facilities; divides the criteria for siting hazardous waste treatment and disposal facilities into two phases (Phase I exclusionary criteria which prohibit the siting of a new hazardous waste treatment or disposal facility in an excluded area delineated under these criteria, and Phase II criteria which identify environmental, social, and economic factors which may effect the suitability of a location for a proposed facility and apply to new hazardous waste treatment or disposal facilities and modifications to existing facilities).

2. Municipal Waste Regulations

   (a) Chapter 271 (25 Pa. Code §§271.1 - 271.744)

   Chapter 271 sets forth provisions that are generally applicable to all municipal waste management activities, including definitions for all chapters (Subchapter A), general requirements for permits and permit applications (Subchapter B), permit review procedures and standards (Subchapter C), bonding and insurance requirements (Subchapter D), civil penalties and enforcement (Subchapter E), requirements for demonstration facilities (Subchapter F), residual waste as it applies to municipal facilities (Subchapter G), general permit requirements for infectious and chemotherapeutic waste (subchapter H). This chapter applies in conjunction with later chapters that are specifically applicable to particular types of facilities.

(b) Chapter 272 (25 Pa. Code §§272.1 - 272.543

This chapter sets forth provisions for municipal planning, recycling and waste reduction. General provisions (Subchapter A), duties and responsibilities of host municipalities and counties under Act 101 (Subchapter B), county plans and revisions requiring municipal waste planning (Subchapter C), provisions for Act 101 grants (Subchapter D), provisions for the operation of the municipal recycling program (Subchapter E), and provisions for the establishment and operation of household hazardous waste collection (Subchapter F).

(c) Chapter 273 (25 Pa. Code §§273.1 - 273.521).

This chapter sets forth the Department's application and operating requirements for municipal waste landfills. This chapter is divided in five major parts: Subchapter A (relating to general requirements), Subchapter B (relating to application requirements), Subchapter C (relating to operating requirements), Subchapter D (relating to additional application requirements for special handling and residual waste) and Subchapter E (relating to additional operating requirements for special handling and residual waste). This chapter is generally applicable to all operations at a municipal waste landfill, not merely the specific disposal area.

(d) Chapter 275 (25 Pa. Code §§275.1 - 275.614)

Chapter 275 sets forth the Department's regulations concerning land application of sewage sludge. Subchapter B sets out general application requirements for the three recognized methods of land application of sewage sludge, which are agricultural utilization, land reclamation, and land disposal. Subchapter C sets forth general operating requirements for all three methods of land application of sewage sludge. Subchapter D sets forth additional application and operating requirements for the agricultural utilization of sewage sludge. Additional application and operating requirements for the land disposal of sewage sludge are set forth in Subchapter F. Finally, Subchapter G sets forth the Department's requirements for the sewage sludge distribution program.

(e) Chapter 277 (25 Pa. Code §§277.1 - 277.312)

Chapter 277 sets forth application and operating requirements for construction and demolition waste landfills. Construction/demolition waste is solid waste resulting from the construction or demolition of buildings and other structures, including but not limited to wood, plaster, metals, asphaltic substances, bricks, block and unsegregated concrete. The term also includes dredging wastes. Subchapter B sets out application requirements, and Subchapter C sets out operating requirements.

(f) Chapter 279 (25 Pa. Code §§279.1 - 279.272)

Chapter 279 sets forth application and operating requirements for transfer facilities. Subchapter B sets forth application requirements for transfer stations, and Subchapter C sets forth operating requirements for transfer facilities.

(g) Chapter 281 (25 Pa. §§Code 281.1 - 281.282)

Chapter 281 contains permitting requirements for composting facilities.

(h) Chapter 283 (25 Pa. §§Code 283.1 - 283.434)

Chapter 283 concerns resource recovery and other processing facilities. This chapter is applicable to a number of municipal waste processing facilities, including resource recovery facilities, that are not transfer stations or composting facilities. Subchapter B sets forth application requirements stating what an applicant must submit to the Department in order to obtain a permit. Subchapter C sets forth operating requirements for persons or municipalities that operate such facilities. Subchapter D sets forth additional application requirements for special handling wastes. Subchapter E sets forth additional operating requirements for special handling wastes.

(i) Chapter 285 (25 Pa. Code §§285.1 - 285.222)

Chapter 285 sets forth standards for storage, collection and transportation of municipal wastes. Subchapter A sets forth standards for storage of municipal waste. Subchapter B sets forth standards for collection and transportation of municipal wastes. Subchapter C provides for transporter Licensing for infectious and chemotherapeutic waste. Subchapter D provides for the manifesting of infectious and chemotherapeutic waste.

3. Residual Waste Regulations

(a) Chapter 287 (25 Pa. Code §§287.1 - 287.666)
This chapter specifies general procedures, definitions and rules for the generation, management and handling of residual waste.

(b) Chapter 288 (25 Pa. Code §§288.1 - 288.625)
This chapter sets forth application and operating requirements for Class I, II and III residual waste landfills.

(c) Chapter 289 (25 Pa. Code§§289.1 - 289.557)
This chapter sets forth application and operating requirements for Class I and II residual waste disposal impoundments.

(d) Chapter 291 (25 Pa. Code §§291.1 - 291.258)
This chapter provides for the application and operation requirements for residual waste by land application.

(e) Chapter 293 (25 Pa. Code §§293.1 - 293.262)
This chapter sets forth application and operating requirements for residual waste transfer facilities.

(f) Chapter 295 (25 Pa. Code §§295.1 - 295.282)
This chapter provides for the application and operation of residual waste composting facilities.

(g) Chapter 297 (25 Pa. Code §§297.1 - 297.272)
This chapter sets forth application and operation requirements for residual waste processing facilities other than transfer or composting facilities.

(h) Chapter 299 (25 Pa. Code §§299.101 - 299.232)
This chapter provides standards for the storage of residual waste (subchapter A), and standards for collecting and transporting of residual waste (Subchapter B).

C. Guidance Documents:

1. Guidance Manual for Groundwater Monitoring, July 1985.
2. Guidance Manual for Landfill Gas Management.
3. Guidelines for Benthic Macroinvertebrate Stream Surveys for Landfills, June 1988.
4. Management Policy for Ash Residue from Municipal Waste Incineration Resource Recovery Facilities.
5. Application for Storage, Treatment, Disposal of Hazardous Waste - Module #1.
6. Ground Water Quality Protection Strategy. February, 1992.
7. Policy and Procedure for the Disposal of Fuel Contaminated Soils. May 1990.
8. ARARs Determination. DER Office of Chief Counsel correspondence to EPA regarding groundwater and soil remediation levels. June 15, 1990 and July 2, 1990.

Additional guidance and policy available by contacting the Bureau of Waste Management Regional or Central Office personnel.

DER's Bureau of Water Quality Management

A. Statutory Authority:

1. The Department's major source of standards and requirements governing water quality are found under the Clean Streams Law, Act of June 22, 1937, P.L. 1987, as amended, 35 P.S. §§691.1 et. seq.

2. Additional requirements specific to community and individual sewage treatment and disposal systems are found under the Sewage Facilities Act (537), Act of January 24, 1966, P.L. 1535, as amended, 35 P.S. §§750.9 et seq.

3. Storage Tank and Spill Prevention Act, Act of July 6, 1989, 35 P.S. §§6021.101-6021.2105.

B. Regulations:

Numerous requirements are promulgated under the Clean Streams Law, the Sewage Facilities Act and the Administrative Code; refer to the Pa. Bulletin and Title 25 of the Pa. Code. Relevant chapters are as follows:

1. Chapter 71 (25 Pa. Code §§71.1 et seq.) - This chapter sets forth regulations requiring Planning Requirements for Sewage Facilities, administration of permits for individual and community sewage systems, and the powers and duties of the Certification Board.

2. Chapter 72 (25 Pa. Code §§72.1 et. seq.) - This chapter sets forth regulations governing the issuance of permits by local agencies for retaining tanks, and individual and community on-lot sewage systems which handle less than 10,000 gallons per day and utilize subsurface absorption areas for effluent renovation.

3. Chapter 73 (25 Pa. Code §§73.1 et. seq.) - This chapter sets forth regulations pertaining to site and soil suitability for on-lot sewage disposal, the size and type of treatment tanks, treatment tank effluent dosing and distribution requirements, absorption area requirements, retaining tank standards, and experimental and alternate systems.

4. Chapter 91 (25 Pa. Code §§91.1 et. seq.) - This chapter sets forth general provisions for administration and enforcement of Pennsylvania's water pollution control program, and establishes specific application requirements and conditions for the approval and permitting of the construction and operation of waste treatment projects.

5. Chapter 92 (25 Pa. Code §§92.1 et. seq.) - This chapter sets forth provisions for the administration of the National Pollutant Discharge Elimination System (NPDES) Program within Pennsylvania, and establishes criteria for the content of NPDES permit applications, effluent standards, monitoring requirements, standard permit conditions, public notification procedures, and other requirements related to the NPDES Program.

6. Chapter 93 (25 Pa. Code §§93.1 et. seq.) - This chapter sets forth general and specific standards for the quality of Pennsylvania's waters and includes specific water quality criteria and designated water use protection for each

stream in Pennsylvania. It is reviewed and updated, as necessary, at least once every three years. Section 93.8a establishes Chapter 16 regarding the toxics management strategy and statement of policy.

7. Chapter 94 (25 Pa. Code §§94.1 et. seq.) - This chapter sets forth provisions for municipalities to address pretreatment and other management requirements for wastewaters discharged into municipal sewage collection and treatment systems.

8. Chapter 95 (25 Pa. Code §§95.1 et. seq.) - This chapter sets forth waste treatment requirements for all dischargers including general requirements for "High Quality Waters" and "Exceptional Value Waters" and procedures for dealing with special circumstances, such as developing wasteload allocations, discharges to acid impregnated streams and discharges to lakes, ponds, and impoundments.

9. Chapter 97 (25 Pa. Code §§97.1 et. seq.) - This chapter sets forth specific provisions concerning the discharge of industrial wastes to Pennsylvania waters.

10. Chapter 101 (25 Pa. Code §§101.1 et. seq.) - This chapter sets forth special provisions for incidences which would endanger downstream users of Pennsylvania waters, and specifies actions to be taken when such emergency incidences occur.

11. Chapter 102 (25 Pa. Code §§102.1 et. seq.) - This chapter sets forth requirements for the control of soil erosion and sedimentation resulting in earthmoving activities.

    Note: The administration of Chapter 102, in most cases, has been delegated to County Conservation Districts working in cooperation with the DER's Bureau of Land and Water Conservation.

Storage Tank and Spill Prevention Regulations for Corrective Action are under development. Other promulgated standards are as follows:

1. Chapter 245 (25 Pa. Code §§245.1-245.141 et. seq) - This chapter provides for the certification program for installers and inspectors of aboveground and underground storage tanks.

C. Guidances and Strategies:

1. 25 Pa. Chapter 16, Statement of Policy.
2. Industrial Waste Manual.
3. Sewerage Manual.
4. Spray Irrigation Manual.
5. Strategy for Making Water Quality Management Plan Amend./Consistency.
6. Toxics Management Strategy.

7. Technical Guidance for NPDES Permitting of Landfill Leachate Discharges.

8. Wastewater Treatment Technology Assessment for Municipal Waste Landfills.

9. Staff Guidance For Underground Storage Systems in Pennsylvania.

10. Implementation Procedure for Protection of High Quality and Exceptional Value Waters.

11. Ground Water Quality Protection Strategy. February 1992.

DER's Bureau of Water Supply and Community Health

A. Statutory Authority:

Pennsylvania Safe Drinking Water Act, Act of May 1, 1984, P.L. 206, 35 P.S. §§721.1 et. seq.

B. Regulations:

Regulations promulgated under the Safe Drinking Water Act; refer to the Pa. Bulletin and Title 25 of the Pennsylvania Code:

Chapter 109 (25 Pa. Code §§109 et. seq.) - This chapter sets forth drinking water quality standards at least as stringent as federal standards: maximum contaminant levels (MCLs), and additional state requirements: secondary maximum contaminant levels (SMCLs) for public water systems including permit design and construction, source quality and siting requirements. Chapter 109 also sets requirements for bottled water retail facilities.

C. Guidance Documents:

The guidance for limiting unregulated contaminants in public water supplies is referenced in Chapter 109.203 and in the following:

1. Unregulated Contaminants Guidance and Health Effects Information Document.

   Public water systems shall supply finished water that complies with the maximum unregulated contaminant concentrations (MUCC) determined as follows:

   (a) The MUCC will be the concentration at which EPA has proposed to set or is considering setting a primary MCL for the contaminant; or

   (b) If EPA has not established a concentration as set forth in (a) above, the MUCC will be the concentration associated with a lifetime cancer risk of 10^{-6} for carcinogenic contaminants or the concentration equal to the lifetime health advisory concentration for non-carcinogenic contaminants, provided that this concentration is equal to or greater than the practical quantitation level and achievable through the use of available treatment technology; or

   (c) If the concentration specified in (b) above is not equal to or greater than the practical quantitation level or is not achievable through the use of available treatment technology, the MUCC will be set at the lowest concentration these limiting factors will allow.

2. DER Public Water Supply Manual

   In an effort to develop, maintain and attain the above drinking water quality requirements, the Bureau has developed a Public Water Supply Manual. The Manual contains siting, treatment design and construction standards which the Department finds to be acceptable.

DER's Bureau of Air Quality Control

A. Statutory Authority:

The Department's major source of standards and requirements governing air quality are found under the Air Pollution Control Act, Act of January 8, 1960, P.L. 2119, 35 P.S. §§4001, et. seq.

B. Regulations:

Numerous requirements are promulgated under the Air Pollution Control Act; refer to the Pa. Bulletin and Title 25 of the Pennsylvania Code. Relevant chapters are as follows:

1. Chapter 123 (25 Pa. Code §§123.1 et. seq.) - This chapter on "Standards for Contaminants" sets forth requirements for fugitive emissions, including open burning and demolition activities; specific limitations for particulate matter sulfur dioxide, odor, and visible emissions.

2. Chapter 127 (25 Pa. Code §§127.1 et. seq.) - This chapter on "Construction, Modification, Reactivation and Operation of Sources" requires the use of Best Available Technology (BAT) for control of new sources, plan approval and operating permit requirements, and special requirements for sources in nonattainment areas.

   25 Pa. Code §§127.12(a)(5) requires that new air contaminant sources reduce emissions to the minimum attainable level through the use of best available technology (BAT). Applicants are responsible for demonstrating that BAT will be utilized on the sources in its plan approval application. BAT is defined in 25 Pa. Code 121.1. In order to determine that a plan approval application has demonstrated that the source will control emissions of air contaminants to the appropriate level, the Department needs to review each plan approval application on a case-by-case basis. Source-specific factors can impact on what devices, methods or techniques are needed to control emissions. The Department bases its case-by-case determinations of BAT on the engineering judgment of the plan approval application reviewers. The Department needs to review each plan approval application to apply the BAT requirement. If plan approvals (construction permits) will not be required, the Department will need to evaluate plan approval type technical information regarding the source to make a BAT determination.

3. Chapter 129 (25 Pa. Code §§129.1 et. seq.) - This chapter on "Standards for Sources" governs for open burning and specific industrial sources.

4. Chapter 131 (25 Pa. Code §§131.1 et. seq.) - This chapter on "Ambient Air Quality Standards" adopts Federal ambient air quality standards plus sets forth additional State standards for settled particulate, beryllium, sulfates, fluorides, and hydrogen sulfide.

5. Chapter 135 (25 Pa. Code §§135.1 et. seq.) - This chapter on "Reporting of Sources" requires the submission of data necessary for the identification and quantification of potential and actual air contaminant emissions.

6. Chapter 137 (25 Pa. Code §§137.1 et. seq.) - This chapter on "Air Pollution Episodes" sets forth requirements for standby plans and the implementation of emission reduction procedures to prevent the excessive buildup of air pollutants during air pollution episodes.

7. Chapter 139 (25 Pa. Code §§139.1 et. seq.) - This chapter on "Sampling and Testing" sets forth requirements for sampling of facilities, sampling methods and analytical procedures.

8. Chapter 141 (25 Pa. Code §§139.1 et. seq.) - This chapter on "Variances and Alternative Standards" establishes that the Department may impose more stringent standards than set forth in other Bureau of Air Quality regulations where 1) the standard is related to achieving ambient air quality standards, 2) the standard can be achieved through BAT, or 3) the standard is necessary to protect the public health, safety or welfare.

C. Guidance Documents:

1. "Hazardous Waste and Petroleum Products Contamination Cleanup Projects" requires plan approval and BAT for air strippers and other equipment designed to remove volatile contaminants from soil, water, and other materials.

2. "BAT criteria for Municipal Incinerators."

3. "BAT criteria for Hospital/Infectious Waste Incinerators."

4. "Interim Operating Guidance for Air Toxic Substances", provides a consistent procedure for permitting new and modified sources that emit air toxic substances. The guidance specifies how to evaluate sources, based mainly on the chronic (annual) low level exposure air quality guidelines for approximately 99 compounds. It also requires an acute (weekly) exposure assessment for formaldehyde and nickel compounds. This guidance is intended to provide a framework to assess the potential for public health hazards from the emissions of air toxic substances. The guidance provides criteria for the acceptance/rejection of plan approval applications for air contaminant sources. The requirements are both site and source specific, being established on a case by case basis.

5. "Air Quality Permitting Criteria for Remediation Projects Involving Air Strippers and Soil Decontamination Units." Provides a permit exemption policy for remediation projects involving the Bureau of Air Quality Control.

6. "Air Quality Permitting Criteria Including Best Available Technology Criteria for Municipal Waste Landfills." This document specifies plan approval requirements and guidelines to satisfy BAT requirements as established by 127.12(a)(5) for municipal waste landfills.

7. "Multi-pathway Risk Assessment Guidelines." This document specifies risk assessment methodology for the burning of hazardous waste. These guidelines are applicable to commercial hazardous waste incinerators, boilers, and industrial furnaces subject to 40 CFR Parts 260-271 and DER's Chapter 126 and 264.

DER's Bureau of Land and Water Conservation

A. Statutory Authority:

The Clean Streams Law, the Act of June 22, 1937, as amended, P.L. 1987, 35 P.S. 691.1 et. seq.

B. Regulations:

Requirements promulgated under the Clean Streams Law; see the Pa. Bulletin and Title 25 of the Pennsylvania Code:

1. Chapter 102 (25 Pa. Code SS102.1 et. seq.) - Erosion Control. This chapter sets forth provisions that impose requirements on earth moving activities which create accelerated erosion or danger of accelerated erosion and which require planning and implementation of effective soil conservation measures. The Bureau administers the program for the control of erosion and sedimentation in cooperation with County Conservation Districts.

Regulations promulgated under the Storm Water Management Act; see the Pa. Bulletin and Title 25 of the Pa. Code:

1. Chapter 111 (25 Pa. Code SS111.1 et. seq.) - This chapter sets forth provisions governing the awards of grants to counties and municipalities for preparing and implementing storm water management plans.

C. Guidance Documents:

Erosion and Sediment Pollution Control Program Manual (1990)

Erosion and Sedimentation Control Plan Development Checklist

DER's Bureau of Dams, Waterways and Wetlands

A. Statutory Authority:

1. The Flood Plain Management Act, Act of October 4, 1978, P.L. 851, No. 166, 32 P.S. §§679.101 et. seq.

2. The Dam Safety and Encroachments Act, Act of 1978, P.L. 1375, as amended, 32 P.S. §§693.1 et. seq.

3. The Storm Water Management Act, Act of October 4, 1978, P.L. 864, No. 167, as amended, 32 P.S. §§680.1 - 680.17.

4. The Clean Streams Law of Pennsylvania, Act of June 22, 1937, P.L. 1987, 35 P.S. §§691.1 et. seq.

B. Regulations:

1. Regulations promulgated under the Dam Safety and Encroachments Act; see the Pa. Bulletin and Title 25 of the Pennsylvania Code:

   Chapter 105 (25 Pa. Code §§105.1 et. seq.) - This chapter sets forth provisions for the regulation and supervision of dams, reservoirs, water obstructions and encroachments in waters of the Commonwealth including wetlands. Central Office, Bureau of Dams, Waterways and Wetlands, Division of Dam Safety, processes dam permits and evaluates the environmental assessments for out-of-scope dams. The Regional Offices of Water Management, Soils and Waterways Section are responsible for enforcement activities, processing permit applications for water obstructions and encroachments, and for inspecting dams.

2. Regulations promulgated under the Flood Plain Management Act; see the Pa. Bulletin and Title 25 of the Pa. Code:

   Chapter 106 (25 Pa. Code §§106.1 et. seq.) - This chapter sets forth provisions for the regulation of obstructions and highway obstructions constructed, owned or maintained by a political subdivision of the Commonwealth, or a public utility, and located in the 100 year floodplain as delineated by FEMA Flood Hazard Boundary Maps.

C. Guidance Documents:

1. An outline of Pennsylvania Wetlands Protection Program: Regulations, Policy and Ecological Considerations.

2. Overview of Changes to Chapter 105, December 1991.

3. Guidelines for Small Projects, September 1992. Small projects are those water obstructions or encroachments with insignificant impact as defined in Chapter 105, excluding wetlands.

4. Abridged National List of Plant Species that Occur in Wetlands.

DER's Bureau of Radiation Protection

A. Statutory Authority:

The Radiation Protection Act, Act of July 10, 1984, P.L. 688, 35 P.S. §§7110.101 et. seq.

B. Regulations:

Several regulations promulgated under the authority of the Atomic Energy Development and Radiation Control Act; see the Pa. Bulletin and Title 25 of the Pennsylvania Code.

1. Chapter 215 (25 Pa. Code §§215.1 et. seq.) - This chapter sets forth general provisions for all persons who use, manufacture, produce, transport, transfer, receive, acquire, possess or dispose of any radiation source.
2. Chapter 217 (25 Pa. Code §§217.1 et. seq.) - This chapter sets forth provisions for application and licensing requirements for persons who manufacture, produce, transport, transfer, receive, acquire, possess or dispose of any radioactive material.
3. Chapter 219 (25 Pa. Code §§219.1 et. seq.) - This chapter sets forth provisions for individual exposure limits, emission standards, and safety requirements.

C. Additional Requirements:

1. Chapter 403 - This chapter sets forth the Pennsylvania Department of Transportation requirements for transporting radioactive materials.
2. The Nuclear Regulatory Commission should be notified if high level wastes are involved.

DER's Bureau of Topographic and Geologic Survey

A. Statutory Authority:

The Water Well Drillers License Act, Act of May 29, 1956, P.L. 1840, 32 P.S. §645.1 et. seq.

B. Regulations:

Requirements promulgated under the Water Well Driller License Act; see the Pa. Bulletin and Title 25 of the Pennsylvania Code:

Chapter 107 (25 Pa. Code §§107.1 et. seq.) - This chapter sets forth requirements for the licensing of water well drillers, prevention of pollution of underground waters, submittal of well construction records and well abandonment notification.

DER's Bureau of Oil and Gas Management

A. Statutory Authority:

1. The Oil and Gas Act of 1984, Act of December 19, 1984, P.L. 1140, as amended, 58 P.S. §§ 601.101 et. seq. The Oil and Gas Act is the fundamental law governing activities for the oil and gas industry. It sets forth permitting, drilling, operating, casing, plugging, reporting, financial responsibility, gas storage, well location restrictions, and other requirements.

2. The Coal and Gas Coordination Act, Act of December 18, 1984, P.L. 1069, 58 P.S. §§501 et. seq. The Coal and Gas Coordination Act coordinates the activities of coal mines and gas wells dealing with non-conservation wells that penetrate a working coal seam.

3. The Oil and Gas Conservation Law of 1961, Act of July 25, 1961, P.L. 825, 58 P.S. §§401 et. seq.

4. The Clean Streams Law (35 P.S. §§641.1-691.1001).

5. The Solid Waste Management Act (35 P.S. §§6018.101-6018.1003).

6. Article XIX-A of The Administrative Code of 1929 (71 P.S. §§510.1-510.108).

B. Regulations:

1. Chapter 78 (25 PA Code §§78.1 et. seq.) - This chapter regulates the drilling and production of oil and gas wells. Included in this chapter are regulations concerning environmental protection and well drillings, operations and plugging.

2. Chapter 79 (25 Pa. Code §§79.1 et. seq.) - This chapter regulates conservation wells, those wells which penetrate the Onondaga or deeper horizon, or are drilled to greater than 3,800 ft.

C. Guidance Documents:

DER "Oil and Gas Operators Manual"

Note: The sections of these acts, regulations and guidelines which are most likely to be used as ARARs in a cleanup response action are the requirements for plugging of oil and gas wells, as follows:

(a) 58 P.S. §§601.210 - Plugging requirements; and 610.211 - Alternative methods

(b) 25 Pa. Code §§78.91-.98 - Well Plugging

(c) 25 Pa. Code Chapter 78, Subchapter C, "Environmental Protection Performance Standards."

DER's Bureau of Mining and Reclamation

A. Statutory Authority:

1. The Surface Mining Conservation and Reclamation Act, Act of May 31, 1945, P.L. 1198, as amended, 52 P.S. §§1396.1 et. seq.
2. The Coal Refuse Disposal Control Act, Act of September 28, 1968, P.L. 1080, as amended, 52 P.S. §§30.51 et. seq.
3. The Bituminous Mine Subsidence and Land Conservation Act, Act of April 22, 1966, P.L. 30-1, as amended, 52 P.S. §§1406.1 et. seq.
4. The Administrative Code, Act of April 9, 1929, P.L. 177, as amended, 71 P.S. §§510 et. seq.
5. The Clean Streams Law, Act of June 22, 1937, P.L. 1987, as amended, 35 P.S. §§691.1 et. seq.
6. Noncoal Surface Mining Conservation and Reclamation Act, Act of December 19th, 1984, P.L. 1093, 52 P.S. §§3301 et. seq.

B. Regulations:

Numerous regulations promulgated under the above statutes; see the Pa. Bulletin and Title 25 of the Pennsylvania Code:

1. Chapter 77 (25 Pa. Code §§77.1 et. seq.) - This chapter sets forth procedures and regulations for non-coal mining activities and establishes informational requirements for permit applicants, siting criteria, and operational standards.
2. Chapter 86 (25 Pa. Code §§86.1 et. seq.) - This chapter sets forth general permit application requirements for all coal mining activities, permit procedures and siting criteria.
3. Chapter 87 (25 Pa. Code §§87.1 et. seq.) - This chapter sets forth informational requirements to support permit applications for bituminous surface mining operations and establishes land reclamation and environmental protection standards, including requirements for the preservation of hydrologic balances.
4. Chapter 88 (25 Pa. Code §§88.1 et. seq.) - This chapter sets forth requirements governing anthracite surface and deep mining activities. Chapter 88 establishes mine siting criteria and environmental protection performance standards, including requirements for the preservation of a hydrologic balance, proper closure of mines, and subsidence control.
5. Chapter 89 (25 Pa. Code §§89.1 et. seq.) - This chapter governs bituminous deep mining activities. Chapter 89 establishes mine siting criteria and environmental protection performance standards, including requirements for the preservation of a hydrologic balance, proper closure of mines, and subsidence control.

6. Chapter 90 (25 Pa. Code SS90.1 et. seq.) - This chapter sets forth requirements regarding coal refuse disposal in surface and deep mines, including provisions for application requirements and environmental performance standards.

C. Guidance Documents:

1. Bureau of Mining and Reclamation Program Guidance Manual.

2. Program Guidance Manual for Surface Bituminous Coal Mining.

DER's Bureau of Abandoned Mine Reclamation

No regulations. This Bureau should be notified of Superfund site work in abandoned mine areas.

Other Potential Applicable or Relevant and Appropriate Requirements

Pennsylvania Scenic Rivers Act, Act of Dec. 5, 1972, P.L. 1277, as amended, 32 P.S. §§820.21 et. seq.

Historic Preservation Act of Nov. 22, 1978, P.L. 1160, as amended, 71 P.S. §§1047.1 et. seq.,

Department of Environmental Resources: Policies and Procedures for the Implementation of the History Code (37 Pa. C.S.A., Section 101 et. seq.). January 1, 1993. Also: Procedures for DER Permittees and for DER Projects.

The Fish and Boat Code, Act of Oct. 16, 1980, P.L. 996, as amended, 30 Pa. C.S. §§101 et. seq.

The Game and Wildlife Code, Act of July 8, 1986, P.L. 1225, 34 Pa. C.S. §§101 et. seq.

The Soil Conservation Law, Act of May 15, 1945, P.L. 547, as amended, 3 P.S. 849.

Pennsylvania Dept. of Transportation, Act of June 1, 1945 (P.L. 1242, No. 428) (36 P.S. §§670-411, 670-420, 670-421 and 670-702).

Pennsylvania State Police, Title 37, Part I, Chapters 11 and 13. Flammable and Combustible Liquids.

FEDERAL AND STATE STATUTE/REGULATION GUIDE

Program	Federal		State		Roles of Federal and State Governments
	Statute	Regulation	Statute	Regulation	
Water Pollution	33 U S C §1251	40 C F R Parts 100-149 and 400 471	35 P.S. §691.1 et seq. 35 P.S. §751.1 et seq.	25 PA Code, Chapter(s) 92 Chapter(s) 71, 73 Chapter(s) 94, 95	Federal Government's role in water pollution is almost exclusively oversight when NPDES permits have been delegated to a state as they have in PA. PA administers permit program for direct discharges and in conjunction with local government to administer the septic tank program.
Air Pollution	42 U S C §7401 et seq	40 C F R Parts 50-87	35 P.S. §4001 et seq.	25 PA Code, Chapter(s) 127,143 Chapter(s) 122, 124	Federal Government adopts National Ambient Standards, certain New Source Standards, and certain Hazardous Waste Standards and acts in major oversight role of State activities. PA develops state implementation plan to meet federal ambient standards and issues permits for point sources. Federal government retains some enforcement authority but major authority exercised by State.
Mining	30 U S C §1201 et seq	30 C F R Parts 761 955	52 P.S. §1396 et seq. 52 P.S. §1406.1 et seq.	25 PA Code, Chapter(S) 86-90	State has been delegated authority to implement mining law with the Department of Interior playing oversight role.
Waste Management (Hazardous, Residual & Municipal Waste except Superfund)	42 U S C §6901 et seq 15 U S C §2601 et seq	40 C F R Parts 240 280 40 C F R Parts 702-799	35 P.S. §6018.101 et seq	25 PA Code, Chapters 260-270 Chapters 287-299 Chapters 271-285	State implements RCRA after federal delegation. Pennsylvania has been delegated most but not all of federal RCRA. State implements independent program for municipal and residual waste.
Drinking Water	42 U S C §300f-300j	40 C F R Parts 141-147	35 P.S. §721.1 et seq.	25 PA Code, Chapter(s) 109	State implements program after federal delegation Federal role in Pennsylvania is largely oversight.
Superfund/Hazardous Sites Cleanup Act	42 U S C §9601 et seq	40 C F R Parts 300, 306	35 P.S. §6020.101 et seq.	Regulations in development	Federal superfund implemented by federal government. State plays supporting role. State statute created an independent state program, (Hazardous Sites Cleanup Act).
Wetlands Protection	33 U S C §404 33 U S C §401	33 C F R Parts 300, 306	35 P.S. §693.1 et seq.	25 PA Code, Chapter(s) 105	Both state and federal permits are required to fill wetlands
General Environmental Impact Analysis	42 U S C §4321		PA Const. Art 1, §27	Self executing	Federal government is required under NEPA to develop environmental impact statement for federal actions. Constitution requires that state and local government comply with environmental provision of constitution.
Flood Plain Management	42 U S C §4001	44 C F R Part 60	32 P.S. §679.101 et seq.	25 PA Code, Chapter(s) 106 16 PA Code, Chapter(s) 38	State law requires that municipalities pass regulations that comply with federal law.
Dam Safety & Encroachment	33 U S C §404	33 C F R Part 320, 330	32 P.S. §693.1 et seq.	25 PA Code, Chapter(s) 105	Army Corps of Engineers Issues "404" permits in wetlands Pennsylvania independent authority.
Oil & Gas Management	--	--	58 P.S. §601.101 et seq. 58 P.S. §501, et seq. 58 P.S. §471, et seq.	25 PA Code, Chapter(s) 78, 79	No express federal program except to the extent groundwater regulated under other federal statutes.
Stormwater	33 U S C §402	40 C F R §122 21	32 P.S. §680.1 et seq.	25 PA Code, Chapter(s) 111, 102 and 92	Federal program implemented by the state in conjunction with the NPDES permits. State law requires municipalities to prepare stormwater management plans.

Appendix A

Water Quality Criteria for Toxic Substances

Table 1 lists the human health and aquatic life criteria for toxic substances which the Department will use in development of effluent limits in NPDES permits. The human health criteria are further defined as to the specific effect (that is, carcinogenicity, taste and odor, general health). For those aquatic life criteria which are hardness related and specified as a formula, such as several of the heavy metals, criteria for hardness values of 50, 100 and 200 are provided as examples. The Department will use the specific hardness of the receiving stream in calculating criteria on a case-by-case basis for these substances. The parameters are grouped according to chemical/analytical properties and denoted alphanumerically: M = Metals; A = Acid Soluble; V = Volatile; B = Base Neutral;and P = Pesticide. Some of these criteria may be superseded for Drainage Lists W (Ohio River Basin) and X (Lake Erie Basin) under interstate and international compact agreements with Ohio River Valley Sanitation Commission and International Joint Commission, respectively. See Section 93.9 (relating to designated water uses and water quality criteria) for specific parameters and criteria.

Acronyms and Footnotes to Table 1

H = Threshold effect human health criterion.

CRL = Cancer risk level criterion at 1×10^{-6}.

T&O = Taste and odor criterion.

1nH = Natural logarithm of the hardness of stream as mg/l $CaCO_3$.

N/A = Insufficient data to develop criterion.

b = Criterion is for total of halomethanes (5V + 8V + 12V + 20V + 21V) present.

c = Criterion is for total dichlorobenzenes (20B + 21B + 22B) present.

d = Criterion is for total PCBs (18P + 19P + 20P + 21P + 22P + 23P + 24P).

See 25 Pa. Code Chapter 16 for specific details.

Refer to 25 Pa. Code Chapter 93 for other specific Water Quality Standards.

TABLE 1

WATER QUALITY CRITERIA FOR TOXIC SUBSTANCES

PP NO	CHEMICAL NAME	CAS NUMBER	FISH and AQUATIC LIFE CRITERIA		HUMAN HEALTH CRITERIA (ug/l)	
			CRITERIA CONTINUOUS CONCENTRATIONS (ug/l)	CRITERIA MAXIMUM CONCENTRATIONS (ug/l)		
1M	ANTIMONY	07440360	219	1095	10	H
2M	ARSENIC	07440382	190(As3+)	360(As3+)	0.02	CRL
3M	BERYLLIUM	07440417	0.01 x 96hr LC50	0.05 x 96hr LC50	N/A	-
4M	CADMIUM	07440439	Exp(0.7852[lnH]-3.490)	Exp(1.128[lnH]-3.828)	10	H
5M	CHROMIUM, VI	07440473	11	16	N/A	-
6M	COPPER	07440508	Exp(0.8545[lnH]-1.465)	Exp(0.9422[lnH]-1.464)	1000	T&O
7M	LEAD	07439921	Exp(1.266[lnH]-4.661	Exp(1.266[lnH]-1.416	50	H
8M	MERCURY	07439976	0.012	2.4	0.144	H
9M	NICKEL	07440020	Exp(0.8460[lnH]+1.1645)	Exp(0.8460[lnH]+3.3612)	600	H
10M	SELENIUM	07782492	5	20	N/A	-
11M	SILVER	07440224	0.2	Exp(1.72[lnH]-6.52)	200	AES
12M	THALLIUM	07440280	13	65	2	H
13M	ZINC	07440666	Exp(0.8473[lnH]+0.7614)	Exp(0.8473[lnH]+0.8604)	5000	T&O
14M	CYANIDE, FREE	00057125	5	22	700	H
1A	2-CHLOROPHENOL	00095578	112	560	0.1	T&O
2A	2,4-DICHLOROPHENOL	00120832	337	1685	0.3	T&O

TABLE 1

WATER QUALITY CRITERIA FOR TOXIC SUBSTANCES

PP NO	CHEMICAL NAME	CAS NUMBER	FISH and AQUATIC LIFE CRITERIA		HUMAN HEALTH CRITERIA (ug/l)	
			CRITERIA CONTINUOUS CONCENTRATIONS (ug/l)	CRITERIA MAXIMUM CONCENTRATIONS (ug/l)		
3A	2,4-DIMETHYLPHENOL	00105679	132	660	400	T&O
4A	4,6-DINITRO-o-CRESOL	00534521	16	80	13.4	H
5A	2,4-DINITROPHENOL	00051285	131	655	70	H
6A	2-NITROPHENOL	00088755	1600	8000	N/A	-
7A	4-NITROPHENOL	00100027	467	2335	N/A	-
8A	p-CHLORO-m-CRESOL	00059507	31	155	3000	T&O
9A	PENTACHLOROPHENOL	00087865	Exp(1.005[pH]-5.290) @pH= 6.5 7.8 9.0 Crit= 3.5 13 43	Exp(1.005[pH]-4.830) @pH= 6.5 7.8 9.0 Crit= 5.5 20 68	0.3	CRL
10A	PHENOL	00108952	20	100	300	T&O
11A	2,4,6-TRICHLOROPHENOL	00088062	91	455	2	CRL
1V	ACROLEIN	00107028	1	5	320	H
2V	ACRYLONITRILE	00107131	129	645	0.06	CRL
3V	BENZENE	00071432	128	640	1	CRL
5V	BROMOFORM	00075252	365	1825	4	CRL
6V	CARBON TETRACHLORIDE	00056235	556	2780	0.3	CRL

TABLE 1

WATER QUALITY CRITERIA FOR TOXIC SUBSTANCES

PP NO	CHEMICAL NAME	CAS NUMBER	FISH and AQUATIC LIFE CRITERIA		HUMAN HEALTH CRITERIA (ug/l)	
			CRITERIA CONTINUOUS CONCENTRATIONS (ug/l)	CRITERIA MAXIMUM CONCENTRATIONS (ug/l)		
7V	CHLOROBENZENE	00108907	236	1180	20	T&O
8V	CHLORODIBROMOMETHANE	00124481	N/A	N/A	0.4	CRL
9V	CHLOROETHANE	00075003	N/A	N/A	N/A	-
10V	2-CHLOROETHYL VINYL ETHER	00110758	3500	17,500	N/A	-
11V	CHLOROFORM	00067663	389	1945	6	CRL
12V	DICHLOROBROMOMETHANE	00075274	N/A	N/A	0.3	CRL
14V	1,1-DICHLOROETHANE	00075343	N/A	N/A	N/A	-
15V	1,2-DICHLOROETHANE	00107062	3088	15,440	0.4	CRL
16V	1,1-DICHLOROETHYLENE	00075354	1492	7460	0.06	CRL
17V	1,2-DICHLOROPROPANE	00078875	2165	10,825	N/A	-
18V	1,3-DICHLOROPROPYLENE	00542756	61	305	N.D.	CRL
19V	ETHYLBENZENE	00100414	580	2900	3000	H
20V	METHYL BROMIDE	00074839	110	550	50	H

TABLE 1

WATER QUALITY CRITERIA FOR TOXIC SUBSTANCES

PP NO	CHEMICAL NAME	CAS NUMBER	FISH and AQUATIC LIFE CRITERIA		HUMAN HEALTH CRITERIA (ug/1)	
			CRITERIA CONTINUOUS CONCENTRATIONS (ug/1)	CRITERIA MAXIMUM CONCENTRATIONS (ug/1)		
21V	METHYL CHLORIDE	00074873	5500	27,500	N/A	-
22V	METHYLENE CHLORIDE	00075092	2368	11,840	5	CRL
23V	1,1,2,2-TETRACHLOROETHANE	00079345	208	1040	0.2	CRL
24V	TETRACHLORO-ETHYLENE	00127184	139	695	0.7	CRL
25V	TOLUENE	00108883	330	1650	7000	H
26V	1,2-trans-DICHLOROETHYLENE	00156605	1350	6750	700	H
27V	1,1,1-TRICHLOROETHANE	00071556	605	3025	1000	H
28V	1,1,2-TRICHLOROETHANE	00079005	678	3390	0.6	CRL
29V	TRICHLOROETHYLENE	00079016	450	2250	3	CRL
31V	VINYL CHLORIDE	00075014	N/A	N/A	0.02	CRL
1B	ACENAPHTHENE	00083329	17	85	20	T&O
2B	ACENAPHTHYLENE	00208968	N/A	N/A	N/A	-
3B	ANTHRACENE	00120127	N/A	N/A	10,000	H
4B	BENZIDINE	00092875	59	295	0.0001	CRL

TABLE 1

WATER QUALITY CRITERIA FOR TOXIC SUBSTANCES

PP NO	CHEMICAL NAME	CAS NUMBER	FISH and AQUATIC LIFE CRITERIA		HUMAN HEALTH CRITERIA (ug/l)	
			CRITERIA CONTINUOUS CONCENTRATIONS (ug/l)	CRITERIA MAXIMUM CONCENTRATIONS (ug/l)		
5B	BENZO(a)ANTHRACENE	00056553	0.1	0.5	0.003	CRL
6B	BENZO(a)PYRENE	00050328	N/A	N/A	0.003	CRL
7B	3,4-BENZOFLUORANTHENE	00205992	N/A	N/A	0.003	CRL
8B	BENZO(ghi)PERYLENE	00191242	N/A	N/A	N/A	-
9B	BENZO(k)FLUORANTHENE	00207089	N/A	N/A	0.003	CRL
10B	BIS(2-CHLOROETHOXY) METHANE	00111911	N/A	N/A	N/A	-
11B	BIS(2-CHLOROETHYL) ETHER	00111444	6000	30,000	0.03	CRL
12B	BIS(2-CHLOROISOPROPYL)ETHER	39638329	N/A	N/A	1000	H
13B	BIS(2-ETHYLHEXYL) PHTHALATE	00117817	909	4545	2	CRL
14B	4-BROMOPHENYL PHENYL ETHER	00101553	54	270	N/A	-

TABLE 1

WATER QUALITY CRITERIA FOR TOXIC SUBSTANCES

PP NO	CHEMICAL NAME	CAS NUMBER	FISH and AQUATIC LIFE CRITERIA		HUMAN HEALTH CRITERIA (ug/l)	
			CRITERIA CONTINUOUS CONCENTRATIONS (ug/l)	CRITERIA MAXIMUM CONCENTRATIONS (ug/l)		
15B	BUTYLBENZYL PHTHALATE	00085687	35	140	300	H
16B	2-CHLORONAPHTHALENE	00091587	N/A	N/A	N/A	-
17B	4-CHLOROPHENYL PHENYL ETHER	07005723	N/A	N/A	N/A	-
18B	CHRYSENE	00218019	N/A	N/A	0.003	CRL
19B	DIBENZO(a,h) ANTHRACENE	00053703	N/A	N/A	0.003	CRL
20B	1,2-DICHLOROBENZENE	00095501	164	820	400 for dichlorobenzene	H
21B	1,3-DICHLOROBENZENE	00541731	69	345	see 20B	H
22B	1,4-DICHLOROBENZENE	00106467	146	730	see 20B	H
23B	3,3'-DICHLOROBENZIDINE	00091941	N/A	N/A	0.04	CRL
24B	DIETHYL PHTHALATE	00084662	800	4000	20,000	H
25B	DIMETHYL PHTHALATE	00131113	495	2475	313,000	H

TABLE 1

WATER QUALITY CRITERIA FOR TOXIC SUBSTANCES

PP NO	CHEMICAL NAME	CAS NUMBER	FISH and AQUATIC LIFE CRITERIA		HUMAN HEALTH CRITERIA (ug/l)	
			CRITERIA CONTINUOUS CONCENTRATIONS (ug/l)	CRITERIA MAXIMUM CONCENTRATIONS (ug/l)		
26B	DI-N-BUTYL PHTHALATE	00084742	21	105	3000	H
27B	2,4-DINITROTOLUENE	00121142	318	1590	0.05 for dinitrotoluene	CRL
28B	2,6-DINITROTOLUENE	00606202	198	990	see 27B	CRL
29B	DI-N-OCTYL PHTHALATE	00117840	N/A	N/A	N/A	-
30B	1,2-DIPHENYLHYDRAZINE	00122667	3	15	0.04	CRL
31B	FLUORANTHENE	00206440	40	200	300	H
32B	FLUORENE	00086737	N/A	N/A	1000	H
33B	HEXACHLOROBENZENE	00118741	N/A	N/A	0.0007	CRL
34B	HEXACHLOROBUTADIENE	00087683	2	10	0.5	CRL
35B	HEXACHLOROCYCLOPENTADIENE	00077474	1	5	1	T&O
36B	HEXACHLOROETHANE	00067721	12	60	2	CRL
37B	INDENO(1,2,3-cd)PYRENE	00193395	N/A	N/A	0.003	CRL

TABLE 1

WATER QUALITY CRITERIA FOR TOXIC SUBSTANCES

PP NO	CHEMICAL NAME	CAS NUMBER	FISH and AQUATIC LIFE CRITERIA		HUMAN HEALTH CRITERIA (ug/l)	
			CRITERIA CONTINUOUS CONCENTRATIONS (ug/l)	CRITERIA MAXIMUM CONCENTRATIONS (ug/l)		
38B	ISOPHORONE	00078591	2080	10,400	700	H
39B	NAPHTHALENE	00091203	43	135	10	T&O
40B	NITROBENZENE	00098953	808	4040	20	H
41B	N-NITROSODI-METHYLAMINE	00062759	3420	17,100	0.0007	CRL
42B	N-NITROSODI-N-PROPYLAMINE	00621647	N/A	N/A	0.005	CRL
43B	N-NITROSODI-PHENYLAMINE	00086306	59	295	5	CRL
44B	PHENANTHRENE	00085018	1	5	N/A	-
45B	PYRENE	00129000	N/A	N/A	1000	H
46B	1,2,4-TRICHLOROBENZENE	00120821	26	130	700	H
1P	ALDRIN	00309002	0.1	1.5	0.0001	CRL
2P	alpha-BHC	00319846	N/A	N/A	0.004	CRL
3P	beta-BHC	00319857	N/A	N/A	0.02	CRL
4P	gamma-BHC (LINDANE)	00058899	0.08	1	0.02	CRL
5P	delta-BHC	00319868	N/A	N/A	N/A	-

TABLE 1

WATER QUALITY CRITERIA FOR TOXIC SUBSTANCES

PP NO	CHEMICAL NAME	CAS NUMBER	FISH and AQUATIC LIFE CRITERIA		HUMAN HEALTH CRITERIA (ug/l)	
			CRITERIA CONTINUOUS CONCENTRATIONS (ug/l)	CRITERIA MAXIMUM CONCENTRATIONS (ug/l)		
6P	CHLORDANE	00057749	0.0043	1.2	0.0005	CRL
7P	4,4′-DDT	00050293	0.001	0.55	0.0005	CRL
8P	4,4′-DDE	00072559	0.001	0.55	N.D.	CRL
9P	4,4′-DDD	00072548	0.001	0.55	N.D.	CRL
10P	DIELDRIN	00060571	0.0019	1.3	0.0001	CRL
11P	alpha-ENDOSULFAN	00095988	0.056	0.11	0.9 for endosulfan	H
12P	beta-ENDOSULFAN	33212659	0.056	0.11	see 11P	H
13P	ENDOSULFAN SULFATE	01031078	N/A	N/A	N/A	-
14P	ENDRIN	00072208	0.0023	0.09	0.8	H
15P	ENDRIN ALDEHYDE	07421934	N/A	N/A	N/A	H
16P	HEPTACHLOR	00076448	0.0038	0.26	0.0002	CRL
17P	HEPTACHLOR EPOXIDE	01024573	0.1	0.5	N.D.	CRL
18P	PCB-1242	53469219	0.014	1	0.00004 for PCBs	CRL
19P	PCB-1254	11097691	0.014	1	see 18P	CRL
20P	PCB-1221	11104282	0.014	1	see 18P	CRL

TABLE 1

WATER QUALITY CRITERIA FOR TOXIC SUBSTANCES

PP NO	CHEMICAL NAME	CAS NUMBER	FISH and AQUATIC LIFE CRITERIA CRITERIA CONTINUOUS CONCENTRATIONS (ug/l)	FISH and AQUATIC LIFE CRITERIA CRITERIA MAXIMUM CONCENTRATIONS (ug/l)	HUMAN HEALTH CRITERIA (ug/l)	
21P	PCB-1232	11141165	0.014	1	see 18P	CRL
22P	PCB-1248	12672296	0.014	1	see 18P	CRL
23P	PCB-1260	11096825	0.014	1	see 18P	CRL
24P	PCB-1016	12674112	0.014	1	see 18P	CRL
25P	TOXAPHENE	08001352	0.0002	0.37	0.0007	CRL
PP	2,3,7,8-TCDD	01746016	N/A	N/A	1 E-8	CRL
--	BARIUM	07440393	4100	20,500	1000	H
--	BORON	07440428	1610	8050	3000	H
--	COBALT	07440484	19	95	N/A	-
--	LITHIUM	07439932	N/A	N/A	900	H
--	VANADIUM	07440622	103	515	N/A	-
--	ACETONE	00067641	86,000	446,000	4000	H
--	p-CRESOL	00106445	159	795	2000	H
--	2-HEXANONE	00591786	4280	21,400	N/A	-
--	METHYLETHYL KETONE	00078933	32,200	161,000	2000	H
--	METHYLISOBUTYL KETONE	00108101	5000	26,000	2000	H

TABLE 1

WATER QUALITY CRITERIA FOR TOXIC SUBSTANCES

PP NO	CHEMICAL NAME	CAS NUMBER	FISH and AQUATIC LIFE CRITERIA		HUMAN HEALTH CRITERIA (ug/l)	
			CRITERIA CONTINUOUS CONCENTRATIONS (ug/l)	CRITERIA MAXIMUM CONCENTRATIONS (ug/l)		
--	1-PROPANOL	00071238	45,550	227,750	N/A	-
--	2-PROPANOL	00067630	88,633	443,165	N/A	-
--	1,2,3-TRICHLOROPROPANE	00096184	N/A	N/A	200	H
--	XYLENE	01330207	211	1055	300	T&O
--	FORMALDEHYDE	00050000	436	2180	N.D.	CRL

Appendix A
Table 2

Pennsylvania Maximum Contaminant Levels
January 1993

Primary Contaminants	Maximum Contaminant Level
Metals:	
Arsenic	0.05 mg/L
Barium[1]	1 mg/L
Cadmium	0.005 mg/L
Chromium[1]	0.05 mg/L
Copper	1.3 mg/L
(Not an MCL. Level at which public water systems must take action to reduce the concentration of copper)	
Lead	0.015 mg/L
(Not an MCL. Level at which public water systems must take action to reduce the concentration of lead)	
Mercury	0.002 mg/L
Selenium[1]	0.01 mg/L
Silver[2]	0.05 mg/L
Non-Metallic Inorganic Chemicals:	
Asbestos	7 million fibers (longer than 10um)/L
Fluoride	2 mg/L
Nitrate, as nitrogen	10 mg/L
Nitrite, as nitrogen	1 mg/L
Total Nitrate & Nitrite as nitrogen	10 mg/L
[illegible]latile Organic Chemicals:	
Benzene	0.005 mg/L
Carbon tetrachloride	0.005 mg/L
o-Dichlorobenzene	0.6 mg/L
p-Dichlorobenzene	0.075 mg/L
1,2-Dichloroethane	0.005 mg/L
1,1-Dichloroethylene	0.007 mg/L
cis-1,2-Dichloroethylene	0.07 mg/L
trans-1,2-Dichloroethylene	0.1 mg/L
1,2-Dichloropropane	0.005 mg/L
Ethylbenzene	0.7 mg/L
Monochlorobenzene	0.1 mg/L
Styrene	0.1 mg/L
Tetrachloroethylene	0.005 mg/L
Toluene	1 mg/L
Total Trihalomethanes	0.10 mg/L
1,1,1-Trichloroethane	0.2 mg/L
Trichloroethylene (TCE)	0.005 mg/L
Vinyl chloride	0.002 mg/L
Xylenes (total)	10 mg/L

Primary Contaminants	Maximum Contaminant Level
Pesticides, PCBs:	
Alachlor	0.002 mg/L
Atrazine	0.003 mg/L
Carbofuran	0.04 mg/L
Chlordane	0.002 mg/L
2,4-D	0.07 mg/L
Dibromochloropropane (DBCP)	0.0002 mg/L
Endrin[1]	0.0002 mg/L
Ethylene dibromide (EDB)	0.00005 mg/L
Heptachlor	0.0004 mg/L
Heptachlor epoxide	0.0002 mg/L
Lindane	0.0002 mg/L
Methoxychlor	0.04 mg/L
PCBs	0.0005 mg/L
Pentachlorophenol	0.001 mg/L
Toxaphene	0.003 mg/L
2,4,5-TP (Silvex)	0.01 mg/L
Radiological:	
Gross Alpha	15 pCi/L
Combined Radium 226/228	5 pCi/L
Man-made Radionuclides (beta particle and photon radioactivity)	4 mrem/yr
Microbiological:	
Coliform bacteria	5% positive when ≥ 40 samples per month 1 positive per month when < 40 samples per month

Secondary Contaminants	Maximum Contaminant Level
Chloride	250 mg/L
Color	15 color units
Copper	1 mg/L
Corrosivity	non-corrosive
Foaming Agents	0.5 mg/L
Iron	0.3 mg/L
Manganese	0.05 mg/L
Odor	3 threshold odor number
pH	6.5-8.5
Sulfate	250 mg/L
Total dissolved solids	500 mg/L
Zinc	5 mg/L

[1] Recently revised federal MCLs for these chemicals are less stringent than the current state MCLs. The more stringent state MCLs will remain in effect in Pennsylvania until changed by adoption of new state regulations.

[2] The federal primary MCL for silver was deleted on July 30, 1992. However, the state primary MCL for silver remains in effect.

APPENDIX B

LOCATION-SPECIFIC APPLICABLE OR RELEVANT APPROPRIATE REQUIREMENTS

Location	Requirement	Prerequisite	Citation
Property line isolation distances	Must maintain a 50 ft. buffer zone between property line and treatment, storage, disposal activities unless variance is granted NOTE: Ignitables/Reactives in containers - no variance allowed.	Activities within regulated distance of property line	PA SWMA, Act 97 Chapters 264 or 265 and Chapter 288
Within 1 mile of a fault displaced in Holocene time	Disposal prohibited unless demonstration is made that unit is designed to withstand fault activity.	Disposal within 1 mile of fault NOTE: Disposal 1 mile or more from a fault acceptable with no demonstration.	PA SWMA, Act 97 Chapter 269
Within 100-year floodplain	No treatment or disposal within 100 yr. floodplain Storage units must withstand 100 yr. flood forces.	None	PASWMA, Act 97 Chapters 269 and 288
	Obstructions must comply with Chapter 106 requirements	Construction, earthmoving, filling, excavation within 100 yr. floodplain	Floodplain Management Act of 1978, PL 851, No 166 Dam Safety & Encroachment Act of 1978, PL 1375
Within area where action may cause irreparable harm, loss, or destruction of significant artifacts	Coal Mining Prohibited	Surface Mining and valid existing rights	Surface Mining Conservation & Reclamation Act
	Prohibition of adverse environmental visual or traffic impacts - must provide impact analysis	Activity within one mile of property owned by PA Historical & Museum Commission Activity within 1/4 mile of site listed in PA Inventory of Historic Places or in PA Archaeological Site Survey	PA SWMA, Act 97 Chapter 269 PA History Code (37 Pa Cons Stat)

APPENDIX B

LOCATION-SPECIFIC
APPLICABLE OR RELEVANT APPROPRIATE REQUIREMENTS

Location	Requirement	Prerequisite	Citation
Historic project owned or controlled by Federal or State agency	Prohibition of adverse environmental, visual or traffic impacts must provide impact analysis Treatment & Disposal prohibition	Activity within one mile of property owned by PA Historical & Museum Commission or on National Register of Historic Places.	PA SWMA, Act 97 Chapter 269
	Coal Mining prohibited unless approved jointly by DER <u>and</u> agency with jurisdiction over the property/place	Surface Mining/Valid Existing Rights	Surface Mining Conservation & Reclamation Act
Critical habitat upon which endangered species or threatened species depends	Action to conserve endangered species or threatened species including consultation with DER Bureau of Forestry	Determination of presence of endangered or threatened species	Wild Resource Conservation Act, PL 547, No 170, 32 P S 5301-5314
Wetlands	No treatment or disposal within Wetland Area. Isolation distances may apply.	Must be a wetland area as defined by State and Federal law.	PA SWMA, Act 97, Chapters 269 and 288
	Obstructions and encroachments must comply with Chapter 105 requirements		Dam Safety & Encroachments Act of 1978, PL 1375
Wilderness Area	Prohibition of adverse environmental, visual or traffic impacts - must provide impact analysis. No Disposal or Treatment in Landmark Areas	Activity within one mile of wild, natural or landmark area	PA SWMA, Act 97, Chapters 269
Wildlife refuge, fish hatchery	Same as Wilderness area, also no disposal or treatment in National or State refuges or hatcheries	Activity within one mile of wild, natural or landmark area	PA SWMA, Act 97, Chapters 269

APPENDIX B

LOCATION-SPECIFIC
APPLICABLE OR RELEVANT APPROPRIATE REQUIREMENTS

Location	Requirement	Prerequisite	Citation
Area affecting stream or river	Obstructions and encroachments must comply with Chapter 105 requirements.	Obstruction or encroachment at or in regulated waters of the State.	Dam Safety & Encroachments Act of 1978, PL 1375
	Water Quality Criteria must be met in stream.	Activity potentially affecting stream or river	PASWMA, Act 97, Chapters 269 and 288 25 PA Code 93 4, 93 7, 93 8(a), 93 9, 25 Pa Code 16
Within area affecting national or State wild, scenic, or recreational river	Prohibit activities that may create adverse environmental, visual or traffic impacts on a river.	River or river corridor designated pursuant to the PA Scenic Rivers Act or listed as a 1-A priority for study by DER	The PA Scenic River Act and all subsequent legislation designating waterways as scenic PA SWMA, Act 97, Chapter 269
Within coastal zone	Conduct activities consistent with state program requirements.	Activities affecting designated PA Coastal Zones	Final Program EIS, PA Coastal Zone Management Program, 1980
Agricultural areas	Treatment and Disposal prohibited in Agricultural Areas established under PA Ag Area Security Law or in farmland classified as Class I agricultural land by SCS.	Area must be designated by Soil Conservation Service or under PA Ag Area Security Law	PA SWMA, Act 97, Chapter 269
Exceptional value watershed	Treatment or disposal prohibited.	Must be designated exceptional value	PA SWMA, Act 97 Chapter 269
	Impact analysis on pending designated exceptional value watershed	DER/EQB must have received a written request for designation	PA SWMA, Act 97 Chapter 269
	Maintain existing quality	Designated in 25 PA Code Section 93 9	25 PA Code 5 1(c)

APPENDIX B

LOCATION-SPECIFIC
APPLICABLE OR RELEVANT APPROPRIATE REQUIREMENTS

Location	Requirement	Prerequisite	Citation
Oil and gas wells	Disposal prohibited over active or inactive oil and gas wells or gas storage areas located within or beneath site. If abandoned facilities exist, but not below disposal unit, need analysis of expected subsurface discharges for approval of unit.	Active, Inactive, Abandoned oil and gas wells and gas areas must meet definition in Oil & Gas Act of 1984.	PA SWMA, Act 97 Chapter 269
Underlain by fractured bedrock	Disposal prohibited over areas of coarse unconsolidated deposits including heavily fractured bedrock. Other activities acceptable if subsurface conditions pose no threat.	Existence of geologic condition.	PA SWMA, Act 97 Chapter 269
Underlain by carbonate or limestone formations (>5 feet)	Disposal prohibited over these formations: Areas mapped by PA Geologic Survey.	Formations must be >5 feet thick and be the topmost geologic unit	PA SWMA, Act 97 Chapters 269 and 288
Landslide prone area	Treatment and Disposal activities: must provide impact analysis on unit design with respect to landslide.	Unit must be in or adjacent to landslide prone area	PA SWMA, Act 97 Chapter 269
Within 5 miles of Earthquake epicenter	Treatment and Disposal activities: demonstrate unit design can withstand seismic activities.	Earthquake Epicenter mapped by USGS or PA Geologic Survey	PA SWMA, Act 97 Chapter 269
Deep mines/Surface mines	Treatment and Disposal activities: provide analysis of subsidence risk Further mining of minerals providing support of unit prohibited	Existence of deep or surface mines and supporting data for future mining areas	PA SWMA, Act 97 Chapters 269 and 288

APPENDIX B

LOCATION-SPECIFIC
APPLICABLE OR RELEVANT APPROPRIATE REQUIREMENTS

Location	Requirement	Prerequisite	Citation
State Forest Natural Areas State Forest Wild Areas	Area must be administered in such a manner so as to leave it unimpaired as a Natural or Wild Area and to preserve its unique features for which it was designated	Commonwealth-owned area designated as a Natural or Wild Area	Administrative Code of 1929, PL 177 and 1902A PA SWMA, Act 97 Chapter 269
Public or Private Wild Plant Sanctuary	Area must be administered in such a manner as will leave it unimpaired as a wild plant sanctuary and to preserve its unique habitat values for which it was designated.	Area designated by DER, Bureau of Forestry as a Public or Private Wild Plant Sanctuary.	Wild Resource Conservation Act, PL 597, No 170, 32 P S 5301-5314; PA SWMA, Act 97 Chapter 269
Park, Forest, Gameland, Appalachian Trail (or other State Trail)	Prohibit activities that may create adverse environmental, visual or traffic impacts.	Within one mile of facility.	PA SWMA, Act 97 Chapter 269
Rare, threatened, endangered species habitat	prohibition of adverse impacts on species or habitat	Habitat or species protected by Federal Endangered Species Act, Wild Resource Conservation Act or recognized by PA Fish & Game Commissions	PA SWMA, Act 97 Chapter 269
Water Supply Area	Disposal prohibited unless permanent alternative supply provided and consent obtained	Regulated isolation distances between wells, spring and/or supply intake	PA SWMA, Act 97 Chapters 269 and 288
40 ft setback from building	Containers holding ignitables and reactives must maintain a 40 ft setback from a building for outdoor storage	Outdoor storage in containers	PA SWMA, Act 97 Chapters 264 and 265

APPENDIX C

ACTION-SPECIFIC
APPLICABLE OR RELEVANT APPROPRIATE REQUIREMENTS

Location	Requirement	Prerequisite	Citation
Air stripping	Use BAT, Meet "Haz. Waste and Petroleum Products Contamination Clean-up" Procedures, and Air Toxics Substance Guidance limits.		Air Pollution Control Act (APCA)
Capping (see also Closure with Waste in Place for additional associated requirements)	Meet design and performance standards Table 3. Final grade 2-15%; cover soils USDA class. loams. Permeability of cap $\leq$ permeability of liner. Vegetation based on PennDOT Form 408 or Penn State Agronomy Guide.		PA SWMA, Act 97 Chapters 264 or 265 and 288
Clean Closures (removal of waste and contaminated soils - no groundwater contamination)	Demonstrate no subsoil contamination and no groundwater contamination from that unit. Use sampling grid to determine sampling locations		PA SWMA, Act 97 Chapters 264 or 265
Closure with Waste in Place (including capping and groundwater monitoring, pumping)	Stabilize waste to support cap. Must withstand dynamic and static loading with a minimum of F.O.S of 1.5. Install gas monitoring and venting systems if appropriate. Install groundwater monitoring system - minimum three (3) downgradient, one (1) upgradient per aquifer. Prepare and implement assessment and abatement plan if contamination is detected. Need approval of groundwater treatment plant design. 30 yr. post-closure monitoring; notice in property deed. Leachate storage capacity - 1,000 gal/ acre of closed unit.		PA SWMA, Act 97 Chapters 264 or 265 and 288 Clean Streams Law

APPENDIX C

ACTION-SPECIFIC
APPLICABLE OR RELEVANT APPROPRIATE REQUIREMENTS

Location	Requirement	Prerequisite	Citation
Closure of Land Treatment Units	Establish/Maintain Vegetative cover; maintain run-on, run-off control, wind dispersal; prohibit growth of food chain crops		PA SWMA, Act 97 Chapters 264 or 265 and 288
Consolidation within a Unit	Closure of old units: either clean closure or capping		PA SWMA, Act 97 Chapters 264 or 265
Consolidation between Units	Disposal in a different unit prohibited unless unit meets "permit" standards Old unit must meet closure standards.		PA SWMA, Act 97 Chapters 264 or 265
Container Storage	Meet spacing and set back requirements, secondary containment. Containers must be in good condition and labeled, Cannot store over 1 yr without cause.		PA SWMA, Act 97 Chapters 264 or 265 and 299
Tank Storage	Meet generally accepted industry standards; UL142, API650, etc. Have: secondary containment, alarms, pressure/overflow controls, min. shell thickness established, meet NFPA Code 30 standard, Tank Evaluation Repair Plan, VONC plan, standby equipment. VOC emission control device		PA SWMA, Act 97 Chapters 264 and 299
Tank treatment (neutralization, filtration, separation, chemical treatment, dewatering)	See tank storage. Also have treatability study program/waste analysis trial treatment test. VOC, fugitive emission controls.		PA SWMA, Act 97 Chapters 264 or 265

APPENDIX C

ACTION-SPECIFIC
APPLICABLE OR RELEVANT APPROPRIATE REQUIREMENTS

Location	Requirement	Prerequisite	Citation
Construction of New Landfill On-Site (see Closure with Waste in Place)	Meet design and performance standard for liners. Meet groundwater isolation distance - no groundwater manipulation allowed Meet buffer zone, subbase slope and flow zone permeability requirements. Meet leachate and run-off storage requirements Meet EPA's CQA and MTR Develop and implement groundwater monitoring program (see closure with waste in place).		PA SWMA, Act 97 Chapters 264 and 288
Construction of New Surface Impoundments	See above, plus meet dike and slope limitation		PA SWMA, Act 97 Chapters 264 or 265 and 288
Dike Stabilization	Construct dikes with sufficient strength to prevent failure Meet dike slope limitations for impoundments.		Dam Safety and Encroachments Act, PA SWMA, Act 97 Chapters 264 or 265 and 288
Discharge of Treatment System Effluent	Bureau of Water Quality authorization of NPDES discharge and treatment facility construction.		25 PA Code Chapters 91, 92
Incineration	Need approval from Bureaus of Air Quality Control and Waste Management Meet Air Toxics Substances Guidance limits Prepare Trial Burn Plan; establish POHC's demonstrate 99 99% DRE See also tank storage. Use BAT. Meet buffer zone, odor and noise control.		PA SWMA, Act 97 Chapters 264 or 265 and 297

APPENDIX C

ACTION-SPECIFIC
APPLICABLE OR RELEVANT APPROPRIATE REQUIREMENTS

Location	Requirement	Prerequisite	Citation
Thermal treatment (Pryolysis, Virtification, etc)	Obtain Air Quality Plan approval Meet buffer zone. Develop test plans See also tank storage. NOTE: No open burning except for detonation of explosives - meet specific buffer zones.		APCA; PA SWMA, Act 97 Chapters 264 or 265
Land Treatment	Bureau of Water Quality authorization of any treatment facility construction. Meet food-chain crop prohibition, cadmium restriction. Prepare unsaturated zone monitoring Plan, VONC plan. Meet setback requirements. Application rates consistent with DER's "Sewage Septic Tank and Holding Tank Waste Use on Agricultural Land" Guide.		25 PA Code Chapter 91; PA SWMA, Act 97 Chapters 264 or 265 and 291
Treatment (when Waste will be Land Disposed)	See Tank Treatment Prepare Treatability Study Plan. Meet EPA's Land Disposal Restriction Treatment Standard Prepare Waste Analysis Plan for QA/QC of treatment process. For landfills, meet 20% min. solids content		PA SWMA, Act 97 Chapters 264 or 265 and 288
Underground Injection of Wastes and Treated Groundwater	Bureau of Water Quality authorization of any treatment facility construction. NOTE: This is prohibited for listed or "derived-from" listed wastes No Waste Management standards except groundwater monitoring.	Must be a treated waste or groundwater	25 PA Code Chapter 91 PA SWMA, Act 97 Chapters 264 or 265
Waste Piles	Meet liner standards, leachate and run-off storage requirements as for landfills Meet groundwater isolation distances and setback. Prepare Waste Pile Evaluation and Repair Plan.	Indoor piles have less stringent requirements	PA SWMA, Act 97 Chapters 264 or 265 and 299

APPENDIX C

ACTION-SPECIFIC
APPLICABLE OR RELEVANT APPROPRIATE REQUIREMENTS

Location	Requirement	Prerequisite	Citation
Biological Treatment (soils or groundwater)	Meet Air Quality "Haz. Waste and Petroleum Product Contamination Clean-up" procedures. Prepare treatability study plan See Tank Treatment. Prepare groundwater abatement plan.		PA SWMA, Act 97 Chapters 264 or 265 and 297
Stabilization	Prepare treatability study plan See Tank Treatment.		PA SWMA, Act 97 Chapters 264 or 265 and 297
Activated carbon treatment of ground/surface water	See above. May need Air Quality approval if VOCs are treated.		PA SWMA, Act 97 Chapters 264 or 265 and 297; APCA
Recovery/Reclamation (solvents, metals, oils)	Air Quality Plan Approval. Hazardous waste recycling/disposal requirements.	Waste, product, coproduct, byproduct definition	PA SWMA, Act 97 Chapters 261 and 266
Mining and Reclamation Facility Involvement	Mined land must be restored to approximate original contour (AOC) except areas previously mined prior to current practices and standards may be restored by terracing Alternatives to AOC and terracing may be approved for certain mining when proposed in conjunction with achieving postmining land use.	Lands affected by "surface mining" as defined in SMCRA and Noncoal SMCRA Waters affected by mining operations Mining subsidence damage to surface land	surface Mine Conservation and Reclamation Act (SMCRA) Sec ; Noncoal SMCRA Sec 7 Coal Refuse Disposal Act; Bituminous Mine Subsidence and Land Conservation Act; Clean Streams Law
OTHER Non-specific Earthmoving Activit	Meet Chapter 102 requirements, develop Erosion and Sedimentation Control Plan		Chapter 102 4, 31