Evaluation of
Risk-based Decision Making
Connecticut Department of Energy and Environmental Protection (CT DEEP)

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Section 1

Introduction, Executive Summary, and Overview

This report evaluates the assessment and management of chemically contaminated real estate ("contaminated properties") in Connecticut and elsewhere. In particular, the Report:

- Reviews current, health risk-based practices for contaminated property assessment and management in the State and other states and regions;
- Identifies "best practices" for health risk-based contaminated property assessment and management; and
- Makes suggestions, based on these best practices, for the reform of health risk-based contaminated property assessment and management in Connecticut.

With regard to the last point, ***our six primary suggestions*** are presented (in ***bold-face and italicized type***) below, with supporting documentation throughout the report and in the appendices.

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Connecticut, like many other states, has hundreds of properties that have been contaminated by past industrial and other commercial uses. Many of these properties have become "brownfields," defined (in *Connecticut General Statutes* §32-9kk(a)(1)) as:

> *. . . any abandoned or underutilized site where redevelopment, reuse or expansion has not occurred due to the presence or potential presence of pollution in the buildings, soil or groundwater that requires investigation or remediation before or in conjunction with the restoration, redevelopment, reuse and expansion of the property.*

Our (and others') research has found that successfully addressing and redeveloping brownfields and other contaminated sites requires balancing many factors. In particular, success often depends on (U.S. EPA 2005)

- *Communication — build and maintain lasting relationships among stakeholders.*
- *Incentives — explore stakeholders' interests and seek alternatives that provide benefits to all parties.*
- *Planning — working . . .[to develop] a unified vision of what is desired for the project and making sure it is consistent with past, future, and neighboring land uses.*
- *Maximize resources — explore all resources available, including state programs or working with a third party to complete a project.*

We have also found that using health risk assessment to address contaminated properties requires *both science and judgment* (NRC, 1983a, 1994, 2009, 2014b). This is why two of the most important attributes of **best practices** for site risk assessment and management are **Scientific Accuracy** and **Knowledgeable Stakeholder Involvement**. Indeed, Connecticut's multi-stakeholder "transformation workgroups" have been established in recognition of these two important attributes, and have already made many important suggestions for improving both the accuracy and the relevance of Connecticut's remediation standards. A good example of this is the diverse, 17-person workgroup, co-lead by Gary Trombly and Larry Hogan, that made excellent recommendations for reforming the evaluation of contaminated site soils and sediments (Hogan, Trombly, *et al*., 2012).

In addition to scientific accuracy and knowledgeable stakeholder involvement, our research has identified the following best practice attributes for site risk assessment and risk management:

- **Protection of Public Health and the Environment**
- **Proportionality**
- **Reproducibility**
- **Appropriateness/Relevance**
- **Flexibility**
- **Specification/Full Documentation**
- **Transparency**
- **Incorporation of Uncertainty/Variability**

Our research has shown, as expected, that no single method can optimally incorporate all attributes of best practices; and, of course, that people (including the many whom we interviewed for this project) will inevitably vary among themselves as to what they consider to be "protective" and "flexible." Acceptance of this fundamental tension among stakeholders is a key to agreeing upon appropriate clean-up objectives. Everyone has biases, and no one has a monopoly on the best ideas for health-based assessment or management.

Different sites call for different risk assessment methods, which in turn have different combinations of attributes. Evaluation of the methods used by multiple states and agencies (as performed in this Report) shows that these methods can be distinguished and ranked; but the ranking, and hence the selection of the "best" practices, depends on the relative weights assigned by individual analysts to these different attributes. For example, we have found that the simplest methods are those that are most fully specified, reproducible, and dependent on a well-documented set of default assumptions and inputs; but such methods also tend to be less flexible and, when applied to specific sites, generally less scientifically accurate. In other words, trade-offs are inevitable.

The simplest methods (in CT and elsewhere) often rely on default criteria for allowable upper-concentrations of contaminants in soil (and other media, such as sediments). These default criteria (such as CT's Remediation Standards Regulation [RSR] criteria) should ideally be based on appropriate levels of protection for (i) individuals, (ii) affected populations, and (iii) the environment. Such methods should also be (i) fully documented, (ii) readily reproducible by knowledgeable environmental practitioners and/or risk assessors, and (iii) readily updatable with changes in scientific knowledge and/or following expert peer-review. With regard to these points, to the extent that there are impediments to the ability of the staff of the CT Department of Energy and Environmental Protection (DEEP) and/or the CT Department of Public Health (DPH) to readily update individual RSR default criteria, these impediments should be reduced or eliminated.

Our research has indicated that perhaps the best default criteria are those promulgated by British Columbia, as part of their Contaminated Sites Regulation (CSR; available at http://www.env.gov.bc.ca/epd/remediation/leg_regs/csr.htm). These criteria are appropriately protective of both public health and some aspects of ecological health (primarily with regard to soil invertebrates, such as earthworms, and plants). And, as recommended by the soil and sediment workgroup cited above (Hogan, Trombly, *et al.*, 2012), states such as Massachusetts, New Jersey, Pennsylvania, and Wisconsin have well developed programs that provide ecologically-based guidance for risk-based site assessment and management.

Among other attributes, British Columbia's CSR contains default soil standards (analogous to Connecticut's RSR criteria) that are tailored to five different types of land use — agricultural, urban-park, residential, commercial, and industrial — and, as noted above, that explicitly provide for some aspects of both ecological protection and public health protection. Some of these criteria are also "matrix specific" in recognizing that the physical-chemical behaviors of many metals, for example, depend on the pH-levels of site soils. *These CSR soil standards are presented in full in* Appendix D *and* Appendix E *of this Report.*

The British Columbia CSR also contains health-based default criteria for sediments. Like all default values, these soil and sediment criteria are intended to be overridden — indeed, are best overridden — in specific situations, based on professional judgment and site-specific, development-specific, and exposure pathway-specific considerations.

Next, with regard to protection of public health and the "reasonably maximally exposed individual" (RMEI) in particular, we note that British Columbia's CSR default criteria for known or suspected carcinogens are established at a human health risk estimate-limit of 1 in 100,000 (10^{-5}) *per* chemical, rather than at 1 in 1,000,000 (10^{-6}); and that, *based on the judgment of the local public health official*, the clean-up criteria can be less (but not more) stringent than the default criteria.

We have found that successful clean-up programs depend on good default criteria, *but even the best default criteria cannot be appropriate for all sites*. Thus, non-generic methods are needed as well.

Intermediate-level, non-generic methods are typically based on the same *principles* as those used to derive the default values, but with one or more inputs that are based instead on site-specific, as opposed to generic, characteristics.

And advanced-level methods incorporate greater levels and types of site-specificity, and may incorporate more complex modeling approaches together with, as appropriate, risk management options for achieving successful site closure and/or redevelopment.

At present, the CT RSRs allow for use of all three methods; but we have found that the most advanced-level risk assessment methods are not often used in practice in the State. Given the established benefits of these advanced methods in other states and regions (including at federal Superfund sites and brownfield sites), we believe that this should change.

As suggested above, a best method for site management may be one that involves, at least for some complex sites, local government in addition to state government. This is because all sites are, after all, local; and because the professional and political judgment of local government (along with their designated environmental and health professionals) can bring important perspectives. CT DEEP has informed us that they have worked with local governments on some sites in the past, and we believe that it is a best practice for Staff to continue to do so.

Next, several states, including CT, have recognized the benefit of creating a board of trained, registered environmental professionals to investigate and remediate contaminated properties. In CT, these scientists and engineers are termed licensed environmental professionals (LEPs). Empowering LEPs to implement site cleanup programs, with sufficient oversight and auditing from the relevant state agency(ies), is key to efficient program management and site processing.

CT now has many highly trained LEPs and health risk assessors, and we suggest that some sites might be best addressed by a combination of (1) an LEP/risk assessor representing the local city or town and (2) an LEP/risk assessor representing the private party/landowner. Two LEPs, representing interests that are both opposing and overlapping, may well develop solutions superior to those produced by either LEP working alone. Of course, the professionals at DEEP would still be the ultimate arbiters.

Moreover, DEEP has sometimes worked with nongovernmental agencies, such as the Nature Conservancy, in recognition that genuine ecological improvement is sometimes best done *not* on individual, developed, and otherwise disturbed and fragmented sites, but instead at the scale and in the habitats (such as large wetlands and conservation areas) that are already protected in the State, by both DEEP and non-profit environmental organizations. Fundamentally, since resources for contaminated site evaluation and redevelopment are not infinite, best practices are those that accomplish the best they can with what they have — no less, but also no more.

Next, our research has indicated no relevant differences between contaminated properties in Connecticut and sites in Massachusetts or other nearby states. Thus, rather than reinvent the wheel, to the extent that Massachusetts, New Jersey, New York, or similar states and regions have developed some specific best practices, Connecticut could benefit from using these as starting points (in addition to those established by British Columbia) for its review and reforms. Moreover, other information and education available in neighboring states — such as courses in site risk assessment for environmental professionals provided by the MA licensed site professional association (LSPA) — could be helpful to private LEPs in CT and to DEEP staff alike. Similarly, environmental professionals at DEEP might consider participating in as many relevant meetings, training sessions, and other activities of the Environmental Professionals' Organization of Connecticut (EPOC) as possible. In our experience, both sets of professionals can learn a lot from each other in such settings — scientifically and otherwise.

Connecticut is somewhat unusual, but not unique, in that health risk assessors reside not at DEEP but at DPH. Although we understand that there is close cooperation between the agencies, since DEEP is responsible for risk-based remediation, we suggest that it should also be responsible for risk assessment. States such as Massachusetts have been successful at risk-based remediation in part because risk assessment activities are also within the DEP, rather than within the DPH. Accordingly, one of our suggestions is to incorporate all (or at least most) aspects of human and ecological risk assessment *and* risk management within one agency — DEEP.

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As suggested above, this report and the accompanying database contain information on the four sets of activities that are performed for risk-based site evaluation and management:

1. Human health risk assessment (HHRA),
2. Human health risk management (HHRM),
3. Ecological health risk assessment (ERA), and
4. Ecological health risk management (ERM).

Based on this information, input from public and private stakeholders, and our professional experience and judgment, we respectfully offer the following perspectives and, in ***bold-face and italicized type***, suggestions for a path forward.

* * * * *

First, we suggest that Connecticut consider amending relevant law to place these four activities — HHRA, HHRM, ERA, and ERM — all within DEEP.

By current law in Connecticut, the first of these activities (HHRA) takes place within one agency (the Department of Public Health, DPH), while the second, third, and fourth (HHRM, ERA, and ERM) take place within a second agency (the Department of Energy and Environmental Protection, DEEP).

In contrast, at the federal level, HHRA does not take place within the Department of Health and Human Services (HHS), but instead takes place within the Environmental Protection Agency (EPA), where the other three activities, HHRM, ERA, and ERM, also are performed. Similarly, states such as Massachusetts and New Jersey — which have long histories of successfully using risk-based methods for site evaluation and management — have designated that the state environmental protection agencies are responsible for all four activities comprising risk assessment and risk management. Among other things, this centralization recognizes that fully informed site risk managers must rely on, collaborate with, and instruct knowledgeable site risk assessors (and vice-versa), and that these activities are best performed under one roof. Site investigations and remediation intended to protect both public health and ecological health should be performed (and later, audited) as a single, integrated effort. Such integration may be best supported by having all of the appropriate resources and expertise located within DEEP.

Second, we suggest that DEEP establish a process whereby property owners, local governmental officials, and other stakeholders are encouraged to develop and present to DEEP, for its approval, nonstandard solutions to improve public health in communities burdened with brownfields. Such solutions could also include improvements to already protected habitats and conservation areas elsewhere in the State, in lieu of costly but likely less effective restoration at the developed sites per se. To the extent that DEEP needs to be granted additional authority to approve such nonstandard solutions (as permanent solutions), the legislature should grant the Agency this authority.

In a perfect world, there would be no brownfields, and those that did exist would be easy to clean. But in the real world in Connecticut, hundreds of brownfields have been created, and many cannot be cost effectively redeveloped according to criteria that are based strictly on health and ecological risk. On the other hand, leaving these (sometimes blighted) sites as they are may create (indeed, have created) public health problems of their own. These un-remediated brownfields maximally affect people in the immediate neighborhood. In our judgment, best risk management practices for these sites would involve local officials, rely on appropriate environmental professionals, and work in conjunction with local landowners, all under the purview of the state environmental agency. In our experience, motivated risk managers can work with stakeholders and regulators to devise nonstandard solutions that improve public health in ways that are more actual than theoretical. In Connecticut, these solutions could be suggested or aided by the State's Office of Brownfield Remediation and Development (OBRD) and others within the Department of Economic and Community Development (DECD).

Third, we suggest that (i) DEEP fully and electronically document all of the underlying assumptions, models, exceptions, and other aspects of each default criterion in the RSRs; (ii) DEEP consider updating these criteria, per British Columbia's criteria, to account for risks to soil invertebrates and to plants as well as for risks to public health; and (iii) to the extent that legislative involvement is currently required before criteria are updated, this requirement be modified to grant DEEP the requisite authority.[1]

Although many private environmental practitioners in CT expressed their opinions that the State's default criteria for acceptable concentrations of contaminants in soil are unusually restrictive, an objective comparison of these default criteria with those of two neighboring states — Massachusetts and New York — showed no such systematic bias. Instead, compared with one or both of these two states, some of Connecticut's default criteria were found to be the same; some were more restrictive; and some were less restrictive. We believe that some of the practitioners' frustrations are due instead to related issues that are indeed problems: (i) the risk assessment and environmental professional community's inability to fully understand the bases

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[1] DEEP and the stakeholder community have developed robust and productive working groups, including the Remediation Roundtable, for frequent communication and collaboration among practitioners and other experts. It should thus be possible to gain broad stakeholder support for criteria changes without additional legislative processes, just as it is in neighboring states and other regions.

of all default criteria (and thus the community's inability to reproduce and fully peer-review these criteria); and (ii) impediments to readily and appropriately updating these criteria.

Fourth, we suggest that DEEP adopt and, as needed, adapt the successful ecological risk assessment and ecological risk management programs already in place in Massachusetts and in British Columbia.

An important aspect of the scope of work for this project was to examine several specific characteristics of the State of Connecticut and neighboring states. As discussed in the Report, we found that Connecticut is similar to the neighboring states of Massachusetts and New York in many relevant regards. In all three states: (i) there are rich and long industrial and post-industrial histories; (ii) groundwater tends to be both shallow and an important resource; (iii) significant fractions of the population derive their drinking water from private wells; and (iv) many residents consume at least some locally caught fish. We also found that Massachusetts has a well-developed, multi-tiered program for ecological risk assessment and risk management, and that this (along with a well-developed program in British Columbia) could serve as a basis for DEEP as it continues to refine and document its program for site-based ERA and ERM. DEEP's refined program, like that of Massachusetts, should specify screening-level approaches *and exemptions*, in explicit recognition that many small, developed sites will not likely be habitat for wildlife regardless of whether contaminant concentrations are or are not reduced.

Fifth, we suggest that DEEP encourage the use of advanced, site-specific risk assessments for sites where application of RSR default criteria may be inappropriate.

As noted above, although successful clean-up programs depend on good default criteria, *even the best default criteria cannot be appropriate for all sites*. Indeed, for some properties, strict reliance on RSR default criteria might well suggest site-actions that are wasteful of resources and not likely to produce actual improvements in public health or ecological health.

Advanced-level methods (such as Method 3 assessments performed in Massachusetts) incorporate greater levels and types of site-specificity, and may incorporate more complex modeling approaches together with risk management options for achieving successful site closure and/or redevelopment. *These methods are inherently both the most flexible and potentially the most scientifically accurate of approaches to site assessment and management.*

Finally, sixth, for potentially carcinogenic site contaminants, we suggest that DEEP adopt risk management goals for the reasonably maximally exposed individual (RMEI) of up to 1 in 100,000 per chemical, and up to 1 in 10,000 per site.

Our research, experience, and judgment indicate that levels of acceptable risk to public health should be based on the *size of the affected population*, the *nature* of the risk (such as whether it is *theoretical or actuarial*), and the *size and type of uncertainties* surrounding the risk-estimates. For the vast majority of contaminated sites, the size of the affected population is small, the risks are theoretical, and the concatenation of conservative assumptions inherent in risk assessment methods results in intentionally, but too often extremely, worst case estimates. *Best practices in risk management are those that take these important factors into account when setting remediation goals.*

As noted above, these important considerations are embodied in the approach taken in British Columbia, where the "no significant risk level" is set at 10^{-5} per chemical at any given site — subject to less stringency, at the discretion of the local public health official.

This best risk management approach recognizes:

(i) that theoretical health risk estimates for a reasonably maximally exposed individual of up to 1 in 10,000 (10^{-4}) are presumptively acceptable — as noted also by U.S. EPA, U.S. Department of Energy, California, Texas, Vermont, and other regions and analysts (Cohen, 2001; Kelly, 1991); and

(ii) *more importantly*, that risk goals meant to protect populations of potentially millions of people (such as those pertaining to national air quality) should be *much more stringent* than those applicable to individual plots of land — where risks are theoretical, not actuarial; and where *far* fewer than millions of people are maximally exposed.

For additional discussion with regard to acceptable risk levels, please see Section 6.4.4 in the body of this Report, as well as Appendix M to this Report.

Connecticut's well-developed system of working groups, under the auspices of the Remediation Roundtable, could be used to implement some of the above-mentioned suggestions. Indeed, as DEEP moves forward with its Site Transformation, many more sites will be brought into formal programs, and DEEP and stakeholders alike will need to collaborate on efficient and effective ways to assess and successfully manage these sites.

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The remainder of this report is structured as follows.

In Section 2, we discuss the nature of site risk assessments and their (sizable) uncertainties.

In Section 3, we characterize current site remediation, risk assessment, and risk management practices in Connecticut. We discuss the RSRs as currently implemented, summarize the public meeting at which public comment on this evaluation was sought, and present information gathered during extensive interviews of CT DEEP and DPH staff.

In Section 4, we discuss relevant characteristics of Connecticut and its groundwater, development patterns, government, and other characteristics that may affect the establishment of best practices for the remediation of contaminated sites.

In Section 5, we characterize existing practices in site remediation, risk assessment, and risk management in other states and by other agencies. We examine site remediation programs in the other five New England States, New York, New Jersey, California, Illinois, Michigan, Montana, and Texas. We also look at site remediation by the Department of Energy (DOE), EPA, and Canada.

In Section 6, we discuss best practices in human health risk management (HHRM) and human health risk assessment (HHRA). We present best practice recommendations from the National

Academy of Sciences and present quantitative and qualitative results from our assessment of practices used by other states and agencies.

In Section 7, we present analogous material for ecological risk assessment (ERA) and ecological risk management (ERM).

Section 8 contains the references.

We also present the following Appendices:

Appendix A Public Meeting Presentation Slides

Appendix B Transcript of March 12, 2014 Public Meeting

Appendix C Minutes from March 19, 2014 Interviews with CT DEEP Staff

Appendix D British Columbia General Numerical Soil Standards

Appendix E British Columbia Matrix Numerical Soil Standards

Appendix F Full List of Questions and Potential Responses in the Database

Appendix G Questionnaire and Database Details

Appendix H Detailed results for HHRA, Requirements A to C

Appendix I Detailed results for ERA, Requirements A to C

Appendix J Flow Diagrams of Practices

Appendix K Documents Consulted

Appendix L Role of Science in Stakeholder-Based Risk Management Decision-Making

Appendix M Excerpt from textbook by Wilson & Crouch, 2001

Finally, we gratefully acknowledge the many people (named elsewhere in this report, except for those who wished to remain anonymous) in Connecticut, in both the public and private sectors, who shared their ideas with us. Learning from them has helped us shape a much better (and, we hope, more relevant) report than we could have written on our own. We hasten to add that any errors, omissions, or biases are our own. Please note that this report, because it focuses on “best practices,” cannot be wholly objective, since there is no wholly objective definition of “best.” We have used our (and others’) professional judgment in seeking and characterizing best practices, but we fully recognize that other professionals may differ with us with regard to some of our characterizations. And, of course, we acknowledge that DEEP and DPH Staff and others in CT government have mandates and constraints that we may not fully appreciate.

We hope that this report helps CT DEEP, DPH, and others who are working diligently to improve the process of contaminated property assessment and management throughout the State.

Section 2

The Nature of Site Risk Assessments and their Uncertainties

The Connecticut Department of Energy and Environmental Protection (DEEP) endeavors to conserve, protect, and improve the environment and the public health of the State (Esty, 2012). To accomplish these tasks —for parcels of real estate ("properties" or "sites") that are, or might be, contaminated with potentially hazardous chemicals or other substances — DEEP relies on its Remediation Standard Regulations (RSRs; discussed in Section 3). Implicit in these RSRs is a "conceptual site model." Such a model can be depicted as follows.

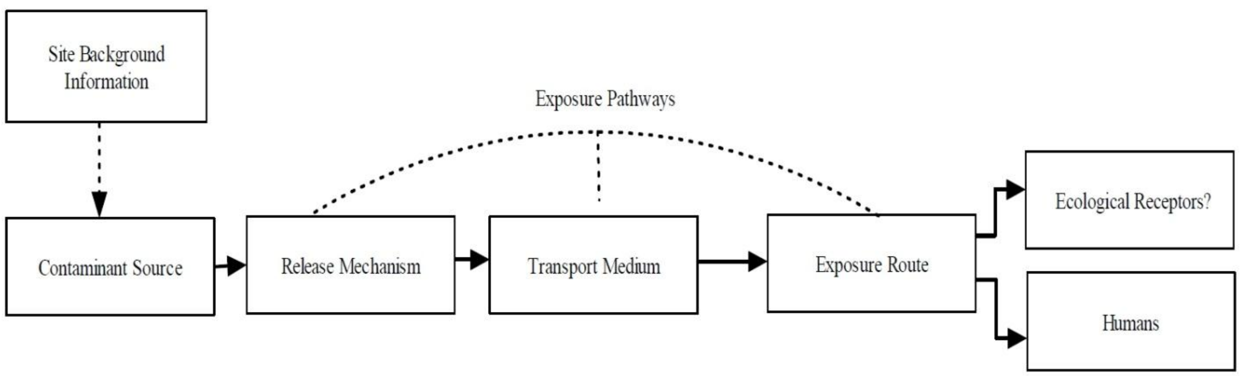

Figure 2-1 **Conceptual site model for assessing (potentially) contaminated properties (adapted from Science Advisory Board for Contaminated Sites in British Columbia, 2005)**

As shown, routes of exposure (such as via contact with contaminated soil or water) at and from a site can bring humans and other animals and organisms into contact with contaminants; and the goal of site risk assessment, fundamentally, is to determine whether such contact does or does not constituent a significant risk to public health (via quantitative human health risk assessments; HHRAs) and/or to ecological health (via ecological risk assessments; ERAs).

All such assessments, however, are based on incomplete information and knowledge, and thus fundamentally uncertain. They require inputs — such as the amounts of soil that a child, teenager, and adult may inadvertently ingest from a site daily — that can be estimated but not really "known"; and, more importantly, require estimates of toxic potencies for specific situations that have not been, or cannot reasonably be, studied *per se*. Typically, the toxicity components of risk assessments for contaminated sites are based partly on experimental (or epidemiological) data, and partly on mathematical models and extrapolations. This makes them uncertain in ways that risk assessments based on, for example, tobacco and lung cancer are not.

In particular, abundant data indicate that cigarette smoking increases people's risks of developing lung cancer. And, based on reliable, clinical and epidemiological observations of lung cancer (and other diseases) among smokers, we have quite precise estimates that allow us to predict by how much a person increases his risk by his smoking, at least for typical rates of smoking (5 cigarettes per day and higher). These risk estimates can be based on, among other things, at what age a person started smoking, at what rate he smoked, if and when he quit smoking, and other factors.

Not so with risk estimates based on, for example, the amount of benzo[*a*]pyrene (a specific and well-studied, polycylic aromatic hydrocarbon, or PAH) in soil on a contaminated property. We know that large exposures to benzo[*a*]pyrene in air — via inhalation of large amounts of coke oven emissions or tobacco smoke and via occupational, dermal contact (such as experienced by chimney sweeps in the 19th century) — can cause lung cancer and skin cancer (IARC, 2010); but we also know that chronic skin treatment with moderate, but still sizable exposures to benzo[*a*]pyrene in medicines — such as in therapeutic coal tar preparations used to treat patients with psoriasis — do not appear to cause cancer in large groups of well-studied patients (Roelofzen *et al*., 2010; Green *et al*., 2013). Moreover and more generally, the biology and physiology of human skin cells are well known to provide resistance against PAH-induced (as opposed to sunlight-induced) skin cancers (Crump, 2000). This means that estimates of the carcinogenic risks posed by part per million concentrations of benzo[*a*]pyrene in site soils, for example, are inherently and highly uncertain: the true risk of cancer from contacting such soils could range from as low as zero to as high as a risk directly proportional to the observed potencies in over-dosed laboratory rodents.

Because of such uncertainties, NRC (2014a) recommends that when risk assessors at U.S. EPA, for example, are deriving values for the Integrated Risk Information System (IRIS), they present both a conservative (essentially, a worst case) estimate and a central tendency estimate. In the U.S., at least, the central tendency estimate is rarely used in practice.

Many HHRAs (and soil clean-up criteria based on health-risks) concern themselves not only with direct contact between an exposed person and contaminated soil, but also with "indirect contact" *via* soil that may contaminate drinking water; and *via* soil that contaminates soil gas that may infiltrate into overlying residences or other buildings. Still more models — collectively termed "fate and transport" models — are required to derive these indirect clean-up criteria for site soils; and, again, these models are rarely verified in the usual scientific sense of direct comparison with experimental observations in the conditions of use. Even if they are more or less scientifically correct under appropriate conditions and with valid inputs, they contain idealizations, approximations, and input values that are often made quite conservative (sometimes only implicitly), in order to be protective in virtually any environmental setting.

The assessment and management of ecological health tends to be more difficult than the assessment and management of public health. Of course, there is the obvious difference that we humans are only one species, whereas ecology encompasses literally countless species and variants. But there is more to it than that. To explain some of the key issues, we quote at length from Robert Lackey, Ph.D. (1996) — a renowned fisheries biologist, formerly with U.S. EPA, and currently with Oregon State University:

> *. . . [another] concept is ecological risk assessment. Risk assessment has been used effectively in many fields (i.e., automobile, casualty, health, and life insurance, flood management, nuclear accidents) as an aid in decision making. It is used to estimate the likelihood of an event occurring that is clearly recognized as adverse. Its typical use in decision making with regard to ecological issues is similar: estimating the likelihood of a certain, defined event occurring (e.g., the event of a species going extinct, as is outlawed by the Endangered Species Act). The key requirement is that the consequence is adverse by definition, which enables the analyst to conduct the risk assessment. In classical risk assessment this assumption of what is adverse is relatively easy to justify: a nuclear accident is universally accepted as adverse, as is an*

> *automobile fatality, a skiing injury, heart attack, or an airplane crash. Achieving consensus on the analogous adverse event in ecological risk assessment has proved to be more elusive.*
>
> *Ecological risk assessment also has enjoyed widespread support and become a commonly used tool in policy analysis . . . but its use continues to be controversial. . . . Opinions are diverse; they range from fervent support to caustic dismissal. Much of the controversy with using risk assessment in ecological policy analysis revolves around defining the initial policy question or problem to be assessed . . . rather than technical details.*
>
> *Like all analytical techniques used to assist management, ecological risk assessment has strengths and weaknesses; it is used appropriately in some circumstances, but not in others.*

Picking up on Lackey's last point, we note that many states, such as Massachusetts, have explicit instructions for when ecological risk assessments are *not needed* for contaminated properties. In particular, properties may be "screened out" of this requirement based on (i) consideration of site size, (ii) comparison of site conditions to background or local conditions, (iii) consideration of rare wildlife or Areas of Critical Environmental Concern (ACECs), and (iv) "effects-based" screening. Thus, terrestrial sites that are (i) small — by MA DEP (1995) regulation, smaller than two undeveloped acres or six undeveloped acres with no potentially significant habitat — and that (ii) have no rare wildlife or critical habitats are excluded from further consideration with regard to ERA. Similar recommendations are made for aquatic environments, for which MA DEP has developed guidelines to indicate the minimum areal or linear extent of contaminated sediment that the State would consider to be significant.

More generally, as discussed below in Section 7, we consider a "best practice" in ecological health risk assessment to be one in which simple, initial, "screening assessments" are used to determine the need for (and type of) additional analysis. Typically, screening assessments first evaluate habitat quality to eliminate sites where habitat is not of sufficient quality (for reasons other than simply chemical contamination) to merit further consideration. A small, urban gas station with a limited spill on impervious pavement, for example, might well be screened out as unlikely to harm aquatic organisms in a nearby but physically unconnected stream. At the other extreme, sites that are obviously harmful to the environment would be addressed as rapidly as possible, without the need for elaborate, "theoretical" risk assessments. In all cases, screening assessments should follow standard, technically defensible procedures, and, of course, should be well documented.

Section 3

Current Site Remediation, Risk Assessment, and Risk Management Practices in Connecticut

3.1 A Brief History of CT's Site Evaluation and Remediation Program

In Connecticut, evaluation and remediation of (potentially) contaminated real estate ("sites" or properties) are commonly driven by the State's Transfer Act of 1985 (*Conn. Gen. Stat.* § 22a-134, *et seq.*). This law applies to properties or businesses are defined as establishments within the statute. A property owner is not necessarily responsible for the investigation and remediation of the establishment when ownership is transferred. Instead any "party associated with the transfer . . ." may take responsibility and "certify" that they will investigate and remediate the establishment thereby assuming responsibility of the "certifying party." The transfer of an establishment, not just real estate, triggers the Transfer Act. This may include a business transfer if the business qualifies as an establishment.

There are several methods by which an establishment may be conveyed which do not meet the definition of "transfer" (are exempt from definition of "transfer"). Therefore, only a small fraction of transfers of property trigger a Transfer Act filing which would then require a property to be investigated and remediated under the Transfer Act. Sections 22a-430, 432, and 467 of the Connecticut General Statutes, among others, compel responsible parties to investigate and remediate polluted sites in Connecticut.

Sites with significant environmental hazards do not necessarily overlap with sites that must be investigated and remediated under the Transfer program. Under the significant environmental hazards law, the hazard must be abated. This does not require the same level of investigation and/or remediation that would be required under the Transfer program.

The two voluntary remediation programs (CGS 22a-113x and 133y) were established in 1995 under Public Acts 95-183 and 95-190 respectively. A licensed environmental professional (LEP) program (CGS 22a-133v) was established under Section 4 of PA 95-183. The transfer program was significantly modified under PA 95-183 to authorize LEPs to verify the investigation and remediation of sites in lieu of approval by the Department (CGS 22a-134 TO 22a-134e).

Prior to the mid-1990's, site evaluation and remediation was primarily conducted on a case-by-case basis. By 1994, however, the Department (and others) felt the need for a more uniform approach. In particular, it proposed a set of Remediation Standard Regulations (RSRs) that would "provide detailed guidance and standards that may be used at any site to determine whether or not remediation of contamination is necessary to protect human health and the environment." (CT DEEP, 2013). As the Department (CT DEP, 1994) noted:

> *The Department has, in the past, made remedial decisions on a case-by-case basis . . . The Clean-up Standard Regulations will be based on the same goals and will make the remedial decision-making process as clear and predictable as possible. By establishing clear written standards, the*

> *Department will improve the efficiency of remediation programs and ensure the consistency of clean-up decisions made by the Department.*

In particular, the RSRs shifted site evaluations to primarily standardized and "default" methods, while still allowing for consideration of various site-specific issues.

In its report of the RSRs public hearing of November 6, 1995 (CT DEP, 1995), the Department noted that it:

> *. . . must focus on its primary legislatively affirmed goal: fully protecting human health and the environment. However, in doing so, we must often strike a balance between this and other significant, and in some ways competing, interests, such as contributing to a healthy state economy. 'Striking a balance' is a theme common to many of the issues discussed in this report.*

During interviews with DEEP staff, we learned that these concerns remain as valid today as they were almost 20 years ago. Accordingly, striking this balance is a filter through which any risk assessment or risk management best practice must pass before it can be considered, in the context of site evaluation and remediation in Connecticut, to be best.

3.2 The Practice of Remediation

Before delving into the details of the State's remediation program, it may be useful to summarize the (i) current practice of remediation in Connecticut and (ii) recent and current efforts to improve upon parts of that practice.

First, although the Remediation Standard Regulations (RSRs) provide the standard of care for clean-up of any site, the RSRs *per se* do not obligate any party to proceed with remediation. Instead, the RSRs provide the rules for the clean-up, once site evaluation is completed.

The most common triggers for site remediation include the following three types:

1. Connecticut's Transfer Act – applicability for certain sites undergoing an ownership transfer as defined by the Act;

2. Unilateral and consent orders issued or entered into by the Department of Energy and Environmental Protection (DEEP); and,

3. Private property transactions or site redevelopment not subject to the Transfer Act and motivated by various reasons to mitigate environmental liability associated with the property. Connecticut maintains two voluntary remediation programs under which such efforts may proceed.

Currently, DEEP is working toward a new, contaminant "release-based" model for what would trigger remediation of sites in Connecticut. In general, the concept for this new model is to capture a broader set of sites or release areas (both new and historical) and to couple that process with a more flexible system of "exits," or means of establishing compliance for those releases. It is beyond the scope of this report to describe in any detail how this new model would function. Suffice it to say that certain releases of limited scope and risk will be able to exit the system more easily as a reflection of the lower risks they pose. As releases or sites become more complex, hence generally representing more risk, the requirements to exit or establish compliance will be correspondingly more comprehensive. This means of risk management is generally consistent with the overall remediation objectives as summarized in Section 6.

Similarly, as noted above, DEEP already has a framework in place for recognizing and addressing, in a timely manner, what are called "Significant Environmental Hazards." A proposal to add a category of "Imminent Hazards" has been made as well. Both of these categories would apply to sites posing risks of an urgent nature that, thus, would dictate a correspondingly urgent response.

As noted above, the LEP program in Connecticut (like similar programs in many other states) allows the private sector to conduct site remediation without direct DEEP supervision or approval2. Under either the Transfer Act or one of the Voluntary Remediation Programs, the end product of the LEP's work is a "Verification Report" that documents compliance with the RSRs. The DEEP has three years in which to decide whether to audit the Verification Report. The net effect of this program, as intended, has been to increase the number of sites proceeding through the remediation process. This is because (i) the remediation workload in Connecticut has been distributed over a larger number of professionals, and (ii) the interactive process of submittal, review, comment, and approval has been minimized.

By law in CT, decisions related to human health risks are delegated not to DEEP but instead to the Department of Public Health (DPH). In general, what this means is that any risk-based human health decisions that are not codified in the RSRs are made by DPH, in cooperation with DEEP. For instance, if a contaminant (referred to as an additional polluting substance [APS]) is found on a site that does not have published RSR criterion, a request for such a criterion is sent to DEEP, but the risk assessment and criterion development, approval, and/or modifications are in fact made by DPH.

3.3 RSRs as the Standard of Care

As noted above, The Remediation Standard Regulations (RSRs) represent the standard of care for site remediation in Connecticut. These standards are prescriptive, which makes the remediation outcomes generally predictable. The tenor of the regulations is to allow LEPs to proceed without DEEP involvement, to the extent feasible — except when the flexibility of some types of site-specific approvals are deemed, generally by the property owner or would-be redeveloper, to be worthwhile.

The RSRs contain sets of default criteria that have been developed based on various assumptions about contaminants' (i) toxic properties and potencies, (ii) environmental fate and transport, and (iii) interactions between and among these contaminants and humans (and, to a limited extent, aquatic life). The public may comment on these criteria and their underlying bases prior to regulatory promulgation, but the promulgation of new criteria has been infrequent in Connecticut. That changes to the RSR criteria require legislative review is an impediment to updating the criteria on a regular basis.

The RSR criteria consider land use by presenting both residential and industrial/commercial-based criteria; DEEP is currently considering adding a category to cover recreational land-uses. The RSRs

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[2] Certain options for remediation available under the RSRs do require approval by DEEP, as discussed in Section 2.3. It is, however, possible for a site to proceed to compliance with the RSRs without any DEEP interaction, if default criteria are met and if no Environmental Land Use Restrictions (ELURs) are filed.

also take into account the Connecticut ground water classification scheme by presenting criteria applicable to both GA and GB ground water classifications.[3]

Risk management is likewise built into the RSRs in the form of various exceptions, variances, and alternatives that allow for flexibility in remedial decision-making. As discussed in Section 3.5 below, some of these alternatives are self-implementing, and others require various degrees of DEEP involvement. Here are three examples.

Example No. 1: physical barriers to direct human contact with soils:

The RSRs include criteria for allowable levels of contaminants in soil based on direct human contact. As a risk management tool, the RSRs also recognize that physical barriers to soil (such as the presence of buildings, clean soil or asphalt on top of that polluted soil) mitigate that human contact. So, it is possible to address soils that contain contaminants at concentrations larger than their respective Direct Exposure Criteria (DEC) for soils by recognizing the safety afforded by these physical barriers. In such a case, a corresponding Environmental Land Use Restriction (ELUR) would be filed in order to ensure that the physical barrier is not removed or disturbed in the future.

This concept has been recently further developed with urban sites in mind. In the 2013 revisions to the RSRs, an acceptable physical barrier for some circumstances was changed from three inches of asphalt ***plus*** two feet of clean soil to three inches of asphalt alone.

Example No. 2: infiltration barriers to leaching from soils into ground water:

The RSRs include criteria for the potential for soil pollutants to leach into the underlying and down-gradient ground water. As a risk management tool, the RSRs also recognize that physical barriers (such as buildings or engineered barriers) to ground water infiltration mitigate, if not entirely eliminate, the potential for leaching. So, it is sometimes possible to address contaminated soils by explicit reference to these physical barriers. As above, an ELUR would be filed in order to ensure that the barrier is not removed or disturbed so as to expose underlying soils to infiltration and leaching in the future.

Example No. 3: certain criteria do not apply to certain kinds of urban fill:

Fill material containing coal or wood ash is commonly found in urban areas: this material is commonly termed "urban fill." The RSRs recognize the pervasive nature of this material in urban areas and the typical circumstance that these areas are supplied by protected public water systems (and not typically from aquifers directly underneath contaminated properties). Accordingly, these urban fill materials are provided an exemption from the PMC as a risk management accommodation.

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[3] Briefly, a ground water classification of GA presumes that the water is sufficiently clean as a drinking water source without treatment, while a GB classification indicates that ground water quality is not sufficient for drinking without treatment.

3.4 Ecological Assessment

The RSRs are predominantly focused on protection of human health, with one exception: the surface water protection criteria[4]. Otherwise, risks to CT's ecological health from contaminated sites are addressed within the RSRs via:

1. a requirement — on a case-by-case (and thus site-by-site) basis — to perform an ecological risk assessment, specified as being guided by a (1992) U.S. EPA guidance document[5], with additional guidance posted to DEEP's Ecological Risk Assessment webpage, http://www.ct.gov/deep/cwp/view.asp?a=2715&q=325016;

2. a requirement, on a case-by-case basis, to assess and remediate sediments; and

3. a requirement, on a case-by-case basis, to develop ecologically-protective clean-up criteria for "additional polluting substances" — that is, for substances for which CT has no chemical-specific criteria.

CT DEEP (and others) desire to improve how ecological risk issues are addressed within the RSRs. In particular, what is wanted is a set of guidelines and processes (for both ecological health risk assessment and ecological health risk management) that are explicit, well-documented, scientifically-defensible, up-to-date, flexible, easily implemented, and otherwise in line with best practices implemented in other states and regions (insofar as these requirements are not [i] mutually exclusive and [ii] incompatible with immutable aspects of CT laws or policies).

Along those lines, DEEP has two DRAFT documents under development:

A DRAFT Ecological Risk Assessment Guidance, Connecticut Department of Energy and Environmental Protection; and

Connecticut DEEP Screening Level Ecological Risk Assessment Guidance Document, DRAFT DOCUMENT.

3.5 Prescriptive vs. Site-Specific Evaluations

It can be useful to view the Connecticut remediation programs in terms of "momentum." As such, the momentum has been in the direction of moving away from site-specific assessment, as done historically (pre-RSRs), and to a more prescriptive approach. A prescriptive approach is predictable and the more difficult decision-making has been incorporated into the rules. This is not to say that there is no place for site-specific decision-making or flexibility. Rather, the momentum places site-specific decision-making at the end of the spectrum that represents the exception, more than the rule. A few examples[6] are provided below.

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[4] The surface water protection criteria are actually criteria for *ground water* that discharges into a surface water body. Regardless, they are intended to be protective of surface water ecology.

[5] U.S. EPA, February, 1992. *Framework for Ecological Risk Assessment*. EPA/630/R-92/001.

[6] The examples provided are not a thorough treatment of the options available under the RSRs; but they do illustrate the categories of DEEP involvement.

The default-criteria case: The simplest case is that in which a site can be demonstrated to be in compliance by achieving all relevant default criteria for all site contaminants. This case also incorporates the use of any self-implementing exceptions or alternatives as are available in the RSRs. Assuming proper site characterization, these sites proceed to completion predictably and quickly. No interaction with DEEP is required.[7]

The use of exceptions or alternatives that require specific DEEP notice: One example of this alternative is use of a site-specific dilution attenuation factor in a GB area. The rules for application and formula for calculation are prescriptive, and only notice to DEEP is required; no response or approval from DEEP is necessary.

The use of exceptions or alternatives that require specific DEEP approval: In cases for which no published criteria exists for a site pollutant, appropriate additional polluting substance criteria must be obtained from DEEP (in cooperation with DPH). The process is fairly straightforward. Depending on the specific contaminant, the outcome may or may not be predictable.

The engineered control & ELUR case: Arguably the most complex case available under the RSRs, approval by DEEP for both the engineered control and the ELUR are required. A public notice step is also required. The engineered control technical standard is specified in the regulations, but the design is generally site-specific. The language and components of the ELUR are closely modeled against standard forms, but some site-specific details must also be incorporated. Despite the site-specific elements of engineered controls and ELURs, the framework for both is fairly prescriptive.

Detailed, site-specific risk assessment: While this alternative is available within the framework of the RSRs[8], it is rarely used. Both DEEP and DPH would be involved in the review of any such submittals. The process and outcome are uncertain for this alternative.

As described above, the kinds of alternatives available within the framework of the RSRs has a range of predictability, but, the overall trend is toward predictability for the majority of cases. And, the LEP is able to exercise some judgment in deciding to stay the course with remediation to default criteria vs. adding levels of complexity that are associated with the flexibility of various available alternatives.

It may be instructive to consider the success of the General Permit program for wastewater discharges in Connecticut. For wastewater permits, the momentum has been away from site-specific permitting to General Permits that apply generically to categories of discharges. The general permits are prescriptive as to discharge limits and monitoring requirements. They are self-implementing, and so do not require review or approval by DEEP. The overall effect of the general permit program is to free up DEEP staff time to focus the relatively fewer sites that require site-specific permits.

3.6 Flow Diagram of Connecticut Practice

Figure 3-1 is a flow diagram of the Connecticut site-based remediation practice. The figure describes the governing regulations and guidance documents that go into characterizing human health and

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[7] However, a developer would not know that the site is closed until the period for potential audit is over. Also, there are two types of ELUR, and only the ELUR that stipulates that industrial land stay industrial can be executed without specific DEEP approval.

[8] 22a-133k-2(d)(2) Alternative Direct Exposure Criteria.

ecological risk at contaminated sites, factors that go into risk assessment, consideration of affected resources, and risk management.

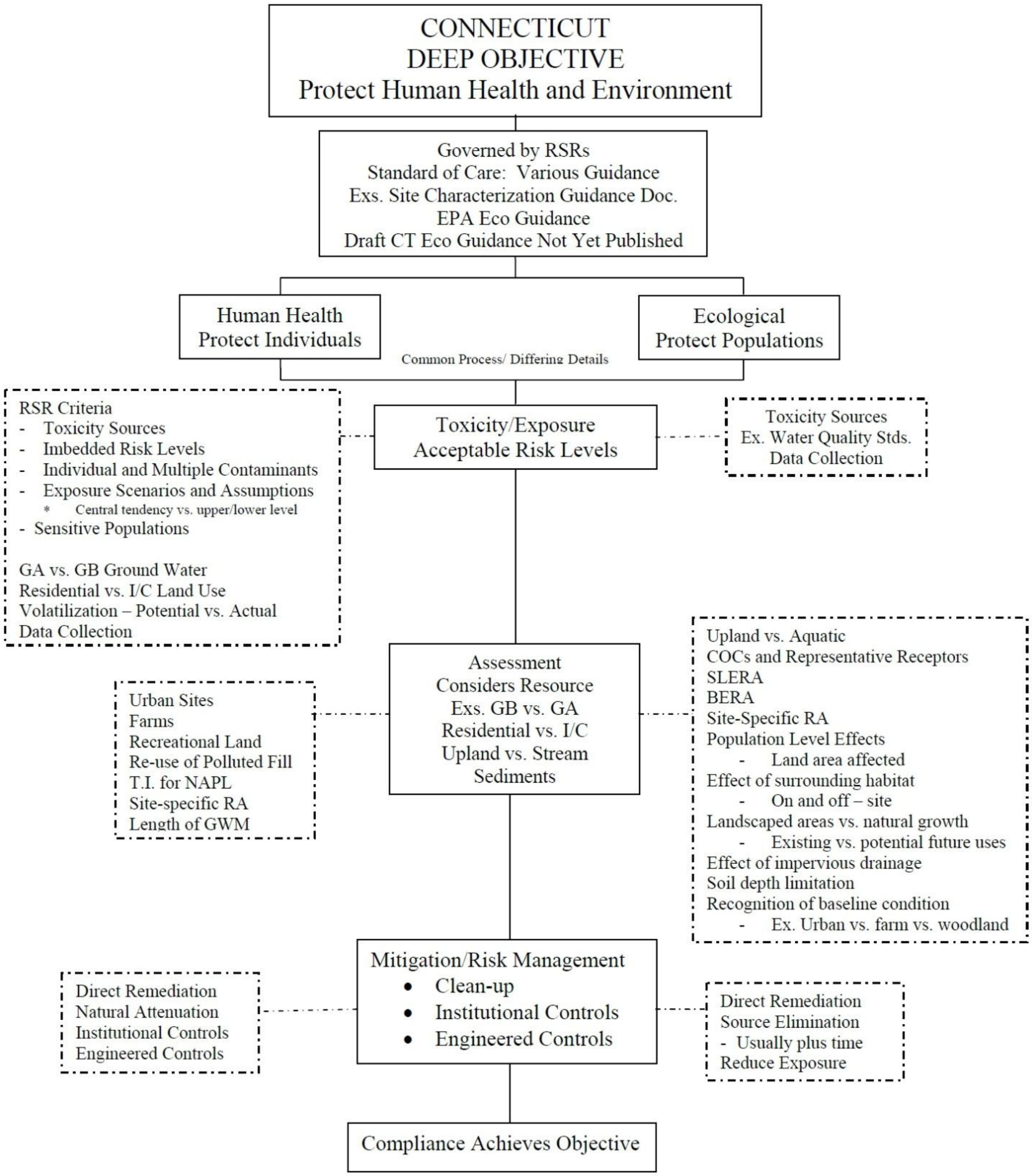

Figure 3-1 Flow diagram of the Connecticut risk-based remediation practice

3.7 Interviews and Documentation of Existing Practices

As part of our information gathering process, the project team participated in several activities to inform stakeholders about the proposed plan for our evaluation and to gather relevant institutional knowledge and other information.

3.7.1 Public Meeting

On March 12, 2014, a public meeting was held in Hartford to inform stakeholders and other interested parties about our evaluation and to seek feedback on the process. Ms. Cheryl Chase of CT DEEP introduced the project team, represented by Mr. Richard Lester and Mr. Mark Franson. A brief presentation provided an overview of the project and the project team, and then the meeting was opened up for feedback.

Several comments were offered by stakeholders at the meeting. In particular:

- A representative from the Environmental Professionals Organization of Connecticut (EPOC) requested that our project team include a review of reports that EPOC had commissioned from several risk assessment experts.
- A representative from the Connecticut Fund for the Environment (CFE) requested that the project team focus on whether Connecticut's approach to risk assessment is being done scientifically and properly. It was also requested that the report put some context to the policy tradeoffs that may be necessary such as the balance between risk-limits, cleanup costs, and other factors necessary to achieve prompt remediation of contaminated properties. The representative also suggested that the project team consider the issue of enforcement. If it is recommended that Connecticut provide more flexibility in the risk assessment process, it is important that stakeholders understand the degree of confidence that can be had that any additional flexibility will be exercised in a conscientious manner.
- A member of Connecticut's Brownfield Working Group emphasized the need to make our report simple and understandable by the legislature. It was emphasized that the goal is for CT DEEP to offer a proposal to the legislature that will be understandable to everyone — particularly legislators.
- A consultant from the Connecticut site-remediation community suggested that the project team consider recommending multiple risk assessment methods instead of solely a comparison to RSR criteria.

Appendix A contains the PowerPoint presentation from the public meeting. Appendix B is a transcript including the full text of all comments offered at the public meeting.

3.7.2 CT DEEP Interview Information

On March 19, 2014, we conducted a series of interviews with Connecticut DEEP staff, and followed up with interviews over the following two months with additional staff and outside personnel familiar with the Connecticut risk-based remediation program. In particular, we interviewed:

CT DEEP Materials Management and Compliance Assurance (MMCA)

- Lori Saliby – Supervising Environmental Analyst for Storage Tank and PCB Enforcement Unit

- Peter Zack – Assistant Director of the Emergency Response and Spill Prevention Division
- Yvonne Bolton – Bureau Chief for the Bureau of Materials Management and Compliance Assurance

CT DEEP Water Protection and Land Reuse Bureau (WPLR)/Remediation/Operations

- Jan Czeczotka – Assistant Director
- William Warzecha – Staff Supervisor, Risk Management
- Maurice Hamel – Environmental Analyst
- Raymond Frigon – Environmental Analyst
- Robert Bell – Assistant Director
- Mark Lewis – Environmental Analyst

CT DEEP WPLR/Planning and Standards

- Traci Iott – Supervisor – Aquatic Toxicity and Ecological Risk Assessment
- Corinne Fitting – Supervisor – Groundwater Drinking Supply and Aquifer Protection
- Chris Sullivan – Environmental Analyst
- Rosemary Gatter-Evarts – Environmental Analyst
- Robert Hust – Water Bureau Assistant Director

CT DEEP WPLR

- Betsey Wingfield – Bureau Chief for the Bureau of Water Protection and Land Reuse

Additional Interviews

- Elsie Patton – Former Director of the Remediation Division
- Bart Hoskins – EPA
- Stephanie Carr – EPA
- David MacDonald – EPA
- Kenneth Finkelstein - NOAA

All interview participants readily agreed that some of the key goals of the Department at the time the RSRs were first developed remain relevant today. They told us that the Department must focus on fully protecting human health and the environment while striking a balance with other, sometimes competing interests, such as contributing to a healthy state economy. Also, the cleanup standard regulations should make the remedial decision-making process as clear and predictable as possible to improve the efficiency of the remediation program.

Interview participants contributed many thoughts and ideas regarding best practices, sources of past controversies over updates to the RSRs, and many other aspects of the risk-based remediation program. In particular:

- Suggestions for best practices included:
    - Allowing interim corrective action to start quickly to lower risk;
    - Building in program flexibility to allow approaches to match site-circumstances;
    - Not relying exclusively on RSR standards but also giving consideration to what would be an acceptable human health and ecological risk;
    - Achieving the most health and environmental gain for a reasonable cost;
    - Developing a good communication strategy;
    - Sharing the basis for all criteria;
    - Ensuring DEEP and private consultants both have the same understanding and goals for site-cleanup; and
    - Establishing a clear means to exit the site-remediation process.
- Sources of past controversies included:
    - Adding program flexibility was viewed as relaxing standards by some stakeholders but as a positive by others since it allowed contaminated properties to be brought back to productive use;
    - Disagreement over the appropriate balance of environmental protection versus implementability;
    - Revised standards were compared to other standards out-of-context by polarized parties;
    - There was a disconnect between how to handle cleanups of more recent releases when they overlay historic contamination; and
    - The basis for proposed changes has not always been clearly communicated.

Detailed minutes from the March 19, 2014 and subsequent interviews are attached to this report in Appendix C.

3.7.3 CT DPH Interview Information

On May 28, 2014, a telephone interview was conducted with Connecticut DPH staff. Staff included:

CT DPH

- Brian Toal – Risk Assessor
- Gary Ginsberg – Risk Assessor
- Margaret Harvey – Toxicologist and Risk Assessor

DPH communicated a number of ideas during the course of the interview. In particular:

- DPH communicated their role as risk assessors in the site assessment process, while DEEP are the risk managers;
- DPH responds to requests regarding additional polluting substances;
- In terms of best practices, they feel that there needs to be an established method to update the RSRs, perhaps keeping the RSR criteria separate from the regulation itself to allow for easier updating without the need for legislative review;
- Distribution of alternative polluting substance determinations to risk assessors and the public may be useful; and
- DPH does not feel that they have been strongly impacted by past controversies over the RSRs.

Notes from the May 28, 2014 interview are included in Appendix C.

3.7.4 Other Interview Information

In addition to the interviews conducted with DEEP and DPH staff, a discussion was held with Daniel Esty, the former commissioner of CT DEEP (and now a Professor at Yale). He identified the Transfer Act as a problem with the cleanup of contaminated sites in Connecticut, since sites are not generally identified until a property transfer occurs. Properties tend to remain as brownfields, because towns and developers wish to avoid liability and expense. He felt that a main goal of our project should be to establish effective risk-based priority guidance, including consideration of proposed land use, that would provide appropriate incentives for parties to redevelop contaminated sites (in addition to continuing to rely on a property-transfer-based approach). Through the identification of sites that pose lower risks or that will not be used in ways that are likely to pose risks, developers could take responsibility for proposing reasonable remediation approaches and use-scenarios, without the need for extensive DEEP involvement.

We also sought input from Timothy Sullivan, CT Director of Brownfield, Waterfront and Transit-Oriented Development; and attorneys Nancy Mendel and Lee Hoffman.

3.7.5 Accessibility of Documentation

Available material in Connecticut is generally accessible via CT DEEP's website or by request. Some documents, such as guidance documents for ecological risk assessment, are under development and are not publically available. Early draft copies of Connecticut's ecological risk assessment guidance were made available to the project team for review.

3.7.6 Feedback Mechanisms

CT DEEP holds a regular "Remediation Roundtable", with monthly informational meetings and regular updates by web site. DEEP also forms and uses work groups on specific topics regularly and invites comments on just about any draft work product. These interactions between and among DEEP staff, practitioners (technical and legal), business and industry groups, and environmental groups tend to be productive. DEEP is usually the interface with the legislature and with attorneys tracking events as they happen.

3.8 Current RSR Criteria in Soil

Though a thorough review of the existing RSR criteria was not called for in the scope of our review, we felt it worthwhile to review relevant aspects of the Direct Exposure Criteria (DEC) and Pollutant Mobility Criteria (PMC) derived and specified in RSRs.

3.8.1 Direct Exposure Criteria

As an initial step we compared Connecticut's residential Direct Exposure Criteria to Massachusetts' Direct Contact Standards for S-1 (residential) soil (310 CMR 40.0985(6)). By making this comparison, we are not necessarily endorsing Massachusetts' standards, but we felt it worthwhile to determine whether the Connecticut standards were systematically more or less conservative than those of a neighboring state.

Massachusetts has developed similar standards for 78 of the 89 chemicals for which DECs exist in the RSRs. Of the standards for these 78 chemicals, the two states have developed identical DECs for 18 (23%) of them and the standards differ by less than a factor of five for 62 of them (79%). Of the chemicals with standards differing by a factor of five or more, ten of the Connecticut standards are less than the Massachusetts' standards, while six are higher. For some of the chemicals with very different standards, the reasons for the differing standards are easily explained. 1,1-dichloroethene, for example, has a Connecticut residential DEC of 1 mg/kg and a Massachusetts S-1 Direct Contact Standard of 500 mg/kg. The factor of 500 difference is the largest for any chemical. The Connecticut DEC, however, was calculated back in 1995, while the Massachusetts standard was calculated in 2014. In 2002, EPA updated the toxicological data for 1,1-dichloroethene on which the DCEs are based, explaining the reason for the very large difference between the two standards. Hence, the Connecticut DECs are not systematically more or less conservative than those from Massachusetts. Table 3-1 summarizes the Connecticut and Massachusetts Direct Exposure Criteria and highlights the values that differ by a factor greater than or equal to five.

In reviewing the method used to derive the Connecticut DECs, we find that the general approach to deriving the criteria is mostly valid, with one exception, explained below. The exposure model presented in section 22a-133k-2 (b)(5) of the RSRs for the calculation of the Direct Exposure Criteria is similar to that used to estimate health risks due from the soil ingestion pathway in risk assessments performed under guidelines issued by EPA and many states. The formula used to calculate the residential Direct Exposure Criteria are:

$$\text{Carcinogenic:} \quad DEC_{RB} = \frac{Risk}{CSF} \div \left[\left(\frac{IR_C \times ED_C \times EF \times CF}{BW_C \times AT} \right) + \left(\frac{IR_A \times ED_A \times EF \times CF}{BW_A \times AT} \right) \right]$$

$$\text{Non-cancer:} \quad DEC_{RB} = (RFD \times HI) \div \left[\left(\frac{IR_C \times ED_C \times EF \times CF}{BW_C \times AT_C} \right) + \left(\frac{IR_A \times ED_A \times EF \times CF}{BW_A \times AT_A} \right) \right]$$

where the terms are:

DEC_{RB}	risk-based direct exposure criterion (mg/kg);
Risk	target cancer risk level (1×10^{-6});
HI	target hazard index (1);
CSF	cancer slope factor (kg-d/mg);
RFD	reference dose (mg/kg-d);
IR_C	ingestion rate – child (200 mg/d);
IR_A	ingestion rate – adult (100 mg/d);
EF	exposure frequency (365 d/yr);
ED_C	exposure duration – child (6 yrs);
ED_A	exposure duration – adult (24 yrs);
CF	conversion factor (0.000001 kg/mg);
BW_C	body weight – child (15 kg);
BW_A	body weight – adult (70 kg);
AT	averaging time for carcinogens (25,550 d);
AT_C	averaging time for non-carcinogens – child (2,190 d); and
AT_A	averaging time for non-carcinogens – adult (8,760 d).

However, it is not appropriate to sum the child and adult exposures as they are summed in the derivation of non-cancer criteria. The formula sums the average exposure over six years of childhood with the average exposure over 24 years of adulthood in an incorrect way that is equivalent to saying a person who takes one aspirin a day as a child and 2 aspirins a day as an adult, takes an average of 3 aspirins a day over the whole period. To correct the equation, it should be changed to include (i) only the child term or (ii) the adult term (choosing the smaller of the *DEC* obtained), or (iii) to calculate an average exposure over both a child and an adult; the choice depends on the relevant circumstances, the *RFD* and the averaging times used — for the averaging times selected, it is appropriate to use a subchronic *RFD* for the child, and a chronic RFD for the adult or child plus adult (see the definitions of the various RFD [acute, short-term, sub-chronic, chronic] provided, for example, in the IRIS glossary at http://ofmpub.epa.gov/sor_internet/registry/termreg/searchandretrieve/termsandacronyms/search.do) .

Typically, it is more important to evaluate non-carcinogenic exposure to children given their larger exposure rates (such as incidental soil ingestion) and lower body weight. Therefore, non-carcinogenic residential risks should be calculated for children rather than adults, for circumstances in which children may be exposed. In this case, the corrected equation would be:

$$\text{Non-cancer:} \quad DEC_{RB} = (RFD \times HI) \div \left(\frac{IR_C \times ED_C \times EF \times CF}{BW_C \times AT_C} \right)$$

For occupational exposure only, it would likely be correct to assume that exposure will be limited to adults, and use appropriate adult exposure factors.

The correct equation if both child and adult are to be included (using a chronic *RFD* with the given averaging times) is

$$\text{Non-cancer:}\quad DEC_{RB} = (RFD \times HI) \div \left\{ \frac{\left[\left(\frac{IR_C \times ED_C \times EF \times CF}{BW_C}\right) + \left(\frac{IR_A \times ED_A \times EF \times CF}{BW_A}\right)\right]}{AT_C + AT_A} \right\}$$

The specific exposure parameters, target risk limits, and chemical specific toxicological data that go into the derivation are primarily policy decisions, some of which are discussed elsewhere in this report. It is very important, however, that all exposure parameters, toxicity criteria, chemical specific parameters, and policy decisions that are used to calculate the DECs (and all other criteria in the RSRs, including pollutant mobility criteria) be thoroughly documented. Thorough documentation promotes confidence in, and better understanding of, the criteria that are calculated by CT DEEP or others.

Table 3-1 Comparison between Connecticut and Massachusetts Direct Exposure Criteria for residential soil

Chemical	Connecticut Direct Exposure (mg/kg)	Massachusetts Direct Contact (mg/kg)	Chemical	Connecticut Direct Exposure (mg/kg)	Massachusetts Direct Contact (mg/kg)
Volatile Organic Substances			**Volatile Organic Substances (cont.)**		
Acetone	500	500	Di-n-octyl phthalate	1000	NA
Acrylonitrile	1.1	NA	2,4-Dichlorophenol	200	70
Benzene	21	40	Fluoranthene	1000	1000
Bromoform	78	300	Fluorene	1000	1000
2-Butanone(MEK)	500	500	Hexachloroethane	44	50
Carbon tetrachloride	4.7	30	Hexachlorobenzene	1	0.7
Chlorobenzene	500	500	Naphthalene	1000	500
Chloroform	100	500	Pentachlorophenol	5.1	3
Dibromochloromethane	7.3	20	Phenanthrene	1000	500
1,2-Dichlorobenzene	500	1000	Phenol	1000	500
1,3-Dichlorobenzene	500	100	Pyrene	1000	1000
1,4-Dichlorobenzene	26	80	**Inorganic Substances**		
1,1-Dichloroethane	500	500	Antimony	27	20
1,2-Dichloroethane	6.7	20	Arsenic	10	20
1,1-Dichloroethylene	1	500	Barium	4700	1000
cis-1,2-Dichloroethylene	500	100	Beryllium	2	90
trans-1,2-Dichloroethylene	500	500	Cadmium	34	70
1,2-Dichloropropane	9	30	Chromium, trivalent	3900	1000
1,3-Dichloropropene	3.4	20	Chromium, hexavalent	100	100
Ethylbenzene	500	500	Copper	2500	NA
Ethylene dibromide	0.007	1	Cyanide	1400	30
Methyl-tert-butyl-ether	500	100	Lead	400	200
Methyl isobutyl ketone	500	500	Mercury	20	20
Methylene chloride	82	400	Nickel	1400	600
Styrene	500	70	Selenium	340	400
1,1,1,2-Tetrachloroethane	24	80	Silver	340	100
1,1,2,2-Tetrachloroethane	3.1	10	Thallium	5.4	8
Tetrachloroethylene	12	30	Vanadium	470	400
Toluene	500	500	Zinc	20000	1000
1,1,1-Trichloroethane	500	500	**Pesticides, PCB's and Total Petroleum Hydrocarbons**		
1,1,2-Trichloroethane	11	40	Alachlor	7.7	NA
Trichloroethylene	56	30	Aldicarb	14	NA
Vinyl chloride	0.32	1	Atrazine	2.8	NA
Xylenes	500	500	Chlordane	0.49	5
Acenaphthylene	1000	1000	Dieldrin	0.038	0.08
Anthracene	1000	1000	Endrin	20	10
Benzo(a)anthracene	1	7	2-4 D	680	NA
Benzo(b)fluoranthene	1	7	Heptachlor epoxide	0.067	0.1
Benzo(k)fluoranthene	8.4	70	Heptachlor	0.14	0.3
Benzo(a)pyrene	1	2	Lindane	20	NA
Bis(2-chloroethyl)ether	1	2	Methoxychlor	340	200
Bis(2-chloroisoprop)ether	8.8	30	Toxaphene	0.56	NA
Bis(2-EH)phthalate	44	90	PCBs	1	1
Butyl benzl phthalate	1000	NA	TPH by 418.1	500	1000
2-chlorophenol	340	100	ETPH	500	1000
Di-n-butyl phthalate	1000	NA			

NA indicates that no MA standard is available. Shading indicates a criterion that is a factor of at least 5 times larger (that is, less stringent) than the other.

3.8.2 Pollutant Mobility Criteria

Pollutant Mobility Criteria (PMC) are an important component of Connecticut's RSR program. As explained by the Department (CTDEEP, 2013)[9]:

> *Two remediation criteria must be met when remediating soil. These two criteria are the Direct Exposure Criteria and the Pollutant Mobility Criteria. . . .*
>
> *Pollutant Mobility Criteria are established to prevent the pollution of groundwater caused by soil contamination that is available to migrate into groundwater. With some exceptions, these criteria apply to soil located above the seasonal low water table. The Pollutant Mobility Criteria vary depending on the groundwater quality classification of the site. The RSRs also specify when an alternative Pollutant Mobility Criteria [sic] is appropriate. The amended RSRs include a compliance option using groundwater quality.*
>
> *The RSRs also specify circumstances in which the Pollutant Mobility Criteria do not apply. In general, these circumstances include cases where: polluted soil is located beneath a building, provided an Environmental Land Use Restriction is recorded to prohibit the building from being intentionally destroyed; widespread polluted fill exists, provided the groundwater in the subject area is not used for drinking water purposes; or an engineered control, such as an engineered cap, has been constructed to prevent the contamination of underlying groundwater.*

The RSR program envisions three means by which pollutants could migrate from soils and lead to exposure through other environmental media. Thus the State has established:

- Groundwater Protection Criteria (GWPC), that account for the potential leaching of chemicals to groundwater, with subsequent use of the groundwater as drinking water;
- Groundwater Volatilization Criteria (GWVC), that consider the volatilization of chemicals from groundwater into the soil vadose zone, further migration of the vapors into buildings, and subsequent exposure to building occupants *via* inhalation; and
- Surface Water Protection Criteria (SWPC), that assume that chemicals leach to groundwater that is subsequently discharged to surface water, potentially endangering aquatic organisms and predators that feed on them. The SWPC are the only RSR criteria that address non-human organisms.

Pollutant Mobility Criteria (PMCs) are not unique to the Connecticut program. For example, the Massachusetts Department of Environmental Protection (MA DEP) soil standards consider the same transport/exposure possibilities through leaching to groundwater. PMCs and similar criteria in other states tend to be substantially more stringent than standards that consider only direct contact by people with soil.

Mathematical equations (obtained by manipulating mathematical descriptions of simplified physical models of a particular conceptual site model) are used to estimate plausible relationships between a PMC concentration in soil and GWPC. CT DEEP's proposed 2008 updates to the RSR criteria also based PMC concentrations on GWVC and SWPC concentrations in groundwater and surface water. In

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[9] CT DEEP (2013). *Remediation Standard Regulations; An Environmental Program Fact Sheet*. Available at: http://www.ct.gov/deep/cwp/view.asp?a=2715&q=325014&deepNav_GID=1626.

order to be protective under essentially all foreseeable conditions, these modeled relationships are typically based on the worst-case assumption that the concentration of a chemical contaminant in soil is sufficient to (i) supply a local *equilibrium* concentration in groundwater, *and* (ii) sustain this concentration essentially indefinitely, *and* (iii) apply over an arbitrarily large area. Thus, not accounted for in such models is the loss of the chemical from soil, and hence depletion from the "contaminant reservoir" present in soil. In fact, when the total amount of the contaminant in soil is limited, transport can more or less rapidly reduce, and perhaps even deplete, the soil reservoir. In other words, when there is only a limited amount of contamination in soil, the default model can violate the fundamental principle of conservation of mass.

At many sites, actual soil contamination is not extensive enough to sustain the assumptions inherent in the default PMC conceptual site models. As presently structured, unfortunately, Connecticut PMCs do not provide the flexibility to account for finite source considerations. Application of a PMC to concentrations measured at each point can lead to unnecessarily over-protective and highly cost-ineffective remediation. Means of providing site-specific flexibility, including consideration of conceptual site models and realistic fate-and-transport models that account for spatial and temporal variability of contamination, would markedly improve the application of PMC approaches. Such an approach would not be difficult to incorporate into mathematical formulae representing such more realistic conceptual site models. Moreover, measurements of actual contaminant concentrations in relevant groundwater, from a sufficient number of representative samples, may provide more reliable indications of the actual mobility of pollutants at the site.

Table 3-2 compares Connecticut's PMCs to related criteria in the neighboring states of New York and Massachusetts for a set of contaminants frequently found at contaminated sites. Such comparisons are not straightforward. This is because the three states define groundwater classifications differently, impose ceiling concentrations at different points in the process, and apply the standards in different ways.

Connecticut classifies groundwater as GA/GAA (actual or potential drinking water sources) and GB (not drinking water). The Connecticut PMCs are applied both separately and in addition to the soil criteria (22a-133k-2).

Massachusetts classifies groundwater as GW-1 (drinking water), GW-2 (potential source for vapor intrusion), and GW-3 (potential to discharge to surface water), with all groundwater being considered at a minimum GW-3. Massachusetts does not develop a separate set of PMC equivalent concentrations, but instead combines consideration of contaminant migration to groundwater into its RSR-equivalent soil standards (the "Method 1" standards). Massachusetts does, however, make available in spreadsheet form the full derivation of all of its standards (MA DEP, 2014). In these spreadsheets, Massachusetts provides calculations of soil criteria associated with the leaching of soil contaminants to groundwater.[10] It is these intermediate soil concentrations that are summarized in .

New York develops a single set of criteria for "Protection of Groundwater" (NY DEC, 2006).

In Table 3-2 it is most appropriate to compare the Connecticut GA/GAA PMC with the Massachusetts S/GW-1 and New York Protection of Groundwater criteria. In this table, values that are more

[10] Importantly, the Massachusetts standards are adjusted upward if the derived leaching standard is less than either the background concentration or the Practical Quantitation Limit (PQL) for the contaminant of concern.

restrictive than the Connecticut PMCs are shaded green, while those less restrictive than the Connecticut PMCs are shaded red. Only the columns relevant to drinking water are shaded, since the other standards lack genuinely relevant points of comparison. With some exceptions, for the selected set of chemicals, the Connecticut PMCs are generally more restrictive than the related Massachusetts standards, but less restrictive than the New York standards. The comparison cannot be performed for metals and PCBs, because New York is the only one of the three that has derived standards for these contaminants, and Connecticut relies primarily on TCLP or SPLP testing to evaluate the possibility of metal migration to groundwater.

Table 3-2 Comparison of Connecticut Pollutant Mobility Criteria with groundwater protection standards in adjacent states

Contaminant	Connecticut PMC GA, GAA (mg/kg)	Connecticut PMC GB (mg/kg)	Massachusetts S/GW-1 Leaching/PQL (mg/kg)	Massachusetts S/GW-2 Leaching/PQL (mg/kg)	Massachusetts S/GW-3 Leaching/PQL (mg/kg)	New York Protection of Groundwater (mg/kg)
Arsenic	TCLP/SPLP	TCLP/SPLP	NA	NA	NA	16
Benzene	0.02	0.2	2	400	100000	0.06
Benzo(a)pyrene	1	1	NA	NA	NA	22
Cadmium	TCLP/SPLP	TCLP/SPLP	NA	NA	NA	7.5
Chromium III	TCLP/SPLP	TCLP/SPLP	NA	NA	NA	NA
Chromium VI	TCLP/SPLP	TCLP/SPLP	NA	NA	NA	19
cis-1,2-Dichloroethylene	1.4	14	0.3	0.1	2000	0.25
trans-1,2-Dichloroethylene	2	20	1	1	8000	0.19
Ethylbenzene	10.1	10.1	40	1000	4000	1
EPH	500	2500	1000	NA	3000000	NA
Lead	TCLP/SPLP	TCLP/SPLP	NA	NA	NA	450
Mercury	TCLP/SPLP	TCLP/SPLP	NA	NA	NA	0.73
PCBs	TCLP/SPLP	TCLP/SPLP	NA	NA	NA	3.2
Tetrachloroethylene	0.1	1	1	NA	100000	1.3
Toluene	20	67	30	2000	10000	0.7
TPH	500	2500	NA	NA	NA	NA
1,1,1-Trichloroethane	4	40	30	600	50000	0.68
Trichloroethylene	0.1	1	0.3	0.3	3000	0.47
Vinyl chloride	0.04	0.4	0.9	0.7	1000000	0.02
Xylene	19.5	19.5	400	100	3000	1.6

(light green)	Less than (that is, **more restrictive**/"conservative") the Connecticut Standard
(green)	Factor of 5 or more less than (that is, 5 or more times **more restrictive**/"conservative") the Connecticut Standard
(light red)	Greater than (that is, **less restrictive**/less "conservative") the Connecticut Standard
(red)	Factor of 5 or more greater than (that is, 5 or more times **less restrictive**/less "conservative")the Connecticut Standard
(yellow)	Equal to the Connecticut Standard

EPH: The Massachusetts EPH number is the lowest of the three EPH classes.
Mercury: New York number is "total mercury".
NA indicates not available.
TCLP/SPLP indicates that Connecticut evaluates potential leaching to groundwater via TCLP and/or SPLP analyses.

Section 4

Relevant Characteristics of Connecticut

In examining "best practices" for site risk assessment and risk management in other states — especially in neighboring states such as Massachusetts and New York — we wanted to make certain that such practices would comport with relevant, specific characteristics of the State of Connecticut. Characteristics that we considered included geography, industrial/colonial history, physical and geological characteristics, and reliance on groundwater supplies and other water resources. Further, we considered whether any Connecticut-specific characteristics of state or local government might present barriers to the adoption of best practices.

In general, we found that Connecticut was similar to both Massachusetts and New York in all relevant regards. In all three states: (i) groundwater tends to be both shallow and an important resource; (ii) there are rich and long industrial and post-industrial histories; (iii) significant fractions of the population derive their drinking water from private wells; and (iv) many residents consume at least some locally caught fish.

4.1 Groundwater

Groundwater is an important natural resource in Connecticut and elsewhere, and one that is correspondingly carefully managed and protected. According to the interviews with DPH staff, approximately 30% of Connecticut's drinking water is supplied by private wells. These wells tend not be intentionally disinfected or otherwise treated, so that this groundwater needs to be potable *per se*.

Groundwater is commonly found at relatively shallow depths in Connecticut, which has at least three important implications with regard to the potential for contamination:

1. Groundwater is susceptible to contamination from surface sources. To the extent that releases of contaminants at the surface enter the soils, infiltration commonly results in groundwater contaminant plumes;
2. In places where groundwater becomes contaminated with volatile substances (such as gasoline constituents or dry-cleaning solvents), the potential exists, in shallow groundwater systems, for volatilization of contaminants to result in those contaminants entering air within overlying structures; and
3. All groundwater is presumed to discharge to surface water. Shallow groundwater that becomes contaminated is, therefore, at least a potential source of contamination to the receiving surface water. The RSRs address this concept through the surface water protection criteria (SWPCs), which establish clean-up criteria in groundwater on the basis of protecting water quality in the receiving surface water body.

The Connecticut Water Quality Standards (WQS) (Sections 22a-426-1 through 9) establish, in pertinent part, the overall policy for management of groundwater resources in Connecticut. In part, the WQS provide for the protection of groundwater from degradation, as well as for the restoration of degraded groundwater to conditions consistent with the designated uses. Three components comprise the WQS: (i) narrative statements of policy; (ii) numerical water quality criteria; and (iii) classification maps for groundwater within Connecticut.

As it pertains to pollutant risk management in Connecticut, groundwater is divided into two primary classifications, summarized below:

GA: Groundwater is presumed to be of sufficient quality for drinking without treatment. Therefore, the RSRs establish standards consistent with this goal in both groundwater and soils. For groundwater, the RSRs establish the groundwater protection criteria (GWPCs). To the extent that groundwater is polluted above these criteria, it must be remediated to meet these criteria. For soils, there are pollutant mobility criteria (PMCs) for GA groundwater classifications, intended to protect groundwater for drinking from infiltrating contaminants from soils.

GB: Groundwater is presumed to not be suitable for drinking without treatment. Further, these groundwater resources are not actively restored to a condition suitable for drinking. Typically, these classifications are centered in and around urban or other developed areas, where historic uses may have degraded groundwater, and where municipal water is typically available as a drinking water source. For soils, the PMCs are correspondingly higher (that is, less restrictive). Notably, new contamination may not further degrade groundwater so as to interfere with any existing uses (such as use of this water for an industrial water supply).

4.2 Background Concentrations in Soil and Water

The issue of background concentrations of chemicals in soil and water has at least four aspects:

1. Naturally occurring substances;
2. Off-site groundwater plumes entering a subject site;
3. Historical conditions such as urban fill; and
4. Farms.

An extensive survey of environmental professionals in CT was conducted in 2012 on the topic of "background"; that survey is available on DEEP's web site (http://www.ct.gov/deep/lib/deep/site_clean_up/remediation_roundtable/backgroundsurveyresults.pdf). It does not appear that additional guidance has yet been published in response to that survey.

4.2.1 Naturally occurring substances

Studies of background concentrations of many metals, including in the northeastern U.S., have been published by the U.S. Geological Survey (USGS), and are comprehensive sources of such data in soils. These and other studies have demonstrated that arsenic, for example, is a naturally occurring metal in Connecticut (and elsewhere), and may be found in soils and ground water at concentrations larger than the RSR clean-up criteria. In such cases, "cleaning up" to below background would be wasteful at best.

The geological formations containing arsenic and radionuclides (radon, uranium and radium) run from Connecticut up through Massachusetts, Vermont, and New Hampshire. These States all supply fact sheets to the public on testing well water for these substances.

In addition to natural sources, human activities have affected the quality of groundwater from New England's crystalline rock aquifers. Examples of substances introduced to some aquifers by human activity include sodium and chloride from road salt; nitrates; MtBE (methyl tert-butyl ether); chloroform; and in some cases, pesticides.

Very local background concentrations of metals and other constituents may vary from area-wide averages, however, such that background concentrations may sometimes need to be established for a particular site. Nevertheless, the USGS sources provide a reasonable first assessment of the range of concentrations that may reasonably and/or naturally be present on a site. The Massachusetts DEP has also published background concentration data (available at http://www.mass.gov/eea/docs/dep/cleanup/laws/backtu.pdf) for many metals, organic contaminants such as polycyclic aromatic hydrocarbons (PAHs), and other hazardous substances: these published, peer-reviewed lists can and should be consulted with regard to sites in Connecticut.

4.2.2 Off-site groundwater plumes entering a subject site

Connecticut sites are often small, with multiple neighboring sites. Therefore, it is not uncommon for a groundwater plume to originate on an up-gradient site and affect groundwater quality on a subject site. The policy of DEEP is well established in this case (http://www.ct.gov/deep/cwp/view.asp?a=2715&q=324960&depNav_GID=1626). The down-gradient property owner is not liable for the dissolved contamination entering his site. However, if light non-aqueous phase liquid (LNAPL) enters the subject site, this does become the responsibility of the down-gradient property owner. As another matter, if contaminant volatilization is an actual threat to building occupants, this needs to be addressed. Appropriate site characterization is necessary to document the off-site source.

4.2.3 Historical conditions such as presence of "urban fill"

Connecticut, like many other northern, colonial states, has a long history of industrial development, including the use of wood and coal-fired boilers. As a result, and particularly in urban areas, it is common to find fill materials that contain coal or wood ash mixed with other discarded materials, generically referred to as "urban fill". Commonly, in certain areas, urban fill is extensive and underlies large portions of sites or multiple sites in an area. As such, this fill represents an historic background condition, typified by elevated concentrations of PAHs and certain metals. As a risk management tool, the RSRs allow exemption from certain criteria (PMC) where urban fill is documented to be present. This is a sensible risk management accommodation since the urban fill would be too costly to remove (if even physically possible) and these areas are generally supplied with public water, so the groundwater resource would not be used as drinking water.

4.2.4 Farms

Historical use of pesticides and herbicides can create another condition of background of large tracts of land. DEEP has policies recognizing the potential for this condition. During development of former farmland, developers are encouraged to test for the presence of pesticides or herbicides, and to contact DPH if these substances are found above applicable RSR criteria.

4.3 Development

Connecticut has an objective to preserve 21% of its land as open space by the year 2023 (Public Act 12-152). The majority of Connecticut land is privately owned and/or controlled. Connecticut has 169 towns or cities, including a small number of densely populated urban centers (*e.g.* Hartford, New

Haven, Waterbury, and Bridgeport). Overall, Connecticut has a diverse mix of cities, towns, suburban development and rural land use.

Connecticut, like Massachusetts and New York, has a long and rich manufacturing history (including foundries and mills) dating back to the earliest periods of industrialization. Many, but not all, of the former manufacturing centers are located in today's urban centers; and many are no longer operating as industries. There is a correspondingly rich and diverse legacy of contamination that resulted from historical industrial activities (Table 4-1).

Table 4-1 Examples of activities and types of contamination (modified from Thomas, 1993)

Activity	Type
Accidents	On-site spills, leaking equipment or machinery, releases during fire, migration from neighboring sites
Apple Orchards	Arsenic (used as a pesticide)
Atmospheric emissions	Cadmium, lead, other particle-bound pollutants
Community landfills	Hazardous household waste (*e.g.* weed killers, corrosive drain cleaners) and products of biodegradation
Construction materials	Asbestos, insulation, paints and pigments
Industrial and commercial land use (current or past)	Automobile repair and maintenance Battery, used oil recycling Dry cleaning Pesticides industry Service stations
Industrial landfills	Various chemicals and products of biodegradation
Soil deposit and removal	Unknowing use of contaminated soil from elsewhere
Storage and transfer	Stockpiling materials, on-site burial of wastes, sludges, or septic tanks
Tobacco farms	Pesticides
Underground storage tanks	Service stations, other properties
Water contamination	Farms, landfill sites

While some large sites are present in Connecticut (such as certain aerospace manufacturing sites), it is more typical that sites are relatively small in size. In some cases, larger historical sites have been subdivided into the current configuration of smaller sites. Evaluation of smaller sites presents particular challenges with regard to risk assessment and risk management. It is not uncommon for contamination issues to bridge property boundaries for one reason or another. Again, Massachusetts and New York face similar issues.

Finally, Connecticut has no large mineral or other resource mines in Connecticut, so that mine-related risk management issues are not addressed by the RSRs.

4.4 Government

The primary governing body for issues of environmental contamination is the Connecticut DEEP. The RSRs fall under DEEP's jurisdiction. However, with regard to issues of public health, CT DPH has the decision-making authority by state statute. Therefore, with regard to risk assessment decisions, DEEP and DPH work in cooperation.

The substantial number of private drinking water wells also fall under the jurisdiction of DPH. Regulations pertaining to private drinking water wells are written by DPH, but the rules are enforced at the local (town) level.

Connecticut is otherwise governed at the town level and does not have a significant county governmental role. With regard to issues of environmental contamination, cities and towns currently defer to DEEP and/or DPH. As argued elsewhere in this report, however, we feel that individual cities and towns (and/or their designated LEPs and risk assessors) do and should have important roles to play in at least some site assessment and site management decisions.

Section 5

Methods for evaluating Agencies' Practices

5.1 Specific Areas Evaluated

We evaluated the risk-based remediation practices of the States/Agencies described in Section 5.2 (below) using the requirements listed in the following paragraphs A-O (as defined in our contract for this project; the interpolated numbers in brackets refer to questionnaire numbers, as explained below):

A. Determine how exposures are currently defined:[Question 1 in our questionnaire and database]

i. How is the characterization of the exposure setting defined? [1.1] What environmental media are included in risk assessment [1.2] or criteria derivation? [1.3]

ii. What exposure pathways are evaluated? [1.4, 1.5] Are there exposure pathways that are omitted? [1.6, 1.7]

iii. How are exposure estimates based on direct environmental measurements or predictive models? [1.8] What models, if any, are used? [1.9]

iv. How are exposures to sensitive populations, groups or life-stages addressed? [1.10]

v. How are exposure estimates quantified? [1.11] Are central tendency or maximum exposure estimates used? [1.12]

vi. How are cumulative[11] exposures across multiple pathways addressed? [1.13]

vii. How are cumulative exposures to multiple substances across single [1.14] and multiple pathways addressed? [1.15]

viii. How uncertainty and variability are addressed in current exposure assessments?[1.16]

B. Assess how toxic effects are currently determined: [2]

i. What sources of toxicological information are considered? [2.1]

ii. How are toxic effects assessed for carcinogenic substances? [2.2]

iii. How are toxic effects assessed for non-carcinogenic substances? [2.3]

iv. How are subchronic and genotoxic effects assessed, including mutagenesis and teratogenesis? [2.4]

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[11] The term "cumulative" here was understood to mean the standard term "aggregate" for combination of exposures to a single substance through multiple pathways.

v. How is acute and chronic toxicity evaluated for ecological receptors? [2.5]

vi. How are appropriate toxicity values selected? [2.6]

vii. How are toxicity estimates made for substances for which no toxicity values are available? [2.7]

viii. How are vulnerable populations such as children addressed in toxicity assessments? [2.8]

ix. How are uncertainty and variability addressed in current toxicity assessments? [2.9]

C. Characterize how risks are currently estimated: [3]

i. How are risks for individual substances quantified? [3.1]

ii. How are risks from multiple substances quantified? [3.2]

iii. How are risks evaluated using point estimates or probabilistic assessments? [3.3]

iv. How are risks combined across multiple exposure pathways? [3.4]

v. What is the role of a Weight of Evidence approach in estimating risks? [3.5]

vi. How are variability and uncertainty addressed in the risk characterization process? [3.6]

D. Determine how remedial goals are set: [4]

i. How is risk management incorporated into risk-based decision making? [4.1]

ii. Are remedial goals set solely on the basis of risk assessment or are final remedial goals informed by other risk management considerations? Explain. [4.2]

iii. How have specific risk management policies and regulations affected how and which risks were addressed and which were not? [4.3]

iv. What administrative and legal tools are available for implementing remedial decisions? [4.4]

E. Determine what roles the following play in the risk management process:

i. Scientific factors; [Attribute evaluated for all questions, see also 4.2.2.14]

ii. Background or reference conditions; [2.5.1.2, 2.5.2.2, 2.5.3.2, 4.2.2]

iii. State and Federal Laws including the Resource Conservation and Recovery Act, the Comprehensive Environmental Response, Compensation and Liability Act, and the Clean Water Act; [4.2.2]

iv. State and Federal policies, laws and legal decisions; [4.2.2]

v. Economic factors including the costs and benefits of reducing risks; [4.2.2]

vi. Social factors; [4.2.2]

vii. Technological constraints; [4.2.2]

viii. Political and legal factors; [4.2.2] and

ix. Valuation of ecological systems and services. [4.2.2]

F. Determine roles and legal responsibilities, as applicable, of state agencies [for Connecticut, this would include DEEP and the Connecticut Department of Public Health ("DPH")], local agencies, Licensed Environmental Professionals (or similarly designated persons), and stakeholders such as the public and responsible parties in making risked based decisions. [5]

G. Assess what roles exist for regulation or guidance within risk-based decision making. [5, together with the legal status of references in answers]

H. Determine if adaptive management is considered during the risk-based decision making. [6]

I. Evaluate how risk-based decisions and risk management decisions are communicated to the regulated community, stakeholders and the public, and at what stages of the decision-making process such communication occurs. [7]

J. Determine how current remediation practices support risk assessment and risk management activities:

i. Do site characterization, as described in applicable guidance or rules (for Connecticut, the Site Characterization Guidance Document), activities provide sufficient information to assess risks at contaminated sites?

ii. What is the relationship between the Conceptual Site Model and the exposure assessment? [1.1]

K. Determine the legislated or regulated timeliness of responses by agencies. What deadlines are required by law or regulation? [8]

L. Evaluate the accessibility of documentation of methods and procedures. How easy is it to locate and retrieve information on the legislated or regulated requirements for remedial actions? [This is answered separately, in Section 6.4.3.]

M. Determine what feedback mechanisms from users to regulators and legislators exist. What web sites, public dockets, working committees, or other mechanisms allow feedback from the regulated community and the public? [This is answered separately, in Section 6.4.3.]

N. What mechanisms are available for updating procedures and values? Are there mechanisms built into legislation or regulation that require updates, revisions, and corrections to toxicity values and other risk-related parameters, and what is the timeline for such modifications? [9]

O. How flexible are the approaches allowed for site evaluation and remedial options? Is there a single track or multiple options for site evaluations, and are there alternative options for remediation (*e.g.*, depending on site use)? [10]

To efficiently evaluate these requirements, we constructed a questionnaire that incorporated these questions (except as noted), but limited the potential responses to a defined set, and incorporated the results into a database (see Section 5.4). The questionnaire numbering (in brackets) is included in the list above to show the relationship between the requirements and the questionnaire. This approach was taken to limit the detail necessary to extract from individual State/Agency documentation, although such details are accessible by any user from the original documentation through the references that we have coded in the database. The limitation was necessary for four reasons: first, the limitation on resources available in any such examination; second, the commonality of much of the detail; third, the State/Agency specificity of other details; and fourth, the impossibility of evaluating best practices at the finest level of detail, since such details are interdependent and often subject to substantial scientific uncertainty.[12] The full content of the database is provided in Excel workbook file "CTDEEP Project Database & Results.xlsm" accompanying this report.

Since many of the requirements are essentially open-ended in the level of detail to be examined, and any examination is necessarily resource constrained, we limited the level of detail examined by pre-selecting all responses to questions about the State/Agency programs. This also facilitated the construction of a database to hold those responses, and allowed a ranking system to be used for comparisons. The limitation on the level of detail was also suggested by the commonality to be expected between many State/Agency programs — since all are examining the same problem of risk-based remediation of contaminated sites, and HHRA methodologies (at least) are well-established; and such commonalities allow pre-selection of the most important variations in responses. Finally, while there will be State/Province/Agency variations in particular small details, such variations may be specific to location, local legislation, local discussions with affected parties, or other factors that might not be readily translatable to sites in Connecticut.

5.2 States and Agencies Evaluated

We originally intended to evaluate the following lists of States or Agencies (as incorporated in the contract): New Jersey, New York, the other five New England states, California, Montana, Michigan, Illinois, Texas, the Department of Energy, the European Union, Canada, and the U.S. Environmental Protection Agency; with the European Union limited to evaluation of Directives of the European Union, and with evaluation of Canada limited to the practices required or recommended by Federal Government, and then only with respect to paragraphs A to C (see Section 5.1). During preliminary fact-finding, we learned that the limitations of the evaluation of the European Union would mean that the questions would be essentially unanswerable, since the European Union has delegated risk-based remedial actions to individual States of the Union rather than issuing Union-wide Directives. With the concurrence of CT DEEP, the European Union was therefore dropped from consideration. For Canada, we did not limit the inquiry to just paragraphs A to C, but incorporated responses to all questions in the database (where such responses were possible).

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[12] Many of these fine details are set by policy choices of the State/Agency; best practice is thus that the required policy choices have been made (by whatever process is applied by that State/Agency), rather than the values finally adopted. For example, attempting to determine a best practice for specific age ranges that should separately be evaluated would require further assumptions about the range of chemicals and end points to be evaluated, and specifying relative values to be applied for each of those different chemicals and end points. The same exponential increase in complexity would occur through evaluation of finer levels of detail for most of the inputs into risk assessments. In this case, we characterize best practice as the adoption of multiple age ranges, rather than attempting to second-guess the State/Agency as to the specific values of those age ranges.

We also evaluated certain, but not all, aspects of British Columbia, Canada, since that we have found that province to have a long history of successfully protecting environmental resources while simultaneously encouraging economic development.

Individual States and Agencies (including Connecticut and the DEEP) generally do not have single risk-based decision-making processes for remediation of contaminated sites. In most cases there are multiple options, or the defined processes can be classified into such options. We therefore evaluated each such option separately — these options are called "Methods" subsequently (matching nomenclature used in Massachusetts, Rhode Island, and New Hampshire).[13] With the omission of the European Union, we evaluated sixteen States or Agencies; however, these States and Agencies collectively had 38 Methods for risk-based site remediation, so that is the number of Methods we incorporated in the database. The States/Agencies and Methods evaluated are listed in Table 5-1, together with the Method name used in the database and subsequently in tables here.

Table 5-1 States/Agencies and names of Methods as recorded in the database

State/Agency	Method	Method Description
California	Prelim Endang Assess	Preliminary Endangerment Assessment
California	RI/FS Predictive Eco	Remedial Investigation / Feasibility Study accompanied by a Predictive Ecological Assessment
Canada	1 PQRA HHRA	Preliminary Quantitative Risk Assessment – Human Health Risk Assessment
Canada	2 DQRA HHRA	Detailed Quantitative Risk Assessment – Human Health Risk Assessment
Canada	3 ERA SL/PQRA/DQRA	Ecological Risk Assessment, Screening Level / Preliminary Quantitative Risk Assessment / Detailed Quantitative Risk Assessment
Connecticut	Default	Default comparison to RSR criteria
Connecticut	EC / ELUR	Application of Engineered Controls and Environmental Land Use Restrictions
Connecticut	Var / except / alt	Variations, exceptions, and alternate methods
DOE	1	DOE practices were evaluated as a single method
EPA	1 ERA	Ecological Risk Assessment practices
EPA	2 HHRA	Human Health Risk Assessment practices
Illinois	Tier 1	Comparison of contaminant concentrations to baseline remediation objectives
Illinois	Tier 2	Development of remediation objectives applying site-specific data to modeling equations
Illinois	Tier 3	Development of full site-specific remediation objectives
Maine	1	Maine practices were evaluated as a single method
Massachusetts	Method 1	Comparison to Massachusetts DEP derived soil and groundwater standards
Massachusetts	Method 2	Modification of the DEP derived standards or derivation of standards for chemicals not having Method 1 standards
Massachusetts	Method 3	Site-specific risk assessment
Michigan	Generic Criteria	Comparison to criteria

[13] We capitalize "Method" in what follows where we specifically refer to State/Agency processes for risk-based site remediation. Otherwise "method" has its usual meaning.

State/Agency	Method	Method Description
Michigan	Site Specific RA	Site-specific risk assessment
Montana	1	Tier 1. Comparison to pre-determined risk-based screening levels
Montana	2	Tier 2. Site-specific risk assessment
New Hampshire	1	Method 1. Comparison to soil and groundwater remediation standards
New Hampshire	2	Method 2. Modification of remediation standards
New Hampshire	3	Method 3. Site-specific risk assessment
New Jersey	ERA	Ecological Risk Assessment
New Jersey	HHRA	Human Health Risk Assessment
New York	QHHEA/FWRIA	Qualitative Human Health Exposure Assessment / Fish and Wildlife Resource Impact Analysis
Rhode Island	Method 1 & 2	Comparison to RIDEM developed criteria and additional criteria calculated using provided formulas
Rhode Island	Method 3	Risk assessment using EPA guidance
Texas	eco 1	Ecological Risk Assessment – Exclusion Criteria Checklist
Texas	eco 2	Ecological Risk Assessment – Screening Level Ecological Risk Assessment
Texas	eco 3	Ecological Risk Assessment – Site-specific ecological risk assessment
Texas	human 1	Human Health Risk Assessment - Comparison to generic Protective Concentration Levels
Texas	human 2	Human Health Risk Assessment - Modification of Protective Concentration Levels using site-specific parameters
Texas	human 3	Human Health Risk Assessment - Site-specific risk assessment
Vermont	Risk Assessment	Site-specific risk assessment
Vermont	State Provided Value	Comparison of contaminant concentrations to state provided values

As can be inferred from the naming, some States/Agencies combine HHRA and ERA in single Methods, while others separate them (although they tend to have many common features — particularly the exposure assessments involved). Of the 38 Methods, six are specifically for ecological risk assessment (ERA) only and seven specifically for human health risk assessment (HHRA) only, while the remaining 25 incorporate both. The original requirements listed in Section 5.1 in many cases did not separate HHRA and ERA (and clearly has most emphasis on HHRA), so in cases where we considered an important distinction was possible, we expanded our questionnaire to separately evaluate HHRA and ERA. To the extent possible, we attempted to be consistent across the various agencies in determining what constituted a distinct method. If States/Agencies themselves named distinct methods, we used them, since all documents consulted referred to those methods. Otherwise, due to major differences between programs, it was not always possible to separate the methods in identical ways, and we used professional judgment in determining how best to evaluate each program. As an example, the use of Engineered Controls (ECs) and Environmental Land Use Restrictions (ELURs) in Connecticut was treated as a separate method, because a number of the questions posed by CT DEEP required different answers for these risk assessments, along with different regulatory citations. Neighboring Massachusetts also allows for the use of engineered barriers and Activity and Use Limitations (similar to ECs and ELURs), but because of the explicit divisions in the Massachusetts regulations between Method 1, 2, and 3 risk characterizations, the use of engineered barriers and AULs is not treated as a separate method in Massachusetts.

5.3 Consideration of Site-Based Remediation in States Adjacent to Connecticut

While differences exist between conditions in Connecticut and those in other parts of the country, we think it informative to compare in more detail the risk-based remediation program in Connecticut to the programs in the neighboring states of New York and Massachusetts; indeed, many of the same considerations that go (or should go) into the remediation of contaminated sites in Connecticut would also apply to sites in these adjacent states.

5.3.1 Massachusetts

Massachusetts's contaminated site remediation program is conducted under the Massachusetts Contingency Plan (MCP), which outlines three Methods for evaluating risks at contaminated sites. Method 1 is a direct comparison to soil and groundwater standards, similar to Connecticut's RSR criteria. Method 2 involves the development of new standards or modification of existing standards based on site-specific parameters, similar to Connecticut's methods for deriving RSR criteria for Additional Polluting Substances (APS) or alternative RSR criteria. Method 3 is a site-specific evaluation of risks. A Method 3 risk characterization can be performed at any site, though in practice, its use is generally limited to sites at which a Method 1 risk characterization cannot be used to achieve the desired remedial objective. Site-specific human health risk assessments of this type are generally not performed in Connecticut, with the exception of at large federal Superfund sites. Site-specific ecological risk assessments are performed in Connecticut under the oversight of CT DEEP, but with very little formal guidance for assessment and/or management. CT DEEP is currently developing guidance for the conduct of such site-specific ecological risk assessments.

Massachusetts site investigations are typically conducted by (or under the oversight of) a Licensed Site Professional (LSP). Some aspects of the role filled by LSPs are similar to those filled by Licensed Environmental Professionals (LEPs) in Connecticut. In discussions with regulators and risk assessors in both states, however, we have found that Massachusetts LSPs are generally given greater responsibility for making site-specific determinations without direct oversight from DEP than are Connecticut LEPs with regard to DEEP. Connecticut LEPs are required to have more consultation with and approvals from DEEP for site-specific determinations when deriving RSR criteria for APSs or conducting site-specific environmental risk assessments. In both states, decisions made by LSPs/LEPs are subject to audits, which are conducted on a subset of remediated sites.

Practicing environmental professionals who have worked in both states have indicated to us that there appears to be a greater degree of productive and collegial interaction between the LSP Association (LSPA) and MA DEP than occurs between the Environmental Professionals Organization of Connecticut (EPOC) and CT DEEP. These interactions take the form of joint training programs, close working relationships with respect to audits and changes to regulations or policies, and other forms. To be sure, many interactions do occur in both states. Connecticut DEEP has formed many workgroups to examine various aspects of the site-remediation program; LEPs and a broad group of stakeholders make up these workgroups. To the extent that such interactions establish relationships and promote shared understanding of the issues involved in site remediation, we believe that making an effort to further increase the level of interaction between LEPs and CT DEEP would be beneficial to all.

One aspect of the Massachusetts program that generally receives strong praise is the documentation of the derivation of the Method 1 soil and groundwater standards. MA DEP publishes a set of spreadsheets documenting the derivation of every soil and groundwater standard included in the MCP. All inputs to the derivation are clearly displayed in the spreadsheet, and in the few cases for which exceptions have been made, or policy decisions have been made, regarding a specific chemical, notes in the spreadsheet clearly indicate the basis for the standard. While there will never be consensus that cleanup standards are perfect, or even "correct," the Massachusetts risk assessment community does, at least, have a thorough understanding of MA DEP's derivation of the standards. By contrast, the documentation of Connecticut's RSR criteria is incomplete, therefore, the bases for the criteria are not transparent.

5.3.2 New York

New York's remedial program is described by two key documents. The first is *New York Regulations Chapter IV Quality Services – Part 375 Environmental Remediation Programs*. These regulations promulgate New York's Soil Cleanup Objectives. The second is NYS DEC's policy document, *DER-10 / Technical Guidance for Site Investigation and Remediation* (NYS DEC, 2010). This policy document provides an overview of the site investigation and remediation Process administered by NYS DEC's Division of Environmental Remediation.

Not all aspects of a State's remediation program are always evident solely from a review of legislation, regulation, and guidance documents. While the scope of our review did not include discussions with regulators and practitioners in all of the states and agencies we evaluated, we felt it worthwhile to talk with practitioners in New York, given its close proximity to Connecticut.

The consensus among those with whom we spoke is that there is some flexibility to New York's remediation program that is not immediately evident upon a review of the documentation. New York allows for both comparison to standards or site-specific risk assessment. New York's Project Managers (PMs) for contaminated sites have some flexibility to make site-specific decisions based on cost-benefit analyses. We learned of examples of sites where NYS DEC PMs have allowed relatively small areas of contamination to remain at levels exceeding their soil cleanup objectives (with continued monitoring), at sites where a cleanup would be excessively costly and the resources would be better spent on other parts of a site. NYS DEC PMs have generally made themselves available to consultants conducting response actions to meet and discuss the best remedial options. We did receive comments that there appear to be some regional differences across the state, perhaps depending on the individual PM and site-specific circumstances, and that some regions and some PMs are more willing to be flexible than others. This is perhaps always the case in such matters. Practitioners also voiced opinions that NYS DEC has exercised increased flexibility over the past ten years, perhaps in part due to the need to continue cleaning up contaminated sites while faced with budget cuts and more limited resources than in the past.

New York State does not have an LEP or LSP program analogous to those in Connecticut or Massachusetts. Part of the role played by LEPs or LSPs is filled by either Professional Engineers (PEs) or Qualified Environmental Professionals (QEPs). Either a PE or QEP is generally required to sign off on most submissions related to site investigations and remediation. The role has not been privatized, however, as it has been in Connecticut and Massachusetts.

As in Massachusetts, practitioners in New York believe that the cleanup objectives are well documented by NYSDEC.

5.4 Questionnaire Contents and Scoring

5.4.1 Questionnaire Construction

In order to facilitate the comparisons required (Section 5.1), we constructed a questionnaire with a 2-level question structure, the top level corresponding to individual paragraphs of the contract requirements, and the 2nd level corresponding to the multiple sub-questions present in those requirements. The relation of the question numbering to the contract requirements is shown above in Section 5-1.

For each such question, a list of potential responses was also constructed with the aim of allowing yes/no responses based on documentation for each of the States and Agencies. The level of detail of the potential responses was designed to elucidate distinct potentially relevant differences between States and Agencies. Some potential responses could be quite extensive, so that the some potential responses had multiple sub-levels.

The set of responses to each question was designed to be all-inclusive but not necessarily unique — indeed, multiple responses to some questions were expected. All explicit potential responses were included that were considered likely (prior to examination of the documentation from all the States and Agencies), and all generally included a catchall "Other" category of response, together with a "Not specified" response. The former was used when none of the listed responses corresponded to what was documented by the State or Agency, and "Not specified" was used when the response to the question could not be found in the documentation we examined. A full list of the questions and potential responses is given in Appendix F, and full details of the questionnaire construction are described in Appendix G.

5.4.2 Responses collected

We obtained all relevant and locatable documentation from all the States and Agencies listed in Section 5.2 (Appendix K) and provide them accompanying this document. Where only web pages were available, they were converted to Portable Document Format files for storage. We extracted appropriate responses to the questions, based on our reading of the documentation, and coded them in a database. Each response was coded with an explicit reference to a document, and that reference was also coded as to the authority of the documentation (legislation, regulation, guidance, or other). The referencing allows for follow-up to obtain more detail by users.

There is a complete set of responses for each Method specified by each State/Agency or otherwise constructed, as described in Section 5.2, so we evaluated a total of 16 States/Agencies with 38 Methods.

Full details of the database contents are in Appendix G, which also includes instructions on easily accessing all selected responses and the documents justifying those responses for any individual question.

5.4.3 Scoring

We assigned a weight to each of the possible responses to the questionnaire for each of the relevant attributes of best practice described in Section 6.3, as described more fully in Appendix G. For each Method, we looked at the selected responses to the questions in the questionnaire, and used the weights assigned to those selected responses to construct a score for that Method for each of the attributes. Construction of scores depended on the question involved and the attribute. For some questions and attributes, the score consists of the sum of the weights of selected responses (recall that some questions allowed for multiple responses); for other questions and attributes the score is the maximum weight assigned to any selected response; and we used a total of six such alternative approaches (including ignoring the question where it is irrelevant for a particular attribute). For example, Question 1.12 has 10 possible responses, two of which are marked as selected for Massachusetts Method 1. The weights assigned to those two particular responses for the "Protectiveness" attribute are 0.1 and 1.0, and the approach taken in this case was to choose the maximum, so the score for the attribute of "Protectiveness" for Massachusetts Method 1 for question 1.12 is 1.0.

Full details of the method we used to construct the scores from the assigned weights is described in Appendix G; the result is a score for each attribute of best practice for each of the questions for each Method evaluated. We then also constructed the average of the scores for each attribute.

5.4.4 Limitations of the Scoring

Sections 5.4.1 through 5.4.3 summarize the methodology used to evaluate and compare the Methods for risk-based decision making processes of other States and Agencies with those of Connecticut. The comparison is made with respect to our contract-specified requirements by assigning weighting factors for each of the attributes of best practices described in Section 6.3, and accumulating scores constructed from these weights using the responses (describing the Methods) that we recorded in the database. Section 6.3 describes 10 attributes, although only the first nine are incorporated in the analysis — the 10^{th}, stakeholder involvement, was incorporated as part of the Appropriateness attribute in the evaluation of weights.

We applied this methodology to requirements A (exposure assessment), B (toxic effects assessment), and C (risk characterization) (questions 1 through 3 of the database), since they had sufficient detail to allow such a quantitative methodology. The results for other requirements were coded in the database, and the same methodology can be readily applied; however, we consider the results to be too sparse for quantitative evaluation. For subsequent requirements (questions 4 through 10 of the database) we therefore give a qualitative description.

There are several limitations of this approach. The level of detail was limited for the four reasons given in Section 5.1, so there are relatively few questionnaire responses to analyze (although still a large number). Moreover, in many cases the required information is not specified by the documentation obtained for the Methods evaluated, leaving it indeterminate how to score the program against the attributes of best practice. In the results presented here, we have chosen to penalize the "not specified" response by assigning it the lowest weight for every attribute. This has the advantage that all of the questions posed by CT DEEP are incorporated in the scores for every Method, but may be unrepresentative of actual practice in some cases. Insofar as the various contract specified requirements are scored differently (as is inevitable to some extent), differences in the final score between Methods may reflect both the different relationships to best practices (as measured by the individual attribute scores) and the variation between Methods in the amount of explicit documentation.

In order to obtain summary scores, we also average the scores accumulated up to the top level of the questions (for requirements A–C — questions 1–3 in the database); and average the resulting scores across attributes and across the three requirements A–C. For requirements B and C, there was no discrimination between Methods for some of the attributes (*e.g.*, if the attributes do not apply, as for proportionality for requirement B, "Assess how toxic effects are currently determined"). Thus once again, differences in the final average weight may reflect differences in the attributes included in the average for the three requirements.

5.5 Flow Diagrams of Practices

As part of our review, we have constructed or located within the documentation from each state or agency flow diagrams for the procedures used to set remedial goals and how the risk management process is perceived by the particular state or agency. These are based on the documentation retrieved in constructing the database as discussed in Section 5.4. Because the flow diagrams were created by different agencies communicating varying aspects of the remedial and risk management processes, the flow diagrams highlight different parts of the remediation process and present varying levels of detail. For a few programs, we felt it necessary to present more than one flow diagram to communicate different aspects of the remedial goal and risk management processes. For others, flow diagrams were identified for only part of the remedial process. The practices described in the flow diagrams are described and coded in the database.

Appendix J contains the flow diagrams for each agency evaluated.

Section 6

Best Practices in Public Health Risk Management and Public Health Risk Assessment

6.1 What Are the Attributes of "Best Practices"?

One of our tasks for this project has been to determine "best practices" for four sets of activities with regard to (potentially) contaminated parcels of land: (i) human health risk assessment (HHRA), (ii) human health risk management (HHRM), (iii) ecological health risk assessment (ERA), and (iv) ecological health risk management (ERM).

To begin, we adopt the definition of risk management offered by Omenn *et al*. (1997), is:

> *. . . the process of identifying, evaluating, selecting, and implementing actions to* ***reduce risk to human health and to ecosystems****. The goal of risk management is scientifically sound, cost-effective, integrated actions that reduce or prevent risks while taking into account social, cultural, ethical, political, and legal considerations.* [emphasis added]

Now, of course, the best way to "reduce risk to human health and to ecosystems" is not to pollute land, water, or air in the first place. For brownfields and other contaminated sites, however, pollution prevention is no longer an option. By definition, some risks are already present at these sites, so that the "prevention" aspect of risk management pertains to the prevention of future risks if the site remains as is with current or altered future use, as well as to the prevention, or at least minimization, of the (typically different) risks associated with taking remedial actions at the property.

For any given property, the *specific goals of risk management should dictate the specific tasks of risk assessment* to be undertaken. For example, is the site to be managed so as to reduce the rate of habitat loss for (one or more species of) wildlife? If so, then the assessments to be performed should differ from those required to meet the different goals of, for example, property redevelopment for commercial use. In that sense, some aspects of risk management precede risk assessment. So too does the important risk management aspect of stakeholder involvemen***t***.

Quoting again from Omenn *et al*. (1997):

> In the case of a contaminated site, stakeholders would include those whose health, economic well-being, and quality of life are currently affected or would be affected by the cleanup and the site's subsequent use. They would also include those who are legally responsible for the site's contamination and cleanup, those with regulatory responsibility, and those who may speak on behalf of ecological considerations or future generations.

Ideally, the scope of a risk assessment for any given site would be agreed upon by — or at least presented to — all relevant stakeholders before the assessment begins. Too many times, stakeholders are brought in — via "risk communication" — only after the results of the risk assessment, if not the risk management decisions themselves, are already in.

On the other hand, involving stakeholders takes time and money, and does not in and of itself guarantee "success," however defined; nor does it ensure consensus. Stakeholder involvement should be done in proportion to the complexities, controversies, and other issues associated with any given site. Accordingly, optimal types and extents of stakeholder involvement will vary from site to site.

Moreover, since each site will have its own set of stakeholders, stakeholder involvement may well lead to different decisions being made at different sites. This means that best practices must be flexible — although not so flexible, of course, as to become arbitrary, baseless, or irreproducible. Flexibility is an advantage, but also should have limits.

To decide on other "best practices" in risk assessment and risk management (recognizing, of course, that others may disagree with our choices and/or definitions), it may be helpful to consider an analogy.

In some senses, land that has become contaminated is like a person who has become sick. So, just as we want to use "best practices" to diagnose and treat a patient, so too do we want to use "best practices" to assess and restore parcels of contaminated land. Of course, this analogy has its limits, and should not be taken to the extreme; but it may provide some perspective, as follows.

First, it is currently believed that "evidence-based medicine" is better than medical decisions made more or less on the basis of an individual physician's personal knowledge or inclinations. So too should "*evidence-based risk assessment*", however defined, be considered to be a best practice. And, of course, since science is never finished, toxicological, ecological, chemical, and other knowledge will change with time. The methods and details of health and ecological risk assessments must change accordingly.

Next, the scientific evidence on which risk assessments are made must be *well-documented*, and the calculations underlying the assessments must be readily *reproducible* by other professionals.

Next, most of us would agree that a patient's evaluation and treatment should be *proportional* to the nature and extent of his disease. So too, then, should the assessment and restoration of parcels of land be proportional to the nature and extent of the contamination of that land. To state the obvious, diagnosing and treating a headache is straightforward (and can be done by a nurse, if not by the patient himself); whereas diagnosing and treating a brain tumor is much more complicated (and should be done by a neurosurgeon). Similarly, a small amount of gasoline that has recently leaked from an underground storage tank on a two acre site will be easier to assess and remediate (by an LEP alone) than a large former manufacturing site that has been home to hundreds of years of activities, few of which have been well documented (so that perhaps an LEP, a risk assessor, and others need all be involved).

Similarly, we all know that a patient's *treatment should not be worse than his disease*. For some diseases, time itself may heal the wound. For other diseases, aggressive interventional treatment is the best approach. And in still other instances, physicians (and others) should admit that the disease cannot be cured, so that implementing aggressive treatments may do more harm than good. Again, the analogy holds for contaminated lands.

Next, best practices must be *practical*. Modifying a bit what we just noted, we would add that not all sites need extensive stakeholder involvement. Most contaminated properties in the State are small, relatively uncomplicated, and otherwise straightforward with regard to their assessment and management. Similarly, the more that environmental professionals can rely on default methods and criteria, the better.

6.2 National Academies Recommendations

We examined the National Academy of Sciences (NAS) reports listed in Section 6.2.1, and the Presidential/Congressional Committee report (Omenn *et al*., 1997) for recommendations for best practices relevant to risk-based remediation for contaminated sites. These reports were selected as those most likely to contain such recommendations, since they dealt with topics on or related to risk assessment in general or in specific cases. Some of the reports (NRC, 1987, 2006b, 2007b, 2010b,2014b; IOM, 2009) are workshop, symposium, or interim reports with no recommendations. Many of the 448 recommendations identified are too specific for general application for remediation of contaminated sites; many others are specific (for example, are directed at the agency that commissioned the report) but generalizable to risk-based remediation of contaminated sites; and many are general recommendations with direct application to almost any risk assessment/risk management situation. Because of the authoritativeness of National Academy panels, we rely on these recommendations, as practiced by one or more States or Agencies, for peer-reviewed definitions of best practices.

Only three of the reports contained recommendations primarily directed at ecological risks (Omenn *et al*., 1997; NRC 2005, 2013b), and these are examined in Section 7.1, with the remainder examining human health risk assessment/risk management. The general or generalizable human health recommendations (a total of 205 recommendations, although some are near duplicates) could be categorized as primarily dealing with:

- Management of the process of risk assessment
- Requirements versus guidelines
- Characterization of risk
- Evaluation of risk
- Uncertainty analysis
- Default assumptions
- Use of best available scientific information
- Planning of risk assessments
- Evaluation of dose-response relationships
- Cumulative assessment
- Evaluation of multiple outcomes
- External/peer/stakeholder review
- Use of expert judgment
- Documentation and communication
- Identification of data sources and methodology
- Susceptibility
- Coordination of different Agency offices
- Economic considerations
- Remedial effectiveness
- Judicial review

Some of the recommendations encompassed multiple of these categories, and some of the categories listed (*e.g.*, on judicial review) are not relevant to our task.

6.2.1 National Academies Reports Reviewed for Section 6.2

The following National Academies reports were reviewed in our evaluation of best practices. Full references for these reports are included in Section 8.

- Environmental Health Sciences Decision Making: Risk Management, Evidence, and Ethics: Workshop Summary (IOM, 2009)
- Environmental Decisions in the Face of Uncertainty (IOM, 2013)
- Risk Assessment in the Federal Government: Managing the Process (NRC, 1983a)
- Risk Assessment in the Federal Government: Managing the Process Working Papers (NRC, 1983b)
- Drinking water and health, Volume 8: Pharmacokinetics in Risk Assessment (NRC, 1987)
- Issues in Risk Assessment (NRC, 1993)
- Science and Judgment in Risk Assessment (NRC, 1994)
- Risk Assessment of Radon in Drinking Water (NRC, 1999)
- Superfund and Mining Megasites: Lessons from the Coeur d'Alene River Basin (NRC, 2005)
- Assessing the Human Health Risks of Trichloroethylene: Key Scientific Issues (NRC, 2006a)
- Toxicity Testing for Assessment of Environmental Agents: Interim Report (NRC, 2006b)
- Applications of Toxicogenomic Technologies to Predictive Toxicology and Risk Assessment (NRC, 2007a)
- Toxicity Testing in the 21st Century: A Vision and a Strategy (NRC, 2007b)
- Scientific Review of the Proposed Risk Assessment Bulletin from the Office of Management and Budget (NRC, 2007c)
- Phthalates and Cumulative Risk Assessment: The Task Ahead (NRC, 2008)
- Science and Decisions: Advancing Risk Assessment (NRC, 2009)
- Review of the Environmental Protection Agency's Draft IRIS Assessment of Tetrachloroethylene (NRC, 2010a)
- Toxicity Pathway-Based Risk Assessment: Preparing for Paradigm Change: A Symposium Summary (NRC, 2010b)
- Review of the Environmental Protection Agency's Draft IRIS Assessment of Formaldehyde (NRC, 2011)
- Critical Aspects of EPA's IRIS Assessment of Inorganic Arsenic: Interim Report (NRC, 2013a)
- Assessing Risks to Endangered and Threatened Species from Pesticides (NRC, 2013b)

- Review of EPA's Integrated Risk Information System (IRIS) Process (NRC, 2014a)
- Best Practices for Risk-Informed Decision Making Regarding Contaminated Sites: Summary of a Workshop Series (NRC, 2014b)
- The Presidential/Congressional Commission on Risk Assessment and Risk Management. Final Report: Vol. 1 — Framework for Environmental Health Risk Management. Vol. 2. — Risk Assessment and Risk Management in Regulatory Decision Making (Omenn *et al.*, 1997)

6.3 Attributes of Best Practices

Based on the review of NAS recommendations and evaluation of States' and Agencies' practices, we view the following attributes as characteristic of best practice for risk-based remediation, and evaluate best practices as those that hew most closely to having these attributes:

1. Scientific accuracy
2. Protectiveness of human health and the environment
3. Proportionality
4. Reproducibility
5. Appropriateness
6. Flexibility
7. Specification
8. Transparency
9. Incorporation of uncertainty/variability
10. Stakeholder involvement

These attributes are described in more detail in the following sections. We note that they overlap substantially with the CT DEEP program goals/attributes listed in the *Draft Proposal for a Transformed Cleanup Proposal*.[14] In fact, of these ten, the only attributes explicitly missing from DEEP's *Draft Proposal* are the first and the last – scientific accuracy and stakeholder involvement.

6.3.1 Scientific Accuracy

By scientific accuracy, we mean the application of the best available scientific evidence and methodology to the practice of risk assessment and management for site remediation. NAS reports,

[14] Available at http://www.ct.gov/deep/lib/deep/site_clean_up/comprehensive_evaluation/draft_cleanup_transformation_proposal.pdf, linked from http://www.ct.gov/deep/cwp/view.asp?a=2715&q=481484&deepNav_GID=1626.

and the Presidential/Congressional Commission, repeatedly, and quite appropriately, emphasize this requirement for risk assessment and risk management in all contexts. For example:

> *EPA should continue and expand use of the best, most current science to support and revise default assumptions. EPA should work toward the development of explicitly stated defaults to take the place of implicit defaults. EPA should develop clear, general standards for the level of evidence needed to justify the use of alternative assumptions in place of defaults. In addition, EPA should describe specific criteria that need to be addressed for the use of alternatives to each particular default assumption. When EPA elects to depart from a default assumption, it should quantify the implications of using an alternative assumption, including how use of the default and the selected alternative influences the risk estimate for risk management options under consideration. EPA needs to more clearly elucidate a policy on defaults and provide guidance on its implementation and on evaluation of its impact on risk decisions and on efforts to protect the environment and public health. (NRC, 2009)*

> *OMB should develop goals for risk assessment that emphasize the central objective of enhanced scientific quality and the complementary objectives of efficiency and consistency among agencies evaluating the same or similar risks. The goals should support the production of risk assessments that provide clear, relevant, and scientifically sound information for policy-makers. (NRC, 2007c)*

Indeed, we caution that, without application of relevant scientific principles, risk assessments are arbitrary and risk management decisions are liable to be based on assumptions or models that are physically impossible or meaningless. Further attributes of "best practices" fundamentally rely on scientific accuracy.

6.3.2 Protectiveness of Human Health and the Environment

The essential reason for a remedial action is to protect human health and the environment, so this attribute of best practices is indispensable. However, its meaning is not entirely clear, and requires application of the best available science together with risk management decisions. Protectiveness does not necessarily require "bright lines" (such as fixed lifetime risk limits such as 10^{-5} so often specified in regulations); although these can be useful, flexibility (see Section 6.3.6, below) is also required:

> *We recommend that Congress not legislate particular bright lines. (Omenn et al., 1997)*

> *Bright lines can be helpful as guideposts in screening risk assessments (see Tiered Scheme for Determining and Managing Residual Risks on page 109). Bright lines or ranges of bright lines tied to specific exposure or contaminant concentrations can be used for compliance. In addition to bright lines intended to protect the general population, bright lines can be used by regulators to protect especially susceptible subpopulations, such as young children, pregnant women, or adults with lung disease. Because of the need for flexibility, Congress should leave the establishment of specific bright lines or ranges of bright lines to the regulatory agencies. (Omenn et al., 1997)*

6.3.3 Proportionality

It is obvious that one need not attack ants with nuclear weapons; and it would be pointless, at the other extreme, to attempt to clean up a massive and complex spill with a cheap and superficial method. In the middle are proportional approaches that scale the assessment and remediation effort in proportion with the likely size of the task and the stakes involved, and ideally allow iterative improvements as necessary. As noted:

> *Rather than a tiered risk-assessment process, EPA should develop the ability to conduct iterative risk assessments, allowing improvements in the process until the risk, assessed conservatively, is below the applicable decision-making level (e.g., 1×10^{-6}, etc.); until further improvements would not significantly change the risk estimate; or until EPA, the source, or the public determines that the stakes are not high enough to warrant further analysis. (NRC, 1994)*

6.3.4 Reproducibility

Any risk-based remedial program would ideally be definite and repeatable: the output should be in the metric required, and the analysis should be repeatable so that anyone duplicating the program should reach the same conclusion. Thus given the ground rules of the program, everyone should agree that the output of the risk assessment for a particular site will contain the information desired, and everyone should reach the same conclusion for that site.

> *Uniform inference guidelines[15] should be developed for the use of federal regulatory agencies in the risk assessment process. (NRC 1983a)*
>
> *The inference guidelines should be comprehensive, detailed, and flexible. They should make explicit the distinctions between the science and policy aspects of risk assessment. Specifically, they should have the following characteristics:*
>
> - *They should describe all components of hazard identification, dose-response assessment, and risk characterization and should require assessors to show that they have considered all the necessary components in each step.*
> - *They should provide detailed guidance on how each component should be considered, but permit flexibility to depart from the general case if an assessor demonstrates that an exception is warranted on scientific grounds.*
> - *They should provide specific guidance on components of data evaluation that require the imposition of risk assessment policy decisions and should clearly distinguish those decisions from scientific decisions.*
> - *They should provide specific guidance on how an assessor is to present the results of the assessment and the attendant uncertainties.*
>
> *(NRC 1983a)*

6.3.5 Appropriateness

The risk measures or other metrics evaluated by the risk-based remedial program should be tailored to specific sites and to specific populations at and near those sites. For example, Omenn *et al*. (1997) note:

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15 "An inference guideline is an explicit statement of a predetermined choice among the options that arise in inferring human risk from data that are not fully adequate or not drawn directly from human experience." (NRC 1983a).

> *We recommend that the performance of risk assessments be guided by an understanding of the issues that will be important to managers' decisions and to the public's understanding of what is needed to protect public health and the environment. (Omenn et al., 1997)*

6.3.6 Flexibility

While reproducibility is important, so is flexibility to account for particular situations; and the two are not necessarily contradictory. Thus we expect best practices to also be flexible, in that appropriate modifications to account for particular situations (*e.g.*, site-specific variations from default assumptions) can be incorporated in the process (see also Section 6.3.4, Reproducibility).

6.3.7 Specification

All requirements for Risk Assessments for remedial actions should be documented and accessible to all. That is, what the Risk Assessor has to do in or for the Risk Assessment is documented and accessible.

6.3.8 Transparency

All inputs and procedures that are used in Risk Assessments are documented and accessible to all, at both the program level and at the individual site level. That is, given the specification of what has to be done in a Risk Assessment, everything not site-specific that describes how it has to be done, and the derivations of all program components (*e.g.*, the RSR criteria in the case of Connecticut) is accessible and documented. Such transparency is necessary for some of the other attributes described here to be feasible (*e.g.*, derivation of alternative clean-up goals based on site-specific information requires access to a program-acceptable methodology for such derivations).

6.3.9 Incorporation of Uncertainty/Variability

A scientifically justifiable treatment of uncertainties and variabilities should be incorporated in the program. This would preferably incorporate an explicit computation with uncertainties and variabilities, although screening approaches might incorporate such computations implicitly (with the screening criteria developed using explicit uncertainty and variability computations).

> *The committee believes that the uncertainty in a risk estimate can be handled through an iterative process with the following parts: conduct a conservative screening analysis, conduct a default-uncertainty analysis, and conduct testing or analysis to develop site-specific probability distributions for each important input. The key factor in deciding to increase the intensiveness of uncertainty analysis should be the extent to which changes in estimates of costs and risks could affect risk-management decisions. (NRC, 1994)*

> *EPA should encourage risk assessments to characterize and communicate uncertainty and variability in all key computational steps of risk assessment—for example, exposure assessment and dose-response assessment. Uncertainty and variability analysis should be planned and managed to reflect the needs for comparative evaluation of the risk management options. In the short term, EPA should adopt a "tiered" approach for selecting the level of detail to be used in the uncertainty and variability assessments, and this should be made explicit in the planning stage. To facilitate the characterization and interpretation of uncertainty and variability in risk assessments, EPA should develop guidance to determine the appropriate level of detail needed in uncertainty and variability analyses to support decision-making and should provide clear definitions and methods for identifying and addressing different sources of uncertainty and variability. (NRC, 2009)*

Although some analysis and description of uncertainty is always important, how many and what types of uncertainty analyses are carried out should depend on the specific decision problem at hand. The effort to analyze specific uncertainties through probabilistic risk assessment or quantitative uncertainty analysis should be guided by the ability of those analyses to affect the environmental decision. (IOM, 2013)

6.3.10 Stakeholder Involvement

CT DEEP does not list stakeholder involvement as one of its goals for reforming its site evaluation and management process. Nonetheless, DEEP clearly understands the importance of stakeholder involvement, as indicated by DEEP's extensive remediation roundtable forums. DEEP has also been actively seeking stakeholder input in a number of workgroups related to site remediation. In particular, all sites are local sites, and at least some people in each affected town or city are stakeholders. They, represented by skilled, professional engineers and/or risk assessors, deserve a seat at the table (see Appendix L, Charnley, 2000). As noted by other experts:

Risk managers and stakeholders should aggressively seek alternatives to command-and-control regulation to improve the efficiency and effectiveness of health and environmental protection and to reduce compliance and litigation costs. A sense of experimentation and a commitment to valuation should be key elements of identifying and implementing alternatives. A safety net of command-and-control regulations should be maintained, however, to avoid reducing current levels of protection . . .

Regulatory agencies should maximize consensual approaches to decision-making—such as negotiated rulemaking, alternative dispute resolution techniques, expert peer review, and informal practices such as meetings with groups of stakeholders (such as regulated parties and community representatives) and workshops—to explore alternative regulatory approaches . . .

Advisory groups should be used periodically to evaluate the use of technical information and the results of peer reviews in regulatory decision-making. Advisory groups for this purpose should be composed of stakeholders, including those with financial stakes. Such advisory groups would review the process, not override pending decisions. (Omenn *et al*., 1997)

The U.S. Environmental Protection Agency should continue to work with stakeholders, particularly the general public, in efforts to identify their values and concerns in order to determine which uncertainties in other factors, along with those in the health risk assessment, should be analyzed, factored into the decision-making process, and communicated. (IOM, 2013)

EPA should establish a formal process for stakeholder involvement in the framework for risk-based decision-making with time limits to ensure that decision-making schedules are met and with incentives to allow for balanced participation of stakeholders, including impacted communities and less advantaged stakeholders. (NRC, 2009)

6.4 Best Practices Used by Other States and Agencies

6.4.1 Results of Database Evaluation, Requirements A to C

Table 6-1 provides summary averages for accumulated scores for the State and Agency Methods that apply to HHRA. Pure best practices would produce scores of 1.0 in all cases using this methodology (and worst practices everywhere would produce a weight of 0.1). The average weights range from 0.14 to 0.56, so provide a fair degree of discrimination between programs, with the Connecticut

Methods ranging from 0.39 to 0.48, with ranks 13, 14, and 18 out of 32 (where rank 1 corresponds to the overall "best practice" Method as measured by this scale).

Table 6-1 Summary results scoring HHRA methods against best practices

State/Agency	Method	Accumulated Scores
California	Preliminary Endangerment Assessment	0.55
California	RI/FS Predictive ERA	0.14
Canada	1 Preliminary Quantitative Risk Assessment HHRA	0.37
Canada	2 Detailed Quantitative Risk Assessment HHRA	0.56
Connecticut	Default	0.39
Connecticut	Engineered Controls / ELUR	0.41
Connecticut	Variations / Exceptions / Alternative Methods	0.48
DOE	Method 1	0.42
EPA	2 HHRA	0.53
Illinois	Tier 1	0.28
Illinois	Tier 2	0.27
Illinois	Tier 3	0.30
Maine	Method 1	0.46
Massachusetts	Method 1	0.37
Massachusetts	Method 2	0.38
Massachusetts	Method 3	0.52
Michigan	Generic Criteria	0.29
Michigan	Site Specific Risk Assessment	0.22
Montana	Method 1	0.31
Montana	Method 2	0.50
New Hampshire	Method 1	0.26
New Hampshire	Method 2	0.27
New Hampshire	Method 3	0.33
New Jersey	HHRA	0.15
New York	QHHEA/FWRIA	0.16
Rhode Island	Method 1 & 2	0.21
Rhode Island	Method 3	0.52
Texas	Human 1	0.33
Texas	Human 2	0.33
Texas	Human 3	0.33
Vermont	Risk Assessment	0.52
Vermont	State Provided Value	0.23

ELUR – Environmental Land Use Restrictions
QHHEA – Qualitative Human Health Exposure Assessment
RI/FS – Remedial Investigation / Feasibility Study
HHRA – Human Health Risk Assessment
FWRIA – Fish and Wildlife Resource Impact Analysis
ERA – Ecological Risk Assessment

It can be seen that this methodology does provide some discrimination between Methods, but the interpretation of even such highly condensed results may be compromised by the limitations previously mentioned. Examination at a substantially higher level of detail can be more informative, since the problems leading to the limitations can often be detected. Table H-1, Table H-2, and Table H-3 show the accumulated weights for each of the nine evaluated attributes for requirements A (Exposure assessment), B (Toxicity assessment), and C (Risk characterization), respectively. Examination of these tables illustrates the tradeoffs that often occur in selection of practical Methods;

for example, Massachusetts Methods 1, 2, and 3 show the expected tradeoff of increasing scientific accuracy from Method 1 (a comparison with fixed standards) to Method 3 (a full site-specific risk assessment), but corresponding decreasing specification and transparency attributes. The expected decrease in reproducibility from Massachusetts Method 1 to Method 3 does not appear in Table H-1 because of the choice to penalize "not specified"; changing the scoring to omit "not specified" responses demonstrates such a decrease (this change can be readily effected using he workbook supplied).

Further limitations of the methodology can also be seen in results that seem implausible, such as worst case values of 0.10, best case values of 1.00, or even exact multiples of 0.10 — these are likely due to all "not specified" questionnaire responses (which were assigned a value of 0.10 in the scoring to penalize "not specified" responses), just one questionnaire response getting included in the scoring (e.g. because only one question contributed to that attribute), or a limited number of questionnaire responses getting included. Zero entries in particular show that no weights were assigned, because the potential responses could not discriminate on that particular attribute.

To evaluate where Connecticut's Methods lie with respect to the best practices in use among all the State/Agency Methods evaluated, we identified the top scoring Method(s) for each of the questions posed in Requirements A through C (questions 1 through 3), and ranked Connecticut's three methods for each of these questions separately. Table H-4 shows these rankings, and identifies the top ranking Method(s) for each of the questions. The ranks shown are average ranks, so that equally scoring Methods are all ranked at the same value (*e.g.* with one top Method, and two equally ranked below it, the top Method would be ranked 1, and the next two 2.5, the average of 2 and 3; the next below that would be ranked 4, and so on). As can be seen, no single State/Agency Method ranks highest for all questions. Connecticut's three Methods rank highest for question 2.7 —"How are toxicity estimates made for substances for which no toxicity values are available" because the response to obtain such values from the State agency has highest score when averaged across all attributes; and join other Methods ranked highest for three other questions, although one of these has all 32 Methods equally ranked.

Such questions , with large numbers of Methods tying for top place are likely to be those where there is little or nothing to distinguish the Methods (although possibly they would be slightly distinguished with a different weighting applied to the attributes), or where the response to the particular question is largely "not specified".

We caution that these rankings use the average of all the attributes, with equal weighting applied to each. It can be expected that rankings would change if different attributes were to be weighted differently in such an average. Such different weightings might be considered appropriate for selecting "best practices" for alternative Methods (such as Connecticut's three). We also caution on selecting the relevant pieces of the identified "best practice" Methods for each question and attempting to meld them into a single "best practice" Method, since the various parts of each Method are may be interdependent (and that would not be identified by the methodology used here).

6.4.1.1 Models Used to Estimate Exposure

Question A.iii in the contract (1.9 in the database) includes a question regarding what models, if any, are used to estimate exposure. Specific models used are not identified in the database summary and are discussed herein.

When models are used to develop exposure estimates, the models are most frequently implemented as mathematical formulas specified by the agency in legislation, regulation, or guidance. These formulas are implementations of simplified mathematical models of physical processes. The mathematical models and physical processes, and the necessary simplifications, are rarely described in detail. These implementations generally estimate intake or contact rates of contaminants based on concentrations of chemicals in environmental media, chemical-specific fate and transport parameters, and exposure parameters that are either specified in guidance or developed by the risk assessor. In a few cases, named exposure models are used to develop exposure estimates. In particular:

- Illinois Tier 2 – Risk-Based Corrective Action (RBCA) models are used to predict exposure from soil and groundwater. Furthermore, the Johnson & Ettinger model is used to estimate indoor air exposure based on contamination observed in soil gas and/or groundwater.
- DOE – DOE employs the RESRAD (RESidual RADioactivity) model to evaluate exposure to residual radioactive materials. GENII (Generation II) is also used to calculate radiation dose and risk from radionuclides released into the environment. RASCAL (Radiological Assessment System for Consequence AnaLysis) is used to evaluate releases from nuclear power plants, spent fuel storage pools and casks, fuel cycle facilities, and radioactive material handling facilities.
- Montana – Montana's Tier 1 makes use of the VS2DT Solute Transport in Variably Saturated Porous Media model, combined with the Hydrologic Evaluation of Landfill Performance (HELP) model to calculate Risk-Based Screening Levels (RBSLs) for soil leaching to GW for petroleum products. These models are not identified as being required for use in other evaluations, although their use would presumably be acceptable in suitable circumstances.

Other models are permitted to be used by some agencies, especially in the context of site-specific risk assessments that do not rely on criteria or standards developed by the agency. Examples of such models include models to evaluate lead exposure such as the Adult Lead Model or the Integrated Exposure Update Biokinetic model. In general, however, these models are not identified by name in the documents that we examined.

6.4.2 Results of Database Evaluation, Requirements D to O

Requirements D, F, H, I, K, N, and O of our contract were also coded in the database in such a way as to provide an adequate level of detail to allow comparisons. However, these requirements do not allow a quantitative comparison based on best attributes, so an approach that compared them at the relevant level of detail was adopted. Potential responses were prepared for each question posed in the requirements at the level of detail appropriate for the resources available, and these responses were coded from the documents we retrieved that describe Methods. Of the potential 118 responses, 36 were never selected while 82 were selected once or more.

We summarize the responses to these requirements in Table H-5 for the 38 Methods evaluated, showing counts of the responses obtained from relevant legislation, regulation, guidance, or other documentation. The "None" entry corresponds to cases where no information was specified in the documentation. These responses are further examined below.

Requirement G (Assess what roles exist for regulation or guidance within risk-based decision making) is incorporated throughout this Section by separation of results by legislation, regulation, guidance, or other documentation (a similar separation is available for all the results in the database), while requirements E and J have been incorporated as described above and requirements L and M are examined in Section 6.4.3.

D. (Database question 4). Determine how remedial goals are set

D. i. (4.1): How is risk management incorporated into risk-based decision making?

In the documents we examined, California, Canada, Connecticut, Illinois, Massachusetts, Montana, New Hampshire, Rhode Island, Texas, and Vermont were found to provide at least some explicit instructions on circumstances where risk management may or must be incorporated in risk-based decision making (beyond the automatic risk management decision of acceptance of sites that meet defined remedial standards) in the context of at least one Method. California, Canada, DOE, EPA, Illinois, and New Jersey include generic statements on risk management, while Connecticut, Michigan, New Hampshire, New Jersey, and New York do not specify any role for risk management for at least one Method.

There is no apparent commonality in how risk management is incorporated into risk-based decision making. For example, California, in its *Preliminary Endangerment Assessment Guidance Manual*, simply indicates that there may be "sites with specific circumstances that allow for a risk management decision to increase the acceptable screening levels"; Connecticut incorporates various risk-management approaches into regulation (e.g. at 22a-133k-2(C)(4)(A) and (B), Exceptions); and Canada's *Part V – Guidance on Human Health Detailed Quantitative Risk Assessment for Chemicals* illustrates an integrated view of the Risk Management Process (Figure 6-1).

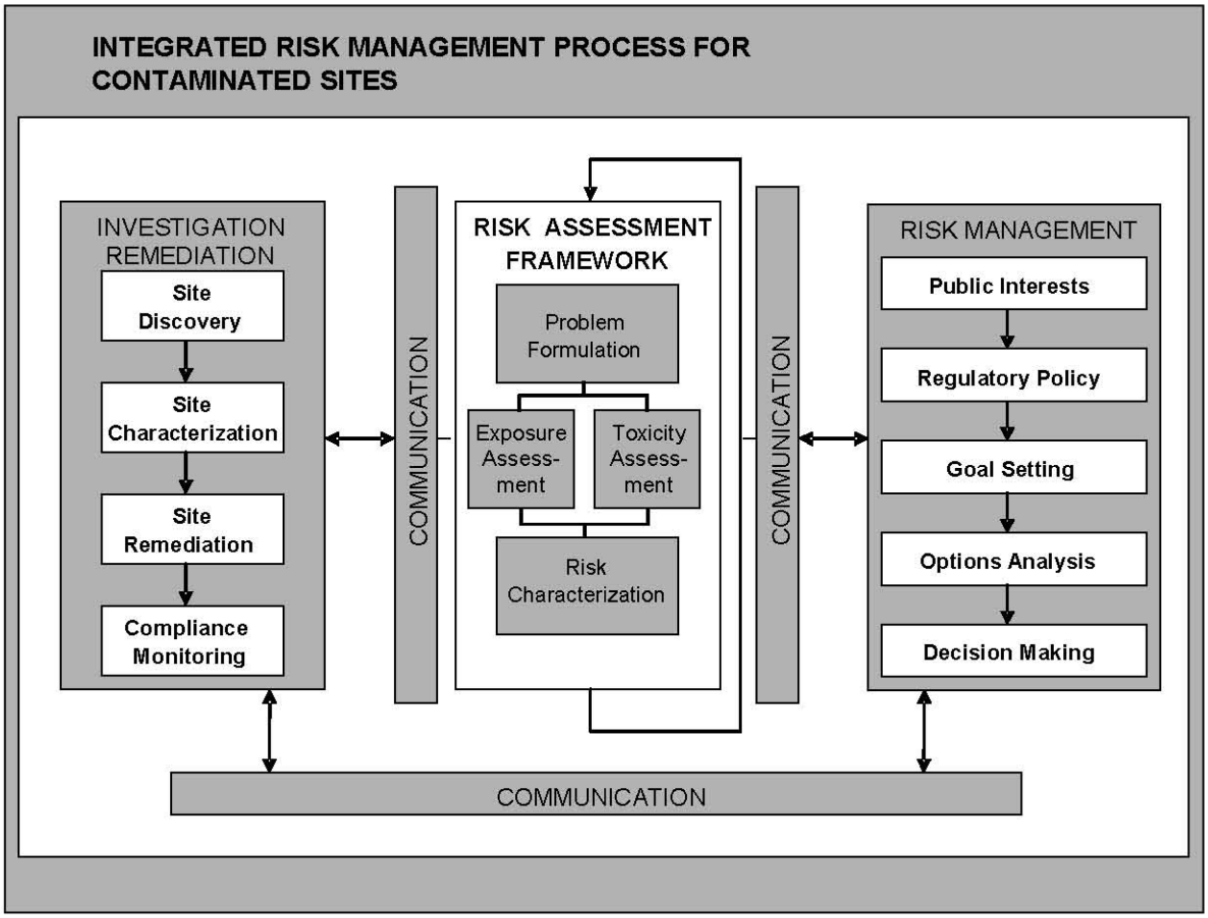

Figure 6-1 **Integrated View of Canadian Risk Management Process (Figure 2.2 of Canada's *Part V – Guidance on Human Health Detailed Quantitative Risk Assessment for Chemicals*)**

D.ii. (4.2): Are remedial goals set solely on the basis of risk assessment or are final remedial goals informed by other risk management considerations? Explain

In many cases, remedial goals are not set solely on the basis of risk assessment. Cost is a factor in at least some cases for DOE, EPA, Maine, Montana, New Hampshire, New York, and Texas. Feasibility may be a factor for Connecticut, DOE, EPA, Maine, Montana, New Hampshire, New York, and Texas. Background concentrations may affect decisions in California, Illinois, Maine, Montana, New Hampshire, New York, and Texas. Ecosystem preservation or valuation may affect decisions for California, DOE, New York, and Texas. Public preference may affect DOE decisions. In at least some circumstances in California and Illinois, the Agency also has discretion to alter remedial goals. Conformity to other laws is explicitly recognized as potentially affecting decisions in DOE guidance and Montana legislation. EPA must legislatively show deference to state and federal policies, while New Hampshire regulations call for similar deference; while California and DOE have guidance and regulation respectively calling for deference to other agencies.

D. iii. (4.3) How have specific risk management policies and regulations affected how and which risks were addressed and which were not?

Maine guidance specifically references EPA's Technical Impracticality Waiver policies in evaluating a technical impracticality waiver. Connecticut, Illinois, Massachusetts, and Rhode Island incorporate management of specific risks within regulations.

D.iv. (4.4) What administrative and legal tools are available for implementing remedial decisions? (Explicitly listed in the legislation/regulation documentation on site clean-up we collected; do not attempt to locate references to other legislation/regulation)

California, Canada, Connecticut, DOE, EPA, Massachusetts, and New Hampshire have legislation providing for fines, while New Jersey has regulations providing for fines. Canada, Massachusetts, and New Hampshire have legislation providing for jail time. Connecticut, DOE, and New Hampshire have other provisions in legislation, as do Montana, New York, Rhode Island in regulations, for such as tools as issuance of unilateral orders, civil actions, and cost recovery actions.

F. (Database question 5) Determine roles and legal responsibilities, as applicable, of state agencies [for Connecticut, this would include DEEP and the Connecticut Department of Public Health ("DPH")], local agencies and stakeholders such as the public and responsible parties in making risked based decisions:

Defining exact legal responsibilities would require legal opinions, which CDM Smith cannot do. However, we have determined that there are legal requirements for other state agencies to have some role in making risk-based decisions in California, Canada (and specifically in the province of British Columbia), by DOE, EPA, and in Vermont.

DOE and EPA are required to consult with the states and abide by state regulations and standards to the extent described by CERCLA. In California, all assessments and any subsequent cleanup activities have to be performed under the oversight of the Department of Toxic Substances Control (DTSC) or the appropriate Regional Water Quality Control Board, or, under limited circumstances, a local regulatory agency. The agency is selected by DTSC and the State Water Resources Control Board (SWRCB) jointly. Once selected, the single agency has oversight, although any local agency selected is monitored by DTSC and SWRCB.

In Canada, remedial actions in the provinces of Nova Scotia, New Brunswick, Prince Edward Island, and Newfoundland and Labrador are apparently under the initial oversight of the Canadian Coast Guard. For the other provinces and territories, Canada has delegated authority over remedial actions to the appropriate provincial or territorial agency. However, we have not further inquired into the responsibilities of these individual agencies, nor whether they are required to consult with others.

In Vermont, remedial actions are overseen by the Dept. of Environmental Conservation. However, if an HHRA is necessary it must follow standard USEPA risk assessment methodology, possibly with default parameters adjusted for Vermont, and it must be approved by the VT Dept. of Health.

In Maine, the Department of Environmental Protection (DEP) determines clean-up requirements on a site-specific basis. While the guidance on HHRA was developed in conjunction with the ME Center for Disease Control and Prevention, we located no indication that oversight is by any agency but DEP. Similarly in New Hampshire, the NH Dept. of Environmental Services (DES) states that Risk Characterizations have to take account of the regulations, policies, and guidelines also of the NH Dept. of Health and Human Services, and USEPA; but there is no indication that oversight is by any agency but DES.

We also found indications that there is some legal role for local agencies in California; for the responsible parties to have some role in Canada and Massachusetts; for the public to have some role in New York and Rhode Island; and for various others to be involved in Connecticut, DOE, Massachusetts, and Rhode Island.

Besides the legal requirements, some roles are specified for other state agencies by DOE, EPA, Maine, New Hampshire and Vermont; for local agencies and responsible parties by DOE; by the public by Canada, DOE, and Massachusetts; and by other parties by DOE, Rhode Island, and Texas.

H. (Database question 6) Determine if adaptive management is considered during the risk-based decision making.

For Canada, adaptive management is explicitly incorporated in ecological risk-based decision making for remedial actions. The Federal Contaminated Sites Action Plan (FCSAP) Decision-Making Framework (2013) implies, but does not explicitly state, that adaptive management could be part of the decision-making framework at any federal contaminated site; however, CDM Smith did not locate any further discussion with respect to human health risk-based decision making for remedial actions. In Connecticut, adaptive management is implicitly forbidden by the adoption of prescriptive approaches, but is not explicitly discussed in any documents CDM Smith examined. For the other States/Agencies, the documentation CDM Smith consulted provided no indication of whether adaptive management is considered.

I. (Database question 7) Evaluate how risk-based decisions are communicated to the regulated community, stakeholders and the public, and at what stages of the decision-making process such communication occurs.

California, Connecticut, DOE, Massachusetts, Montana, New York, and Rhode Island explicitly spell out requirements for communication (other than with responsible parties) compatible with or beyond those required by Federal law. Canadian guidance mentions communication with stakeholders.

California has published the *California Department of Toxic Substances Control Public Participation Manual* (https://dtsc.ca.gov/LawsRegsPolicies/Policies/PPP/PublicParticipationManual.cfm) describing the procedures required. The state Health and Safety Code requires that prior to adoption of a final remedial action, a draft plan be circulated for public comment, affected local and state agencies be notified, notices be published in newspapers and at the location affected, and contiguous property owners be notified by direct mailing. Further, meetings have to be held with the lead and responsible agencies, the potentially responsible parties, and the interested public, "to provide the public with the information that is necessary to address the issues that concern the public." Any public comments have to be considered and the draft plan revised if appropriate (California HSC 25356.1).

For high priority sites, California also requires that the public, particularly persons living in close proximity to the site, be notified of the existence of the site and the intent to conduct action at the site. Further, a survey of the public is required to gauge public interest and a public participation plan prepared commensurate with that interest. For these sites, any person affected by the action must be provided with an opportunity to participate in the decisionmaking process, primarily by receiving notice of public meetings but potentially including involvement in the process, including the health risk assessment, preliminary assessment, site inspection, remedial investigation, and feasibility study. Further, there is the potential for community advisory groups to be formed to participate in the process, and such groups may request funds from responsible parties for technical assistance grants. (California HSC 25358.7, 25358.8).

The Canadian Environmental Protection Act (1999) does not mention any requirement for communication with stakeholders other than the responsible party. Authority over most sites has been delegated to the provinces (which we did not evaluate), but for federal sites Health Canada has published a guidance document *Improving Stakeholder Relationships: Public Involvement and the Federal Contaminated Sites Action Plan: A Guide for Site Managers* (http://www.hc-sc.gc.ca/ewh-semt/pubs/contamsite/managers-guide-gestionnaires/index-eng.php).

Under the Property Transfer Act, Connecticut requires that prior to the initiation of remediation the relevant party publishes notice in a newspaper, notify the director of health in the relevant municipality, and either erect a large sign providing telephone contact information or mail notices of the remediation to abuttors. Similar requirements for notice are applied by regulation when an engineered control is proposed, with an opportunity for the public to request, or the Commissioner to require, a public meeting.

DOE and EPA are required, under CERCLA, to publish notice and brief analysis of any proposed plan for remedial action, make the plan available to the public, provide reasonable opportunity for submission of written and oral comments, and provide an opportunity for a public meeting. All significant comments must be responded to in the final plan, and any changes to the final plan must be published together with reasons for the changes. Publication must be (at least) in a major local newspaper, and all material "developed, received, published, or made available to the public" must be available for public inspection. Technical assistance grants may be made available for any group of individuals affected by the release or threatened release from a National Priorities List site. EPA has published guidance document *Risk Assessment Guidance for Superfund: Volume 1 – Human Health Evaluation Manual Supplement to Part A: Community Involvement in Superfund Risk Assessments* (http://www.epa.gov/oswer/riskassessment/ragsa/ci-ra.htm) detailing the aims of involving the local community in remedial actions from the outset. EPA regulations (40 CFR 300, the National Contingency Plan) contain extensive requirements for community relations throughout all remedial activities.

Massachusetts legislation requires that the Department of Environmental Protection (DEP) hold a public meeting (or require a responsible party) to present a proposed plan for involving the public in decisions involving response actions at a site, if petitioned by 10 or more residents or *sua sponte*. The plan is required to ensure that interested members of the public will have sufficient notice, access to documents, and opportunity to comment to enable them to affect decisions about the site. The plan must then be modified to account for comments and made available to the public. Technical assistance grants may be available to affected persons, or to the affected city or town, or any body politic owning or operating a potentially affected public water supply system. The chief municipal officer of the affected city or town may appoint a committee of potentially affected people to inspect the site before, during, and after any major response action, and they may bring experts along with them.

Massachusetts regulations for public involvement are substantially more extensive, and only some are summarized here. All sites must undertake a minimal set of actions to notify at least the chief municipal officer and board of health of any potentially affected community of various listed activities on the site. Local officials or ten or more residents may request an opportunity for public involvement activities, triggering the legislated minimum requirements for provision of information, holding a public meeting, and taking notice of public comments. Certain sites may be designated public involvement sites (PIPs), triggering additional public involvement activities including preparation of a public involvement plan. That plan must, among other things, identify local concerns, inform the public about the response action, provide background information, provide opportunities to comment on response actions, incorporate relevant and material public comments into the planning and implementation of the response action, and ensure that public involvement activities continue throughout the entire response action process.

Montana regulations require that the prior to listing of a site on the CECRA priority list, and prior to delisting from that list, the Montana Department of Environmental Quality provide notice and hold a public meeting if ten or more persons, or a governing body of a city, town, or county, request it. Written comments in response to the notice or meeting have to be provided with written responses. For each confirmed release that requires a cleanup plan the department has to notify those members of the public directly affected of the release and the planned cleanup activities, and may hold a public meeting if there is sufficient interest "or for any other reason."

New York regulations require that all remedial programs include citizen participation activities. The minimal requirements are preparation of a citizen participation plan, establishment of a document repository, and public notice with prescribed comment period at select milestones. The plan has to be proportional in scope to the proposed remedial program, local interest and history, and other relevant factors. It has to embody opportunities for citizen involvement as early as possible, be reflective of the diversity of interests and perspective in the community, and provide full and timely disclosure and sharing of information. Technical assistance grants may be available.

Rhode Island requires public notice at two points during site investigation — prior to conducting field activities at known contaminated sites, and when the site investigation is deemed complete. Both notices go to abutting property owners, tenants, easement holders, and the municipality, and the latter goes also to community well suppliers near the contaminated site. For sites considered for reuse as schools, child-care facilities, or public recreational facilities there is an additional requirement to hold a public meeting to obtain information on the history of the site and to provide a written report documenting all available information and comments. There are special provisions for preparation of fact sheets in Environmental Justice Focus Areas. Requests by 25 persons, or by governmental subdivisions or agencies, or associations with at least 25 members, are sufficient to require a community meeting. Information repositories may be required. If 25 persons, local officials, or other interested parties request it, a site specific public involvement plan might be required. The Director of the Department of Environmental Management identifies preferred remedial alternatives on completion of the site investigation report, and all preferred alternatives are subject to public review and comment. There are special provisions with minimal notification for situations where the only contaminant is arsenic in soil (because of the natural prevalence of high levels of arsenic).

K. (Database question 8) Determine the legislated or regulated timeliness of responses by agencies. What deadlines are required by law or regulation?

K. i. (8.1) Are there timelines specified in legislation or regulation for response by the Agency to all communications from: PRPs; Risk Assessors; Stakeholders; or The Public?

New York stands out as unique in specifying communications response timelines under its various regulatory programs: General Remedial Program Requirements; Inactive Hazardous Waste Disposal Site Remedial Program; Brownfield Cleanup Program; and Environmental Restoration Program.

K.ii. (8.2) Are there timelines specified in legislation or regulation for response by the Agency to some communications from: PRPs; Risk Assessors; Stakeholders; or The Public?

Massachusetts, New York, Connecticut and EPA all have timelines specified for certain communications. This is part of the Massachusetts Contingency Plan, the National Contingency PLan (regulations) and the same New York regulatory programs as cited in the response to question 8.1. In Connecticut, the Property Transfer Program (legislation) contains a provision limiting the amount of time in which the state may decide to audit a Licensed Environmental Professional site verification.

K.iii. (8.3) Are the timelines specified as a time certain, or do they contain conditional clauses?

Similar to the responses for 8.1 and 8.2 above, New York and Massachusetts have regulatory sections that address these timelines (regulatory citations are the same as above). In addition, Rhode Island also has regulatory sections that address these timelines. In Vermont, timelines are addressed in guidance only. In each case, either numerous citations are provided in the database or such timelines are found throughout the regulations.

K.iv. (8.4) What is the effect specified in legislation or regulation if the Agency does not meet a deadline?

In the vast majority of cases, the effect of Agencies failure to meet a deadline is not specified. For Massachusetts (under the MCP) and Connecticut (under the Property Transfer Program), there are provisions in certain circumstances where the effect of no action by the Agency within the specified timeframe has the effect of an approval. As mentioned in the response to 8.2, this particularly applies in Connecticut to the time limit for auditing an LEP site verification.

K.v. (8.5) What recourse is included in the legislation or regulation if the Agency does not meet a deadline?

Only Massachusetts was found to address this issue in its MCP regulatory program in the automatic granting of any petition. Otherwise, this issue is not addressed by other agencies, other than what is described under question 8.4 for Connecticut.

N. (Database question 9) What mechanisms are available for updating procedures and values? Are there mechanisms built into legislation or regulation that require updates, revisions, and corrections to toxicity values and other risk-related parameters, and what is the timeline for such modifications?

Massachusetts legislation (Chapter 21E, 3(b)) calls for the update of the Massachusetts Contingency Plan “from time to time;” such updates may include the specification of any or all risk-related parameters. CDM Smith did not locate other specific regulatory or legislative wording calling generically for updates. States/Agencies using a hierarchy of toxicity values would generally use those valid at the time of use — for example, Texas has such a provision explicitly in regulations (TAC Chapter 350, Subchapater D, at 350.73), although no other explicit statements were located in legislation or regulation.

O. (Database question 10) How flexible are the approaches allowed for site evaluation and remedial options? Is there a single track or multiple options for site evaluations, and are there alternative options for remediation (e.g. depending on site use)?

The northeastern states evaluated all have some provisions for flexibility in their remediation programs. Connecticut exercises considerable flexibility in its Remediation Standard Regulations, beyond the application of default standards, through the use of alternatives, variances, exceptions, engineered controls and environmental land use restrictions. Massachusetts similarly provides for opportunities for flexible approaches in its MCP program. New Hampshire, Rhode Island, Vermont and New York also provide some degree of flexibility in their remedial regulatory programs. Looking beyond the northeast, Texas was found to also provide flexible options for remediation. Even so, there was a considerable number of agencies reviewed where such flexibility was not specified.

Canada apparently allows for adaptive management in risk-based decision making for federal sites, explicitly for ecological risk management and implicitly for human health risk management. This would allow for considerable flexibility in site evaluation and remedial options.

6.4.3 Requirements L and M

L. Evaluate the accessibility of documentation of methods and procedures. How easy is it to locate and retrieve information on the legislated or regulated requirements for remedial actions?

Appendix K documents all retrieved material that presents methods and procedures for each program evaluated. Appendix K also classifies all retrieved documentation as legislation, regulation, guidance, or other.

In general, documentation regarding methods and procedures was readily accessible electronically for the programs evaluated. The ease of obtaining documentation varied by program. Complexity of the program being evaluated and familiarity of the reviewer with the program affected perceived accessibility, as would be expected — the major difficulty was determining the existence of documents, not obtaining them once their existence was known. However, we could not fully assess the unavailability of certain types of documentation — if standards or guidelines were in place but not themselves documented, we would have noted these as “not specified” in the database because we would have had no means of determining their existence unless they were specifically mentioned in the parts of the available documentation that we were required to review.

Connecticut’s documentation was generally readily available. The portion of DEEP’s website dedicated to risk-based remediation provides many fact sheets and links to the most important documents describing site-remediation in Connecticut. The primary aspect of existing documentation identified by the reviewer as being somewhat difficult to obtain was complete supporting documentation of the derivation of each of the RSR criteria. At the time of the draft 2008 criteria update, the Technical Support Document for the 2008 proposed revisions to the RSR criteria did provide more extensive documentation of criteria derivation than had been previously available.

Information for similar programs in Michigan and Massachusetts tends to be most accessible. In particular, Michigan incorporates supporting documentation for the derivation of standards directly in their regulations. Massachusetts provides a set of summary spreadsheets documenting every factor included in the derivation of the Massachusetts cleanup standards.

Examples of risk-based remediation programs similar in complexity to Connecticut's with very accessible documentation included Illinois, Michigan, and Massachusetts. The websites for all three programs included informative summary pages that made it fairly straightforward to identify and find relevant information. EPA has extensive guidance, which is very accessible through the EPA website. It was easy to find information on Canada's program despite the reviewer not previously being familiar with Canadian practices.

Examples of programs with less complex programs than Connecticut included those in Maine, Montana, Rhode Island, and Vermont. It is perhaps partially due to the fact that less documentation is available for these programs that the reviewers of these programs felt that available information was easily accessible.

The reviewers found it less easy to locate and retrieve information on legislated or regulated requirements in states with fairly extensive programs with which the reviewer was not well-versed prior to beginning review. Texas and California are examples of states with extensive documentation, but for which reviewers found that it took quite a bit of effort to develop a thorough understanding of the program. All documentation was generally accessible for these states, but took more time to find and review, and in the case of both states, it was felt useful to contact regulators to ensure that important aspects of the risk-based remediation programs were not overlooked. In the case of Texas, it was found difficult to obtain some legislation and regulations in a form that was electronically searchable because the main website provided each individual small section of the legislation (or regulation) separately. The reviewer found it necessary to combine these sections into a single document to facilitate review. The reviewer of New York's practices commented that while she was familiar with the program and therefore was able to locate all necessary information, she felt that it would not have been straightforward to locate all of the information if she wasn't previously familiar with the program. Some of the New York information was available on websites, but not in a formal published document.

Some primary documentation was not available directly from a state web site — the New Hampshire Contaminated Sites Risk Characterization and Management Policy (RCMP) document is listed as under revision with no direct link (CDM Smith did locate a copy in the Internet Archive; and a link appears in the database), although a revised set of appendices containing the material essential for performing risk assessments is available.

M. Determine what feedback mechanisms from users to regulators and legislators exist. What web sites, public dockets, working committees, or other mechanisms allow feedback from the regulated community and the public?

We examined publicly available documentation, including websites, of relevant regulatory agencies to determine the existence of working committees (or similar organizations) providing for feedback from the user community. Those reviewing each program noted, however, that it was not always obvious when such feedback mechanisms existed based on review of state websites. Connecticut, for example, has a very active program, but the reviewer commented that if he had not been aware prior to his review that one such mechanism is the Remediation Roundtable, he would not have discovered its existence through his search. Several of the evaluated programs have established work groups to encourage feedback between the regulated community, the public, and regulators on various issues.

Examples of feedback mechanisms from users to regulators and legislators included those in the following states:

- California – The California Department of Toxic Substances Control (DTSC) encourages online feedback via an online customer survey form. Until recently the state also maintained a Regulatory Assistance Officer position who would communicate with the regulated community, but this service was discontinued. According to Mr. James Polisini in DTSC's Human and Ecological Risk Division, public workshops are generally formed when changes to regulations are being considered. Informal workshops are sometimes formed regarding issues that are addressed in guidance. California does not, however, have a formal program to encourage such feedback.

- Connecticut – The Remediation Roundtable provides an open forum for the exchange of ideas and information on the various site cleanup programs in Connecticut and to solicit opinions, Connecticut DEEP has also established many workgroups to solicit stakeholder input on aspects of risk-based remediation and related topics.

- Massachusetts – The Massachusetts DEP has established a Waste Site Cleanup Advisory Committee, the meetings of which are open to the interested public. Like Connecticut DEEP, Massachusetts DEP has established numerous workgroups to solicit stakeholder input on issues affecting the regulated community. The Massachusetts Licensed Site Professional Association (LSPA) is also quite active, and interactive, with regard to the DEP and other stakeholders.

- Texas – The Texas Commission on Environmental Quality website indicates that TCEQ has established workgroups comprised of technical experts from industry, government, consulting firms, and academia was formed to assist in developing guidance.

In some of the smaller states evaluated, such as Rhode Island and Vermont, it appears that less formal mechanisms are used such as communication between practioners and regulators on a case-by-case basis.

It is likely that additional mechanisms exist to allow feedback from the regulated community and the public to regulators for several of the evaluated programs; however, the presence of these programs was not evident from the review of legislation, regulations, and guidance.

6.4.4 Acceptable Levels of Cancer Risk-Estimates for Sites

Deciding what levels and types of risk to public health are acceptable is not straightforward. Cohen (2001) explains:

> *'Acceptable risk' in regulatory decision making, a concept originally equated loosely with the absence of risk, has become a particularly vexing issue in the . . . decades since the passage of sweeping environmental regulation in the United States in the early 1970's. The wide range of activities now regulated, and vastly improved technical abilities to detect much smaller risks, have forced society to think explicitly about which risks justify regulatory consideration, and which are small enough to be deemed acceptable. Clinging to an absence of risk as the standard of acceptability, after all, would be extremely costly and technologically infeasible. . . .*
>
> *[T]hree different frameworks . . . help shape how standards of acceptable environmental risk are developed and interpreted. . . . U.S. regulatory practice reflects elements of each framework . . . including:*

> - *Decision Theory, which prescribes that the benefit of reduced risk be compared to the costs associated with attendant control measures . . .;*
> - *The Precautionary Principle, which calls for the prevention of unnecessary risks . . .; and*
> - *Cognitive risk perception theory, which describes those attributes of a risk, other than its magnitude, that influence the public's tendency to either accept that risk or to demand its mitigation . . . .*
>
> *What these frameworks all have in common is that none identifies a particular maximum risk magnitude as acceptable in all circumstances. Instead, they wrestle with determination of acceptability given a risk's other characteristics. Because these characteristics vary from risk to risk, acceptability cannot have a fixed maximum magnitude.*

Regarding this last point, although it is of course true that "acceptability cannot have a fixed maximum magnitude," it is also true to decisions must be made according to some specific criteria for acceptable levels of risk. As it happens, levels of incremental excess risk of cancer (over a maximally exposed person's lifetime) that are permitted by relevant federal regulation varies greatly, from as little as "as close to zero as technically feasible" to as much as one in one hundred (that is, 1×10^{-2}; reviewed in Sadowitz and Graham, 1995).

Another important point is that public health risk estimates can (and ideally should) be formulated in at least two main ways: (i) for a maximally exposed individual, and (ii) for exposed populations. Best practices entail producing both types of risk-estimates, and managing risks according to both metrics (Omenn *et al*., 1997).

For risks due to air pollution, risk assessors routinely estimate populational risks by accounting for the numbers of people in given "air-sheds." (See, for example, http://scorecard.goodguide.com/env-releases/hap/ and associated links). Population risk-estimates can also be made for public water systems. But populational risks are more difficult to estimate for direct exposures to soil at individual brownfields or other parcels of land: one typically cannot reliably estimate how many children, for example, will ingest how much dirt from that land-parcel, how often, over what time frame, and so on.

What one *can* account for, however, is the fact that populations ingesting pollution in soil at any local site are vastly smaller than populations breathing pollution in urban and suburban ambient air, for example, which risk managers seek to minimize so as to reduce risks of lung cancer (Straif *et al*., 2013).

With regard to cancer-risks posed by contaminants in soils at Superfund sites, U.S. EPA notes that the National Contingency Plan (NCP) "provides that . . . preliminary remediation goals should generally be set at levels that represent an upper-bound lifetime cancer risk *to an individual* of between 10^{-4} and 10^{-6}. 40 CFR § 300.430(e)(2)(I)(A)(1)." (*emphasis added*). This 100-fold risk-range is provided primarily to account for differences in sizes of affected populations: *pollution that affects millions of people should be regulated much more stringently than pollution that affects much smaller populations*.

Indeed, U.S. EPA has sometimes allowed individual cancer risk-estimates as high as 10^{-3} when affected populations are small. Thus, U.S. EPA (1997b) states:

> *Under appropriate circumstances, risks of greater than 1×10^{-4} may be acceptable. CERCLA guidance states that 'the upper boundary of the risk range is not a discrete line at 1×10^{-4}, although EPA generally uses 1×10^{-4} in making risk management decisions. A specific risk estimate around 10^{-4} may be considered acceptable if justified based on site-specific conditions.'. . . Other EPA regulatory programs have developed a similar approach to determining acceptable levels of cancer risk. For example, in a Clean Air Act rulemaking establishing NESHAPs for NRC licensees, Department of Energy facilities, and many other kinds of sites, EPA concluded that a risk level of "3×10^{-4} is essentially equivalent to the presumptively safe level of 1×10^{-4}." 54 Fed. Reg. at 51677 and 51682 (December 15, 1989).*

Various U.S. EPA risk management decisions have indeed turned on estimates of populational risks as well as on estimates of individual risks. Thus, EPA has deemed acceptable RMEI risks (of cancer) of up to 3×10^{-3} in circumstances in which populational risks from local air pollution are small (see Table 2 in Travis *et al.,* 1987). For example, EPA has decided *not* to reduce by regulation RMEI risks from: zinc oxide plants (individual risk estimate [upper-bound] of 3×10^{-3}); secondary lead smelters (individual risk estimate [upper-bound] of 3×10^{-3}); and elemental phosphorus plants (individual risk estimate [upper-bound] of 1×10^{-3}) — in each case because EPA performed a populational risk analysis as well, and found that the *aggregate* risks to the affected populations were too small to require additional regulation.

Since, among other reasons, the numbers of people who would be reasonably maximally exposed at a local site cannot be in the millions or tens of millions, allowable individual risk estimates (following U.S. EPA's lead) should not be as stringent as 10^{-6}. We believe it prudent and appropriate to peg individual chemical risk estimates at 10^{-5} and total site risk estimates at 10^{-4}. This suggestion is consistent with practices followed by British Columbia, California (depending on population risk and other factors)[16], Michigan, Texas, U.S. Department of Energy, and, (again, depending on population risk and other factors, such as feasibility) U.S. EPA, but differs from default practices followed in Illinois, Maine, Massachusetts, New Hampshire, and Rhode Island.

Table 6-2 summarizes how various states and agencies characterize acceptable risk estimates for RMEIs at sites. For additional discussion, please see Appendix M.

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[16] By law in California, under Proposition 65, the "No Significant Risk Level" for individual carcinogens is 10^{-5}. (See, for example, http://oehha.ca.gov/prop65/pdf/2012StatusReportJune.pdf).

Table 6-2 Acceptable risk estimates for RMEIs for various states and agencies

State/Province/Agency	Legal Basis	Acceptable Risk Estimate for the Reasonably Maximally Exposed Individual (RMEI), for each chemical contaminant at a site		Legal Basis	Acceptable Risk Estimate, RMEI, for entire site	
		Cancer Risk Estimate	HQ		Cancer Risk Estimate	HI
British Columbia, Canada	Reg.	10^{-5} or less stringent; based on decision by the local public health official	1 or less stringent; based on decision by the local public health official	Reg.	Decided by the local public health official	
California				Reg.	10^{-6} - 10^{-4}	1
Canada, federal guidance	Guid.[17]	10^{-5}	0.2	Guid.[17]	10^{-5} (per set of chemicals affecting same tissues, same mechanism)	0.2 (per set of chemicals affecting same tissues, same mechanism)
Connecticut	Reg.	10^{-6}	1	Reg.	10^{-5}	1 (same target organ)
Illinois				Reg.	10^{-6}	1 (same target organ)
Maine	Guid.		1		10^{-5}	1
Massachusetts	Reg.	10^{-6}	0.2	Reg.	10^{-5}	1
Michigan	Leg.	10^{-5}	1			
Montana	Not specified					
New Hampshire				Guid.	10^{-5}	1 (same target organ)
New Jersey	Not specified					
New York	Not specified					
Rhode Island	Reg.	10^{-6}	1	Reg.	10^{-5}	1 (same target organ)
Texas	Reg.	10^{-5}	1	Reg.	10^{-4}	10
U.S. Dept. of Energy	Guid.	10^{-4}	1			
U.S. EPA				Guid.	10^{-6} - 10^{-4}	1
Vermont	Guid.	Defers to U.S. EPA's *RAGS*				

Notes: Leg. = Legislation Reg. = Regulation Guid. = Guidance *RAGS = Risk Assessment Guidance for Superfund*

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17 Canadian federal guidance indicates these values are considered both essentially negligible and acceptable. This *guidance* also specifies deferring to local provincial *regulations* (such as those specified by British Columbia) when the two conflict.

Section 7

Best Practices in Ecological Risk Assessment and Ecological Risk Management

As noted above, CT DEEP has four main objectives for site remediation. These are:

- providing the environmental professional with clear standards and goals;
- implementing predictable and efficient processes;
- providing consistent decisions among sites under its jurisdiction; and
- delivering site outcomes that balance protecting human health and the environment with economic vitality.

Despite the uncertainties and site-specific nature associated with an evaluation of risks to the large number of non-human organisms that may (at least potentially) inhabit a site, ecological risk assessment can play a vital role in informing regulators, responsible parties, practitioners, and other interested parties in making sound remedial decisions at sites across the State. To assist CT DEEP in determining how ecological risk assessment can best be implemented, we began by reviewing recommendations provided in several reports completed by the National Academies and the Presidential/Congressional Commission on Risk Assessment (NRC, 2005; NRC, 2013b; Omenn *et al*., 1997), and then reviewed the ERA and ERM practices implemented by several states and provincial and national agencies.

7.1 National Academies and Presidential/Congressional Committee Recommendations

The National Academies have made several recommendations to assist in development or revision of ERA and ERM practices. The recommendations provided below are those that may assist CT DEEP in finalizing the draft ecological risk assessment guidance with respect to achieving the overall goals of site remediation described above, while recognizing that ERA is only one aspect of the remedial decision making process. The selection of the recommendations below reflect some of the concerns with risk assessment practice in general, including those identified by regulatory agencies, practitioners, and stakeholders. The topics range from data-use in ERA to selection of site remedy based on site-specific evaluation. The recommendations to facilitate ERA practice and subsequent related risk management that can be applied in Connecticut include the following (provided as verbatim quotations from the cited sources):

- *To ensure that the best data available are captured, a broad data search is needed at the beginning of the process. Dates of searches and search strategies should be clearly documented to ensure transparency of the process. If a repository database is searched, its contents and scope should be described, including criteria for data inclusion and exclusion, periodicity of updates, and quality control for data entry (NRC, 2013b).*

In addition, the data set used for the ERA should be complete and validated with at least a Stage 2 validation (U.S.EPA, 2009) prior to starting the assessment. It is also critical that the media and sample needs are clearly defined (*i.e.*, sediment depths, soil depths, dissolved or total metals in water), so that samples relevant to organisms and exposures can be collected and accepted by the agency for use in characterizing the nature and extent of contamination at a site and estimation of resulting risks.

- *Given that stakeholders are aware of and can provide valuable and relevant data, the Committee encourages provision for their involvement at the early stage and throughout the ERA process. Stakeholder data are expected to meet the same data relevance and quality standards as all other data (NRC, 2013b).*

- *To ensure that the best data available are used, information should first be screened for relevance and then subjected to quality review (NRC, 2013b).*

Further, dates of applicable data should be decided (*e.g.*, data range = 2003 - 2012) based on site history and current characterization needs. Prior to the onset of an ERA, discussions should either occur with the Agency on a site-specific basis, so that there is concurrence, or the Agency should provide generic documentation of data requirements. For example, New York requires a minimum of three groundwater wells and and recommends multiple seasonal sampling rounds if any standards, criteria, or guidance is exceeded (NYS DEC, 2010). Similarly, MA DEP requires four quarters of groundwater data to characterize current conditions. MA DEP further indicates in guidance that more than a single sample is necessary to establish background/local conditions. Data requirements could be incorporated in CT's Site Characterization Guidance document , so that all site characterization (for both human health and ecological risk) is integrated.

- *The agencies should, at a minimum, subject all information to a review based on OMB criteria of "objectivity, utility, and integrity." Information sources that fail any of the criteria can be used at the discretion of the risk assessor, provided that their limitations are clearly described (NRC, 2013b).*

- *Comparisons of all information sources with the relevance and quality attributes should be documented in the risk assessment and described in the overall characterization of uncertainties (NRC, 2013b).*

- *Model predications are only as accurate or precise as parameter information. Thus, key processes need to be identified and the associated parameter values well defined (NRC, 2013b).*

Models, such as food web models, can be quite site-specific in that key organisms and pathways differ among sites. Since it is not possible for an agency to identify specific (yet generic) parameters, interaction between the Agency and ecological risk assessor should be both required and facilitated.

- *In the absence of quantitative estimates of exposure, assessors should exclude potential mixture components from quantitative assessments. Uncertainties associated with the identities or exposure concentrations of potential mixture constituents should be qualitatively described to a decision-maker (NRC 2013b). In the absence of such quantitative data . . .the risk assessor should describe the possible effects of mixture components on the risk estimate to the decision-maker (NRC, 2013b).*

Discussion of chemical mixtures can be included in exposure, effects, and uncertainty sections (*e.g.*, total PAHs vs. individual, PCB congeners vs. total PCBs, total chromium vs. hexavalent chromium). In some cases, evaluation is only possible for chemical mixtures (*i.e.*, screening levels might only be available for total PCBs as opposed to individual Aroclors or congeners). However, NRC does not recommend that unrelated chemicals be grouped together by medium or across media to calculate hazard indices, since the science is lacking regarding additive effects (or related antagonistic or synergistic effects) to provide any meaning for such treatment of the data.

- *Therefore, if the agencies want to obtain more accurate modeling results, a subset of case-specific exposure estimates should be evaluated by pursing a measurement campaign specifically coordinated with several pesticide field applications (NRC, 2013b).*

Modeling, such as food web models, should be limited to site-specific risk assessment so that site-specific data can be used as model inputs. Use of generic input parameters at an early step of the risk assessment process only introduces uncertainties and can mislead the practitioner or agency on conclusions and remedial decisions.

- *Because some indirect effects can be quantified, the committee recommends that they be incorporated into effects analysis (NRC, 2013b).*

- *To determine whether a pesticide is "likely to adversely affect" a listed species, a broad search should be conducted to identify information on sublethal effects of the pesticide and possible concentration-response relationships (NRC, 2013b).*

- *Because listed species are not inherently more sensitive to chemicals than species that are not listed, similar methods of cross-species extrapolations can be used for any ecological risk assessment and include interspecies correlation analysis and species sensitivity distributions (NRC, 2013b).*

- *Life histories need to be considered whether one is identifying a single surrogate species or using an alternative approach (NRC, 2013b).*

Selection of representative receptors is critical and should be done in consultation with all relevant parties (relevant parties will depend particularly on the size and complexity of the site – for typical two or three acre commercial sites containing building, pavement, lawn, landscaping, and a storm drainage ditch in the back, inviting external stakeholders may be inappropriate).

- *EPA and other agencies should continue together to implement the EPA ecological risk assessment framework. EPA's guidelines should be improved by an explicit discussion of how and when stakeholder involvement should be sought so that it is consistent with the Commission's Risk Management Framework and by a description of how measures and models should be selected. Other agencies should develop clear guidance for putting various problems into context, choosing methods and tools for characterizing exposure and effects, characterizing uncertainty, and applying weight-of evidence evaluations (Omenn et al., 1997).*

Ongoing stakeholder involvement is recommended throughout the risk assessment process (depending on the size and complexity of the site), using the scientific decision management points (SDMPs) in EPA ecological risk assessment guidance as direction as to when to involve other parties (U.S. EPA, 1997a). Explicit direction of roles and opportunities for stakeholder involvement provides transparency in the process and indicates that different value systems are deemed important in decision-making.

- *In developing restoration goals and performance metrics, additional consideration should be given to habitat modifications (for example, stream channelization) resulting from human activities that may prevent a return to pre-mining conditions (NRC, 2005).*

Human activities might also be the entire reason for the presence of "habitat" features, for example drainage ditches and similar structures in developed areas may be entirely unnatural. Application of standards corresponding to natural streams may be inappropriate, even if the drainage channel has some base flow. Similarly, for small developed sites with patches of "natural" habitat, clear guidance as to the relevance of these patches to population-level ecological effects would be most helpful.

Similarly, in a site-specific setting, remediation based on estimated risks should be weighed against the physical cost of remediation to the potentially valuable and ecologically functioning habitat (in other words, would remediation do more harm than good in a particular situation).

- *EPA should improve its planned adaptive management approach by establishing unambiguous links between management objectives, management options, performance benchmarks, and quantitative monitoring indicators for the habitats and ecologic communities addressed in the ROD [Record of Decision (NRC, 2005).*

CT DEEP might wish to update their guidance to address the critiques of EPA's approaches in instances where similar critiques might be made of CT DEEP's approach.

- *Where final remedies cannot be realistically implemented, establish a rigorous and responsive adaptive management process for environmental remediation. ERAs at such sites should be designed to support remedy selection . . . (NRC, 2005).*
- *The committee recommends that such collaboration meetings be formal, structured workshops that have stated goals and objectives, be led by professional facilitators, and have formal agendas agreed to by all parties (NRC, 2013b).*

In a contentious situation such formality might be necessary. However, some of the best results come from informal, low-pressure, collaborative situations during which thoughts are shared openly and freely, with simple documentation in follow-up or in process emails. CT DEEP might consider indicating in their guidance when such communication is required and when less formal discussion can facilitate progress in achieving site closure.

- *To estimate pesticide exposure concentrations at various stages, the committee proposes a stepwise approach to exposure modeling. Step 1 would determine whether a pesticide and listed species overlap geographically and temporally. Step 2 would first identify the most important fate processes and other related considerations and then simplify the pesticide-fate model to estimate time-varying and space-varying pesticide concentrations in generic habitats relevant to the listed species. Step 3 would use refined models and the regional specific or site-specific input values relevant to the listed species (NRC, 2013b).*

These should be accounted for in the Problem Formulation step of the ecological risk assessment process.

7.2 Characteristics of Best Practices for Risk Assessment and Risk Management

Ecological risk assessment guidance, is just that, guidance. Given the site-specific nature of the evaluation of the myriad of plants and animals that may inhabit a site, it is simply not possible to provide rigid requirements for every aspect of an ERA that would meet the needs of every site in Connecticut. Nonetheless, several regulatory agencies in various states, provinces, and the U.S. have successfully implemented ecological risk assessment guidance that is both specific yet flexible, allowing practitioners to work through the process and achieve site closure. In these instances, the Agency provides the foundation and framework upon which all risk assessments are developed, but provides options through the process to allow for successful completion of the risk assessment and appropriate remedy selection based, in part, on risks to ecological receptors. In each instance, the Agency publishes this guidance and, when necessary, provides updates. These updates may be based on newly available science or may clarify existing guidance, especially if and when the same sorts of questions arise repeatedly from different practitioners or other parties.

To meet agency objectives, those objectives and means by which they can be achieved should be clear. Thus, the most critical aspect of conducting risk assessments is knowledge of the framework and the goals. This is only achieved by the agency publishing and making widely available such guidance, and providing a specific, direct contact to whom direct questions can be addressed (and from whom direct answers will flow). Publishing guidance allows practitioners to understand the expectations of the process. LEPs, property owners, and other stakeholders are thus enabled; they gain the ability to understand how the sites for which they are responsible fit into the overall process and goals of the State. Although providing a direct agency contact for questions may seem daunting for any agency with so many responsibilities, this allows for consistent application of the guidance and minimizes delays in completion of risk assessments. This also assists the agency, providing a vehicle by which its community can receive feedback and direct relevant updates. If the questions from all stakeholders are consistent, those can be addressed and published, in something like a "frequently asked questions" document or technical update. This assists the agency in that similar errors are not repeated by multiple practitioners over time, and then limits the time spent by agency personnel reviewing and commenting on such issues. This time spent early can reduce the effort by both the agency and practitioner over time.

Thus, we recommend that CT DEEP's ecological risk assessment process be published in full as soon as possible, and be explicit, transparent, and frequently updated.

As noted above, it is not possible for the Agency to provide rigid requirements for every aspect of an ERA that will meet the needs of every site in Connecticut. However, the general framework can be provided with some built-in flexibility at specific steps in the process. For example, U.S. EPA provides a tiered approach (U.S. EPA, 1997a) – a screening level ecological risk assessment (SLERA) and a baseline ecological risk assessment (BERA); and EPA provides several decision points within each part so that a site can exit or, instead, can continue through the remedial process appropriately. This tiered approach accounts for the complexity of the site, type of contamination, presence or absence or types of ecological receptors and habitats, and whether there is a complete pathway by which receptors are exposed to contaminants. A tiered approach also allows for property owners, practitioners, regulatory agencies, and other stakeholders to focus efforts and funding on those sites warranting action.

Thus, we recommend that CT DEEP implement a tiered approach to completion of ecological risk assessments, progressing from generic evaluations to the need for site-specific information, so that there is both consistency in general approach across the state, and flexibility to address site-specific considerations.

One aspect of a tiered approach may be borrowed from the states, such as Massachusetts, that have explicit instructions for when ERAs are *not needed* for contaminated properties. In particular, properties may be "screened out" of this requirement based on (i) consideration of site size, (ii) comparison of site conditions to background or local conditions, (iii) consideration of rare wildlife or Areas of Critical Environmental Concern (ACECs), and (iv) "effects-based" screening. Thus, terrestrial sites that are (i) small and that (ii) have no rare wildlife or critical habitats might be excluded from further consideration with regard to ERA. Similar recommendations could be made for aquatic environments, based on guidelines developed to indicate the minimum areal or linear extent of contaminated sediment that the State would consider to be significant. One way to implement such an approach, which goes beyond the SLERA/BERA paradigm, is that used in Texas, by Ohio EPA, and by Oregon DEQ: truly negligible sites are screened out with a checklist/site visit (*e.g.,* indicating no habitat, receptors, or complete pathways).

The basis of any ecological risk assessment, with the exception of presence/absence evaluations (habitat, receptors, complete pathways), is a strong data set. Often an ERA is thought of relatively late in the evaluation process, and ERA practitioners must use existing data that may not be ecologically relevant. This, of course, introduces uncertainties and may limit the accuracy of conclusions.

In other words, to successfully estimate risks to ecological receptors, data relevant to ecological exposures are critical. For example, most terrestrial receptors are exposed to the top foot of soil, and in the case of burrowing mammals, up to three feet. Aquatic receptors are typically exposed to sediments no more than one foot deep, which represents the biologically active zone. Thus, data collection should be focused on these depth intervals, unless there is a site-specific reason to assess different exposures (*e.g.*, sediments are to be dredged and deeper sediments would be exposed). Thus, it is recommended that CT DEEP publish guidelines related to data collection specifically for ERA purposes, and integrate these into the extant Site Characterization Guidance. Further, beyond data collection, which addresses exposure, the assessment is only as good as the quality of the data. The data need to be scientifically valid, accurate, and to the extent possible reproducible (*e.g.,* using field duplicates, or perhaps better, re-sampling). The data quality review currently employed in Connecticut may be sufficient to ensure data validation at many sites. In some cases, however, it may be prudent to implement the requirement that data be validated prior to use in the risk assessment to a level equivalent to EPA's Stage 2B Validation (U.S. EPA, 2009). This will ensure, to the extent possible, that the data supporting risk assessment and to some degree the selection of a remedial decision are based on sound science and data. This is supported by several NRC recommendations, including conducting a broad data search, then screening the available information, and subjecting it to quality review (NRC, 2013b, see above).

Any risk assessment provides just one measure by which remedial decisions are made. Many factors, including risks to human and ecological receptors, feasibility, and economic concerns, should inform selection of a remedy. At times, these factors conflict, thus supporting different remedial needs rather than support selection of a single remedy. The risk manager must weigh each factor to determine what short-term and long-term solutions are most appropriate on a site-specific basis while balancing these interests. As recommended by NRC (2005), consideration should be given to habitat modification resulting from human actions and how that would impact future conditions. Remediation to achieve ecologically-based protective levels may not be necessary or appropriate if human use would return site conditions to pre-remedial conditions. Additionally, some ecological receptors adapt to elevated contaminant levels if the habitat is functional and supportive. Neither regulatory bodies nor responsible parties want to leave contamination in place if it can be removed to the benefit of others; yet, if the habitat is removed or destroyed, the chemical quality of the media would not matter. Thus, the agency should consider provisions for allowing for habitat considerations in remedial decisions.

One of the primary concerns surrounding ecological risk assessment is the level of uncertainty, which is introduced at each phase of the process. Uncertainties can be introduced by selection of data, representative receptors, ecological screening levels (ESLs) and toxicity reference values (TRVs), and lines of evidence incorporated into the process. Many of the recommendations from NRC above (NRC, 2013b) speak to uncertainties. CT DEEP can assist in reducing the types of uncertainties and degree to which they affect the results of ERAs by providing clear guidance on a number of aspects, such as ecological screening level selection, use of background, preferred lines of evidence, in agency guidance.

7.3 Best Practices Used by Other States and Agencies

7.3.1 Requirements

Only two of the requirements in our contract explicitly called for evaluation of ecologically-related material (Question B.v., "How is acute and chronic toxicity evaluated for ecological receptors?"; and Request E.ix, "Valuation of ecological systems and services"). However, the responses we coded for our questionnaire accounted for both HHRA and ERA, with distinct potential responses for human and ecological receptors where appropriate (see Appendix F). All potential responses were coded as relevant for HHRA, or ERA, or for both, so the same methodology (see Section G.3) could be applied for either HHRA or ERA.

7.3.2 Results of Database Evaluation

Table 7-1 provides summary averages for accumulated scores for the State and Agency Methods that apply to ERA. Pure best practices would produce scores of 1.0 in all cases using this methodology (and worst practices everywhere would produce a weight of 0.1). The average scores range from 0.16 to 0.55, so provide a fair degree of discrimination between programs although less than that for HHRA, with the Connecticut Methods ranked at 8, 9, and 10 out of 31 (with 1 representing overall "best practice").

Table 7-1 Summary results scoring ERA methods against best practices

State	Method	Accumulated Weight
California	Prelimary Endangerment Assessment	0.54
California	RI/FS Predictive ERA	0.25
Canada	3 ERA SL/PQRA/DQRA	0.40
Connecticut	Default	0.32
Connecticut	Engineered Controls / ELUR	0.32
Connecticut	Variations / Exceptions / Alternative Methods	0.33
DOE	Method 1	0.52
EPA	1 ERA	0.26
Illinois	Tier 1	0.23
Illinois	Tier 2	0.24
Illinois	Tier 3	0.25
Maine	Method 1	0.30
Massachusetts	Method 1	0.35
Massachusetts	Method 2	0.37
Massachusetts	Method 3	0.55
Michigan	Generic Criteria	0.26
Michigan	Site Specific Risk Assessment	0.18
Montana	Method 1	0.30
Montana	Method 2	0.46
New Hampshire	Method 1	0.22
New Hampshire	Method 2	0.23
New Hampshire	Method 3	0.40
New Jersey	ERA	0.37
New York	QHHEA/FWRIA	0.16
Rhode Island	Method 1 & 2	0.36
Rhode Island	Method 3	0.55
Texas	Eco 1	0.46
Texas	Eco 2	0.32
Texas	Eco 3	0.45
Vermont	Risk Assessment	0.53
Vermont	State Provided Value	0.16

ELUR – Environmental Land Use Restrictions
ERA SL – Ecological Risk Assessment, Screening Level
DQRA – Detailed Quantitative Risk Assessment
FWRIA – Fish and Wildlife Resource Impact Analysis
ERA – Ecological Risk Assessment
PQRA – Preliminary Quantitative Risk Assessment
QHHEA – Qualitative Human Health Exposure Assessment
RI/FS – Remedial Investigation / Feasibility Study

It can be seen that this methodology does provide discrimination between Methods, but as for the HHRA the interpretation of such highly condensed results may be compromised by the limitations discussed in Section 5.4.4. As for the HHRA, examination at a substantially higher level of detail is more informative, since the problems leading to the limitations can often be detected.

Table I-1, Table I-2 , and Table I-3 show the accumulated weights for each of the nine evaluated attributes for requirements A (Exposure), B (Assess how toxic effects are currently determined), and C (Characterize how risks are currently estimated) respectively. The same features can be seen as for the HHRA, and again as for the HHRA, the limitations of the methodology can be seen in results that seem implausible, such as perfect values of 1.00, or exact multiples of 0.10 — these are more likely due to a limited number of questionnaire responses being answerable than to all of them indicating the highest possible rank. Zero entries in particular show either that no weights were assigned (because the potential responses could not discriminate on that particular attribute), or failure of the Method to document the aspect of the Method being questioned.

As for the HHRA in Section 6.4.1, to evaluate where Connecticut's Methods lie with respect to the best practices in use among all the State/Agency Methods evaluated, we identified the top scoring Method(s) for each of the questions posed in Requirements A through C (questions 1 through 3), and ranked Connecticut's three methods for each of these questions separately. Table I-4 shows these rankings, and identifies the top ranking Method(s) for each of the questions. Again, no single State/Agency Method ranks highest for all questions. Connecticut's three Methods rank highest for questions 1.15 and 2.7, as for HHRA; these two questions do not distinguish HHRA and ERA. The same caveats apply to these rankings as were pointed out in Section 6.4.1 for HHRA.

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Appendix A

Public Meeting Presentation Slides

Risk-Based Decision Making Public Meeting

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CT DEEP Phoenix Auditorium
Hartford, Connecticut

March 12, 2014

CDM Smith

Overview

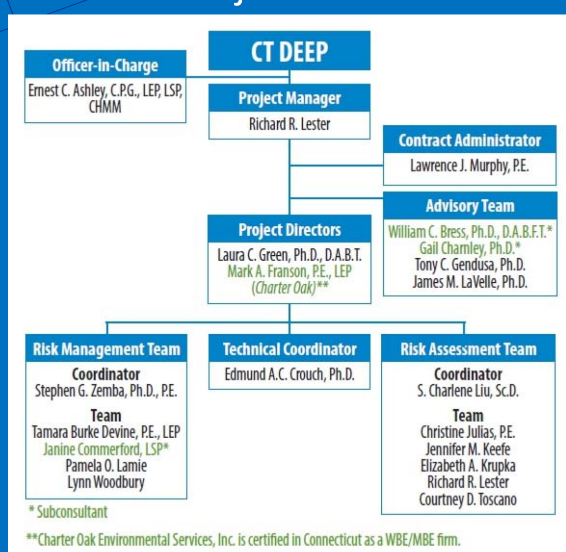
- Introduction to CDM Smith & Project Team
- Project Overview
- Comments and Questions

- The meeting is being recorded
- Meeting minutes will be provided to CT DEEP and the full project team

CDM Smith

- International environmental consulting and engineering firm
- Headquartered in Cambridge, Massachusetts
- 700 staff in New England
  - East Hartford and New Haven offices
- Leaders in risk-based decision making and site evaluation

Project Team



Team Experience

- Team includes risk assessment experts, retired regulators
- Decades of experience in risk-based decision making
- Charter Oak Environmental Services
  - 30 years of experience in remediation
- Hundreds of human health and ecological risk assessments

CDM Smith

Project Overview - Scope

- Three main components
  - Assess the existing process in Connecticut for risk-based decision making
  - Identify best practices in human health and ecological risk assessment & risk management
  - Evaluate the extent to which specific characteristics of Connecticut affect best practices

CDM Smith

Project Overview – Connecticut Process

- Develop a database to document the CT risk-based remediation process
- Obtain documentation of CT process
- Execute the methodology requested by CT DEEP
- Clarify details with CT DEEP and DPH

CDM Smith

Connecticut Risk-Based Decision Making

Project Overview - Methodology

- How are exposures are defined?
- How are toxic effects determined?
- How are risks estimated?
- How are remedial goals set?
- Roles of the state, local agencies, and public?
- Roles of regulation and guidance?
- Is adaptive management used?

CDM Smith

Connecticut Risk-Based Decision Making

Project Overview - Methodology

- Communication of risk-based decisions
- Determine how remediation practices support risk assessment & management
- Timeliness of agency response
- Accessibility of documentation
- Feedback mechanisms to regulators
- Mechanisms to update procedures & values
- Flexibility

Project Overview – Best Practices

- Execute methodology for other programs
  – New England states, NY, NJ, five additional states, EPA, DOE, Canada, and EU
- Establish "Best Practices"
  – Consider NAS reports, scientific advisory boards, literature, practices identified

Project Overview – Best Practices

- Determination of a practice as "best" will account for
  - Availability of required source material
  - Transparency
  - Protection of health & the environment
  - Degree of scientific validity and rigor
  - Flexibility in application
  - Use of risk management approaches
  - Ease of implementation

CDM Smith

Project Overview
Connecticut-specific characteristics

- Best practices will be examined to determine whether they are compromised by Connecticut-specific characteristics
  - Geographic location
  - Industrial history
  - Physical & geological characteristics
  - Reliance on groundwater & water resources
  - Constitutional barriers

CDM Smith

Project Overview – Deliverables

- Draft Report – July 1, 2014
  - Summarize results of study and public comments
- Final Report – 30 days after receiving comments from CT DEEP
- Final Public Meeting – 10 days after Final Report is accepted

Comments and Questions

We seek feedback on the process from stakeholders and interested parties

Thank you for your time and comments.

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Appendix B

Transcript of March 12, 2014 Public Meeting

RISK-BASED DECISION MAKING

PUBLIC MEETING

DATE: March 12, 2014

TIME: 10:00 a.m.

HELD AT: CT DEEP Phoenix Auditorium
Hartford, Connecticut

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MS. CHASE: Thank you for coming. My name is Cheryl Chase. I am the director of the inland water resources division. Today I am playing a different role as project manager for DEEP for the risk-based decision making project. As you probably all know, a public act last year required us to go through the process of assessing Connecticut's process for risk management and risk assessment. And comparing them to many, many other entities. And making some recommendations for changes if needed.

So to do that we went through the selection process for a contractor. We got some fabulous responses and ended up with CDM Smith, who is going to be taking over from me in just a few minutes, but they will basically go through an introduction of who they are and what they are doing. And then we would like to open it up for comments, questions, suggestions, and all of that. And if you come up to speak if you could just give your name clearly and who you are working for so we can make sure we capture that, that would be lovely. And basically this is your opportunity for input. Until the point where we may be to making some legislative suggestions for changes there is not really another opportunity for public input into this particular process, although there are many other things going on in the department that you can be involved with.

So I encourage you if you have anything to say, please feel free to say it now or you can also e-mail Mark or myself later, and I can give you that information if you need it.

So with that I would like to turn it over to Mark Franson -- I am sorry, to Rich Lester from CDM Smith. And he will take it from here. Thank you.

MR. LESTER: Thank you all for coming today. I am Rich Lester. I am the project manager for CDM Smith Risk-Based Decision Making Project with the Connecticut DEEP. My contact information is on the first slide here. And DEEP or we can provide a copy of this presentation if you would like a copy.

I am accompanied here today by one of our team members, Mark Franson from Charter Oak Environmental. He has been involved in risk-based decision making here in Connecticut for over 30 years.

I would first like to give a brief introduction of who we are, who CDM Smith is and who our project team members are. And then a brief overview of what we have been asked to do by Connecticut DEEP. Then, as Cheryl mentioned, we would like to open this up to comments and suggestions.

This is the primary source, the primary opportunity for you to offer your comments into this process. The meeting is being recorded. And the meeting minutes will be provided to the Connecticut DEEP and the full project team. While we only have a couple members of our project team here today, the full project team will certainly be aware of all comments offered and take them into consideration.

CDM Smith is an international environmental consulting and engineering firm. We are headquartered in Cambridge, Massachusetts. That is where my office is. We have about 600 people in Cambridge, Massachusetts. But we also have two offices here in Connecticut, one of which is in East Hartford, not too far from here, and in New Haven as well. We are leaders in risk-based decision making and site evaluation.

This is an organizational chart of our project team. I know you probably can't all read this from the back of the room, but I am the project manager. Again, my name is Richard Lester. We have a number of people on the team who have a lot of experience in a lot of different states doing risk-based site remediation.

A few of my colleagues at CDM Smith, let's see, the project director, Laura Green. And the technical coordinator Edmund Crouch. And the risk management team coordinator Steve Zemba. They have been colleagues of mine for over 20 year. The four of us were together at a small company called Cambridge Environmental up until about a year ago when we were acquired by CDM Smith. We specialized in human health risk assessment.

Laura is a toxicologist. She is a diplomat of the American Board of Toxicology.

Edmund is a risk assessor. He is one of the nation's preeminent risk assessors. He is involved in a lot of National Academy of Sciences Committees. He has an extraordinary background in probabilistic risk assessment and risk assessment in general.

Steve Zemba is an air modeler and risk assessor with again about 25 years of experience at Cambridge Environmental and CDM Smith.

Mark Franson, as I mentioned earlier, he is from Charter Oak Environmental. They have over 30 year's experience in Connecticut and other states doing risk-based for mediation. And we also have many team members with experience in specific states.

William Bress is a toxicologist up in Vermont.

Charlene Liu is in CDM Smith's office down in New Jersey. She has a lot of experience with EPA with New Jersey, with New York.

Pam Lamie has a lot of experience with the State of Montana. She has been working with their regulators for decades.

We have some eco-risk assessors. Jenn Keefe is an eco-risk assessor in our Cambridge office.

Tony Gendusa is an ecological risk assessor.

So we have a very broad background that we feel offers us a lot of expertise in which to address the issues that we are going to be addressing in this project.

This just summarizes a lot of what I just told you. As a project team we have done hundreds of human health and ecological risk assessments over the course of 30 years or so.

In terms of the scope of the project, we are basically working on the scope that was outlined for us by the Connecticut DEEP in their request for proposal in their RFP.

There are three main components to the project. And I will be stepping through these in a bit more detail in just a moment. The first is to assess the existing process in Connecticut for risk-based decision making.

Secondly, we are tasked with identifying best practices in human health and ecological risk assessment and risk management.

And, thirdly, we are being asked to evaluate the extent to which specific characteristics of Connecticut may affect the best practices that we identify in our evaluation.

The first part, evaluating the Connecticut process, we are going to develop a database. This will be used for both Connecticut and some of the other state and governmental programs that we evaluate. The database will be a means of storing the information that we gather throughout the course of this evaluation. We are going to, and we have already done the obtaining the documentation of the Connecticut process, and a lot of the other state processes that we are going to be evaluating. We have a little bit left. We are still going to be conducting some interviews next week of Connecticut DEEP staff, and within the next couple of weeks DPH staff, EPA and NOAA staff that have former experience with the State of Connecticut. And we will, I am sure we will be adding to the documentation as we go through the process and identify additional sources of information.

Once we obtain all the documentation we will be executing a specific methodology that was outlined in the request for proposal. And again I will give some more information on that in just a moment. Any questions we have we will be clarifying details with Connecticut DEEP and Department of Public Health.

The methodology: These are some broad questions that we are being asked to address in the methodology. There are several specific questions underneath each of these broad areas that I have listed up here.

But we are being asked for the State of Connecticut and then subsequently for a bunch of other programs to look at how exposures are defined. How are toxic affects determined. What toxicity factors are used in risk assessment. How do we go about estimating risks. How are remedial goals set. What are the roles of the various state and local agencies and the general public and licensed environmental professionals in Connecticut? What are the roles that regulation and guidance play in the state? Is adaptive management used in Connecticut and in these other programs that we are going to be looking at? We are evaluating the communication of risk-based decisions. How decisions are communicated to the stakeholders, to the public. We are determining how the remediation practices support risk assessment and risk management. We will be evaluating the timeliness of agency response, the accessibility of documentation, feedback mechanisms, mechanisms to update procedures and values, and the flexibility of the whole risk-based remediation process.

The second part of the process is evaluating best practices. And in doing that we will be performing the same methodology we performed for Connecticut for a number of other programs. We will be looking at all six New England states, so Connecticut, and the other five states, plus New York and New Jersey. The reason for looking at these is because they are close regionally to the State of Connecticut. Then we have selected five other states for various reasons. Primarily because they have unique site-based remediation programs or extensive programs that may be different from other states or because the project team has extensive experience in those states.

The states we have identify are California, Texas, Michigan, Montana, and Illinois. We will also be looking at EPA programs, the Department of Energy, Canada, and the European Union.

We will be establishing best practices. And that is one of the areas in which we are looking for some comment from you today, is whether you have any suggestions or recommendations for what you might consider best practices. We will, of course, be considering all the information we identified from the various states when establishing best practices. We will look at National Academy of Sciences reports. Any reports from the scientific advisory boards, the scientific literature in general.

When we determine the practice actually is best we will be accounting for a number of parameters. We will be looking at the availability of information, the source material on which the risk-based remediation programs are based. We will be looking into the transparency of the process. How protective the programs are of health and the environment. The degree of scientific validity and rigor that is inherent in these processes. The flexibility in applying the process to various sites. The use of risk management approaches, and the ease of implementation. And these are not in any particular order. We are going to be considering which of these is most important as we go through the evaluation process.

Finally, we are going to be looking at any Connecticut specific characteristics that may affect the best practices that we identify. Certain examples of these are Connecticut's geographic locations. Certainly there are differences in Connecticut that wouldn't necessarily apply to Texas or to an area that has different environment, different geography.

The industrial history of Connecticut. This is certainly a more industrial state than some of the western states. Physical and geological characteristics. We will be looking at the reliance, the state's reliance on ground water and water resources. Any constitutional barriers that are Connecticut specific. We will be considering all of these when we are looking at Connecticut specific characteristics that may affect the best practices.

Once we go through all these steps we are being asked to provide several or three deliverables to the State of Connecticut. We will be providing a draft report which is due July 1st. We have every intention of meeting this deadline because there is a legislative deadline of which we are aware, which I believe is October 1st for Connecticut DEEP to respond to what we found and everything else that they have been looking into over the past months and years. They will be commenting on our draft report. 30 days after we receive comments we will be providing a final report to Connecticut DEEP. And 10 days after that or at least 10 days after that we will be presenting the results of the evaluation at a final public meeting.

But this right now, this public meeting really is the main opportunity to offer comments into this process because that final public meeting is going to be well after a lot of things have already been decided.

With that I would certainly like to open this up for feedback on the process from any stakeholders, any interested parties, or any questions you might have on the scope of the project. I certainly thank you for your time, and look forward to hearing any comments you have. I would like to reiterate that we would like you to state your name, and what company you are from or whether you are just a member of the general public who is interested, and offer any comments you have. Thank you.

MR. FRANSON: As it stands right now, I am Mark Franson, Charter Oak Environmental, we don't have anybody signed up. So if you are so inclined just walk up to the mic and provide the information.

MR. MOLOFSKY: Good morning, my name is Seth Molofsky. I am the Executive Director of the Environmental Professionals Organization of Connecticut. We are a trade organization that represents Connecticut LEPs, mostly providing education and training and keeping them informed of regulation changes and such.

So I am curious in this process over the years our organization has responded to numerous changes in the regulations and proposals by the agency that have involved changing risk-based numbers and such and proposing new standards. We have commissioned reports from several different special risk experts, and have those reports available. And wondering if your group is willing to accept any documents that have -- that we have produced and would look at those. A lot of these review the process and compare numbers to other states, and have done a similar procedure that you are doing obviously on a much finer scale with specific numbers. So that is my question today.

MR. LESTER: Thank you for the comment. We are certainly going to be considering all information that is provided to us. We are aware that quite a bit of study has gone into some of the transformation that is going on in the State of Connecticut or the studies that have been going into a transformation of the site-based remediation process. We will look at anything we are provided with from your organization or from any of the work groups that have been established.

MR. MOLOFSKY: Very good. I appreciate that.

MS. MORELLA: Hi. My name is Amy Morella. I am a volunteer here on behalf of the Connecticut Fund for the Environment. I am here, I wanted to ask a couple of questions. If you could go back to your slide that shows methodology to start with.

Now, the methodology would be for your report. I am looking specifically at Connecticut. Yes, that is it. So my first question is in terms of how you define methodology. You went on to a second slide that talked about communication of risk-based decisions, et cetera. Some of these issues that you have here are issues that have been ongoing addressed by the department because of an effort to implement lean concepts. So these issues seem to go less to whether or not sort of scientifically risk assessment is being done properly and risk management decisions to just how quickly the agency communicates and works with all stakeholders.

And I was wondering to what extent this part is going to be looking at what other states deliver and how important is this part of it versus the more scientific piece on your previous slide. If you could give me some understanding of how you intend to tackle those two characteristics of assessment.

MR. LESTER: Okay. We do intend to look at the entire methodology for each state. We are certainly doing it in more detail for Connecticut. In Connecticut we are interviewing many, many people within the state to make sure that we thoroughly understand the process, including the parts that aren't well documented in guidance documents, or legislation, or regulations. In many of the other states we will be relying more heavily on what is available on the web, what is available in documentation, in regulations, in guidance, in legislation. But we will not unfortunately be able to conduct extensive interviews with much of the staff in these areas. Now, we do have expertise in a number of these states. So we will be able to draw from our own experience in a number of these states in evaluating the timeliness of agency response, and some of these other factors that we have listed on this second methodology slide, but it won't be in quite a great as detail.

MS. MORELLA: I would encourage you as you develop your report to make sure you distinguish the things that are process lean oriented, such as what is on this page, versus whether or not you are correct in using 10 to the minus 6 and whether you are assessing those kinds of things which are more scientific based questions about how you go about determining risk. I think that will make it easier for legislators to understand because they are not experts. I am not saying that I am an expert either, but as a person who dabbles in this I think distinguishing clearly to the extent you have improvements to suggest will be helpful for the next stage.

My other question is about the context of the report. And it is something that perhaps goes beyond your scope. But I just want to be sure that it is understood that to the extent this report only goes at risk assessment, and risk management issues, and doesn't look at the policy trade-off at each state between flexibility and between really just some lessening of a risk concerns as a tradeoff to getting the properties cleaned up promptly, and having an affirmative obligation on property holders to clean up, that is something of great concern, I believe, to

CFE based on their prior statements, and legislative efforts, and efforts by the agency to transform the process. And so I hope that the report can actually have some context so that Massachusetts, as an example, may have greater flexibility than our state does currently. But also has a much more affirmative obligation. And I think if this is done in a vacuum without some color to provide the context of the larger overall program, again, you will leave legislators not understanding, and that would not be in the interests of anybody in this room or in Connecticut. Thank you.

MR. LESTER: Thank you.

MR. HACKMAN: Matt Hackman. I am a sole practitioner, LSP, LEP, PE. Since you came all the way down from Cambridge, Rich, and have three hours, sort of following along Ms. Morella's comments, are you going to distinguish a number of the states you have mentioned and I work in like Massachusetts, New York, Rhode Island, as well as Connecticut? The standards that have been set under the MCP in Massachusetts or DER10 in New York, they have been in the remediation regs in Rhode Island, a lot of those numeric criteria are not only risk-based but they are also influenced by public policy or there may be other considerations. So, for example, Massachusetts sets upper concentration limits sort of arbitrarily. Just saying even if there is not a risk at these levels we think that the existence of this high a concentration of a particular substance just ought to be cleaned up. It shouldn't be allowed to remain in the environment. Are you going to look at some of those things and sort of try to distinguish between the specifically risk basis and then maybe some of the other factors that have come in along with this methodology, the setting of standards in other states, and things that Connecticut might want to look at?

MR. LESTER: Yes, we do plan to look at all of the factors that go into the development of standards for states that have specific standards. There certainly is more than just health risks that goes into the development of a lot of these standards, and we will be looking at that.

MR. HACKMAN: To Ms. Morella's point this will be sort of made clear because sometimes those modifiers, you know, shift numeric criteria for two orders of magnitude.

MR. LESTER: That is true. We are not going to be looking at specific criteria chemical by chemical. We are creating a database in which are going to summarize the scientific aspects, which are the first two questions on this slide here. Those are more scientific, and those are more easily answered in a database where we can just list answers that each state provides. We will have a comments area in that database where we will identify anything that departs from just a strict health based definition of standards. We will be considering other factors.

MR. HACKMAN: It sort of goes between the third and fourth question there. The risks are often estimated, sort of a mathematical scientific basis, whereas the remedial goals set may incorporate a whole bunch of other considerations.

MR. LESTER: When it comes to identifying best practices we do plan to come up with a method for ranking some of these criteria here when establishing best practices. We have not developed that ranking yet. We certainly want to go through the whole evaluation process before we discuss which of these would be more important and assign some sort of weight to each of these parameters.

MS. CATINO: Hi. I am Ann Catino. I am an environmental lawyer, but also I serve as co-chair of the state's task force on brownfields. It is called Brownfield Working Group now.

What you are doing actually grew out of a dialogue that the Brownfield Working Group had with DEEP when last session there was a proposal to reduce our significant environmental hazard reporting which was based on the RSRs from a 30 times standard to a 10 times standard. And at that time there was discussion as to why are we doing this? Is it more protected? Is it not more protected? And then what is the risk? And if we are going 10 times or 30 times, whatever times the number is, is that something that we should be focused on? And what is the basis? What is the underlying basis for going to a 10 or 30, whatever times, standard for reporting significant environmental hazards.

So what we were doing is we were questioning with the legislators because they were very intimately involved in this whole initiative as well. So I think to capitalize on what Amy Morella said, you need to keep it simple and explainable to them. Because the questions they are going to have are, are existing RSRs, maybe not certainly constituent by constituent, but is the basis for them supportable? Are they protective of environmental and public health risk? Are the formulas that they rely upon in general accurate or not accurate? Should they be updated? Is

10 to the minus 5 a direction we should be going in as opposed 10 to the minus 6? What are the other states doing?

So I think the framework of where this came from becomes important in order to answer the questions of the legislature, as well as the regulated community. We are looking for certainty as far as what does the regulated community need to do? But some flexibility as well given the context of a site. We understand certainly that there are certain unique aspects to Connecticut, our reliance on ground water for drinking. That is significant. But there are so many questions about our industrial areas versus protection of our groundwater resources. How are we going to make for a developable area or are we just going to create more brownfields? That is always in the back of the legislators' minds who represent those municipalities because we all have brownfields. What are we going to do and how are we going to stimulate brownfield development and not turn sites into brownfields because you end up scratching your head because you are never going to be able to achieve some magic number.

So to the extent we can move more to a risk base that is understandable for the legislators as well as the public and the regular community certainly, I think that is a goal here.

I just caution you on spending a whole lot of time frankly on really evaluating hard our existing program because there are a lot of issues we have with our existing program which I think Seth can certainly give you the documents on it. You can talk to any LEPs. Certainly the staff, DEEP staff has its only probably issues with the existing program as well. But we need to take something and make something that is better and workable.

So I am encouraged by what you laid out here. I see a lot of frankly questions and confusion in my own mind as to where this is going to go. And I want to make sure that you understand that it is going to go to a proposal that needs to be understandable to everyone, particularly the legislators, of course.

MS. LESTER: Thank you very much.

MR. SHARP: Good morning. I hadn't planned to speak but I did have a question. I am Greg Sharp from Murtha Cullina. I am an environmental lawyer. I am also on the brownfields task force. What do we call ourselves? Brownfields Working Group.

You indicated the schedule towards the end of your presentation with the draft report July 1, final report 30 days later. And then a public meeting 10 days after that. Are you intending to release the draft report to the public or only to DEEP at the time you put it out?

MR. LESTER: We are providing it only to Connecticut DEEP. What is done with it is up to them.

MR. SHARP: Understood. So public -- DEEP is going to give the public 10 days to review this before the public meeting? That just seems an incredibly short period of time for members of the public to try to master this incredible amount of material. At least I assume it is going to be an incredible amount of material based on what you presented.

MS. CHASE: I just want to address that. The intent of the draft report and final report is not provable. It is not something we need the public input on. Because in general what they are going to be reporting on is their findings. Their findings for what Connecticut is doing. Their findings on what other entities are doing. And their recommendations for what they think the best practices may be in those areas that we could adopt. The time for public input is during the legislative process. When DEEP makes its recommendations for legislative changes that is really the time that the public will be involved.

The report is not -- it is not something that we are going to take verbatim and say, okay, here you go legislators. It is something that we have to digest as the DEEP and the DPH as well who are involved. And determine based on that report which direction we are going to go. So when you say we only, the public only has 10 days to absorb it, really that is kind of mischaracterizing it. It is actually the public meeting is for the purposes of getting the report introduced to the public as these are our recommendations. And if there are any comments at that point, well, these recommendations are terrible or they are great or, no, this is the direction you should go. That is what we will be using as the basis for DEEP's recommendations. Does that make sense?

MR. SHARP: Yes. I mean, you have clarified the purpose of the public meeting is not to receive comments from the public on the report. It is more to roll out the report to the public.

MS. CHASE: That is fight.

MR. SHARP: I had a detail question because I know your presentation is sort of at the 50,000-foot level. When you look into how standards are set and so on, are you going to look at both the way the standards are set under the remediation standard regulations as well as, for example, how standards are set for aquatic toxicity under the water quality standards as well as the eco-risk?

MR. LESTER: We are looking at both human health and ecological risk.

MR. SHARP: So water toxicity would be part of your exercise?

MR. LESTER: I believe that will be part of it, yes.

MR. SHARP: Okay. Thanks.

MR. WOIKE: Hi. My name is Herb Woike with GES. You said this is a time for a wish list so I am going to throw that out. I don't know who I speak for, whether it is the regulated community, whether it is LEPs, or things like that. But I guess a wish list is that the -- when you come back with talks about different methods like, not so much coming up with new regulatory standards, but we have different avenues to explore in our risk characterization. And I don't think we have that now in the State of Connecticut. I guess I am referring to Massachusetts has method one, two, and three. Rebecca has a lot of things like that. So I guess I would look hopefully when you guys come back you recommend what best practice would be that there are different alternatives. If it is an easy site you can use this method. If it is more complex you can use a more complex or more alternatives to get yourself in and out of closed sites. So different methods. I know like Rebecca does things like risk, the exposure pathways. We can eliminate exposure pathways because of the conceptual site model. Connecticut does use the conceptual site model, but sometimes I don't know that we are allowed to say, well, we can eliminate this exposure pathway due to these reasons. And, therefore, it demonstrates there is no risk and therefore it is easier to close the site. So I am looking at those kind of things as best practices and that is part of my wish list.

MR. LESTER: We certainly will be identifying to the extent to which the various programs we are looking at have multiple methods for characterizing risk. We certainly will be identifying that, giving that information to DEEP. And if we determine in our evaluation of best practices that that would be a best practice we would certainly make that recommendation.

MS. MORELLA: Excuse me for speaking again, but there don't seem to be a lot of other people. You had a slide that explained constitutional barriers.

Could you explain what you mean by that please?
MR. LESTER: Anything in the Connecticut State Constitution or anything that would be difficult to change legislatively that we wouldn't be able to implement a recommendation that, a program that another state has in place. I don't have a specific example for you at present.
MS. MORELLA: I guess my question will be, will you have attorneys in your mix to make that assessment or who is going to be making that assessment of constitutional barriers.
MR. LESTER: We do not currently have an attorney on the project team. We considered that for this reason, but it would just be the project team as a whole making that decision.
MS. MORELLA: I would also like to add one other programmatic context that I would urge you to include, which is enforcement. One of the factors in giving more flexibility is ensuring that there is rigorous enforcement for violation of that. Whether it be a matter of negligence or intentional misuse. And I think there are quite different programs in place in other states than what we have currently in Connecticut. So I think it is very important to have a layer in this report which provides some

understanding of what degree of confidence you can have that to the extent you give people more flexibility, and less oversight, that they will do that, exercise that flexibility in a conscientious matter that ensures protection of public health and the environment.

MR. LESTER: Thank you. We will certainly take that into consideration.

MS. MORELLA: Thank you.

MS. PETERS: Hello. I am Anne Peters from Carmody Torrance Sandak & Hennessey. I am an environmental attorney. I would like to follow up on one of Greg Sharp's comments about the public input process.

One of the things that is very important about this overall project is its -- the perception that it is a truly independent, non-biased report that takes into account if not all the stakeholders involved and their concerns, but at least a wide range of data. So this is really a comment for DEEP, as well as for you, I would urge that the draft report be made publicly available to the extent possible and that this process be as transparent as possible and as inclusive so that it doesn't appear that this is really DEEP's report to the agency but really DEEP the regulated community, the environmental advocacy groups, and everyone's report to the legislature.

MR. LESTER: We certainly have every intention of being as unbiased as is possible in preparing this report. I honestly feel that one reason we may have been selected, and this is for Connecticut DEEP to know, would be that we are not solely focused on Connecticut by any means. We haven't been extremely closely involved in the transformation process. We have certainly done some work in Connecticut. But we have a lot of experience in many different states, and I do feel that that offers us an opportunity to be unbiased. So we do plan to be unbiased.

MS. POTOCKI: Good morning, Rich. Bonnie Potocki, Ecosolutions. I apologize for coming in late. I was fighting with the parking meter.

One of the things that I was hoping, I applaud this effort going forward. I have struggled with and I think LEPs have struggled with contaminated sediments, management of contaminated sediments. One of the things I was hoping would come out this is we have a risk management approach. We have a legacy of industrialization, the use of our urban rivers. And I think it is really struggling what is background and what is really related to a site. What is related to storm water discharges. And I think attention has to be paid to that. And having different decision points when have you examined background to your best available practices and when do you move forward and come up with some sort of remedial approach, or is a remedial approach really the best decision making for closing out a site? So that is one thing I was hoping could be addressed.

The other I was hoping to be addressed is that once you have some sort of approaches and best management practices laid out that some sort of a pilot study could be done because, you know, the LEPs have a wealth of knowledge but they have different backgrounds and they would all approach maybe things differently. And I think some sort of kind of a test would be probably beneficial and maybe Connecticut DEEP consider that when they have a draft report for approaching the legislature. So that is part of my wish list. Thank you.

MR. LESTER: Thank you. Risk management is certainly part of our scope. So we will be taking that into consideration. In terms of a pilot study that is obviously not part of our scope.

MR. FRANTZEN: Good morning, Rich. My name is Kurt Frantzen. I am with RemVer. I am a sole practitioner, many years of experience as a risk assessor here in Connecticut, as well as across the nation. Could you go back to your best practices and what needs to be determined. One of the thoughts I had in reviewing the RFP was the question of whether this is an assessment, an analysis of best practices of the best practices of doing a risk assessment or best practices of making a risk-based decision or both or neither. That certainly is very important to clarify in the scope in the ultimate dialog that this report has with the department, both departments as well as with the legislature.

One of the critical aspects of Connecticut is the issue of making decisions about each release area versus the entire site. And as any risk assessor can tell you, how you define the decision that is going to be made with regard to the risk assessment, and how you design the risk assessment is very critical. A lot gets dealt with in the conceptual site model. But what often is lost is how the ultimate decision is going to be made.

So you have to begin with the end in mind. And I think in your assessment, and I am sure this will come out in your discussions with the DEEP, is the importance of figuring out just how you are going to define best practices in terms of the risk assessment itself, but also how it interplays with the ultimate decision making about each release area within a larger site, within both the aspects of a piece of property and beyond. So it is a much more difficult, multi-tiered effort that you need to differentiate upon. And one of the things that I struggled with as I was trying to compete against CDM Smith and the RFP, so congratulations. It was a very well done procurement process. That is my initial thoughts, and I am sure I will have more thoughts as the process goes on. So good luck.

MR. LESTER: Thank you very much. We certainly do understand that we are not solely looking at best practices and risk assessment. We are looking at risk-based decision making.

MS. CHASE: So it looks like you guys have said all you have come to say. Please feel free to contact me or Rich -- did you have something else?

MR. FRANTZEN: At this point is to you, Cheryl. The request for written comments was limited until March 11th, as I recall the announcement. I think reflecting the somewhat lack of commentary I think many individuals are somewhat looking at this as somewhat of a black box. In that the best way to make a process transparent and evoke commentary is to have folks respond to something. And right now, as I think you can see by the paucity of comments, folks aren't commenting because they are not reflecting back at anything.

One of the thoughts I had in trying to imagine how I would do this particular meeting was the importance of stimulating commentary by presenting, for example, some of the process of how Connecticut makes decisions. And I realize you have a very tight time frame, and a very specific set of things that you want to see accomplished. I don't think you are going to get the kind of input from the public and from stakeholders that is so essential to achieve the transparency that was spoken of earlier by just having one public meeting and limiting all written comments until March 11. I realize that extending a written commentary period complicates the approach that CDM Smith has to achieve in terms of its time line. You can't allow this to continue on. So you had to make some decisions. But I think you are opening yourselves up to criticism for lack of transparency, and not getting enough input in terms of what are the best processes and best practices as viewed by the stakeholders by limiting the input. And I think that is going to be a possible kink in your armor of this whole process.

So I encourage you to reevaluate the deadline, and how you would cope with additional written commentary going forward.

MS. CHASE: So, thank you. Very, very good comments. The reason that we originally asked for comments to come in yesterday was more for the purposes of being, if someone was unable to be here, we could reflect on them, and perhaps expand on what we said based on some of the questions that had come in. But there is really no comment period. And I am sorry that wasn't clear. We encourage any comments to come in at any time. And, obviously, it can't go on forever, as you said, because we have a deadline in the public act of getting a proposal to the legislature, unless that is extended, which at this point it has not been for us. But we absolutely take that to heart. It definitely needs to be a transparent process. And as for the comment about the draft report, we will take that back and think about it. As you said, it can't go on indefinitely, but as much as we can we would like to hear what you have to say and incorporate that into how we produce this report.

So, thank you. Those are good comments from all of you. And, in addition, Mark Franson would like to say a couple of things.

MR. FRANSON: Hi, Mark Franson, Charter Oak Environmental Services. We are a contractor to CDM Smith. Just in reflecting on some of the comments today, I want to make a couple of comments because I am the LEP practitioner in Connecticut that deals with all the problems that many of you encounter with regard to your site remediation. We have an open dialogue with DEEP. It wasn't really said today, but I think it needs to be said. We are already exchanging information, for instance, in trying to reconstruct, if you will, the entire basis for the criteria that we now have. It is not entirely transparent to people who look at it from the outside. We are visibly trying to work on that.

I also understand the tension between the complexities that are involved in risk-based assessments and risk-based decisions versus making remediation of sites attainable, simple, understandable. And so I bring that perspective to this process. And when it comes to best practices that is going to be a reflection of what Connecticut does and what other states do, but also it has to interact with the other side of the fence, if you will, which is all of the programmatic aspects of remediation that Connecticut has. They are visibly working towards a transformation. There is it a framework to that. So our risk assessment, risk management piece is a complimentary piece and they obviously intersect. That is where that dialogue back and forth needs to occur and it will be occurring as we go forward over these months.

MS. CHASE: Thank you again for coming. Again, if you would like to see me I have some business cards, if you need my e-mail address. I think we are also going to try to put the presentation on our web site so that you will have all that information. And I don't know if we are going to be able to put the video recording on the web site, but if that is possible we will try to do that as well.

So thank you again for coming.

(Whereupon the meeting adjourned at 11:00 a.m.)

C E R T I F I C A T E

I hereby certify that I am a Notary Public, in and for the State of Connecticut, duly commissioned and qualified to administer oaths.

I further certify that the foregoing meeting was by me duly sworn and thereupon testified as appears in the foregoing meeting; that said meeting was taken by me stenographically and reduced to typewriting under my direction, and the foregoing is a true and accurate transcript of the proceedings.

I further certify that I am not interested in the outcome of said cause.

Witness my hand and seal as Notary Public the 17th day of March, 2014.

____

Notary Public

My Commission Expires:

November 30, 2017

Appendix C

Minutes from March 19, 2014 Interviews with CT DEEP Staff

Interviews with CT DEEP
March 19 2014

Overall Comments

Two quotations were read to most groups, and the interview participants were asked if the statements remain as true today:

1. From the Report on a public hearing held on November 6, 1995: ". . . the Department must focus on its primary legislatively affirmed goal: fully protecting human health and the environment. However, in doing so, we must often strike a balance between this and other significant, and in some ways competing, interests, such as contributing to a healthy state economy. "Striking a balance" is a theme common to many of the issues discussed in this report."

2. From the December 1994, "Proposal for the Connecticut Clean-up Standard Regulations": "The Department has, in the past, made remedial decisions on a case-by-case basis… The Clean-up Standard Regulations will be based on the same goals and will make the remedial decision-making process as clear and predictable as possible. By establishing clear written standards, the Department will improve the efficiency of remediation programs and ensure the consistency of clean-up decisions made by the Department."

When these statements were put on the table in the interviews, there was ready agreement that they remain as valid today as they were then.

CT DEEP Staff Interviewed

Robert Bell
Yvonne Bolton
Jan Czeczotka
Corinne Fitting
Raymond Frigon
Rosemary Gatter-Evarts
Maurice Hamel
Robert Hust
Traci Iott
Mark Lewis
Elsie Patton
Lori Saliby
Chris Sullivan
William Warzecha

Betsey Wingfield
Peter Zack

NOAA Staff Interviewed

Kenneth Finkelstein

CT DPH Staff Interviewed

Gary Ginsberg
Margaret Harvey
Brian Toal

EPA Staff Interviewed

David McDonald

CT DEEP Materials Management and Compliance Assurance (MMCA)

What practices would you consider to be best practices?

Remove mass, eliminate exposure pathways. DEEP contractor would do work necessary to reduce risk if PRP will not. Important to start interim corrective action as soon as possible to lower risk to residuals. Build-in flexibility to allow the approach to match the circumstances.

What are sources of the controversy regarding the RSRs?

Factions formed. Adding flexibility to the program was viewed as relaxing standards by environmentalists and the public, while others (attorneys and developers) considered flexibility as positive, enabling contaminated properties to be brought back into productive use (unlock value in Brownfields). The tension between the factions was not able to be resolved.

Initial development and implementation of RSRs in 1995 was a big step forward in allowing sites to be cleaned up, but while they provided standardization, they were also rigid, and better suited for cleaning up big, complicated sites than for addressing small releases.

Why are Connecticut's standards more stringent than some federal standards?

One-third of the Connecticut population uses groundwater for drinking water, and it is important to be protective.

Multiple COCs: Not addressed in current standards, this lack needs to be fixed.

PCBs: RSRs carve out PCBs; PCBs are handled separately and not covered by the RSR program. PCBs are handled under the federal program.

95% UCL Guidance: It is unclear what this guidance was intended to do. It appears that it allows high levels of contaminants to be left in place (hotspots), which may pose an ecological risk. Connecticut staff are unsure if this guidance is available on the web.

Technical Impracticability Policy: Appears to expand scope from what is truly technically impracticable to allow PRPs to not do work because they don't want to do it. Goals appear unclear.

Reuse of Polluted Soils Policy (draft): This policy has not been finalized, and needs reconciliation between the waste program and the remediation program. Anti-degradation rules impact on soil reuse: DEEP is looking at the interplay between these issues.

Farm Policy: Policy in place for farms to continue operating as farms. Policy for when farms are redeveloped for other uses is contemplated but not yet drafted; would provide guidance on how to protectively deal with pesticide-contaminated soil when land use changes from farm to residential and other uses.

"More site-specific risk-based clean-ups should be allowed" The EPA RBCA model was specifically identified. The RSR program is too rigid for small sites.

How is the baseline land use or condition of the site considered?

Cleanups need to be fair, and language and risk communication on cleanup issues needs to be clear and understandable. Actual vs. perceived risk – sometimes disconnect.

Need to educate public better on risk and risk management.

Need a way to provide better access to information on location and terms of institutional controls

No list of sites with status/progress is available on-line, other than the list of "potentially contaminated sites" that have been reported to DEEP over the years.

More information should be made available to the public regarding contamination at specific sites.

CT DEEP Water Protection and Land Reuse Bureau (WPLR)/Remediation/Operations

Any comments regarding the risk-based decision making project?

"Clarify the mission!" There are misperceptions and misunderstanding about what the mandate is / goals are.

What would you consider to be best practices?

Shouldn't look only at the numbers (standards) but also at what is considered an acceptable level of risk (both to human health and eco).

Make sure the program drives to the right level of protection without costing more than necessary – and with a good communication strategy.

Need the flexibility to do site-specific risk assessments in addition to default standards.

Need to have DEEP and private consultants on the same page up front.

LEPs are in a tough position, between DEEP and their clients; flexibility and professional judgment are important, but the program regulations need to provide a sufficient backstop to ensure protectiveness in the face of client push-back.

The basis for the existing RSR criteria have not been fully documented. All aspects of the RSRs should be fully documented and transparent.

What is the basis for past controversies regarding the RSRs?

No one liked the new standards that were proposed in previous efforts; everyone leapt on the numbers themselves, and the sides were polarized; after that it became impossible to discuss the context for the numbers and the process of updating the numbers failed. Out-of-context comparisons were made.

People may be willing to clean up spills on their own properties, but don't want to deal with urban soils that pre-dated their ownership. Current disconnect between how to handle cleanups of more recent releases when they overlay historic contamination.

Risk management important – need to figure out how to handle evaluation of chemicals such as benzo (a) pyrene that may drive risk at low levels, be ubiquitous at low levels, and not be related to current releases. Current practice can drive cleanup of urban fill.

DEEP sometimes accused of overreaching, regulating things that are not within their purview.

"Protection with balance" seen as important, but there is fear at the staff level about who will strike that balance, whether it will be in the right place to truly be protective, and concerns that sites will be signed off as clean when they still pose risk.

Remediation vs. risk assessment – different approaches.

CT DEEP WPLR/Remediation/Planning

What would you consider to be best practices?

Tends to be evolving. Where you sit is where you stand; each person you ask will have their own perspective on the proper balance of risk reduction, practicality and cost. "Pure protection" is not a reasonable concept in the absence of economic balance. Most gain for a reasonable cost. Be practical.

Comparisons to other states may be difficult. Work Group looked at this in five states in September of 2012. One of the difficulties was that the vocabulary was different between the states – hard to standardize. DEEP gave up on the effort.

Exit ramps, clarity of criteria, certainty, value-added, "lean", the less expensive the better (because it is more likely to be done).

Risk management – it is easier to deal with a current situation and exposures than to predict future use and protect against possible future risk.

RSRs have no intrinsic process – they are only numbers. It would be helpful if process, timing, endpoints, and responsibility were laid out in one set of regulations – and then the RSRs could be updated separately as needed, as new scientific data become available.

The perfect is the enemy of the good – balance is important; often some cleanup is better than nothing. Guidance should be developed that strikes the appropriate balance on cleaning up pesticides in soils (at farms and on residential property), historic fill, etc.

See RSRs as a kind of "toolbox" – default criteria, but also alternatives as options.

It is problematic that the RSRs do not address the "Who" – or set specific timelines. Goal of transformation is to get all aspects into one unified program.

Controversy: Providing risk numbers without risk management context caused new toxicity numbers to be perceived as being more (too) conservative. Communication was piecemeal. Let raw information out too soon – before the background explanation was available – and cost implications were not known. Change is huge policy issue. Unknowns = Fear. Clarity is important.

CT DEEP WPLR/Planning and Standards

Water Quality Standards/criteria are important bases to the RSRs, and should also be covered in this evaluation as risk assessment, risk management and remediation programs are interrelated and must match. The values inform the remediation program, which then implements the values.

What would you consider to be best practices?

Need to have a good site assessment/characterization in order to be able to do a risk assessment.

Risk standards should be technically supported, goal focused, and broadly accepted.

Program goals are consistency and flexibility.

Goal (post-transformation process) is to develop a self-implementing approach that will be laid out in guidance, have specific numbers for LEPs to meet.

What is the basis of past controversies?

There was disagreement among stakeholders as to what was acceptable as a standard. Economics (business community vs. environmental community). Depending on perspective (business vs regulator), appropriate balance of environmental protection vs implementability comes in a different place. The endpoint is set by the criteria so changing the criteria changes the program as a whole.

Eco standards and process:

The eco risk process has been laid out for LEPs in various PowerPoint presentations. The guidance document is in draft, and has not been completely QC'd. Connecticut uses a tiered approach, which considers level of complication posed by a site and has decision points after each tier. Tiers are "scoping" (is there habitat/receptors and a pathway between them leading to the potential for risk), "screening" (done for a fully characterized site, compare data from site assessment to soil, sediment and water benchmarks, use of groundwater plumes to model to surface water concentrations as opposed to comparison of surface water concentrations to benchmarks alone), and "site specific" (toxicity testing, fish tissue analysis, food web models). The guidance document identifies the preferred benchmarks. They expect that the majority of sites will stop following the screening level step, which should/can be completed by the LEP (should be straightforward enough so that there is no need for risk assessor to complete until a site-specific evaluation is needed).

Habitat is assessed in two stages: on the property only; and considering surrounding land.

Future land use is considered with "common sense".

Is the target significant threshold at 20% of population effects?

Connecticut does not always use that number, and neither does EPA; depends on several factors, including whether endangered species or not, and whether observed effects are acute or chronic. Population-level effects need to be determined by an appropriate expert.

Is there such a thing as *de minimis* land area affected?

Connecticut has not considered determining a *de minimus* size of affected land below which no cleanup would be needed to address eco risk.

How is surrounding habitat considered?

Screening level evaluation should be done in two ways – 100% exposure to site; % exposure to site based on typical range size of a particular species' habitat, and for both current and future land use.

How is the baseline land use or condition of the site considered?

Urban uses will likely remain urban. If a less-protective cleanup is allowed, need to lock in restrictions to land use in an institutional control.

Connecticut staff would like to see the ecological assessment through the screening level be readily performed by the LEP community. Subsequent steps would be performed by appropriate experts.

"Background conditions" defined in several ways, depending on the site specifics. Background samples (more than one) cannot be collected at a location affected by another release. They are typically collected from an upstream area in the same basin but can be in area with similar habitat/land use if not within the basin. Sediment toxicity testing is one way to determine background – chemical footprint may be different, but if similar toxicity levels exist, cleanup may not be required. Background can also be used to ID a site marker chemical. Determining background for an urban stream does take into account upstream levels coming on to the site. Background is critical since it drives remediation - a site need not be remediated to levels below background. Connecticut prefers a "robust" evaluation of background.

Connecticut staff has a strong preference for toxicity tests (as opposed to benthic community surveys) in a site-specific risk assessment, but will look at the triad approach.

Connecticut staff discussed how eco risk process currently works, and how much flexibility there is in determining/managing eco risk at a site. For example, if only one Hazard Quotient is exceeded, by only a small amount, is a site-specific eco risk assessment always required? Is there some flexibility?

Connecticut eco-risk practitioners have learned the current program by doing, and by having multiple meetings with DEEP to work out scopes, because no guidance documents have been released. The business community wants a self-implementing program so it will need rigid components but may have some "outs" for collaboration in decision making since it is difficult to have self-implementation and flexibility at the same time.

For HHRA, they work with the health department to ID toxicity values since IRIS is not the preferred source in many cases; use of 10^{-6}, HI<1, RSR for multiple chemicals/carcinogen is 10^{-5} and aggregate non-cancer hazard by target organ. Sensitive population (children) currently only marginally protected; certain pathways (like gardening) are missing.

What is the current state of Connecticut's ecological risk assessment guidance?

Connecticut-specific guidance is in DRAFT form / not yet ready for public release. DEEP cautioned that it is incomplete. We should get to see that in its current form. When asked what guidance current practitioners should use, EPA? DEEP responded that EPA guidance is too general and that practitioners should ask DEEP for site-specific guidance – call them. DEEP's view is that a standardized ecological assessment and risk management practice is operating and in force today in Connecticut – it is just not written down.

2008 Technical support document should plug the holes in how the current RSR criteria were developed.

The 1992 WQS is the basis for the SWPC – same means as for 2013.

RSRs – policy that if 10 COCs, must apply 10^{-5} risk standard. Non-carcinogens are grouped by effects on target organ.

Exposure assumptions are changing at the EPA level.

CT DEEP WPLR

Some stakeholders have noted that they believe that Connecticut's cleanup standards are out of step with those in the rest of the country. Connecticut wants its environmental programs, cleanup levels, and bases for determining risk to be competitive with those of other New England states, and believes that is important to maintain a strong level of protectiveness – for example, there should be no change to the cleanup goal of not exceeding 1×10^{-6} in excess lifetime cancer risk – but it is also important to view cleanup numbers in the appropriate risk management context, as they are actually implemented by the various jurisdictions.

This evaluation process is being done because Connecticut needs to determine on an objective basis whether Connecticut standards are in step with those of other jurisdictions. The evaluation will show how Connecticut standards are derived; determine if substantive differences exist between Connecticut standards and their derivation, as compared to other jurisdictions; determine whether characteristics unique to Connecticut justify any differences that may exist; and identify and recommend best practices that should be implemented by Connecticut as it completes its environmental "transformation."

Outreach regarding the transformation process will need to include a communications component that shows cleanup standards in the context of how the program as a whole functions.

The discussion of revising criteria in Connecticut has never gone well.

Controversial – One problem has been communication: not getting the message across.

Ideal outcome (subject to the actual findings):

- Connecticut is not out of step with other jurisdictions;
- Connecticut-specific issues are identified, properly incorporated and clearly communicated;

- If Connecticut is an "outlier" that is a problem – need to identify and indicate what fix would bring Connecticut into the mainstream;
- How other states deal with toxicity factors and how Connecticut compares is key;
- Clearly identify toxicity factor sources and their hierarchy.

The WQS are not in our SOW. It would be helpful if the same sort of process or Best Practices could be applied to them as well.

CT DEEP Planning and Standards

What are Best Practices?

1. Those that fit with Connecticut's regulatory and statutory programs. If they don't fit into that framework, they can't be best practices for CT.
2. RA and RM decisions that hold up to reasonable possible changes in future circumstances. That is to say that RA/RM decisions can be so site and circumstance specific as to invalidate them down the road because some temporal circumstance has changed. The decision has to remain valid into the future, even if circumstances change.

What is the basis for the "controversy" in attempts to change criteria?

Groups that represent the business community (such as CBIA) can sometimes take extreme positions in advocating for their constituency. They sometimes tend towards dogma (not her word, but what she meant) with regard to any more stringent criteria translating into anti-development. The debate can stray from "reasonableness." It is DEEP's job to say why criteria need to be what they are – thinks that DEEP failed significantly in recent attempts and did not communicate what backed up the decisions. DEEP needs to communicate strongly these underlying bases.

What was true then remains true. The idea from 1995 that DEEP should fully protect human health and the environment while also striking a balance with a healthy economy rings true today. It is also true that the predictability of the RSRs (knowing what needs to be done without having to ask DEEP) remains an objective. This runs somewhat counter to those that say they want more site-specific flexibility – which tends to shift the burden for decision-making back towards DEEP.

Reason for GWPC being more stringent than MCLs in some cases. The DPH and DEEP have a kind of symbiotic relationship with regard to protecting water resources. DPH establishes the criteria – which then empowers DEEP to take actions if those criteria are exceeded. In some cases, IRIS criteria had not been updated more recently when DPH made decisions about protecting certain water resources. So, the DPH decisions took into account more recent information. It is also the case that CT relies very much on ground water resources for drinking water supply. There are many private wells. Private well water supplies are thought to be uncontrolled, so they are protected in a manner that reflects that lack of control.

Reconstruction of the RSR criteria. DEEP does not have a file that contains all of the decisions that went into the existing criteria development. DEEP could help reconstruct it, if necessary. I commented that other interviewees had said that they had reconstructed the criteria and that they will provide that information to us.

NOAA
Kenneth Finkelstein

What has your role been in interacting with Connecticut's site-based remediation program?

NOAA deals with federal superfund sites and has been involved with sites in Connecticut since 1987. They get involved under CERCLA section 104(b) which states that Federal and State natural resource trustees must be notified of potential damages to natural resources resulting from contaminant releases. NOAA is a natural resource trustee interested in ensuring that natural resource damage concerns are taken into consideration as a remedy is developed.

Usually the State of Connecticut is a 2nd party at the sites – EPA is the primary oversight agency. NOAA usually looks to be somewhat aggressive when seeking to remedy natural resource damage. EPA is generally very involved in the cleanups in these sites. Connecticut DEEP tends to be very, very quiet until some sort of number or standard is exceeded, at which point they speak up.

NOAA finds that you cannot achieve cleanup of a site if you are too conservative and believes that you need to make some compromises when cleaning up sites.

What do you perceive to be the basis for the "controversy" in previous efforts to revise the RSR criteria?

Connecticut's Standards are extremely rigid. When looking for a term to describe Connecticut's program it was suggested that it was the "opposite of creative." Basically, it was felt that Connecticut's program is completely inflexible and that Connecticut staff have no ability to do any kind of give and take negotiation with a responsible party.

Part of the issue may be personalities. In almost every case, the State of Connecticut is exceedingly quiet in interactions between EPA and PRPs. The State simply doesn't say anything (unless a standard is exceeded). EPA runs the show. State personnel either cannot or will not budge from their standards. At times, the state should speak up a bit more and support some of NOAA's suggestions for remedial strategies at Superfund sites. The State should be more proactive and not just sit back and rely on their standards.

Those interviewed do think highly of Traci Iott. She is a "Wonderful ecological risk assessor" but does not get support from her management. Sometimes her recommendations get ignored. She could do a much better job of getting things done if she had the support of her management.

What would you consider to be "best practices" in risk assessment and risk management?

NOAA's main suggestion regarding best practices involved giving CT project managers more leeway. They should not be entirely focused on standards and should have the ability to think a bit more on their own.

CT DPH

DPH communicated their role in the risk assessment process, namely as risk assessors while DEEP is the risk managers. DEEP is the agency that considers background concentrations and exposure parameters.

DPH reviews requests for RSRs for Additional Polluting Substances (APS) at the rate of about 50 per year. There is no log or public notification of RSRs for APSs that have been developed. DPH says that site-specific risk assessments are performed for some Superfund sites in Connecticut, but are rarely developed otherwise. Numerous alternative criteria assessments, however, have been submitted to DEEP and reviewed by DPH. In effect these are site-specific risk assessments because they involve alternative exposure assumptions based upon local conditions and often involve the application of land use restrictions to ensure that current conditions do not change in the future in a manner that would allow for greater exposure. Probabilistic risk assessment has not been done anywhere in the state, though there may be some probabilistic aspects to sensitivity analyses.

Uncertainty in toxicological factors is determined using uncertainty factors as in EPA's IRIS database.

Pathways not included in the RSRs are evaluated qualitatively.

In terms of best practices, DPH recommends easier updating of the RSRs and perhaps keeping the RSRs separate from the regulation itself to allow for easier updating. They also suggested the possible use of multiple reference doses for chemicals to allow for a better job on cumulative risk assessment. Distribution of APS determinations to the public may also be useful.

Toxicity values are selected on a case-by-case basis. They usually select IRIS values if the various toxicity values differ by less than a factor of 3.

DPH generally examines background by looking at the national, regional, and local levels to make sure that the RSR value is attainable, but no former statistical analysis is generally performed. For indoor air, they have also looked at Massachusetts' background concentrations.

DPH has not felt the effects of past controversies over the RSRs since most of the political pressures fall on DEEP as opposed to DPH.

DPH is always happy to have an LEP or other practitioner contact them for advice about toxicity values or derivations of standards.

DPH does not feel limited by resources.

What is Connecticut specific?

- A significant fish-eating population
- Shallow groundwater – volatilization from groundwater is important
- Background or fill-related concentrations of arsenic and PAHs in soil, especially at brownfields
- 30% of Connecticut is on private drinking water wells
- They are seeing many more applications and approvals for land use restrictions

Who regulates private wells?

Local health departments regulate private wells when the wells are new, but then their authority wanes. The state health department writes the regulations that the local health departments enforce.

EPA Ecological Risk Assessment, RCRA Program
David McDonald

We explained the purpose of the project and asked Mr. McDonald to describe his experience with the CT program and with the other New England states, including mention of best practices from any of the programs with which he is familiar.

Mr. McDonald has almost 20 years of experience in the ecological risk assessment field, spent primarily on CERCLA and RCRA sites. His most recent experience has been with the RCRA program. He has worked on RCRA sites in several New England states, with the majority of his time spent on CT sites. These sites have been located throughout the state, and ranged from rural to urban settings.

His primary interactions with CT DEEP are with WPLR/Planning and Standards Ecological Risk program staff including Rosemary Gatter-Everts, Tracy Iott and Chris Sullivan. He has not interacted with CT DPH.

In his experience, CT eco risk procedures are very similar to those used by EPA, and are based on EPA's 1997 eco guidance. CT does not have CT-specific eco guidance documents that can be used to guide EPA's efforts to address ARARs, but this has not been an issue as he is very familiar with EPA guidance. He uses the EPA guidance document as a starting point, and uses CT RSRs, eco SSLs, and ambient WQCs as needed.

Best practices: The CT eco risk program is charged with protecting the non-human environment; eco risk assessment is much more complicated than human health risk assessment due to the number of species to be considered, and the difficulty in assigning a broadly accepted value to the life or health of an invertebrate. He thinks that CT tries to be reasonable but protective; different tools are available for use on sites of differing size or complexity. He stated that the CT eco risk program is a good program overall, with a complicated mission and many species to consider, which made it an easy but unfair target for criticism.

Appendix D

British Columbia General Numerical Soil Standards

B.C. Reg. 375/96
O.C. 1480/96 and M271/2004

Deposited December 16, 1996
effective April 1, 1997

Environmental Management Act

CONTAMINATED SITES REGULATION

Note: Check the Cumulative Regulation Bulletin 2014
for any non-consolidated amendments to this regulation that may be in effect.

[includes amendments up to B.C. Reg. 4/2014, January 31, 2014]

Point in Time

Schedule 4

[en. B.C. Reg. 324/2004, s. 68; am. B.C. Reg. 343/2008, s. 13.]

Generic Numerical Soil Standards [1]

COLUMN I Substance	COLUMN II Agricultural (AL)	COLUMN III Urban Park (PL)	COLUMN IV Residential (RL)	COLUMN V Commercial (CL)	COLUMN VI Industrial (IL)
Inorganic Substances					
antimony	20	20	20	40	40
beryllium	4	4	4	8	8
boron (hot water soluble)	2				
cobalt	40	50	50	300	300
cyanide (WAD)[2]	0.5	10	10	100	100
cyanide (SAD)[3]	5	50	50	500	500
fluoride	200	400	400	2 000	2 000
molybdenum	5	10	10	40	40
nickel	150	100	100	500	500
selenium	2	3	3	10	10
silver	20	20	20	40	40
sulphur (elemental)	500				
thallium[4]	2				

tin	5	50	50	300	300
vanadium	200	200	200		
Miscellaneous Inorganic and Organic Substances					
nonaqueous phase liquids	not present[5]	not present[5]	not present[5]	not present[5]	not present[5]
odorous substances	not present[6]	not present[6]	not present[6]	not present[6]	not present[6]
petroleum hydrocarbons					
VPHs[7]	200	200	200	200	200
LEPHs[8]	1 000	1 000	1 000	2 000	2 000
HEPHs[9]	1 000	1 000	1 000	5 000	5 000
Organic Substances Chlorinated Hydrocarbons *chlorinated aliphatics*					
chlorinated aliphatics[10] (each)	0.1	5	5	50	50
chlorinated benzenes					
chlorobenzenes[11] (each)	0.05	2	2	10	10
dichlorobenzenes[12] (each)	0.1	1	1	10	10
hexachlorobenzene	0.05	2	2	10	10
lindane	0.01				
monochlorobenzene	0.1	1	1	10	10
Monocyclic Aromatic Hydrocarbons (MAHs)					
styrene	0.1	5	5	50	50
Phenolic Substances					
chlorinated phenols					
chlorinated phenols[13] (each)	0.05	0.5	0.5	5	5
nonchlorinated phenols					
nonchlorinated phenols[14] (each)	0.1	1	1	10	10
Phthalic Acid Esters					

phthalic acid esters[15] (each)	30				
Polycyclic Aromatic Hydrocarbons (PAHs)					
benz[a]anthracene	0.1	1	1	10	10
benzo[b] fluoranthene	0.1	1	1	10	10
benzo[k] fluoranthene	0.1	1	1	10	10
dibenz[a,h] anthracene	0.1	1	1	10	10
indeno [1,2,3-cd] pyrene	0.1	1	1	10	10
naphthalene	0.1	5	5	50	50
phenanthrene	0.1	5	5	50	50
pyrene	0.1	10	10	100	100

Footnotes

1. All values in µg/g unless otherwise stated. Substances must be analyzed using methods specified in a director's protocol or alternate methods acceptable to a director.
2. WAD means weak acid dissociable.
3. SAD means strong acid dissociable.
4. Standard has been adjusted based on analytical detection limit of 2 µg/g for substance.
5. Soil must be remediated so that nonaqueous phase liquids are not present in quantities in excess of that acceptable to a director.
6. Soil must be remediated so that odorous substances are not present in quantities in excess of that acceptable to a director.
7. VPHs include:

   volatile petroleum hydrocarbons with the exception of benzene, toluene, ethylbenzene and xylenes.
8. LEPHs include:

   light extractable petroleum hydrocarbons with the exception of benz[a]anthracene, benzo[a] pyrene, benzo[b]fluoranthene, benzo[k]fluoranthene, dibenz[a,h]anthracene, indeno [1,2,3-cd] pyrene, naphthalene, phenanthrene and pyrene.
9. HEPHs include:

   heavy extractable petroleum hydrocarbons with the exception of benz[a]anthracene, benzo[a] pyrene, benzo[b]fluoranthene, benzo[k]fluoranthene, dibenz[a,h]anthracene, indeno [1,2,3-cd] pyrene, naphthalene, phenanthrene and pyrene.
10. Chlorinated aliphatics include:

    chloroform,

    dichloroethane (1,1-, 1,2-),

    dichloroethene (1,1-, 1,2-),

dichloromethane,

1,2-dichloropropane,

1,3-dichloropropene (cis and trans),

carbon tetrachloride,

trichloroethane (1,1,1-, 1,1,2-).

11. Chlorobenzene includes:

trichlorobenzene,

tetrachlorobenzene, and

pentachlorobenzene.

12. Dichlorobenzene includes:

1,2-dichlorobenzene,

1,3-dichlorobenzene, and

1,4-dichlorobenzene.

13. Chlorinated phenols include:

chlorophenol isomers (ortho, meta, para),

dichlorophenols (2,6-, 2,5-, 2,4-, 3,5-, 2,3-, 3,4-),

trichlorophenols (2,4,6-, 2,3,6-, 2,4,5-, 2,3,5-, 2,3,4-, 3,4,5-), and

tetrachlorophenols (2,3,5,6-, 2,3,4,5-, 2,3,4,6-).

14. Nonchlorinated phenols include:

2,4-dimethylphenol,

2,4-dinitrophenol,

2-methyl 4,6-dinitrophenol,

nitrophenol (2-, 4-),

phenol, and

cresol.

15. Phthalic acid esters include:

dibutyl phthalate (DBP), and

di(2-ethylhexyl) phthalate (DEHP).

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Appendix E

British Columbia Matrix Numerical Soil Standards

B.C. Reg. 375/96
O.C. 1480/96 and M271/2004

Deposited December 16, 1996
effective April 1, 1997

Environmental Management Act

CONTAMINATED SITES REGULATION

Note: Check the Cumulative Regulation Bulletin 2014
for any non-consolidated amendments to this regulation that may be in effect.

[includes amendments up to B.C. Reg. 4/2014, January 31, 2014]

Point in Time

Schedule 5

[am. B.C. Regs. 244/99, ss. 18 and 19; 17/2002, s. 29;

324/2004, s. 69; 239/2007, s. 6; 343/2008, s. 14; 6/2013, ss. 2 to 23; 4/2014.]

Matrix Numerical Soil Standards [1]

Arsenic (Chemical Abstract Service # 7440-38-2)

COLUMN I	COLUMN II	COLUMN III	COLUMN IV	COLUMN V	COLUMN VI	Note
Site-specific Factor	SOIL STANDARD FOR PROTECTION OF SITE-SPECIFIC FACTOR					
	Agricultural (AL)	Urban Park (PL)	Residential (RL)	Commercial (CL)	Industrial (IL)	2
HUMAN HEALTH PROTECTION						
Intake of contaminated soil	100	100	100	300	300	3,4
Groundwater used for drinking water	15	15	15	15	15	5
ENVIRONMENTAL PROTECTION						
Toxicity to soil invertebrates and plants	50	50	50	100	100	
Livestock ingesting soil and fodder	25					

Major microbial functional impairment	NS					6
Groundwater flow to surface water used by aquatic life						
Freshwater	20	20	20	20	20	5
Marine	25	25	25	25	25	5
Groundwater used for livestock watering	15					5
Groundwater used for irrigation	25	25	25			5

Notes

1. All values in µg/g unless otherwise stated. Substances must be analyzed using methods specified in a director's protocol or alternate methods acceptable to the director.

2. The site-specific factors of human intake of contaminated soil and toxicity to soil invertebrates and plants specified in this matrix apply at all sites.

3. Standards have been derived based on results of clinical studies at sites. Standards represent the rounded sum of the toxicologically-based value plus the applicable soil ingestion clinical study factor, if one is available. For AL, PL, and RL, the soil ingestion clinical study factor is 80 µg/g. For CL, the soil ingestion clinical study factor is 240 µg/g. For IL, no soil ingestion clinical study factor is available. For IL, the toxicologically-based value without addition of a clinical study factor approximates the CL soil standard, therefore the IL standard was set equal to the CL standard.

4. Intake pathway of exposure modeled is inadvertent ingestion of soil.

5. Standard has been adjusted based on a reference provincial background soil concentration. Standard represents the rounded sum of the toxicologically-based value plus the reference provincial background soil concentration. For all land uses, the reference provincial background soil concentration is 14.9 µg/g.

6. NS — no standard. Insufficient acceptable scientific data exists, so no standard is calculated.

Matrix Numerical Soil Standards [1]

Barium (Chemical Abstract Service # 7440-39-3)

COLUMN I	COLUMN II	COLUMN III	COLUMN IV	COLUMN V	COLUMN VI	Note
Site-specific Factor	SOIL STANDARD FOR PROTECTION OF SITE-SPECIFIC FACTOR					
	Agricultural (AL)	Urban Park (PL)	Residential (RL)	Commercial (CL)	Industrial (IL)	2
HUMAN HEALTH PROTECTION						
Intake of contaminated soil	6 500	6 500	6 500	20 000	> 1 000mg/g	3
Groundwater used for drinking water	400	400	400	400	400	4, 5
ENVIRONMENTAL PROTECTION						
Toxicity to soil invertebrates and plants	1 000	1 000	1 000	1 500	1 500	
Livestock ingesting soil and fodder	400					5
Major microbial functional impairment	NS					6
Groundwater flow to surface water used by aquatic life						
Freshwater	3 500	3 500	3 500	3 500	3 500	4
Marine	1 500	1 500	1 500	1 500	1 500	4
Groundwater used for livestock watering	NS					7
Groundwater used for irrigation	NS	NS	NS			7

Notes

1. All values in µg/g unless otherwise stated. Substances must be analyzed using methods specified in a director's protocol or alternate methods acceptable to the director.

2. The site-specific factors of human intake of contaminated soil and toxicity to soil invertebrates and plants specified in this matrix apply at all sites.

3. Intake pathway of exposure modeled is inadvertent ingestion of soil.

4. Assumes barium Kd = 100 L/kg.

5. Standard has been adjusted based on a reference provincial background soil concentration. Standard represents the reference provincial background soil concentration.

For all land uses, the reference provincial background soil concentration is 412 µg/g.

6. NS — no standard. Insufficient acceptable scientific data exists, so no standard is calculated.

7. NS — no standard. No appropriate standard, guideline or criterion exists to use to develop a soil quality standard.

Matrix Numerical Soil Standards [1]

Benzene (Chemical Abstract Service # 71-43-2)

COLUMN I	COLUMN II	COLUMN III	COLUMN IV	COLUMN V	COLUMN VI	Note
	SOIL STANDARD FOR PROTECTION OF SITE-SPECIFIC FACTOR					
Site-specific Factor	**Agricultural (AL)**	**Urban Park (PL)**	**Residential (RL)**	**Commercial (CL)**	**Industrial (IL)**	**2**
HUMAN HEALTH PROTECTION						
Intake of contaminated soil	1000	1000	1000	4000	6500	3
Groundwater used for drinking water	0.04	0.04	0.04	0.04	0.04	4
ENVIRONMENTAL PROTECTION						
Toxicity to soil invertebrates and plants	70	70	70	150	150	
Livestock ingesting soil and fodder	NS					5
Major microbial functional impairment	NS					5
Groundwater flow to surface water used by aquatic life						
Freshwater	10	10	10	10	10	
Marine	2.5	2.5	2.5	2.5	2.5	

Groundwater used for livestock watering	NS					6
Groundwater used for irrigation	NS	NS	NS			6

Notes

1. All values in µg/g unless otherwise stated. Substances must be analyzed using methods specified in a director's protocol or alternate methods acceptable to the director.

2. The site-specific factors of human intake of contaminated soil and toxicity to soil invertebrates and plants specified in this matrix apply at all sites.

3. Intake pathway of exposure modeled is inadvertent ingestion of soil.

4. Standard is equivalent to the reference analytical detection limit of 0.04 µg/g. The toxicologically-based value equals the reference analytical detection limit for the substance.

5. NS — no standard. Insufficient acceptable scientific data exists, so no standard is calculated.

6. NS — no standard. No appropriate standard, guideline or criterion exists to use to develop a soil quality standard.

Matrix Numerical Soil Standards [1]

Benzo[a]pyrene (B[a]P) (Chemical Abstract Service # 50-32-8)

COLUMN I	COLUMN II	COLUMN III	COLUMN IV	COLUMN V	COLUMN VI	Note
Site-specific Factor	**SOIL STANDARD FOR PROTECTION OF SITE-SPECIFIC FACTOR**					
	Agricultural (AL)	**Urban Park (PL)**	**Residential (RL)**	**Commercial (CL)**	**Industrial (IL)**	**2**
HUMAN HEALTH PROTECTION						
Intake of contaminated soil	5	5	5	15	50	3
Groundwater used for drinking water	NS	NS	NS	NS	NS	4
ENVIRONMENTAL PROTECTION						

Toxicity to soil invertebrates and plants	0.1	1	1	10	10	5
Livestock ingesting soil and fodder	NS					6
Major microbial functional impairment	NS					6
Groundwater flow to surface water used by aquatic life	NS	NS	NS	NS	NS	4
Groundwater used for livestock watering	NS	NS	NS			7
Groundwater used for irrigation	NS					7

Notes

1. All values in µg/g unless otherwise stated. Substances must be analyzed using methods specified in a director's protocol or alternate methods acceptable to the director.

2. The site-specific factors of human intake of contaminated soil and toxicity to soil invertebrates and plants specified in this matrix apply at all sites.

3. Intake pathway of exposure modeled is inadvertent ingestion of soil.

4. NS — no standard. Model predicts that under the scenario used to derive matrix standards, Canadian Water Quality Guidelines will not be exceeded.

5. Insufficient acceptable environmental data exists, so standards are set equal to the Canadian Council of Ministers of the Environment interim soil quality criteria.

6. NS — no standard. Insufficient acceptable scientific data exists, so no standard is calculated.

7. NS — no standard. No appropriate standard, guideline or criterion exists to use to develop a soil quality standard.

Matrix Numerical Soil Standards [1]

Cadmium (Chemical Abstract Service # 7440-43-9)

COLUMN I	COLUMN II	COLUMN III	COLUMN IV	COLUMN V	COLUMN VI	Note
	SOIL STANDARD FOR PROTECTION OF SITE-SPECIFIC FACTOR					

Site-specific Factor	Agricultural (AL)	Urban Park (PL)	Residential (RL)	Commercial (CL)	Industrial (IL)	2
HUMAN HEALTH PROTECTION						
Intake of contaminated soil	3 or 35	3 or 35	3 or 35	100	3500	3,4,5
Groundwater used for drinking water						
pH < 6.5	1.5	1.5	1.5	1.5	1.5	6,7
pH 6.5 — < 7.0	3	3	3	3	3	6,7
pH 7.0 — < 7.5	15	15	15	15	15	6,7
pH 7.5 — < 8.0	200	200	200	200	200	6,7
pH ≥ 8.0	1 000	1 000	1 000	1 000	1 000	6,7
ENVIRONMENTAL PROTECTION						
Toxicity to soil invertebrates and plants	70	70	70	500	500	
Livestock ingesting soil and fodder	9					
Major microbial functional impairment	NS					8
Groundwater flow to surface water used by aquatic life						
Freshwater						
pH < 7.0	2	2	2	2	2	6,7
pH 7.0 — < 7.5	2.5	2.5	2.5	2.5	2.5	6,7
pH 7.5 — < 8.0	25	25	25	25	25	6,7
pH ≥ 8.0	150	150	150	150	150	6,7
Marine						
pH < 7.0	2	2	2	2	2	6,7
pH 7.0 — < 7.5	3.5	3.5	3.5	3.5	3.5	6,7
pH 7.5 — < 8.0	35	35	35	35	35	6,7
pH ≥ 8.0	200	200	200	200	200	6,7
Groundwater used for livestock watering						
pH < 6.0	2.5					6,7

pH 6.0 — < 6.5	6					6,7
pH 6.5 — < 7.0	30					6,7
pH 7.0 — < 7.5	200					6,7
pH 7.5 — < 8.0	3 000					6,7
pH ≥ 8.0	20 000					6,7
Groundwater used for irrigation						
pH < 6.5	2	2	2			6,7
pH 6.5 — < 7.0	3	3	3			6,7
pH 7.0 — < 7.5	15	15	15			6,7
pH 7.5 — < 8.0	200	200	200			6,7
pH ≥ 8.0	1 000	1 000	1 000			6,7

Notes

1. All values in µg/g unless otherwise stated. Substances must be analyzed using methods specified in a director's protocol or alternate methods acceptable to the director.

2. The site-specific factors of human intake of contaminated soil and toxicity to soil invertebrates and plants specified in this matrix apply at all sites.

3. For AL, PL and RL, if the land is used to grow produce for human consumption, the standard is 3 µg/g, if not, the standard is 35 µg/g. For CL and IL, standards are applicable only to land that is not used to grow produce for human consumption.

4. Standards have been derived based on results of clinical studies at sites. For AL, PL and RL, the 3 µg/g standard represents the rounded remainder of the toxicologically-based value (35 µg/g) minus the soil ingestion clinical study factor (32 µg/g). For CL, the standard was set equal to the soil ingestion clinical study factor (100 µg/g). For IL, no soil ingestion clinical study factor is available, therefore the IL standard was set equal to the toxicologically-based value.

5. Intake pathway of exposure modeled is inadvertent ingestion of soil.

6. The pH is the pH of the soil at a site.

7. Standard has been adjusted based on a reference provincial background soil concentration. Standard represents the rounded sum of the toxicologically-based value plus the reference provincial background soil concentration. For all land uses, the reference provincial background soil concentration is 1.3 µg/g.

8. NS — no standard. Insufficient acceptable scientific data exists, so no standard is calculated.

Matrix Numerical Soil Standards [1]

Chloride Ion (Cl-) (Chemical Abstract Service # 7647-14-5)

COLUMN I	COLUMN II	COLUMN III	COLUMN IV	COLUMN V	COLUMN VI	Note
Site-specific Factor	SOIL STANDARD FOR PROTECTION OF SITE-SPECIFIC FACTOR					
	Agricultural (AL)	Urban Park (PL)	Residential (RL)	Commercial (CL)	Industrial (IL)	2
HUMAN HEALTH PROTECTION						
Intake of contaminated soil	> 1 000 mg/g	> 1 000 mg/g	> 1 000 mg/g	> 1 000 mg/g	> 1 000 mg/g	3, 4
Groundwater used for drinking water	90	90	90	90	90	5
ENVIRONMENTAL PROTECTION						
Toxicity to soil invertebrates and plants	350	350	350	2 500	2 500	
Livestock ingesting soil and fodder	NS					6
Major microbial functional impairment	NS					7
Groundwater flow to surface water used by aquatic life	550	550	550	550	550	5,8
Groundwater used for livestock watering	200					5
Groundwater used for irrigation	35	35	35			5

Notes

1. All values in µg/g unless otherwise stated. Substances must be analyzed using methods specified in a director's protocol or alternate methods acceptable to the director.

2. The site-specific factors of human intake of contaminated soil and toxicity to soil invertebrates and plants specified in this matrix apply at all sites.

3. Intake pathway of exposure modeled is inadvertent ingestion of soil.

4. Standard established based on toxic reference dose (tolerable daily intake) derived for NaCl. Toxicity attributed primarily to cation (Na+) not anion (Cl-).

5. Standard varies with Kd for chloride ion in the soil of a site. Standard is appropriate to a chloride:soil Kd range of 0 to 0.1 mL/g. Consult Director for further advice.

6. NS — no standard. No appropriate standard, guideline or criterion exists to use to develop a soil quality standard.

7. NS — no standard. Insufficient acceptable scientific data exists, so no standard is calculated.

8. Standard to protect freshwater aquatic life.

Matrix Numerical Soil Standards [1]

Chromium (Chemical Abstract Service # 7440-47-3)

COLUMN I	COLUMN II	COLUMN III	COLUMN IV	COLUMN V	COLUMN VI	Note
	SOIL STANDARD FOR PROTECTION OF SITE-SPECIFIC FACTOR					
Site-specific Factor	Agricultural (AL)	Urban Park (PL)	Residential (RL)	Commercial (CL)	Industrial (IL)	2
HUMAN HEALTH PROTECTION						
Intake of contaminated soil	100	100	100	300	20 000	3,4
Groundwater used for drinking water	60	60	60	60	60	5,6
ENVIRONMENTAL PROTECTION						
Toxicity to soil invertebrates and plants	300	300	300	700	700	5
Livestock ingesting soil and fodder	150 50					4 7
Major microbial functional impairment	50					5,8
Groundwater flow to surface water used by aquatic life						
Freshwater	60 65	60 65	60 65	60 65	60 65	4,6 6,7

Marine	60 95	60 95	60 95	60 95	60 95	4,6 6,7
Groundwater used for livestock watering	60					9
Groundwater used for irrigation	60	60	60			9

Notes

1. All values in µg/g unless otherwise stated. Substances must be analyzed using methods specified in a director's protocol or alternate methods acceptable to the director.

2. The site-specific factors of human intake of contaminated soil and toxicity to soil invertebrates and plants specified in this matrix apply at all sites.

3. Intake pathway of exposure modeled is inadvertent ingestion of soil.

4. Standard is for chromium (+6).

5. Standard is for chromium (total).

6. Standard has been adjusted based on a reference provincial background soil concentration. Standard represents the rounded sum of the toxicologically-based value plus the reference provincial background soil concentration. For all land uses and chromium species, the reference provincial background soil concentration is 58.9 µg/g.

7. Standard is for chromium (+3).

8. Standard is set equal to the Canadian Council of Ministers of the Environment, 1999 — Nutrient and energy cycling check value.

9. Standard is applicable to both chromium (+3) and chromium (+6).

Matrix Numerical Soil Standards [1]

Copper (Chemical Abstract Service # 7440-50-8)

COLUMN I	COLUMN II	COLUMN III	COLUMN IV	COLUMN V	COLUMN VI	Note
Site-specific Factor	SOIL STANDARD FOR PROTECTION OF SITE-SPECIFIC FACTOR					
	Agricultural (AL)	Urban Park (PL)	Residential (RL)	Commercial (CL)	Industrial (IL)	3
HUMAN HEALTH PROTECTION						

Intake of contaminated soil	15 000	15 000	15 000	50 000	200 000	3
Groundwater used for drinking water						
pH < 5.0	250	250	250	250	250	4,5
pH 5.0 — < 5.5	400	400	400	400	400	4,5
pH 5.5 — < 6.0	1 500	1 500	1 500	1 500	1 500	4,5
pH 6.0 — < 6.5	15 000	15 000	15 000	15 000	15 000	4,5
pH ≥ 6.5	350 000	350 000	350 000	350 000	350 000	4,5
ENVIRONMENTAL PROTECTION						
Toxicity to soil invertebrates and plants	150	150	150	250	250	
Livestock ingesting soil and fodder	150					
Major microbial functional impairment	NS					6
Groundwater flow to surface water used by aquatic life						7
pH < 5.0	90	90	90	90	90	4,5
pH 5.0 — < 5.5	100	100	100	100	100	4,5
pH 5.5 — < 6.0	200	200	200	200	200	4,5
pH 6.0 — < 6.5	1 500	1 500	1 500	1 500	1 500	4,5
pH ≥ 6.5	30 000	30 000	30 000	30 000	30 000	4,5
Groundwater used for livestock watering						
pH < 5.0	100					4,5
pH 5.0 — < 5.5	150					4,5
pH 5.5 — < 6.0	500					4,5
pH 6.0 — < 6.5	5 000					4,5
pH ≥ 6.5	90 000					4,5
Groundwater used for irrigation						
pH < 5.0	100	100	100			4,5
pH 5.0 — < 5.5	150	150	150			4,5
pH 5.5 — < 6.0	350	350	350			4,5

pH 6.0 — < 6.5	3 500	3 500	3 500			4,5
pH ≥ 6.5	75 000	75 000	75 000			4,5

Notes

1. All values in µg/g unless otherwise stated. Substances must be analyzed using methods specified in a director's protocol or alternate methods acceptable to the director.

2. The site-specific factors of human intake of contaminated soil and toxicity to soil invertebrates and plants specified in this matrix apply at all sites.

3. Intake pathway of exposure modeled is inadvertent ingestion of soil.

4. The pH is the pH of the soil at a site.

5. Standard has been adjusted based on a reference provincial background soil concentration. Standard represents the rounded sum of the toxicologically-based value plus the reference provincial background soil concentration. For all land uses, the reference provincial background soil concentration is 74.0 µg/g.

6. Standard is applicable to livestock other than sheep. Consult director for further advice.

7. NS — no standard. Insufficient acceptable scientific data exists, so no standard is calculated.

Matrix Numerical Soil Standards [1]

Dichloro-diphenyl-trichloroethane (DDT) [2] (Chemical Abstract Service # 50-29-3)

COLUMN I	COLUMN II	COLUMN III	COLUMN IV	COLUMN V	COLUMN VI	Note
Site-specific Factor	SOIL STANDARD FOR PROTECTION OF SITE-SPECIFIC FACTOR					
	Agricultural (AL)	Urban Park (PL)	Residential (RL)	Commercial (CL)	Industrial (IL)	3
HUMAN HEALTH PROTECTION						
Intake of contaminated soil	15	15	15	50	3 500	4
Groundwater used for drinking water	NS	NS	NS	NS	NS	5
ENVIRONMENTAL PROTECTION						

Toxicity to soil invertebrates and plants	10	10	10	15	15	
Livestock ingesting soil and fodder	NS					6
Major microbial functional impairment	550					7
Groundwater flow to surface water used by aquatic life	NS	NS	NS	NS	NS	5
Groundwater used for livestock watering	NS					5
Groundwater used for irrigation	NS	NS	NS			5,8

Notes

1. All values in µg/g unless otherwise stated. Substances must be analyzed using methods specified in a director's protocol or alternate methods acceptable to the director.

2. Standards are for the sum of DDT and DDT metabolites.

3. The site-specific factors of human intake of contaminated soil and toxicity to soil invertebrates and plants specified in this matrix apply at all sites.

4. Intake pathway of exposure modeled is inadvertent ingestion of soil.

5. NS — no standard. Substance is sufficiently hydrophobic to render it essentially insoluble and therefore immobile in aqueous media.

6. NS — no standard. Insufficient acceptable scientific data exists, so no standard is calculated.

7. Standard is set equal to the Canadian Council of Ministers of the Environment, 1999 - Nutrient and energy cycling check value.

8. NS — no standard. No appropriate standard, guideline or criterion exists to use to develop a soil quality standard.

Matrix Numerical Soil Standards [1]

Ethylbenzene (Chemical Abstract Service # 100-41-4)

COLUMN I	COLUMN II	COLUMN III	COLUMN IV	COLUMN V	COLUMN VI	Note
	SOIL STANDARD FOR PROTECTION OF SITE-SPECIFIC FACTOR					

Site-specific Factor	Agricultural (AL)	Urban Park (PL)	Residential (RL)	Commercial (CL)	Industrial (IL)	2
HUMAN HEALTH PROTECTION						
Intake of contaminated soil	3 500	3 500	3 500	10 000	700 000	3
Groundwater used for drinking water	7	7	7	7	7	
ENVIRONMENTAL PROTECTION						
Toxicity to soil invertebrates and plants	1	1	1	20	20	4
Livestock ingesting soil and fodder	NS					5
Major microbial functional impairment	NS					5
Groundwater flow to surface water used by aquatic life						
Freshwater	6 000	6 000	6 000	6 000	6 000	6
Marine	7 000	7 000	7 000	7 000	7 000	6
Groundwater used for livestock watering	NS					7
Groundwater used for irrigation	NS	NS	NS			7

Notes

1. All values in µg/g unless otherwise stated. Substances must be analyzed using methods specified in a director's protocol or alternate methods acceptable to the director.

2. The site-specific factors of human intake of contaminated soil and toxicity to soil invertebrates and plants specified in this matrix apply at all sites.

3. Intake pathway of exposure modeled is inadvertent ingestion of soil.

4. Insufficient acceptable data exists, so standards are set equal to the Canadian Council of Ministers of the Environment 1999 provisional soil quality criteria.

5. NS — no standard. Insufficient acceptable scientific data exists, so no standard is calculated.

6. Standard would generate leachate concentrations at source in excess of solubility limit for substance. Substance would be present as NAPL in groundwater at soil concentrations greater than 1 000 µg/g.

7. NS — no standard. No appropriate standard, guideline or criterion exists to use to develop a soil quality standard.

Matrix Numerical Soil Standards [1]

Ethylene Glycol (Chemical Abstract Service # 107-21-1)

COLUMN I	COLUMN II	COLUMN III	COLUMN IV	COLUMN V	COLUMN VI	Note
Site-specific Factor	**SOIL STANDARD FOR PROTECTION OF SITE-SPECIFIC FACTOR**					
	Agricultural (AL)	**Urban Park (PL)**	**Residential (RL)**	**Commercial (CL)**	**Industrial (IL)**	**2**
HUMAN HEALTH PROTECTION						
Intake of contaminated soil	65 000	65 000	65 000	200 000	> 1 000 mg/g	3
Groundwater used for drinking water	NS	NS	NS	NS	NS	4
ENVIRONMENTAL PROTECTION						
Toxicity to soil invertebrates and plants	5 500	5 500	5 500	20 000	20 000	
Livestock ingesting soil and fodder	NS					4
Major microbial functional impairment	NS					5
Groundwater flow to surface water used by aquatic life	1 500	1 500	1 500	1 500	1 500	
Groundwater used for livestock watering	NS					4
Groundwater used for irrigation	NS	NS	NS			4

Notes

1. All values in µg/g unless otherwise stated. Substances must be analyzed using methods specified in a director's protocol or alternate methods acceptable to the director.

2. The site-specific factors of human intake of contaminated soil and toxicity to soil invertebrates and plants specified in this matrix apply at all sites.

3. Intake pathway of exposure modeled is inadvertent ingestion of soil.

4. NS — no standard. No appropriate standard, guideline or criterion exists to use to develop a soil quality standard.

5. NS — no standard. Insufficient acceptable scientific data exists, so no standard is calculated.

Matrix Numerical Soil Standards [1]

Lead (Chemical Abstract Service # 7439-92-1)

COLUMN I	**COLUMN II**	**COLUMN III**	**COLUMN IV**	**COLUMN V**	**COLUMN VI**	**Note**
Site-specific Factor	**SOIL STANDARD FOR PROTECTION OF SITE-SPECIFIC FACTOR**					
	Agricultural (AL)	**Urban Park (PL)**	**Residential (RL)**	**Commercial (CL)**	**Industrial (IL)**	**2**
HUMAN HEALTH PROTECTION						
Intake of contaminated soil	400	400	400	700	4 000	3,4
Groundwater used for drinking water						
pH < 6.0	100	100	100	100	100	5,6
pH 6.0 — < 6.5	250	250	250	250	250	5,6
pH ≥ 6.5	4 000	4 000	4 000	4 000	4 000	5,6
ENVIRONMENTAL PROTECTION						
Toxicity to soil invertebrates and plants	1 000	1 000	1 000	2 000	2 000	
Livestock ingesting soil and fodder	350					
Major microbial functional impairment	NS					7
Groundwater flow to surface water used by aquatic life						
pH < 5.5	150	150	150	150	150	5,6
pH 5.5 — < 6.0	250	250	250	250	250	5,6
pH 6.0 — < 6.5	2 000	2 000	2 000	2 000	2 000	5,6

pH ≥ 6.5	40 000	40 000	40 000	40 000	40 000	5,6
Groundwater used for livestock watering						
pH < 5.5	150					5,6
pH 5.5 — < 6.0	250					5,6
pH 6.0 — < 6.5	1 500					5,6
pH ≥ 6.5	30 000					5,6
Groundwater used for irrigation						
pH < 5.5	150	150	150			5,6
pH 5.5 — < 6.0	400	400	400			5,6
pH 6.0 — < 6.5	3 500	3 500	3 500			5,6
pH ≥ 6.5	100 000	100 000	100 000			5,6

Notes

1. All values in µg/g unless otherwise stated. Substances must be analyzed using methods specified in a director's protocol or alternate methods acceptable to the director.

2. The site-specific factors of human intake of contaminated soil and toxicity to soil invertebrates and plants specified in this matrix apply at all sites.

3. Intake pathway of exposure modeled is inadvertent ingestion of soil.

4. Standards have been derived based on results of clinical studies at sites. Standards represent the rounded sum of the toxicologically-based value plus the applicable soil ingestion clinical study factor, if one is available. For AL, PL and RL, the soil ingestion clinical study factor is 385 µg/g. For CL, the soil ingestion clinical study factor is 650 µg/g. For IL, no soil ingestion clinical study factor is available, therefore the IL standard was set equal to the toxicologically-based value.

5. The pH is the pH of the soil at a site.

6. Standard has been adjusted based on a reference provincial background soil concentration. Standard represents the rounded sum of the toxicologically-based value plus the reference provincial background soil concentration. For all land uses, the reference provincial background soil concentration is 108.6 µg/g.

7. NS — no standard. Insufficient acceptable scientific data exists, so no standard is calculated.

Matrix Numerical Soil Standards [1]

Mercury (Inorganic) (Chemical Abstract Service # 7439-97-6)

COLUMN I	COLUMN II	COLUMN III	COLUMN IV	COLUMN V	COLUMN VI	Note
Site-specific Factor	SOIL STANDARD FOR PROTECTION OF SITE-SPECIFIC FACTOR					
	Agricultural (AL)	Urban Park (PL)	Residential (RL)	Commercial (CL)	Industrial (IL)	2
HUMAN HEALTH PROTECTION						
Intake of contaminated soil	15	15	15	40	2 000	3
Groundwater used for drinking water	NS	NS	NS	NS	NS	4
ENVIRONMENTAL PROTECTION						
Toxicity to soil invertebrates and plants	100	100	100	150	150	
Livestock ingesting soil and fodder	0.6					
Major microbial functional impairment	20					5
Groundwater flow to surface water used by aquatic life	NS	NS	NS	NS	NS	4
Groundwater used for livestock watering	NS					4
Groundwater used for irrigation	NS	NS	NS			4

Notes

1. All values in µg/g unless otherwise stated. Substances must be analyzed using methods specified in a director's protocol or alternate methods acceptable to a director.

2. The site-specific factors of human intake of contaminated soil and toxicity to soil invertebrates and plants specified in this matrix apply at all sites.

3. Intake pathway of exposure modeled is inadvertent ingestion of soil.

4. NS — no standard. Insufficient acceptable scientific data exists, so no standard is calculated.

5. Standard is set equal to the Canadian Council of Ministers of the Environment, 1999 — Nutrient and energy cycling check value.

Matrix Numerical Soil Standards [1]

Pentachlorophenol (Chemical Abstract Service # 87-86-5)

COLUMN I	COLUMN II	COLUMN III	COLUMN IV	COLUMN V	COLUMN VI	Note
Site-specific Factor	SOIL STANDARD FOR PROTECTION OF SITE-SPECIFIC FACTOR					
	Agricultural (AL)	Urban Park (PL)	Residential (RL)	Commercial (CL)	Industrial (IL)	2
HUMAN HEALTH PROTECTION						
Intake of contaminated soil	100	100	100	300	35 000	3
Groundwater used for drinking water						
pH < 4.5	750 000	750 000	750 000	750 000	750 000	4
pH 4.5 — < 5.0	450 000	450 000	450 000	450 000	450 000	4
pH 5.0 — < 5.5	4 000	4 000	4 000	4 000	4 000	4
pH 5.5 — < 6.0	70	70	70	70	70	4
pH 6.0 — < 6.5	6.5	6.5	6.5	6.5	6.5	4
pH 6.5 — < 7.0	2.0	2.0	2.0	2.0	2.0	4
pH 7.0 — < 7.5	1.5	1.5	1.5	1.5	1.5	4
pH ≥ 7.5	1.0	1.0	1.0	1.0	1.0	4
ENVIRONMENTAL PROTECTION						
Toxicity to soil invertebrates and plants	20	20	20	50	50	
Livestock ingesting soil and fodder	NS					5
Major microbial functional impairment	NS					5
Groundwater flow to surface water used by aquatic life						
pH <4.5	300 000	300 000	300 000	300 000	300 000	
pH 4.5 — <5.0	20 000	20 000	20 000	20 000	20 000	4,6
pH 5.0 — <5.5	150	150	150	150	150	4,6
pH 5.5 — <6.0	2.5	2.5	2.5	2.5	2.5	4,6
pH 6.0 — <6.5	0.3	0.3	0.3	0.3	0.3	4,6
pH 6.5 — <7.0	0.15	0.15	0.15	0.15	0.15	4,6

pH 7.0 — <7.5	0.15	0.15	0.15	0.15	0.15	4,6
pH 7.5 — <8.0	0.2	0.2	0.2	0.2	0.2	4,6
pH ≥ 8.0	0.35	0.35	0.35	0.35	0.35	4,6
Groundwater used for livestock watering						
pH < 4.5	750 000					4
pH 4.5 — < 5.0	450 000					4
pH 5.0 — < 5.5	4 000					4
pH 5.5 — < 6.0	70					4
pH 6.0 — < 6.5	6.5					4
pH 6.5 — < 7.0	2.0					4
pH 7.0 — < 7.5	1.5					4
pH ≥ 7.5	1.0					4
Groundwater used for irrigation	NS	NS	NS			7

Notes

1. All values in µg/g unless otherwise stated. Substances must be analyzed using methods specified in a director's protocol or alternate methods acceptable to the director.

2. The site-specific factors of human intake of contaminated soil and toxicity to soil invertebrates and plants specified in this matrix apply at all sites.

3. Intake pathway of exposure modeled is inadvertent ingestion of soil.

4. The pH is the pH of the soil at a site.

5. NS — no standard. Insufficient acceptable scientific data exists, so no standard is calculated.

6. Standard varies with temperature of surface water used by aquatic life; 20°C is assumed. Consult director for further advice.

7. NS — no standard. No appropriate standard, guideline or criterion exists to use to develop a soil quality standard.

Matrix Numerical Soil Standards [1]

Polychlorinated Biphenyls (PCBs) [2] (Chemical Abstract Service # 1336-36-3)

COLUMN I	COLUMN II	COLUMN III	COLUMN IV	COLUMN V	COLUMN VI	Note

Site-specific Factor	SOIL STANDARD FOR PROTECTION OF SITE-SPECIFIC FACTOR					
	Agricultural (AL)	Urban Park (PL)	Residential (RL)	Commercial (CL)	Industrial (IL)	3
HUMAN HEALTH PROTECTION						
Intake of contaminated soil	5	5	5	15	50	4
Groundwater used for drinking water	NS	NS	NS	NS	NS	5
ENVIRONMENTAL PROTECTION						
Toxicity to soil invertebrates and plants	0.5	5	5	50	50	6
Livestock ingesting soil and fodder	NS					7
Major microbial functional impairment	NS					7
Groundwater flow to surface water used by aquatic life	NS	NS	NS	NS	NS	8
Groundwater used for livestock watering	NS					8
Groundwater used for irrigation	NS	NS	NS			8

Notes

1. All values in µg/g unless otherwise stated. Substances must be analyzed using methods specified in a director's protocol or alternate methods acceptable to the director.

2. Polychlorinated biphenyls (PCBs) include Arochlor mixtures 1242, 1248, 1254 and 1260.

3. The site-specific factors of human intake of contaminated soil and toxicity to soil invertebrates and plants specified in this matrix apply at all sites.

4. Intake pathway of exposure modeled is inadvertent ingestion of soil.

5. NS — no standard. No appropriate standard, guideline or criterion exists to use to develop a soil quality standard.

6. Insufficient acceptable environmental data exists, so standards are set equal to the Canadian Council of Ministers of the Environment interim soil quality criteria.

7. NS — no standard. Insufficient acceptable scientific data exists, so no standard is calculated.

8. NS — no standard. No appropriate model to calculate environmental transport of complex mixtures exists.

Matrix Numerical Soil Standards [1]

Polychlorinated Dioxins and Furans (PCDDs and PCDFs) (Chemical Abstract Service # 1746-01-6) [2]

COLUMN I	COLUMN II	COLUMN III	COLUMN IV	COLUMN V	COLUMN VI	Note
Site-specific Factor	SOIL STANDARD FOR PROTECTION OF SITE-SPECIFIC FACTOR					
	Agricultural (AL)	Urban Park (PL)	Residential (RL)	Commercial (CL)	Industrial (IL)	3
HUMAN HEALTH PROTECTION						
Intake of contaminated soil	0.00035	0.00035	0.00035	0.001	0.07	4
Groundwater used for drinking water	NS	NS	NS	NS	NS	5
ENVIRONMENTAL PROTECTION						
Toxicity to soil invertebrates and plants	0.00001	0.001	0.001	0.0025	0.0025	6
Livestock ingesting soil and fodder	NS					7
Major microbial functional impairment	NS					7
Groundwater flow to surface water used by aquatic life	NS	NS	NS	NS	NS	5
Groundwater used for livestock watering	NS					5
Groundwater used for irrigation	NS	NS	NS			5

Notes

1. All values in µg/g unless otherwise stated. Substances must be analyzed using methods specified in a director's protocol or alternate methods acceptable to the director.

2. Polychlorinated dibenzo-p-dioxins (PCDDs) and polychlorinated dibenzofurans (PCDFs) expressed in 2,3,7,8-tetrachlorodibenzo-p-dioxin (2,3,7,8-TCDD) toxicity equivalents NATO International Toxicity Equivalency Factors (I-TEFs) for congeners and isomers of PCDDs and PCDFs are as follows:

Polychlorinated Dioxins and Furans (PCDDs and PCDFs)

PCDD Congener	I-TEF	PCDF Congener	I-TEF
2,3,7,8-T_4CDD	1.0	2,3,7,8-T_4CDF	0.1
1,2,3,7,8-P_5CDD	0.5	2,3,4,7,8-P_5CDF	0.5
1,2,3,4,7,8-H_6CDD	0.1	1,2,3,7,8-P_5CDF	0.05
1,2,3,7,8,9-H_6CDD	0.1	1,2,3,4,7,8-H_6CDF	0.1
1,2,3,6,7,8-H_6CDD	0.1	1,2,3,7,8,9-H_6CDF	0.1
1,2,3,4,6,7,8-H_7CDD	0.01	1,2,3,6,7,8-H_6CDF	0.1
O_8CDD	0.001	2,3,4,6,7,8-H_6CDF	0.1
		1,2,3,4,6,7,8-H_7CDF	0.01
		1,2,3,4,7,8,9-H_7CDF	0.01
		O_8CDF	0.001

Notes

3. The site-specific factors of human intake of contaminated soil and toxicity to soil invertebrates and plants specified in this matrix apply at all sites.

4. Intake pathway of exposure modeled is inadvertent ingestion of soil.

5. NS — no standard. No appropriate standard, guideline or criterion exists to use to develop a soil quality standard.

6. Insufficient acceptable environmental data exists, so AL, PL, and RL standards are set equal to the Canadian Council of Ministers of the Environment interim soil quality criteria.

7. NS — no standard. Insufficient acceptable scientific data exists, so no standard is calculated.

Matrix Numerical Soil Standards [1]

Sodium Ion (Na+) (Chemical Abstract Service # 7440-23-5)

COLUMN I	COLUMN II	COLUMN III	COLUMN IV	COLUMN V	COLUMN VI	Note
Site-specific Factor	SOIL STANDARD FOR PROTECTION OF SITE-SPECIFIC FACTOR					
	Agricultural (AL)	Urban Park (PL)	Residential (RL)	Commercial (CL)	Industrial (IL)	2
HUMAN HEALTH PROTECTION						
Intake of contaminated soil	> 1 000 mg/g	> 1 000 mg/g	> 1 000 mg/g	> 1 000 mg/g	> 1 000 mg/g	3
Groundwater used for drinking water	15 000	15 000	15 000	15 000	15 000	
ENVIRONMENTAL PROTECTION						
Toxicity to soil invertebrates and plants	200	200	200	1 000	1 000	
Livestock ingesting soil and fodder	NS					4
Major microbial functional impairment	NS					4
Groundwater flow to surface water used by aquatic life	NS	NS	NS	NS	NS	5
Groundwater used for livestock watering	NS					5
Groundwater used for irrigation	NS	NS	NS			5

Notes

1. All values in µg/g unless otherwise stated. Substances must be analyzed using methods specified in a director's protocol or alternate methods acceptable to the director.

2. The site-specific factors of human intake of contaminated soil and toxicity to soil invertebrates and plants specified in this matrix apply at all sites.

3. Intake pathway of exposure modeled is inadvertent ingestion of soil.

4. NS — no standard. Insufficient acceptable scientific data exists, so no standard is calculated.

5. NS — no standard. No appropriate standard, guideline or criterion exists to use to develop a soil quality standard.

Matrix Numerical Soil Standards [1]

Tetrachloroethylene (PERC) (Chemical Abstract Service # 127-18-4)

COLUMN I	COLUMN II	COLUMN III	COLUMN IV	COLUMN V	COLUMN VI	Note
Site-specific Factor	SOIL STANDARD FOR PROTECTION OF SITE-SPECIFIC FACTOR					
	Agricultural (AL)	Urban Park (PL)	Residential (RL)	Commercial (CL)	Industrial (IL)	2
HUMAN HEALTH PROTECTION						
Intake of contaminated soil	1 000	1 000	1 000	3 500	70 000	3
Groundwater used for drinking water	NS	NS	NS	NS	NS	4
ENVIRONMENTAL PROTECTION						
Toxicity to soil invertebrates and plants	0.1	5	5	50	50	5
Livestock ingesting soil and fodder	NS					6
Major microbial functional impairment	NS					6
Groundwater flow to surface water used by aquatic life	5	5	5	5	5	
Groundwater used for livestock watering	NS					4
Groundwater used for irrigation	NS	NS	NS			4

Notes

1. All values in µg/g unless otherwise stated. Substances must be analyzed using methods specified in a director's protocol or alternate methods acceptable to the director.

2. The site-specific factors of human intake of contaminated soil and toxicity to soil invertebrates and plants specified in this matrix apply at all sites.

3. Intake pathway of exposure modeled is inadvertent ingestion of soil.

4. NS — no standard. No appropriate standard, guideline or criterion exists to use to develop a soil quality standard.

5. Insufficient acceptable environmental data exists, so standards are set equal to the Canadian Council of Ministers of the Environment interim soil quality criteria.

6. NS — no standard. Insufficient acceptable scientific data exists, so no standard is calculated.

Matrix Numerical Soil Standards [1]

Toluene (Chemical Abstract Service # 108-88-3)

COLUMN I	COLUMN II	COLUMN III	COLUMN IV	COLUMN V	COLUMN VI	Note
	SOIL STANDARD FOR PROTECTION OF SITE-SPECIFIC FACTOR					
Site-specific Factor	Agricultural (AL)	Urban Park (PL)	Residential (RL)	Commercial (CL)	Industrial (IL)	2
HUMAN HEALTH PROTECTION						
Intake of contaminated soil	40 000	40 000	40 000	100 000	550 000	3
Groundwater used for drinking water	2.5	2.5	2.5	2.5	2.5	
ENVIRONMENTAL PROTECTION						
Toxicity to soil invertebrates and plants	1.5	1.5	1.5	25	25	4
Livestock ingesting soil and fodder	NS					5
Major microbial functional impairment	NS					5
Groundwater flow to surface water used by aquatic life						
Freshwater	40	40	40	40	40	6
Marine	350	350	350	350	350	6
Groundwater used for livestock watering	NS					7
Groundwater used for irrigation	NS	NS	NS			7

Notes

1. All values in µg/g unless otherwise stated. Substances must be analyzed using methods specified in a director's protocol or alternate methods acceptable to the director.

2. The site-specific factors of human intake of contaminated soil and toxicity to soil invertebrates and plants specified in this matrix apply at all sites.

3. Intake pathway of exposure modeled is inadvertent ingestion of soil.

4. Insufficient acceptable environmental data exists, so standards are set equal to the Canadian Council of Ministers of the Environment 1999 provisional soil quality criteria.

5. NS — no standard. Insufficient acceptable scientific data exists, so no standard is calculated.

6. Standard comes into effect January 1, 2002. Until that date, applicable standard is 300 µg/g.

7. NS — no standard. No appropriate standard, guideline or criterion exists to use to develop a soil quality standard.

Matrix Numerical Soil Standards [1]

Trichloroethylene (TCE) (Chemical Abstract Service # 79-01-6)

COLUMN I	COLUMN II	COLUMN III	COLUMN IV	COLUMN V	COLUMN VI	Note
Site-specific Factor	SOIL STANDARD FOR PROTECTION OF SITE-SPECIFIC FACTOR					
	Agricultural (AL)	Urban Park (PL)	Residential (RL)	Commercial (CL)	Industrial (IL)	2
HUMAN HEALTH PROTECTION						
Intake of contaminated soil	200	200	200	600	10 000	3
Groundwater used for drinking water	0.015	0.015	0.015	0.015	0.015	
ENVIRONMENTAL PROTECTION						
Toxicity to soil invertebrates and plants	0.1	5	5	50	50	4
Livestock ingesting soil and fodder	NS					5
Major microbial functional impairment	NS					5

Groundwater flow to surface water used by aquatic life	0.65	0.65	0.65	0.65	0.65	
Groundwater used for livestock watering	0.15					
Groundwater used for irrigation	NS	NS	NS			6

Notes

1. All values in µg/g unless otherwise stated. Substances must be analyzed using methods specified in a director's protocol or alternate methods acceptable to the director.

2. The site-specific factors of human intake of contaminated soil and toxicity to soil invertebrates and plants specified in this matrix apply at all sites.

3. Intake pathway of exposure modeled is inadvertent ingestion of soil.

4. Insufficient acceptable environmental data exists, so standards are set equal to the Canadian Council of Ministers of the Environment interim soil quality criteria.

5. NS — no standard. Insufficient acceptable scientific data exists, so no standard is calculated.

6. NS — no standard. No appropriate standard, guideline or criterion exists to use to develop a soil quality standard.

Matrix Numerical Soil Standards [1]

Xylene (Chemical Abstract Service # 1330-20-7)

COLUMN I	COLUMN II	COLUMN III	COLUMN IV	COLUMN V	COLUMN VI	Note
Site-specific Factor	**SOIL STANDARD FOR PROTECTION OF SITE-SPECIFIC FACTOR**					
	Agricultural (AL)	**Urban Park (PL)**	**Residential (RL)**	**Commercial (CL)**	**Industrial (IL)**	**2**
HUMAN HEALTH PROTECTION						
Intake of contaminated soil	65 000	65 000	65 000	200 000	> 1 000 mg/g	3
Groundwater used for drinking water	20	20	20	20	20	
ENVIRONMENTAL PROTECTION						

Toxicity to soil invertebrates and plants	0.1	5	5	50	50	4
Livestock ingesting soil and fodder	NS					5
Major microbial functional impairment	NS					5
Groundwater flow to surface water used by aquatic life	NS	NS	NS	NS	NS	6
Groundwater used for livestock watering	NS					6
Groundwater used for irrigation	NS	NS	NS			6

Notes

1. All values in µg/g unless otherwise stated. Substances must be analyzed using methods specified in a director's protocol or alternate methods acceptable to the director.

2. The site-specific factors of human intake of contaminated soil and toxicity to soil invertebrates and plants specified in this matrix apply at all sites.

3. Intake pathway of exposure modeled is inadvertent ingestion of soil.

4. Insufficient acceptable environmental data exists, so standards are set equal to the Canadian Council of Ministers of the Environment interim soil quality criteria.

5. NS — no standard. Insufficient acceptable scientific data exists, so no standard is calculated.

6. NS — no standard. No appropriate standard, guideline or criterion exists to use to develop a soil quality standard.

Matrix Numerical Soil Standards [1]

Zinc (Chemical Abstract Service # 7440-66-6)

COLUMN I	COLUMN II	COLUMN III	COLUMN IV	COLUMN V	COLUMN VI	Note
Site-specific Factor	**SOIL STANDARD FOR PROTECTION OF SITE-SPECIFIC FACTOR**					
	Agricultural (AL)	**Urban Park (PL)**	**Residential (RL)**	**Commercial (CL)**	**Industrial (IL)**	**2**
HUMAN HEALTH PROTECTION						

Intake of contaminated soil	10 000	10 000	10 000	30 000	> 1 000 mg/g	3
Groundwater used for drinking water						
pH < 5.0	150	150	150	150	150	4,5
pH 5.0 — < 5.5	200	200	200	200	200	4,5
pH 5.5 — < 6.0	300	300	300	300	300	4,5
pH 6.0 — < 6.5	1 000	1 000	1 000	1 000	1 000	4,5
pH 6.5 — < 7.0	7 500	7 500	7 500	7 500	7 500	4,5
pH ≥ 7.0	15 000	15 000	15 000	15 000	15 000	4,5
ENVIRONMENTAL PROTECTION						
Toxicity to soil invertebrates and plants	450	450	450	600	600	
Livestock ingesting soil and fodder	200					
Major microbial functional impairment	320					6
Groundwater flow to surface water used by aquatic life						
Freshwater						
pH < 6.0	150	150	150	150	150	4,5,7
pH 6.0 — < 6.5	300	300	300	300	300	4,5,7
pH 6.5 — < 7.0	1 500	1 500	1 500	1 500	1 500	4,5,7
pH ≥ 7.0	3 000	3 000	3 000	3 000	3 000	4,5,7
Marine						
pH < 6.5	150	150	150	150	150	4,5,7
pH 6.5 — < 7.0	300	300	300	300	300	4,5,7
pH 7.0 — < 7.5	2 000	2 000	2 000	2 000	2 000	4,5,7
pH ≥ 7.5	35 000	35 000	35 000	35 000	35 000	4,5,7
Groundwater used for livestock watering						
pH < 5.5	150					4,5
pH 5.5 — < 6.0	200					4,5
pH 6.0 — < 6.5	500					4,5
pH 6.5 — < 7.0	3 000					4,5

pH ≥ 7.0	7 000					4,5
Groundwater used for irrigation						
pH < 6.0	150	150	150			4,5
pH 6.0 — < 6.5	500	500	500			4,5
pH 6.5 — < 7.0	3 000	3 000	3 000			4,5
pH ≥ 7.0	15 000	15 000	15 000			4,5

Notes

1. All values in µg/g unless otherwise stated. Substances must be analyzed using methods specified in a director's protocol or alternate methods acceptable to the director.

2. The site-specific factors of human intake of contaminated soil and toxicity to soil invertebrates and plants specified in this matrix apply at all sites.

3. Intake pathway of exposure modeled is inadvertent ingestion of soil.

4. The pH is the pH of the soil at a site.

5. Standard has been adjusted based on a reference provincial background soil concentration. Standard represents the rounded sum of the toxicologically-based value plus the reference provincial background soil concentration. For all land uses, the reference provincial background soil concentration is 138.1 µg/g.

6. Standard is set equal to the Canadian Council of Ministers of the Environment, 1999 - Nutrient and energy cycling check value.

7. Standard varies with receiving water hardness (H). H = 100 — < 200 mg/L as $CaCO_3$ is assumed. Consult director for further advice.

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Appendix F

Full List of Questions and Potential Responses in the Database

1 Exposure (Contract Question A)

- 1.1 How is the characterization of the exposure setting defined?
  - 1.1.1 Definition implicit in the method
  - 1.1.2 Specific list of exposure settings
  - 1.1.3 Conceptual site model or equivalent (with specific guidance)
  - 1.1.4 Conceptual site model or equivalent (without specific guidance)
  - 1.1.5 Required, but explicitly left to Risk Assessor's expertise
  - 1.1.6 To be obtained from the Agency in every case
  - 1.1.7 Other
  - 1.1.8 Not specified
- 1.2 What (abiotic) environmental media are required to be included in risk assessment (human health or ecological)
  - 1.2.1 Surface Soil
  - 1.2.2 Subsurface soil
  - 1.2.3 Outdoor Air
  - 1.2.4 Indoor Air
  - 1.2.5 Surface Water
  - 1.2.6 Sediment
  - 1.2.7 Pore water (at interface between sediment and surface water)
  - 1.2.8 Groundwater
  - 1.2.9 Drinking water
  - 1.2.10 Outside dust
  - 1.2.11 Household dust
  - 1.2.12 Media to be selected by Risk Assessor
  - 1.2.13 Media to be selected by Agency in each case
  - 1.2.14 Other
  - 1.2.15 Not specified
- 1.3 What environmental media are included in criteria derivation?
  - 1.3.1 Surface Soil
  - 1.3.2 Subsurface soil
  - 1.3.3 Outdoor Air
  - 1.3.4 Indoor Air
  - 1.3.5 Surface Water
  - 1.3.6 Sediment
  - 1.3.7 Pore water (at interface between sediment and surface water)
  - 1.3.8 Groundwater
  - 1.3.9 Drinking water
  - 1.3.10 Outside dust
  - 1.3.11 Household dust

- 1.3.12 Media to be selected by Risk Assessor
- 1.3.13 Media to be selected by Agency in each case
- 1.3.14 Other
- 1.3.15 Not specified

1.4 What exposure pathways are generally required to be evaluated in risk assessments?

- 1.4.1 Direct soil ingestion
- 1.4.2 Direct house dust ingestion
- 1.4.3 Direct ingestion of groundwater
- 1.4.4 Direct ingestion of surface water
- 1.4.5 Direct ingestion of sediments
- 1.4.6 Direct ingestion of pore water (ecological)
- 1.4.7 Direct ingestion of other materials
- 1.4.8 Inhalation of vapor indoors
- 1.4.9 Inhalation of vapor outdoors
- 1.4.10 Inhalation of particulates/dust indoors
- 1.4.11 Inhalation of particulates/dust outdoors
- 1.4.12 Direct dermal contact with soil
- 1.4.13 Direct dermal contact with indoor dust
- 1.4.14 Direct dermal contact with surface water
- 1.4.15 Direct dermal contact with groundwater
- 1.4.16 Direct dermal contact with sediments
- 1.4.17 Direct dermal contact with pore water (ecological)
- 1.4.18 Direct dermal absorption of vapor
- 1.4.19 Direct dermal absorption from airborne particulates/dust
- 1.4.20 Vapor transport from groundwater to outdoor air (inhalation)
- 1.4.21 Vapor transport from vadose zone to outdoor air (inhalation)
- 1.4.22 Vapor transport from groundwater to indoor air (inhalation)
- 1.4.23 Vapor transport from vadose zone to indoor air (inhalation)
- 1.4.24 Specified indirect pathways (e.g. soil – plant – ingestion; air – plant – cow – milk – ingestion)
  - 1.4.24.1 Chemical-dependent pathways
  - 1.4.24.2 Chemical-independent pathways
  - 1.4.24.3 Circumstance-dependent pathways (e.g. in a school)
  - 1.4.24.4 Circumstance-independent pathways
  - 1.4.24.5 Other
- 1.4.25 Indirect pathways to be selected by Risk Assessor
- 1.4.26 Indirect pathways to be selected by Agency
- 1.4.27 Other
- 1.4.28 Not specified

1.5 What exposure pathways were evaluated in criteria derivation?

- 1.5.1 Direct soil ingestion
- 1.5.2 Direct house dust ingestion
- 1.5.3 Direct ingestion of groundwater
- 1.5.4 Direct ingestion of surface water
- 1.5.5 Direct ingestion of sediments
- 1.5.6 Direct ingestion of pore water (ecological)
- 1.5.7 Direct ingestion of other materials
- 1.5.8 Inhalation of vapor indoors

1.5.9 Inhalation of vapor outdoors
1.5.10 Inhalation of particulates/dust indoors
1.5.11 Inhalation of particulates/dust outdoors
1.5.12 Direct dermal contact with soil
1.5.13 Direct dermal contact with indoor dust
1.5.14 Direct dermal contact with surface water
1.5.15 Direct dermal contact with groundwater
1.5.16 Direct dermal contact with sediments
1.5.17 Direct dermal contact with pore water (ecological)
1.5.18 Direct dermal absorption of vapor
1.5.19 Direct dermal absorption from airborne particulates/dust
1.5.20 Vapor transport from groundwater to outdoor air (inhalation)
1.5.21 Vapor transport from vadose zone to outdoor air (inhalation)
1.5.22 Vapor transport from groundwater to indoor air (inhalation)
1.5.23 Vapor transport from vadose zone to indoor air (inhalation)
1.5.24 Specified indirect pathways (e.g. soil – plant – ingestion; air – plant – cow – milk – ingestion)
1.5.24.1 Chemical-dependent pathways
1.5.24.2 Chemical-independent pathways
1.5.24.3 Circumstance-dependent pathways (e.g. in a school)
1.5.24.4 Circumstance-independent pathways
1.5.24.5 Other
1.5.25 Indirect pathways to be selected by Risk Assessor
1.5.26 Indirect pathways to be selected by Agency
1.5.27 Other
1.5.28 Not specified

1.6 Are there exposure pathways that are explicitly omitted from risk assessments?
1.6.1 All chemicals, all circumstances
1.6.1.1 Direct soil ingestion
1.6.1.2 Direct house dust ingestion
1.6.1.3 Direct ingestion of groundwater
1.6.1.4 Direct ingestion of surface water
1.6.1.5 Direct ingestion of sediments
1.6.1.6 Direct ingestion of pore water (ecological)
1.6.1.7 Direct ingestion of other materials
1.6.1.8 Inhalation of vapor indoors
1.6.1.9 Inhalation of vapor outdoors
1.6.1.10 Inhalation of particulates/dust indoors
1.6.1.11 Inhalation of particulates/dust outdoors
1.6.1.12 Direct dermal contact with soil
1.6.1.13 Direct dermal contact with indoor dust
1.6.1.14 Direct dermal contact with surface water
1.6.1.15 Direct dermal contact with groundwater
1.6.1.16 Direct dermal contact with sediments
1.6.1.17 Direct dermal contact with pore water (ecological)
1.6.1.18 Direct dermal absorption of vapor
1.6.1.19 Direct dermal absorption from airborne particulates/dust
1.6.1.20 Vapor transport from groundwater to outdoor air (inhalation)

1.6.1.21 Vapor transport from vadose zone to outdoor air (inhalation)
1.6.1.22 Vapor transport from groundwater to indoor air (inhalation)
1.6.1.23 Vapor transport from vadose zone to indoor air (inhalation)
1.6.1.24 Specified indirect pathways (e.g. soil – plant – ingestion; air – plant – cow – milk – ingestion)
1.6.1.24.1 Chemical-dependent pathways
1.6.1.24.2 Chemical-independent pathways
1.6.1.24.3 Circumstance-dependent pathways (e.g. in a school)
1.6.1.24.4 Circumstance-independent pathways
1.6.1.24.5 Other
1.6.1.25 Indirect pathways to be selected by Risk Assessor
1.6.1.26 Indirect pathways to be selected by Agency
1.6.1.27 Other
1.6.1.28 Not specified

1.6.2 Specific chemicals, all circumstances
1.6.2.1 Direct soil ingestion
1.6.2.2 Direct house dust ingestion
1.6.2.3 Direct ingestion of groundwater
1.6.2.4 Direct ingestion of surface water
1.6.2.5 Direct ingestion of sediments
1.6.2.6 Direct ingestion of pore water (ecological)
1.6.2.7 Direct ingestion of other materials
1.6.2.8 Inhalation of vapor indoors
1.6.2.9 Inhalation of vapor outdoors
1.6.2.10 Inhalation of particulates/dust indoors
1.6.2.11 Inhalation of particulates/dust outdoors
1.6.2.12 Direct dermal contact with soil
1.6.2.13 Direct dermal contact with indoor dust
1.6.2.14 Direct dermal contact with surface water
1.6.2.15 Direct dermal contact with groundwater
1.6.2.16 Direct dermal contact with sediments
1.6.2.17 Direct dermal contact with pore water (ecological)
1.6.2.18 Direct dermal absorption of vapor
1.6.2.19 Direct dermal absorption from airborne particulates/dust
1.6.2.20 Vapor transport from groundwater to outdoor air (inhalation)
1.6.2.21 Vapor transport from vadose zone to outdoor air (inhalation)
1.6.2.22 Vapor transport from groundwater to indoor air (inhalation)
1.6.2.23 Vapor transport from vadose zone to indoor air (inhalation)
1.6.2.24 Specified indirect pathways (e.g. soil – plant – ingestion; air – plant – cow – milk – ingestion)
1.6.2.24.1 Chemical-dependent pathways
1.6.2.24.2 Chemical-independent pathways
1.6.2.24.3 Circumstance-dependent pathways (e.g. in a school)
1.6.2.24.4 Circumstance-independent pathways
1.6.2.24.5 Other
1.6.2.25 Indirect pathways to be selected by Risk Assessor
1.6.2.26 Indirect pathways to be selected by Agency
1.6.2.27 Other

1.6.2.28 Not specified

1.6.3 All chemicals, specific circumstances

1.6.3.1 Direct soil ingestion
1.6.3.2 Direct house dust ingestion
1.6.3.3 Direct ingestion of groundwater
1.6.3.4 Direct ingestion of surface water
1.6.3.5 Direct ingestion of sediments
1.6.3.6 Direct ingestion of pore water (ecological)
1.6.3.7 Direct ingestion of other materials
1.6.3.8 Inhalation of vapor indoors
1.6.3.9 Inhalation of vapor outdoors
1.6.3.10 Inhalation of particulates/dust indoors
1.6.3.11 Inhalation of particulates/dust outdoors
1.6.3.12 Direct dermal contact with soil
1.6.3.13 Direct dermal contact with indoor dust
1.6.3.14 Direct dermal contact with surface water
1.6.3.15 Direct dermal contact with groundwater
1.6.3.16 Direct dermal contact with sediments
1.6.3.17 Direct dermal contact with pore water (ecological)
1.6.3.18 Direct dermal absorption of vapor
1.6.3.19 Direct dermal absorption from airborne particulates/dust
1.6.3.20 Vapor transport from groundwater to outdoor air (inhalation)
1.6.3.21 Vapor transport from vadose zone to outdoor air (inhalation)
1.6.3.22 Vapor transport from groundwater to indoor air (inhalation)
1.6.3.23 Vapor transport from vadose zone to indoor air (inhalation)
1.6.3.24 Specified indirect pathways (e.g. soil – plant – ingestion; air – plant – cow – milk – ingestion)

1.6.3.24.1 Chemical-dependent pathways
1.6.3.24.2 Chemical-independent pathways
1.6.3.24.3 Circumstance-dependent pathways (e.g. in a school)
1.6.3.24.4 Circumstance-independent pathways
1.6.3.24.5 Other

1.6.3.25 Indirect pathways to be selected by Risk Assessor
1.6.3.26 Indirect pathways to be selected by Agency
1.6.3.27 Other
1.6.3.28 Not specified

1.6.4 Specific chemicals, specific circumstances

1.6.4.1 Direct soil ingestion
1.6.4.2 Direct house dust ingestion
1.6.4.3 Direct ingestion of groundwater
1.6.4.4 Direct ingestion of surface water
1.6.4.5 Direct ingestion of sediments
1.6.4.6 Direct ingestion of pore water (ecological)
1.6.4.7 Direct ingestion of other materials
1.6.4.8 Inhalation of vapor indoors
1.6.4.9 Inhalation of vapor outdoors
1.6.4.10 Inhalation of particulates/dust indoors
1.6.4.11 Inhalation of particulates/dust outdoors

1.6.4.12 Direct dermal contact with soil
1.6.4.13 Direct dermal contact with indoor dust
1.6.4.14 Direct dermal contact with surface water
1.6.4.15 Direct dermal contact with groundwater
1.6.4.16 Direct dermal contact with sediments
1.6.4.17 Direct dermal contact with pore water (ecological)
1.6.4.18 Direct dermal absorption of vapor
1.6.4.19 Direct dermal absorption from airborne particulates/dust
1.6.4.20 Vapor transport from groundwater to outdoor air (inhalation)
1.6.4.21 Vapor transport from vadose zone to outdoor air (inhalation)
1.6.4.22 Vapor transport from groundwater to indoor air (inhalation)
1.6.4.23 Vapor transport from vadose zone to indoor air (inhalation)
1.6.4.24 Specified indirect pathways (e.g. soil – plant – ingestion; air – plant – cow – milk – ingestion)
1.6.4.24.1 Chemical-dependent pathways
1.6.4.24.2 Chemical-independent pathways
1.6.4.24.3 Circumstance-dependent pathways (e.g. in a school)
1.6.4.24.4 Circumstance-independent pathways
1.6.4.24.5 Other
1.6.4.25 Indirect pathways to be selected by Risk Assessor
1.6.4.26 Indirect pathways to be selected by Agency
1.6.4.27 Other
1.6.4.28 Not specified

1.6.5 Other
1.6.5.1 Direct soil ingestion
1.6.5.2 Direct house dust ingestion
1.6.5.3 Direct ingestion of groundwater
1.6.5.4 Direct ingestion of surface water
1.6.5.5 Direct ingestion of sediments
1.6.5.6 Direct ingestion of pore water (ecological)
1.6.5.7 Direct ingestion of other materials
1.6.5.8 Inhalation of vapor indoors
1.6.5.9 Inhalation of vapor outdoors
1.6.5.10 Inhalation of particulates/dust indoors
1.6.5.11 Inhalation of particulates/dust outdoors
1.6.5.12 Direct dermal contact with soil
1.6.5.13 Direct dermal contact with indoor dust
1.6.5.14 Direct dermal contact with surface water
1.6.5.15 Direct dermal contact with groundwater
1.6.5.16 Direct dermal contact with sediments
1.6.5.17 Direct dermal contact with pore water (ecological)
1.6.5.18 Direct dermal absorption of vapor
1.6.5.19 Direct dermal absorption from airborne particulates/dust
1.6.5.20 Vapor transport from groundwater to outdoor air (inhalation)
1.6.5.21 Vapor transport from vadose zone to outdoor air (inhalation)
1.6.5.22 Vapor transport from groundwater to indoor air (inhalation)
1.6.5.23 Vapor transport from vadose zone to indoor air (inhalation)

1.6.5.24 Specified indirect pathways (e.g. soil – plant – ingestion; air – plant – cow – milk – ingestion)
1.6.5.24.1 Chemical-dependent pathways
1.6.5.24.2 Chemical-independent pathways
1.6.5.24.3 Circumstance-dependent pathways (e.g. in a school)
1.6.5.24.4 Circumstance-independent pathways
1.6.5.24.5 Other
1.6.5.25 Indirect pathways to be selected by Risk Assessor
1.6.5.26 Indirect pathways to be selected by Agency
1.6.5.27 Other
1.6.5.28 Not specified

1.7 Are there exposure pathways that are explicitly omitted from criteria derivation?
1.7.1 All chemicals, all circumstances
1.7.1.1 Direct soil ingestion
1.7.1.2 Direct house dust ingestion
1.7.1.3 Direct ingestion of groundwater
1.7.1.4 Direct ingestion of surface water
1.7.1.5 Direct ingestion of sediments
1.7.1.6 Direct ingestion of pore water (ecological)
1.7.1.7 Direct ingestion of other materials
1.7.1.8 Inhalation of vapor indoors
1.7.1.9 Inhalation of vapor outdoors
1.7.1.10 Inhalation of particulates/dust indoors
1.7.1.11 Inhalation of particulates/dust outdoors
1.7.1.12 Direct dermal contact with soil
1.7.1.13 Direct dermal contact with indoor dust
1.7.1.14 Direct dermal contact with surface water
1.7.1.15 Direct dermal contact with groundwater
1.7.1.16 Direct dermal contact with sediments
1.7.1.17 Direct dermal contact with pore water (ecological)
1.7.1.18 Direct dermal absorption of vapor
1.7.1.19 Direct dermal absorption from airborne particulates/dust
1.7.1.20 Vapor transport from groundwater to outdoor air (inhalation)
1.7.1.21 Vapor transport from vadose zone to outdoor air (inhalation)
1.7.1.22 Vapor transport from groundwater to indoor air (inhalation)
1.7.1.23 Vapor transport from vadose zone to indoor air (inhalation)
1.7.1.24 Specified indirect pathways (e.g. soil – plant – ingestion; air – plant – cow – milk – ingestion)
1.7.1.24.1 Chemical-dependent pathways
1.7.1.24.2 Chemical-independent pathways
1.7.1.24.3 Circumstance-dependent pathways (e.g. in a school)
1.7.1.24.4 Circumstance-independent pathways
1.7.1.24.5 Other
1.7.1.25 Indirect pathways to be selected by Risk Assessor
1.7.1.26 Indirect pathways to be selected by Agency
1.7.1.27 Other
1.7.1.28 Not specified
1.7.2 Specific chemicals, all circumstances

1.7.2.1 Direct soil ingestion
1.7.2.2 Direct house dust ingestion
1.7.2.3 Direct ingestion of groundwater
1.7.2.4 Direct ingestion of surface water
1.7.2.5 Direct ingestion of sediments
1.7.2.6 Direct ingestion of pore water (ecological)
1.7.2.7 Direct ingestion of other materials
1.7.2.8 Inhalation of vapor indoors
1.7.2.9 Inhalation of vapor outdoors
1.7.2.10 Inhalation of particulates/dust indoors
1.7.2.11 Inhalation of particulates/dust outdoors
1.7.2.12 Direct dermal contact with soil
1.7.2.13 Direct dermal contact with indoor dust
1.7.2.14 Direct dermal contact with surface water
1.7.2.15 Direct dermal contact with groundwater
1.7.2.16 Direct dermal contact with sediments
1.7.2.17 Direct dermal contact with pore water (ecological)
1.7.2.18 Direct dermal absorption of vapor
1.7.2.19 Direct dermal absorption from airborne particulates/dust
1.7.2.20 Vapor transport from groundwater to outdoor air (inhalation)
1.7.2.21 Vapor transport from vadose zone to outdoor air (inhalation)
1.7.2.22 Vapor transport from groundwater to indoor air (inhalation)
1.7.2.23 Vapor transport from vadose zone to indoor air (inhalation)
1.7.2.24 Specified indirect pathways (e.g. soil – plant – ingestion; air – plant – cow – milk – ingestion)
1.7.2.24.1 Chemical-dependent pathways
1.7.2.24.2 Chemical-independent pathways
1.7.2.24.3 Circumstance-dependent pathways (e.g. in a school)
1.7.2.24.4 Circumstance-independent pathways
1.7.2.24.5 Other
1.7.2.25 Indirect pathways to be selected by Risk Assessor
1.7.2.26 Indirect pathways to be selected by Agency
1.7.2.27 Other
1.7.2.28 Not specified
1.7.3 All chemicals, specific circumstances
1.7.3.1 Direct soil ingestion
1.7.3.2 Direct house dust ingestion
1.7.3.3 Direct ingestion of groundwater
1.7.3.4 Direct ingestion of surface water
1.7.3.5 Direct ingestion of sediments
1.7.3.6 Direct ingestion of pore water (ecological)
1.7.3.7 Direct ingestion of other materials
1.7.3.8 Inhalation of vapor indoors
1.7.3.9 Inhalation of vapor outdoors
1.7.3.10 Inhalation of particulates/dust indoors
1.7.3.11 Inhalation of particulates/dust outdoors
1.7.3.12 Direct dermal contact with soil
1.7.3.13 Direct dermal contact with indoor dust

1.7.3.14 Direct dermal contact with surface water
1.7.3.15 Direct dermal contact with groundwater
1.7.3.16 Direct dermal contact with sediments
1.7.3.17 Direct dermal contact with pore water (ecological)
1.7.3.18 Direct dermal absorption of vapor
1.7.3.19 Direct dermal absorption from airborne particulates/dust
1.7.3.20 Vapor transport from groundwater to outdoor air (inhalation)
1.7.3.21 Vapor transport from vadose zone to outdoor air (inhalation)
1.7.3.22 Vapor transport from groundwater to indoor air (inhalation)
1.7.3.23 Vapor transport from vadose zone to indoor air (inhalation)
1.7.3.24 Specified indirect pathways (e.g. soil – plant – ingestion; air – plant – cow – milk – ingestion)
1.7.3.24.1 Chemical-dependent pathways
1.7.3.24.2 Chemical-independent pathways
1.7.3.24.3 Circumstance-dependent pathways (e.g. in a school)
1.7.3.24.4 Circumstance-independent pathways
1.7.3.24.5 Other
1.7.3.25 Indirect pathways to be selected by Risk Assessor
1.7.3.26 Indirect pathways to be selected by Agency
1.7.3.27 Other
1.7.3.28 Not specified
1.7.4 Specific chemicals, specific circumstances
1.7.4.1 Direct soil ingestion
1.7.4.2 Direct house dust ingestion
1.7.4.3 Direct ingestion of groundwater
1.7.4.4 Direct ingestion of surface water
1.7.4.5 Direct ingestion of sediments
1.7.4.6 Direct ingestion of pore water (ecological)
1.7.4.7 Direct ingestion of other materials
1.7.4.8 Inhalation of vapor indoors
1.7.4.9 Inhalation of vapor outdoors
1.7.4.10 Inhalation of particulates/dust indoors
1.7.4.11 Inhalation of particulates/dust outdoors
1.7.4.12 Direct dermal contact with soil
1.7.4.13 Direct dermal contact with indoor dust
1.7.4.14 Direct dermal contact with surface water
1.7.4.15 Direct dermal contact with groundwater
1.7.4.16 Direct dermal contact with sediments
1.7.4.17 Direct dermal contact with pore water (ecological)
1.7.4.18 Direct dermal absorption of vapor
1.7.4.19 Direct dermal absorption from airborne particulates/dust
1.7.4.20 Vapor transport from groundwater to outdoor air (inhalation)
1.7.4.21 Vapor transport from vadose zone to outdoor air (inhalation)
1.7.4.22 Vapor transport from groundwater to indoor air (inhalation)
1.7.4.23 Vapor transport from vadose zone to indoor air (inhalation)
1.7.4.24 Specified indirect pathways (e.g. soil – plant – ingestion; air – plant – cow – milk – ingestion)
1.7.4.24.1 Chemical-dependent pathways

1.7.4.24.2 Chemical-independent pathways
1.7.4.24.3 Circumstance-dependent pathways (e.g. in a school)
1.7.4.24.4 Circumstance-independent pathways
1.7.4.24.5 Other
1.7.4.25 Indirect pathways to be selected by Risk Assessor
1.7.4.26 Indirect pathways to be selected by Agency
1.7.4.27 Other
1.7.4.28 Not specified
1.7.5 Other
1.7.5.1 Direct soil ingestion
1.7.5.2 Direct house dust ingestion
1.7.5.3 Direct ingestion of groundwater
1.7.5.4 Direct ingestion of surface water
1.7.5.5 Direct ingestion of sediments
1.7.5.6 Direct ingestion of pore water (ecological)
1.7.5.7 Direct ingestion of other materials
1.7.5.8 Inhalation of vapor indoors
1.7.5.9 Inhalation of vapor outdoors
1.7.5.10 Inhalation of particulates/dust indoors
1.7.5.11 Inhalation of particulates/dust outdoors
1.7.5.12 Direct dermal contact with soil
1.7.5.13 Direct dermal contact with indoor dust
1.7.5.14 Direct dermal contact with surface water
1.7.5.15 Direct dermal contact with groundwater
1.7.5.16 Direct dermal contact with sediments
1.7.5.17 Direct dermal contact with pore water (ecological)
1.7.5.18 Direct dermal absorption of vapor
1.7.5.19 Direct dermal absorption from airborne particulates/dust
1.7.5.20 Vapor transport from groundwater to outdoor air (inhalation)
1.7.5.21 Vapor transport from vadose zone to outdoor air (inhalation)
1.7.5.22 Vapor transport from groundwater to indoor air (inhalation)
1.7.5.23 Vapor transport from vadose zone to indoor air (inhalation)
1.7.5.24 Specified indirect pathways (e.g. soil – plant – ingestion; air – plant – cow – milk – ingestion)
1.7.5.24.1 Chemical-dependent pathways
1.7.5.24.2 Chemical-independent pathways
1.7.5.24.3 Circumstance-dependent pathways (e.g. in a school)
1.7.5.24.4 Circumstance-independent pathways
1.7.5.24.5 Other
1.7.5.25 Indirect pathways to be selected by Risk Assessor
1.7.5.26 Indirect pathways to be selected by Agency
1.7.5.27 Other
1.7.5.28 Not specified
1.8 How are exposure estimates based on direct environmental measurements or predictive models?
1.8.1 For air concentrations:
1.8.1.1 Measurements always trump predictions (even when predictions are less than LOD)

1.8.1.2 Measurements trump predictions when the predictions are falsifiable (e.g. above LOD)
1.8.1.3 Predictions always trump measurements
1.8.1.4 Predictions trump measurements only when not falsified
1.8.1.5 Only measured values used, predictions of unsampled media not included in risk assessment
1.8.1.6 All unsampled media must have predictions to be used in risk assessment
1.8.1.7 Left to the discretion/expertise of the Risk Assessor
1.8.1.8 To be Agency specified in each individual case
1.8.1.9 Other
1.8.1.10 Not specified

1.8.2 For soil concentrations:
1.8.2.1 Measurements always trump predictions (even when predictions are less than LOD)
1.8.2.2 Measurements trump predictions when the predictions are falsifiable (e.g. above LOD)
1.8.2.3 Predictions always trump measurements
1.8.2.4 Predictions trump measurements only when not falsified
1.8.2.5 Only measured values used, predictions of unsampled media not included in risk assessment
1.8.2.6 All unsampled media must have predictions to be used in risk assessment
1.8.2.7 Left to the discretion/expertise of the Risk Assessor
1.8.2.8 To be Agency specified in each individual case
1.8.2.9 Other
1.8.2.10 Not specified

1.8.3 For surface water concentrations
1.8.3.1 Measurements always trump predictions (even when predictions are less than LOD)
1.8.3.2 Measurements trump predictions when the predictions are falsifiable (e.g. above LOD)
1.8.3.3 Predictions always trump measurements
1.8.3.4 Predictions trump measurements only when not falsified
1.8.3.5 Only measured values used, predictions of unsampled media not included in risk assessment
1.8.3.6 All unsampled media must have predictions to be used in risk assessment
1.8.3.7 Left to the discretion/expertise of the Risk Assessor
1.8.3.8 To be Agency specified in each individual case
1.8.3.9 Other
1.8.3.10 Not specified

1.8.4 For groundwater concentrations
1.8.4.1 Measurements always trump predictions (even when predictions are less than LOD)
1.8.4.2 Measurements trump predictions when the predictions are falsifiable (e.g. above LOD)
1.8.4.3 Predictions always trump measurements
1.8.4.4 Predictions trump measurements only when not falsified
1.8.4.5 Only measured values used, predictions of unsampled media not included in risk assessment

1.8.4.6 All unsampled media must have predictions to be used in risk assessment
1.8.4.7 Left to the discretion/expertise of the Risk Assessor
1.8.4.8 To be Agency specified in each individual case
1.8.4.9 Other
1.8.4.10 Not specified

1.8.5 For sediment concentrations
1.8.5.1 Measurements always trump predictions (even when predictions are less than LOD)
1.8.5.2 Measurements trump predictions when the predictions are falsifiable (e.g. above LOD)
1.8.5.3 Predictions always trump measurements
1.8.5.4 Predictions trump measurements only when not falsified
1.8.5.5 Only measured values used, predictions of unsampled media not included in risk assessment
1.8.5.6 All unsampled media must have predictions to be used in risk assessment
1.8.5.7 Left to the discretion/expertise of the Risk Assessor
1.8.5.8 To be Agency specified in each individual case
1.8.5.9 Other
1.8.5.10 Not specified

1.8.6 For animal tissue concentrations
1.8.6.1 Measurements always trump predictions (even when predictions are less than LOD)
1.8.6.2 Measurements trump predictions when the predictions are falsifiable (e.g. above LOD)
1.8.6.3 Predictions always trump measurements
1.8.6.4 Predictions trump measurements only when not falsified
1.8.6.5 Only measured values used, predictions of unsampled media not included in risk assessment
1.8.6.6 All unsampled media must have predictions to be used in risk assessment
1.8.6.7 Left to the discretion/expertise of the Risk Assessor
1.8.6.8 To be Agency specified in each individual case
1.8.6.9 Other
1.8.6.10 Not specified

1.8.7 For plant tissue concentrations
1.8.7.1 Measurements always trump predictions (even when predictions are less than LOD)
1.8.7.2 Measurements trump predictions when the predictions are falsifiable (e.g. above LOD)
1.8.7.3 Predictions always trump measurements
1.8.7.4 Predictions trump measurements only when not falsified
1.8.7.5 Only measured values used, predictions of unsampled media not included in risk assessment
1.8.7.6 All unsampled media must have predictions to be used in risk assessment
1.8.7.7 Left to the discretion/expertise of the Risk Assessor
1.8.7.8 To be Agency specified in each individual case
1.8.7.9 Other
1.8.7.10 Not specified

1.8.8 For other media concentrations (specify)

1.8.8.1 Measurements always trump predictions (even when predictions are less than LOD)
1.8.8.2 Measurements trump predictions when the predictions are falsifiable (e.g. above LOD)
1.8.8.3 Predictions always trump measurements
1.8.8.4 Predictions trump measurements only when not falsified
1.8.8.5 Only measured values used, predictions of unsampled media not included in risk assessment
1.8.8.6 All unsampled media must have predictions to be used in risk assessment
1.8.8.7 Left to the discretion/expertise of the Risk Assessor
1.8.8.8 To be Agency specified in each individual case
1.8.8.9 Other
1.8.8.10 Not specified

1.9 What (predictive) models, if any, are used in estimating media concentrations ?
1.9.1 Specified models that may or must be used
1.9.1.1 Direct soil ingestion
1.9.1.1.1 As mathematical formula
1.9.1.1.2 Specification of physical/chemical situation to be modeled
1.9.1.1.3 Reference to EPA or other authoritative document (provide reference in comments)
1.9.1.1.4 Named computer program
1.9.1.1.5 Other
1.9.1.1.6 None specified
1.9.1.2 Direct house dust ingestion
1.9.1.2.1 As mathematical formula
1.9.1.2.2 Specification of physical/chemical situation to be modeled
1.9.1.2.3 Reference to EPA or other authoritative document (provide reference in comments)
1.9.1.2.4 Named computer program
1.9.1.2.5 Other
1.9.1.2.6 None specified
1.9.1.3 Direct ingestion of groundwater
1.9.1.3.1 As mathematical formula
1.9.1.3.2 Specification of physical/chemical situation to be modeled
1.9.1.3.3 Reference to EPA or other authoritative document (provide reference in comments)
1.9.1.3.4 Named computer program
1.9.1.3.5 Other
1.9.1.3.6 None specified
1.9.1.4 Direct ingestion of surface water
1.9.1.4.1 As mathematical formula
1.9.1.4.2 Specification of physical/chemical situation to be modeled
1.9.1.4.3 Reference to EPA or other authoritative document (provide reference in comments)
1.9.1.4.4 Named computer program
1.9.1.4.5 Other
1.9.1.4.6 None specified
1.9.1.5 Direct ingestion of sediments

1.9.1.5.1 As mathematical formula
1.9.1.5.2 Specification of physical/chemical situation to be modeled
1.9.1.5.3 Reference to EPA or other authoritative document (provide reference in comments)
1.9.1.5.4 Named computer program
1.9.1.5.5 Other
1.9.1.5.6 None specified

1.9.1.6 Direct ingestion of pore water (ecological)
1.9.1.6.1 As mathematical formula
1.9.1.6.2 Specification of physical/chemical situation to be modeled
1.9.1.6.3 Reference to EPA or other authoritative document (provide reference in comments)
1.9.1.6.4 Named computer program
1.9.1.6.5 Other
1.9.1.6.6 None specified

1.9.1.7 Direct ingestion of other materials
1.9.1.7.1 As mathematical formula
1.9.1.7.2 Specification of physical/chemical situation to be modeled
1.9.1.7.3 Reference to EPA or other authoritative document (provide reference in comments)
1.9.1.7.4 Named computer program
1.9.1.7.5 Other
1.9.1.7.6 None specified

1.9.1.8 Inhalation of vapor indoors
1.9.1.8.1 As mathematical formula
1.9.1.8.2 Specification of physical/chemical situation to be modeled
1.9.1.8.3 Reference to EPA or other authoritative document (provide reference in comments)
1.9.1.8.4 Named computer program
1.9.1.8.5 Other
1.9.1.8.6 None specified

1.9.1.9 Inhalation of vapor outdoors
1.9.1.9.1 As mathematical formula
1.9.1.9.2 Specification of physical/chemical situation to be modeled
1.9.1.9.3 Reference to EPA or other authoritative document (provide reference in comments)
1.9.1.9.4 Named computer program
1.9.1.9.5 Other
1.9.1.9.6 None specified

1.9.1.10 Inhalation of particulates/dust indoors
1.9.1.10.1 As mathematical formula
1.9.1.10.2 Specification of physical/chemical situation to be modeled
1.9.1.10.3 Reference to EPA or other authoritative document (provide reference in comments)
1.9.1.10.4 Named computer program
1.9.1.10.5 Other
1.9.1.10.6 None specified

1.9.1.11 Inhalation of particulates/dust outdoors

- 1.9.1.11.1 As mathematical formula
- 1.9.1.11.2 Specification of physical/chemical situation to be modeled
- 1.9.1.11.3 Reference to EPA or other authoritative document (provide reference in comments)
- 1.9.1.11.4 Named computer program
- 1.9.1.11.5 Other
- 1.9.1.11.6 None specified

1.9.1.12 Direct dermal contact with soil
- 1.9.1.12.1 As mathematical formula
- 1.9.1.12.2 Specification of physical/chemical situation to be modeled
- 1.9.1.12.3 Reference to EPA or other authoritative document (provide reference in comments)
- 1.9.1.12.4 Named computer program
- 1.9.1.12.5 Other
- 1.9.1.12.6 None specified

1.9.1.13 Direct dermal contact with indoor dust
- 1.9.1.13.1 As mathematical formula
- 1.9.1.13.2 Specification of physical/chemical situation to be modeled
- 1.9.1.13.3 Reference to EPA or other authoritative document (provide reference in comments)
- 1.9.1.13.4 Named computer program
- 1.9.1.13.5 Other
- 1.9.1.13.6 None specified

1.9.1.14 Direct dermal contact with surface water
- 1.9.1.14.1 As mathematical formula
- 1.9.1.14.2 Specification of physical/chemical situation to be modeled
- 1.9.1.14.3 Reference to EPA or other authoritative document (provide reference in comments)
- 1.9.1.14.4 Named computer program
- 1.9.1.14.5 Other
- 1.9.1.14.6 None specified

1.9.1.15 Direct dermal contact with groundwater
- 1.9.1.15.1 As mathematical formula
- 1.9.1.15.2 Specification of physical/chemical situation to be modeled
- 1.9.1.15.3 Reference to EPA or other authoritative document (provide reference in comments)
- 1.9.1.15.4 Named computer program
- 1.9.1.15.5 Other
- 1.9.1.15.6 None specified

1.9.1.16 Direct dermal contact with sediments
- 1.9.1.16.1 As mathematical formula
- 1.9.1.16.2 Specification of physical/chemical situation to be modeled
- 1.9.1.16.3 Reference to EPA or other authoritative document (provide reference in comments)
- 1.9.1.16.4 Named computer program
- 1.9.1.16.5 Other
- 1.9.1.16.6 None specified

1.9.1.17 Direct dermal contact with pore water (ecological)

- 1.9.1.17.1 As mathematical formula
- 1.9.1.17.2 Specification of physical/chemical situation to be modeled
- 1.9.1.17.3 Reference to EPA or other authoritative document (provide reference in comments)
- 1.9.1.17.4 Named computer program
- 1.9.1.17.5 Other
- 1.9.1.17.6 None specified

1.9.1.18 Direct dermal absorption of vapor

- 1.9.1.18.1 As mathematical formula
- 1.9.1.18.2 Specification of physical/chemical situation to be modeled
- 1.9.1.18.3 Reference to EPA or other authoritative document (provide reference in comments)
- 1.9.1.18.4 Named computer program
- 1.9.1.18.5 Other
- 1.9.1.18.6 None specified

1.9.1.19 Direct dermal absorption from airborne particulates/dust

- 1.9.1.19.1 As mathematical formula
- 1.9.1.19.2 Specification of physical/chemical situation to be modeled
- 1.9.1.19.3 Reference to EPA or other authoritative document (provide reference in comments)
- 1.9.1.19.4 Named computer program
- 1.9.1.19.5 Other
- 1.9.1.19.6 None specified

1.9.1.20 Vapor transport from groundwater to outdoor air (inhalation)

- 1.9.1.20.1 As mathematical formula
- 1.9.1.20.2 Specification of physical/chemical situation to be modeled
- 1.9.1.20.3 Reference to EPA or other authoritative document (provide reference in comments)
- 1.9.1.20.4 Named computer program
- 1.9.1.20.5 Other
- 1.9.1.20.6 None specified

1.9.1.21 Vapor transport from vadose zone to outdoor air (inhalation)

- 1.9.1.21.1 As mathematical formula
- 1.9.1.21.2 Specification of physical/chemical situation to be modeled
- 1.9.1.21.3 Reference to EPA or other authoritative document (provide reference in comments)
- 1.9.1.21.4 Named computer program
- 1.9.1.21.5 Other
- 1.9.1.21.6 None specified

1.9.1.22 Vapor transport from groundwater to indoor air (inhalation)

- 1.9.1.22.1 As mathematical formula
- 1.9.1.22.2 Specification of physical/chemical situation to be modeled
- 1.9.1.22.3 Reference to EPA or other authoritative document (provide reference in comments)
- 1.9.1.22.4 Named computer program
- 1.9.1.22.5 Other
- 1.9.1.22.6 None specified

1.9.1.23 Vapor transport from vadose zone to indoor air (inhalation)

- 1.9.1.23.1 As mathematical formula
- 1.9.1.23.2 Specification of physical/chemical situation to be modeled
- 1.9.1.23.3 Reference to EPA or other authoritative document (provide reference in comments)
- 1.9.1.23.4 Named computer program
- 1.9.1.23.5 Other
- 1.9.1.23.6 None specified

1.9.1.24 Specified indirect pathways (e.g. soil – plant – ingestion; air – plant – cow – milk – ingestion)

- 1.9.1.24.1 Chemical-dependent pathways
  - 1.9.1.24.1.1 As mathematical formula
  - 1.9.1.24.1.2 Specification of physical/chemical situation to be modeled
  - 1.9.1.24.1.3 Reference to EPA or other authoritative document (provide reference in comments)
  - 1.9.1.24.1.4 Named computer program
  - 1.9.1.24.1.5 Other
  - 1.9.1.24.1.6 None specified
- 1.9.1.24.2 Chemical-independent pathways
  - 1.9.1.24.2.1 As mathematical formula
  - 1.9.1.24.2.2 Specification of physical/chemical situation to be modeled
  - 1.9.1.24.2.3 Reference to EPA or other authoritative document (provide reference in comments)
  - 1.9.1.24.2.4 Named computer program
  - 1.9.1.24.2.5 Other
  - 1.9.1.24.2.6 None specified
- 1.9.1.24.3 Circumstance-dependent pathways (e.g. in a school)
  - 1.9.1.24.3.1 As mathematical formula
  - 1.9.1.24.3.2 Specification of physical/chemical situation to be modeled
  - 1.9.1.24.3.3 Reference to EPA or other authoritative document (provide reference in comments)
  - 1.9.1.24.3.4 Named computer program
  - 1.9.1.24.3.5 Other
  - 1.9.1.24.3.6 None specified
- 1.9.1.24.4 Circumstance-independent pathways
  - 1.9.1.24.4.1 As mathematical formula
  - 1.9.1.24.4.2 Specification of physical/chemical situation to be modeled
  - 1.9.1.24.4.3 Reference to EPA or other authoritative document (provide reference in comments)
  - 1.9.1.24.4.4 Named computer program
  - 1.9.1.24.4.5 Other
  - 1.9.1.24.4.6 None specified
- 1.9.1.24.5 Other
  - 1.9.1.24.5.1 As mathematical formula

1.9.1.24.5.2 Specification of physical/chemical situation to be modeled
1.9.1.24.5.3 Reference to EPA or other authoritative document (provide reference in comments)
1.9.1.24.5.4 Named computer program
1.9.1.24.5.5 Other
1.9.1.24.5.6 None specified

1.9.1.25 Other
1.9.1.25.1 As mathematical formula
1.9.1.25.2 Specification of physical/chemical situation to be modeled
1.9.1.25.3 Reference to EPA or other authoritative document (provide reference in comments)
1.9.1.25.4 Named computer program
1.9.1.25.5 Other
1.9.1.25.6 None specified

1.9.2 Other
1.9.3 None specified

1.10 How are exposures to sensitive populations, groups or life-stages addressed?
1.10.1 Human health
1.10.1.1 Specification of sensitive populations, groups or life-stages
1.10.1.1.1 Defined set of sensitive populations, groups or life-stages to be evaluated
1.10.1.1.2 Sensitive populations, groups or life-stages to be evaluated, but they are left undefined
1.10.1.1.3 Risk assessor required to specify/define sensitive populations, groups or life-stages
1.10.1.1.4 Agency required to specify/define sensitive populations, groups or life-stages
1.10.1.1.5 Follow EPA guidance on specification of sensitive populations, groups and life-stages
1.10.1.1.6 Other
1.10.1.1.7 None specified

1.10.1.2 Evaluation of exposures to sensitive populations, groups or life-stages
1.10.1.2.1 EPA guidance on exposure assessment
1.10.1.2.2 Other general guidance on exposure assessment
1.10.1.2.3 Specified guidance for all defined populations, groups and life-stages
1.10.1.2.4 Specified guidance for some defined populations, groups or life-stages
1.10.1.2.5 Risk Assessor to propose evaluation in each case
1.10.1.2.6 Agency specifies evaluation in each case
1.10.1.2.7 Other
1.10.1.2.8 No guidance specified

1.10.2 Ecological
1.10.2.1 Specification of sensitive populations, groups or life-stages
1.10.2.1.1 Defined set of sensitive populations, groups or life-stages to be evaluated

1.10.2.1.2 Sensitive populations, groups or life-stages to be evaluated, but they are left undefined
1.10.2.1.3 Risk assessor required to specify/define sensitive populations, groups or life-stages
1.10.2.1.4 Agency required to specify/define sensitive populations, groups or life-stages
1.10.2.1.5 Follow EPA guidance on specification of sensitive populations, groups and life-stages
1.10.2.1.6 Other
1.10.2.1.7 None specified

1.10.2.2 Evaluation of exposures to sensitive populations, groups or life-stages
1.10.2.2.1 EPA guidance on exposure assessment
1.10.2.2.2 Other general guidance on exposure assessment
1.10.2.2.3 Specified guidance for all defined populations, groups and life-stages
1.10.2.2.4 Specified guidance for some defined populations, groups or life-stages
1.10.2.2.5 Risk Assessor to propose evaluation in each case
1.10.2.2.6 Agency specifies evaluation in each case
1.10.2.2.7 Other
1.10.2.2.8 No guidance specified

1.11 How are exposure estimates quantified?

1.11.1 Human

1.11.1.1 Special cases
1.11.1.1.1 Exposure quantification methods different for cancer and non-cancer end-points
1.11.1.1.2 Special-purpose estimates for particular chemicals (e.g. lead) (specify)
1.11.1.1.3 Special-purpose estimates for particular circumstances (specify)
1.11.1.1.4 Other special considerations (specify)
1.11.1.1.5 None specified

1.11.1.2 Absorption
1.11.1.2.1 Is incorporated in exposure estimate
1.11.1.2.2 Is not incorporated in exposure estimate
1.11.1.2.3 Other
1.11.1.2.4 Not specified

1.11.1.3 Averaging times:
1.11.1.3.1 Must evaluate averages over specified distinct age ranges (or "life")
1.11.1.3.2 Averaging periods depend on evaluated end point (cancer, non-cancer, specific end points) in some or all cases (specify)
1.11.1.3.3 Averaging periods depend on chemical in some or all cases (specify)
1.11.1.3.4 Averaging periods depend on pre-defined scenarios

1.11.1.3.5 Analyst to choose suitable age ranges for averages in each case
1.11.1.3.6 Agency to choose suitable age ranges for averages in each case
1.11.1.3.7 Other
1.11.1.3.8 Not specified
1.11.1.4 Use of qualitative statements is:
1.11.1.4.1 Never acceptable
1.11.1.4.2 Acceptable in defined circumstances (specify)
1.11.1.4.3 Acceptable generically if quantitation not possible
1.11.1.4.4 Other
1.11.1.4.5 Not specified as to acceptability
1.11.2 Ecological
1.11.2.1 Some metric other than media concentration is used
1.11.2.2 Special-purpose estimates for particular chemicals (specify)
1.11.2.3 Special-purpose estimates for particular circumstances (specify)
1.11.2.4 Use of qualitative statements is:
1.11.2.4.1 Never acceptable
1.11.2.4.2 Acceptable in defined circumstances (specify)
1.11.2.4.3 Acceptable generically if quantitation not possible
1.11.2.4.4 Other
1.11.2.4.5 Not specified as to acceptability
1.11.2.5 Other special considerations (specify)
1.12 Are central tendency or maximum exposure estimates used?
1.12.1 Central tendency exposure estimates required
1.12.2 Central tendency exposure estimates optional
1.12.3 Maximum exposure estimates required
1.12.4 Maximum exposure estimates optional
1.12.5 Some other metric of the exposure distribution required
1.12.6 Some other metric of the exposure distribution optional
1.12.7 Distributional exposure estimates required
1.12.8 Distributional exposure estimated optional
1.12.9 Required metric of exposure distribution is selected in more complex manner
1.12.10 Other
1.12.11 Not specified
1.13 How are aggregate exposures across multiple pathways for a single substance addressed?
1.13.1 How many pathways are evaluated?
1.13.1.1 All non-negligible pathways
1.13.1.1.1 Can negligible pathways be dismissed qualitatively or is a quantitative demonstration required?
1.13.1.2 Major pathway(s) only
1.13.1.3 Maximum pathway only
1.13.1.4 Pre-defined scenario(s) select(s) pathways
1.13.1.5 Risk Assessor determines which pathways to include
1.13.1.6 Agency determines which pathways to include
1.13.1.7 Other
1.13.1.8 Not specified
1.13.2 How are multiple routes of exposure (i.e. ingestion, inhalation, dermal) combined?

1.13.2.1 Exposures always summed
1.13.2.2 Pre-defined scenario(s) specify methods
1.13.2.3 Exposures are not combined in principle [HQ and risk estimates may be combined, see below]
1.13.2.4 Risk Assessor determines whether to combine pathways
1.13.2.5 Agency determines whether to combine pathways
1.13.2.6 Other
1.13.2.7 Not specified

1.13.3 How are exposure estimates (leading to same route of exposure) from multiple pathways combined?
1.13.3.1 Always all summed
1.13.3.2 Major pathway(s) only summed
1.13.3.3 Maximum pathway only selected
1.13.3.4 Pre-defined scenarios specify methods
1.13.3.5 Risk Assessor determines
1.13.3.6 Agency determines
1.13.3.7 Other
1.13.3.8 Not specified

1.14 How are cumulative exposures to multiple substances through a common pathway addressed? (Note: this is for exposures, so the only such combinations are for chemicals that are treated together as a single substance like dioxins/PCBs/PAH, or that act through common mechanisms like radioisotopes)

1.14.1 TEF or similar schemes are used to combine exposures only for
1.14.1.1 Dioxins using the EPA/WHO scheme
1.14.1.2 Dioxins using some other scheme
1.14.1.3 PCBs using the EPA Aroclor schemes
1.14.1.4 PCBs using some other scheme
1.14.1.5 PAH using the draft EPA TEF scheme
1.14.1.6 PAH using some other scheme
1.14.1.7 Radioisotopes using the HEAST coefficients
1.14.1.8 Radioisotopes using some other scheme
1.14.1.9 Other

1.14.2 Other
1.14.3 Not specified

1.15 How are cumulative and aggregate exposure exposures to multiple substances through multiple pathways addressed?

1.15.1 Combination of 1.13. and 1.14.
1.15.2 Specified as other than a combination of 1.13. and 1.14.
1.15.3 Other
1.15.4 Not specified

1.16 How are uncertainty and variability addressed in current exposure assessments?

1.16.1 Specified by pre-defined scenario
1.16.2 A distinction is made between uncertainty and variability
1.16.3 A distributional metric (e.g. average, 95th percentile) is specified for one or both (specify, e.g. for individual parameters; for overall exposure; with additional constraints)
1.16.4 Full distribution allowed or required (specify)

1.16.5 Qualitative specification (e.g. reasonable maximum) specified for one or both (specify, e.g. for individual parameters, for overall exposure; with additional constraints)
1.16.6 Specific instructions (e.g. Superfund guidance)
1.16.7 Risk Assessor determines in each case
1.16.8 Agency determines in each case
1.16.9 Other
1.16.10 Not specified

2 Assess how toxic effects are currently determined: (Contract Question B)

2.1 What sources of toxicological information are considered (for human health)?
2.1.1 Ordered list of sources (place in order, add to list as needed)
2.1.1.1 Listed values
2.1.1.2 IRIS
2.1.1.3 PPRTV
2.1.1.4 ATSDR
2.1.1.5 CalEPA HotSpots Database
2.1.1.6 Mass DEP
2.1.1.7 HEAST
2.1.1.8 Specified Agency source(s)
2.1.1.9 Other
2.1.2 Risk assessor must evaluate other sources
2.1.3 Risk assessor may evaluate other sources
2.1.4 Risk assessor may not evaluate other sources
2.1.5 Other
2.1.6 Not specified

2.2 How are (human) toxic effects assessed for carcinogenic substances?
2.2.1 Lifetime probability of cancer
2.2.2 Comparison to standards (e.g. in pre-defined scenarios)
2.2.3 Other
2.2.4 Not specified

2.3 How are (human) toxic effects assessed for non-carcinogenic substances?
2.3.1 Special evaluation for some substances (e.g. lead) (specify)
2.3.2 HQ/HI approach
2.3.2.1 Acute HQ/HI
2.3.2.2 Subchronic HQ/HI
2.3.2.3 Chronic HQ/HI
2.3.2.4 Other HQ/HI (specify)
2.3.3 Other
2.3.4 Not specified

2.4 How are (human) subchronic and genotoxic effects assessed, including mutagenesis and teratogenesis?
2.4.1 Subchronic
2.4.1.1 Incorporated in toxicity values
2.4.1.2 Modified toxicity values for certain life stages
2.4.1.3 Explicitly excluded
2.4.1.4 Other
2.4.1.5 Not specified
2.4.2 Mutagenicity
2.4.2.1 Incorporated in toxicity values

2.4.2.2 Modified toxicity values for certain life stages
2.4.2.3 Explicitly excluded
2.4.2.4 Other
2.4.2.5 Not specified
2.4.3 Genotoxic (other than mutagenicity)
2.4.3.1 Incorporated in toxicity values
2.4.3.2 Modified toxicity values for certain life stages
2.4.3.3 Explicitly excluded
2.4.3.4 Other
2.4.3.5 Not specified
2.4.4 Teratogenicity
2.4.4.1 Incorporated in toxicity values
2.4.4.2 Modified toxicity values for certain life stages
2.4.4.3 Explicitly excluded
2.4.4.4 Other
2.4.4.5 Not specified
2.5 How is acute and chronic toxicity evaluated for ecological receptors?
2.5.1 Acute
2.5.1.1 Comparison of concentrations with criteria (e.g. NRWQC, CMC)
2.5.1.2 Comparison of concentrations with background/unaffected site
2.5.1.3 Qualitative (Pass/fail) using specified aquatic organism tests
2.5.1.4 Quantitative evaluation using specified aquatic organism tests
2.5.1.5 Specific EPA guidance
2.5.1.6 Specific other guidance
2.5.1.7 Risk assessor required to select methodology
2.5.1.8 Risk assessor allowed to select methodology
2.5.1.9 Agency specifies methodology in each case
2.5.1.10 Other
2.5.1.11 Not specified
2.5.2 Chronic
2.5.2.1 Comparison of concentrations with criteria (e.g. NRWQC, CCC)
2.5.2.2 Comparison of concentrations with background/unaffected site
2.5.2.3 Qualitative (Pass/fail) using specified aquatic organism tests
2.5.2.4 Quantitative evaluation using specified aquatic organism tests
2.5.2.5 Specific EPA guidance
2.5.2.6 Specific other guidance
2.5.2.7 Risk assessor required to select methodology
2.5.2.8 Risk assessor allowed to select methodology
2.5.2.9 Agency specifies methodology in each case
2.5.2.10 Other
2.5.2.11 Not specified
2.5.3 Community structure comparisons
2.5.3.1 Specified metrics
2.5.3.2 Specified comparisons with background/unaffected site
2.5.3.3 Specific EPA guidance
2.5.3.4 Specific other guidance
2.5.3.5 Risk assessor required to select methodology
2.5.3.6 Risk assessor allowed to select methodology

2.5.3.7 Agency specifies methodology in each case
2.5.3.8 Other
2.5.3.9 Not specified
2.6 How are appropriate toxicity values selected?
2.6.1 Matched from sources specified in 2.1.
2.6.2 Other
2.7 How are toxicity estimates made for substances for which no toxicity values are available?
2.7.1 Omitted
2.7.2 Surrogate value may/must be used
2.7.2.1 Required to be obtained from Agency
2.7.2.2 Required to be proposed by Risk Assessor
2.7.2.3 Left to discretion of Risk Assessor
2.7.2.4 Provided by Agency
2.7.2.5 Other
2.7.2.6 Not specified
2.7.3 Qualitative discussion only
2.7.4 Other
2.7.5 Not specified
2.8 How are vulnerable populations such as children addressed in toxicity assessments?
2.8.1 Vulnerable populations must be evaluated
2.8.1.1 Following EPA guidance
2.8.1.2 Following Agency guidance
2.8.1.3 Specified populations
2.8.1.4 Specified methods of evaluation
2.8.1.5 Other
2.8.1.6 Not specified
2.8.2 Explicit rejection of special treatment for vulnerable populations
2.8.3 Other
2.8.4 Not specified
2.9 How are uncertainty and variability addressed in current toxicity assessments?
2.9.1 Explicitly surrogated to toxicity value selection
2.9.2 No distinction made between uncertainty and variability
2.9.3 Distributional metric (e.g. average, 95th percentile) for one or both (specify)
2.9.4 Full distribution allowed or required (specify)
2.9.5 Qualitative specification (e.g. reasonable maximum) for one or both (specify)
2.9.6 Specific instructions
2.9.7 Left to discretion of Risk Assessor
2.9.8 Required to obtain direction from Agency
2.9.9 Other
2.9.10 Not specified
3 Characterize how risks are currently estimated: (Contract Question C)
3.1 How are risks for individual substances quantified?
3.1.1 Human
3.1.1.1 Special cases
3.1.1.1.1 Some substance-specific evaluations (e.g. lead) (specify)
3.1.1.1.2 None specified
3.1.1.2 Combination of routes (ingestion, inhalation, dermal)
3.1.1.2.1 All routes combined in characterizing risk

3.1.1.2.2 Some chemical-specific combination of routes used (specify)
3.1.1.2.3 Other
3.1.1.3 Non-cancer toxicity
3.1.1.3.1 Hazard Quotients used
3.1.1.3.1.1 Acute
3.1.1.3.1.2 Subchronic
3.1.1.3.1.3 Chronic
3.1.1.3.1.4 HQs separated by life-stage
3.1.1.3.1.5 Other
3.1.1.3.2 Some end-points treated using non-HQ measure(s) (specify)
3.1.1.3.3 Qualitative statement(s) allowed (specify)
3.1.1.3.4 Other
3.1.1.4 Cancer
3.1.1.4.1 Lifetime risk estimate used
3.1.1.4.1.1 All life stages combined
3.1.1.4.1.2 By life stage
3.1.1.4.1.3 Other
3.1.1.4.2 Qualitative statement(s) allowed (specify)
3.1.1.4.3 Other
3.1.2 Ecological
3.1.2.1 Hazard Quotients used
3.1.2.1.1 Acute
3.1.2.1.2 Chronic
3.1.2.1.3 Other
3.1.2.2 Some end-points treated using non-HQ measure(s) (specify)
3.1.2.3 Qualitative statement(s) allowed (specify)
3.1.2.4 Other
3.2 How are risks from multiple substances quantified?
3.2.1 Human
3.2.1.1 Non-cancer toxicities quantified
3.2.1.1.1 Some end-points treated differently (specify)
3.2.1.1.2 Some organ systems treated differently (specify)
3.2.1.1.3 Hazard index used
3.2.1.1.3.1 EPA approach (summed HQ initially over all end points/organ systems, then refined as desired/necessary)
3.2.1.1.3.2 Other
3.2.1.1.4 Other
3.2.1.2 Cancer risk quantified
3.2.1.2.1 Risk estimates for different substances added
3.2.1.2.2 Other
3.2.1.3 Other
3.2.2 Ecological
3.2.2.1 Some end-points treated differently (specify)
3.2.2.2 Some organ systems treated differently (specify)
3.2.2.3 EPA standard approach (HI, % difference from control, community metrics)

3.2.2.4 Other

3.3 How are risks evaluated using point estimates or probabilistic assessments?

3.3.1 Point estimates

3.3.1.1 Point estimates required
3.3.1.2 Point estimates optional
3.3.1.3 Explicit quantitative statement of bounds (e.g. above 95%ile)
3.3.1.4 Explicit qualitative statement of bounds (e.g. worst-case)
3.3.1.5 Other
3.3.1.6 Not specified

3.3.2 Probabilistic estimates

3.3.2.1 Probabilistic estimate required
3.3.2.2 Probabilistic estimate optional
3.3.2.3 Specific percentage points on probabilistic estimates established
3.3.2.4 Exposure distributions allowed
3.3.2.5 Toxicity distributions allowed
3.3.2.6 Susceptibility distributions allowed
3.3.2.7 Other
3.3.2.8 Not specified

3.3.3 Qualitative statements allowable

3.3.3.1 In defined circumstances (specify)
3.3.3.2 Generically if quantitative evaluation not possible
3.3.3.3 Never
3.3.3.4 Other
3.3.3.5 Not specified

3.3.4 Standards of comparisons

3.3.4.1 Human health

3.3.4.1.1 HI less than specified value (give values where appropriate)

3.3.4.1.1.1 For single chemicals
3.3.4.1.1.2 For all chemicals combined
3.3.4.1.1.3 For single organs
3.3.4.1.1.4 For multiple organs combined
3.3.4.1.1.5 For single end-points
3.3.4.1.1.6 For multiple end-points combined
3.3.4.1.1.7 Other
3.3.4.1.1.8 Not specified

3.3.4.1.2 Lifetime risk less than specified value (give values where appropriate)

3.3.4.1.2.1 For single chemicals
3.3.4.1.2.2 For all chemicals combined
3.3.4.1.2.3 Other
3.3.4.1.2.4 Not specified

3.3.4.2 Ecological

3.3.4.2.1 EPA standard approach
3.3.4.2.2 HQ standard specified (e.g. HQ<1)
3.3.4.2.3 % difference from controls specified (e.g. <80%)
3.3.4.2.4 Community comparison specified
3.3.4.2.5 Other
3.3.4.2.6 Not specified

3.4 How are risks combined across multiple exposure pathways?
- 3.4.1 Not combined in general
- 3.4.2 Combined
  - 3.4.2.1 Special cases
    - 3.4.2.1.1 Special considerations for certain substances (specify)
    - 3.4.2.1.2 Special considerations for certain end points (specify)
    - 3.4.2.1.3 No special cases specified
  - 3.4.2.2 Hazard Quotients or Hazard Indexes
    - 3.4.2.2.1 Added
    - 3.4.2.2.2 Major pathways added
    - 3.4.2.2.3 Major pathway only, others ignored
    - 3.4.2.2.4 Other
  - 3.4.2.3 Risk estimates
    - 3.4.2.3.1 Added
    - 3.4.2.3.2 Major Pathways added
    - 3.4.2.3.3 Major pathway only, others ignored
    - 3.4.2.3.4 Other
  - 3.4.2.4 Other measures (specify)
    - 3.4.2.4.1 Added
    - 3.4.2.4.2 Major Pathways added
    - 3.4.2.4.3 Other combination methods used (specify)
    - 3.4.2.4.4 Other

3.5 What is the role of a Weight of Evidence (WoE) approach in estimating risks?
- 3.5.1 Non-cancer toxicities
  - 3.5.1.1 Hazard Index/Quotient approaches
    - 3.5.1.1.1 No account taken of Confidence
    - 3.5.1.1.2 Only incorporate toxicity values above a specified Confidence
    - 3.5.1.1.3 Some combinations (pathway, route, substance, end points) maintained separately by Confidence
    - 3.5.1.1.4 Other
    - 3.5.1.1.5 Not specified
  - 3.5.1.2 Other approaches
    - 3.5.1.2.1 No account taken of any WoE measure
    - 3.5.1.2.2 Other
    - 3.5.1.2.3 Not specified
- 3.5.2 Cancer
  - 3.5.2.1 No account taken of WoE
  - 3.5.2.2 EPA-specified WoE incorporated
    - 3.5.2.2.1 Risk estimates of different WoE kept separately
    - 3.5.2.2.2 Only incorporate toxicity values above a specified WoE
    - 3.5.2.2.3 Other
  - 3.5.2.3 Other
  - 3.5.2.4 Not specified

3.6 How are variability and uncertainty addressed in the risk characterization process?
- 3.6.1 Not explicitly addressed
- 3.6.2 No distinction made between uncertainty and variability
- 3.6.3 Distributional metric (e.g. average, 95th percentile) for one or both (specify)
- 3.6.4 Full distribution allowed or required (specify)

3.6.5 Qualitative specification (e.g. reasonable maximum) for one or both (specify)
3.6.6 Specific instructions provided
3.6.7 Risk assessor has discretion
3.6.8 Agency specifies approach on case-by-case basis
3.6.9 Other
3.6.10 Not specified

4 Determine how remedial goals are set (Contract Question D)

4.1 How is risk management incorporated into risk-based decision making?
4.1.1 Explicit methodology
4.1.2 Generic statements
4.1.3 Not specified

4.2 Are remedial goals set solely on the basis of risk assessment or are final remedial goals informed by other risk management considerations? Explain
4.2.1 Are clean-up goals fixed, or does the Agency have discretion to select alternative clean-up goals (e.g. within a range of risks, as for EPA)?
4.2.1.1 Clean-up goals specified as concentrations, inflexible
4.2.1.2 Clean-up goals specified as risk, inflexible
4.2.1.3 Clean-up goals specified as concentrations, flexible
4.2.1.4 Clean-up goals specified as risk values, flexible
4.2.1.5 Clean-up goals specified in other terms, inflexible
4.2.1.6 Clean-up goals specified in other terms, flexible
4.2.1.7 Not specified
4.2.2 If clean-up goals are not fixed, what other considerations are explicitly included as affecting the decision on final clean-up goals?
4.2.2.1 Cost
4.2.2.2 Feasibility
4.2.2.3 Background concentrations
4.2.2.4 Ecosystem valuation or preservation
4.2.2.5 Public preferences
4.2.2.6 Neighbor preferences
4.2.2.7 Agency discretion
4.2.2.8 Conformity to other laws
4.2.2.9 Deference to other laws
4.2.2.10 Deference to State & Federal policies
4.2.2.11 Deference to or conformity with legal decisions
4.2.2.12 Deference to other state agencies
4.2.2.13 Deference to state officer requests or orders
4.2.2.14 Scientific uncertainty
4.2.2.15 Other
4.2.2.16 Not specified

4.3 How have specific risk management policies and regulations affected how and which risks were addressed and which were not?
4.3.1 Specific risk management policies are referenced affecting selection of regulated risks (list policies and references)
4.3.2 Specific regulations manage specific risks (list regulations and risks)
4.3.3 None specified

4.4 What administrative and legal tools are available for implementing remedial decisions? (Explicitly listed in the legislation/regulation documentation on site clean-up we collected; do not attempt to locate references to other legislation/regulation)
- 4.4.1 Fines
- 4.4.2 Jail time
- 4.4.3 Refusal of other agency actions (e.g. other permits)
- 4.4.4 Removal of licenses or permits
- 4.4.5 Other
- 4.4.6 None specified

5 (Determine roles and legal responsibilities, as applicable, of state agencies [for Connecticut, this would include DEEP and the Connecticut Department of Public Health ("DPH")], local agencies and stakeholders such as the public and responsible parties in making risked based decisions.) Apart from the Agency being evaluated here, are other state agencies, local agencies, or other stakeholders (including the public and responsible parties) documented anywhere as having a role in making risk-based decisions? (Contract Question F)

5.1 Legal requirements
- 5.1.1 Other state agencies
- 5.1.2 Local agencies
- 5.1.3 Responsible parties
- 5.1.4 Neighbors
- 5.1.5 Public
- 5.1.6 Other
- 5.1.7 None specified

5.2 Some role specified
- 5.2.1 Other state agencies
- 5.2.2 Local agencies
- 5.2.3 Responsible parties
- 5.2.4 Neighbors
- 5.2.5 Public
- 5.2.6 Other
- 5.2.7 None specified

6 (Determine if adaptive management is considered during the risk-based decision making. Only explicit references to adaptive management or equivalent management practices in the legislation or guidance documents examined during the project will be documented; no attempt will be made to evaluate whether adaptive management is used in practice with the exception of the State of Connecticut where CTDEEP personnel will be interviewed.) Is adaptive management (defined as "A framework and flexible decision-making process for ongoing knowledge acquisition, monitoring, and evaluation leading to continuous improvements in management planning and implementation of a project to achieve specified objectives") or an equivalent mentioned in any documentation? (Contract Question H)
- 6.1 Explicitly incorporated, allowing complete flexibility in timelines
- 6.2 Implicit in the flexible timelines and accommodation to technological possibilities
- 6.3 Explicitly forbidden
- 6.4 Implicitly forbidden by adoption of inflexible timelines or failure to account for technical impossibilities
- 6.5 Not possible to determine

7 Evaluate how risk-based decisions are communicated to the regulated community, stakeholders and the public, and at what stages of the decision-making process such communication occurs. (Contract Question I)

- 7.1 There are requirements on communication to the regulated community, stakeholders and the public for all sites
  - 7.1.1 Methods of communication are specified
  - 7.1.2 Timelines are specified
  - 7.1.3 Persons/agencies responsible for communications are specified
  - 7.1.4 Generic statements only
  - 7.1.5 Other
- 7.2 Special communication provisions are made for certain sites
  - 7.2.1 Selection of such sites is specified
  - 7.2.2 Methods of communication are specified
  - 7.2.3 Timelines are specified
  - 7.2.4 Persons/agencies responsible for communications are specified
  - 7.2.5 Generic statements only
  - 7.2.6 Other
- 7.3 Not specified (no communication provisions)

8 Determine the legislated or regulated timeliness of responses by agencies. What deadlines are required by law or regulation? (Contract Question K)

- 8.1 Are there timelines specified in legislation or regulation for response by the Agency to all communications from
  - 8.1.1 PRPs
  - 8.1.2 Risk Assessors
  - 8.1.3 Stakeholders
  - 8.1.4 The public
- 8.2 Are there timelines specified in legislation or regulation for response by the Agency to some communications from
  - 8.2.1 PRPs
  - 8.2.2 Risk Assessors
  - 8.2.3 Stakeholders
  - 8.2.4 The public
- 8.3 Are the timelines specified as a time certain, or do they contain conditional clauses?
- 8.4 What is the effect specified in legislation or regulation if the Agency does not meet a deadline?
  - 8.4.1 Any proposal to the Agency takes effect as though fully approved by the Agency
  - 8.4.2 Any proposal to the Agency is automatically denied
  - 8.4.3 Any proposal is left in limbo
  - 8.4.4 Other
  - 8.4.5 Not specified
- 8.5 What recourse is included in the legislation or regulation if the Agency does not meet a deadline?
  - 8.5.1 Monetary relief
  - 8.5.2 Oversight relief
  - 8.5.3 Automatic granting of any petition
  - 8.5.4 Automatic denial of any petition
  - 8.5.5 Appeal to higher authority within the Agency
  - 8.5.6 Appeal outside the Agency
  - 8.5.7 Appeal to the courts
  - 8.5.8 Other
  - 8.5.9 Not specified

9 What mechanisms are available for updating procedures and values? Are there mechanisms built into legislation or regulation that require updates, revisions, and corrections to toxicity values and other risk-related parameters, and what is the timeline for such modifications? (Contract Question N)

- 9.1 Are there explicit timelines with specified times in the legislation or regulations for updates to:
  - 9.1.1 Toxicity values
  - 9.1.2 Exposure parameters
  - 9.1.3 Methodologies
  - 9.1.4 Other
  - 9.1.5 None specified
- 9.2 Are there other explicit provisions in the legislation or regulations that call for updates in other circumstances (e.g. at the discretion of the relevant Agency) to
  - 9.2.1 Toxicity values
  - 9.2.2 Exposure parameters
  - 9.2.3 Methodologies
  - 9.2.4 Other
  - 9.2.5 None specified
- 9.3 Do the legislation or regulations explicitly provide for accepting updates made externally to the relevant Agency (e.g. if IRIS or the Exposure Factors Handbook gets updated) for:
  - 9.3.1 Toxicity values
  - 9.3.2 Exposure parameters
  - 9.3.3 Methodologies
  - 9.3.4 Other
  - 9.3.5 None specified
- 9.4 Do the legislation or regulations implicitly provide for accepting updates made externally to the relevant Agency (e.g. if IRIS or the Exposure Factors Handbook gets updated)
  - 9.4.1 Toxicity values
  - 9.4.2 Exposure parameters
  - 9.4.3 Methodologies
  - 9.4.4 Other
  - 9.4.5 None specified
- 9.5 Do the legislation or regulations explicitly forbid accepting updates made externally to the relevant Agency for:
  - 9.5.1 Toxicity values
  - 9.5.2 Exposure parameters
  - 9.5.3 Methodologies
  - 9.5.4 Other
  - 9.5.5 None specified

10 How flexible are the approaches allowed for site evaluation and remedial options? Is there a single track or multiple options for site evaluations, and are there alternative options for remediation (e.g. depending on site use)? (Contract Question O)

- 10.1 For the current method, the legislation or regulations allow or require consideration of site use or other factors in decisions on remediation
- 10.2 For the current method, the legislation or regulations forbid consideration of site use or other factors in decisions on remediation
- 10.3 Other
- 10.4 Not specified

Appendix G

Questionnaire and Database Details

G.1 Questionnaire Construction

The questionnaire consisted of 10 top-level general topics or questions, some having several sub-questions as indicated in Figure G-1, for a total of 37 sub-questions (this distribution of sub-questions corresponds to the number and detail of the sub-questions in Paragraphs A–O, see Section 5-1). There are 1,136 potential responses to these 37 sub-questions, with substantial variation in the number and depth of detail for the various questions (*e.g.*, for some questions, the responses had to be subdivided to provide distinct potential responses for HHRA and ERA, and/or for different exposure pathways and routes). A full list of questions and potential responses is given in Appendix F.

Table G-1 List of questionnaire topics and number of sub-questions per topic

General Topics or Questions	Number of sub-questions
1. Exposure	16
2. Assess how toxic effects are currently determined	9
3. Characterize how risks are currently estimated	6
4. Determine how remedial goals are set	4
5. Determine roles and legal responsibilities of state agencies	2
6. Determine if adaptive management is considered during risk-based decision making	0
7. Evaluate how risk-based decisions are communicated to the regulated community, stakeholders, and the public	0
8. Determine the legislated or regulated timeliness of responses by agencies	0
9. What mechanisms are available for updating procedures and values?	0
10. How flexible are the approaches allowed for site evaluation and remedial options?	0
Total number of sub-questions	**37**

Since it was found that some States/Agencies have separate and/or distinct approaches to risk assessment of contaminated sites for purposes of human health evaluation as opposed to ecological health evaluation, every question in the database was coded as being relevant to human health risk assessment, to ecological risk assessment, or to both. This coding is present in the table named "Schema" in the sheet named "Schema" in the Excel workbook "Project Database & Results.xlsm" accompanying this report.

Paragraph E of the contract requirements is not explicitly represented in the questionnaire, but responses to other questions cover the contents of this paragraph (see Section 5-1 and also the full list of questions and responses in Appendix F).

Paragraph G is also not explicitly coded in our questionnaire, but is included implicitly by the attribution of every response to Legislation, Regulation, Guidance, or Other documentation in the database, as detailed in Section G.2.

G.2 Contents of Database

The database as originally constructed contains:

- For each State/Agency, a list of all documents obtained, coded as to legal status as Legislation, Regulation, Guidance, or Other. The list is of document names or titles, often in abbreviated form. Associated with each document is a URL linking to the source of the document, and the name of the file on the accompanying CD containing the document. The combination of State/Agency, legal status, and abbreviated name/title, uniquely defines the document.

- For each State/Agency, and each Method (see Section 5.2) a list of the 1,136 potential responses to the 37 questions. Each potential response is coded as selected or unselected. All selected responses except "Other" and "Not specified" (or equivalent) have one or more associated reference(s) to (a) document(s) providing the justification for the selection, coded in four fields as the legal status of the reference, the abbreviated name of that document, the page or section number of the document, and an optional text entry providing further details. All responses, whether selected or not, may also have a short "Response text" associated with them. "Other" responses may also have a reference; where they do not, there should be a Response text indicating the reason for the lack. "Not specified" or equivalent entries cannot have any reference (any response indicating an explicit reference to "Not specified" would be coded as "Other"). For convenience, each of the 1,136 potential responses also has coded the response number (Appendix F) and the text of the potential response.

The database contains 38 completed questionnaires, one for each Method specified in Section 5.2. However, each potential response is also associated with HHRAs, ERAs, or both. For the Methods that are specifically defined for either HHRAs or ERAs, the corresponding specific opposite part of the questionnaire may be blank (i.e. for a Method specifically for HHRA, a response specific to ERAs only may be blank and is in any case ignored; for a Method specifically for ERA, a response specific to HHRAs only may be blank and is in any case ignored).

G.3 Methodology for Database Evaluation and Scoring

The questions and potential responses form a tree structure (see Appendix F) that has 1,136 leaves at the end of its branches. Each of those 1,136 leaves represents one possible response to one of the questions posed, although, as noted above, multiple responses are possible for many questions, and these multiple responses are included in the database. Figure G-1 illustrates the tree structure of the database questions and responses. The root is represented by Question 4 (Remedial Goals) in the figure.[18] Sub-questions are represented by 4.1, 4.2, etc., with potential sub-sub-questions represented by 4.2.1 and 4.2.2. The leaves represent question responses. For each Method evaluated, each potential response was either selected or not selected.

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[18] We use Question 4 for the diagram because it is short enough to show the entire tree structure. Question 4 was not however scored in the manner described (although the database is set up to allow this if desired).

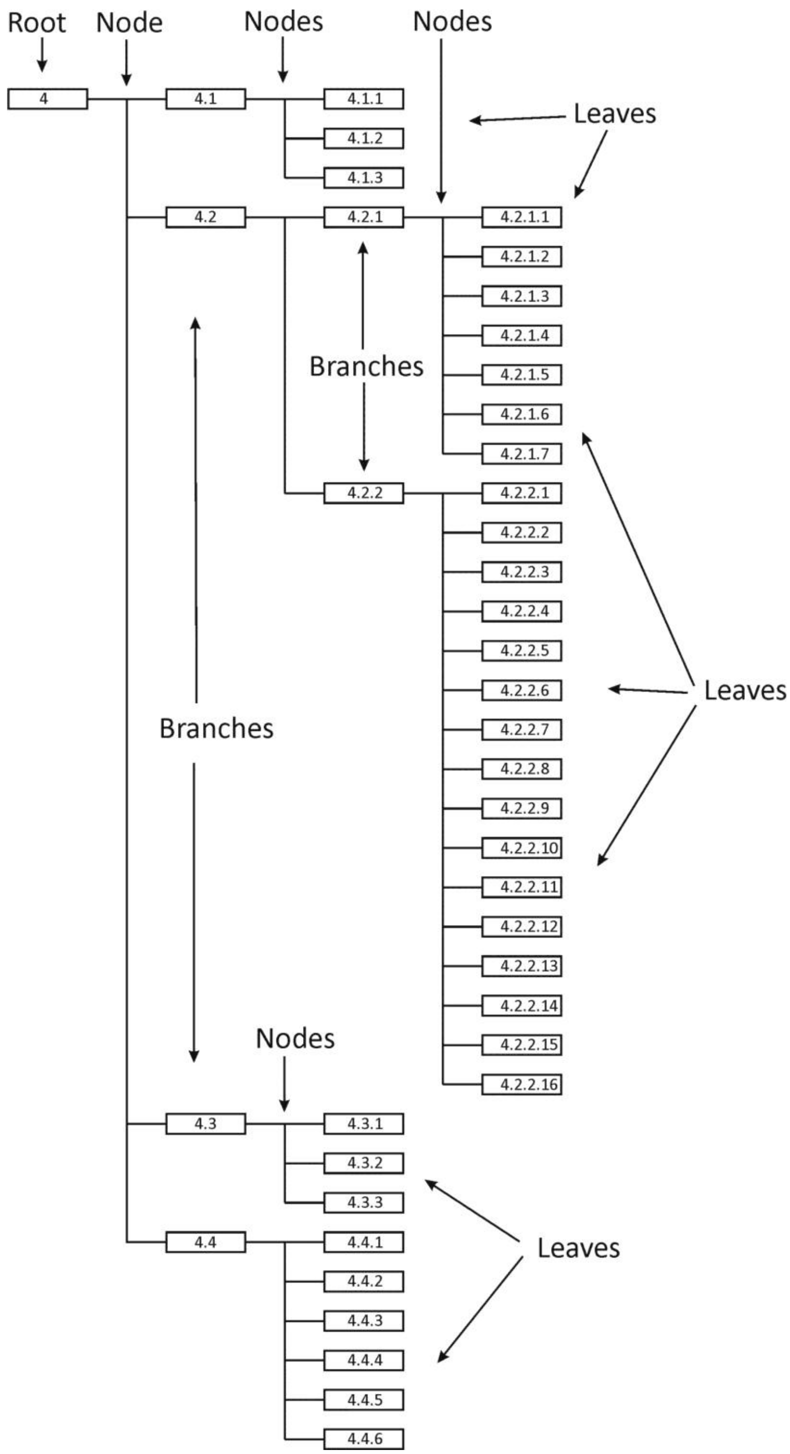


Figure G-1 Illustration of the tree structure of the database questions and responses

To obtain an overall score for a Method, or for parts of that Method represented by the 10 major questions/topics, it is necessary to integrate all the selected responses below the nodes of the tree representing these questions/topics. Moreover, the evaluation of the score has to be performed for each of the 9 attributes of "best practices" (see Section 6.3), and separately for HHRAs and ERAs.

The approach that we took was to assign a weight to each of the potential responses for each of the relevant attributes of "best practice", and to accumulate the weights associated with selected responses (see below) up the tree to the appropriate node, the result of the accumulation being the score for that node. Since there were 1,136 responses (leaves), and 9 attributes, this potentially required the definition of 10,224 weights. However, we evaluated only the first three questions in the database using this methodology, although those accounted for 1,018 of the potential responses, reducing the potential number of weights to 9,162. Moreover, most of the potential responses did not provide discrimination on some of the attributes of best practice — for example, only the questions specifically directed at the handling of uncertainty had associated potential responses providing any discrimination for the Uncertainty attribute; and the potential responses to these questions did not provide any discrimination for any of the other best practice attributes.

Thus while many of the questions/responses were clearly irrelevant to particular attributes, reducing the number of weights required (we actually defined 4,262 weights, although only 1,751 of these are used because the other 2,511 are associated with potential responses that were never selected), it clearly would be counterproductive to attempt to justify fine distinctions between weights. Instead, rough estimates were made based on an assessment of the relative merit of the various responses to each attribute. The weights were generally chosen as a decimal between 0.1 and 1.0 in steps of 0.1, with higher values corresponding to higher merit for the attribute. Special values of 0 and -1 were also included. The special weight value 0 was used for attributes that were irrelevant for a particular response, or for responses that were never selected among the 38 Methods (approximately 500 responses) and hence could not contribute any discriminatory information between those Methods. The special value –1 was reserved as a weight for the "Not specified" responses, if it was desired to ignore those responses in the accumulation. Some summary notes compiled during construction of the weights are listed in Section G.4.

Where necessary, assumptions were made about the relative merit of the various potential responses. In particular, it was assumed when weighting potential responses incorporating Risk Assessor or Agency input that the Risk Assessor would be well-informed and appropriately motivated to provide scientifically accurate and protective solutions, and that the Agency would be similarly informed and motivated but with potentially less site-specific information than the Risk Assessor.

The full set of weights used in the evaluation is coded in the array named "All_characteristics" in the sheet "Lists" in the accompanying workbook "CTDEEP Project Database & Results.xlsm."

We also defined a set of methods to accumulate the weights of selected responses up the tree of questions/responses to provide a score for any specific question. Four principal methods were used to accumulate selected weights or scores at any given node from the selected weights or scores on the branches or leaves stemming from those nodes:

Average	The average of selected positive weights, or zero if there are no selected positive weights
Maximum	The maximum of the selected positive weights, or zero if there are no selected positive weights
Sum	The sum of selected positive weights, or zero if there are no selected positive weights
AntiSum	Defined as 1.1–Sum

These were used to appropriately combine the leaves and branches based on the response sets — the set of selected responses on the leaves or branches. Generally averaging was used over branches of nodes representing the questions themselves, but at lower level nodes and at the leaves (the actual potential responses) a method appropriate to the type of potential response set was chosen. For example, if the responses enumerated multiple non-exclusive possibilities where multiple responses were expected to be selected and the attribute being evaluated was stronger for more selections, the weights of selected responses would be summed – the weights having been chosen appropriately for this eventuality; correspondingly, if more selected responses indicated lower ranking for the attribute, the AntiSum method was used. If the responses enumerated mutually exclusive or non-exclusive possibilities that had distinct relative merit for the attribute, the maximum weight would be selected. All weights were chosen to lie in the range 0.1 to 1, and in such a manner that the combination method would also result in weights in the same range (sums, for example, were truncated at the value 1 if necessary). The result of the evaluation is a score in the range of 0.1 to 1, with scores closer to 1 indicating better practices.

Technically, two other methods of accumulation were defined to account for special cases. The first, Irrelevant, was used where the responses did not provide information about an attribute, and the weights were generally set to zero. The second, Continue, acted to collapse a branch of the tree so the leaves or nodes at the end of a branch were treated as connected to the originating node of the branch.

The methods of accumulating the weights up the tree was coded as an array, with an entry for each of the 182 separate branches of the tree (156 when limited to questions 1 to 3) and each of the 9 attributes of best practice. The accompanying workbook "CTDEEP Project Database & Results.xlsm" contains the array with name "Schema" in sheet "Schema"

For each of the 38 Methods, the combination methods were used separately for all questions/responses corresponding to human health risk assessment (HHRA) and ecological risk assessment (ERA). However, the separation of some of these methods into HHRA and ERA meant that fewer than 76 results were meaningful.

G.4 Notes on weighting

1 Exposure

Accuracy	Average
Protectiveness	Average
Proportionality	Average
Reproducibility	Average
Appropriateness	Average
Flexibility	Average
Transparency	Average
Specification	Average
Uncertainty	Average

1.1 How is the characterization of the exposure setting defined?

Accuracy	Maximum: the more accurately specified, the more accurate the assessment.
Protectiveness	Maximum: tracks with accuracy
Proportionality	Maximum: tracks with accuracy

Reproducibility	Maximum: inversely with accuracy
Appropriateness	Not relevant
Flexibility	Maximum: More pre-specification, the less flexibility
Transparency	Not relevant
Specification	Average:
Uncertainty	Not relevant

1.2 **What (abiotic) environmental media are required to be included in risk assessment (human health or ecological)**

1.3 **What environmental media are included in criteria derivation?**

Accuracy	Sum: the more media included, the more likely to be accurate. Risk assessor/Other assumed to result in more media evaluations.
Protectiveness	Sum: tracks with accuracy
Proportionality	Not relevant
Reproducibility	Not relevant
Appropriateness	Not relevant
Flexibility	Sum: more specified routes allows greater flexibility in choice
Transparency	Not relevant
Specification	Average: selection by Risk Assessor implies lower Specification
Uncertainty	Not relevant

1.4 **What exposure pathways are generally required to be evaluated in risk assessments?**

1.5 What exposure pathways were evaluated in criteria derivation?

Note: 1.4.24 & 1.5.24 sub-lists at the same level as 1.4 and 1.5.

Accuracy	Sum: the more there are, the more likely to be accurate. Risk Assessor/ Other assumed to require selection of all relevant media.
Protectiveness	Sum: tracks with accuracy
Proportionality	Not relevant
Reproducibility	Not relevant
Appropriateness	Not relevant
Flexibility	Sum: including more pathways gives the option for flexibility.
Transparency	Not relevant
Specification	Average: Risk Assessor/ Other substantially less specified.
Uncertainty	Not relevant

1.6 **Are there exposure pathways that are explicitly omitted from risk assessments?**

Accuracy	Average
Protectiveness	Average
Proportionality	Average
Reproducibility	Average
Appropriateness	Average
Flexibility	Average
Transparency	Average
Specification	Average
Uncertainty	Average

1.6.1 All chemicals, all circumstances
1.6.2 **Specific chemicals, all circumstances**
1.6.3 **All chemicals, specific circumstances**
1.6.4 **Specific chemicals, specific circumstances**
1.6.5 Other

Note: all sub-lists continued at the same level as the parent. Many of these entries were not specified by any State/Agency program.

Accuracy	1.1–Sum: omitting pathways degrades accuracy. The more omitted the less accurate. Assume that Risk Assessor/ Other is equivalent to omission of 1 pathway.
Protectiveness	1.1–Sum: tracks with accuracy
Proportionality	Sum: omitting pathways is appropriate for proportionality in certain circumstances.
Reproducibility	Not relevant
Appropriateness	Not relevant
Flexibility	Not relevant.
Transparency	Not relevant
Specification	Sum: the more pathways explicitly omitted, the less the risk assessor has to justify
Uncertainty	Not relevant

1.7 Are there exposure pathways that are explicitly omitted from criteria derivation?

[Same as 1.6]

1.8 How are exposure estimates based on direct environmental measurements or predictive models?

Accuracy	Average
Protectiveness	Average
Proportionality	Average
Reproducibility	Average
Appropriateness	Average
Flexibility	Average
Transparency	Average
Specification	Average
Uncertainty	Average

1.8.1 **For air concentrations:**
1.8.2 **For soil concentrations:**
1.8.3 **For surface water concentrations**
1.8.4 **For groundwater concentrations**
1.8.5 **For sediment concentrations**
1.8.6 **For animal tissue concentrations**
1.8.7 **For plant tissue concentrations**
1.8.8 For other media concentrations (specify)

Accuracy	Average: rarely specified, usually only one selected
Protectiveness	Average: rarely specified, usually only one selected
Proportionality	Not relevant
Reproducibility	Average: rarely specified, usually only one selected
Appropriateness	Not relevant
Flexibility	Average: rarely specified, usually only one selected
Transparency	Not relevant
Specification	Average: rarely specified, usually only one selected

Uncertainty	Average: rarely specified, usually only one selected

1.9 What (predictive) models, if any, are used in estimating media concentrations ?

Accuracy	Average
Protectiveness	Average
Proportionality	Average
Reproducibility	Average
Appropriateness	Average
Flexibility	Average
Transparency	Average
Specification	Average
Uncertainty	Average

[Note: the only alternatives to 1.9.1 are “Other” and “Not specified”]

1.9.1 Specified models that may or must be used

Accuracy	Average: across pathways
Protectiveness	Average: across pathways
Proportionality	Average: across pathways
Reproducibility	Average: across pathways
Appropriateness	Average: across pathways
Flexibility	Average: across pathways
Transparency	Average: across pathways
Specification	Average: across pathways
Uncertainty	Average: across pathways

1.9.1.1 **Direct soil ingestion**
1.9.1.2 **Direct house dust ingestion**
1.9.1.3 **Direct ingestion of groundwater**
1.9.1.4 **Direct ingestion of surface water**
1.9.1.5 **Direct ingestion of sediments**
1.9.1.6 **Direct ingestion of pore water (ecological)**
1.9.1.7 **Direct ingestion of other materials**
1.9.1.8 **Inhalation of vapor indoors**
1.9.1.9 **Inhalation of vapor outdoors**
1.9.1.10 **Inhalation of particulates/dust indoors**
1.9.1.11 **Inhalation of particulates/dust outdoors**
1.9.1.12 **Direct dermal contact with soil**
1.9.1.13 **Direct dermal contact with indoor dust**
1.9.1.14 **Direct dermal contact with surface water**
1.9.1.15 **Direct dermal contact with groundwater**
1.9.1.16 **Direct dermal contact with sediments**
1.9.1.17 **Direct dermal contact with pore water (ecological)**
1.9.1.18 **Direct dermal absorption of vapor**
1.9.1.19 **Direct dermal absorption from airborne particulates/dust**
1.9.1.20 **Vapor transport from groundwater to outdoor air (inhalation)**
1.9.1.21 **Vapor transport from vadose zone to outdoor air (inhalation)**
1.9.1.22 **Vapor transport from groundwater to indoor air (inhalation)**
1.9.1.23 Vapor transport from vadose zone to indoor air (inhalation)

1.9.1.24 Specified indirect pathways (e.g. soil – plant – ingestion; air – plant – cow – milk – ingestion)

1.9.1.25 Other

[Note: 1.9.1.24 sub-lists all treated as being at the same level as these entries]

Accuracy	Max: Math formula most likely to mis-specify situation, giving phys/chem spec. gives most accurate description. Average in case multiple choices allowed.
Protectiveness	Max: Math formula most likely chosen more over-protective than computer program.
Proportionality	Max: Math formula may miss complex situations, but phys/chem spec is overkill or simple situations.
Reproducibility	Max: Math formula most definite, phys/chem spec least definite
Appropriateness	Not relevant
Flexibility	Max: No flexibility with math formula, most with phys/chem spec.
Transparency	Max: Same as Specfication
Specification	Max Math formula says exactly what to do, phys/chem spec. may be ambiguous/too general.
Uncertainty	Max: Math formula, computer program, generally not incorporate uncertainty: Phys/chem spec allows for it.

1.10 How are exposures to sensitive populations, groups or life-stages addressed?

Average of lower levels will select either Human health or Ecologic

Accuracy	Average
Protectiveness	Average
Proportionality	Average
Reproducibility	Average
Appropriateness	Average
Flexibility	Average
Transparency	Average
Specification	Average
Uncertainty	Average

1.10.1 Human health

Accuracy	Average
Protectiveness	Average
Proportionality	Average
Reproducibility	Average
Appropriateness	Average
Flexibility	Average
Transparency	Average
Specification	Average
Uncertainty	Average

1.10.1.1 Specification of sensitive populations, groups or life-stages

Accuracy	Max: more options make for more accuracy
Protectiveness	Max: more options make for higher protectiveness
Proportionality	Not relevant
Reproducibility	Max: pre-specified is definite
Appropriateness	Not relevant
Flexibility	Max: more options makes for flexibility
Transparency	Max: pre-defined is more transparent, unspecified least

Specification	Max: pre-defined is more specific
Uncertainty	Not relevant

1.10.1.2 Evaluation of exposures to sensitive populations, groups or life-stages

Accuracy	Max: Actual situation versus default
Protectiveness	Max: Actual situation versus default, and completeness
Proportionality	Not relevant
Reproducibility	Max : Specific situation versus pre-defined scenarios.
Appropriateness	Max: Specific situation versus pre-defined scenarios
Flexibility	Max: Specific situation versus pre-defined scenarios
Transparency	Max: Specific situation versus pre-defined scenarios
Specification	Max: Specific situation versus pre-defined scenarios
Uncertainty	Not relevant

1.10.2 Ecological

Accuracy	Average
Protectiveness	Average
Proportionality	Average
Reproducibility	Average
Appropriateness	Average
Flexibility	Average
Transparency	Average
Specification	Average
Uncertainty	Average

1.10.2.1 **Specification of sensitive populations, groups or life-stages**

As for 1.10.1.1

1.10.2.2 Evaluation of exposures to sensitive populations, groups or life-stages

As for 1.10.1.2

1.11 How are exposure estimates quantified?

Average will pick out Human or Ecologic as required

Accuracy	Average
Protectiveness	Average
Proportionality	Average
Reproducibility	Average
Appropriateness	Average
Flexibility	Average
Transparency	Average
Specification	Average
Uncertainty	Average

1.11.1 Human

Accuracy	Average
Protectiveness	Average
Proportionality	Average
Reproducibility	Average
Appropriateness	Average
Flexibility	Average
Transparency	Average

Specification	Average
Uncertainty	Average

1.11.1.1 Special cases

Accuracy	Sum: each option improves accuracy
Protectiveness	Sum: each option improves accuracy
Proportionality	Sum: each option improves proportionality
Reproducibility	Not relevant
Appropriateness	Sum: each option improves appropriateness
Flexibility	Not relevant
Transparency	Not relevant
Specification	Not relevant
Uncertainty	Not relevant

1.11.1.2 Absorption

[Note: it is a matter of convenience as to whether exposure estimates or toxicity factors incorporate absorption. The response to this question cannot distinguish the two. Indeed, in no case was "Is not incorporated in exposure estimate" selected.]

Accuracy	Not relevant
Protectiveness	Not relevant
Proportionality	Not relevant
Reproducibility	Not relevant
Appropriateness	Not relevant
Flexibility	Not relevant
Transparency	Not relevant
Specification	Not relevant
Uncertainty	Not relevant

1.11.1.3 Averaging times:

Accuracy	Average: flexibility to choose is important
Protectiveness	Average: flexibility to choose is important
Proportionality	Not relevant
Reproducibility	Average: pre-defined or site/chemical-specific
Appropriateness	Average: Default situation versus actual
Flexibility	Average: Default situation versus actual
Transparency	Average: Default situation versus actual
Specification	Average: Pre-specified versus to-be-determined
Uncertainty	Not relevant

1.11.1.4 Use of qualitative statements is:

Accuracy	Max: any qualitative statements degrade accuracy
Protectiveness	Max: as for accuracy, but dismissing small exposures will maintain protectiveness
Proportionality	Max: Dismissing negligible exposures should be ok
Reproducibility	Max: Greatest agreement with no qualitative statements
Appropriateness	Not relevant
Flexibility	Max: use adds to flexibility
Transparency	Not relevant
Specification	Max: prohibition makes for defined specification
Uncertainty	Not relevant

1.11.2 Ecological

Accuracy	Sum
Protectiveness	Sum
Proportionality	Not relevant
Reproducibility	Not relevant
Appropriateness	Not relevant
Flexibility	Not relevant
Transparency	Not relevant
Specification	Not relevant
Uncertainty	Not relevant

1.11.2.4 Use of qualitative statements is:

As for 1.11.1.4. Weight assigned to this question is (1 – sum of weights of other entries in 1.11.2).

1.12 Are central tendency or maximum exposure estimates used?

Accuracy	Not relevant
Protectiveness	Max: Distributional estimate can be as protective as desired. Others in order.
Proportionality	Not relevant
Reproducibility	Not relevant
Appropriateness	Max: Central too low, Max too high, Usually around 98%, but distributional trumps all.
Flexibility	Max: Distributional best, point estimates inflexible.
Transparency	Not relevant
Specification	Not relevant
Uncertainty	Max: Distributional is appropriate; particular metrics may be acceptable, but central and maximum point estimates do not allow uncertainty evaluation.

1.13 How are aggregate exposures across multiple pathways for a single substance addressed?

Accuracy	Average
Protectiveness	Average
Proportionality	Average
Reproducibility	Average
Appropriateness	Average
Flexibility	Average
Transparency	Average
Specification	Average
Uncertainty	Average

1.13.1 How many pathways are evaluated?

Accuracy	Max: Approaches including all major pathways are best
Protectiveness	Max: The same, with slight quantitative differences
Proportionality	Max: Combination of Accuracy with effort involved
Reproducibility	Not relevant: No good scoring of this question.
Appropriateness	Not relevant:
Flexibility	Max: Risk assessor choice trumps all
Transparency	Not relevant
Specification	Max: Pre-defined trumps all
Uncertainty	Not relevant

[1.13.1.1.1 included as 1.13.1.1]

1.13.2 How are multiple routes of exposure (i.e. ingestion, inhalation, dermal) combined?

[Note: the questions erroneously used "pathway" rather than "route", so may have been misinterpreted.]

Accuracy	Max: Exposure should not be summed: potentially different effect/sensitivity by different routes.
Protectiveness	Max: Similar to accuracy
Proportionality	Not relevant
Reproducibility	Not relevant
Appropriateness	Not relevant
Flexibility	Max: Hard and fast rules are inflexible.
Transparency	Max: It is not clear how one would sum exposures by different routes (e.g. what metric to use?)
Specification	Max:
Uncertainty	Not relevant

1.13.3 How are exposure estimates (leading to same route of exposure) from multiple pathways combined?

Accuracy	Max: Pathway is irrelevant, so summation appropriate
Protectiveness	Max: same as accuracy
Proportionality	Not relevant
Reproducibility	Not relevant
Appropriateness	Not relevant
Flexibility	Max: rules imply little flexibility
Transparency	Max: application is mostly obvious
Specification	Max:
Uncertainty	Not relevant

1.14 How are cumulative exposures to multiple substances through a common pathway addressed? (Note: this is for exposures, so the only such combinations are for chemicals that are treated together as a single substance like dioxins/PCBs/PAH, or that act through common mechanisms like radioisotopes)

Accuracy	Max: Specified schemes likely better than alternative approaches.
Protectiveness	Max: as for accuracy
Proportionality	Not relevant
Reproducibility	Not relevant
Appropriateness	Not relevant
Flexibility	Max: To pick the most flexible of specified options. Other assumed most flexible.
Transparency	Not relevant
Specification	Not relevant
Uncertainty	Not relevant

1.14.1 TEF or similar schemes are used to combine exposures only for

Accuracy	Sum: Defined schemes are best science; others are better than none. Interpret "Other" as being a scheme for other set(s) of compounds (e.g. EPH/VPH).
Protectiveness	Sum: as for accuracy
Proportionality	Not relevant
Reproducibility	Not relevant

Appropriateness	Not relevant
Flexibility	Max: all set equal at lowest value, because none are flexible.
Transparency	Not relevant
Specification	Not relevant
Uncertainty	Not relevant

1.15 How are cumulative and aggregate exposure exposures to multiple substances through multiple pathways addressed?

Accuracy	Max:
Protectiveness	Max:
Proportionality	Not relevant
Reproducibility	Not relevant
Appropriateness	Not relevant
Flexibility	Max:
Transparency	Not relevant
Specification	Not relevant
Uncertainty	Not relevant

1.16 How are uncertainty and variability addressed in current exposure assessments?

Accuracy	Not relevant
Protectiveness	Not relevant
Proportionality	Not relevant
Reproducibility	Not relevant
Appropriateness	Not relevant
Flexibility	Not relevant
Transparency	Not relevant
Specification	Not relevant
Uncertainty	Max: ranked by approach to full distributional treatment

2 Assess how toxic effects are currently determined:

Accuracy	Average
Protectiveness	Average
Proportionality	Average
Reproducibility	Average
Appropriateness	Average
Flexibility	Average
Transparency	Average
Specification	Average
Uncertainty	Average

2.1 What sources of toxicological information are considered (for human health)?

Accuracy	Max:
Protectiveness	Not relevant
Proportionality	Not relevant
Reproducibility	Not relevant
Appropriateness	Not relevant
Flexibility	Max: Lists are least flexible; evaluation of other sources most
Transparency	Max: But precisely how to evaluate them is not specifiable.
Specification	Max: Evaluation of other sources is most flexible option
Uncertainty	Not relevant

2.1.1 Ordered list of sources (place in order, add to list as needed)

Accuracy	Max: rough order of amount of peer review
Protectiveness	Not relevant
Proportionality	Not relevant
Reproducibility	Not relevant
Appropriateness	Not relevant
Flexibility	Max: Any selection here is considered equally in evaluating response next higher in the tree
Transparency	Max: Any selection here is considered equally in evaluating response next higher in the tree
Specification	Max: Any selection here is considered equally in evaluating response next higher in the tree
Uncertainty	Not relevant

2.2 How are (human) toxic effects assessed for carcinogenic substances?

Accuracy	Max: Comparison to standards is of unknown accuracy
Protectiveness	Max: Comparison to standards is of variable protectiveness, depending on exposure circumstances
Proportionality	Not relevant
Reproducibility	Max: Standards require pre-specification of scenarios, so will not match desired outputs for some assessments
Appropriateness	Max: Cancer probability is the generally agreed requirement
Flexibility	Not relevant
Transparency	Not relevant
Specification	Not relevant
Uncertainty	Not relevant

2.3 How are (human) toxic effects assessed for non-carcinogenic substances?

Accuracy	Sum: All are needed for completeness, hence accuracy
Protectiveness	Sum: All are needed for protectiveness
Proportionality	Not relevant
Reproducibility	Sum: All required for complete assessment
Appropriateness	Sum: Each one generally accepted as required.
Flexibility	Not relevant
Transparency	Not relevant
Specification	Not relevant
Uncertainty	Not relevant

2.3.2 HQ/HI approach

Accuracy	Sum: As for 2.3.1
Protectiveness	Sum: As for 2.3.1
Proportionality	Not relevant
Reproducibility	Sum: As for 2.3.1
Appropriateness	Sum: As for 2.3.1
Flexibility	Not relevant
Transparency	Not relevant
Specification	Not relevant
Uncertainty	Not relevant

2.4 How are (human) subchronic and genotoxic effects assessed, including mutagenesis and teratogenesis?

Accuracy	Average
Protectiveness	Average
Proportionality	Average
Reproducibility	Average
Appropriateness	Average
Flexibility	Average
Transparency	Average
Specification	Average
Uncertainty	Average

2.4.1 Subchronic
2.4.2 Mutagenicity
2.4.3 Genotoxic (other than mutagenicity)
2.4.4 Teratogenicity

Accuracy	Max: accuracy demands the most specificity
Protectiveness	Max: same as accuracy
Proportionality	Not relevant
Reproducibility	Max: somewhat inverse to flexibility
Appropriateness	Max: similar to accuracy/protectiveness
Flexibility	Max: allowing modification gives maximum flexibility
Transparency	Not relevant
Specification	Max: exclusion is clear, other options less so
Uncertainty	Not relevant

2.5 How is acute and chronic toxicity evaluated for ecological receptors?

Accuracy	Average
Protectiveness	Average
Proportionality	Average
Reproducibility	Average
Appropriateness	Average
Flexibility	Average
Transparency	Average
Specification	Average
Uncertainty	Average

2.5.1 Acute
2.5.2 Chronic
2.5.3 Community structure comparisons

Accuracy	Max: dependent on specific circumstances, so the closer to using site-specific methods the better
Protectiveness	Max: similar to accuracy
Proportionality	Max: similar to protectiveness
Reproducibility	Not relevant
Appropriateness	Max: same as protectiveness
Flexibility	Max: require modifications for site-specificity
Transparency	Max:
Specification	Max:
Uncertainty	Not relevant

2.6 How are appropriate toxicity values selected?

[Note: the few entries that do not refer back to 2.1 either do not specify, or refer back indirectly. E.g. Rhode Island, method 3, both 2.1 and 2.6 refer to EPA's Superfund Risk Assessment Guidance]

Accuracy	Not relevant
Protectiveness	Not relevant
Proportionality	Not relevant
Reproducibility	Not relevant
Appropriateness	Not relevant
Flexibility	Not relevant
Transparency	Not relevant
Specification	Not relevant
Uncertainty	Not relevant

2.7 How are toxicity estimates made for substances for which no toxicity values are available?

Accuracy	Max: Surrogate value top, omitted bottom
Protectiveness	Max: Qualitative discussion or any surrogate can enhance protectiveness
Proportionality	Not relevant
Reproducibility	Not relevant
Appropriateness	Not relevant
Flexibility	Max:
Transparency	Max:
Specification	Max:
Uncertainty	Not relevant

2.7.2 Surrogate value may/must be used

Accuracy	Max: Including surrogates should improve accuracy
Protectiveness	Max: Any surrogate will improve protectiveness over omission, but a qualitative discussion can also be protective.
Proportionality	Not relevant
Reproducibility	Not relevant
Appropriateness	Not relevant
Flexibility	Max:
Transparency	Max:
Specification	Max:
Uncertainty	Not relevant

2.8 How are vulnerable populations such as children addressed in toxicity assessments?

Accuracy	Max:
Protectiveness	Max:
Proportionality	Not relevant
Reproducibility	Max:
Appropriateness	Not relevant
Flexibility	Max:
Transparency	Max:
Specification	Max:
Uncertainty	Not relevant

2.8.1 Vulnerable populations must be evaluated

2.9 How are uncertainty and variability addressed in current toxicity assessments?

Accuracy	Max:
Protectiveness	Max:
Proportionality	Not relevant
Reproducibility	Max:
Appropriateness	Not relevant
Flexibility	Max:
Transparency	Max:
Specification	Max:
Uncertainty	Not relevant

3 Characterize how risks are currently estimated:

Accuracy	Average
Protectiveness	Average
Proportionality	Average
Reproducibility	Average
Appropriateness	Average
Flexibility	Average
Transparency	Average
Specification	Average
Uncertainty	Average

3.1 How are risks for individual substances quantified?

[Average will select either Human or Ecological as required]

Accuracy	Average
Protectiveness	Average
Proportionality	Average
Reproducibility	Average
Appropriateness	Average
Flexibility	Average
Transparency	Average
Specification	Average
Uncertainty	Average

3.1.1 Human

Accuracy	Average
Protectiveness	Average
Proportionality	Average
Reproducibility	Average
Appropriateness	Average
Flexibility	Average
Transparency	Average
Specification	Average
Uncertainty	Average

3.1.1.1 Special cases

Accuracy	Max:

Protectiveness	Max:
Proportionality	Not relevant
Reproducibility	Max:
Appropriateness	Not relevant
Flexibility	Not relevant
Transparency	Not relevant
Specification	Max:
Uncertainty	Not relevant

3.1.1.2 Combination of routes (ingestion, inhalation, dermal)

[Note: the large number of "Other" entries indicates that this was question was poorly posed, and the answers here are not likely to adequately distinguish methods.]

Accuracy	Not relevant
Protectiveness	Not relevant
Proportionality	Not relevant
Reproducibility	Not relevant
Appropriateness	Not relevant
Flexibility	Not relevant
Transparency	Not relevant
Specification	Not relevant
Uncertainty	Not relevant

3.1.1.3 Non-cancer toxicity

Accuracy	Not relevant
Protectiveness	Max:
Proportionality	Not relevant
Reproducibility	Not relevant
Appropriateness	Max:
Flexibility	Not relevant
Transparency	Not relevant
Specification	Not relevant
Uncertainty	Not relevant

3.1.1.3.1 Hazard Quotients used

Accuracy	Not relevant
Protectiveness	Sum: all needed for adequate protectiveness
Proportionality	Not relevant
Reproducibility	Not relevant
Appropriateness	Sum: all needed for appropriate site risk characterization
Flexibility	Not relevant
Transparency	Not relevant
Specification	Not relevant
Uncertainty	Not relevant

3.1.1.4 Cancer

Accuracy	Not relevant
Protectiveness	Max:
Proportionality	Not relevant
Reproducibility	Not relevant
Appropriateness	Max
Flexibility	Not relevant

Transparency	Not relevant
Specification	Not relevant
Uncertainty	Not relevant

3.1.1.4.1 Lifetime risk estimate used

[Continued from 3.1.1.4]

3.1.2 Ecological

[Note: the lack of references in 14/21 "Other" responses indicate "not specified" in those cases]

Accuracy	Max: Non-HQ (RC) measures likely most accurate
Protectiveness	Max: as for accuracy
Proportionality	Not relevant
Reproducibility	Not relevant
Appropriateness	Max: as for accuracy
Flexibility	Not relevant
Transparency	Not relevant
Specification	Not relevant
Uncertainty	Not relevant

3.1.2.1 Hazard Quotients used

Accuracy	Sum: all would be required, although none are particularly good
Protectiveness	Sum: as for accuracy
Proportionality	Not relevant
Reproducibility	Not relevant
Appropriateness	Sum: as for accuracy
Flexibility	Not relevant
Transparency	Not relevant
Specification	Not relevant
Uncertainty	Not relevant

3.2 How are risks from multiple substances quantified?

[Note: Average will select human or ecological as needed]

Accuracy	Average
Protectiveness	Average
Proportionality	Average
Reproducibility	Average
Appropriateness	Average
Flexibility	Average
Transparency	Average
Specification	Average
Uncertainty	Average

3.2.1 Human

Accuracy	Average
Protectiveness	Average
Proportionality	Average
Reproducibility	Average
Appropriateness	Average
Flexibility	Average
Transparency	Average

Specification	Average
Uncertainty	Average

3.2.1.1 Non-cancer toxicities quantified

[Note: lower levels continued into sum

Accuracy	Sum: All the entries are appropriate, so sum them with equal weights
Protectiveness	Sum: same as accuracy
Proportionality	Not relevant
Reproducibility	Not relevant
Appropriateness	Sum: same as accuracy
Flexibility	Not relevant
Transparency	Not relevant
Specification	Not relevant
Uncertainty	Not relevant

3.2.1.2 Cancer risk quantified

Accuracy	Max: risk estimates should be added
Protectiveness	Max: as for accuracy
Proportionality	Not relevant
Reproducibility	Not relevant
Appropriateness	Max: as for accuracy
Flexibility	Not relevant
Transparency	Not relevant
Specification	Not relevant
Uncertainty	Not relevant

3.2.2 Ecological

Accuracy	Sum: all approaches desirable
Protectiveness	Sum:
Proportionality	Not relevant
Reproducibility	Not relevant
Appropriateness	Sum:
Flexibility	Not relevant
Transparency	Not relevant
Specification	Not relevant
Uncertainty	Not relevant

3.3 How are risks evaluated using point estimates or probabilistic assessments?

Accuracy	Not relevant
Protectiveness	Not relevant
Proportionality	Not relevant
Reproducibility	Not relevant
Appropriateness	Not relevant
Flexibility	Not relevant
Transparency	Not relevant
Specification	Not relevant
Uncertainty	Average

3.3.1 Point estimates
3.3.2 Probabilistic estimates
3.3.3 Qualitative statements allowable

Accuracy	Not relevant
Protectiveness	Not relevant
Proportionality	Not relevant
Reproducibility	Not relevant
Appropriateness	Not relevant
Flexibility	Not relevant
Transparency	Not relevant
Specification	Not relevant
Uncertainty	Max:

3.3.4 Standards of comparisons
[Average will select human or ecologic]

Accuracy	Average
Protectiveness	Average
Proportionality	Average
Reproducibility	Average
Appropriateness	Average
Flexibility	Average
Transparency	Average
Specification	Average
Uncertainty	Average

3.3.4.1 Human health

Accuracy	Average
Protectiveness	Average
Proportionality	Average
Reproducibility	Average
Appropriateness	Average
Flexibility	Average
Transparency	Average
Specification	Average
Uncertainty	Average

3.3.4.1.1 HI less than specified value (give values where appropriate)
3.3.4.1.2 Lifetime risk less than specified value (give values where appropriate)

Accuracy	Not relevant
Protectiveness	Sum: all measures required
Proportionality	Not relevant
Reproducibility	Not relevant
Appropriateness	Sum: all measures required
Flexibility	Not relevant
Transparency	Not relevant
Specification	Not relevant
Uncertainty	Not relevant

3.3.4.2 Ecological

Accuracy	Max: HQ/RC approach considered minimalist. Community comparison best available.
Protectiveness	Max: as for accuracy.
Proportionality	Not relevant
Reproducibility	Not relevant
Appropriateness	Max: as for accuracy
Flexibility	Not relevant
Transparency	Not relevant
Specification	Not relevant
Uncertainty	Not relevant

3.4 How are risks combined across multiple exposure pathways?

Accuracy	Not relevant
Protectiveness	Max:
Proportionality	Not relevant
Reproducibility	Not relevant
Appropriateness	Max:
Flexibility	Not relevant
Transparency	Not relevant
Specification	Not relevant
Uncertainty	Not relevant

3.4.1

3.4.2 Combined

Accuracy	Average
Protectiveness	Average
Proportionality	Average
Reproducibility	Average
Appropriateness	Average
Flexibility	Average
Transparency	Average
Specification	Average
Uncertainty	Average

3.4.2.1 Special cases

Accuracy	Not relevant
Protectiveness	Sum :
Proportionality	Not relevant
Reproducibility	Not relevant
Appropriateness	Sum:
Flexibility	Not relevant
Transparency	Not relevant
Specification	Not relevant
Uncertainty	Not relevant

3.4.2.2 Hazard Quotients or Hazard Indexes
3.4.2.3 Risk estimates
3.4.2.4 Other measures (specify)

Accuracy	Not relevant
Protectiveness	Max:
Proportionality	Not relevant
Reproducibility	Not relevant
Appropriateness	Max:
Flexibility	Not relevant
Transparency	Not relevant
Specification	Not relevant
Uncertainty	Not relevant

3.5 What is the role of a Weight of Evidence (WoE) approach in estimating risks?

Accuracy	Average
Protectiveness	Average
Proportionality	Average
Reproducibility	Average
Appropriateness	Average
Flexibility	Average
Transparency	Average
Specification	Average
Uncertainty	Average

3.5.1 Non-cancer toxicities

Accuracy	Max:
Protectiveness	Max:
Proportionality	Max:
Reproducibility	Max:
Appropriateness	Max:
Flexibility	Max:
Transparency	Max:
Specification	Max:
Uncertainty	Max:

3.5.1.1 Hazard Index/Quotient approaches

Accuracy	Max: Mutually exclusive: taking account should increase accuracy
Protectiveness	Max: Inverse of accuracy
Proportionality	Not relevant
Reproducibility	Max:
Appropriateness	Not relevant
Flexibility	Max: Ignoring is least flexible, most allowed variation most flexible
Transparency	Not relevant
Specification	Not relevant
Uncertainty	Max: Ignoring WoE ignores uncertainty; same as accuracy

3.5.1.2 Other approaches

Same as for 3.5.1.1 (but fewer options)

3.5.2 Cancer

3.5.2.1

3.5.2.2 EPA-specified WoE incorporated

Same as for 3.5.1.1

3.6 How are variability and uncertainty addressed in the risk characterization process?

Accuracy	Not relevant
Protectiveness	Not relevant
Proportionality	Not relevant
Reproducibility	Not relevant
Appropriateness	Not relevant
Flexibility	Not relevant
Transparency	Not relevant
Specification	Not relevant
Uncertainty	Max

4 Determine how remedial goals are set

Accuracy	Average levels below
Protectiveness	Average levels below
Proportionality	Average levels below
Reproducibility	Average levels below
Appropriateness	Average levels below
Flexibility	Average levels below
Transparency	Average levels below
Specification	Average levels below
Uncertainty	Average levels below

4.1 How is risk management incorporated into risk-based decision making?

Accuracy	Not relevant
Protectiveness	Not relevant
Proportionality	Max of selected
Reproducibility	Not relevant
Appropriateness	Not relevant
Flexibility	Max of selected
Transparency	Not relevant
Specification	Not relevant
Uncertainty	Not relevant

4.2 Are remedial goals set solely on the basis of risk assessment or are final remedial goals informed by other risk management considerations? Explain

Accuracy	Not relevant
Protectiveness	Not relevant
Proportionality	Max of selected
Reproducibility	Not relevant
Appropriateness	Not relevant
Flexibility	Max of selected
Transparency	Not relevant
Specification	Not relevant
Uncertainty	Not relevant

4.2.1 Are clean-up goals fixed, or does the Agency have discretion to select alternative clean-up goals (e.g. within a range of risks, as for EPA)?

Accuracy	
Protectiveness	
Proportionality	
Reproducibility	
Appropriateness	
Flexibility	Max of selected
Transparency	
Specification	
Uncertainty	

4.2.2 If clean-up goals are not fixed, what other considerations are explicitly included as affecting the decision on final clean-up goals?

Accuracy	
Protectiveness	
Proportionality	
Reproducibility	
Appropriateness	
Flexibility	Sum of selected
Transparency	
Specification	
Uncertainty	

4.2.2.1 Cost
4.2.2.2 Feasibility
4.2.2.3 Background concentrations
4.2.2.4 Ecosystem valuation or preservation
4.2.2.5 Public preferences
4.2.2.6 Neighbor preferences
4.2.2.7 Agency discretion
4.2.2.8 Conformity to other laws
4.2.2.9 Deference to other laws
4.2.2.10 Deference to State & Federal policies
4.2.2.11 Deference to or conformity with legal decisions
4.2.2.12 Deference to other state agencies
4.2.2.13 Deference to state officer requests or orders
4.2.2.14 Scientific uncertainty
4.2.2.15 Other
4.2.2.16 Not specified

4.3 How have specific risk management policies and regulations affected how and which risks were addressed and which were not?

Accuracy
Protectiveness
Proportionality
Reproducibility

Appropriateness	
Flexibility	Max:
Transparency	
Specification	
Uncertainty	

4.3.1 Specific risk management policies are referenced affecting selection of regulated risks (list policies and references)

4.3.2 Specific regulations manage specific risks (list regulations and risks)

4.3.3 None specified

4.4 What administrative and legal tools are available for implementing remedial decisions? (Explicitly listed in the legislation/regulation documentation on site clean-up we collected; do not attempt to locate references to other legislation/regulation)

Accuracy	Not relevant
Protectiveness	Not relevant
Proportionality	Not relevant
Reproducibility	Not relevant
Appropriateness	Not relevant
Flexibility	Not relevant
Transparency	Not relevant
Specification	Not relevant
Uncertainty	Not relevant

5 **(Determine roles and legal responsibilities, as applicable, of state agencies [for Connecticut, this would include DEEP and the Connecticut Department of Public Health (“DPH”)], local agencies and stakeholders such as the public and responsible parties in making risked based decisions.) Apart from the Agency being evaluated here, are other state agencies, local agencies, or other stakeholders (including the public and responsible parties) documented anywhere as having a role in making risk-based decisions?**

Accuracy	Not relevant
Protectiveness	Not relevant
Proportionality	Not relevant
Reproducibility	Not relevant
Appropriateness	Not relevant
Flexibility	Not relevant
Transparency	Not relevant
Specification	Not relevant
Uncertainty	Not relevant

6 **(Determine if adaptive management is considered during the risk-based decision making. Only explicit references to adaptive management or equivalent management practices in the legislation or guidance documents examined during the project will be documented; no attempt will be made to evaluate whether adaptive management is used in practice with the exception of the State of Connecticut where CTDEEP personnel will be interviewed.) Is adaptive management (defined as “A framework and flexible decision-making process for ongoing knowledge acquisition, monitoring, and evaluation leading to continuous improvements in management planning and implementation of a project to achieve specified objectives") or an equivalent mentioned in any documentation?**

Accuracy	Not relevant
Protectiveness	Not relevant
Proportionality	Not relevant
Reproducibility	Not relevant
Appropriateness	Not relevant
Flexibility	Max of selected
Transparency	Not relevant
Specification	Not relevant
Uncertainty	Not relevant

7 **Evaluate how risk-based decisions are communicated to the regulated community, stakeholders and the public, and at what stages of the decision-making process such communication occurs.**

Accuracy	Not relevant
Protectiveness	Not relevant
Proportionality	Not relevant
Reproducibility	Not relevant
Appropriateness	Not relevant
Flexibility	Not relevant
Transparency	Not relevant
Specification	Not relevant
Uncertainty	Not relevant

8 **Determine the legislated or regulated timeliness of responses by agencies. What deadlines are required by law or regulation?**

Accuracy	Not relevant
Protectiveness	Not relevant
Proportionality	Not relevant
Reproducibility	Not relevant
Appropriateness	Not relevant
Flexibility	Not relevant
Transparency	Not relevant
Specification	Not relevant
Uncertainty	Not relevant

9 **What mechanisms are available for updating procedures and values? Are there mechanisms built into legislation or regulation that require updates, revisions, and corrections to toxicity values and other risk-related parameters, and what is the timeline for such modifications?**

Accuracy	Not relevant
Protectiveness	Not relevant
Proportionality	Not relevant
Reproducibility	Not relevant
Appropriateness	Not relevant
Flexibility	Not relevant
Transparency	Not relevant
Specification	Not relevant
Uncertainty	Not relevant

10 **How flexible are the approaches allowed for site evaluation and remedial options? Is there a single track or multiple options for site evaluations, and are there alternative options for remediation (e.g. depending on site use)?**

[Note: little discrimination since no legislation/regulation forbids consideration of other factors such as site use in remedial decisions.]

Accuracy	Not relevant
Protectiveness	Not relevant
Proportionality	Not relevant
Reproducibility	Not relevant
Appropriateness	Not relevant
Flexibility	Max:
Transparency	Not relevant
Specification	Not relevant
Uncertainty	Not relevant

G.5 Access to the questionnaire results

To tabulate all selected responses, the references justifying the responses, the weights assigned to each response, and the methodology for combining weights, for any question evaluated in this Report, proceed as follows. First, in the Excel workbook “CTDEEP Project Database & Results.xlsm,” open the sheet entitled Comp_Table. Next, in the cell with green-colored background color (this is cell B5) enter the question number for which a table of selected responses is desired. The number should be entered as text (the format of cell B5 is set to text, so that the number may be typed as it appears). All selected responses with left part matching that number will then be displayed in the sheet at columns BD to BS, in the format of the example Table G-2 (this calculation is automatic if Excel has “Calculation” set to “Automatic”). If cell BE (named Prettify) is set to FALSE, the three columns on the left of the table will fill in with repeats of the entries immediately above (this allows the table to be copied by value to another sheet or workbook, and sorted by any column; by default the table is sorted by question, state, and Method).

Thus, for example, entering 1.1 will produce all selected responses 1.1.1, 1.1.2, 1.1.3, through 1.1.8, as shown in Table G-2. If there are further levels of response, they will also be shown. In particular, 1.4 in cell B5 will produce all selected responses numbered 1.4.1, 1.4.2, …, 1.4.23, 1.4.24.1, 1.4.24.2, …, 1.4.24.5, 1.4.25, …, 1.4.28. The number can be at any level of question or response, so entering 1.4.24 in cell B5 will produce just the selected responses to 1.4.24.1, 1.4.24.2, …, 1.4.24.5; and 6 will produce 6.1, 6.2, ..., 6.5. See Appendix F for the complete list of possible numbers — and note that nonexistent numbers, if entered, will produce errors. The length of the table is set by the number of selected responses matching the number; a maximum of 3,200 entries is possible (but never achieved). Unused rows of the table are filled with #REF error. The column to the right of the table (that is, column BT) contains any comments present in the database (these are not shown in the example Table G-2).

Table G-2 All selected responses to Question 1.1

Question							Weights								
1.1 How is the characterization of the exposure setting defined?															
Response		State	Method	Legal standard	Document	Page/ Section	Accuracy	Protectiveness	Proportionality	Reproducibility	Appropriateness	Flexibility	Transparency	Specification	Uncertainty
							M	M	M	M	I	M	I	M	I
1.1.1	**Definition implicit in the method**	Massachusetts	Method 1	Regulation	Massachusetts Contingency Plan - 2014 Revision (310 CMR 40)	40.0972	0.1	0.1	0.1	1	0	0.1	0	1	0
			Method 2	Regulation	Massachusetts Contingency Plan - 2014 Revision (310 CMR 40)	40.0972 and 40.0982									
		Michigan	Generic Criteria	Regulation	Cleanup Criteria Requirements for Response Activity	299.14(4) & 299.26(7)									
			Generic Criteria	Legislation	Natural Resources and Environmental Protection Act (Excerpt) Act 451 of 1994	324.20120a									
1.1.2	**Specific list of exposure settings**	Canada	1 PQRA HHRA	Guidance	Federal Contaminated Site Risk Assessment in Canada, Part I: Guidance on Human Health Preliminary Quantitative Risk Assessment (PQRA), Version 2.0	SECTION 2.4.4 PROBLEM FORMULATION CHECKLIST TABLE 2	0.4	0.2	0.4	0.8	0	0.1	0	1	0
		Connecticut	Default	Regulation	Remediation Standard Regluations	22a-133k-2(b), (c), (g),									

						(h) & 22a.133k-3(a), (b), (c)									
			EC / ELUR	Regulation	Remediation Standard Regluations	22a-133k-2(c)(4)(A); & 22a-133k-2(f)(2)									
			Var / except / alt	Regulation	Remediation Standard Regluations	22a-133k-2(b)(4); 22a-133k-2(c)(2)(E); 22a-133k-2(e)(4)(B); 22a-133k-2(c)(4)(C); 22a-133k-2(c)(5)									
			Var / except / alt	Regulation	Remediation Standard Regluations	22a-133k-2(d)(1-7); 22a-133k-2(f)									
			Var / except / alt	Regulation	Remediation Standard Regluations	22a-133k-3(b)(3); 22a-133k-3(c)(4-5); 22a-133k-3(f)									
		Illinois	Tier 1	Legislation	Environmental Safety 415 ILCS5 Environmental Protection Act	Title 17, Section 58.5 Risk-based Remediation Objecxtives									

			Tier 1	Regulation	Part 742 Tiered Approach to Corrective Action Objectives	Subpart C: Exposure Route Evaluations									
			Tier 1	Guidance	Tiered Approach to Corrective Action Objectives (TACO)	Fact Sheet 6: Tier 1									
			Tier 2	Legislation	Environmental Safety 415 ILCS5 Environmental Protection Act	Title 17, Section 58.5 Risk-based Remediation Objecxtives									
			Tier 2	Regulation	Part 742 Tiered Approach to Corrective Action Objectives	Subpart C: Exposure Route Evaluations									
			Tier 2	Guidance	Tiered Approach to Corrective Action Objectives (TACO)	Fact Sheet 6: Tier 1									
			Tier 3	Legislation	Environmental Safety 415 ILCS5 Environmental Protection Act	Title 17, Section 58.5 Risk-based Remediation Objecxtives									
			Tier 3	Regulation	Part 742 Tiered Approach to Corrective Action Objectives	Subpart C: Exposure Route Evaluations									
			Tier 3	Guidance	Tiered Approach to Corrective Action Objectives (TACO)	Fact Sheet 8: Pathway Exclusion									

			Tier 3	Guidance	Tiered Approach to Corrective Action Objectives (TACO)	Fact Sheet 9: Background Determinatio n									
			Tier 3	Guidance	Tiered Approach to Corrective Action Objectives (TACO)	Fact Sheet 10: Compliance with Remediation Objectives									
			Tier 3	Guidance	Tiered Approach to Corrective Action Objectives (TACO)	Fact Sheet 11: Metals									
		Massachuse tts	Method 3	Regulation	Massachusetts Contingency Plan - 2014 Revision (310 CMR 40)	40.0923(6)									
			Method 3	Guidance	Guidance for Disposal Site Risk Characterization (WSC/ORS-95-141)	7.3.4 Exposure Equations									
		Michigan	Generic Criteria	Regulation	Cleanup Criteria Requirements for Response Activity	299.14(4) & 299.26(7)									
			Generic Criteria	Legislation	Natural Resources and Environmental Protection Act (Excerpt) Act 451 of 1994	324.20120a									
		Vermont	State Provided Value	Guidance	Investigation and Remediation of Contaminated Properties Procedure	Section 4									
1.1.3	**Conceptual site model or equivalent (with specific guidance)**	California	Prelim Endang Assess	Guidance	Preliminary Endangerment Assessment Guidance Manual	2.1.2	0.6	0.5	0.6	0.6	0	0.5	0	0.7	0

		Canada	3 ERA SL/PQRA/ DQRA	Guidance	FCSAP Ecological Risk Assessment Guidance	Section 2.2.7 Conceptual Site Model									
		EPA	2 HHRA	Guidance	Catalog of EPA Guidance and Tools for Risk Assessment	RAGS Part A HHRA, Section 6-3, page 6-8									
		Illinois	Tier 2	Guidance	Tiered Approach to Corrective Action Objectives (TACO)	Fact Sheet 7: Tier 2									
			Tier 3	Legislation	Environmental Safety 415 ILCS5 Environmental Protection Act	Title 17, Section 58.5 Risk-based Remediation Objecxtives									
			Tier 3	Regulation	Part 742 Tiered Approach to Corrective Action Objectives	Subpart C: Exposure Route Evaluations									
			Tier 3	Guidance	Tiered Approach to Corrective Action Objectives (TACO)	Fact Sheet 8: Pathway Exclusion									
			Tier 3	Guidance	Tiered Approach to Corrective Action Objectives (TACO)	Fact Sheet 9: Background Determinatio n									
			Tier 3	Guidance	Tiered Approach to Corrective Action Objectives (TACO)	Fact Sheet 10: Compliance with Remediation									

						Objectives										
			Tier 3	Guidance	Tiered Approach to Corrective Action Objectives (TACO)	Fact Sheet 11: Metals										
		Maine	1	Guidance	Maine Remedial Action Guidelines (RAGs) for Sites Contaminated with Hazardous Waste Substances	11-13										
			1	Guidance	GUIDANCE FOR HUMAN HEALTH RISK ASSESSMENTS FOR HAZARDOUS SUBSTANCE SITES IN MAINE	4 and 10										
			1	Guidance	Standard Guide for Developing Conceptual Site Models for Contaminated Sites	entire document										
		Massachusetts	Method 3	Regulation	Massachusetts Contingency Plan - 2014 Revision (310 CMR 40)	40.0993 and 40.0923										
			Method 3	Guidance	Guidance for Disposal Site Risk Characterization (WSC/ORS-95-141)	7.3.4 Exposure Equations										
		Montana	1	Guidance	Montana Tier 1 Risk-Based Corrective Action Guidance for Petroleum Releases	2										
			2	Guidance	Vapor Intrusion Guidance Document	6										
		New Hampshire	1	Regulation	New Hampshire Code of Administrative Rules Chapter ENV-OR 600 Contaminated Site Management	606.07										
			2	Regulation	New Hampshire Code of Administrative Rules Chapter ENV-OR 600 Contaminated Site Management	606.07										

			3	Regulation	New Hampshire Code of Administrative Rules Chapter ENV-OR 600 Contaminated Site Management	606.07									
		Vermont	State Provided Value	Guidance	Investigation and Remediation of Contaminated Properties Procedure	Section 2.3									
1.1.4	**Conceptual site model or equivalent (without specific guidance)**	Canada	1 PQRA HHRA	Guidance	Federal Contaminated Site Risk Assessment in Canada, Part I: Guidance on Human Health Preliminary Quantitative Risk Assessment (PQRA), Version 2.0	SECTION 2.4 PROBLEM FORMULATIO N PAGE 7	0.8	1	0.8	0.4	0	0.7	0	0.4	0
			1 PQRA HHRA	Guidance	Federal Contaminated Site Risk Assessment in Canada, Part I: Guidance on Human Health Preliminary Quantitative Risk Assessment (PQRA), Version 2.0	Section 2.4.4 PROBLEM FORMULATIO N CHECKLIST TABLE 2									
			2 DQRA HHRA	Guidance	Part V - Guidance On Human Health Detailed Quantitative Risk Assessment for Chemicals	Section 3.7									
			3 ERA SL/PQRA/ DQRA	Guidance	FCSAP Ecological Risk Assessment Guidance	Section 1.1 page A-2									
		DOE	1	Guidance	Guide for Developing Conceptual Models for Ecological Risk Assessment	1-13									
			1	Guidance	Guide for Developing Data Quality Objectives for Ecological Risk Assessments at DOE-ORO Facilities	5, 7-10									
			1	Regulation	National Contingency Plan Section	300.430									

			1	Guidance	Soil Screening Guidance for Radionuclides: User's Guide	2-1 to 2-3, A-1 to A-6									
			1	Guidance	Guidance for Conducting Risk Assessments and Related Risk Activities for the DOE-ORO Environmental Management Program	13, 23, E-9									
			1	Guidance	Approach and Strategy for Performing Ecological Risk Assessments for the U.S. Department of Energy's Oak Ridge Reservation: 1995 Revision	3-1 to 3-23									
		EPA	1 ERA	Guidance	Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments - Interim Final	3-13									
		Montana	2	Guidance	Frequently Asked State Superfund Questions	11									
		New Jersey	ERA	Guidance	Ecological Evaluation Technical Guidance	34									
		New York	QHHEA/FWRIA	Guidance	DER-10 / Technical Guidance for Site Investigation and Remediation	Section 3.2.2 Remedial Investigation page 61									
			QHHEA/FWRIA	Guidance	DER-10 / Technical Guidance for Site Investigation and Remediation	page 123									
			QHHEA/FWRIA	Guidance	DER-10 / Technical Guidance for Site Investigation and Remediation	Section 3.2.2 Remedial Investigation page 61									
		Rhode Island	Method 1 & 2	Regulation	Rules and Regulations for the Investigation and Remediation of Hazardous Materials	section 7.00									

					Releases, last amended November 2011										
			Method 3	Regulation	Rules and Regulations for the Investigation and Remediation of Hazardous Materials Releases, last amended November 2011	section 7.00									
		Texas	eco 2	Guidance	Guidance for Conducting Ecological Risk Assessments at Remediation Sites in Texas	33, 102									
			eco 2	Regulation	Texas Risk Reduction Program (TRRP) 30 TAC Chapter 350 Subchapter D DEVELOPMENT OF PROTECTIVE CONCENTRATION LEVELS	350.77									
			eco 3	Guidance	Guidance for Conducting Ecological Risk Assessments at Remediation Sites in Texas	33, 102									
			eco 3	Regulation	Texas Risk Reduction Program (TRRP) 30 TAC Chapter 350 Subchapter D DEVELOPMENT OF PROTECTIVE CONCENTRATION LEVELS	350.77									
			human 1	Regulation	Texas Risk Reduction Program (TRRP) 30 TAC Chapter 350 Subchapter C AFFECTED PROPERTY ASSESSMENT	350.51									
			human 2	Regulation	Texas Risk Reduction Program (TRRP) 30 TAC Chapter 350 Subchapter C AFFECTED PROPERTY ASSESSMENT	350.51									
			human 3	Regulation	Texas Risk Reduction Program (TRRP) 30 TAC Chapter 350 Subchapter C AFFECTED PROPERTY ASSESSMENT	350.51									
1.1.5	**Required, but explicitly left to Risk Assessor's**	Illinois	Tier 3	Legislation	Environmental Safety 415 ILCS5 Environmental Protection Act	Title 17, Section 58.5 Risk-based Remediation	1	1	1	0.1	0	1	0	0.1	0

	expertise					Objecxtives									
			Tier 3	Regulation	Part 742 Tiered Approach to Corrective Action Objectives	Subpart C: Exposure Route Evaluations									
			Tier 3	Guidance	Tiered Approach to Corrective Action Objectives (TACO)	Fact Sheet 8: Pathway Exclusion									
			Tier 3	Regulation	Part 742 Tiered Approach to Corrective Action Objectives	Fact Sheet 9: Background Determinatio n									
			Tier 3	Guidance	Tiered Approach to Corrective Action Objectives (TACO)	Fact Sheet 10: Compliance with Remediation Objectives									
			Tier 3	Guidance	Tiered Approach to Corrective Action Objectives (TACO)	Fact Sheet 11: Metals									
		Michigan	Site Specific RA	Legislation	Natural Resources and Environmental Protection Act (Excerpt) Act 451 of 1994	324.20120a Cleanup criteria (2)									
			Site Specific RA	Legislation	Natural Resources and Environmental Protection Act (Excerpt) Act 451 of 1994	324.20120b Numeric or non-numeric site-specific criteria									

		Vermont	Risk Assessment	Guidance	Investigation and Remediation of Contaminated Properties Procedure	Section 2.4									
1.1.7	**Other**	California	RI/FS Predictive Eco	Guidance	Guidance for Ecological Risk Assessment at Hazardous Waste Sites and Permitted Facilities; Part A: Overview	Section 4 and Appendix A	0.6	0.5	0.6	0.4	0	0.5	0	0.5	0
		Connecticut	EC / ELUR	Regulation	Remediation Standard Regluations	22a-133q-1									
			Var / except / alt	Regulation	Remediation Standard Regluations	22a - 133k-2 & 3									
		Texas	eco 1	Regulation	Texas Risk Reduction Program (TRRP) 30 TAC Chapter 350 Subchapter D DEVELOPMENT OF PROTECTIVE CONCENTRATION LEVELS	350.77									
			eco 1	Guidance	Guidance for Conducting Ecological Risk Assessments at Remediation Sites in Texas	33, 102									
1.1.8	**Not specified**	New Jersey	HHRA				0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1

Appendix H

Detailed results for HHRA, Requirements A to C

The following pages show more detailed summary tables for HHRA. Further similar tables may be automatically generated using the Excel version of the database.

Table H-1 Summary results scoring HHRA methods for requirement A: Exposure Assessment (Question 1 in the database)

State/ Agency	Method	Accuracy	Protectiveness	Proportionality	Reproducibility	Appropriateness	Flexibility	Transparency	Specification	Uncertainty	Average of non-zero entries
California	Prelim Endang Assess	0.54	0.61	0.33	0.43	0.40	0.36	0.68	0.67	0.33	0.48
California	RI/FS Predictive Eco	0.20	0.19	0.18	0.16	0.10	0.19	0.10	0.20	0.10	0.16
Canada	1 PQRA HHRA	0.36	0.41	0.26	0.49	0.26	0.30	0.49	0.61	0.25	0.38
Canada	2 DQRA HHRA	0.52	0.52	0.33	0.42	0.46	0.41	0.38	0.54	0.33	0.43
Connecticut	Default	0.41	0.38	0.22	0.37	0.23	0.30	0.39	0.54	0.23	0.34
Connecticut	EC / ELUR	0.43	0.41	0.25	0.37	0.23	0.40	0.39	0.53	0.23	0.36
Connecticut	Var / except / alt	0.44	0.43	0.25	0.38	0.27	0.34	0.41	0.53	0.23	0.36
DOE	Method 1	0.46	0.53	0.32	0.38	0.49	0.47	0.38	0.50	0.13	0.41
EPA	2 HHRA	0.45	0.49	0.36	0.46	0.54	0.32	0.60	0.30	0.22	0.42
Illinois	Tier 1	0.29	0.26	0.30	0.26	0.10	0.26	0.33	0.57	0.13	0.28
Illinois	Tier 2	0.38	0.36	0.34	0.27	0.10	0.36	0.35	0.55	0.14	0.32
Illinois	Tier 3	0.49	0.48	0.38	0.32	0.10	0.49	0.11	0.45	0.38	0.36
Maine	Method 1	0.49	0.52	0.23	0.30	0.39	0.38	0.29	0.30	0.22	0.35
Massachusetts	Method 1	0.38	0.42	0.10	0.54	0.20	0.20	0.66	0.69	0.22	0.38
Massachusetts	Method 2	0.37	0.43	0.10	0.52	0.20	0.20	0.71	0.70	0.19	0.38
Massachusetts	Method 3	0.56	0.63	0.39	0.54	0.55	0.47	0.47	0.40	0.73	0.53
Michigan	Generic Criteria	0.32	0.31	0.26	0.30	0.13	0.28	0.60	0.60	0.10	0.32
Michigan	Site Specific RA	0.45	0.42	0.28	0.18	0.10	0.41	0.10	0.26	0.30	0.28
Montana	Method 1	0.32	0.36	0.41	0.38	0.10	0.31	0.65	0.62	0.29	0.38
Montana	Method 2	0.40	0.49	0.27	0.41	0.48	0.33	0.81	0.62	0.18	0.44
New Hampshire	Method 1	0.30	0.33	0.25	0.30	0.25	0.31	0.25	0.52	0.12	0.29
New Hampshire	Method 2	0.30	0.34	0.25	0.30	0.25	0.30	0.31	0.54	0.12	0.30
New Hampshire	Method 3	0.45	0.43	0.32	0.26	0.21	0.38	0.39	0.35	0.28	0.34
New Jersey	HHRA	0.16	0.16	0.10	0.14	0.10	0.16	0.15	0.32	0.10	0.16
New York	QHHEA/FWRIA	0.30	0.30	0.25	0.20	0.10	0.28	0.10	0.44	0.10	0.23
Rhode Island	Method 1 & 2	0.22	0.23	0.22	0.20	0.13	0.21	0.29	0.48	0.10	0.23
Rhode Island	Method 3	0.58	0.60	0.40	0.53	0.63	0.62	0.53	0.50	0.40	0.53
Texas	Human 1	0.40	0.43	0.35	0.16	0.20	0.42	0.21	0.41	0.20	0.31
Texas	Human 2	0.41	0.43	0.36	0.16	0.22	0.42	0.21	0.41	0.20	0.31
Texas	Human 3	0.41	0.43	0.36	0.16	0.22	0.42	0.21	0.41	0.20	0.31
Vermont	Risk Assessment	0.54	0.55	0.43	0.47	0.63	0.56	0.53	0.35	0.40	0.49
Vermont	State Provided Value	0.31	0.29	0.20	0.33	0.23	0.28	0.20	0.43	0.10	0.26

Var / except / alt – Variations, exceptions, and alternate methods
ELUR – Environmental Land Use Restrictions
PQRA – Preliminary Quantitative Risk Assessment
QHHEA – Qualitative Human Health Exposure Assessment
Prelim Endang Assess – Preliminary Endangerment Assessment
ERA – Ecological Risk Assessment
EC – Engineered Controls
HHRA – Human Health Risk Assessment
DQRA – Detailed Quantitative Risk Assessment
FWRIA – Fish and Wildlife Resource Impact Analysis
RI/FS – Remedial Investigation / Feasibility Study

Table H-2 Summary results scoring HHRA methods for requirement B: Toxicity Assessment (Question 2 in the database)

State/ Agency	Method	Accuracy	Protectiveness	Proportionality	Reproducibility	Appropriateness	Flexibility	Transparency	Specification	Uncertainty	Average of non-zero entries
California	Prelim Endang Assess	0.60	0.52	0.00	0.58	0.53	0.38	0.83	0.68	1.00	0.64
California	RI/FS Predictive Eco	0.10	0.10	0.00	0.10	0.10	0.10	0.10	0.10	0.10	0.10
Canada	1 PQRA HHRA	0.59	0.55	0.00	0.57	0.71	0.58	0.53	0.58	0.10	0.52
Canada	2 DQRA HHRA	0.83	0.88	0.00	0.83	0.80	0.83	0.73	0.78	0.10	0.72
Connecticut	Default	0.69	0.63	0.00	0.48	0.55	0.46	1.00	0.78	0.50	0.64
Connecticut	EC / ELUR	0.74	0.69	0.00	0.55	0.65	0.46	1.00	0.78	0.50	0.67
Connecticut	Var / except / alt	0.69	0.63	0.00	0.48	0.55	0.46	1.00	0.78	0.50	0.64
DOE	Method 1	0.62	0.64	0.00	0.55	0.57	0.58	0.63	0.70	0.50	0.60
EPA	2 HHRA	0.63	0.58	0.00	0.64	0.60	0.65	0.60	0.58	0.60	0.61
Illinois	Tier 1	0.48	0.42	0.00	0.40	0.50	0.43	0.53	0.43	0.10	0.41
Illinois	Tier 2	0.38	0.36	0.00	0.33	0.40	0.30	0.53	0.43	0.10	0.35
Illinois	Tier 3	0.42	0.40	0.00	0.38	0.47	0.30	0.37	0.30	0.10	0.34
Maine	Method 1	0.63	0.67	0.00	0.59	0.85	0.51	0.43	0.44	0.10	0.53
Massachusetts	Method 1	0.28	0.24	0.00	0.16	0.19	0.24	0.53	0.46	0.20	0.29
Massachusetts	Method 2	0.43	0.34	0.00	0.16	0.19	0.37	0.43	0.41	0.20	0.32
Massachusetts	Method 3	0.60	0.54	0.00	0.41	0.53	0.37	0.43	0.41	0.20	0.43
Michigan	Generic Criteria	0.40	0.46	0.00	0.33	0.40	0.33	0.40	0.55	0.10	0.37
Michigan	Site Specific RA	0.25	0.28	0.00	0.33	0.40	0.10	0.10	0.10	0.10	0.21
Montana	Method 1	0.33	0.22	0.00	0.31	0.30	0.10	0.40	0.38	0.10	0.27
Montana	Method 2	0.62	0.66	0.00	0.71	0.53	0.58	0.63	0.66	0.20	0.57
New Hampshire	Method 1	0.36	0.26	0.00	0.29	0.36	0.14	0.70	0.58	0.10	0.35
New Hampshire	Method 2	0.36	0.26	0.00	0.29	0.36	0.14	0.70	0.58	0.10	0.35
New Hampshire	Method 3	0.41	0.32	0.00	0.36	0.46	0.14	0.40	0.36	0.20	0.33
New Jersey	HHRA	0.17	0.10	0.00	0.10	0.10	0.20	0.40	0.33	0.10	0.19
New York	QHHEA/FWRIA	0.10	0.10	0.00	0.10	0.10	0.10	0.10	0.10	0.10	0.10
Rhode Island	Method 1 & 2	0.30	0.34	0.00	0.40	0.50	0.10	0.10	0.10	0.10	0.24
Rhode Island	Method 3	0.47	0.46	0.00	0.45	0.43	0.50	0.50	0.50	0.50	0.48
Texas	Human 1	0.58	0.52	0.00	0.46	0.50	0.20	0.50	0.61	0.10	0.43
Texas	Human 2	0.58	0.52	0.00	0.46	0.50	0.20	0.50	0.61	0.10	0.43
Texas	Human 3	0.58	0.52	0.00	0.46	0.50	0.20	0.50	0.61	0.10	0.43
Vermont	Risk Assessment	0.47	0.46	0.00	0.45	0.43	0.50	0.50	0.50	0.50	0.48
Vermont	State Provided Value	0.38	0.28	0.00	0.33	0.40	0.10	0.40	0.33	0.10	0.29

Var / except / alt – Variations, exceptions, and alternate methods
ELUR – Environmental Land Use Restrictions
PQRA – Preliminary Quantitative Risk Assessment
ERA SL – Ecological Risk Assessment, Screening Level
FWRIA – Fish and Wildlife Resource Impact Analysis
RI/FS – Remedial Investigation / Feasibility Study
EC – Engineered Controls
HHRA – Human Health Risk Assessment
DQRA – Detailed Quantitative Risk Assessment
QHHEA – Qualitative Human Health Exposure Assessment
Prelim Endang Assess – Preliminary Endangerment Assessment
ERA – Ecological Risk Assessment

Table H-3 Summary results scoring HHRA methods for requirement C: Risk Characterization (Question 3 in the database)

State/ Agency	Method	Accuracy	Protectiveness	Proportionality	Reproducibility	Appropriateness	Flexibility	Transparency	Specification	Uncertainty	Average of non-zero entries
California	Prelim Endang Assess	0.63	0.54	0.00	0.55	0.62	0.10	0.00	1.00	0.34	0.54
California	RI/FS Predictive Eco	0.15	0.27	0.00	0.10	0.37	0.10	0.00	0.10	0.10	0.17
Canada	1 PQRA HHRA	0.12	0.34	0.00	0.10	0.45	0.10	0.00	0.10	0.23	0.21
Canada	2 DQRA HHRA	0.60	0.52	0.00	0.55	0.61	0.10	0.00	1.00	0.20	0.51
Connecticut	Default	0.12	0.27	0.00	0.10	0.36	0.10	0.00	0.10	0.30	0.19
Connecticut	EC / ELUR	0.12	0.27	0.00	0.10	0.36	0.10	0.00	0.10	0.30	0.19
Connecticut	Var / except / alt	0.42	0.35	0.00	0.55	0.38	0.10	0.00	1.00	0.30	0.44
DOE	Method 1	0.27	0.41	0.00	0.10	0.52	0.10	0.00	0.10	0.23	0.25
EPA	2 HHRA	0.65	0.55	0.00	0.63	0.61	0.25	0.00	1.00	0.34	0.58
Illinois	Tier 1	0.13	0.24	0.00	0.10	0.32	0.10	0.00	0.10	0.10	0.16
Illinois	Tier 2	0.12	0.19	0.00	0.10	0.25	0.10	0.00	0.10	0.10	0.14
Illinois	Tier 3	0.27	0.38	0.00	0.10	0.49	0.10	0.00	0.10	0.10	0.22
Maine	Method 1	0.57	0.53	0.00	0.55	0.62	0.10	0.00	1.00	0.10	0.49
Massachusetts	Method 1	0.42	0.33	0.00	0.55	0.37	0.10	0.00	1.00	0.24	0.43
Massachusetts	Method 2	0.42	0.33	0.00	0.55	0.37	0.10	0.00	1.00	0.24	0.43
Massachusetts	Method 3	0.62	0.55	0.00	0.63	0.61	0.25	0.00	1.00	0.55	0.60
Michigan	Generic Criteria	0.12	0.29	0.00	0.10	0.37	0.10	0.00	0.10	0.10	0.17
Michigan	Site Specific RA	0.12	0.27	0.00	0.10	0.35	0.10	0.00	0.10	0.10	0.16
Montana	Method 1	0.20	0.39	0.00	0.18	0.49	0.25	0.00	0.10	0.28	0.27
Montana	Method 2	0.60	0.46	0.00	0.55	0.51	0.10	0.00	1.00	0.10	0.47
New Hampshire	Method 1	0.12	0.24	0.00	0.10	0.31	0.10	0.00	0.10	0.10	0.15
New Hampshire	Method 2	0.12	0.24	0.00	0.10	0.31	0.10	0.00	0.10	0.10	0.15
New Hampshire	Method 3	0.27	0.58	0.00	0.33	0.64	0.10	0.00	0.10	0.20	0.32
New Jersey	HHRA	0.13	0.11	0.00	0.10	0.12	0.10	0.00	0.10	0.10	0.11
New York	QHHEA/FWRIA	0.15	0.22	0.00	0.10	0.30	0.10	0.00	0.10	0.10	0.15
Rhode Island	Method 1 & 2	0.15	0.24	0.00	0.10	0.34	0.10	0.00	0.10	0.10	0.16
Rhode Island	Method 3	0.55	0.46	0.00	0.70	0.42	0.40	0.00	1.00	0.42	0.56
Texas	Human 1	0.23	0.47	0.00	0.10	0.60	0.10	0.00	0.10	0.10	0.24
Texas	Human 2	0.23	0.47	0.00	0.10	0.60	0.10	0.00	0.10	0.10	0.24
Texas	Human 3	0.23	0.47	0.00	0.10	0.60	0.10	0.00	0.10	0.10	0.24
Vermont	Risk Assessment	0.65	0.35	0.00	0.70	0.28	0.70	0.00	1.00	0.52	0.60
Vermont	State Provided Value	0.15	0.18	0.00	0.10	0.27	0.10	0.00	0.10	0.10	0.14

Var / except / alt – Variations, exceptions, and alternate methods
ELUR – Environmental Land Use Restrictions
PQRA – Preliminary Quantitative Risk Assessment
QHHEA – Qualitative Human Health Exposure Assessment
Prelim Endang Assess – Preliminary Endangerment Assessment
ERA – Ecological Risk Assessment
EC – Engineered Controls
HHRA – Human Health Risk Assessment
DQRA – Detailed Quantitative Risk Assessment
FWRIA – Fish and Wildlife Resource Impact Analysis
RI/FS – Remedial Investigation / Feasibility Study

Table H-4 Summary results for HHRA based on best practice Method(s) in use, and the relative ranking of Connecticut Methods.

Human Health Risk Assessment			Connecticut Methods and rankings (out of 32, where 1 = best practice)		
Question		State/Program Method with best practice (with up to 5 tied practices listed)	Comparison to RSRs	Engineered Controls/ Land Restrictions	Alternate Methods
1.1	How is the characterization of the exposure setting defined?	Illinois: Tier 3	28.5	16	16
1.2	What (abiotic) environmental media are required to be included in risk assessment (human health or ecological)	Vermont: Risk Assessment DOE: 1 Canada: 2 DQRA HHRA California: RI/FS Predictive Eco	22	22	22
1.3	What environmental media are included in criteria derivation?	Illinois: Tier 2 California: Prelim Endang Assess	15	15	15
1.4	What exposure pathways are generally required to be evaluated in risk assessments?	Vermont: State Provided Value New Hampshire: 3 Massachusetts: Method 3	18	18	18
1.5	What exposure pathways were evaluated in criteria derivation?	DOE: 1	12.5	10.5	10.5
1.6	Are there exposure pathways that are explicitly omitted from risk assessments?	Rhode Island: Method 3	9.5	9.5	9.5
1.7	Are there exposure pathways that are explicitly omitted from criteria derivation?	Rhode Island: Method 3 Maine: 1 New Hampshire: 3	10	10	10
1.8	How are exposure estimates based on direct environmental measurements or predictive models?	Michigan: Site Specific RA Illinois: Tier 3 Massachusetts: Method 3	18.5	15.5	15.5
1.9	What (predictive) models, if any, are used in estimating media concentrations ?	Vermont: Risk Assessment Rhode Island: Method 3 Montana: 1	23.5	13	23.5
1.10	How are exposures to sensitive populations, groups or life-stages addressed?	DOE: 1	10	10	10
1.11	How are exposure estimates quantified?	Massachusetts: Method 3	27	27	27
1.12	Are central tendency or maximum exposure estimates used?	Massachusetts: Method 3	7	7	7
1.13	How are aggregate exposures across multiple pathways for a single substance addressed?	EPA: 2 HHRA	7	7	7
1.14	How are cumulative exposures to multiple substances through a common pathway addressed?	California: Prelim Endang Assess	26.5	19.5	14.5

Human Health Risk Assessment			Connecticut Methods and rankings (out of 32, where 1 = best practice)		
Question		State/Program Method with best practice (with up to 5 tied practices listed)	Comparison to RSRs	Engineered Controls/ Land Restrictions	Alternate Methods
1.15	How are cumulative and aggregate exposure exposures to multiple substances through multiple pathways addressed?	Connecticut: Default Connecticut: Var / except / alt Connecticut: EC / ELUR Canada: 2 DQRA HHRA Massachusetts: Method 1 (4 others)	Equal #1	Equal #1	Equal #1
1.16	How are uncertainty and variability addressed in current exposure assessments?	Massachusetts: Method 3	20.5	20.5	20.5
2.1	What sources of toxicological information are considered (for human health)?	EPA: 2 HHRA	14	14	14
2.2	How are (human) toxic effects assessed for carcinogenic substances?	Texas: human 3 Texas: human 2 Texas: human 1 Vermont: State Provided Value Rhode Island: Method 1 & 2 (17 others)	Equal #1	Equal #1	Equal #1
2.3	How are (human) toxic effects assessed for non-carcinogenic substances?	Maine: 1	27.5	27.5	7.5
2.4	How are (human) subchronic and genotoxic effects assessed, including mutagenesis and teratogenesis?	Canada: 2 DQRA HHRA	8	8	8
2.6	How are appropriate toxicity values selected?	Texas: human 3 Texas: human 2 Texas: human 1 Vermont: State Provided Value Vermont: Risk Assessment (27 others)	Equal #1	Equal #1	Equal #1
2.7	How are toxicity estimates made for substances for which no toxicity values are available?	Connecticut: Default Connecticut: Var / except / alt Connecticut: EC / ELUR	Equal #1	Equal #1	Equal #1
2.8	How are vulnerable populations such as children addressed in toxicity assessments?	Montana: 2 Canada: 2 DQRA HHRA EPA: 2 HHRA	5.5	5.5	5.5
2.9	How are uncertainty and variability addressed in current toxicity assessments?	California: Prelim Endang Assess	5.5	5.5	5.5
3.1	How are risks for individual substances quantified?	Maine: 1 Canada: 2 DQRA HHRA Massachusetts: Method 3 EPA: 2 HHRA	16	8	16
3.2	How are risks from multiple substances quantified?	California: Prelim Endang Assess	27	27	27

Human Health Risk Assessment			Connecticut Methods and rankings (out of 32, where 1 = best practice)		
Question		State/Program Method with best practice (with up to 5 tied practices listed)	Comparison to RSRs	Engineered Controls/ Land Restrictions	Alternate Methods
3.3	How are risks evaluated using point estimates or probabilistic assessments?	Rhode Island: Method 3	5	2	5
3.4	How are risks combined across multiple exposure pathways?	New Hampshire: 3	27	27	27
3.5	What is the role of a Weight of Evidence (WoE) approach in estimating risks?	Vermont: Risk Assessment	19.5	19.5	19.5
3.6	How are variability and uncertainty addressed in the risk characterization process?	Massachusetts: Method 3	3.5	3.5	3.5

Table H-5 Responses to requirements D, F, H, I, K, N, and O

Database question	None	Other	Guidance	Regulation	Legislation	Response
4	**D. Determine how remedial goals are set**					
4.1	i. How is risk management incorporated into risk-based decision making?					
	0	0	9	15	0	Explicit methodology
	0	0	6	2	0	Generic statements
	6	0	0	0	0	Not specified
4.2	ii. Are remedial goals set solely on the basis of risk assessment or are final remedial goals informed by other risk management considerations? Explain					
4.2.1	Are clean-up goals fixed, or does the Agency have discretion to select alternative clean-up goals (e.g. within a range of risks, as for EPA)?					
	0	0	4	7	1	Clean-up goals specified as concentrations, inflexible
	0	0	4	2	0	Clean-up goals specified as risk, inflexible
	0	0	2	9	0	Clean-up goals specified as concentrations, flexible
	0	0	4	1	2	Clean-up goals specified as risk values, flexible
	0	0	0	1	0	Clean-up goals specified in other terms, inflexible
	0	0	2	3	0	Clean-up goals specified in other terms, flexible
	8	0	0	0	0	Not specified
4.2.2	If clean-up goals are not fixed, what other considerations are explicitly included as affecting the decision on final clean-up goals?					
	0	0	2	2	10	Cost
	0	0	2	3	10	Feasibility
	0	0	3	8	1	Background concentrations
	0	0	5	1	0	Ecosystem valuation or preservation
	0	0	0	1	0	Public preferences
	0	0	0	0	0	Neighbor preferences
	0	0	0	1	1	Agency discretion
	0	0	1	0	2	Conformity to other laws
	0	0	0	0	0	Deference to other laws
	0	0	0	1	2	Deference to State & Federal policies
	0	0	0	0	0	Deference to or conformity with legal decisions
	0	0	1	1	0	Deference to other state agencies
	0	0	0	0	0	Deference to state officer requests or orders
	0	0	0	0	0	Scientific uncertainty
	5	0	2	8	3	Other
	13	0	0	0	0	Not specified
4.3	iii. How have specific risk management policies and regulations affected how and which risks were addressed and which were not?					
	0	0	1	0	0	Specific risk management policies are referenced affecting selection of regulated risks (list policies and references)
	0	0	0	8	0	Specific regulations manage specific risks (list regulations and risks)
	29	0	0	0	0	None specified
4.4	iv. What administrative and legal tools are available for implementing remedial decisions? (Explicitly listed in the legislation/regulation documentation on site clean-up we collected; do not attempt to locate references to					

Database question	None	Other	Guidance	Regulation	Legislation	Response
	other legislation/regulation)					
	0	0	0	2	17	Fines
	0	0	0	0	9	Jail time
	0	0	0	0	0	Refusal of other agency actions (e.g. other permits)
	0	0	0	0	0	Removal of licenses or permits
	0	0	0	5	7	Other
	14	0	0	0	0	None specified
5	**F. Determine roles and legal responsibilities, as applicable, of state agencies** [for Connecticut, this would include DEEP and the Connecticut Department of Public Health ("DPH")], local agencies and stakeholders such as the public and responsible parties in making risked based decisions: Apart from the Agency being evaluated here, are other state agencies, local agencies, or other stakeholders (including the public and responsible parties) documented anywhere as having a role in making risk-based decisions?					
5.1	Legal requirements					
	0	0	1	0	6	Other state agencies
	0	3	0	0	2	Local agencies
	0	3	0	3	0	Responsible parties
	0	0	0	0	0	Neighbors
	0	0	0	2	0	Public
	0	0	0	8	1	Other
	22	0	0	0	0	None specified
5.2	Some role specified					
	0	0	5	2	0	Other state agencies
	0	0	1	0	0	Local agencies
	0	0	0	1	0	Responsible parties
	0	0	0	0	0	Neighbors
	0	3	0	6	0	Public
	0	0	0	6	0	Other
	21	0	0	0	0	None specified
6	**H: Determine if adaptive management is considered during the risk-based decision making.** Is adaptive management (defined as "A framework and flexible decision-making process for ongoing knowledge acquisition, monitoring, and evaluation leading to continuous improvements in management planning and implementation of a project to achieve specified objectives") or an equivalent mentioned in any documentation?					
	0	0	1	2	0	Explicitly incorporated, allowing complete flexibility in timelines
	0	0	0	0	0	Implicit in the flexible timelines and accommodation to technological possibilities
	0	0	0	0	0	Explicitly forbidden
	0	0	0	3	0	Implicitly forbidden by adoption of inflexible timelines or failure to account for technical impossibilities
	32	0	0	0	0	Not possible to determine
7	**I. Evaluate how risk-based decisions are communicated to the regulated community, stakeholders and the public, and at what stages of the decision-making process such communication occurs.**					
7.1	There are requirements on communication to the regulated community, stakeholders and the public for all sites					
	0	0	2	12	7	Methods of communication are specified

Database question	None	Other	Guidance	Regulation	Legislation	Response
	0	0	2	5	3	Timelines are specified
	0	0	2	5	4	Persons/agencies responsible for communications are specified
	0	0	3	0	0	Generic statements only
	1	0	0	0	0	Other
7.2	Special communication provisions are made for certain sites					
	0	0	2	3	0	Selection of such sites is specified
	0	0	2	4	2	Methods of communication are specified
	0	0	2	3	0	Timelines are specified
	0	0	2	3	0	Persons/agencies responsible for communications are specified
	0	0	0	0	0	Generic statements only
	7	0	0	0	0	Other
7.3	Not specified (no communication provisions)					
	13	0	0	0	0	Not specified (no communication provisions)
8	**K. Determine the legislated or regulated timeliness of responses by agencies. What deadlines are required by law or regulation?**					
8.1	Are there timelines specified in legislation or regulation for response by the Agency to all communications from					
	0	1	0	1	0	PRPs
	0	0	0	0	0	Risk Assessors
	0	0	0	1	0	Stakeholders
	0	0	0	1	0	The public
8.2	Are there timelines specified in legislation or regulation for response by the Agency to some communications from					
	0	0	0	4	0	PRPs
	0	0	0	0	3	Risk Assessors
	0	0	0	1	0	Stakeholders
	0	0	0	3	0	The public
8.3	Are the timelines specified as a time certain, or do they contain conditional clauses?					
	0	0	2	6	0	Are the timelines specified as a time certain, or do they contain conditional clauses?
8.4	What is the effect specified in legislation or regulation if the Agency does not meet a deadline?					
	0	0	0	3	0	Any proposal to the Agency takes effect as though fully approved by the Agency
	0	0	0	0	0	Any proposal to the Agency is automatically denied
	0	0	0	0	0	Any proposal is left in limbo
	1	0	0	0	2	Other
	30	0	0	0	0	Not specified
8.5	What recourse is included in the legislation or regulation if the Agency does not meet a deadline?					
	0	0	0	0	0	Monetary relief
	0	0	0	0	0	Oversight relief
	0	0	0	3	0	Automatic granting of any petition
	0	0	0	0	0	Automatic denial of any petition
	0	0	0	0	0	Appeal to higher authority within the Agency
	0	0	0	0	0	Appeal outside the Agency
	0	0	0	0	0	Appeal to the courts

Database question	None	Other	Guidance	Regulation	Legislation	Response
	0	0	0	0	0	Other
	33	0	0	0	0	Not specified
9	**N. What mechanisms are available for updating procedures and values? Are there mechanisms built into legislation or regulation that require updates, revisions, and corrections to toxicity values and other risk-related parameters, and what is the timeline for such modifications?**					
9.1	Are there explicit timelines with specified times in the legislation or regulations for updates to:					
	0	0	0	0	0	Toxicity values
	0	0	0	0	0	Exposure parameters
	0	0	0	0	0	Methodologies
	0	0	0	0	3	Other
	35	0	0	0	0	None specified
9.2	Are there other explicit provisions in the legislation or regulations that call for updates in other circumstances (e.g. at the discretion of the relevant Agency) to					
	0	0	0	3	0	Toxicity values
	0	0	0	0	0	Exposure parameters
	0	0	0	0	0	Methodologies
	0	0	0	0	3	Other
	32	0	0	0	0	None specified
9.3	Do the legislation or regulations explicitly provide for accepting updates made externally to the relevant Agency (e.g. if IRIS or the Exposure Factors Handbook gets updated) for:					
	0	0	0	2	0	Toxicity values
	0	0	0	0	0	Exposure parameters
	0	0	0	0	0	Methodologies
	0	0	1	0	0	Other
	35	0	0	0	0	None specified
9.4	Do the legislation or regulations implicitly provide for accepting updates made externally to the relevant Agency (e.g. if IRIS or the Exposure Factors Handbook gets updated)					
	0	0	0	0	0	Toxicity values
	0	0	1	0	0	Exposure parameters
	0	0	0	0	0	Methodologies
	0	0	1	0	0	Other
	36	0	0	0	0	None specified
9.5	Do the legislation or regulations explicitly forbid accepting updates made externally to the relevant Agency for:					
	0	0	0	0	0	Toxicity values
	0	0	0	0	0	Exposure parameters
	0	0	0	0	0	Methodologies
	0	0	0	0	0	Other
	38	0	0	0	0	None specified
10	**O. How flexible are the approaches allowed for site evaluation and remedial options? Is there a single track or multiple options for site evaluations, and are there alternative options for remediation (e.g. depending on site use)?**					
	0	0	4	20	0	For the current method, the legislation or regulations allow or require consideration of site use or other factors in decisions on remediation
	0	0	0	0	0	For the current method, the legislation or regulations forbid consideration of site use or other factors in decisions on remediation

Database question	None	Other	Guidance	Regulation	Legislation	Response
	1	0	0	2	0	Other
	13	0	0	0	0	Not specified

Appendix I

Detailed results for ERA, Requirements A to C

The following pages show more detailed summary tables for ERA. Further similar tables may be automatically generated using the Excel version of the database.

Table I-1 Summary results scoring ERA methods for requirement A: Exposure Assessment (Question 1 in the database)

State/ Agency	Method	Accuracy	Protectiveness	Proportionality	Reproducibility	Appropriateness	Flexibility	Transparency	Specification	Uncertainty	Average of non-zero entries
California	Prelim Endang Assess	0.57	0.60	0.28	0.42	0.60	0.40	0.49	0.62	0.33	0.48
California	RI/FS Predictive Eco	0.25	0.24	0.20	0.30	0.30	0.24	0.28	0.24	0.10	0.24
Canada	3 ERA SL/PQRA/DQRA	0.37	0.39	0.40	0.30	0.23	0.38	0.10	0.40	0.30	0.32
Connecticut	Default	0.37	0.35	0.24	0.30	0.23	0.28	0.32	0.56	0.23	0.32
Connecticut	EC / ELUR	0.40	0.38	0.28	0.30	0.23	0.39	0.32	0.55	0.23	0.34
Connecticut	Var / except / alt	0.40	0.39	0.28	0.31	0.30	0.32	0.34	0.55	0.23	0.35
DOE	Method 1	0.44	0.50	0.35	0.32	0.10	0.47	0.32	0.51	0.13	0.35
EPA	1 ERA	0.34	0.39	0.24	0.34	0.23	0.32	0.17	0.22	0.10	0.26
Illinois	Tier 1	0.29	0.26	0.34	0.30	0.10	0.27	0.40	0.61	0.13	0.30
Illinois	Tier 2	0.38	0.36	0.39	0.31	0.10	0.37	0.44	0.59	0.14	0.34
Illinois	Tier 3	0.49	0.48	0.44	0.38	0.10	0.52	0.12	0.48	0.38	0.37
Maine	Method 1	0.47	0.50	0.24	0.35	0.10	0.38	0.14	0.27	0.22	0.30
Massachusetts	Method 1	0.34	0.41	0.10	0.51	0.25	0.18	0.70	0.70	0.22	0.38
Massachusetts	Method 2	0.34	0.42	0.10	0.49	0.25	0.18	0.76	0.71	0.19	0.38
Massachusetts	Method 3	0.51	0.60	0.36	0.49	0.55	0.44	0.60	0.42	0.73	0.52
Michigan	Generic Criteria	0.33	0.32	0.28	0.33	0.10	0.29	0.46	0.60	0.10	0.31
Michigan	Site Specific RA	0.45	0.42	0.32	0.20	0.10	0.44	0.10	0.27	0.30	0.29
Montana	Method 1	0.32	0.36	0.47	0.42	0.10	0.33	0.53	0.62	0.29	0.38
Montana	Method 2	0.39	0.47	0.29	0.47	0.55	0.35	0.75	0.62	0.18	0.45
New Hampshire	Method 1	0.29	0.33	0.28	0.29	0.23	0.31	0.30	0.54	0.12	0.30
New Hampshire	Method 2	0.29	0.34	0.28	0.29	0.23	0.30	0.38	0.56	0.12	0.31
New Hampshire	Method 3	0.45	0.42	0.36	0.28	0.20	0.40	0.18	0.33	0.28	0.32
New Jersey	ERA	0.31	0.32	0.24	0.18	0.10	0.29	0.11	0.46	0.10	0.23
New York	QHHEA/FWRIA	0.30	0.30	0.24	0.18	0.10	0.28	0.10	0.45	0.10	0.23
Rhode Island	Method 1 & 2	0.26	0.27	0.24	0.26	0.40	0.23	0.25	0.48	0.10	0.28
Rhode Island	Method 3	0.59	0.61	0.40	0.55	0.75	0.65	0.67	0.50	0.40	0.57
Texas	Eco 1	0.56	0.56	0.36	0.54	0.50	0.63	0.43	0.43	0.40	0.49
Texas	Eco 2	0.32	0.37	0.25	0.34	0.23	0.33	0.17	0.40	0.13	0.28
Texas	Eco 3	0.24	0.27	0.24	0.44	0.43	0.35	0.17	0.18	0.30	0.29
Vermont	Risk Assessment	0.53	0.54	0.44	0.46	0.75	0.56	0.67	0.34	0.40	0.52
Vermont	State Provided Value	0.30	0.28	0.20	0.28	0.10	0.28	0.10	0.43	0.10	0.23

Var / except / alt – Variations, exceptions, and alternate methods
ELUR – Environmental Land Use Restrictions
PQRA – Preliminary Quantitative Risk Assessment
QHHEA – Qualitative Human Health Exposure Assessment
Prelim Endang Assess – Preliminary Endangerment Assessment
ERA – Ecological Risk Assessment
EC – Engineered Controls
HHRA – Human Health Risk Assessment
DQRA – Detailed Quantitative Risk Assessment
FWRIA – Fish and Wildlife Resource Impact Analysis
RI/FS – Remedial Investigation / Feasibility Study

Table I-2 Summary results scoring ERA methods for requirement B: Toxicity Assessment (Question 2 in the database)

State/ Agency	Method	Accuracy	Protectiveness	Proportionality	Reproducibility	Appropriateness	Flexibility	Transparency	Specification	Uncertainty	Average of non-zero entries
California	Prelim Endang Assess	0.50	0.75	0.70	0.00	1.00	0.70	0.50	0.75	1.00	0.74
California	RI/FS Predictive Eco	0.23	0.40	0.50	0.00	0.70	0.37	0.23	0.40	0.10	0.37
Canada	3 ERA SL/PQRA/DQRA	0.55	0.65	0.23	0.00	0.30	0.50	0.53	0.60	0.10	0.43
Connecticut	Default	0.55	0.55	0.10	0.00	0.10	0.30	0.55	0.55	0.50	0.40
Connecticut	EC / ELUR	0.55	0.55	0.10	0.00	0.10	0.30	0.55	0.55	0.50	0.40
Connecticut	Var / except / alt	0.55	0.55	0.10	0.00	0.10	0.30	0.55	0.55	0.50	0.40
DOE	Method 1	0.68	0.68	0.37	0.00	0.37	0.72	0.47	0.77	0.50	0.57
EPA	1 ERA	0.25	0.25	0.40	0.00	0.40	0.25	0.40	0.40	0.10	0.31
Illinois	Tier 1	0.30	0.30	0.10	0.00	0.10	0.30	0.30	0.30	0.10	0.23
Illinois	Tier 2	0.30	0.30	0.10	0.00	0.10	0.30	0.30	0.30	0.10	0.23
Illinois	Tier 3	0.30	0.30	0.10	0.00	0.10	0.30	0.30	0.30	0.10	0.23
Maine	Method 1	0.35	0.60	0.50	0.00	0.50	0.75	0.35	0.35	0.10	0.44
Massachusetts	Method 1	0.30	0.30	0.10	0.00	0.10	0.30	0.60	0.60	0.20	0.31
Massachusetts	Method 2	0.55	0.55	0.10	0.00	0.10	0.55	0.45	0.50	0.20	0.38
Massachusetts	Method 3	0.75	0.75	0.47	0.00	0.50	0.80	0.45	0.50	0.20	0.55
Michigan	Generic Criteria	0.55	0.55	0.10	0.00	0.10	0.55	0.10	0.55	0.10	0.33
Michigan	Site Specific RA	0.10	0.10	0.10	0.00	0.10	0.10	0.10	0.10	0.10	0.10
Montana	Method 1	0.30	0.30	0.50	0.00	0.50	0.30	0.30	0.30	0.10	0.33
Montana	Method 2	0.40	0.85	0.70	0.00	1.00	0.95	0.35	0.60	0.20	0.63
New Hampshire	Method 1	0.10	0.10	0.10	0.00	0.10	0.10	0.55	0.55	0.10	0.21
New Hampshire	Method 2	0.10	0.10	0.10	0.00	0.10	0.10	0.55	0.55	0.10	0.21
New Hampshire	Method 3	0.33	0.40	0.60	0.00	0.70	0.38	0.40	0.40	0.20	0.43
New Jersey	ERA	0.27	0.35	0.43	0.00	0.60	0.43	0.47	0.55	0.10	0.40
New York	QHHEA/FWRIA	0.10	0.10	0.10	0.00	0.10	0.10	0.10	0.10	0.10	0.10
Rhode Island	Method 1 & 2	0.35	0.55	0.70	0.00	1.00	0.50	0.30	0.55	0.10	0.51
Rhode Island	Method 3	0.55	0.75	0.70	0.00	1.00	0.70	0.50	0.75	0.50	0.68
Texas	Eco 1	0.50	0.50	0.50	0.00	0.50	0.50	0.50	0.50	0.50	0.50
Texas	Eco 2	0.68	0.68	0.37	0.00	0.37	0.68	0.32	0.77	0.10	0.50
Texas	Eco 3	0.63	0.73	0.43	0.00	0.47	0.57	0.67	0.75	0.10	0.54
Vermont	Risk Assessment	0.55	0.75	0.70	0.00	1.00	0.70	0.50	0.75	0.50	0.68
Vermont	State Provided Value	0.10	0.10	0.10	0.00	0.10	0.10	0.10	0.10	0.10	0.10

Var / except / alt – Variations, exceptions, and alternate methods
ELUR – Environmental Land Use Restrictions
PQRA – Preliminary Quantitative Risk Assessment
QHHEA – Qualitative Human Health Exposure Assessment
Prelim Endang Assess – Preliminary Endangerment Assessment
ERA – Ecological Risk Assessment
EC – Engineered Controls
HHRA – Human Health Risk Assessment
DQRA – Detailed Quantitative Risk Assessment
FWRIA – Fish and Wildlife Resource Impact Analysis
RI/FS – Remedial Investigation / Feasibility Study

Table I-3 **Summary results scoring ERA methods for requirement C: Risk Characterization (Question 3 in the database)**

State/ Agency	Method	Accuracy	Protectiveness	Proportionality	Reproducibility	Appropriateness	Flexibility	Transparency	Specification	Uncertainty	Average of non-zero entries
California	Prelim Endang Assess	0.38	0.38	0.00	0.00	0.38	0.00	0.00	0.00	0.47	0.40
California	RI/FS Predictive Eco	0.18	0.18	0.00	0.00	0.18	0.00	0.00	0.00	0.10	0.16
Canada	3 ERA SL/PQRA/DQRA	0.38	0.38	0.00	0.00	0.38	0.00	0.00	0.00	0.67	0.45
Connecticut	Default	0.18	0.18	0.00	0.00	0.18	0.00	0.00	0.00	0.40	0.23
Connecticut	EC / ELUR	0.18	0.18	0.00	0.00	0.18	0.00	0.00	0.00	0.40	0.23
Connecticut	Var / except / alt	0.18	0.18	0.00	0.00	0.18	0.00	0.00	0.00	0.40	0.23
DOE	1	0.75	0.75	0.00	0.00	0.75	0.00	0.00	0.00	0.30	0.64
EPA	1 ERA	0.18	0.18	0.00	0.00	0.18	0.00	0.00	0.00	0.30	0.21
Illinois	Tier 1	0.18	0.18	0.00	0.00	0.18	0.00	0.00	0.00	0.10	0.16
Illinois	Tier 2	0.18	0.18	0.00	0.00	0.18	0.00	0.00	0.00	0.10	0.16
Illinois	Tier 3	0.18	0.18	0.00	0.00	0.18	0.00	0.00	0.00	0.10	0.16
Maine	1	0.18	0.18	0.00	0.00	0.18	0.00	0.00	0.00	0.10	0.16
Massachusetts	Method 1	0.38	0.38	0.00	0.00	0.38	0.00	0.00	0.00	0.32	0.36
Massachusetts	Method 2	0.38	0.38	0.00	0.00	0.38	0.00	0.00	0.00	0.32	0.36
Massachusetts	Method 3	0.53	0.53	0.00	0.00	0.53	0.00	0.00	0.00	0.70	0.57
Michigan	Generic Criteria	0.18	0.18	0.00	0.00	0.18	0.00	0.00	0.00	0.10	0.16
Michigan	Site Specific RA	0.18	0.18	0.00	0.00	0.18	0.00	0.00	0.00	0.10	0.16
Montana	1	0.18	0.18	0.00	0.00	0.18	0.00	0.00	0.00	0.30	0.21
Montana	2	0.38	0.38	0.00	0.00	0.38	0.00	0.00	0.00	0.10	0.31
New Hampshire	1	0.18	0.18	0.00	0.00	0.18	0.00	0.00	0.00	0.10	0.16
New Hampshire	2	0.18	0.18	0.00	0.00	0.18	0.00	0.00	0.00	0.10	0.16
New Hampshire	3	0.53	0.53	0.00	0.00	0.53	0.00	0.00	0.00	0.25	0.46
New Jersey	ERA	0.53	0.53	0.00	0.00	0.53	0.00	0.00	0.00	0.30	0.47
New York	QHHEA/FWRIA	0.18	0.18	0.00	0.00	0.18	0.00	0.00	0.00	0.10	0.16
Rhode Island	Method 1 & 2	0.38	0.38	0.00	0.00	0.38	0.00	0.00	0.00	0.10	0.31
Rhode Island	Method 3	0.38	0.38	0.00	0.00	0.38	0.00	0.00	0.00	0.43	0.39
Texas	eco 1	0.38	0.38	0.00	0.00	0.38	0.00	0.00	0.00	0.43	0.39
Texas	eco 2	0.18	0.18	0.00	0.00	0.18	0.00	0.00	0.00	0.17	0.17
Texas	eco 3	0.63	0.63	0.00	0.00	0.63	0.00	0.00	0.00	0.17	0.51
Vermont	Risk Assessment	0.38	0.38	0.00	0.00	0.38	0.00	0.00	0.00	0.43	0.39
Vermont	State Provided Value	0.18	0.18	0.00	0.00	0.18	0.00	0.00	0.00	0.10	0.16

Var / except / alt – Variations, exceptions, and alternate methods
ELUR – Environmental Land Use Restrictions
PQRA – Preliminary Quantitative Risk Assessment
QHHEA – Qualitative Human Health Exposure Assessment
Prelim Endang Assess – Preliminary Endangerment Assessment
ERA – Ecological Risk Assessment
EC – Engineered Controls
HHRA – Human Health Risk Assessment
DQRA – Detailed Quantitative Risk Assessment
FWRIA – Fish and Wildlife Resource Impact Analysis
RI/FS – Remedial Investigation / Feasibility Study

Table I-4 Summary results for ERA based on the best practice Method(s) in use, and the relative ranking of Connecticut Methods.

Ecological Risk Assessment			Connecticut Methods and rankings (out of 31, where 1 = best practice)		
Question		State/Program Method with best practice (with up to 5 tied Methods listed)	Comparison to RSRs	Engineered Controls/ Land Restrictions	Alternate Methods
1.1	How is the characterization of the exposure setting defined?	Illinois: Tier 3	28.5	16	16
1.2	What (abiotic) environmental media are required to be included in risk assessment (human health or ecological)	Vermont: Risk Assessment DOE: 1 California: RI/FS Predictive Eco	20.5	20.5	20.5
1.3	What environmental media are included in criteria derivation?	Illinois: Tier 2 California: Prelim Endang Assess	13	13	13
1.4	What exposure pathways are generally required to be evaluated in risk assessments?	Vermont: State Provided Value New Hampshire: 3 Massachusetts: Method 3	18	18	18
1.5	What exposure pathways were evaluated in criteria derivation?	DOE: 1	10.5	8.5	8.5
1.6	Are there exposure pathways that are explicitly omitted from risk assessments?	Texas: eco 1 Rhode Island: Method 3	11	11	11
1.7	Are there exposure pathways that are explicitly omitted from criteria derivation?	Texas: eco 1 Rhode Island: Method 3 Maine: 1 New Hampshire: 3	11	11	11
1.8	How are exposure estimates based on direct environmental measurements or predictive models?	Michigan: Site Specific RA Illinois: Tier 3 Massachusetts: Method 3	18.5	15.5	15.5
1.9	What (predictive) models, if any, are used in estimating media concentrations ?	Texas: eco 1 Vermont: Risk Assessment Rhode Island: Method 3 Montana: 1	23	13	23
1.10	How are exposures to sensitive populations, groups or life-stages addressed?	Rhode Island: Method 3	24	24	24
1.11	How are exposure estimates quantified?	Texas: eco 1	24	24	24
1.12	Are central tendency or maximum exposure estimates used?	Massachusetts: Method 3	6	6	6
1.13	How are aggregate exposures across multiple pathways for a single substance addressed?	Illinois: Tier 1 Illinois: Tier 2 Montana: 1	6	6	6
1.14	How are cumulative exposures to multiple substances through a common pathway addressed? (Note: this is for exposures, so the only such combinations are for chemicals that are treated together as a single substance like dioxins/PCBs/PAH, or that act through common mechanisms like radioisotopes)	California: Prelim Endang Assess	26	19.5	11.5
1.15	How are cumulative and aggregate exposure exposures to multiple substances through multiple pathways addressed?	Connecticut: Default Connecticut: Var / except / alt Connecticut: EC / ELUR Massachusetts: Method 1	Equal #1	Equal #1	Equal #1

Ecological Risk Assessment			Connecticut Methods and rankings (out of 31, where 1 = best practice)		
Question		State/Program Method with best practice (with up to 5 tied Methods listed)	Comparison to RSRs	Engineered Controls/ Land Restrictions	Alternate Methods
		Massachusetts: Method 2 (2 others)			
1.16	How are uncertainty and variability addressed in current exposure assessments?	Massachusetts: Method 3	20	20	20
2.5	How is acute and chronic toxicity evaluated for ecological receptors?	Vermont: Risk Assessment Rhode Island: Method 1 & 2 Rhode Island: Method 3 Montana: 2	25.5	25.5	25.5
2.7	How are toxicity estimates made for substances for which no toxicity values are available?	Connecticut: Default Connecticut: Var / except / alt Connecticut: EC / ELUR	Equal #1	Equal #1	Equal #1
2.9	How are uncertainty and variability addressed in current toxicity assessments?	California: Prelim Endang Assess	5	5	5
3.2	How are risks from multiple substances quantified?	DOE: 1	16.5	16.5	16.5
3.3	How are risks evaluated using point estimates or probabilistic assessments?	Texas: eco 3	23.5	23.5	23.5
3.6	How are variability and uncertainty addressed in the risk characterization process?	Massachusetts: Method 3	4	4	4

Appendix J

Flow Diagrams of Practices

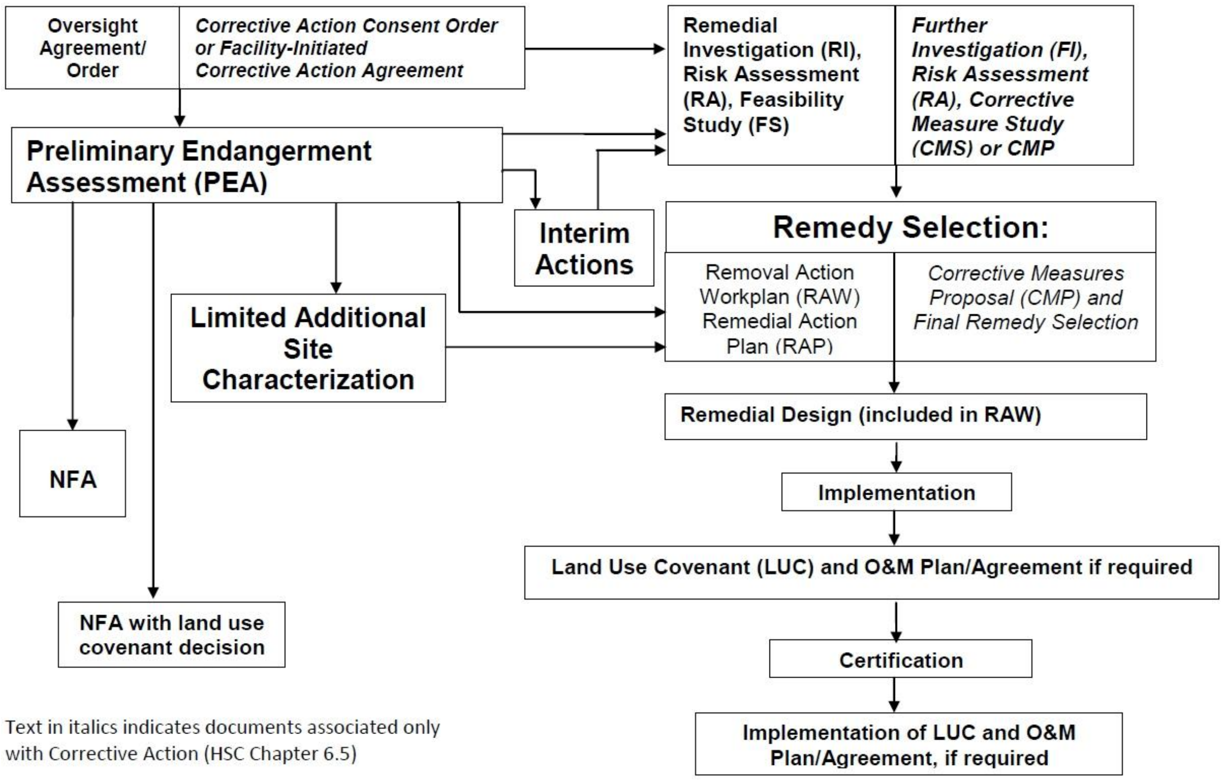


Figure J-1 **Flow diagram of the California cleanup process (Cal EPA, 2013)**

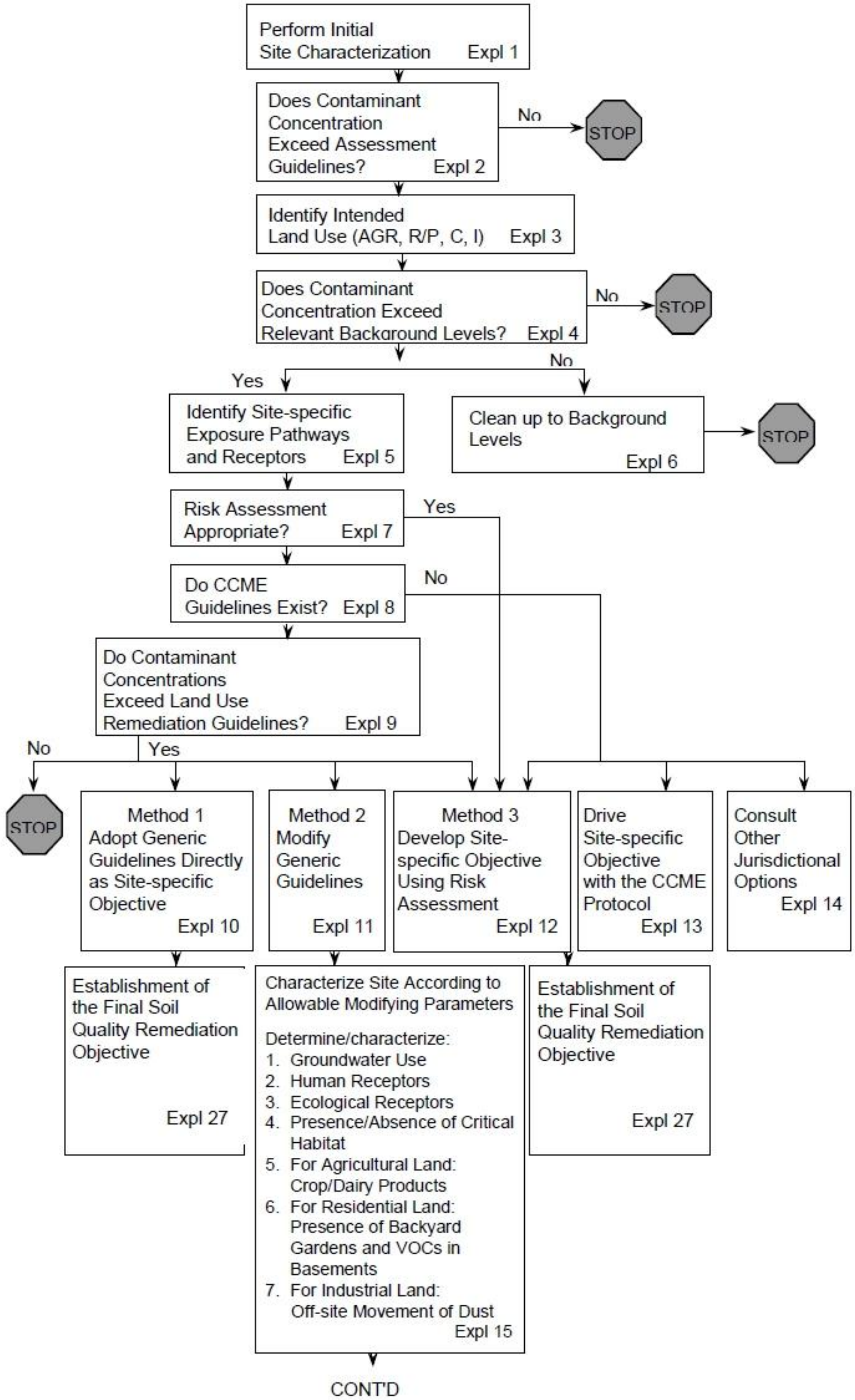


Figure J-2 **Flow diagram for Canada's setting of site-specific soil quality remediation objectives for contaminated sites (Part 1) (Canadian Council of MOE, 1996)**

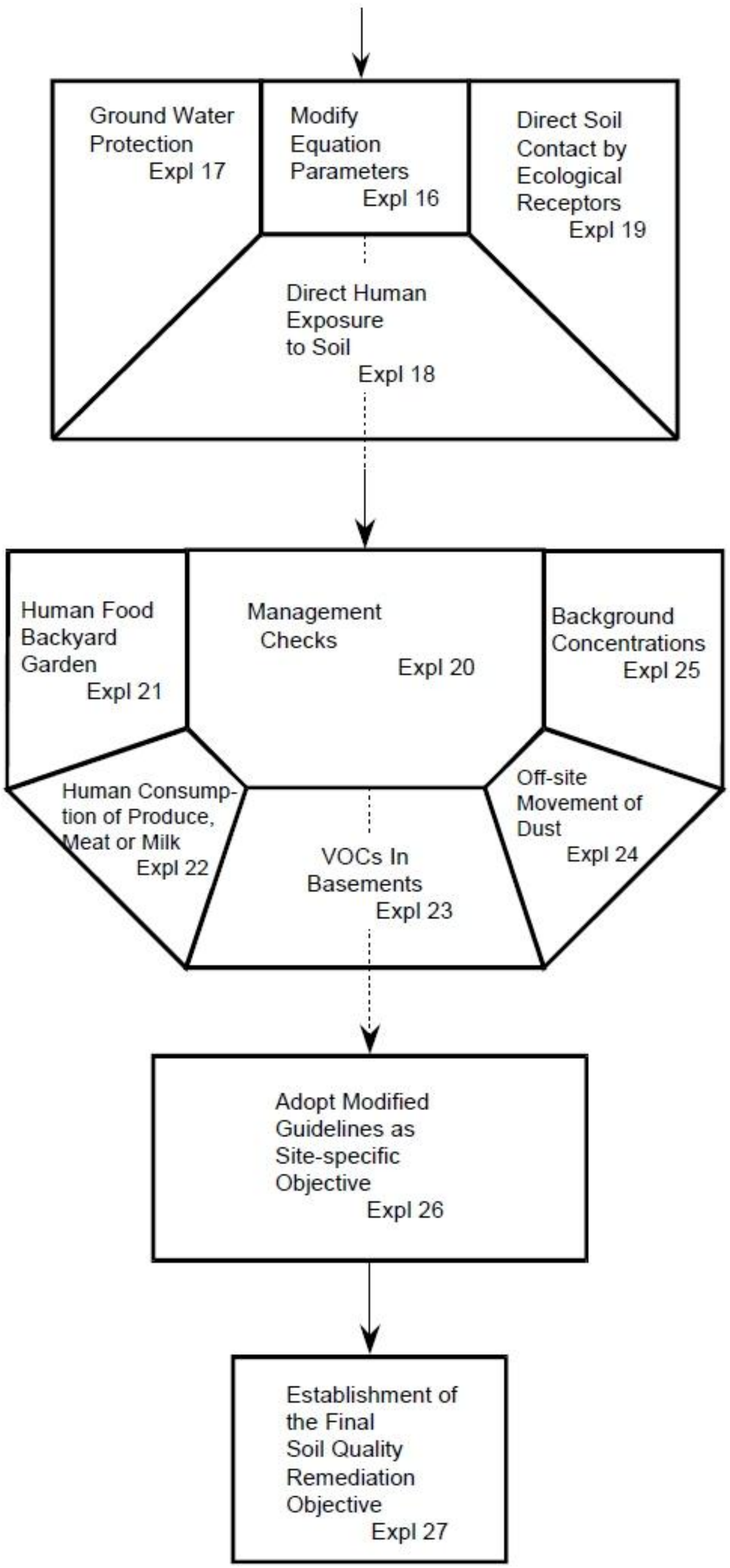


Figure J-3 **Flow diagram for Canada's setting of site-specific soil quality remediation objectives for contaminated sites (Part 2) (Canadian Council of MOE, 1996)**

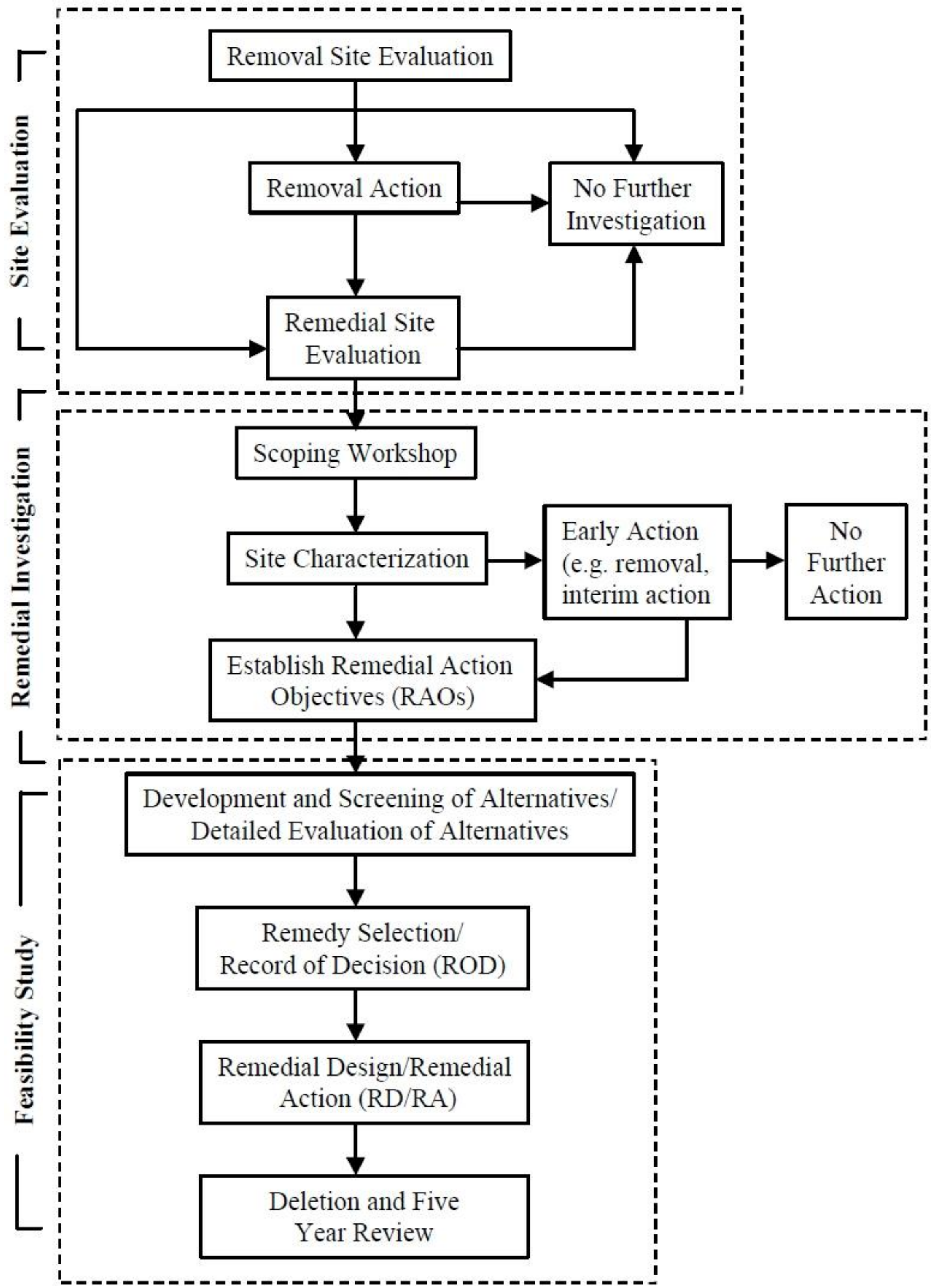


Figure J-4 **Flow diagram of DOE Remedial Investigation/Feasibility Study process (DOE, 1999)**

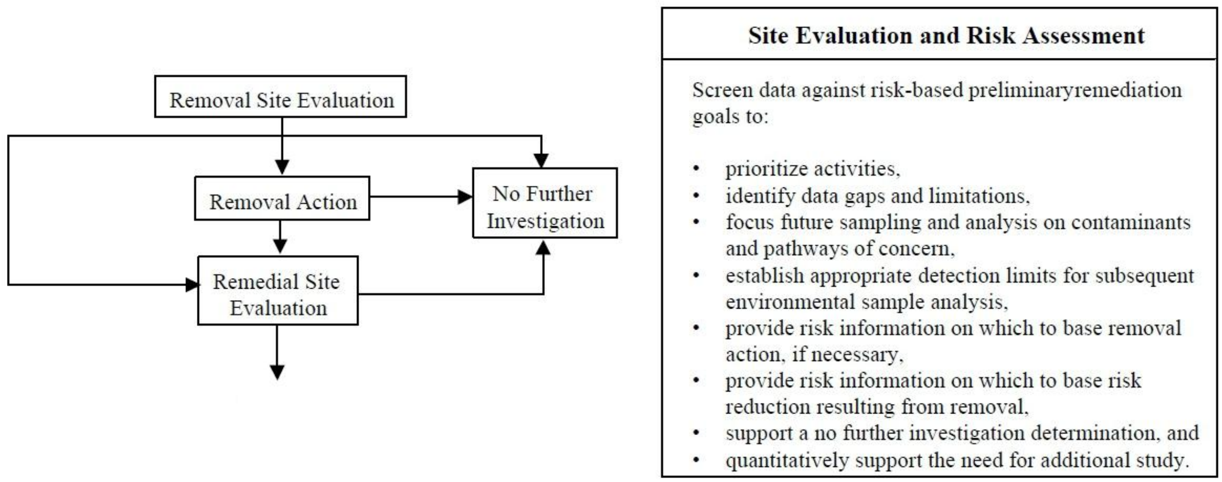


Figure J-5 Flow diagram of DOE Site Evaluation and Risk Assessment (DOE, 1999)

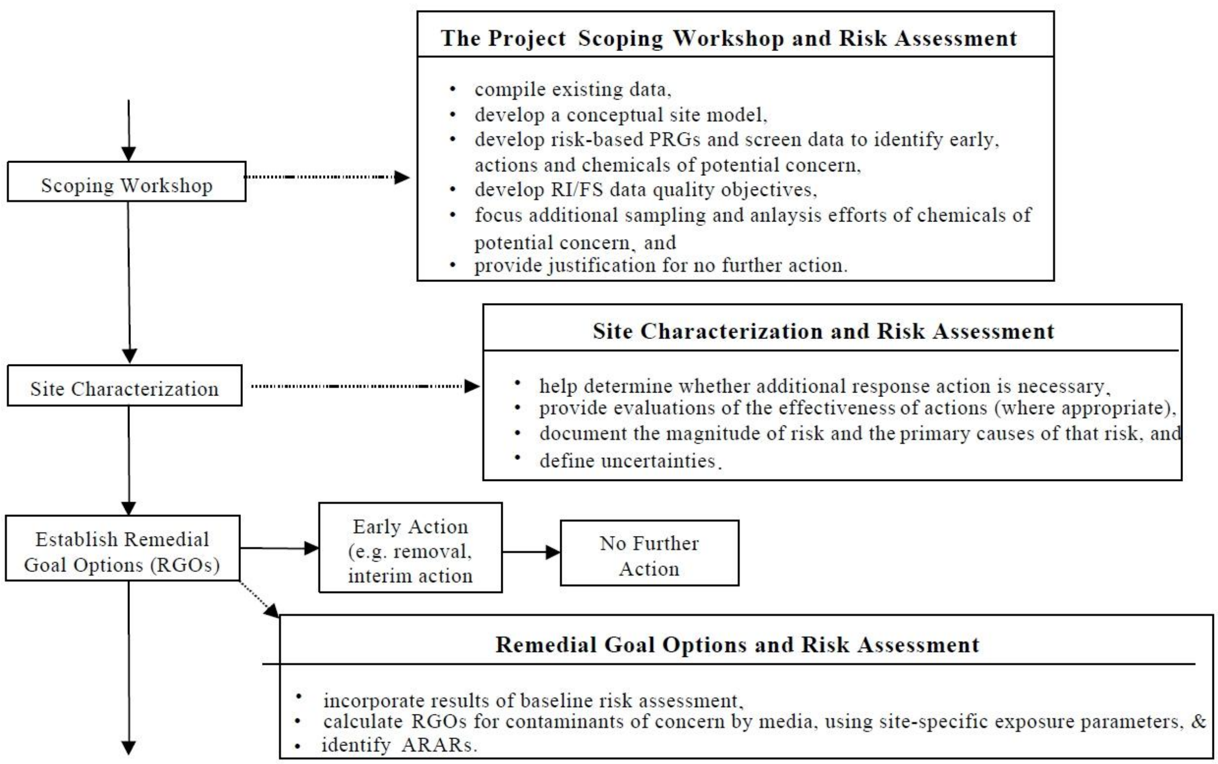


Figure J-6 Flow diagram of DOE Remedial Investigation (DOE, 1999)

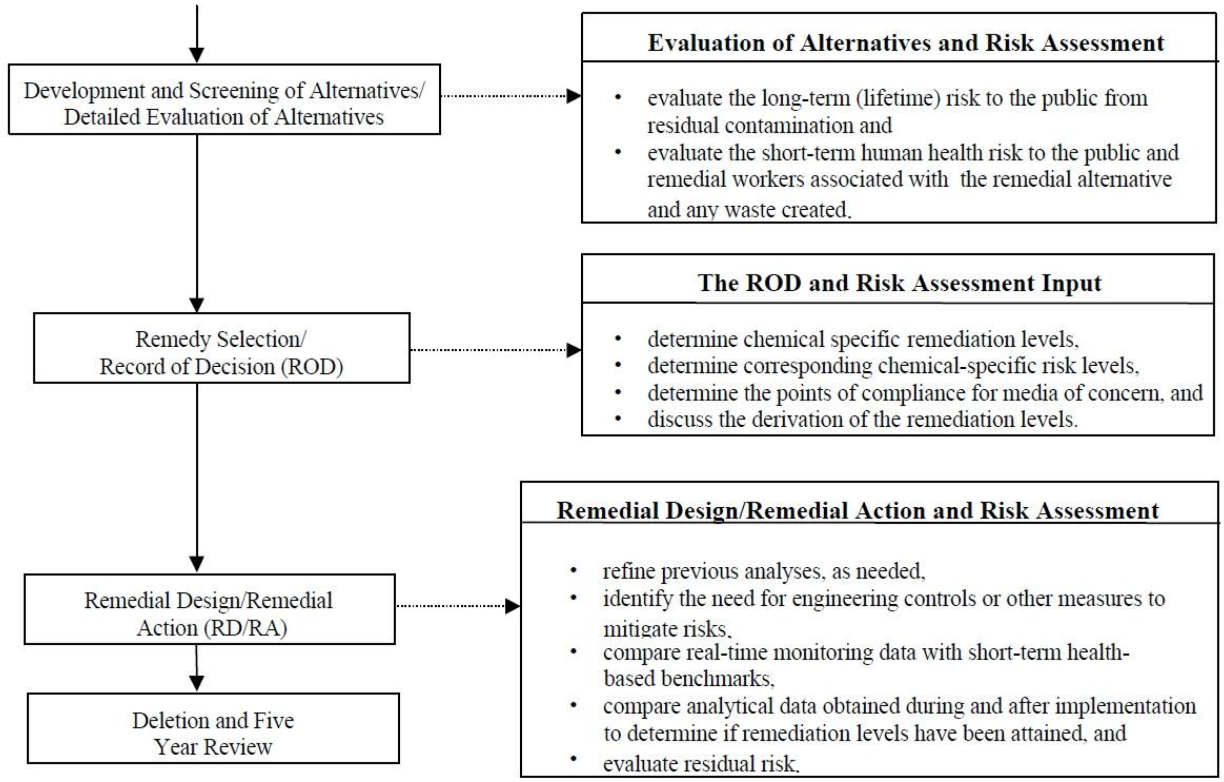


Figure J-7 Flow diagram of DOE Feasibility Study (DOE, 1999)

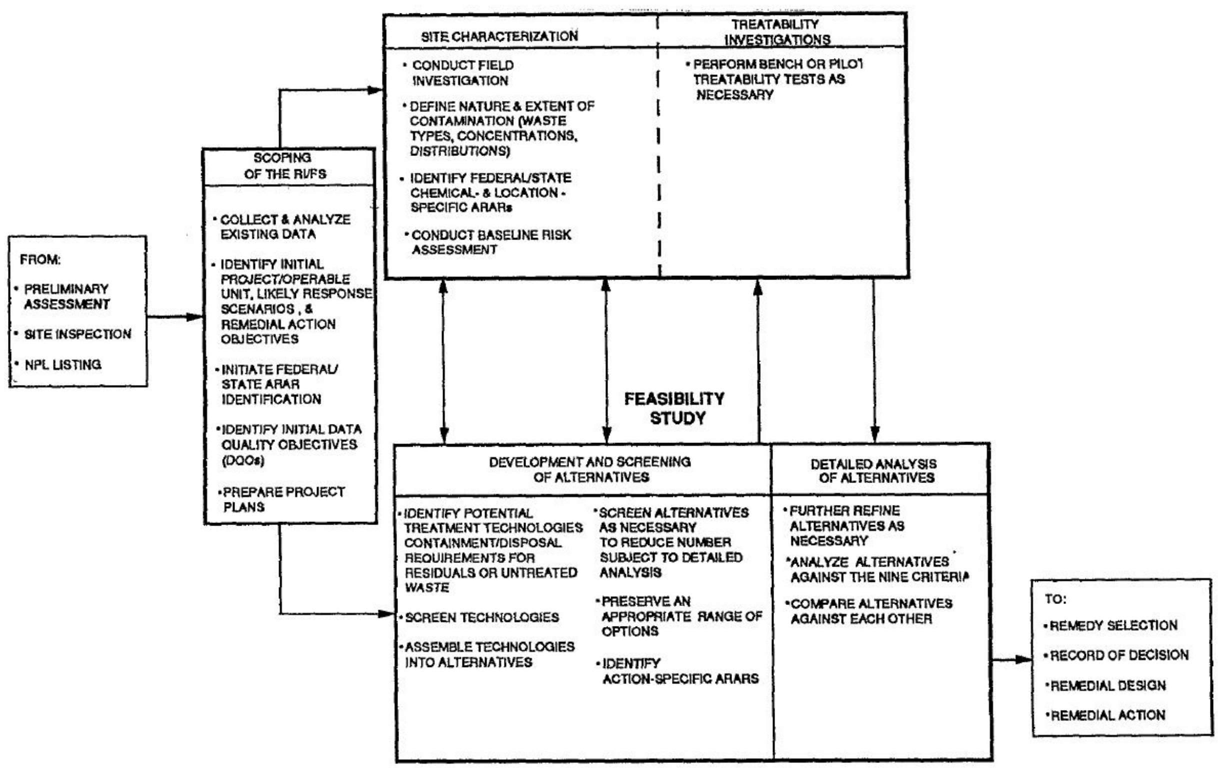


Figure J-8 **Flow diagram of the EPA phased RI/FS process (U.S. EPA, 1988). The State of Maine references EPA guidance and uses the same approach.**

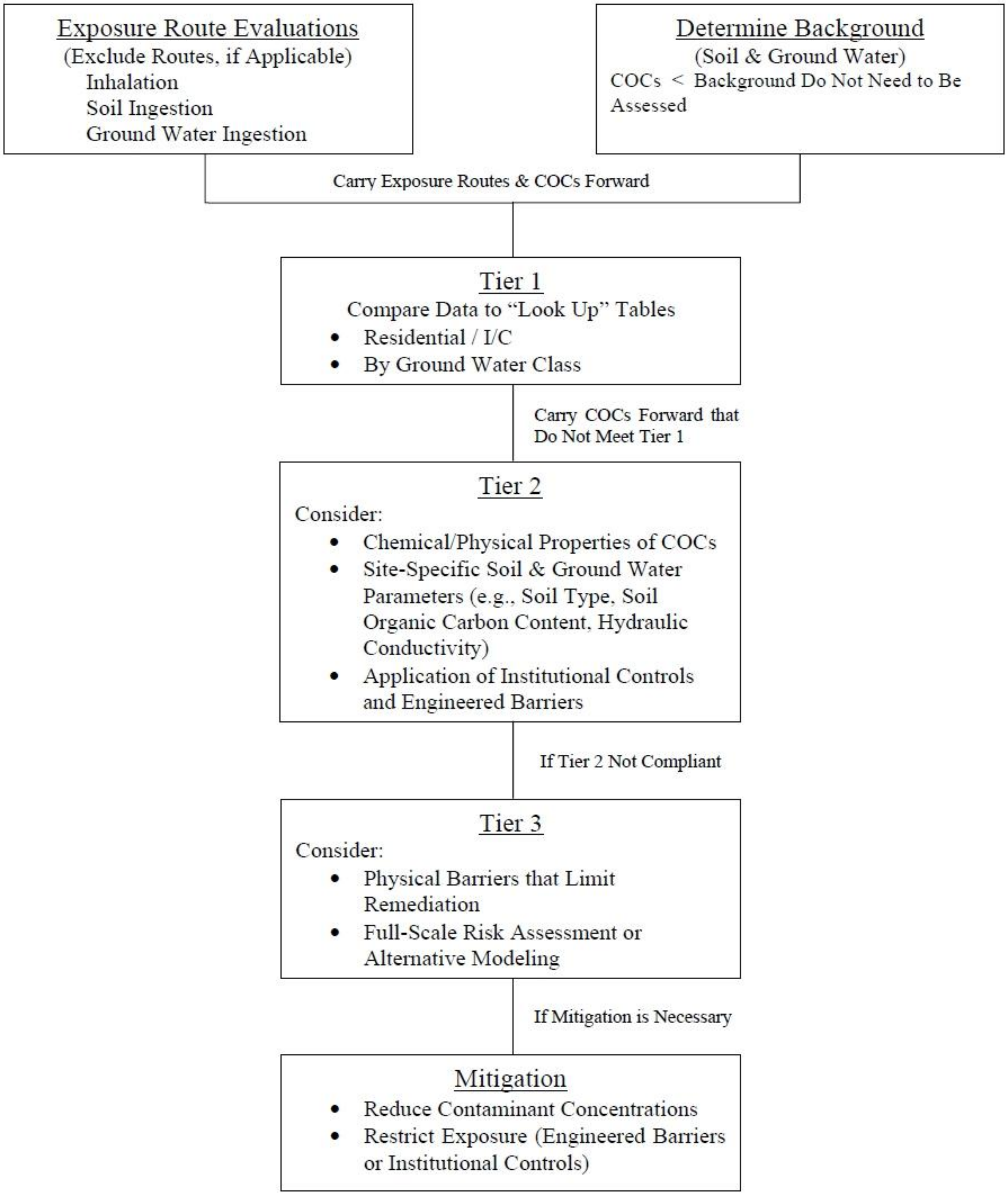


Figure J-9 Flow diagram of Illinois Tiered Approach to Corrective Action (TACO)

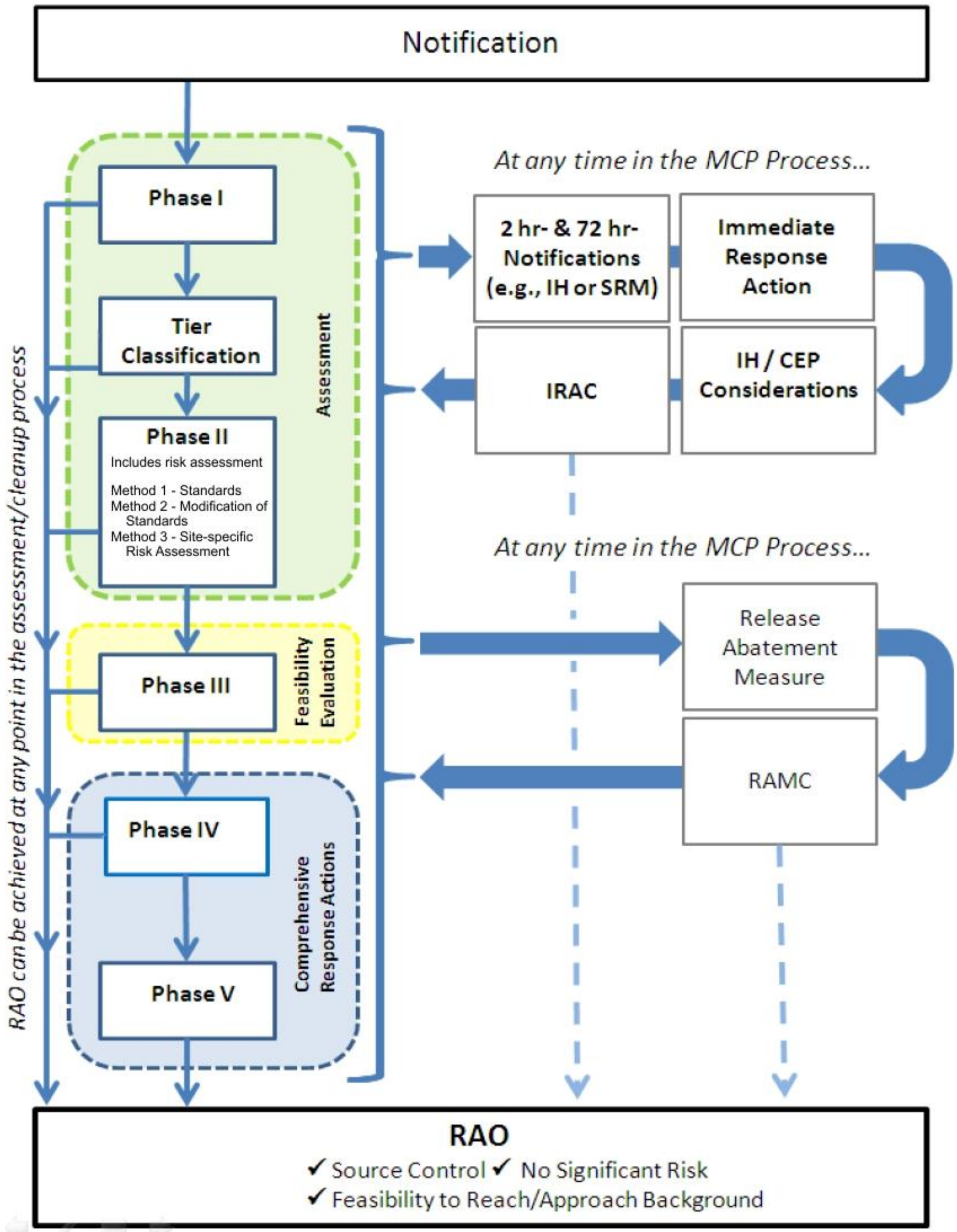


Figure J-10 **Flow diagram of Massachusetts management of contaminated sites (Adapted from MA DEP, 2011)**

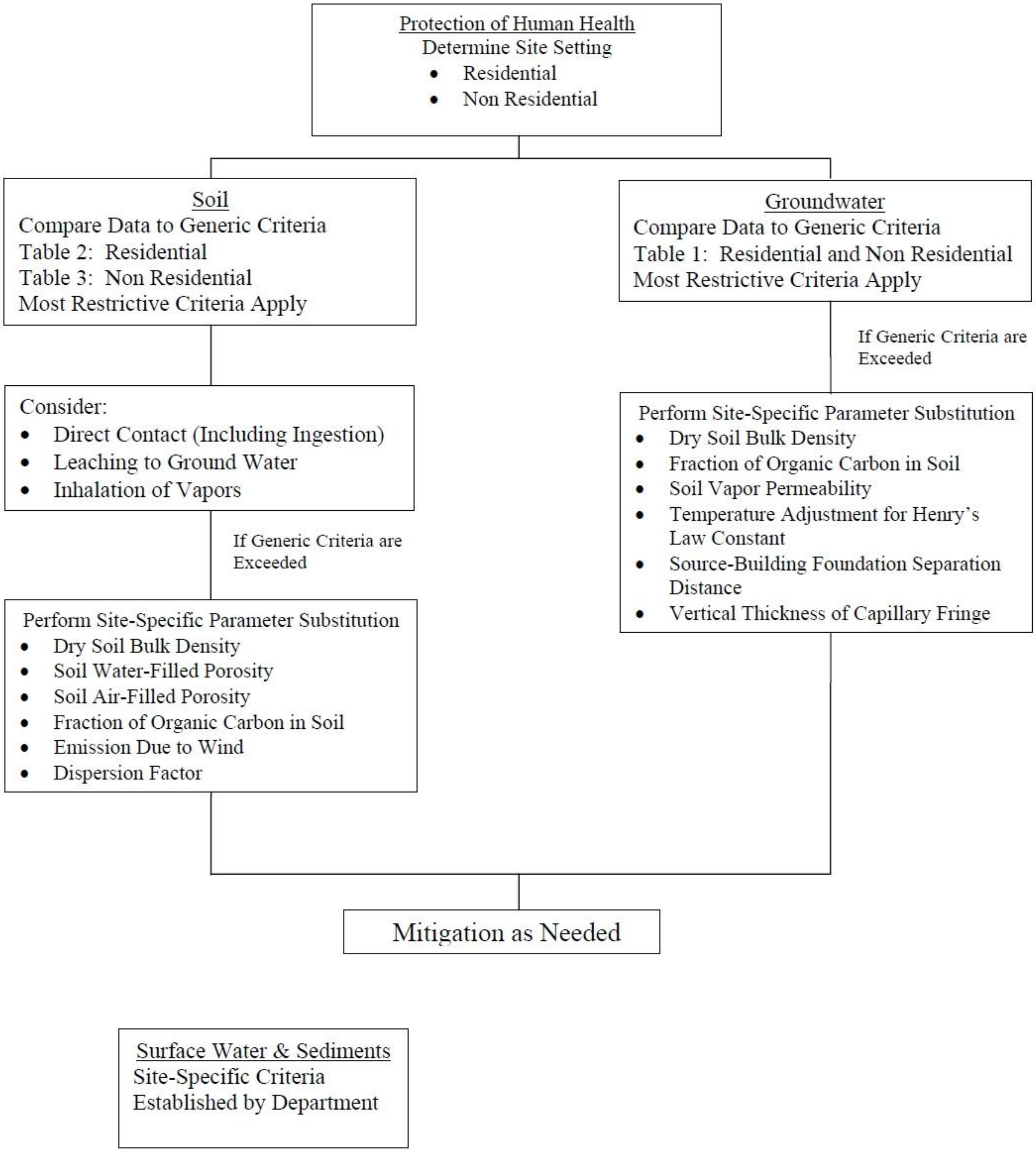
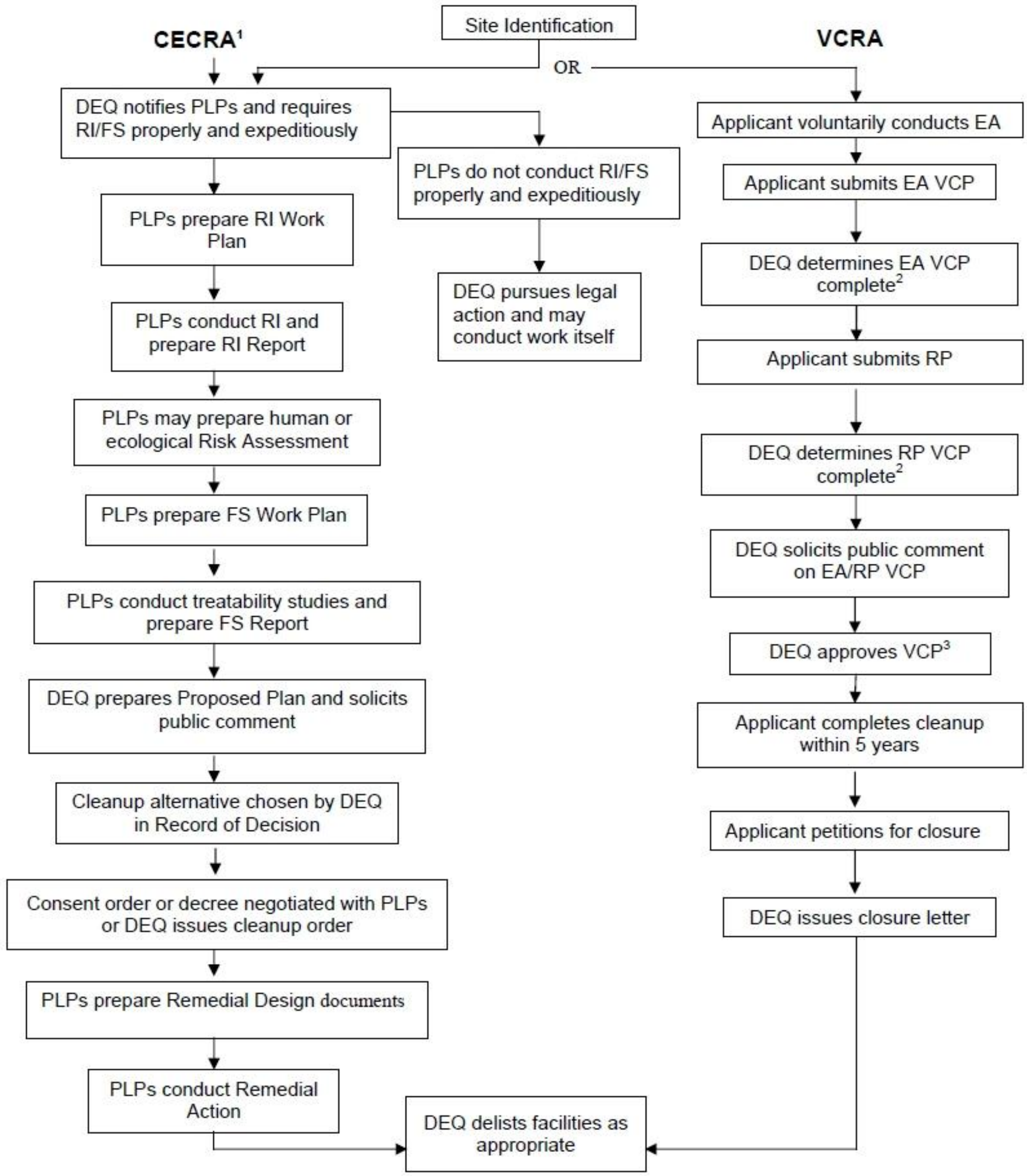


Figure J-11 Flow diagram of Michigan cleanup requirements for response activity



[1] Additional public comment may be solicited, interim actions that are consistent with the final remedy may be conducted, and PLPs may petition for allocation under CALA at any time in the CECRA process.

[2] A VCP may require more than one revision to be deemed complete.

[3] A PLP with an approved VCP may petition for allocation under CALA. If VCP not approved, applicant can revise and resubmit VCP.

CECRA - Montana Comprehensive Environmental Cleanup and Responsibility Act
VCRA - Montana Voluntary Cleanup and Redevelopment Act
CALA - Montana Controlled Allocation of Liability Act
DEQ - Montana Department of Environmental Quality

RI - Remedial Investigation
FS - Feasibility Study
PLP - potentially liable person
RP - Remediation Proposal
EA - Environmental Assessment
VCP - Voluntary Cleanup Plan

Figure J-12 Flow diagram of Montana state superfund process (MT DEQ, 2014)

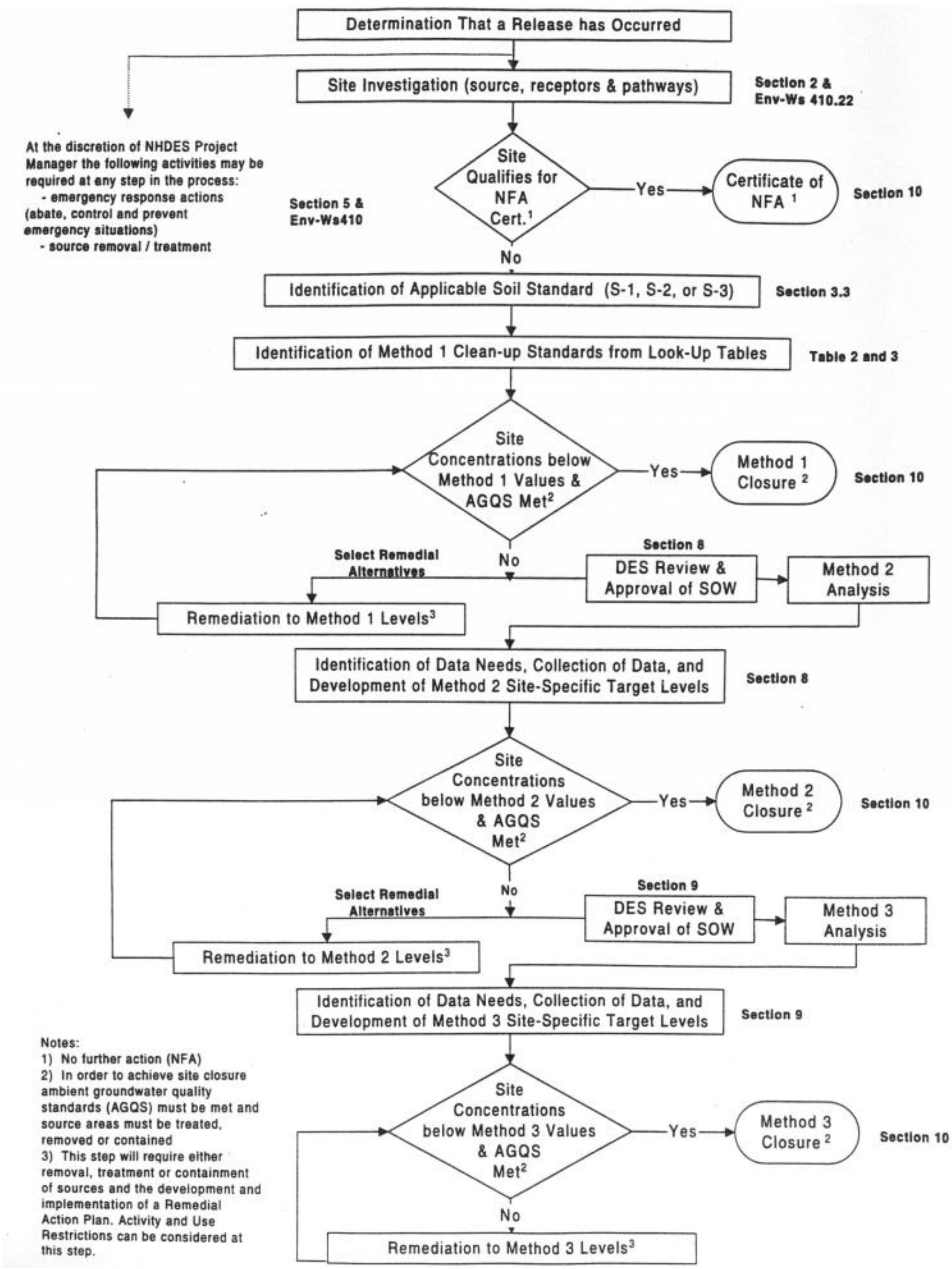


Figure J-13 **Flow diagram of the New Hampshire Risk-Based Corrective Action process (NH DES, 1998)**

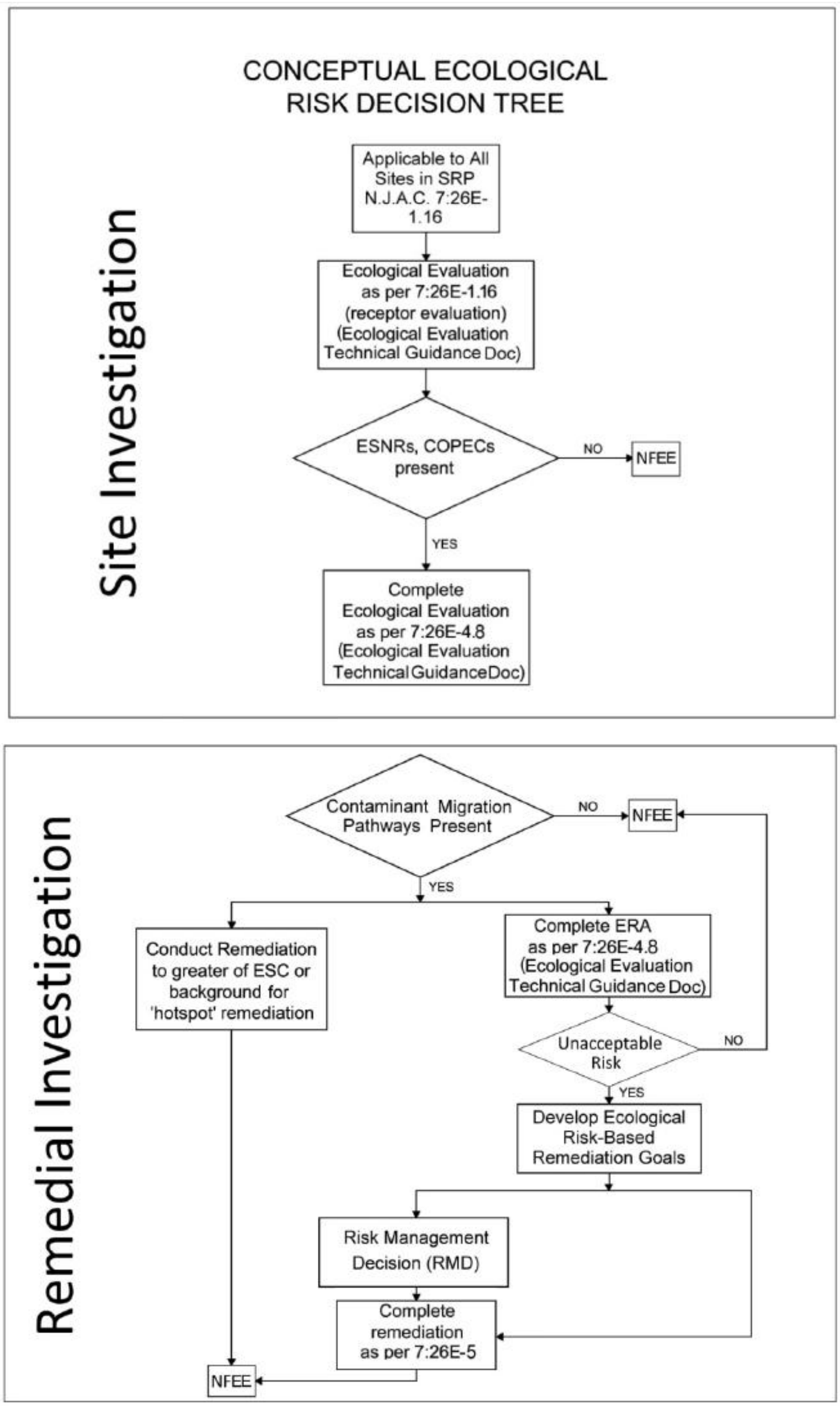


Figure J-14 **Flow diagram of the New Jersey ecological evaluation and risk assessment process (NJ DEP, 2012)**

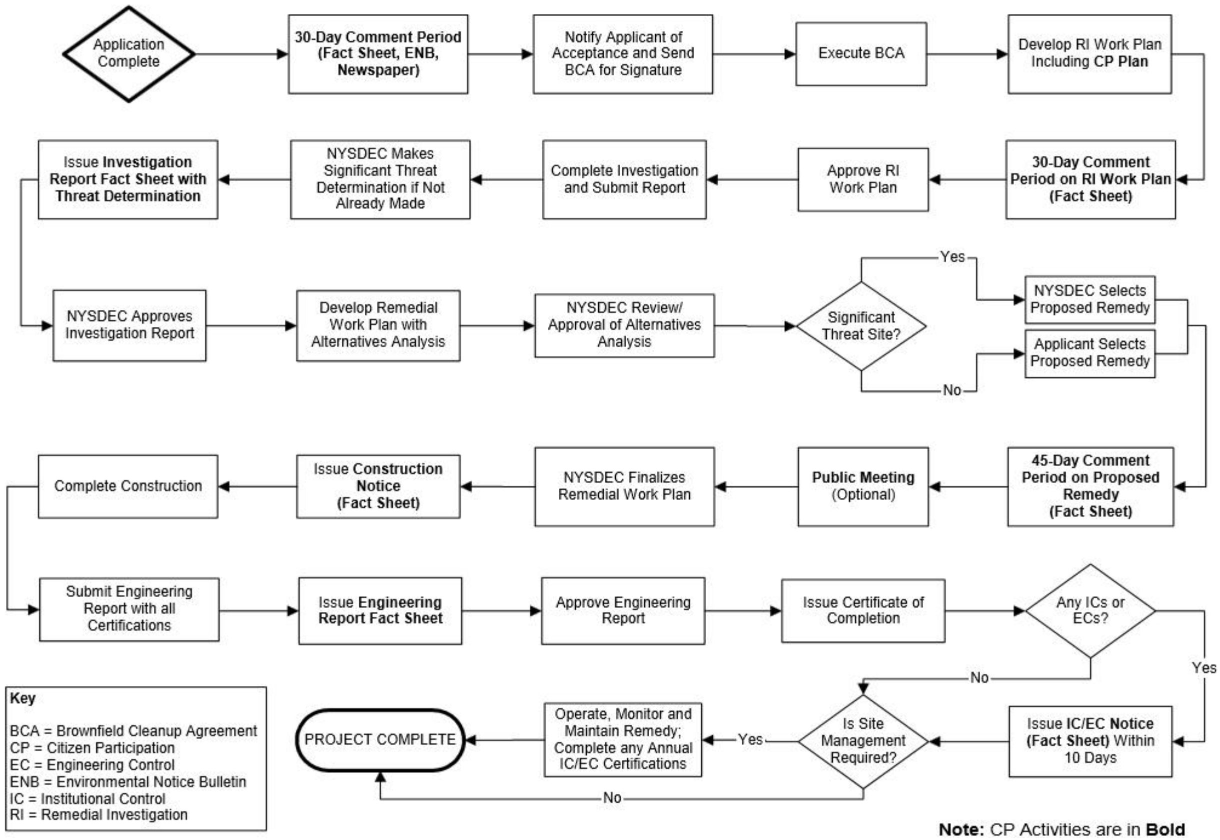


Figure J-15 Flow diagram of New York brownfield program remedial process (AECOM, 2010)

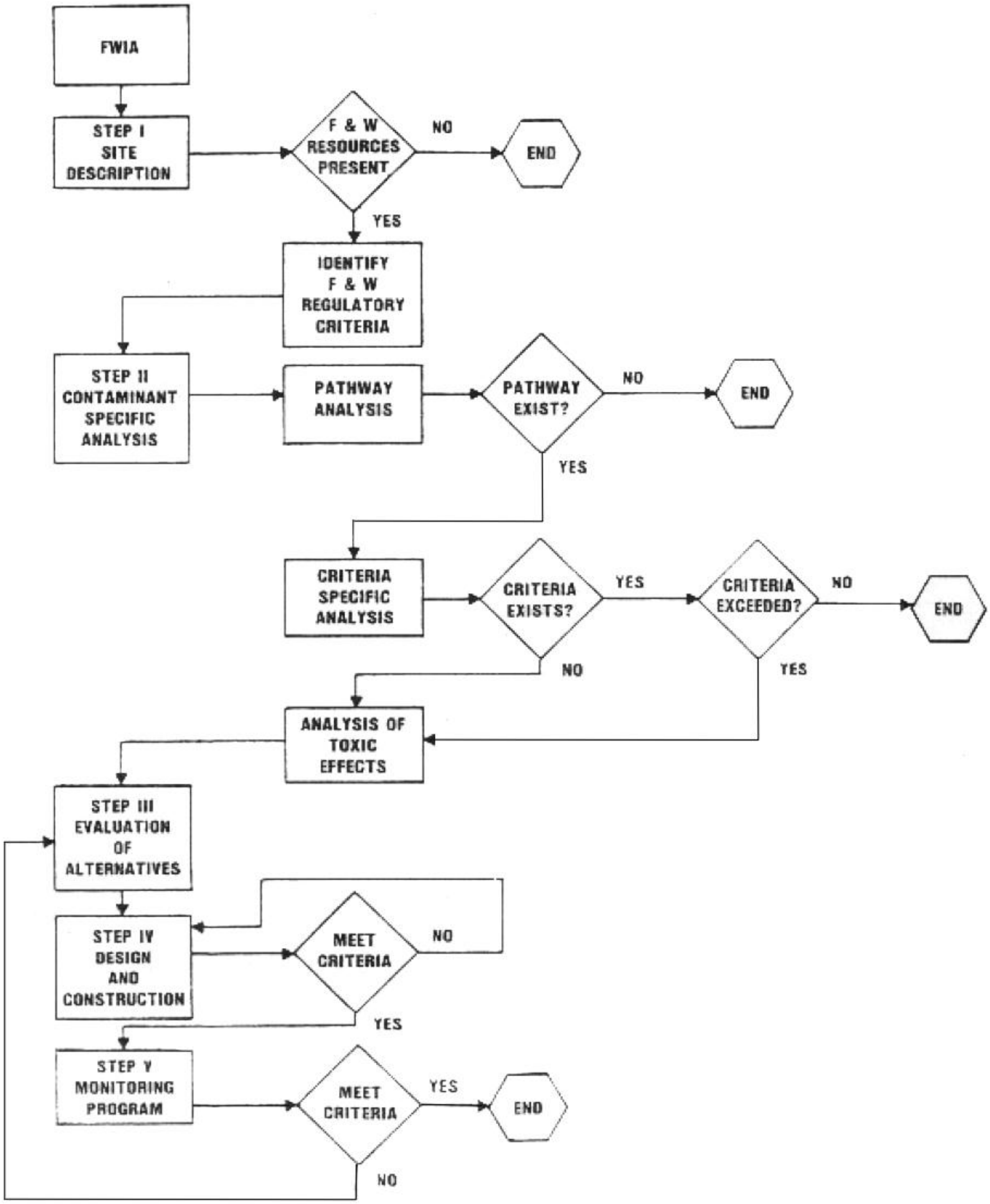


Figure J-16 **Flow diagram of New York Fish and Wildlife Impact Analysis (NYS DEC, 1994)**

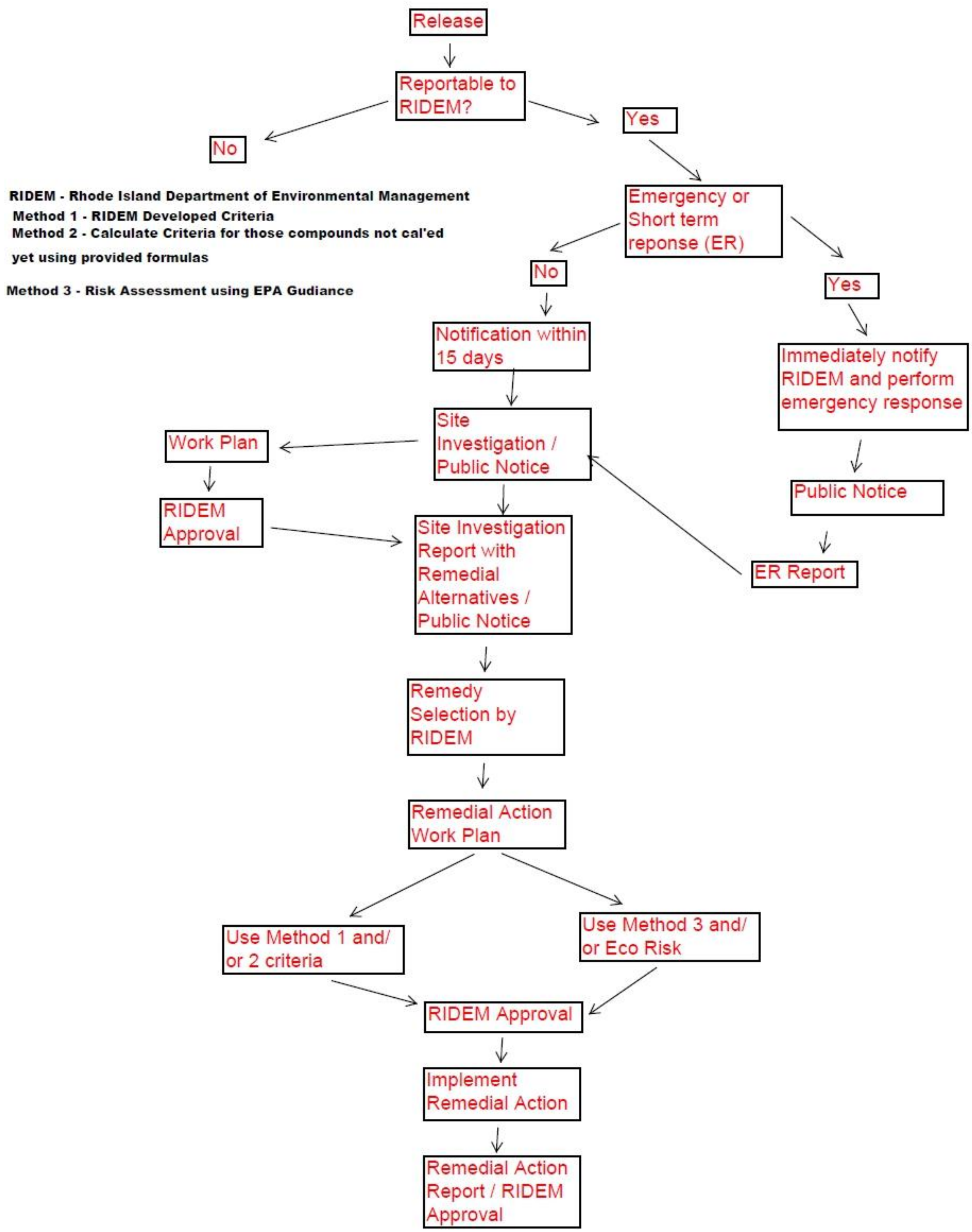


Figure J-17 Flow diagram of the Rhode Island remediation process

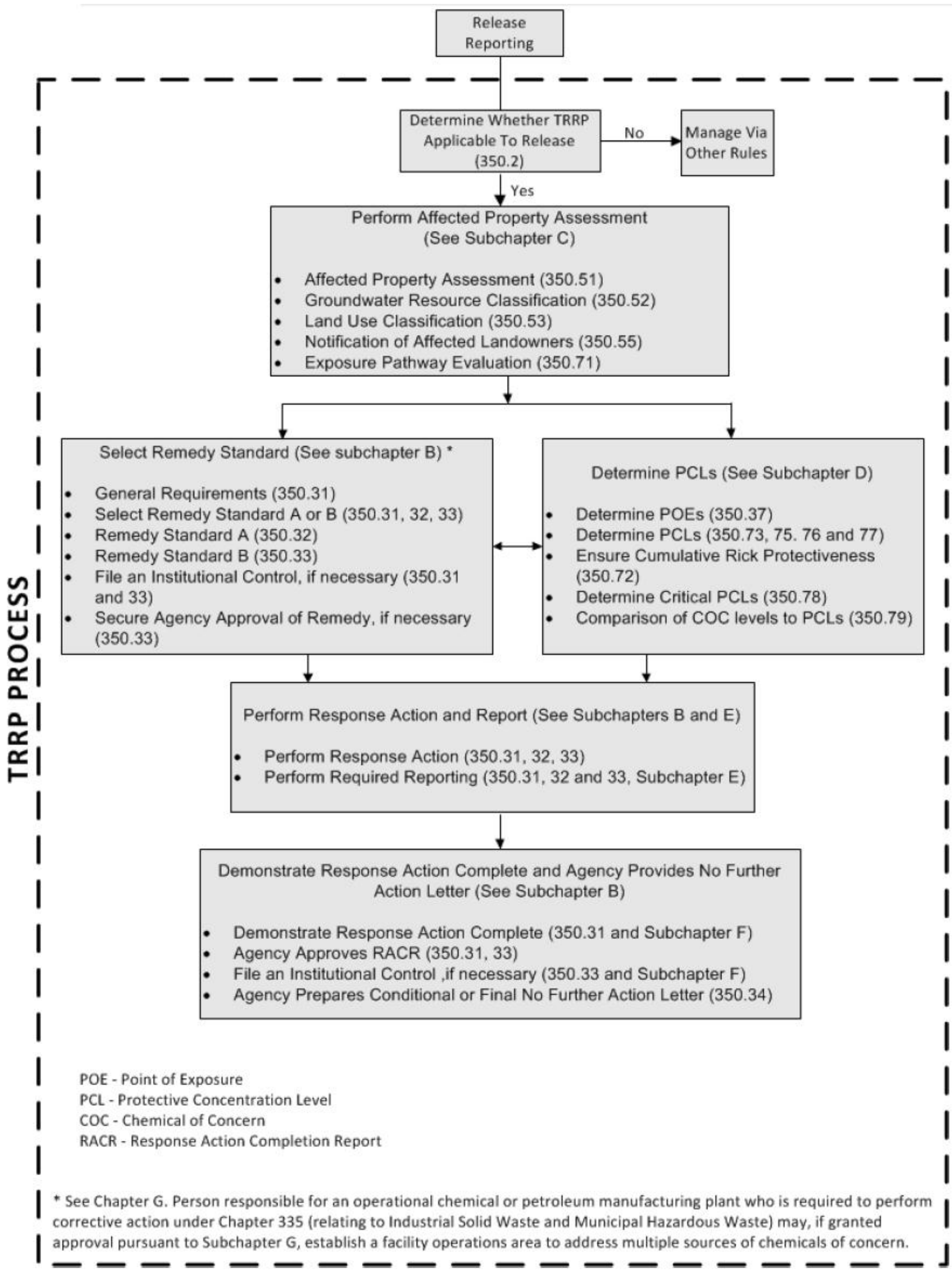


Figure J-18 Flow diagram of the Texas Risk Reduction Program (TCEQ, 2014)

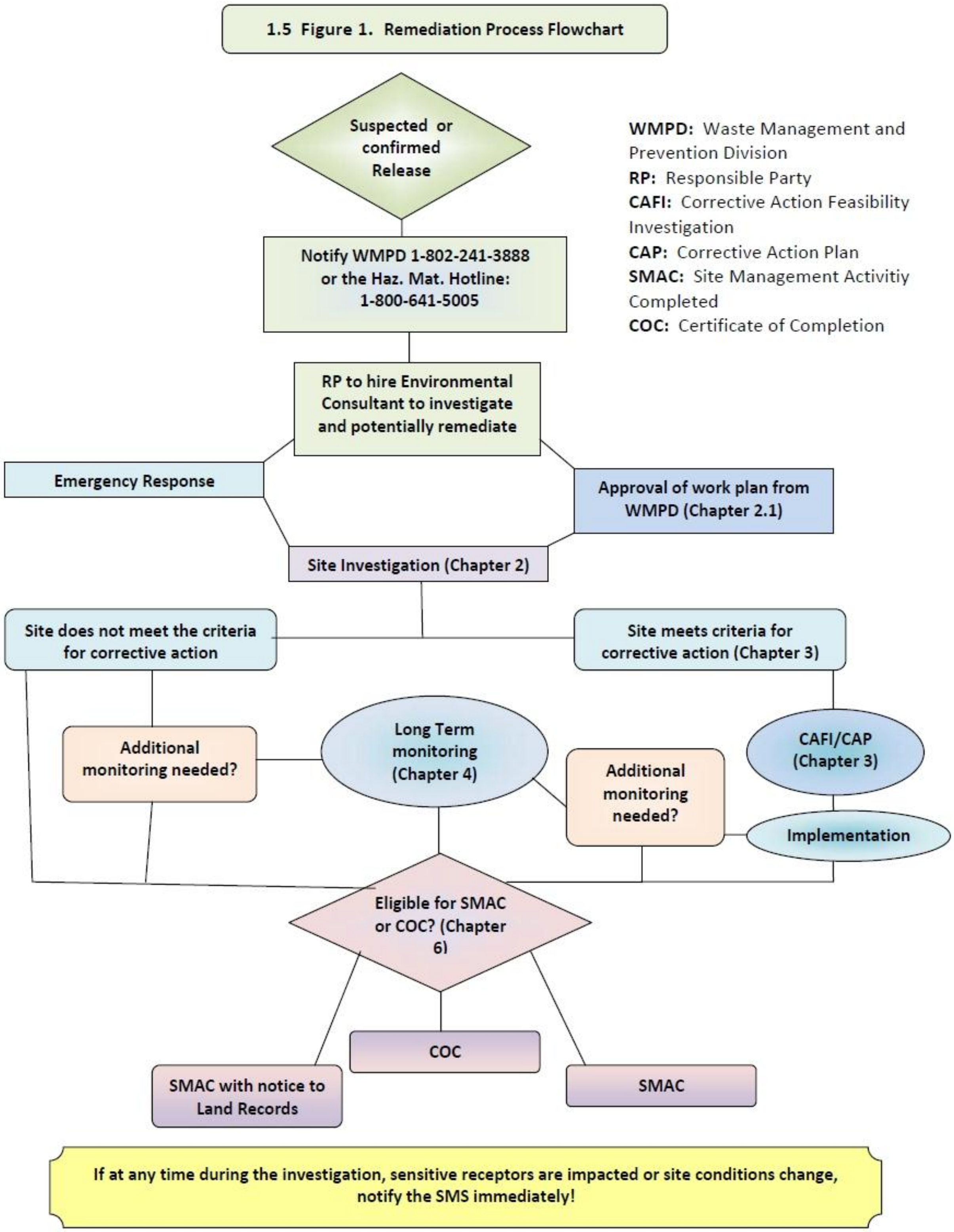


Figure J-19 Flow diagram of the Vermont remediation process (VT DEC, 2012)

Appendix K
Documents Consulted

California

Legislation

Document	URL	Date Accessed	Filename(s)
HSC Division 37 Regulation of Environmental Protection	http://leginfo.legislature.ca.gov/faces/codesTOCSelected.xhtml	3/13/2014	HSC Div 37 Reg of Env Protection.pdf
Carpenter-Presley-Tanner Hazardous Substance Account Act	http://ca.regstoday.com/law/hsc/ca.regstoday.com/laws/hsc/calaw-hsc_DIVISION20_CHAPTER6p8.aspx	3/13/2014	CaLaw-HSC_DIVISION20_CHAPTER6p8.pdf
Porter-Cologne Water Quality Control Act	http://www.swrcb.ca.gov/laws_regulations/docs/portercologne.pdf	3/13/2014	portercologne.pdf
California Land Environmental Restoration and Reuse Act (SB 32)	http://www.leginfo.ca.gov/pub/01-02/bill/sen/sb_0001-0050/sb_32_bill_20011012_chaptered.pdf	3/14/2014	sb_32_bill_20011012_chaptered.pdf

Regulations

Document	URL	Date Accessed	Filename(s)
Policies and Procedures for Investigation and Cleanup Abatement of Discharges Under Water Code Section 13304	http://www.waterboards.ca.gov/water_issues/programs/land_disposal/resolution_92_49.shtml	3/18/2014	resolution_92_49.pdf
Title 22 Social Security Division 4.5 Environmental Health Standards for the Management of Hazardous Waste	https://law.resource.org/pub/us/ccr/gov.ca.oal.title22.html	6/19/2014	Title22Div45.pdf

Guidance

Document	URL	Date Accessed	Filename(s)
Cleanup Guidance: Abandoned Mine Lands Site Discovery Process	http://dtsc.ca.gov/SiteCleanup/Brownfields/upload/SMBRP_AML_Guidance.pdf	3/14/2014	SMBRP_AML_Guidance.pdf
Advisory-Active Soil Investigations	http://dtsc.ca.gov/SiteCleanup/upload/VI_ActiveSoilGasAdvisory_FINAL_043012.pdf	3/14/2014	VI_ActiveSoilGasAdvisory_FINAL_043012.pdf
Guidelines for Oversight Agency Selection (CLERR)	http://www.calepa.ca.gov/brownfields/documents/2002/Guidelines.pdf	3/14/2014	Guidelines.pdf
Use of California Human Health Screening Levels (CHHSLs) in Evaluation of Contaminated Properties	http://www.calepa.ca.gov/brownfields/documents/2005/CHHSLsGuide.pdf	3/14/2014	CHHSLsGuide.pdf
Human-Exposure-Based Screening Numbers Developed to Aid Estimation of Cleanup Costs for Contaminated Soil	http://www.calepa.ca.gov/brownfields/documents/2005/NumberReport.pdf	3/14/2014	NumberReport.pdf
Hazard-Risk Calculator	http://www.calepa.ca.gov/brownfields/documents/2005/Calculator.xls	3/14/2014	Calculator.xls
Implementation Guide - Site Designation	http://www.calepa.ca.gov/programs/sitedesig/guide/default.htm	3/18/2014	SiteDesignationGuide2006.pdf
Aquifer Testing for Hydrogeologic Characterization	http://dtsc.ca.gov/SiteCleanup/upload/SMP_Aquifer_Testing.pdf	3/18/2014	SMP_Aquifer_Testing.pdf
Ground Water Modeling for Hydrogeologic Characterization	http://dtsc.ca.gov/SiteCleanup/upload/SMP_Groundwater_Modeling.pdf	3/18/2014	SMP_Groundwater_Modeling.pdf
Reporting Hydrogeologic Characterization Data at Hazardous Substance Release Sites	http://dtsc.ca.gov/SiteCleanup/upload/SMP_Report-Hydrogeologic_Char_Data.pdf	3/18/2014	SMP_Report-Hydrogeologic_Char_Data.pdf
Representative Sampling of Ground Water for Hazardous Substances	http://www.dtsc.ca.gov/SiteCleanup/upload/SMP_Representative_Sampling_GroundWater.pdf	3/18/2014	SMP_Representative_Sampling_GroundWater.pdf
Application of Surface Geophysics at Contaminated Sites	http://www.dtsc.ca.gov/PublicationsForms/upload/Final_Surface_Geophysics_Guidance.pdf	3/18/2014	Final_Surface_Geophysics_Guidance.pdf
Guidelines for Planning and Implementing Groundwater Characterization of Contaminated Sites	http://www.dtsc.ca.gov/SiteCleanup/upload/Guidelines_GW_Characterization.pdf	3/18/2014	Guidelines_GW_Characterization.pdf
Preliminary Endangerment Assessment Guidance Manual	http://www.dtsc.ca.gov/SiteCleanup/Brownfields/upload/Preliminary-Endangerment-Assessment-Guidance-Manual.pdf	3/18/2014	Preliminary-Endangerment-Assessment-Guidance-Manual.pdf
Drilling, Logging, and Sampling at Contaminated Sites	http://www.dtsc.ca.gov/PublicationsForms/upload/Drilling_Logging_Sampling_Cont_Sites.pdf	3/18/2014	Drilling_Logging_Sampling_Cont_Sites.pdf
Selecting Inorganic Constituents as Chemicals of Potential Concern at Risk Assessments at Hazardous Waste Sites - Final Policyand Permitted Facilities	http://www.dtsc.ca.gov/AssessingRisk/upload/backgrnd.pdf	3/18/2014	backgrnd.pdf
A decision tree incorporating vapor intrusion into screening risk assessments	http://www.dtsc.ca.gov/AssessingRisk/upload/final_SOT_handout_6-19.pdf	3/18/2014	final_SOT_handout_6-19.pdf
Vapor Intrusion Mitigation Advisory	http://www.dtsc.ca.gov/SiteCleanup/upload/VIMA_Final_Oct_20111.pdf	3/18/2014	VIMA_Final_Oct_20111.pdf
Vapor Intrusion Guidance-Final Oct 2011	http://www.dtsc.ca.gov/AssessingRisk/upload/Final_VIG_Oct_2011.pdf	3/18/2014	Final_VIG_Oct_2011.pdf
Air Toxics Hot Spots Program Risk Assessment Guidelines	http://www.oehha.org/air/hot_spots/pdf/HRAguidefinal.pdf	6/18/2014	HRAguidefinal.pdf
Supplemental Guidance for Human Health Multimedia Risk Assessments of Hazardous Waste Sites and Permitted Facilities	https://dtsc.ca.gov/AssessingRisk/Supplemental_Guidance.cfm	6/18/2014	Supp Guidance for HH MMRA.pdf
CalTOX Model	http://www.dtsc.ca.gov/AssessingRisk/ctox_dwn.cfm	6/18/2014	caltox23.exe, datcal.exe, datref.exe
CalTOX, A Multimedia Total Exposure Model for Hazardous-Waste Sites	http://www.dtsc.ca.gov/AssessingRisk/ctox_model.cfm	6/18/2014	CalTOX Model for Haz Waste Sites.pdf
CalTOX Version 2.3 Description of Modifications and Revisions	http://www.dtsc.ca.gov/AssessingRisk/ctox_model.cfm	6/18/2014	mod2_3.pdf
Modifications of CalTOX to Assess the Potential Health Impacts of Hazardous Wastes Landfills	http://www.dtsc.ca.gov/AssessingRisk/ctox_model.cfm	6/18/2014	modrespn.pdf
CalTOX Spreadsheet User's Guide	http://www.dtsc.ca.gov/AssessingRisk/ctox_dwn.cfm	6/18/2014	userman.pdf
LeadSpread 8	http://www.dtsc.ca.gov/AssessingRisk/LeadSpread8.cfm	6/18/2014	BLOODPB8.xls
LeadSpread 8 User's Guide and Recommendations for Evaluation of Lead Exposures in Adults	http://www.dtsc.ca.gov/AssessingRisk/LeadSpread8.cfm	6/18/2014	LeadSpread8_UserGuide.pdf
Human Health Risk Assessment Note 1	http://www.dtsc.ca.gov/AssessingRisk/upload/HHRA_Note1.pdf	6/18/2014	HHRA_Note1.pdf
Human Health Risk Assessment Note 2	http://www.dtsc.ca.gov/AssessingRisk/upload/HHRA_Note2_dioxin-2.pdf	6/18/2014	HHRA_Note2_dioxin-2.pdf
Human Health Risk Assessment Note 3	http://www.dtsc.ca.gov/AssessingRisk/upload/HHRA-Note-3-2.pdf	6/18/2014	HHRA-Note-3-2.pdf
Human Health Risk Assessment Note 4	http://www.dtsc.ca.gov/AssessingRisk/upload/HHRA-Note-4.pdf	6/18/2014	HHRA-Note-4.pdf
Guidance for School Site Risk Assessment Pursuant to Health and Safety Code Section 901(f)	http://oehha.ca.gov/public_info/public/kids/pdf/SchoolscreenFinal.pdf	6/18/2014	SchoolscreenFinal.pdf
Guidance for Ecological Risk Assessment at Hazardous Waste Sites and Permitted Facilities; Part A: Overview	http://www.dtsc.ca.gov/AssessingRisk/upload/overview.pdf	6/19/2014	overview.pdf

Guidance for Ecological Risk Assessment at Hazardous Waste Sites and Permitted Facilities; Part B: Scoping Assessment	http://www.dtsc.ca.gov/AssessingRisk/upload/scope.pdf	6/19/2014	scope.pdf
HERD Ecological Risk Assessment Note 1	http://www.dtsc.ca.gov/AssessingRisk/upload/econote1.pdf	6/19/2014	econote1.pdf
HERD Ecological Risk Assessment Note 2	http://www.dtsc.ca.gov/AssessingRisk/upload/econote2.pdf	6/19/2014	econote2.pdf
HERD Ecological Risk Assessment Note 3	http://www.dtsc.ca.gov/AssessingRisk/upload/econote3.pdf	6/19/2014	econote3.pdf
HERD Ecological Risk Assessment Note 4	http://www.dtsc.ca.gov/AssessingRisk/upload/econote4.pdf	6/19/2014	econote4.pdf
HERD Ecological Risk Assessment Note 5	http://www.dtsc.ca.gov/AssessingRisk/upload/econote5.pdf	6/19/2014	econote5.pdf
HERD Ecological Risk Assessment Note 6	http://www.dtsc.ca.gov/AssessingRisk/upload/CdEconote_Final.pdf	6/19/2014	CdEconote_Final.pdf
Department of Toxic Substances Control Public Participation Manual	http://www.dtsc.ca.gov/LawsRegsPolicies/Policies/PPP/upload/DTSC-PublicParticipationManual.pdf	6/20/2014	DTSC-PublicParticipationManual.pdf

Other

Document	URL	Date Accessed	Filename(s)
A Guide to Health Risk Assessment	http://oehha.ca.gov/pdf/HRSguide2001.pdf	3/14/2014	HRSguide2001.pdf
The Voluntary Cleanup Program	http://dtsc.ca.gov/SiteCleanup/Brownfields/upload/BF_FS_VCP.pdf	3/14/2014	BF_FS_VCP.pdf
Site Investigation and Remediation Processes	http://www.calepa.ca.gov/brownfields/documents/2003/SB32Info.pdf	3/14/2014	SB32Info.pdf
A Review of the California Environmental Protection Agency's Risk Assessment Practices, Policies, and Guidelines	http://oehha.ca.gov/risk/raac/final.html	6/18/2014	Review of CalEPA Risk Assessment Practices.pdf

Canada

Legislation

Document	URL	Date Accessed	File Name
Canadian Environmental Protection Act, 1999 (CEPA 1999)	http://www.ec.gc.ca/lcpe-cepa/default.asp?lang=En&n=26A03BFA-1	3/6/2014	Canadian Environmental Protection Act 1999.pdf

Regulations

Document	URL	Date Accessed	File Name
Storage Tank Systems for Petroleum Products and Allied Petroleum Products Regulations (SOR/SOR/2008-197)	http://www.ec.gc.ca/lcpe-cepa/eng/regulations/detailReg.cfm?intReg=110	3/6/2014	SOR-2008-197.pdf

Guidance

Document	URL	Date Accessed	File Name
Health Canada			
Federal Contaminated Site Risk Assessment in Canada, Part I: Guidance on Human Health Preliminary Quantitative Risk Assessment (PQRA), Version 2.0	http://www.hc-sc.gc.ca/ewh-semt/pubs/contamsite/part-partie_i/index-eng.php	2/27/2014	Part I - Guidance on Human Health Preliminary Quantitative Risk Assessment.pdf
Federal Contaminated Site Risk Assessment in Canada, Part II: Health Canada Toxicological Reference Values (TRVs) and Chemical-Specific Factors, Version 2.0	http://www.hc-sc.gc.ca/ewh-semt/pubs/contamsite/part-partie_ii/index-eng.php	2/27/2014	Part II - Health Canada Toxicological Reference Values and Chemical Specific Factors.pdf
Federal Contaminated Site Risk Assessment in Canada, Part III: Guidance on Peer Review of Human Health Risk Assessments for Federal Contaminated Sites in Canada, Version 2.0	http://www.hc-sc.gc.ca/ewh-semt/pubs/contamsite/part-partie_iii/index-eng.php	2/27/2014	Part III - Guidance on Peer Review of Human Health Risk Assessments.pdf
Part V - Guidance On Human Health Detailed Quantitative Risk Assessment for Chemicals.pdf	http://www.hc-sc.gc.ca/ewh-semt/pubs/contamsite/chem-chim/index-eng.php	6/12/2014	Part V - Guidance On Human Health Detailed Quantitative Risk Assessment for Chemicals.pdf
Federal Contaminated Sites Action Plan (FCSAP)	http://www.federalcontaminatedsites.gc.ca/default.asp?lang=En&n=BAC292EB-1	2/27/2014	Federal Contaminated Sites Portal - Federal Contaminated Sites Portal.htm
FCSAP Ecological Risk Assessment Guidance	http://www.federalcontaminatedsites.gc.ca/B15E990A-C0A8-4780-9124-07650F3A68EA/ERA%20Guidance%2030%20March%202012_FINAL_En.pdf	2/27/2014	ERA Guidance 30 March 2012_FINAL_En.pdf
Ecological Risk Assessment Guidance Module 1: Toxicity Test Selection and Interpretation	http://www.federalcontaminatedsites.gc.ca/B15E990A-C0A8-4780-9124-07650F3A68EA/ERA%20Module%201_en%20Final-R.pdf	2/28/2014	FCSAP ERA Module 1.pdf
Ecological Risk Assessment Guidance Module 2: Selection or Development of Site-specific Toxicity Reference Values	http://www.federalcontaminatedsites.gc.ca/B15E990A-C0A8-4780-9124-07650F3A68EA/13-049%20EC%20ERA%20Module%202_ENG.PDF	2/28/2014	FCSAP ERA Module 2.pdf
Supplemental Guidance for Ecological Risk Assessment Causality Assessment Module 4	http://www.federalcontaminatedsites.gc.ca/B15E990A-C0A8-4780-9124-07650F3A68EA/13-049-ERA_Module%204-ENG.pdf	2/28/2014	FCSAP ERA Module 4.pdf
Statements of Work for Ecological Risk Assessments at Federal Sites	http://www.federalcontaminatedsites.gc.ca/B15E990A-C0A8-4780-9124-07650F3A68EA/13-049-ERA_Module%206-ENG.PDF	2/28/2014	FCSAP ERA Module 6.PDF
Federal Contaminated Sites Action Plan (FCSAP) Decision-Making Framework	http://www.ec.gc.ca/Publications/default.asp?lang=En&xml=9B74C13C-A724-41BD-8FC7-E525E4BC81EE	2/28/2014	FCSAP Decision-Making Framework May 31 2013.pdf
Canadian Council of Ministers of the Environment (CCME)	http://www.ccme.ca/publications/list_publications.html#link4	2/28/2014	CCME Current Publications_html#link4.htm
Guidance Manual on Sampling, Analysis, and Data Management for Contaminated Sites - Volume I: Main Report	http://www.ccme.ca/assets/pdf/pn_1101_e.pdf	2/28/2014	Guidance Manual on Sampling, Analysis, and Data Management for Contaminated Sites - Volume I.pdf
Guidance Manual on Sampling, Analysis, and Data Management for Contaminated Sites, Volume II: Analytical Method Summaries	http://www.ccme.ca/assets/pdf/pn_1103_e.pdf	2/28/2014	Guidance Manual on Sampling, Analysis, and Data Management for Contaminated Sites, Volume II.pdf
Summary of a Protocol for the Derivation of Environmental and Human Health Soil Quality Guidelines		2/28/2014	Protocol for the Derivation of Environmental and Human Health Soil Quality Guidelines (en).pdf
Framework for Ecological Risk Assessment: General Guidance	http://www.ccme.ca/assets/pdf/pn_1195_e.pdf	2/28/2014	Framework for Ecological Risk Assessment General Guidance.pdf
A Framework for Ecological Risk Assessment: Technical Appendices	http://www.ccme.ca/assets/pdf/pn_1274_e.pdf	2/28/2014	A Framework for Ecological Risk Assessment Technical Appendices

Guidance Manual for Developing Site-specific Soil Quality Remediation Objectives for Contaminated Sites in Canada	http://www.ccme.ca/assets/pdf/pn_1197_e.pdf	2/28/2014	Guidance Manual for Developing Site-Specific Soil Quality Remediation Objectives for Contaminated Sites in Canada (en).pdf
Guidance Document on the Management of Contaminated Sites in Canada	http://www.ccme.ca/assets/pdf/pn_1279_e.pdf	2/28/2014	Guidance Document on the Management of Contaminated Sites in Canada.pdf
Environmental Code of Practice for Aboveground and Underground Storage Tank Systems Containing Petroleum and Allied Petroleum Products	http://www.ccme.ca/assets/pdf/pn_1326_eng.pdf	2/28/2014	Environmental Code of Practice for Aboveground and Underground Storage Tank Systems.pdf
Canada-Wide Standard for Petroleum Hydrocarbons (PHC) in Soil: User Guidance Petroleum Hydrocarbons in Soil	http://www.ccme.ca/assets/pdf/pn_1398_phc_user_guide_1.1_e.pdf	2/28/2014	pn_1398_phc_user_guide_1.1_e.pdf
Canada-Wide Standard for Petroleum Hydrocarbons (PHC) in Soil: Scientific Rationale Supporting Technical Document	http://www.ccme.ca/assets/pdf/pn_1399_phc_sr_std_1.2_e.pdf	2/28/2014	pn_1399_phc_sr_std_1.2_e.pdf
National Classifications System for Contaminated Sites (NCSCS) - Guidance Document (2008) (includes excel spreadsheet)	http://www.ccme.ca/assets/pdf/pn_1403_ncscs_guidance_e.pdf	2/28/2014	pn_1403_ncscs_guidance_e.pdf
Spreadsheet Model of the Canada Wide Standard (CWS) for Petroleum Hydrocarbons (PHC) in Soil (v 2.1)	downloaded copy of Excel spreadsheet	2/28/2014	phc_cws_model_2.1_e.xls
Guidance on the Site-Specific Application of Water Quality Guidelines in Canada	http://ceqg-rcqe.ccme.ca/	2/28/2014	Guidance on the Site-Specific Application of Water Quality Guidelines in Canada (en).pdf
Canadian Sediment Quality Guidelines for the Protection of Aquatic Life	http://ceqg-rcqe.ccme.ca/	2/28/2014	Protocol for the Derivation of Canadian Sediment Quality Guidelines for the Protection of Aquatic Life (en).pdf
Canadian Tissue Residue Guidelines for the Protection of Wildlife Consumers of Aquatic Biota	http://ceqg-rcqe.ccme.ca/	2/28/2014	Protocol for Derivation of Canadian Tissue Residue Guidelines.pdf
Canadian Water Quality Guidelines for the Protection of Aquatic Life	http://ceqg-rcqe.ccme.ca/	2/28/2014	Protocol for the Derivation of Water Quality Guidelines for the Protection of Aquatic Life 2007 (en).pdf

Other

Document	URL	Date Accessed	File Name
CCME			
Subsurface Assessment Handbook for Contaminated Sites	http://www.ccme.ca/assets/pdf/pn_1144_e.pdf	2/28/2014	Subsurface Assessment Handbook for Contaminated Sites.pdf
Recommended Principles on Contaminated Sites Liability	http://www.ccme.ca/assets/pdf/csl_14_principles_e.pdf	2/28/2014	Recommended Principles on Contaminated Sites Liability.pdf

Connecticut

Legislation

Document	URL	Date Accessed	Filename
Chapter 445* Hazardous Waste	http://www.cga.ct.gov/2011/pub/chap445.htm	2/26/2014	Chapter 445 Hazardous Waste
Property Transfer Program	http://www.ct.gov/deep/cwp/view.asp?a=2715&q=325004&deepNav_GID=1626	2/26/2014	DEEP Property Transfer Program Fact Sheet
State of CT Substitute House Bill No. 5208 Public Act No. 10-158	http://www.cga.ct.gov/2010/act/Pa/pdf/2010PA-00158-R00HB-05208-PA.PDF	3/5/2014	2010PA-00158-R00HB-05208-PA.pdf

Regulations

Document	URL	Date Accessed	Filename
Underground Storage Tank Regulations	http://www.ct.gov/deep/lib/deep/regulations/22a/22a-449%28d%29-1through113.pdf	2/26/2014	22a-449(d)-1through113.pdf
Underground Storage Tank Regulations Amendments	http://www.ct.gov/deep/lib/deep/regulations/22a/22a-449%28d%29-revisions.pdf	2/26/2014	22a-449(d)-revisions.pdf
Remediation Standard Regluations	http://www.ct.gov/deep/cwp/view.asp?a=2715&q=325014&deepNav_GID=1626	2/26/2014	DEEP Remediation Standard Regulations - Fact Sheet
Underground Storage Tank Regulatory Summary	http://www.ct.gov/deep/cwp/view.asp?a=2692&q=322596&deepNav_GID=1652	2/26/2014	DEEP Underground Storage Tank Regulation Summary
State of CT Regulation of DEEP Concerning Remediation Standard	http://www.ct.gov/deep/lib/deep/regulations/22a/22a-133k-1through3.pdf	2/26/2014	RSRs 22a-133k-1through3.pdf
State of CT Regulation of DEEP Concerning Water Quality Standards	http://www.ct.gov/deep/lib/deep/regulations/22a/22a-426-1through9.pdf	3/5/2014	22a-426-1through9.pdf

Guidance

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Document	URL	Date Accessed	Filename
Remediation Standard	http://www.ct.gov/deep/lib/deep/regulations/22a/22a-133k-1through3.pdf	2/26/2014	DEEP Remediation Standard Regulation
Remediation Roundtable August 14, 2012	http://www.ct.gov/deep/lib/deep/site_clean_up/remediation_roundtable/roundtablepresent8_14_12.pdf	2/26/2014	roundtablepresent8_14_12.pdf

Eco related guidance

Document	URL	Date Accessed	Filename
Ecological Risk Assessment	http://www.ct.gov/deep/cwp/view.asp?a=2715&q=325016&deepNav_GID=1626	2/26/2014	DEEP Ecological Risk Assessment Guidance
Water Quality Standards and Classifications Fact Sheet	http://www.ct.gov/dEep/cwp/view.asp?a=2719&q=325620&deepNav_GID=1654	2/26/2014	DEEP Fact Sheet for the Water Quality Standards and Classifications
Ecological Risk Assessment and its Application to the Remediation Process Traci Iott	http://www.ct.gov/deep/lib/deep/site_clean_up/risk_assessment/eraandremediation.pdf	2/26/2014	eraandremediation.pdf
Water Quality Standards	http://www.ct.gov/deep/lib/deep/water/water_quality_standards/wqs_final_adopted_2_25_11.pdf	2/26/2014	wqs_final_adopted_2_25_11.pdf

Engineered Controls

Document	URL	Date Accessed	Filename
Engineered Control Variances	http://www.ct.gov/deep/cwp/view.asp?a=2715&q=434230&deepNav_GID=1626	2/26/2014	DEEP Engineered Controls Guidance Document

Guidance Document Engineerd Controls pursuant to Section 22a-133k-2(f)	http://www.ct.gov/deep/lib/deep/site_clean_up/guidance/engineered_control/final_ec_guidance_formated.pdf	2/26/2014	final_ec_guidance_formated.pdf

Ground Water Related Guidance

Document	URL	Date Accessed	Filename
Water Supply Well Receptor Survey Guidance Document (effective September 2009)	http://www.ct.gov/deep/cwp/view.asp?a=2715&q=446550&deepNav_GID=1626	2/26/2014	DEEP Well Receptor Guidance
Guidance for Groundwater Monitoring For Demonstrating Compliance with the CT RSRs	http://www.ct.gov/deep/lib/deep/site_clean_up/guidance/gwm_guidance_for_demonstrating_compliance_with_ct_rsr.pdf	2/26/2014	gwm_guidance_for_demonstrating_compliance_with_ct_rsr.pdf
Water Supply Well Receptor Survey Guidance Document	http://www.ct.gov/deep/lib/deep/site_clean_up/guidance/site_characterization/water_supply_well_receptor_survey_guidance.pdf	2/26/2014	water_supply_well_receptor_survey_guidance.pdf

Reuse of Polluted Soil

Document	URL	Date Accessed	Filename
Management of Contaminated Environmental Media Frequently Asked Questions	http://www.ct.gov/deep/cwp/view.asp?A=2718&Q=325456&deepNav_GID=1967	2/26/2014	DEEP Management of Contaminated Environmental Media - FAQs

SEHs

Document	URL	Date Accessed	Filename
Significant Environmental Hazard Program	http://www.ct.gov/deep/cwp/view.asp?a=2715&q=324976&deepNav_GID=1626	2/26/2014	DEEP Requirement to Report Certain Environmental Hazards
Reporting of Certain Significant Environmental Hazards Frequently Asked Questions	http://www.ct.gov/deep/lib/deep/site_clean_up/hazard_notification/faq_report_haz.pdf	2/26/2014	faq_report_haz.pdf
Significant Environmental Hazard Condition Notification Threshold Concentrations - Volatiles	http://www.ct.gov/deep/lib/deep/site_clean_up/hazard_notification/haznottablea-volatiles.pdf	2/26/2014	haznottablea-volatiles.pdf
Significant Environmental Hazard Condition Notification Threshold Concentrations - Semi-Volatile	http://www.ct.gov/deep/lib/deep/site_clean_up/hazard_notification/haznottableb-semivolatiles.pdf	2/26/2014	haznottableb-semivolatiles.pdf
Significant Environmental Hazard Condition Notification Threshold Concentrations - Inorganics	http://www.ct.gov/deep/lib/deep/site_clean_up/hazard_notification/haznottablec-inorganics.pdf	2/26/2014	haznottablec-inorganics.pdf
Reporting of Certain Significant Environmental Hazards Fact Sheet	http://www.ct.gov/deep/lib/deep/site_clean_up/hazard_notification/sehnfactsheet.pdf	2/26/2014	sehnfactsheet.pdf

Soils Related Guidance

Document	URL	Date Accessed	Filename
General Guidance on Development of Former Agricultural Properties (March 1999)	http://www.ct.gov/deep/cwp/view.asp?a=2715&q=324952&deepNav_GID=1626	2/26/2014	DEEP General Guidance on Development of Former Agricultural Properties
Guidance for Utility Company Excavation	http://www.ct.gov/deep/cwp/view.asp?a=2715&q=324962&deepNav_GID=1626	2/26/2014	DEEP Guidance for Utility Company Excavation
CT RSRs Rendering Soil Inaccessible Using Payment	http://www.ct.gov/deep/lib/deep/site_clean_up/remediation_regulations/inaccessible_soil_guidance.pdf	2/26/2014	inaccessible_soil_guidance.pdf
CT RSRs Exemptions for Incidental Sources	http://www.ct.gov/deep/lib/deep/site_clean_up/remediation_regulations/incidental_sources_guidance.pdf	2/26/2014	incidental_sources_guidance.pdf
CT RSRs Pollutant Mobility Criteria Exception for Groundwater Infiltration	http://www.ct.gov/deep/lib/deep/site_clean_up/remediation_regulations/pmc_exception_guidance.pdf	2/26/2014	pmc_exception_guidance.pdf
Remediation Division Roundtable Q&A Newsletter Vol. 5 ~ October 27, 2011	http://www.ct.gov/deep/lib/deep/site_clean_up/remediation_roundtable/q&anewslettervol5.pdf	2/26/2014	q&anewslettervol5.pdf
CTDEEP Urban Fill Stakeholder Workgroup Interim Recommendations September 13, 2011	http://www.ct.gov/deep/lib/deep/site_clean_up/remediation_roundtable/urban_fill_workgroup_handout_9-13-11.pdf	2/26/2014	urban_fill_workgroup_handout_9-13-11.pdf

TI Guidance

Document	URL	Date Accessed	Filename
Technical Impracticability Variance	http://www.ct.gov/deep/cwp/view.asp?a=2715&q=534920&deepNav_GID=1626	2/26/2014	DEEP Technical Impracticability
Technical Impracticability RSRs 22a-133k-3(e)(2)	http://www.ct.gov/deep/lib/deep/site_clean_up/remediation_regulations/ti_factsheet.pdf	2/26/2014	ti_factsheet.pdf
Draft Guidance for Applying Technical Impracticability of Groundwater Remediation Variance Pursuant to the Remediation Standard Regulations	http://www.ct.gov/deep/lib/deep/site_clean_up/remediation_regulations/ti_guidancedraft_2-20-14.pdf	2/26/2014	ti_guidancedraft_2-20-14.pdf
Remediation - List of Guidance Documents (by Program)	http://www.ct.gov/deep/cwp/view.asp?a=2715&q=420646&deepNav_GID=1626	2/26/2014	CT Remediation Guidance List.pdf
Environmental Land Use Restrictions	http://www.ct.gov/deep/cwp/view.asp?a=2715&q=438254&deepNav_GID=1626	2/26/2014	DEEP Environmental Land Use Restrictions
Licensed Environmental Professional Program Fact Sheet	http://www.ct.gov/deep/cwp/view.asp?A=2715&Q=324984	2/26/2014	DEEP Licensed Environmental Professional Program Fact Sheet
Guidance for Residential Underground Home Heating Oil Tank Releases	http://www.ct.gov/deep/cwp/view.asp?a=2692&q=450952&deepNav_GID=1652	2/26/2014	DEEP Residential Underground Home Heating Oil Tank Releases
Site Characterization Guidance Document	http://www.ct.gov/deep/lib/deep/site_clean_up/guidance/Site_Characterization/Final_SCGD.pdf	2/26/2014	Final_SCGD.pdf

Basis for Criteria

Document	URL	Date Accessed	Filename
Email between Mark Franson and Cheryl Chase	NA	2/26/2014	Basis for CT RSR criteria 2-27-2014
State of CT Regulation of DEEP Concerning Remediation Standard Pages 14 - 17	http://www.ct.gov/deep/lib/deep/site_clean_up/remediation_regulations/rsrs__elur_6_27_2013_to_sots_redline.pdf	2/26/2014	DEC calcs.pdf

State of CT Regulation of DEEP Concerning Remediation Standard Pages 82-84	http://www.ct.gov/deep/lib/deep/site_clean_up/remediation_regulations/rsrs__elur_6_27_2013_to_sots_redline.pdf	2/26/2014	GW VolC calcs.pdf
State of CT Regulation of DEEP Concerning Remediation Standard Pages 51-53	http://www.ct.gov/deep/lib/deep/site_clean_up/remediation_regulations/rsrs__elur_6_27_2013_to_sots_redline.pdf	2/26/2014	GWPC calcs.pdf
Toxicology and Risk Assessment Protocol for RSR Additional Polluting Substances CTDPH Jan 2014	Provided by DPH - not available on-line	2/26/2014	RSR APS Protocol.pdf
Source of Toxicity Values for RSR Calculations May 2008 CT DPH	Provided by DPH - not available on-line	2/26/2014	RSR Toxicity Values -2008.pdf
State of CT Regulation of DEEP Concerning Remediation Standard Pages 85-86	http://www.ct.gov/deep/lib/deep/site_clean_up/remediation_regulations/rsrs__elur_6_27_2013_to_sots_redline.pdf	2/26/2014	SV VolC calcs.pdf

Proposed Revisions

Document	URL	Date Accessed	Filename
Public Discussion Draft RSR Wave 2 - Potential Changes to RSRs Class B2 Cleanup	http://www.ct.gov/deep/lib/deep/site_clean_up/comprehensive_evaluation/finaldraft_alternativepmc_2-18-14.pdf	2/27/2014	finaldraft_alternativepmc_2-18-14.pdf
Petroleum Hydrocarbons Using EPH/VPH/APH Analytical Methods and Criteria Development	http://www.ct.gov/deep/lib/deep/site_clean_up/remediation_regulations/technical_support_document_ephvphaph.pdf	2/27/2014	technical_support_document_ephvphaph.pdf

Best Practices

Document	URL	Date Accessed	Filename
Draft Report to the CT DEEP on Evaluation of Best Practices of Various State Cleanup Programs September 29, 2011	http://www.ct.gov/deep/lib/deep/site_clean_up/comprehensive_evaluation/workgroup6_bestpracticesvariousstates.pdf	3/24/2014	Sept 29, 2011 Evaluation of Best Practices of Various State Cleanup Programs.pdf

Department of Energy

Legislation

Document	URL	Date Accessed	Filename
Comprehensive Environemental Response, Compensation, and Liability Act (CERCLA)	http://www.law.cornell.edu/uscode/pdf/lii_usc_TI_42_CH_103.pdf	3/10/2014	CERCLA.pdf
Federal Facility Compliance Act	http://www.labtrain.noaa.gov/ppguide/ffpp_55.htm	3/10/2014	FFCA.pdf
Resource Conservation and Recovery Act	http://www.law.cornell.edu/uscode/pdf/lii_usc_TI_42_CH_82.pdf	3/10/2014	RCRA.pdf
Community Environmental Response Facilitation Act	http://www.epa.gov/fedfac/documents/scan5.htm	3/10/2014	CERFA.pdf
Atomic Energy Act	http://pbadupws.nrc.gov/docs/ML1327/ML13274A489.pdf#page=23	3/10/2014	Atomic energy act.pdf

Regulation

Document	URL	Date Accessed	Filename
Executive Order 12580 Superfund Implementation	http://www.archives.gov/federal-register/codification/executive-order/12580.html	3/10/2014	Executive Orders 12580.pdf
DOE Order 5400.4	https://www.directives.doe.gov/directives/5400.04-BOrder/view	3/10/2014	DOE order 54004.pdf
National Contingency Plan Section	http://www.gpo.gov/fdsys/pkg/CFR-2011-title40-vol28/pdf/CFR-2011-title40-vol28-part300.pdf	3/10/2014	NCP.pdf

Guidance

Document	URL	Date Accessed	Filename
Approach and Strategy for Performing Ecological Risk Assessments for the U.S. Department of Energy's Oak Ridge Reservation: 1995 Revision	http://www.esd.ornl.gov/programs/ecorisk/documents/tm33r2p.pdf	3/10/2014	eco oak ridge.pdf
Institutional Controls: A Guide to Planning, Implementing, Maintaining, and Enforcing Institutional Controls at Contaminated Sites	http://www.epa.gov/superfund/policy/ic/guide/Final%20PIME%20Guidance%20December%202012.pdf	3/11/2014	Ics guide.pdf
Guidance on Accelerating CERCLA Environmental Restoration at Federal Facilities	http://www.epa.gov/fedfac/documents/822memo.htm	3/10/2014	Guidance on Accelerating CERCLA Environmental Restoration at Federal Facilities.pdf
Streamlined Approach for Environmental Restoration (SAFER) Pilot Project	http://homer.ornl.gov/sesa/environment/guidance/cercla/safer.pdf	3/10/2014	safer.pdf
Soil Screening Guidance for Radionuclides: User's Guide	http://rais.ornl.gov/documents/SSG_rad_user.pdf	3/11/2014	SSG_rad_user.pdf
Soil Screening Guidance for Radionuclides: User's Guide and Technical Background Document Final Guidance	http://rais.ornl.gov/documents/SSG_rad_technical.pdf	3/11/2014	SSG_red_technical.pdf
Amended Guidance on Ecological Risk Assessment at Military Bases: Process Considerations, Timing of Activities, and Inclusion of Stakeholders	http://rais.ornl.gov/documents/ecoproc2.pdf	3/11/2014	ecoproc2.pdf
Approach and Strategy for Developing Human Health Toxicity Information for Contaminants of Concern at Sites Administered by the U.S. Department of Energy Oak Ridge Field Office Environmental Restoration Program	http://rais.ornl.gov/documents/tm38ed.pdf	3/11/2014	tox info.pdf
Criteria for Establishing De Minimis Levels of Radionuclides and Hazardous Chemicals in the Environment	http://rais.ornl.gov/documents/tm187.pdf	3/11/2014	de minimis.pdf
Estimating Exposure of Terrestrial Wildlife to Contaminants	http://rais.ornl.gov/documents/tm125.pdf	3/11/2014	terrestrial wildlife.pdf
Environmental Restoration Risk-Based Prioritization Work Package Planning and Risk Ranking Methodology	http://rais.ornl.gov/documents/tm112r2.pdf	3/11/2014	prioritization.pdf
Estimation of Whole-Fish Contaminant Concentrations from Fish Fillet Data	http://rais.ornl.gov/documents/tm202.pdf	3/11/2014	fish.pdf
Emperical Models for the Uptake of Inorganic Chemicals from Soil by Plants	http://rais.ornl.gov/documents/bjcor-133.pdf	3/11/2014	soil to plants.pdf

Guidance for Conducting Risk Assessments and Related Risk Activities for the DOE-ORO Environmental Management Program	http://rais.ornl.gov/documents/bjc_or-271.pdf	3/11/2014	risk guide.pdf
Guide for Developing Conceptual Models for Ecological Risk Assessment	http://rais.ornl.gov/documents/tm186.pdf	3/11/2014	eco csm.pdf
Guide for Developing Data Quality Objectives for Ecological Risk Assessments at DOE-ORO Facilities	http://rais.ornl.gov/documents/tm185.pdf	3/11/2014	DQOs.pdf
Guide for Performing Screening Ecological Risk Assessments at DOE Facilities	http://rais.ornl.gov/documents/tm153.pdf	3/11/2014	eco screen.pdf
Improved Methods for Calculating Concentrations Used in Exposure Assessments	http://rais.ornl.gov/documents/bjc_or416.pdf	3/11/2014	EPCs.pdf
An Introductory Guide to Uncertainty Analysis in Environmental and Health Risk Assessment	http://rais.ornl.gov/documents/tm35r1.pdf	3/11/2014	uncertainty.pdf
Methodology for Estimating Radiation Dose Rates to Freshwater Biota Exposed to Radionuclides in the Environment	http://rais.ornl.gov/documents/tm78.pdf	3/11/2014	rads biota.pdf
Preliminary Remediation Goals for Ecological Endpoints	http://rais.ornl.gov/documents/tm162r2.pdf	3/11/2014	eco prgs.pdf
Radiological Benchmarks for Screening Contaminants of Potential Concern for Effects on Aquatic Biota	http://rais.ornl.gov/documents/bjcor80.pdf	3/11/2014	rad benchmarks.pdf
Radiological Criteria for Remedial Actions at Radioactively Contaminated Sites	http://rais.ornl.gov/documents/tm131.pdf	3/11/2014	rad criteria.pdf
Risk Assessment Program Data Management Implementation Plan	http://rais.ornl.gov/documents/tm232.pdf	3/11/2014	risk program.pdf
Risk Assessment Quality Program Plan	http://rais.ornl.gov/documents/tm117.pdf	3/11/2014	QPP.pdf
Risk Characterization for Ecological Risk Assessment of Contaminated Sites	http://rais.ornl.gov/documents/tm200.pdf	3/11/2014	eco risk.pdf
Toxicological Benchmarks for Screening Potential Contaminants of Concern for Effects on Aquatic Biota: 1996 Revision	http://rais.ornl.gov/documents/tm96r2.pdf	3/11/2014	tox bench aquatic biota.pdf
Toxicological Benchmarks for Screening Potential Contaminants of Concern for Effects on Sediment Associated Biota: 1997 Revision	http://rais.ornl.gov/documents/tm95r4.pdf	3/11/2014	tox bench sed.pdf
Toxicological Benchmarks for Screening Potential Contaminants of Concern for Effects on Soil and Litter Invertebrates and Heterotrophic Processes	http://rais.ornl.gov/documents/tm126r21.pdf	3/11/2014	tox bench soil.pdf
Toxicological Benchmarks for Screening Potential Contaminants of Concern for Effects on Terrestrial Plants: 1995 Version	http://rais.ornl.gov/documents/tm85r3.pdf	3/11/2014	tox bench plants.pdf
Toxicological Benchmarks for Wildlife	http://rais.ornl.gov/documents/tm86r3.pdf	3/11/2014	tox bench wildlife.pdf

Other

Document	URL	Date Accessed	Filename
Groundwater database	http://energy.gov/em/groundwater-database	3/10/2014	
Advanced Simulation Capability for Environmental Management (software project)	http://esd.lbl.gov/research/projects/ascem/	3/10/2014	ASCEM - Home.htm
PRG calculator for radionuclides	http://epa-prgs.ornl.gov/cgi-bin/radionuclides/rprg_search	3/10/2014	
PRG calculator for radionuclides in buildings	http://epa-bprg.ornl.gov/cgi-bin/bprg_search	3/10/2014	
PRG calculator for radionuclides in outdoor surfaces	http://epa-sprg.ornl.gov/cgi-bin/sprg_search	3/10/2014	
radionuclide ARAR dose compliance concentrations (DCCs) calculator	http://epa-dccs.ornl.gov/	3/10/2014	
DCCs for radionuclides in buildings calculator	http://epa-bdcc.ornl.gov/cgi-bin/bdcc_search	3/10/2014	
DCCs for radionuclides in outdoor surfaces calculator	http://epa-sdcc.ornl.gov/cgi-bin/sdcc_search	3/10/2014	
Regional removal management levels for chemicals calculator	http://epa-prgs.ornl.gov/cgi-bin/chemicals/csl_search?tool=rml	3/10/2014	
Radionuclide decay chain tool	http://epa-prgs.ornl.gov/radionuclides/chain/chain.php	3/10/2014	
soil screening for chemicals calculator	http://rais.ornl.gov/epa/ssl1.shtml	3/10/2014	
soil screening for radionuclides calculator	http://rais.ornl.gov/rad-ssg/radssl1.shtml	3/10/2014	
J&E model for subsurface vapor intrusion online calculator	http://www.epa.gov/athens/learn2model/part-two/onsite/JnE_lite_forward.html	3/10/2014	

US EPA Ecological Risk Assessment

Laws

Document	URL	Date Accessed	Filename
US Laws and Regulations and Presidential Executive Orders Pertaining to risk assessment	http://www.epa.gov/risk_assessment/laws.htm#EO	2/25/2014	

Regulations

Document	URL	Date Accessed	Filename

Guidance

Document	URL	Date Accessed	Filename
Catalog of EPA Guidance and Tools for Risk Assessment	http://www.epa.gov/risk_assessment/guidance.htm	2/25/2014	
Catalog of Guidelines for Ecological Risk Assessment	http://www.epa.gov/raf/publications/guidelines-ecological-risk-assessment.htm	2/25/2014	
Guidelines for Ecological Risk Assessment (PDF)	http://www.epa.gov/raf/publications/pdfs/ECOTXTBX.PDF	2/25/2014	
Generic Ecological Assessment Endpoints (GEAE) for Ecological Risk Assessment (2004)	http://www.epa.gov/raf/publications/pdfs/GENERIC_ENDPOINTS_2004.PDF	2/25/2014	
Stressor Identification Guidance Document (2000)	http://water.epa.gov/scitech/swguidance/standards/criteria/aqlife/biocriteria/upload/stressorid.pdf	2/25/2014	
Review of Ecological Assessment Case Studies from a Risk Assessment Perspective Volume II (1994)	http://www.epa.gov/raf/publications/pdfs/ECORISK.PDF	2/25/2014	

Review of Ecological Assessment Case Studies from a Risk Assessment Perspective (1993)	http://nepis.epa.gov/Exe/ZyNET.exe/100041RK.txt?ZyActionD=ZyDocument&Client=EPA&Index=1991+Thru+1994&Docs=&Query=&Time=&EndTime=&SearchMethod=1&TocRestrict=n&Toc=&TocEntry=&QField=pubnumber%5E%22630R92005%22&QFieldYear=&QFieldMonth=&QFieldDay=&UseQField=pubnumber&IntQFieldOp=1&ExtQFieldOp=1&XmlQuery=&File=D%3A%5Czyfiles%5CIndex%20Data%5C91thru94%5CTxt%5C00000003%5C100041RK.txt&User=ANONYMOUS&Password=anonymous&SortMethod=h%7C-&MaximumDocuments=10&FuzzyDegree=0&ImageQuality=r75g8/r75g8/x150y150g16/i425&Display=p%7Cf&DefSeekPage=x&SearchBack=ZyActionL&Back=ZyActionS&BackDesc=Results%20page&MaximumPages=1&ZyEntry=1&SeekPage=x#	2/25/2014
Framework for Ecological Risk Assessment (1992)	http://www.epa.gov/raf/publications/pdfs/FRMWRK_ERA.PDF	2/25/2014
Summary Report on Issues in Ecological Risk Assessment (1991)	http://nepis.epa.gov/Exe/ZyNET.exe/300047P3.txt?ZyActionD=ZyDocument&Client=EPA&Index=1991%20Thru%201994%7CHardcopy%20Publications&Docs=&Query=Summary%20Report%20Issues%20Ecological%20Risk%20Assessment&Time=&EndTime=&SearchMethod=2&TocRestrict=n&Toc=&TocEntry=&QField=&QFieldYear=&QFieldMonth=&QFieldDay=&UseQField=&IntQFieldOp=0&ExtQFieldOp=0&XmlQuery=&File=D%3A%5CZYFILES%5CINDEX%20DATA%5C91THRU94%5CTXT%5C00000002%5C300047P3.txt&User=ANONYMOUS&Password=anonymous&SortMethod=h%7C-&MaximumDocuments=15&FuzzyDegree=0&ImageQuality=r85g16/r85g16/x150y150g16/i500&Display=hpfr&DefSeekPage=x&SearchBack=ZyActionL&Back=ZyActionS&BackDesc=Results%20page&MaximumPages=1&ZyEntry=1&SeekPage=x#	2/25/2014
Generic Assessment Endpoints for Ecological Risk Assessments (External Review Draft)	http://www.epa.gov/raf/publications/pdfs/GEAE_EXT_REV_DRAFT_OCT_02.PDF	2/25/2014
Framework for Application of the Toxicity Equivalence Methodology for Polychlorinated Dioxins, Furans and Biphenyls in Ecological Risk Assessment (2008)	http://www.epa.gov/osa/raf/tefframework/	2/25/2014
Overview of the Ecological Risk Assessment Process in the Office of Pesticide Programs (2004)	http://www.epa.gov/espp/consultation/ecorisk-overview.pdf#search=%22%22risk%20assessment%22%20site%3Awww.epa.gov%22	2/25/2014
Pesticides: Ecological Risk Assessments	http://www.epa.gov/pesticides/ecosystem/ecorisk.htm	2/25/2014
Process for Assessing Pesticide Risks to Endangered Species	http://www.epa.gov/oppfead1/endanger/litstatus/riskasses.htm	2/25/2014
Watershed Ecological Risk Assessment	http://cfpub.epa.gov/watertrain/pdf/modules/wshedecorisk.pdf	2/25/2014
Application of Watershed Ecological Risk Assessment Methods to Watershed Management	http://www.google.com/url?sa=t&rct=j&q=&esrc=s&frm=1&source=web&cd=5&ved=0CEcQFjAE&url=http%3A%2F%2Fofmpub.epa.gov%2Feims%2Feimscomm.getfile%3Fp_download_id%3D472569&ei=MbsMU4bqI6a0sQT-lIHgCg&usg=AFQjCNHY7rLsZNGMHKLxs0Z_TTmJUMi40Q	2/25/2014
Ecotox thresholds	http://www.epa.gov/oswer/riskassessment/ecotox.htm	2/25/2014
Ecotox thresholds database	http://cfpub.epa.gov/ecotox/	2/25/2014
Exposure Factors Handbook (Volume I and Volume II)	http://cfpub.epa.gov/ncea/risk/recordisplay.cfm?deid=2799	2/25/2014
Integrating Ecological Assessment and Decision-Making at EPA: A Path Forward ~ Results of a Colloquium in Response to Science Advisory Board and National Research Council Recommendations (2010)	http://www.epa.gov/raf/publications/pdfs/integrating-ecolog-assess-decision-making.pdf	2/25/2014
Population-level Ecological Risk Assessment Workshop Summary (2009)	http://www.epa.gov/raf/files/population_level_era_report_final.pdf	2/25/2014
Population-level Ecological Risk Assessment Workshop Summary (2009) Supplemental Materials	http://www.epa.gov/raf/files/population_level_era_report_supp_materials.pdf	2/25/2014
Interim Report from Workshop on the Use of Available Data and Methods for Assessing the Ecological Risks of 2,3,7,8-Tetrachlorodibenzo-P-Dioxin to Aquatic Life and Associated Wildlife (1993)	http://www.epa.gov/raf/publications/pdfs/DIOXIN_RISKS_AQUATIC_LIFE_AND_WILDLIFE_1993.PDF	2/25/2014
Screening Criteria		
Soil		
Release of Guidance for Developing Ecological Soil Screening Levels (Eco-SSLs) and Eco-SSLs for Nine Contaminants	http://www.epa.gov/oswer/riskassessment/ecorisk/pdf/ecosslmemo.pdf	2/25/2014
Guidance for Developing Ecological Soil Screening Levels (Eco-SSLs)	http://www.epa.gov/ecotox/ecossl/pdf/ecossl_guidance_chapters.pdf	2/25/2014
Eco SSLs catalog page (separate documents for each chemical--not specifically cataloged here)	http://www.epa.gov/ecotox/ecossl/	2/25/2014
Sediment	none	
Surface Water		
Water Quality Criteria Documents	http://cfpub.epa.gov/ncea/risk/recordisplay.cfm?deid=154011	2/25/2014
NRWQC (2009)	http://water.epa.gov/scitech/swguidance/standards/criteria/current/upload/nrwqc-2009.pdf	2/25/2014

US EPA

Laws

Document	URL	Date Accessed	Filename
The Superfund Amendments and Reauthorization Act	http://www.epw.senate.gov/sara.pdf	2/28/2014	The Superfund Amendments and Reauthorization Act (SARA)
CFR Title 40 Parts 1 to 49 Protection of Environment	http://www.gpo.gov/fdsys/pkg/CFR-2002-title40-vol1/pdf/CFR-2002-title40-vol1.pdf	3/3/2014	CFR-2002-title40-vol1

Comprehensive Environmental Response, Compensation, and Liability Act	http://www.epw.senate.gov/cercla.pdf	3/7/2014	CERCLA
Protection of Children From Environmental Health Risks and Safety Risks	http://www.gpo.gov/fdsys/pkg/FR-1997-04-23/pdf/97-10695.pdf	3/7/2014	Protection of Children From Environmental Health Risks and Safety Risks
Solid Waste Disposal Act	http://www.epw.senate.gov/rcra.pdf	3/7/2014	RCRA
Endangered Species Act	http://www.epw.senate.gov/esa73.pdf	3/7/2014	Endangered Species Act

Regulations

Document	URL	Date Accessed	Filename
National Contingency Plan	http://www.gpo.gov/fdsys/pkg/CFR-2011-title40-vol28/pdf/CFR-2011-title40-vol28-part300.pdf	2/21/2014	CFR-2011-title40-vol28-part300.pdf
Potential Addition of Vapor Intrusion Components to the Hazard Ranking System	http://www.epa.gov/superfund/sites/npl/a110131.pdf	3/7/2014	Potential Addtion of VI to HRS

Guidance

Document	URL	Date Accessed	Filename
Role of the Baseline Risk Assessment in Superfund Remedy Selection Decisions	http://www.epa.gov/oswer/riskassessment/pdf/baseline.pdf	2/28/2014	Role of RA in Remedy Selection
Revised Policy on Performaing Risk Assessment Conducted during RI/FS by PRPs	http://www.epa.gov/oswer/riskassessment/pdf/rifsmemo.pdf	2/28/2014	Policy of RA by PRPs
Presenter's Manual on "Superfund Risk Assessment andf How You can Help"	http://www.epa.gov/oswer/riskassessment/pdf/vdmanual.pdf	2/28/2014	Presenter's Manual on "Superfund Risk Assessment andf How You can Help"
RAGS Part A, Supplement to Part A: Community Involvement	http://www.epa.gov/oswer/riskassessment/ragsa/pdf/ci_ra.pdf	2/28/2014	RAGS Part A Supplement Community Involvement
RAGS Part A HHRA	http://www.epa.gov/oswer/riskassessment/ragsa/pdf/rags_a.pdf	2/28/2014	RAGS Part A HHRA
RAGS Part B Development of Remediation Goals	http://www.epa.gov/oswer/riskassessment/ragsb/index.htm	2/28/2014	RAGS Part B PRGs
RAGS Part C Risk Evaluation of Remedial Alternatives	http://www.epa.gov/oswer/riskassessment/ragsc/index.htm	2/28/2014	RAGS Part C Remedial Alternatives
RAGS Part D Standardized Planning, Reporting, and Review of Superfund Risk Assessments	http://www.epa.gov/oswer/riskassessment/ragsd/tara.htm	3/4/2014	RAGS Part D Standard Planning, Reporting, and Review
RAGS Part E Dermal	http://www.epa.gov/oswer/riskassessment/ragse/pdf/part_e_final_revision_10-03-07.pdf	3/4/2014	RAGS Part E Dermal
RAGS Part F Inhalation	http://www.epa.gov/oswer/riskassessment/ragsf/pdf/partf_200901_final.pdf	3/4/2014	RAGS Part F Inhalation
RAGS Volume III - Part A, Process for Conducting Probabilistic Risk Assessment	http://www.epa.gov/oswer/riskassessment/rags3adt/pdf/rags3adt_complete.pdf	3/4/2014	RAGS Vol 3 Part A Probabilistic Risk Assessment
Land Use in the CERCLA Remedy Selection Process, OSWER Directive No. 9355.7-04	http://www.epa.gov/superfund/community/relocation/landuse.pdf	3/4/2014	Land Use CERCLA Remedy
Guideline for Exposure Assessment	http://cfpub.epa.gov/ncea/cfm/recordisplay.cfm?deid=15263#Download	3/4/2014	Guideline for Exposure Assessment
Exposure Factors Handbook 1997	http://cfpub.epa.gov/ncea/cfm/recordisplay.cfm?deid=12464#Download	3/4/2014	Exposure Factors Handbook 1997
Standard Default Exposure Factors for Superfund Sites	http://www.epa.gov/oswer/riskassessment/pdf/oswer_directive_9285_6-03.pdf	3/6/2014	Standard Default Exposure Factors
Cumulative Risk Assessment Guidance Part 1 - Planning and Scoping	http://www.epa.gov/osa/spc/2cumrisk.htm	3/6/2014	Cumulative Risk Assessment Guidance
Framework for Cumulative Risk Assessment	http://www.epa.gov/raf/publications/pdfs/frmwrk_cum_risk_assmnt.pdf	3/6/2014	Framework for Cumulative Risk Assessment
Soil Screening Guidance: User's Guide	http://www.epa.gov/superfund/health/conmedia/soil/#user	3/6/2014	Soil Screening Guidance: User's Guide
Soil Screening Guidance: Technical Background Document	http://www.epa.gov/superfund/health/conmedia/soil/introtbd.htm	3/6/2014	Soil Screening Guidance Tech Doc
Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites	http://www.epa.gov/superfund/health/conmedia/soil/#user	3/6/2014	Supplemental Soil Screening Guidance
Memorandum, Human Health Toxicity Values in Superfund Risk Assessments	http://www.epa.gov/oswer/riskassessment/pdf/hhmemo.pdf	3/6/2014	HH Toxicity Memo 2003
Tier 3 Toxicity Value White Paper	http://www.epa.gov/oswer/riskassessment/pdf/tier3-toxicityvalue-whitepaper.pdf	3/6/2014	Tier 3 Toxicity Value White Paper
Use of IRIS Value in Superfund Risk Assessment	http://www.epa.gov/oswer/riskassessment/pdf/irismemo.pdf	3/6/2014	IRIS Memo 1993
Reference Dose (RfD): Description and Use in Health Risk Assessments	http://www.epa.gov/iris/rfd.htm	3/6/2014	PDF not available
Guideline for Cancer Risk Assessment	http://www.epa.gov/raf/publications/pdfs/CANCER_GUIDELINES_FINAL_3-25-05.PDF	3/6/2014	Cancer Risk Assessment
Supplemental Guidance for Assessing Susceptibility from Early-Life Exposure to Carcinogens	http://www.epa.gov/raf/publications/pdfs/childrens_supplement_final.pdf	3/6/2014	
Benchmark Dose technical guidance Document	http://www.epa.gov/raf/publications/pdfs/BMD-EXTERNAL_10_13_2000.PDF	3/6/2014	Benchmark Dose 2000
Methods for Derivation of Inhalation Reference Concentrations and Application of Inhalation Dosimetry	http://cfpub.epa.gov/ncea/cfm/recordisplay.cfm?deid=71993#Download	3/6/2014	Methods for Derivation of RfC
Guidelines for the Health Risk Assessment of Chemical Mixtures	http://cfpub.epa.gov/ncea/cfm/recordisplay.cfm?deid=22567	3/7/2014	Guideline for Mixture 1986
Supplemental Guidance for Conducting Health Risk Assessment of Chemical Mixtures	http://cfpub.epa.gov/ncea/cfm/recordisplay.cfm?deid=20533#Download	3/7/2014	Supplemental Guidance for Mixtures 2000
Guidelines for Mutagenicity Risk Assessment	http://www.epa.gov/raf/publications/pdfs/MUTAGEN2.PDF	3/7/2014	Guideline for Mutagen 1986
Guidelines for Neurotoxicity Risk Assessment	http://www.epa.gov/raf/publications/pdfs/NEUROTOX.PDF	3/7/2014	Guideline for Neurotoxicity 1998
Guidelines for Reproductive Toxicity Risk Assessment	http://www.epa.gov/raf/publications/pdfs/REPRO51.PDF	3/7/2014	Guideline for Reproductive Toxicity 1996
Approach for Addressing Dioxin in Soil at CERCLA and RCRA Sites	http://www.epa.gov/superfund/policy/remedy/pdfs/92-00426-s.pdf	3/7/2014	Addressing Dioxin in Soil Memo 1998
Frequently Asked Questions on the Update to the ATSDR Policy Guideline for Dioxins and Dioxin-Like Compounds in Residential Soil	http://www.epa.gov/oswer/riskassessment/pdf/92-857-84fs.pdf	3/7/2014	FAQ Update Dioxin in Residential Soil
Provisional Guidance for Quantitative Risk Assessment of PAHs	http://www.epa.gov/oswer/riskassessment/pdf/1993_epa_600_r-93_c89.pdf	3/7/2014	PAHs 1993
Preliminary Remediation Goals for Radionuclides	http://epa-prgs.ornl.gov/radionuclides/	3/7/2014	PDF not available
Guidance on Risk Characterization for Risk Mangers and Risk Assessors (1992)	http://www.epa.gov/oswer/riskassessment/habicht.htm	3/7/2014	Guidance for Risk Assessment
Science Policy Council Handbook Risk Characterization	http://www.epa.gov/spc/pdfs/rchandbk.pdf	3/7/2014	Handbbook Risk Characterizaton
EPA Risk Characterization Program	http://www.epa.gov/oswer/riskassessment/pdf/1995_0521_risk_characterization_program.pdf	3/7/2014	1995_0521_risk_characterization_program.pdf
Guidance for Comparing Background and Chemical Concentrations in Soil for CERCLA Sites	http://www.epa.gov/oswer/riskassessment/pdf/background.pdf	3/7/2014	Guidance on Background Concentrations
Clarification to the 1994 Revised Interim Soil lead Guidance for CERCLA Sites and RCRA Corrective Action Facilities. OSWER Directive 9200.4-27 1998	http://www.epa.gov/wastes/hazard/correctiveaction/resources/pdfs/pbpolicy.pdf	3/7/2014	Pb policy
Establishment of Cleanup Levels for CERCLA Sites with Radioactive Contamination	http://www.epa.gov/superfund/health/contaminants/radiation/pdfs/radguide.pdf	3/7/2014	Rad guide
Recommendations of the Technical Review Workgroup for Lead for an Approach to Assessing Risks Associated with adult Exposures to Lead in Soil	http://www.epa.gov/superfund/health/contaminants/lead/products/adultpb.pdf	3/7/2014	Adult Lead Model

Update of the Adult Lead Methodology's Default baseline Blood Lead Concentration and geometric Standard Deviation Parameters	http://www.epa.gov/superfund/health/contaminants/lead/products/almupdate.pdf	3/7/2014	Adult Lead Model Update
User's Guide for the IEUBK Model for Lead in Children	http://www.epa.gov/superfund/lead/products/ugieubk32.pdf	3/7/2014	User's Guide IEUBK 2007
Guidance Manual for the IEUBK Model for Lead in Children	http://nepis.epa.gov/EPA/html/DLwait.htm?url=/Exe/ZyNET.exe/2000WN4R.PDF?ZyActionP=PDF&Client=EPA&Index=1991 Thru 1994&File=D%3A%5CZYFILES%5CINDEX%20DATA%5C91THRU94%5CTXT%5C00000016%5C2000WN4R.txt&Query=&SearchMethod=1&FuzzyDegree=0&User=ANONYMOUS&Password=anonymous&QField=&UseQField=&IntQFieldOp=0&ExtQFieldOp=0&Docs=	3/7/2014	Guidance Manual for IEUBK

Vapor Intrusion Guidance

Document	URL	Date Accessed	Filename
OSWER Draft Guidance for Evaluating the Vapor Intrusion to Indoor Air Pathway from Groundwater and Soils (Subsurface Vapor Intrusion Guidance)	http://www.epa.gov/epawaste/hazard/correctiveaction/eis/vapor/complete.pdf	3/7/2014	OSWER VI Guidance
Review of the Draft 2002 Subsurface Vapor Intrusion Guidance	http://www.epa.gov/oswer/vaporintrusion/documents/review_of_2002_draft_vi_guidance_final.pdf	3/7/2014	review_of_2002_draft_vi_guidance_final.pdf
Brownfields Technology Primer: Vapor Intrusion Considerations for Redevelopment	http://www.brownfieldstsc.org/pdfs/BTSC%20Vapor%20Intrusion%20Considerations%20for%20Redevelopment%20EPA%20542-R-08-001.pdf	3/7/2014	BTSC Vapor Intrusion Considerations for Redevelopment EPA 542-R-08-001.pdf
Background Indoor Air Concentrations of VOCs in North American Residences (1990-2005): A Compilation of Statistics for Assessing Vapor Intrusion	http://www.epa.gov/oswer/vaporintrusion/documents/oswer-vapor-intrusion-background-Report-062411.pdf	3/7/2014	oswer-vapor-intrusion-background-Report-062411.pdf
EPA's Vapor Intrusion DATABASE: Evaluation and Characterization of Attenuation Factors for Chlorinated VOCs and Residential Buildings	http://www.epa.gov/oswer/vaporintrusion/documents/OSWER_2010_Database_Report_03-16-2012_Final_witherratum_508.pdf	3/7/2014	OSWER_2010_Database_Report_03-16-2012_Final_witherratum_508.pdf
Conceptual Model Scenarios for the Vapor Intrusion Pathway	http://www.epa.gov/oswer/vaporintrusion/documents/vi-cms-v11final-2-24-2012.pdf	3/7/2014	VI CSM-v11final-2-24-2012.pdf
Indoor Air Vapor Intrusion Mitigation Approaches	http://www.clu-in.org/download/char/600r08115.pdf	3/7/2014	Indoor Air mitigation Approaches
Superfund Vapor Intrusion FAQs	http://www.epa.gov/superfund/sites/npl/Vapor_Intrusion_FAQs_Feb2012.pdf	3/7/2014	Vapor_Intrusion_FAQs_Feb2012.pdf
Petroleum Hydrocarbons and Chlorinated Hydrocarbons Differ in Their Potential for Vapor Intrusion	http://www.epa.gov/oust/cat/pvi/pvicvi.pdf	3/7/2014	Petroleum hydrocarbon VI

Illinois

Legislation

Document	URL	Date Accessed	Filename
Environmental Safety 415 ILCS5 Environmental Protection Act	http://www.ilga.gov/legislation/ilcs/ilcs5.asp?ActID=1585&ChapterID=36	2/28/2014	415 ILCS 5- Environmental Protection Act

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Document	URL	Date Accessed	Filename
Environmental Regulations for the State of Illinois Title 35 of the Illinois Administrative Code	http://www.ipcb.state.il.us/SLR/IPCBandIEPAEnvironmentalRegulations-Title35.aspx	2/24/2014	IL Title 35 Environmental Regulations summary.pdf
Part 740 Site Remediation Program	http://www.ipcb.state.il.us/documents/dsweb/Get/Document-33436	2/24/2014	IL Site Site Remediation Program Part 740 regulations.pdf
Part 742 Tiered Approach to Corrective Action Objectives	http://www.ipcb.state.il.us/documents/dsweb/Get/Document-38408	2/24/2014	IL Part 742 Tiered Approach to Corrective Action Objectives.pdf

Guidance

Document	URL	Date Accessed	
Site Remediation Program	http://www.epa.state.il.us/land/site-remediation/index.html	2/24/2014	IL Site Remediation program one page.pdf
Site Remediation Program Overview	http://www.epa.state.il.us/land/site-remediation/overview.html	2/24/2014	IL Site Remediation program overview.pdf
Title XVII: Site Remediation Program	http://www.epa.state.il.us/land/site-remediation/title-17.html	2/24/2014	IL Site Remediation Program Title XVII Sections.pdf
Site Remediation Program Frequently Asked Questions	http://www.epa.state.il.us/land/site-remediation/site-remediation-faq.html	2/24/2014	IL Site Remediation Program FAQs.pdf
Tiered Approach to Corrective Action Objectives (TACO) Fact Sheet 1: Introduction	http://www.epa.state.il.us/land/taco/1-introduction.html	2/24/2014	TACO - Fact Sheet 1 - Illinois EPA - Bureau of Land.html
Tiered Approach to Corrective Action Objectives (TACO) Fact Sheet 3: No Further Remediation Letters	http://www.epa.state.il.us/land/taco/3-no-further-remediation-letters.html	2/24/2014	TACO Fact Sheet 3 - Illinois EPA - Bureau of Land.html
Tiered Approach to Corrective Action Objectives (TACO)	http://www.epa.state.il.us/land/taco/forms/taco-fact-sheets	2/24/2014	taco-fact-sheets.pdf

Maine

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Small Business Liability Relief and Brownfields Revitalization Act	http://www.gpo.gov/fdsys/pkg/PLAW-107publ118/html/PLAW-107publ118.htm	2/20/2014	Small Bus Liabil Relief and Brnflds Act.pdf
Voluntary Response Action Program Law	http://www.mainelegislature.org/legis/statutes/38/title38sec343-E.html	2/20/2014	Voluntary Response Action Program_title38sec343-E.pdf
Defense Environmental Restoration Program	http://www.denix.osd.mil/references/upload/TITLE-10-U-S-C-CHAPTER-160-Environmental-Restoration.pdf	2/20/2014	TITLE-10-U-S-C-CHAPTER-160-Environmental-Restoration.pdf
Spills and Site Cleanup Laws – Title 38 Waters and Navigation: Chapter 13B Uncontrolled Hazardous Substance Sites	http://www.mainelegislature.org/legis/statutes/38/title38ch13-Bsec0.html	2/26/2014	Chapter 13B Uncontrolled Haz Substances Sites_Combined.pdf
Spills and Site Cleanup Laws – Title 38 Waters and Navigation: Chapter 13D Wellhead Protection	http://www.mainelegislature.org/legis/statutes/38/title38ch13-Dsec0.html	2/26/2014	Chapter 13 D Wellhead Protection_Combined.pdf

Spills and Site Cleanup Laws – Title 38 Waters and Navigation: Chapter 14 Liability of Persons Mitigating the Effects of Discharge of Hazardous Materials	http://www.mainelegislature.org/legis/statutes/38/title38ch14sec0.html	2/26/2014	Chapter 14 Liability Persons Mitigating Effects of Haz Mat Discharge_Combined.pdf
Spills and Site Cleanup Laws – Title 38 Waters and Navigation: Chapter 31 Uniform Environmental Covenants Act	http://www.mainelegislature.org/legis/statutes/38/title38ch31sec0.html	2/26/2014	Chapter 31 Uniform Envir Covenant Acts_Combined.pdf
Spills and Site Cleanup Laws – Title 38 Waters and Navigation: Oil Discharge Prevention and Pollution Control	http://www.mainelegislature.org/legis/statutes/38/title38sec551-A.html	2/26/2014	Title 38 Applicable Sections of 342 to 571_Combined.pdf
Spills and Site Cleanup Laws – Title 38 Waters and Navigation: Underground Oil Storage Facilities and Ground Water Protection	http://www.mainelegislature.org/legis/statutes/38/title38sec566-A.html	2/26/2014	Title 38 Applicable Sections of 342 to 571_Combined.pdf
Maine Solid Waste Management Rules CHAPTER 400 GENERAL PROVISIONS	http://www.maine.gov/dep/spills/landfillclosure/index.html#la	2/20/2014	Chapter 400 - 096c400.doc
Maine Solid Waste Management Rules CHAPTER 401 LANDFILL SITING, DESIGN AND OPERATION	http://www.maine.gov/dep/spills/landfillclosure/index.html#la	2/20/2014	Chapter 401 - 096c401.doc
Maine Solid Waste Management Rules CHAPTER 405 WATER QUALITY MONITORING, LEACHATE MONITORING, AND WASTE CHARACTERIZATION	http://www.maine.gov/dep/spills/landfillclosure/index.html#la	2/20/2014	Chapter 405 - 096c405.doc
Voluntary Response Action Program Law Title 38: Waters and Navigation §342. Commissioner, duties	http://www.mainelegislature.org/legis/statutes/38/title38sec342.html	2/20/2014	title38sec1310-C.pdf
Voluntary Response Action Program Law Title 38: Waters and Navigation §343-E. Voluntary response action program	http://www.mainelegislature.org/legis/statutes/38/title38sec343-E.html	2/20/2014	title38sec1310-C.pdf
Voluntary Response Action Program Law Title 38: Waters and Navigation §343-F. Reporting and disclosure requirements	http://www.mainelegislature.org/legis/statutes/38/title38sec343-F.html	2/20/2014	title38sec1310-C.pdf
UNIFORM ENVIRONMENTAL COVENANTS ACTS	http://www.mainelegislature.org/legis/statutes/38/title38ch31sec0.html	2/20/2014	Chapter 31 Uniform Envir Covenant Acts_Combined.pdf
CERCLA	http://www.epa.gov/superfund/policy/index.htm	2/20/2014	Laws, Policy and Guidance _ Superfund _ US EPA.pdf

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Document	URL	Date Accessed	Filename(s)
Utilization and Storage of Class B Sewage Sludge at Municipal Landfills	http://www.maine.gov/dep/spills/landfillclosure/documents/sludgeuseonlandfills.pdf	2/20/2014	sludgeuseonlandfills.pdf
Development on or near Landfill Cover Systems	http://www.maine.gov/dep/spills/landfillclosure/documents/landfillcoverguidance.pdf	2/20/2014	development on or near LF_landfillcoverguidance.pdf
Remediation Guidelines for Petroleum Contaminated Sites in Maine	http://www.maine.gov/dep/spills/petroleum/documents/111809finalpetroremguidelines.pdf	2/20/2014	111809finalpetroremguidelines.pdf
Standard Practice for Environmental Site Assessments: Phase I environmental Site Assessment Process	Not available online	2/20/2014	E1527.659084-1.pdf
Standard Practice for Environmental Site Assessments: Phase II environmental Site Assessment Process	http://www.polb.com/civica/filebank/blobdload.asp?BlobID=9948	2/20/2014	E1903.603777-1.pdf
HISTORICAL OIL CONTAMINATION TRAVEL DISTANCES IN GROUND WATER AT SENSITIVE GEOLOGICAL SITES IN MAINE	http://www.maine.gov/dep/spills/publications/documents/traveldistancereportexanded.pdf	2/20/2014	Historic Oil_travel distance report exanded.pdf
Standard Guide for Developing Conceptual Site Models for Contaminated Sites	http://enterprise1.astm.org/DOWNLOAD/E1689.659084-1.pdf	2/20/2014	E1689.659084-1.pdf
Remedial Investigations/Feasibility Studies & Treatability Studies & Costing	http://www.epa.gov/superfund/policy/remedy/sfremedy/rifs.htm	2/20/2014	
ITRC Guidance	http://www.itrcweb.org/Guidance	2/20/2014	
Low Flow Ground Water Sampling	http://www.maine.gov/dep/spills/publications/is-lfs.html	2/20/2014	Low Flow Ground Water Sampling.pdf
Maine DEP Sampling and Data Validation (SOPs)	http://www.maine.gov/dep/spills/publications/sops/index.html	2/20/2014	
Vapor Intrusion Evaluation Guidance	http://www.maine.gov/dep/spills/publications/guidance/rags/vi1-14-2010/1-VI_Guide_1_13_10Final.pdf	2/20/2014	MEDEP VI Evaluation Guidance_1-VI_Guide_1_13_10Final.pdf
Vapor Intrusion Evaluation Guidance Tables	http://www.maine.gov/dep/spills/publications/guidance/rags/vi1-14-2010/3-Tables%20B1%20to%20B10%20Interim-Final-Vapor-Intrusion_Guidance_1-14-2010.pdf	2/20/2014	MEDEP VI Evaluation Guidance_2-Tables B1 to B10 Interim-Final-Vapor-Intrusion_Guidance_1-14-2010.xls
DRAFT INDOOR AIR SAMPLE PROTOCOL With Indoor Air Sample Information Collection Form	http://www.maine.gov/dep/spills/publications/guidance/rags/Web_8-27-09/Indoor%20Air%20Sample%20Protocol.pdf	2/20/2014	MEDEP Indoor Air Sample Protocol 2009.pdf
Soil Gas Sampling SOP	http://www.maine.gov/dep/spills/publications/guidance/rags/Web_8-27-09/TS_7_30_09_thin_steel_tubing%20Soil%20Gas%20Collection.pdf	2/20/2014	MEDEp Soil Gas Sampling TS_7_30_09_thin_steel_tubing Soil Gas Collection.pdf
Indoor Air Sampling Field Sheet	http://www.maine.gov/dep/spills/publications/guidance/rags/Web_8-27-09/7_23_09Indoor_air_and%20subslabform.pdf	2/20/2014	7_23_09Indoor_air_and subslabform.pdf
Soil Gas Sampling Field Sheet	http://www.maine.gov/dep/spills/publications/guidance/rags/Web_8-27-09/7_23_09soil_gas_form2a.pdf	2/20/2014	7_23_09soil_gas_form2a.pdf
Protocol for Collecting Soil Gas Samples	http://www.maine.gov/dep/spills/publications/sops/documents/dr026.pdf	2/20/2014	MEDEP SOP Soil Gas Sampling_dr026.pdf
Protocol for Collecting Sub Slab Soil Gas Samples	http://www.maine.gov/dep/spills/publications/sops/documents/dr027.pdf	2/20/2014	MEDEp Soil Gas Sampling TS_7_30_09_thin_steel_tubing Soil Gas Collection.pdf
Soil Gas Sample Collection Method Utilizina Hand Tools	http://www.maine.gov/dep/spills/publications/sops/documents/dr005.pdf	2/20/2014	MEDEPSoil Gas Sampling with Hand Tools_dr005.pdf
Trial Guideline for Protecting Residents from Inhalation Exposure to Petroleum Vapors TRIAL PERIOD FINDINGS	http://www.maine.gov/dep/spills/petroleum/documents/trialfindings.pdf	2/20/2014	MEDEP Guidelines for Protection of Residents_Inhalation_Petroleum_trialfindings.pdf

VAPOR INTRUSION STUDY FOR PETROLEUM SITES	http://www.maine.gov/dep/ftp/vi-study_jan-2012/Statewide-VI-Study01192012.pdf	2/20/2014	MEDEP Statewide-VI-Study_Petroleum Sites_01192012.pdf
TYPICAL CONCENTRATIONS OF PETROLEUM COMPOUNDS IN MAINE RESIDENTIAL INDOOR AIR	http://www.maine.gov/dep/spills/petroleum/documents/typical_compounds4-2012.pdf	2/20/2014	MEDEP_Residential Indoor Air Petroleum Background_typical_compounds4-2012.pdf
Maine CDC Ambient Air Guideline 2010 Update	http://www.maine.gov/dhhs/mecdc/environmental-health/eohp/air/documents/2010aagsapril.pdf	2/20/2014	2010aagsapril.pdf
Chronic Ambient Air Guidelines	http://www.maine.gov/dhhs/mecdc/environmental-health/eohp/air/documents/aagtable.pdf	2/20/2014	aagtable.pdf
Maine Bureau of Health Ambient Air Guidelines	http://www.maine.gov/dhhs/mecdc/environmental-health/eohp/air/documents/aagproc.pdf	2/20/2014	2004_aagproc.pdf
Maine CDC Ambient Air Guidelines addendum	http://www.maine.gov/dhhs/mecdc/environmental-health/eohp/air/documents/06aags.pdf	2/20/2014	2006aags.pdf
GUIDANCE FOR HUMAN HEALTH RISK ASSESSMENTS FOR HAZARDOUS SUBSTANCE SITES IN MAINE	http://www.maine.gov/dep/spills/publications/guidance/rags/final_5-8-2013/1%20Risk%20Manual-Feb_2011-%20CC.pdf	2/20/2014	MEDEP HHRA Guidance_1 Risk Manual-Feb_2011- CC.pdf
Table 1 - Standard Default Exposure Assumptions for Maine Risk Assessments	http://www.maine.gov/dep/spills/publications/guidance/rags/final_5-8-2013/1b%20HHRA%20ExposureFactorTable%201_102913_CC.xlsx	2/20/2014	HHRA Exposure Assumptions_1b HHRA ExposureFactorTable 1_102913_CC.xlsx
Maine Remedial Action Guidelines (RAGs) for Sites Contaminated with Hazardous Waste Substances	http://www.maine.gov/dep/spills/publications/guidance/rags/final_5-8-2013/2%20ME-RAGS_Final_5-8-2013%20Corrected%20Copy.pdf	2/20/2014	2 ME-RAGS_Final_5-8-2013 Corrected Copy.pdf
FINAL DEVELOPMENT OF RISK-BASED CLEANUP LEVELS FOR PETROLEUM HYDROCARBONS MEASURED AS DRO AND GRO	http://www.maine.gov/dep/spills/vrap/documents/ecinterimfinal%20.pdf	2/20/2014	risk based cleanup levels_petroleum_ecinterimfinal.pdf
Interim Guidelines Notification of Environmental Evidence of an Oil Discharge at an Oil Storage Facility When Using the Volatile Petroleum Hydrocarbon (VPH) and Extractable Petroleum Hydrocarbon (EPH) Laboratory Methods	http://www.maine.gov/dep/spills/petroleum/documents/internotifcation.pdf	2/20/2014	Oil discharge_internotifcation.pdf
Guidance for Well and Boring Abandonement	http://www.maine.gov/dep/spills/publications/guidance/documents/dep_well_abandonment_guidance.pdf	2/20/2014	dep_well_abandonment_guidance.pdf
NON-COMPLIANCE RESPONSE GUIDANCE	http://www.maine.gov/dep/publications/documents/ENF_POL_NCR_LEGISLATIVE_03092011.pdf	2/20/2014	ENF_POL_NCR_LEGISLATIVE_03092011.pdf
SUPPLEMENTAL ENVIRONMENTAL PROJECTS POLICY	http://www.maine.gov/dep/publications/documents/sep_pol.pdf	2/20/2014	supplemental environmental projects policy.pdf
SMALL BUSINESS COMPLIANCE INCENTIVES POLICY	http://www.maine.gov/dep/assistance/sbap/sbc_pol.pdf	2/20/2014	small business compliance incentives policy.pdf
Draft Environmental Covenants Draft RCRA Environmental Covenant Template	http://www.maine.gov/dep/spills/publications/guidance/covenant/DRAFT%20EC%20RCRA%20TEMPLATE%202-14-12.doc	2/20/2014	DRAFT EC RCRA TEMPLATE 2-14-12.doc
Draft Environmental Covenants Draft Superfund/Uncontrolled Hazardous Substance Site Environmental Covenant Template	http://www.maine.gov/dep/spills/publications/guidance/covenant/DRAFT%20EC%20SUPERFUND%20UNCONTROLLED%20SITE%20TEMPLATE%202-14-12.doc	2/20/2014	DRAFT EC SUPERFUND UNCONTROLLED SITE TEMPLATE 2-14-12.doc
Draft Environmental Covenants Draft VRAP Environmental Covenant Template	http://www.maine.gov/dep/spills/publications/guidance/covenant/DRAFT%20EC%20VRAP%20TEMPLATE%202-14-12%20(2).doc	2/20/2014	DRAFT EC VRAP TEMPLATE 2-14-12 (2).doc
Draft Environmental Covenants Draft Subordination Agreement Template for Easement	http://www.maine.gov/dep/spills/publications/guidance/covenant/draft%20subordination%20agreement%20template%20for%20easement%202-16-12.doc	2/20/2014	draft subordination agreement template for easement 2-16-12.doc
Draft Environmental Covenants Draft Subordination Agreement Template for Mortgage	http://www.docstoc.com/docs/120161081/draft-subordination-agreement-template-for-mortgage-2-16-12	2/20/2014	draft subordination agreement template for mortgage 2-16-12.doc

Other

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Small Business Liability Relief and Brownfields Revitalization Act	http://www.epa.gov/brownfields/laws/2869ben.htm	2/20/2014	Benefits of Brownfields Legislation Summary of Public Law 107-118.pdf
Small Business Liability Relief and Brownfields Revitalization Act	http://georgewbush-whitehouse.archives.gov/news/releases/2003/06/20030620.html	2/20/2014	Executive Order_Brownfields Act.pdf
Small Business Liability Relief and Brownfields Revitalization Act	http://www.epa.gov/brownfields/laws/2869sum.htm	2/20/2014	Summary of Small Bus Liability Relief and Brnflds Revit Act.pdf
Defense Environmental Restoration Program	http://www.denix.osd.mil/derp/index.cfm	2/20/2014	DENIX - Defense Environmental Restoration Program.pdf
Remedial Action Guidelines Soils Risk Calculator	http://www.maine.gov/dep/spills/publications/guidance/rags/final_5-8-2013/4%20Soils%20%20Risk%20Calculator_081213.xlsx	2/20/2014	4 Soils Risk Calculator_081213.xlsx
Remedial Action Guidelines Indoor Air Risk Calculator	http://www.maine.gov/dep/spills/publications/guidance/rags/final_5-8-2013/5%20Indoor-Air-%20Risk%20Calculator_081213.xlsx	2/20/2014	5 Indoor-Air- Risk Calculator_081213.xlsx
Remedial Action Guidelines Residential Water Cummulative Risk Calculator	http://www.state.me.us/dep/spills/publications/guidance/rags/final_5-8-2013/6%20Res-Water%20Cummulative%20Risk%20Calculator_041713.xlsx	2/20/2014	6 Res-Water Cummulative Risk Calculator_041713.xlsx
Remedial Action Guidelines Construction Worker Water Cummulative Risk Calculator	http://www.maine.gov/dep/spills/publications/guidance/rags/final_5-8-2013/6%20Res-Water%20Cummulative%20Risk%20Calculator_041713.xlsx	2/20/2014	7 CW-Water Cummulative Risk Calculator_041713.xlsx
Remedial Action Guidelines Risk Calculator Guidelines for Soil, Indoor Air and GW		2/20/2014	Risk Calculator Guidelines_soil_Indoor Air_GW_3 ME-RAG Tables 5-8-2013.xlsx
RI/FS and Treatability Studies Overview	http://www.epa.gov/superfund/policy/remedy/sfremedy/rifs/overview.htm	2/20/2014	
FRTF Remediation Technologies Screening Matrix and Reference Guide, Version 4.0	http://www.frtr.gov/matrix2/top_page.html	2/20/2014	

Massachusetts

Legislation

Document	URL	Date Accessed	Filename(s)
Massachusetts Oil and Hazardous Material Release Prevention Act	https://malegislature.gov/Laws/GeneralLaws/PartI/TitleII/Chapter21E	2/27/2014	Chapter 21E.pdf

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Massachusetts Contingency Plan (310 CMR 40)	http://www.mass.gov/eea/docs/dep/service/regulations/310cmr40.pdf	2/27/2014	310cmr40.pdf
Proposed Massachusetts Contingency Plan Amendments	http://www.mass.gov/eea/docs/dep/cleanup/laws/mcpdrtcl.pdf	2/27/2014	mcpdrtcl.pdf
Massachusetts Oil and Hazardous Materials List - Alphabetical (310 CMR 40.1600)	http://www.mass.gov/eea/docs/dep/cleanup/laws/mohmla.pdf	2/27/2014	mohmla.pdf
Massachusetts Oil and Hazardous Materials List - by CAS Number (310 CMR 40.1600)	http://www.mass.gov/eea/docs/dep/cleanup/laws/mohmlb.pdf	2/27/2014	mohmlb.pdf
Oil Spill Prevention and Reponse (310 CMR 19)	http://www.mass.gov/eea/docs/dep/service/regulations/314cmr19.pdf	2/27/2014	310cmr19.pdf

Guidance

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MCP Numerical Standards Development Spreadsheets	http://www.mass.gov/eea/docs/dep/cleanup/laws/mcpsprds.zip	2/27/2014	MCP GW.xls, MCP GW2 alpha.xls, MCP Leach.xls, MCP Numerical Standards Revision History.doc, MCP Soil.xls, MCP Standards.xls, MCP Toxicity.xls
Similar Soils Provision Guidance (WSC#13-500)	http://www.mass.gov/eea/docs/dep/cleanup/laws/13-500.pdf	2/27/2014	13-500.pdf
Interim Final Vapor Intrusion Guidance (WSC-11-435)	http://www.mass.gov/eea/docs/dep/cleanup/laws/vifin.pdf	2/27/2014	vifin.pdf
MCP Representativeness Evaluations and Data Usability Assessments (WSC-07-350)	http://www.mass.gov/eea/docs/dep/cleanup/laws/07-350.pdf	2/27/2014	07-350.pdf
Conducting Feasibility Evaluations Under the MCP (WSC-04-160)	http://www.mass.gov/eea/docs/dep/cleanup/laws/04-160.pdf	2/27/2014	04-160.pdf
Indoor Air Sampling and Evaluiation Guide (WSC-02-430)	http://www.mass.gov/eea/docs/dep/cleanup/laws/02-430.pdf	2/27/2014	02-430.pdf
Characterizing Risks Posed by Petroleum Contaminated Sites: Implementation of the MADEP VPH/EPH Approach (WSC-02-411)	http://www.mass.gov/eea/docs/dep/cleanup/laws/02-411.pdf	2/27/2014	02-411.pdf
Characterizing Risks Posed by Petroleum Contaminated Sites: Implementation of the MADEP VPH/EPH Approach Background Documentation (WSC-02-411)	http://www.mass.gov/eea/docs/dep/cleanup/laws/02-411bg.pdf	2/27/2014	02-411bg.pdf
Construction of Buildings in Contaminated Areas (WSC-00-425)	http://www.mass.gov/eea/docs/dep/cleanup/laws/00-425.pdf	2/27/2014	00-425.pdf
Guidance on Implementing Activity and Use Limitations (WSC-99-300)	http://www.mass.gov/eea/docs/dep/cleanup/laws/99-300.pdf	2/27/2014	99-300.pdf
Numerical Ranking System Guidance Manual (WSC-97)	http://www.mass.gov/eea/docs/dep/cleanup/laws/nrsman.pdf	2/27/2014	nrsman.pdf
Non-Potential Drinking Water Source Areas (WSC-97-701)	http://www.mass.gov/eea/docs/dep/cleanup/laws/gispol.pdf	2/27/2014	gispol.pdf
Underground Storage Tank Closure Assessment Manual (WSC-402-96)	http://www.mass.gov/eea/docs/dep/cleanup/laws/96-402.pdf	2/27/2014	96402.pdf
Guidance for Disposal Site Risk Characterization (WSC/ORS-95-141)	http://www.mass.gov/eea/docs/dep/cleanup/laws/rc1.pdf (and rc2.pdf and rc3.pdf)	2/27/2014	Guidance for Disposal Site Risk Characterization 1995.pdf
Interim Remediation Waste Management Policy for Petroleum Contaminated Soils (WSC-94-400)	http://www.mass.gov/eea/docs/dep/cleanup/laws/94-400.pdf	2/27/2014	94-400.pdf
Off-Gas Treatment of Point Source Remedial Air Emissions (WSC-94-150)	http://www.mass.gov/eea/docs/dep/cleanup/laws/94-150.pdf	2/27/2014	94-150.pdf
Previously Non-participating and Newly Identified Potentially Responsible Parties (PRPs) Who Wish to Assume Responsibility for Response Actions (WSC-601-90)	http://www.mass.gov/eea/docs/dep/cleanup/laws/90-601.pdf	2/27/2014	90-601.pdf
Draft Guidance on Implementing Activity and Use Limitations (WSC-11-300)	http://www.mass.gov/eea/docs/dep/cleanup/laws/auldr.pdf	2/28/2014	auldr.pdf
Assessing Contamination at Residential Underground Heating Oil Tank Closures	http://www.mass.gov/eea/docs/dep/cleanup/homeust.pdf	2/28/2014	homeust.pdf
Guidance on the Regulatory Status of Petroleum-Contaminated Remedial Wastewater	http://www.mass.gov/eea/docs/dep/recycle/laws/pcrwguid.pdf	2/28/2014	pcrwguid.pdf
Draft Guidance on the Use, Design, Construction, and Monitoring of Engineered Barriers	http://www.mass.gov/eea/docs/dep/cleanup/laws/engbar.pdf	2/28/2014	engbar.pdf
Draft Policy: Petitioning for a Case-Specific Designation of a Non-Potential Drinking Water Source Area	http://www.mass.gov/eea/docs/dep/cleanup/laws/petpol.pdf	2/28/2014	petpol.pdf
Technical Update: Considerations for Managing Contaminated Soil: RCRA Land Disposal Restrictions and Contained-In Determinations	http://www.mass.gov/eea/docs/dep/cleanup/laws/contain.pdf	3/4/2014	contain.pdf
Technical Update: Residential Typical Indoor Air Concentrations	http://www.mass.gov/eea/docs/dep/cleanup/laws/iatu.pdf	3/4/2014	iatu.pdf
Technical Update: Expressing the Precision of Exposure Point Concentrations and Risk Estimates in MCP Risk Characterizations	http://www.mass.gov/eea/docs/dep/cleanup/laws/sigfigtu.pdf	3/4/2014	sigfigtu.pdf
Technical Update: Default Fish Ingestion Rates and Exposure Assumptions for Human Health Risk Assessments	http://www.mass.gov/eea/docs/dep/cleanup/laws/fish109.pdf	3/4/2014	fish109.pdf
Technical Update: Background Levels of Polycyclic Aromatic Hydrocarbons and Metals in Soil	http://www.mass.gov/eea/docs/dep/cleanup/laws/backtu.pdf	3/4/2014	backtu.pdf
Technical Update: Characterization of Risks Due to Inhalation of Particulates by Construction Workers	http://www.mass.gov/eea/docs/dep/cleanup/laws/inh0708.pdf	3/4/2014	inh0708.pdf
Technical Update: Calculation of an Enhanced Soil Ingestion Rate	http://www.mass.gov/eea/docs/dep/cleanup/laws/soiling.pdf	3/4/2014	soiling.pdf
Technical Update: Weighted Skin-Soil Adherence Factors	http://www.mass.gov/eea/docs/dep/cleanup/laws/dermadhe.pdf	3/4/2014	dermadhe.pdf
An Evaluation of Vapor Intrusion Into Buildings Through a Study of Field Data	http://www.mass.gov/eea/docs/dep/cleanup/gw2proj.pdf	3/4/2014	gw2proj.pdf
Sediment Toxicity of Petroleum Hydrocarbon Fractions	http://www.mass.gov/eea/docs/dep/cleanup/laws/tphbat.pdf	3/4/2014	tphbat.pdf
Interim Final Petroleum Report: Development of Health-Based Alternative to the Total Petroleum Hydrocarbon (TPH) Parameter	http://www.mass.gov/eea/docs/dep/cleanup/laws/alttph.pdf	3/4/2014	alttph.pdf
Updated Petroleum Hydrocarbon Fraction Toxicity Values for the VPH/EPH/APH Methodology	http://www.mass.gov/eea/docs/dep/cleanup/laws/tphtox03.pdf	3/4/2014	tphtox03.pdf
Methodology for Updating Guidelines: Allowable Ambient Limits (AALs) & Threshold Effect Exposure Limits (TELs)	http://www.mass.gov/eea/docs/dep/toxics/stypes/aaltel11.pdf	3/4/2014	aaltel11.pdf
1995 Ambient Air Exposure Limits (AALs) for Chemicals	http://www.mass.gov/eea/docs/dep/air/aallist.pdf	3/4/2014	aallist.pdf
Summary of 1994 Updates: Chemical Health Effects Assessment Methodology & Method To Derive Allowable Ambient Limits (Superseded)	http://www.mass.gov/eea/docs/dep/air/chem-aal-sum.pdf	3/4/2014	chem-aal-sum.pdf
The Chemical Health Effects Assessment Methodology & The Method To Derive Allowable Ambient Limits (CHEM/AAL), February 1990	http://www.mass.gov/eea/docs/dep/air/laws/chem-aal.pdf	3/4/2014	chem-aal.pdf
CHEM/AAL Appendices	http://www.mass.gov/eea/docs/dep/air/laws/chem-app.pdf	3/4/2014	chem-app.pdf

Homegrown Produce Consumption Pathway: Exposure Assessment for Method 1 Standards	http://www.mass.gov/eea/docs/dep/cleanup/laws/prodcons.pdf	3/4/2014	prodcons.pdf
Plant Uptake Factor Documentation Derivation	http://www.mass.gov/eea/docs/dep/cleanup/laws/pufderiv.pdf	3/4/2014	pufderiv.pdf
A Weight-Of-Evidence Approach For Evaluating Ecological Risks	http://www.mass.gov/eea/docs/dep/cleanup/laws/weightev.pdf	3/4/2014	weightev.pdf
Averaging Area for Benthic Invertebrate Assessments	http://www.mass.gov/eea/docs/dep/water/laws/a-thru-h/ecotuaai.pdf	3/4/2014	ecotuaai.pdf
Assessment Endpoints for Benthic Invertebrates	http://www.mass.gov/eea/docs/dep/water/laws/a-thru-h/ecotuaeb.pdf	3/4/2014	ecotuaeb.pdf
Assessing Risk of Harm to Benthic Invertebrates	http://www.mass.gov/eea/docs/dep/water/laws/a-thru-h/ecotuben.pdf	3/4/2014	ecotuben.pdf
Freshwater Sediment Toxicity Tests	http://www.mass.gov/eea/docs/dep/water/laws/a-thru-h/ecotufws.pdf	3/4/2014	ecotufws.pdf
Revised Sediment Screening Values	http://www.mass.gov/eea/docs/dep/water/laws/a-thru-h/ecoturss.pdf	3/4/2014	ecoturss.pdf
Ecological Value of Surface Water Features	http://www.mass.gov/eea/docs/dep/water/laws/a-thru-h/ecotusw.pdf	3/4/2014	ecotusw.pdf
Area-Based Screening for Sediment Contamination	http://www.mass.gov/eea/docs/dep/water/laws/a-thru-h/ecotused.pdf	3/4/2014	ecotused.pdf
Users Guide: ShortForms for Human Health Risk Assessment under the MCP	http://www.mass.gov/eea/docs/dep/cleanup/compliance/shortfug.pdf	3/4/2014	shortfug.pdf
ShortForms for Human Health Risk Assessment under the MCP	http://www.mass.gov/eea/docs/dep/cleanup/compliance/shortforms.zip	3/4/2014	shortforms.zip
Ecological Risks of Lead Shot	http://www.mass.gov/eea/docs/dep/toxics/stypes/lsersk.pdf	3/4/2014	lsersk.pdf

Other

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Master MCP Q&A: 1993-2009	http://www.mass.gov/eea/agencies/massdep/cleanup/regulations/master-mcp-q-and-a-1993-2009.html	2/28/2014	master-mcp-q-and-a-1993-2009.pdf
The Massachusetts waste site cleanup program - the basics	http://www.mass.gov/eea/docs/dep/cleanup/laws/bhfs.pdf	2/28/2014	bhfs.pdf
Massachusetts' Approach to Waste Site Cleanup: Chapter 21E and the Massachusetts Contingency Plan	http://www.mass.gov/eea/docs/dep/cleanup/laws/msfs.pdf	2/28/2014	msfs.pdf

Michigan

Legislation

Document	URL	Date Accessed	Filename
Natural Resources and Environmental Protection Act (Excerpt) Act 451 of 1994	http://mi.aipg.org/legislation/mcl-451-1994-II-7-201.pdf	2/24/2014	mcl-451-1994-ii-7-201.pdf

Regulations

Document	URL	Date Accessed	Filename
Part 10. Compliance with Section 20107a of Act	http://www7.dleg.state.mi.us/orr/Files%5CAdminCode%5C294_10272_AdminCode.pdf	2/24/2014	294_10272_AdminCode.pdf
Cleanup Criteria Requirements for Response Activity	http://www7.dleg.state.mi.us/orr/Files/AdminCode/1232_2013-056EQ_AdminCode.pdf	2/24/2014	1232_2013-056EQ_AdminCode.pdf

Guidance

Document	URL	Date Accessed	
Announcing The December 30, 2013 Promulgated Cleanup Criteria	http://www.michigan.gov/documents/deq/deq-rrd-cleanupcriteriaAnnouncement-1-24-2014_445565_7.pdf	2/24/2014	cleanupcriteriaAnnouncement-1-24-2014.pdf
Remediation and Redevelopment Division home page	http://www.michigan.gov/deq/0,4561,7-135-3306_28608---,00.html	2/24/2014	Remediation and Redevelopment Division document list.pdf
Guidance Document For The Vapor Intrusion Pathway May 2013	http://www.michigan.gov/documents/deq/deq-rrd-VIGuidanceDoc-May2013_422550_7.pdf	2/24/2014	VIGuidanceDoc-May2013.pdf
Table 1. Response to Comments on May 2012 DRAFT Vapor Intrusion Guidance Document	http://www.michigan.gov/documents/deq/deq-rrd-VI-ResponseToComments_427097_7.pdf	2/24/2014	VI-ResponseToComments.pdf

Part 201 & 213 Program Redesign

Document	URL	Date Accessed	Filename
Part 201 & 213 Cleanup and Redevelopment Program Redesign	http://www.michigan.gov/deq/0,1607,7-135-3311_4109_9846-204636--,00.htm	2/25/2014	Part 201 & 213 Program Redesign file list.pdf
Program Redesign 2009: Draft Proposed Immediate Response Activity Screening Levels	http://www.michigan.gov/documents/deq/deq-rrd-PART201-AIASLs_ASGSLs_EWSLs-9-24-09_293419_7.pdf	2/25/2014	PART201-AIASLs_ASGSLs_EWSLs-9-24-09.pdf
Proposals for the Cleanup Criteria - An Introduction	http://www.michigan.gov/documents/deq/deq-rrd-PART201-CriteriaProposalsGeneral-9-10-09_291918_7.pdf	2/25/2014	PART201-CriteriaProposalsGeneral-9-10-09.pdf
Cleanup Criteria	http://www.michigan.gov/documents/deq/deq-rrd-PART201-GeneralCriteria_11-10-09_303656_7.pdf	2/25/2014	PART201-GeneralCriteria_11-10-09.pdf
Program Redesign 2009: Draft Proposed Groundwater Sump Screening Levels	http://www.michigan.gov/documents/deq/deq-rrd-PART201-GWsumpSLs-9-24-09_293421_7.pdf	2/25/2014	PART201-GWsumpSLs-9-24-09.pdf
Program Redesign 2009: Draft Proposed Vapor Intrusion Indoor Air Criteria (IAC), Soil Gas Criteria (SGC), and Groundwater Screening Levels (GWSLs)	http://www.michigan.gov/documents/deq/deq-rrd-PART201-IndoorAirAndSoilGasCriteria-9-24-09_293422_7.pdf	2/25/2014	PART201-IndoorAirAndSoilGasCriteria-9-24-09.pdf
Draft Proposed Immiediate Response Activity Screening Levels	http://www.michigan.gov/documents/deq/deq-rrd-PART201-IRASLsBackgroundDocument-9-24-09_293417_7.pdf	2/25/2014	PART201-IRASLsBackgroundDocument-9-24-09.pdf
Immediate Response Activity Screeening Levels	http://www.michigan.gov/documents/deq/deq-rrd-PART201-IRASLsStatutoryLanguageOnly-9-10-09_291921_7.pdf	2/25/2014	PART201-IRASLsStatutoryLanguageOnly-9-10-09.pdf
Program Redesign New Criteria and SLs	http://www.michigan.gov/documents/deq/deq-rrd-PART201-NewCriteriaAndScreeningLevelsMatrix-9-10-09_291923_7.pdf	2/25/2014	PART201-NewCriteriaAndScreeningLevelsMatrix-9-10-09.pdf

Soil Criteria	http://www.michigan.gov/documents/deq/deq-rrd-PART201-SoilCriteria-11-10-09_303628_7.pdf	2/25/2014	PART201-SoilCriteria-11-10-09.pdf
Vapor Intrusion Criteria and Screening Levels.	http://www.michigan.gov/documents/deq/deq-rrd-PART201-VaporIntrusion-11-4-09_303627_7.pdf	2/25/2014	PART201-VaporIntrusion-11-4-09.pdf
New Vapor Intrusion Criteria and Immediate Response Activity Screening Levels	http://www.michigan.gov/documents/deq/deq-rrd-PART201-VaporIntrusionCriteriaIntroAndImmediateResponseScreeningLevels-9-10-09__291902_7.pdf	2/25/2014	PART201-VaporIntrusionCriteriaIntroAndImmediateResponseScreeningLevels-9-10 09.pdf
Program Redesign: The Vapor Intrusion to Indoor Air Pathway	http://www.michigan.gov/documents/deq/deq-rrd-PART201-VaporIntrusionProgramRedesign2009Presentation-9-24-09_293425_7.pdf	2/25/2014	PART201-VaporIntrusionProgramRedesign2009Presentation-9-24-09.pdf
Background Document: Draft Proposed Vapor Intrusion Indoor Air Criteria (IAC), Soil Gas Criteria (SGC), and Groundwater Screening Levels (GWSLs)	http://www.michigan.gov/documents/deq/deq-rrd-PART201-VICriteria_SLBackgroundDocument-9-24-09_293424_7.pdf	2/25/2014	PART201-VICriteria_SLBackgroundDocument-9-24-09.pdf
Redesign Draft Flow chart	http://www.michigan.gov/documents/deq/deq-rrd-PART201-VIProgramRedesignDraftFlowChart-9-24-09_293426_7.pdf	2/25/2014	PART201-VIProgramRedesignDraftFlowChart-9-24-09.pdf
Highlights of the Changes to Michigan's Cleanup Programs In Public Act 446 of 2012	http://www.michigan.gov/documents/deq/deq-rrd-ChangesToPart201AndPart213-12-27-2012_416935_7.pdf	2/25/2014	Public Act 446 changes highlighted.pdf

Cleanup Criteria

Document	URL	Date Accessed	Filename
Cleanup Criteria Requirements for Response Activity (Formerly the Part 201 Generic Cleanup Criteria and Screening Levels	http://www.michigan.gov/deq/0,4561,7-135-3311_4109_9846-251790--,00.html	2/24/2014	Cleanup criteria file summary.pdf
Changes in Part 201 Cleanup Criteria and Screening Levels	http://www.michigan.gov/documents/deq/deq-rrd-Rules-2013CriteriaChanges_447067_7.pdf	2/24/2014	2013CriteriaChanges.pdf
R299.49 Footnotes For Generic Cleanup Criteria Tables	http://www.michigan.gov/documents/deq/deq-rrd-Rules-2013Footnotes_447068_7.pdf	2/24/2014	2013Footnotes.pdf
ERRATA December 30, 2013 Part 201 Criteria Tables	http://www.michigan.gov/documents/deq/deq-rrd-Rules-2013RulesErrata_447069_7.pdf	2/24/2014	2013RulesErrata.pdf
Footnote (G) GSI/GSIPC Calculation (excel spreadsheet)	http://www.michigan.gov/deq/0,4561,7-135-3311_4109_9846-251790--,00.htm	2/24/2014	rrd-opmemo18-G_398350_7.xls
Table 1. Groundwater: Residential and Non-Residential	http://www.michigan.gov/documents/deq/deq-rrd-Rules-Table1GroundwaterResidentialandNon_447070_7.pdf	2/24/2014	Table1GroundwaterResidentialandNon.pdf
Table 2. Soil: Residential	http://www.michigan.gov/documents/deq/deq-rrd-Rules-Table2SoilResidential_447072_7.pdf	2/24/2014	Table2SoilResidential.pdf
Table 3. Soil: Nonresidential	http://www.michigan.gov/documents/deq/deq-rrd-Rules-Table3SoilNonresidential_447075_7.pdf	2/24/2014	Table3SoilNonresidential.pdf
Table 4. Toxicological and Chemical-Physical Data	http://www.michigan.gov/documents/deq/deq-rrd-Rules-Table4ToxicologicalChemicalPhysicalData_447077_7.pdf	2/24/2014	Table4ToxicologicalChemicalPhysicalData.pdf

Other

Document	URL	Date Accessed	Filename
Highlights of the Changes to Michigan's Cleanup Programs in Public Act 446 of 2012	http://www.michigan.gov/documents/deq/deq-rrd-ChangesToPart201AndPart213-12-27-2012_416935_7.pdf	2/24/2014	Highlights to cleanup changes 1-2-2013.pdf
Site Investigation and Cleanup Home page	http://www.michigan.gov/deq/0,1607,7-135-3311_4109_9846---,00.html	2/24/2014	Site Investigation and Cleanup summary sheet.pdf

Montana

Legislation

Document	URL	Date Accessed	Filename(s)
Comprehensive Environmental Cleanup and Responsibility Act (CECRA)	http://leg.mt.gov/bills/mca_toc/75_10_7.htm	3/6/2014	CECRA.pdf
Voluntary Cleanup and Redevelopment Act (VCRA)	http://leg.mt.gov/bills/mca_toc/75_10_7.htm	3/6/2014	VCRA.pdf
Controlled Allocation of Liability Act (CALA)	http://leg.mt.gov/bills/mca_toc/75_10_7.htm	3/6/2014	CALA.pdf

Regulation

Document	URL	Date Accessed	Filename(s)
Environmental Quality Chapter 55 CECRA Remediation	http://deq.mt.gov/dir/legal/title17.mcpx	3/6/2014	CH55-01.pdf
Environmental Quality Chapter 56 Underground Storage Tanks Petroleum and Chemical Substances Subchapter 5	http://deq.mt.gov/dir/legal/Chapters/Ch56-toc.mcpx	3/6/2014	CH56-05.pdf
Environmental Quality Chapter 56 Underground Storage Tanks Petroleum and Chemical Substances Subchapter 6	http://deq.mt.gov/dir/legal/Chapters/Ch56-toc.mcpx	3/6/2014	CH56-06.pdf
Environmental Quality Chapter 30 Water Quality Subchapter 7 Nondegradation of Water Quality	http://deq.mt.gov/dir/legal/Chapters/Ch30-toc.mcpx	3/6/2014	CH30-07.pdf

Guidance

Document	URL	Date Accessed	Filename(s)
Frequently Asked State Superfund Questions	http://deq.mt.gov/StateSuperfund/FrequentlyAskedQuestions.mcpx	3/6/2014	Frequently Asked State Superfund Questions.pdf
Soil Screening Process	http://deq.mt.gov/StateSuperfund/resources.mcpx	3/6/2014	soil screening_flowchart.pdf
Background Concentrations of Inorganic Constituents in Montana Surface Soils	http://deq.mt.gov/StateSuperfund/background.mcpx	3/6/2014	BkgdInorganicsReport.pdf

Vapor Intrusion Guidance Document	http://deq.mt.gov/statesuperfund/viguide.mcpx#Typical_Indoor_Air_Study	3/6/2014	VaporIntrusionGuidance.pdf
Typical Indoor Air Concentrations of Volatile Organic Compounds in Non-Smoking Montana Residences Not Impacted by Vapor Intrusion	http://deq.mt.gov/statesuperfund/viguide.mcpx#Typical_Indoor_Air_Study	3/6/2014	CompleteIndoorVOCReport.pdf
Montana Tier 1 Risk-Based Corrective Action Guidance for Petroleum Releases	http://deq.mt.gov/statesuperfund/rbca_guide.mcpx	3/6/2014	RBCA.pdf
Action Level for Arsenic in Surface Soil	http://deq.mt.gov/StateSuperfund/resources.mcpx	3/6/2014	ArsenicPositionPaper-1.pdf
Circular DEQ-7 Montana Numeric Water Quality Standards	http://deq.mt.gov/StateSuperfund/resources.mcpx	3/6/2014	DEQ7_2012.pdf
Data Validation Guidelines for Evaluating Analytical Data	http://deq.mt.gov/StateSuperfund/resources.mcpx	3/6/2014	DataValidationReport.pdf
Montana Dioxin Background Investigation Report	http://deq.mt.gov/StateSuperfund/dioxinguide.mcpx	3/6/2014	DioxinBackgroundStudy.pdf
Technical Guidance General Field Data Needs for Fate and Transport Modeling	http://deq.mt.gov/StateSuperfund/resources.mcpx	3/6/2014	DeqRemFateTransoortGuide.pdf
Voluntary Cleanup and Redevelopment Act Application Guide	http://deq.mt.gov/StateSuperfund/vcraguide.mcpx	3/6/2014	VCRAGuide.pdf
SRS Low-Flow Purging and Sampling Guidelines	http://deq.mt.gov/StateSuperfund/resources.mcpx	3/6/2014	srs_lowflow_memo.pdf
Montana Light Non-Aqueous Phase Liquid (LNAPL) Recovery and Monitoring Guidance	http://deq.mt.gov/StateSuperfund/resources.mcpx	3/6/2014	LNAPL Recovery and Monitoring Guidance.pdf
Site Response Section (SRS) Map Guidance	http://deq.mt.gov/StateSuperfund/resources.mcpx	3/6/2014	SrsMapGuidance.pdf
Ecological Risk Assessment Guidance	http://www.deq.mt.gov/StateSuperfund/FrequentlyAskedQuestions.mcpx	6/11/2014	Ecorisk.pdf

Other

Document	URL	Date Accessed	Filename(s)
Air-Phase Petroleum Hydrocarbon VI Screening Level Calculator	http://deq.mt.gov/StateSuperfund/aphvicalc.mcpx	3/6/2014	Aphvisl_calc.xlsx
2005 TEQ Dioxins/Furans Calculator for Soil and Water Samples	http://deq.mt.gov/StateSuperfund/TEQs.mcpx	3/6/2014	teqcalculator_soil.xlsx

New Hampshire

Legislation

Document	URL	Date Accessed	Filename(s)
RSA 146A Oil Spillage in Public Waters	http://www.gencourt.state.nh.us/rsa/html/x/146-a/146-a-mrg.htm	3/5/2014	RSA 146A.pdf
RSA 146C Underground Storage Facilities	http://www.gencourt.state.nh.us/rsa/html/NHTOC/NHTOC-X-146-C.htm	3/5/2014	RSA 146C.pdf
RSA 146D Oil Discharge and Disposal Cleanup Fund	http://www.gencourt.state.nh.us/rsa/html/x/146-d/146-d-mrg.htm	3/5/2014	RSA 146D.pdf
RSA 147A Hazardous Waste Management Act	http://www.gencourt.state.nh.us/rsa/html/X/147-A/147-A-mrg.htm	3/5/2014	RSA 147A.pdf
RSA 147B Hazardous Waste Cleanup Fund	http://www.gencourt.state.nh.us/rsa/html/X/147-B/147-B-mrg.htm	3/5/2014	RSA 147B.pdf
RSA 147F Brownfields Program	http://www.gencourt.state.nh.us/rsa/html/X/147-F/147-F-mrg.htm	3/5/2014	RSA 147F.pdf
RSA 485C Groundwater Protection Act	http://www.gencourt.state.nh.us/rsa/html/L/485-C/485-C-mrg.htm	3/5/2014	RSA 485C.pdf

Regulation

Document	URL	Date Accessed	Filename(s)
New Hampshire Code of Administrative Rules Chapter ENV-OR 600 Contaminated Site Management	http://des.nh.gov/organization/commissioner/legal/rules/documents/env-or600.pdf	3/5/2014	env-or600.pdf
Reporting and Remediation of Oil Discharge Rules Env-Ws 412	http://www.epa.gov/oust/directiv/apg45015.htm#a412.01	3/5/2014	env-ws 412.pdf
Groundwater Protection Rules Env-Ws 410	Not obtainable online	3/5/2014	
New Hampshire Code of Administrative Rules Chapter ENV-OR 800 Brownfields Program Under RSA 147F	http://des.nh.gov/organization/commissioner/legal/rules/documents/env-or800.pdf	3/5/2014	env-or800.pdf

Policy

Document	URL	Date Accessed	Filename(s)
Contaminated Sites Risk Characterization and Management Policy	http://des.nh.gov/organization/divisions/waste/hwrb/sss/hwrp/guidance_documents.htm	3/5/2014	RCMP.pdf
Development of Background Metals Concentrations Database for New Hampshire Soils	http://des.nh.gov/organization/divisions/waste/hwrb/documents/background_metals.pdf	3/5/2014	background_metals.pdf
Environmental Fact Sheet Reporting Spills, Hazardous Waste Spills and Groundwater Contamination	http://des.nh.gov/organization/commissioner/pip/factsheets/rem/documents/rem-13.pdf	3/5/2014	spill reporting fact sheet.pdf
Environmental Fact Sheet Best Management Practices (BMPs) for Groundwater Protection	http://des.nh.gov/organization/commissioner/pip/factsheets/dwgb/documents/dwgb-22-4.pdf	3/5/2014	BMP groundwater fact sheet.pdf
Draft Evaluation of Sediment Quality Guidance	http://des.nh.gov/organization/divisions/waste/hwrb/documents/ws-04-9_evaluation_of_sediment.pdf	3/6/2014	Sediment quality guidance.pdf
Vapor Intrusion Guidance and Updates	http://des.nh.gov/organization/divisions/waste/hwrb/documents/vapor_intrusion.pdf	3/6/2014	vapor_intrusion.pdf
Soil Excavation and Disposal Specifications	http://des.nh.gov/organization/commissioner/pip/publications/wmd/documents/soil_excavation.pdf	3/6/2014	soil_excavation specs.pdf
Soil Sampling for VOC Analysis Policy	http://des.nh.gov/organization/divisions/waste/hwrb/documents/voc.pdf	3/6/2014	voc sampling.pdf
Clarification of Requirements for VOC Analyses	http://des.nh.gov/organization/divisions/waste/hwrb/documents/voc_changes.pdf	3/6/2014	voc_changes.pdf
Recommended Analytical Methods for Petroleum Contaminated Sites	http://des.nh.gov/organization/divisions/waste/hwrb/documents/matrix.pdf	3/6/2014	petroleum method matrix.pdf
Contaminated Site Management Remedial Action Plan Check List	http://des.nh.gov/organization/divisions/waste/hwrb/sss/hwrp/guidance_documents.htm	3/6/2014	remedial_action_plan_checklist.pdf
Contaminated Site Management Site Investigation Report Check List	http://des.nh.gov/organization/divisions/waste/hwrb/sss/hwrp/guidance_documents.htm	3/6/2014	site_investigation_report_checklist.pdf

Groundwater Quality Table 2, Appenix A-E with Soil Values	http://des.nh.gov/organization/divisions/waste/hwrb/documents/rcmp.pdf	3/6/2014	rcmp_revised standards addendum.pdf
A Guide to Groundwater Reclassification	http://des.nh.gov/organization/commissioner/pip/publications/wd/documents/wd-11-24.pdf	3/6/2014	groundwater reclassification.pdf
Requirements For Underground and Aboveground Storage Tank Closure Sampling and Reporting	http://des.nh.gov/organization/divisions/waste/orcb/ocs/ustp/documents/closure.pdf	3/6/2014	tank closure.pdf
Master Quality Assurance Project Plan	http://des.nh.gov/organization/divisions/waste/hwrb/documents/hwrb_master_qapp.pdf	3/6/2014	hwrb_master_qapp.pdf

Other

Document	URL	Date Accessed	Filename(s)
Sites with Activity and Use Restrictions Database	http://www2.des.state.nh.us/OneStop/ORCB_Remediation_restrictions.aspx	3/6/2014	ORCB_UST_stastistics.htm

New Jersey

Legislation

Document	URL	Date Accessed	Filename(s)
Site Remediation Reform Act; NJSA 58:10C-1 et seq.	http://www.nj.gov/dep/srp/regs/statutes/srra.pdf	2/26/2014	SRRA
Brownfield and Site Remediation Act; NJSA 58:10B-1 et seq.	http://www.nj.gov/dep/srp/regs/statutes/bcsra.pdf	2/26/2014	Brownfield and Site Remediation Act
Spill Compensation and Control Act; NJSA 58:10-23	http://www.nj.gov/dep/srp/regs/statutes/spill_act.pdf	2/26/2014	Spill Compensation and Control Act
Industrial Site Recovery Act; NJSA 13:1K	http://www.nj.gov/dep/srp/regs/statutes/isra.pdf	2/26/2014	Industrial Site Recovery Act

Regulations

Document	URL	Date Accessed	Filename(s)
Processing of Damage Claims Pursuant to the Spill Compensation and Control Act; NJAC 7:1J	http://www.nj.gov/dep/srp/regs/spillfund/spillfund_rule.pdf	2/28/2014	NJAC7_1J Spill Rule
Surface Water Quality Standards; NJAC 7:9B	http://www.nj.gov/dep/rules/rules/njac7_9b.pdf	2/28/2014	NJAC7_9B Surface Water Quality Stds
Groundwater Quality Standards; NJAC 7:9C	http://www.state.nj.us/dep/wms/bwqsa/docs/njac79C.pdf	2/28/2014	NJAC7_9C Groundwater Quality Stds
Underground Storage Tanks; NJAC 7:14B	http://www.nj.gov/dep/rules/rules/njac7_14b.pdf	2/26/2014	NJAC 7:14B
Industrial Site Recovery Act Rules; NJAC 7:26B	http://www.nj.gov/dep/rules/rules/njac7_26b.pdf	2/26/2014	NJAC 7:26B
Administrative Requirement for the Remediation of Contaminated Sites; NJAC 7:26C	http://www.nj.gov/dep/rules/rules/njac7_26c.pdf	2/26/2014	NJAC 7:26C
Remediation Standards; NJAC 7:26D	http://www.nj.gov/dep/rules/rules/njac7_26d.pdf	2/26/2014	NJAC 7:26D
Technical Requirement for Site Remediation; NJAC 7:26E	http://www.nj.gov/dep/rules/rules/njac7_26e.pdf	2/26/2014	NJAC 7:26E
Rule Adoption	http://www.nj.gov/dep/rules/adoptions/adopt_20120507a.pdf	2/26/2014	adopt_20120507
RCRA, CERCLA, and Federal Facility Sites Process for SRRA Implementation	http://www.nj.gov/dep/srp/srra/training/matrix/quick_ref/rcra_cercla_fed_facility_sites.pdf	2/28/2014	rcra_cercla_fed facility_sites

Guidance

Document	URL	Date Accessed	Filename(s)
Guidance on when DEP May Take Direct Oversight of a Remediation of a Contaminated Site	http://www.nj.gov/dep/srp/guidance/srra/direct_oversight.pdf	2/26/2014	direct oversight
Presumptive and Alternative Remedy Technical Guidance	http://www.nj.gov/dep/srp/guidance/srra/presumptive_remedy_guidance.pdf	2/26/2014	presumptive remedy guidance
Ecological Evaluation Technical Guidance	http://www.nj.gov/dep/srp/guidance/srra/ecological_evaluation.pdf	2/27/2014	ecological evaluation
Guidance for Conducting Receptor Evaluation- slides	http://www.nj.gov/dep/srp/srra/training/sessions/re_lnapl_20110630_re.pdf	2/27/2014	guidance for receptor evaluation
Guidance for Site Investigation, Remedial Investigation, and Remedial Action Verification Sampling for Soil - Slides	http://www.nj.gov/dep/srp/srra/training/sessions/soil_presentation.pdf	2/27/2014	Guidance for soil RI - Slides
Development of Alternative Remediation Standards for the Ingestion-Dermal Pathway, Ingestion-Dermal Standards Compliance	http://www.nj.gov/dep/srp/guidance/rs/ing_derm_guidance.pdf	2/27/2014	Ingestion-dermal guidance
Inhalation Standards Compliance Development of Alternative Remediation Standards for the Inhalation Pathway	http://www.nj.gov/dep/srp/guidance/rs/compl_ars_inhalation.pdf	2/27/2014	Inhalation guidance
Inhalation Exposure Pathway Alternative Remediation Standards Calculation Spreadsheet	http://www.nj.gov/dep/srp/guidance/rs/	2/27/2014	Inhalation alternative remediation stds
Impact to Groundwater Soil Remediation Standards Guidance Document	http://www.nj.gov/dep/srp/guidance/rs/igw_intro.pdf	2/27/2014	Impact to GW guidance
Protocol for Addressing Extractable Petroleum Hydrocarbons	http://www.nj.gov/dep/srp/guidance/srra/eph_protocol.pdf	2/27/2014	Impact to GW guidance
Technical Guidance for Preparation and Submission of a Conceptual Site Model	http://www.state.nj.us/dep/srp/guidance/srra/csm_tech_guidance.pdf	3/14/2014	NEWJERSEY_csm_tech_guidance2011.pdf

Other

Document	URL	Date Accessed	Filename(s)
NJDEP Vapor Intrusion Technical Guidance	http://www.nj.gov/dep/srp/guidance/vaporintrusion/vig_main.pdf	2/26/2014	NJ VI guidance
Vapor Intrusion Screening Levels	http://www.nj.gov/dep/srp/guidance/vaporintrusion/vig_tables.pdf	2/26/2014	NJ VI Screening Levels
VISL Implementation Strategy Flow Chart	http://www.nj.gov/dep/srp/guidance/vaporintrusion/visl_implementation_flowchart.pdf	2/26/2014	visl implementation Flow chart
NJDEP Implementation Strategy for revised VISL (3/2013)	http://www.nj.gov/dep/srp/guidance/vaporintrusion/visl_implementation_strategy.pdf	2/26/2014	revised visl implementation Flow chart
Instructions for New Jersey Johnson & Ettinger Spreadsheets	http://www.nj.gov/dep/srp/guidance/vaporintrusion/njje_instructions.pdf	2/26/2014	NJ J&E instrructions
NJ J&E Groundwater Screen	http://www.nj.gov/dep/srp/guidance/vaporintrusion/njje.htm	2/26/2014	njje_gw screen
NJ J&E Groundwater Advanced	http://www.nj.gov/dep/srp/guidance/vaporintrusion/njje.htm	2/26/2014	njje_gw avd
NJDOH VI DATA SUBMISSION CHECKLIST	http://www.nj.gov/dep/srp/guidance/vaporintrusion/njdoh_vi_data_submission_checklist.p df	2/26/2014	njdoh_vi_data_submission_checklist

VI Factsheet	http://www.nj.gov/dep/srp/guidance/vaporintrusion/indoor_air.pdf	2/26/2014	VI Factsheet
VI Guidance_20130130_slides	http://www.nj.gov/dep/srp/srra/training/sessions/vitg_20130130_slides.pdf	2/26/2014	VI Guidance_20130130_slides

New York

Legislation

Document	URL	Date Accessed	File Name
Environmental Conservation Act	http://public.leginfo.state.ny.us/LAWSSEAF.cgi?QUERYTYPE=LAWS+&QUERYDATA=@LLENV+&LIST=LAW+&BROWSER=EXPLORER+&TOKEN=13535263+&TARGET=VIEW	5/19/2014	Laws of New York.htm

Regulations

Document	URL	Date Accessed	File Name
6 CRR Part 375: Environmental Remediation Programs	http://www.dec.ny.gov/regs/2491.html	2/28/2014	Chapter IV- Quality Services - NYS Dept_ of Environmental Conservation.htm
Subpart 375-1: General Remedial Program Requirements	http://www.dec.ny.gov/regs/4374.html	2/28/2014	SubPart 375-1.pdf
Subpart 375-2: Inactive Hazardous Waste Disposal Site Remedial Program	http://www.dec.ny.gov/regs/4373.html	2/28/2014	SubPart 375-2.pdf
Subpart 375-3: Brownfield Cleanup Program	http://www.dec.ny.gov/regs/4372.html	2/28/2014	SubPart 375-3.pdf
Subpart 375-4: Environmental Restoration Program	http://www.dec.ny.gov/regs/4371.html	2/28/2014	SubPart 375-4.pdf
Subpart 375-6: Remedial Program Soil Cleanup Objectives	http://www.dec.ny.gov/regs/15507.html	3/6/2014	SubPart 375-6.pdf
Chapter X - Division of Water			
Part 703: Surface Water and Groundwater Quality Standards and Groundwater Effluent Limitations	http://www.dec.ny.gov/regs/4590.html	2/28/2014	Part 703 SW and GW Quality Standards and GW Effluent Limitations.pdf

Guidance

Document	URL	Date Accessed	File Name
Remediation Guidance and Policy Documents	http://www.dec.ny.gov/regulations/2393.html	2/28/2014	Remediation Guidance and Policy Documents - NYS Dept_ of Environmental Conservation.htm
Site Investigation and Remediation			
DER-10 / Technical Guidance for Site Investigation and Remediation	http://www.dec.ny.gov/docs/remediation_hudson_pdf/der10.pdf	2/28/2014	der10.pdf
DER-10 / Technical Guidance for Site Investigation and Remediation	http://www.dec.ny.gov/regulations/67386.html	2/28/2014	Technical Guidance for Site Investigation and Remediation (DER-10) - NYS Dept_ of Environmental Conservation.html
Standards, Criteria and Guidance for DER-10	http://www.dec.ny.gov/regulations/67548.html	2/28/2014	Standards, Criteria and Guidance for DER-10.pdf
Index of Standards, Criteria and Guidance (SCGs) for Investigation and Remediation of Inactive Hazardous Waste Disposal Sites	http://www.dec.ny.gov/regulations/61794.html	2/28/2014	SCGs for Investigation and Remediation of Inactive Hazardous Waste Disposal Sites.pdf
DER-10 Powerpoint from the DER-10: Technical Guidance for Site Investigation and Remediation - October 7, 2010 Public Seminar	http://www.dec.ny.gov/docs/remediation_hudson_pdf/der10powerpoint.pdf	3/6/2014	der10powerpoint.pdf
Generic Remedial Action Objectives (RAOs)	http://www.dec.ny.gov/regulations/67560.html	3/6/2014	RAOs.pdf
Vapor Intrusion Guidance	http://www.dec.ny.gov/regulations/2588.html	2/28/2014	Vapor Intrusion Guidance - NYS Dept_ of Environmental Conservation.htm
DER-13 / Strategy For Evaluating Soil Vapor Intrusion at Remedial Sites in New York	http://www.dec.ny.gov/docs/remediation_hudson_pdf/der13.pdf	2/28/2014	der13.pdf
Soil Cleanup			
CP-51 / Soil Cleanup Guidance	http://www.dec.ny.gov/docs/remediation_hudson_pdf/cpsoil.pdf	2/28/2014	cpsoil.pdf
Technical Guidance for Screening Contaminated Sediments	http://www.dec.ny.gov/docs/wildlife_pdf/seddoc.pdf	3/6/2014	seddoc.pdf
Green Remediation			
DER-31 / Green Remediation	http://www.dec.ny.gov/docs/remediation_hudson_pdf/der31.pdf	2/28/2014	der31.pdf
Brownfield Cleanup Program			
DER-32 / BROWNFIELD CLEANUP PROGRAM APPLICATIONS AND AGREEMENTS	http://www.dec.ny.gov/docs/remediation_hudson_pdf/der32.pdf	2/28/2014	der32.pdf
Development of Soil Cleanup Objectives Technical Support Document	http://www.dec.ny.gov/docs/remediation_hudson_pdf/techsuppdoc.pdf	3/6/2014	techsuppdoc.pdf
Technical & Operational Guidance Series (TOGS)			
1.1.1 Ambient Water Quality Standards and Guidance Values and Groundwater Effluent Limitations	http://www.dec.ny.gov/docs/water_pdf/togs111.pdf	3/6/2014	togs111.pdf
April 2000 Addendum (PDF)	http://www.dec.ny.gov/docs/water_pdf/tog111table1.pdf	3/6/2014	tog111table1.pdf
June 2004 Addendum (PDF)	http://www.dec.ny.gov/docs/water_pdf/june04togs111.pdf	3/6/2014	june04togs111.pdf
1.1.3 Procedures for Derivation of Site-Specific Standards and Guidance Values for Protection of Aquatic Life	http://www.dec.ny.gov/docs/water_pdf/togs113.pdf	3/6/2014	togs113.pdf
1.1.4 Procedures for Derivation of Bioaccumulation Factors	http://www.dec.ny.gov/docs/water_pdf/togs114.pdf	3/6/2014	togs114.pdf
1.1.5 Procedures for Deriving Ambient Water Quality Standards and Guidance Values for the Protection of Wildlife	http://www.dec.ny.gov/docs/water_pdf/togs115.pdf	3/6/2014	togs115.pdf

2.1.1 Groundwater Contamination Remediation Strategy	http://www.dec.ny.gov/docs/water_pdf/togs211.pdf	3/6/2014	togs211.pdf
2.1.2 UIR at Groundwater Remediation Sites	http://www.dec.ny.gov/docs/water_pdf/togs212.pdf	3/6/2014	togs212.pdf
Groundwater Monitoring Well Decommissioning Policy			
CP-43:Groundwater Monitoring Well Decommissioning Policy	http://www.dec.ny.gov/docs/remediation_hudson_pdf/cp43mwdecomm.pdf	3/6/2014	cp43mwdecomm.pdf
Making Changes to Selected Remedies			
DER-2 / Making Changes to Selected Remedies	http://www.dec.ny.gov/docs/remediation_hudson_pdf/der2.pdf	3/6/2014	der2.pdf
Citizen Participation Handbook for Remedial Programs			
DER-23 / Citizen Participation Handbook for Remedial Programs New York State Department of Environmental Conservation	http://www.dec.ny.gov/docs/remediation_hudson_pdf/der23.pdf	3/6/2014	der23.pdf
Assistance for Contaminated Water Supplies			
DER-24 / Assistance for Contaminated Water Supplies	http://www.dec.ny.gov/docs/remediation_hudson_pdf/der24.pdf	3/6/2014	der24.pdf
INSTITUTIONAL CONTROLS			
DER-33 / INSTITUTIONAL CONTROLS: A GUIDE TO DRAFTING AND RECORDING INSTITUTIONAL CONTROLS	http://www.dec.ny.gov/docs/remediation_hudson_pdf/der33.pdf	3/6/2014	der33.pdf
Petroleum-Contaminated Soil Guidance Policy			
STARS #1	http://www.dec.ny.gov/regulations/30902.html	3/6/2014	Petroleum-Contaminated Soil Guidance Policy.pdf
Petroleum Bulk Storage (PBS) Inspection			
DER-25 / Petroleum Bulk Storage (PBS) Inspection Handbook	http://www.dec.ny.gov/docs/remediation_hudson_pdf/der25.pdf	3/6/2014	der25.pdf
Spill Guidance Manual (selected sections)	http://www.dec.ny.gov/regulations/2634.html	3/6/2014	Spill Guidance Manual (SGM) - NYS Dept_ of Environmental Conservation.htm
1.4 Site Investigation Procedures	http://www.dec.ny.gov/docs/remediation_hudson_pdf/1x4.pdf	3/6/2014	Site Investigation Procedures.pdf
1.5 Corrective Plans and Responsible Party Reports	http://www.dec.ny.gov/docs/remediation_hudson_pdf/1x5.pdf	3/6/2014	Corrective Action Plans.pdf
1.6 Corrective Action	http://www.dec.ny.gov/docs/remediation_hudson_pdf/1x61.pdf	3/6/2014	Corrective Action.pdf
CORRECTIVE ACTION PART 2 - SOIL REMEDIATION	http://www.dec.ny.gov/docs/remediation_hudson_pdf/1x62.pdf	3/6/2014	CORRECTIVE ACTION - SOIL REMEDIATION.pdf

Rhode Island

Legislation

Document	URL	Date Accessed	Filename
CHAPTER 23-19.8 Hazardous Waste Cleanup	http://webserver.rilin.state.ri.us/Statutes/TITLE23/23-19.8/INDEX.HTM	2/28/2014	Chapter 23-19.8 Hazardous Waste Cleanup.pdf
CHAPTER 46-12 Water Pollution	http://webserver.rilin.state.ri.us/Statutes/TITLE46/46-12/INDEX.HTM	2/28/2014	Chapter 46-12 Water Pollution.pdf
CHAPTER 46-13.1 Groundwater Protection	http://webserver.rilin.state.ri.us/Statutes/TITLE46/46-13.1/INDEX.HTM	2/28/2014	Chapter 46-13.1 Groundwater Protection.pdf

Regulations

Document	URL	Date Accessed	Filename
Oil Pollution Control Regulations	http://www.dem.ri.gov/pubs/regs/regs/compinsp/oilpollu.pdf	2/21/2014	Oil Pollution Control Regulations.pdf
Rules and Regulations For Underground Storage Facilities Used for Petroleum Products and Hazardous Materials, April 2011	http://www.dem.ri.gov/pubs/regs/regs/waste/ustreg11.pdf	2/21/2014	Rules and Regulations For Underground Storage Facilities Used for Petroleum Products and Hazardous Materials.pdf
Rules and Regulations For Hazardous Waste Management, last amended January 17, 2014	http://www.dem.ri.gov/pubs/regs/regs/waste/hwregs14.pdf	2/21/2014	Rules and Regulations For Hazardous Waste Management.pdf
Rules and Regulations For Hazardous Waste Management, last amended January 17, 2014 (Fact Sheet)	http://www.dem.ri.gov/programs/benviron/waste/pdf/hwfs14.pdf	2/22/2014	Rules and Regulations For Hazardous Waste Management (Fact Sheet).pdf
Rules and Regulations for the Investigation and Remediation of Hazardous Materials Releases, last amended November 2011	http://www.dem.ri.gov/pubs/regs/regs/waste/remreg11.pdf	2/21/2014	Rules and Regulations for the Investigation and Remediation of Hazardous Materials Releases.pdf
Water Quality Regulations, last amended December 2010	http://www.dem.ri.gov/pubs/regs/regs/water/h2oq10.pdf	2/21/2014	Water Quality Regulations.pdf
Groundwater Quality Rules, June 2012	http://www.dem.ri.gov/pubs/regs/regs/water/gwqual10.pdf	2/21/2014	Groundwater Quality Rules.pdf

Texas

Legislation

Document	URL	Date Accessed
General Remediation Rules page	http://www.tceq.texas.gov/remediation/remediationrules.html	2/21/2014
Texas Risk Reduction Program (TRRP) 30 TAC Chapter 350	http://info.sos.state.tx.us/pls/pub/readtac$ext.ViewTAC?tac_view=4&ti=30&pt=1&ch=350	2/21/2014
Petroleum Storage Tank Rule 30 TAC Chapter 334	http://info.sos.state.tx.us/pls/pub/readtac$ext.ViewTAC?tac_view=4&ti=30&pt=1&ch=334	2/21/2014

Risk Reduction Rule (30 TAC Chapter 335)	http://info.sos.state.tx.us/pls/pub/readtac$ext.ViewTAC?tac_view=4&ti=30&pt=1&ch=335	2/21/2014
Program Rules		
Texas Water Code 26.408 (HB 3030 requirements)	http://www.tceq.texas.gov/remediation/twc26_408.html	2/21/2014
	http://law.onecle.com/texas/water/26.408.00.html	2/24/2014
Dry Cleaner Remediation Program	http://www.tceq.texas.gov/remediation/dry_cleaners/index.html	2/21/2014
State Law	http://www.statutes.legis.state.tx.us/Docs/HS/htm/HS.374.htm	2/21/2014
Industrial Solid Waste and Municipal Hazardous Waste	http://www.tceq.texas.gov/remediation/corrective_action/spill.html	2/21/2014
30 TAC Chapter 327 Rule Section 327.5	http://info.sos.state.tx.us/pls/pub/readtac$ext.TacPage?sl=R&app=9&p_dir=&p_rloc=&p_tloc=&p_ploc=&pg=1&p_tac=&ti=30&pt=1&ch=327&rl=5	2/21/2014
Industrial and Hazardous Waste Corrective Action Program Summary	http://www.tceq.texas.gov/remediation/corrective_action/ihwca.html	2/21/2014
Petroleum Storage Tank Program	http://www.tceq.texas.gov/remediation/pst_sl/pst_sl.html	2/21/2014
30 TAC Chapter 334 Index	http://info.sos.state.tx.us/pls/pub/readtac$ext.ViewTAC?tac_view=4&ti=30&pt=1&ch=334	2/21/2014
Superfund	http://www.tceq.texas.gov/remediation/superfund/index.html	2/21/2014
Rules Index Page	http://www.tceq.texas.gov/remediation/superfund/rules.html	2/21/2014
30 TAC Chapter 335 Subchapter K	http://info.sos.state.tx.us/pls/pub/readtac$ext.ViewTAC?tac_view=5&ti=30&pt=1&ch=335&sch=K&rl=Y	2/21/2014
Health and Safety Code Title 5 Subtitle B Chapter 361 Subchapter A	http://www.statutes.legis.state.tx.us/SOTWDocs/HS/htm/HS.361.htm#F	2/21/2014
Texas Superfund Registry	http://www.tceq.texas.gov/remediation/superfund/registry.html	2/21/2014
Voluntary Cleanup Program -- 30 TAC Chapter 350	http://info.sos.state.tx.us/pls/pub/readtac$ext.ViewTAC?tac_view=4&ti=30&pt=1&ch=350	2/21/2014
Health and Safety Code Title 5 Subtitle B Chapter 361 Subchapter A	http://www.statutes.legis.state.tx.us/Docs/HS/htm/HS.361.htm#361.603	2/21/2014
30 TAC Chapter 333 Subchapter A	http://info.sos.state.tx.us/pls/pub/readtac$ext.ViewTAC?tac_view=5&ti=30&pt=1&ch=333&sch=A&rl=Y	2/21/2014

Guidance

Document	URL	Date Accessed
TRRP Guidance:	http://www.tceq.texas.gov/remediation/trrp/guidance.html/#intro	2/21/2014
General Topics		
Determining Which Releases Are Subject to TRRP	http://www.tceq.texas.gov/assets/public/remediation/trrp/releasesTRRPrev.pdf	2/21/2014
Guidance for Conducting Ecological Risk Assessments at Remediation Sites in Texas	http://www.tceq.texas.gov/assets/public/remediation/trrp/rg263-draft.pdf	2/21/2014
(Under Revision) Common Issues Encountered During the Review of ERAs	http://www.tceq.texas.gov/assets/public/remediation/positionpaper.pdf	2/21/2014
Tier 1 eco exclusion criteria checklist	http://www.tceq.texas.gov/remediation/trrp/guidance.html/#intro	2/21/2014
Tier 2 PCL Equations	http://www.tceq.texas.gov/assets/public/remediation/trrp/tier2.pdf	2/21/2014
Evaluation of the Potential Health Impacts of Exposure to Iron, Calcium, Magnesium, Potassium, Sodium, and Phosphorus through Soil Ingestion	http://www.tceq.texas.gov/assets/public/remediation/trrp/essentialiom.pdf	2/21/2014
COCs for which Calculation of a Human Health PCL is not Required	http://www.tceq.texas.gov/assets/public/remediation/trrp/nohealth-trrp033007.pdf	2/21/2014
Transition to Texas Risk Reduction Program of projects with portions closed under the 30 TAC 335 Risk Reduction rule	http://www.tceq.texas.gov/assets/public/remediation/trrp/splmedia.pdf	2/21/2014
TRRP Questions and Answers	http://www.tceq.texas.gov/assets/public/remediation/trrp/trrpqa601.pdf	2/21/2014
Update to TRRP Questions and Answers	http://www.tceq.texas.gov/assets/public/remediation/trrp/update033104.pdf	2/21/2014
Use of Software Programs for TRRP	http://www.tceq.texas.gov/assets/public/remediation/trrp/trrpsoftware.pdf	2/21/2014
Chromium	http://www.tceq.texas.gov/assets/public/remediation/trrp/chromium.pdf	2/21/2014
Implementation of the new arsenic MCL in the Remediation Programs	http://www.tceq.texas.gov/assets/public/remediation/trrp/arsenicmemo.pdf	2/21/2014
Affected Property Assessments (TRRP-6 to TRRP-17)		
Planning and Assessment Surveys (TRRP-6)	Not yet developed. Not available.	2/21/2014
Land Use Classification (TRRP-7)	http://www.tceq.texas.gov/publications/rg/rg-366_trrp_07.html	2/21/2014
	http://www.tceq.texas.gov/publications/rg/rg-366_trrp_07.html/at_download/file	2/21/2014
Groundwater Classification (TRRP-8)	http://www.tceq.texas.gov/publications/rg/rg-366_trrp_08.html	2/21/2014
Exposure Pathway Evaluation (TRRP-9)	will not be issued at this time	2/21/2014
Selecting Target Chemicals of Concern (TRRP-10)	http://www.tceq.texas.gov/publications/rg/rg-366_trrp_10.html	2/21/2014
Data Needs for Tiered PCL Development (TRRP-11)	Not yet developed. Not available	2/21/2014
Affected Property Assessment Requirements (TRRP-12)	http://www.tceq.texas.gov/publications/rg/rg-366_trrp_12.html	2/21/2014
Review and Reporting of COC Concentration Data (pdf) (TRRP-13)	http://www.tceq.texas.gov/publications/rg/rg-366_trrp_13.html	2/21/2014
Screening Target Chemicals of Concern from PCL Development (TRRP-14)	http://www.tceq.texas.gov/publications/rg/rg-366_trrp_14.html	2/21/2014
Determining Representative Concentrations (TRRP-15hh)	Not yet developed. Not available.	2/21/2014
Determining Representative Concentrations of Chemicals of Concern for Ecological Receptors (TRRP-15eco)	http://www.tceq.texas.gov/publications/rg/rg-366_trrp_15eco.html	2/21/2014
GW-SW Discharge Concentration	http://www.tceq.texas.gov/remediation/trrp/guidance.html/#intro	2/21/2014
Institutional Controls (TRRP-16)	http://www.tceq.texas.gov/publications/rg/rg-366_trrp_16.html	2/21/2014
Notification Requirements (TRRP-17)	http://www.tceq.texas.gov/publications/rg/rg-366_trrp_17.html	2/21/2014
Development of Human Health PCLs (TRRP-18 to TRRP-27)		
Risk Levels, Hazard Indices, and Cumulative Adjustments (TRRP-18)	http://www.tceq.texas.gov/publications/rg/rg-366_trrp_18.html	2/21/2014
Toxicity Factors and Chemical/Physical Parameters (TRRP-19)	http://www.tceq.texas.gov/publications/rg/rg-366_trrp_19.html	2/21/2014

Exposure Factors (TRRP-20)	will not be issued at this time	2/21/2014
Human Health Points of Exposure (TRRP-21)	http://www.tceq.texas.gov/publications/rg/rg-366_trrp_21.html	2/21/2014
Tiered Development of Human Health PCLs (TRRP-22)	http://www.tceq.texas.gov/publications/rg/rg-366_trrp_22.html	2/21/2014
Tier 1 PCL Tables (TRRP-23)	http://www.tceq.texas.gov/publications/rg/rg-366_trrp_23.html	2/21/2014
Determining PCLs for Surface Water and Sediment (TRRP-24)	http://www.tceq.texas.gov/publications/rg/rg-366_trrp_24.html	2/21/2014
Human Health Sediment PCL table	http://www.tceq.texas.gov/assets/public/remediation/trrp/sedpcls_2006.pdf	2/21/2014
Human Health Surface Water RBELs tables	http://www.tceq.texas.gov/remediation/trrp/guidance.html/#intro	2/21/2014
Aquatic Life RBELs tables	http://www.tceq.texas.gov/remediation/trrp/guidance.html/#intro	2/21/2014
Surface Water Contact Recreation PCLs	http://www.tceq.texas.gov/assets/public/remediation/trrp/contactrecpcls.pdf	2/21/2014
Stream low flow (7Q2) and harmonic mean flow data	http://www.tceq.texas.gov/remediation/trrp/guidance.html/#intro	2/21/2014
Critical PCLs (TRRP-25)	http://www.tceq.texas.gov/publications/rg/rg-366_trrp_25.html	2/21/2014
Application of Tier 1 and 2 NAF Models (TRRP-26)	Not yet developed. Not available.	2/21/2014
Development of Human Health PCLs for Total Petroleum Hydrocarbon Mixtures (TRRP-27)	http://www.tceq.texas.gov/publications/rg/rg-366_trrp_27.html	2/21/2014
Remedy Standards (TRRP-28 to TRRP-34)		
Application of Remedy Standards A and B (TRRP-28)	http://www.tceq.texas.gov/publications/rg/rg-366_trrp_28.html	2/21/2014
Soil and Groundwater Response Objectives (TRRP-29)	http://www.tceq.texas.gov/publications/rg/rg-366_trrp_29.html	2/21/2014
Compliance Sampling and Monitoring (TRRP-30)	Not yet developed. Not available.	2/21/2014
Evaluating Remedy Effectiveness (TRRP-31)	Not yet developed. Not available.	2/21/2014
Risk-Based NAPL Management (TRRP-32)	http://www.tceq.texas.gov/publications/rg/rg-366_trrp_32.html	2/21/2014
Monitored Natural Attenuation Demonstrations (TRRP-33)	http://www.tceq.texas.gov/publications/rg/rg-366_trrp_33.html	2/21/2014
Facility Operations Areas (TRRP-34)	http://www.tceq.texas.gov/publications/rg/rg-366_trrp_34.html	2/21/2014
Program Guidance:		
Texas Water Code 26.408 (HB 3030 requirements)	http://www.tceq.texas.gov/publications/rg/rg-428.html	2/21/2014
Dry Cleaner Remediation Program	http://www.tceq.texas.gov/remediation/dry_cleaners/index.html	2/21/2014
Industrial Solid Waste and Municipal Hazardous Waste		
Petroleum Storage Tank Program	http://www.tceq.texas.gov/remediation/pst_rp/pst.html	2/21/2014
IOMs		
IOM-090606, Chapter 334 Closure Criteria for Domestic Irrigation Wells	http://www.tceq.texas.gov/assets/public/remediation/rpr/documents/iom090606.pdf	2/21/2014
IOM-073103, Sample Handling and Preservation Procedures; Collection Procedures for Groundwater Samples	http://www.tceq.texas.gov/assets/public/remediation/rpr/documents/iom073103.pdf	2/21/2014
IOM-071703, Process for Expedited Closure Evaluation for Priority 4.1 Petroleum Hydrocarbon LPST Sites	http://www.tceq.texas.gov/assets/public/remediation/rpr/documents/4pt1iom.pdf	2/21/2014
IOM-111201, LPST Program Corrective Action Deadlines Effective September 1, 2001	http://www.tceq.texas.gov/assets/public/remediation/rpr/documents/guidance.pdf	2/21/2014
IOM-051801, Guidelines for Sampling Domestic Water Wells for Petroleum Storage Tank Contaminants	http://www.tceq.texas.gov/assets/public/remediation/rpr/documents/iom051801.pdf	2/21/2014
IOM-011001, Standard Operating Procedure for Evaluation of Costs of Sampling & Analysis of Groundwater Samples for Monitor Wells with Water Levels Above the Top of the Wellscreen	http://www.tceq.texas.gov/assets/public/remediation/rpr/documents/iom011001.pdf	2/21/2014
IOM-110199, Guidance for Leaking Petroleum Storage Tank (LPST) Sites Located on State Designated Major/Minor Aquifers or Local Water Supply	http://www.tceq.texas.gov/assets/public/remediation/rpr/documents/iom011001.pdf	2/21/2014
IOM-022398, Preapproval Costs for Groundwater Monitoring of RNA Parameters	http://www.tceq.texas.gov/assets/public/remediation/rpr/documents/rna.pdf	2/21/2014
IOM-081297, Protective Concentrations in Groundwater for Construction Worker Exposure	http://www.tceq.texas.gov/assets/public/remediation/rpr/documents/constgw.pdf	2/21/2014
	http://www.tceq.texas.gov/assets/public/remediation/rpr/documents/constgw.pdf	2/21/2014
	http://www.tceq.texas.gov/assets/public/remediation/rpr/documents/refer.pdf	2/21/2014
IOM-042997, Interim Guidance1: Monitoring Natural Attenuation for Verification of Groundwater Plume Stability	http://www.tceq.texas.gov/assets/public/remediation/rpr/documents/refer.pdf	2/21/2014
IOM-030697, Clarifications and Amendments for Implementation of RG-36	http://www.tceq.texas.gov/assets/public/remediation/rpr/documents/rg-36cl1.pdf	2/21/2014
IOM-021097. The following two IOMs were issued on 2/10/97: Guidance for Judging the Adequacy of Contaminant Delineation for Purposes of Determining if Further Corrective Action is Needed and Process for Closure Evaluation of Petroleum Hydrocarbon LPST Sites Exceeding Target Concentrations.	http://www.tceq.texas.gov/assets/public/remediation/rpr/documents/combind4.pdf	2/21/2014
Regulatory Guidance		
RG-36, Risk-Based Corrective Action for Leaking Petroleum Storage Tank Sites	being updated and is currently unavailable	2/21/2014
RG-175, Guidance for Risked-Based Assessments at LPST Sites in Texas	not available online	2/21/2014
RG-411, Investigating and Reporting Releases from Petroleum Storage Tanks (PSTs)	http://www.tceq.texas.gov/publications/rg/rg-411.html	2/21/2014
LPST Action Levels and Target Levels	http://www.tceq.texas.gov/remediation/pst_rp/downloads.html	2/21/2014
Action Levels		
Plan A Target Concentrations		
Equations used to derive the target concentrations		
Toxicity parameters and chemical/physical factors		

Superfund	http://www.tceq.texas.gov/remediation/programdesc.html	2/21/2014
Voluntary Cleanup Program	http://www.tceq.texas.gov/remediation/vcp/vcp.html	2/21/2014
Program Guide	http://www.tceq.texas.gov/remediation/vcp/vcpguide.html	2/21/2014
Establishing Critical Protective Concentration Levels for Lead-Affected Soils	http://www.tceq.texas.gov/assets/public/remediation/vcp/leadguid.pdf	2/21/2014
Legal Property Descriptions for VCP Certificates of Completion	http://www.tceq.texas.gov/assets/public/remediation/vcp/legaldesc.pdf	2/21/2014
Disposal of Tetrachloroethylene in Permitted Municipal Solid Waste Landfills	http://www.tceq.texas.gov/assets/public/remediation/vcp/percmswl.pdf	2/21/2014
Groundwater Sampling - Filtering, Low Flow Purging	http://www.tceq.texas.gov/assets/public/remediation/vcp/gwsampli.pdf	2/21/2014
Phasing Certificates of Completion	http://www.tceq.texas.gov/assets/public/remediation/vcp/gwsampli.pdf	2/21/2014
Response Action/Operationand Maintenance Failure	http://www.tceq.texas.gov/assets/public/remediation/vcp/gwsampli.pdf	2/21/2014
Guidance for Initiating and Reporting Response Actions Conducted Under TNRCC's Voluntary Cleanup Program (RG-215, April 1996)	http://www.tceq.texas.gov/assets/public/remediation/vcp/rg215.pdf	2/21/2014
Use of Statistics for Determining Cleanup Levels under the Risk Reduction Rules	http://www.tceq.texas.gov/assets/public/remediation/vcp/rg215.pdf	2/21/2014

Vermont

Legislation

Document	URL	Date Accessed	Filename
The Vermont Statutes Online Title 10: Conservation and Development Chapter 48: Groundwater Protection	http://www.leg.state.vt.us/statutes/sections.cfm?Title=10&Chapter=048	2/28/2014	The Vermont Statutes Online

Regulations

Document	URL	Date Accessed	Filename
Chapter 12 of the Environmental Rules: Groundwater Protection Rule and Stragety	http://drinkingwater.vt.gov/dwrules/pdf/signedcopygwprs2005.pdf	February 28, 2014	VT signedcopygwprs2005.pdf
Vermont Water Quality Standards Vt. Cod R. 12 004 052	http://www.watershedmanagement.vt.gov/rulemaking/docs/wrprules/wsmd_wqs.pdf	February 28, 2014	VT wsmd_wqs.pdf

Guidance

Document	URL	Date Accessed	Filename
Investigation and Remediation of Contaminated Properties Procedure	http://www.anr.state.vt.us/dec/wastediv/sms/pubs/irocp.pdf	February 28, 2014	VT GW mapping RptLeg.pdf
Report on the Stattus of Groundwater and Aquifer Mapping in the State of Vermont January 2003	http://www.anr.state.vt.us/dec/geo/pdfdocs/rptleg.pdf	February 28, 2014	VT IROCP.pdf

Other

Document	URL	Date Accessed	Filename
VT Dept of Environmental Conservation Alphabetical Topic Index	http://www.anr.state.vt.us/dec/topic.htm	February 28, 2014	VT DEC rules summary.pdf
DEC Rules Summary	http://www.anr.state.vt.us/dec/rulessum.htm	February 28, 2014	VT topic index.pdf

Appendix L

Role of Science in Stakeholder-Based Risk Management Decision-Making

Charnley, G. (2000). Democratic Science; Enhancing the Role of Science in Stakeholder-Based Risk Management Decision-Making. Health Risk Strategies. Washington, DC. July 2000.

Democratic Science

Enhancing the Role of Science in Stakeholder-Based Risk Management Decision-Making

Gail Charnley, PhD
HealthRisk Strategies
Washington, DC
July 2000

FOREWORD

This report was prepared at the request of the American Industrial Health Council and the American Chemistry Council in response to their concern that the growing use of stakeholder processes in environmental risk management decision-making has the potential to compromise the integrity and importance of science as a guide to risk management. As stakeholders themselves, those organizations believe that all stakeholders should recognize that scientific information and science-based risk analysis are central elements of effective risk management. Their concern is that without the factual knowledge provided by science, risk management priorities will be misidentified and risk management resources will be misdirected.

This report seeks to draw lessons from case examples of stakeholder processes, both successful and unsuccessful. It focuses on the role of science in risk management decisions made by convening groups of stakeholders who met, debated, and either agreed or disagreed about appropriate actions. For example, it evaluates efforts by stakeholders convened to determine whether MTBE should be added to gasoline, to make decisions about cleaning up DOE weapons sites, and to preserve air quality in Alaska. This report does not focus on policy decisions made by regulators, debated in the media and in the courts, where different stakeholders disagreed about the nature of the scientific evidence related to the decisions. In other words, it does not evaluate EPA Administrator Browner's chloroform decision, the events that led to the high-production-volume-chemical testing initiative, or the politics of using disagreements about scientific uncertainty as a trade barrier.

There is a notable absence of literature on the combination of science, stakeholder processes, and decision-making. Yet there is considerable debate about how science gets used in stakeholder-based decision-making, suggesting that this is an area ripe for study and empirical research. It is the hope of this author that the contrast between the somewhat haphazard information on which this report is based and the importance of this topic will provide an incentive to others to study this subject with greater rigor.

Acknowledgments

In addition to the American Industrial Health Council and the American Chemistry Council, who supported this project, I would also like to acknowledge the generous contributions of time and expertise of those who were interviewed for this report and who reviewed an earlier draft and provided comments. The case studies were drawn in part from interviews with George Busenberg, Bernie Goldstein, Dan Greenbaum, and Hank Topper, who also provided comments on the draft. Valuable comments were also received from Tom Beierle, Bill Bishop, Caron Chess, Jamie Conrad, Don Elliott, and Granger Morgan. Juliana Birkhoff, Terry Davies, Ortwin Renn, and Terry Yosie also provided valuable insights. I appreciate everyone's willingness to share their time and abilities.

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Executive Summary

Involving stakeholders in making decisions about the best ways to characterize and manage risks to our health, safety, and environment has been recommended increasingly over the past decade. This trend reflects a move towards increased democratization of risk management decision-making. One concern about increasingly democratic risk management decision-making is whether stakeholders have the ability to respect and preserve the role that science can play in informing decisions. Some argue that greater stakeholder involvement will marginalize science; others argue that decision-making is already tyrannized by science and scientific experts and that involvement of non-scientific, non-expert stakeholders represents a needed swing of the pendulum back towards an emphasis on social values.

Risk assessment has emerged over the last two decades as the dominant paradigm in the US, and increasingly elsewhere, for including science in regulatory decision-making about the best ways to manage threats to health and the environment. But because both science and judgment play important roles in risk assessment, decisions about the nature, extent, and appropriate response to risks remain controversial. This controversy is exacerbated by the inherent uncertainty of science, and by the concern that those in control of the science can use this uncertainty to serve their own ends. The case examples in this report illustrate the problem of resolving technically intensive policy disputes, as well as the challenges and difficulties associated with using risk assessment as one input to decision-making by stakeholders when the credibility of the underlying science is either in doubt or inconsistent with stakeholder concerns.

The successful case studies examined in this report used stakeholder processes to establish at the outset what the role of science would be in the risk management decision; in effect, practicing Democratic Science. In each case where Democratic Science was practiced, science played an important role, but a role that was shaped by stakeholder values to address their concerns and that was able to inform an evolving understanding of the scope of the problem. The report concludes that scientific integrity is maintained and its credibility is assured

when stakeholders are involved in deciding how science is used to answer their questions and in obtaining the scientific information needed to answer those questions. In other words, the case studies demonstrate the effectiveness of implementing what the National Academy of Sciences report *Understanding Risk* called the "analytic-deliberative process" and what the Commission on Risk Assessment and Risk Management outlined with its framework for stakeholder-based risk management decision-making.

Making effective risk management decisions will continue to be a struggle as we seek to give fair consideration to both science and values and to find the right balance between analysis and deliberation. A Framework for Democratic Science is described here that uses stakeholder goals and concerns to guide the use of technical information in risk management decision-making as part of an iterative analytic-deliberative process. In the context of the Democratic Science Framework, stakeholder values help clarify concerns about potential risks and risk management goals. Questions that must be answered to address stakeholder concerns are articulated and the factual information needed to answer those questions is identified. Stakeholders then identify and agree on whom should be responsible for obtaining the needed factual information. After the needed scientific information is obtained, it is combined with other information and used either to re-frame the problem and risk management goals or to guide decision-making. In the case examples described here, a model that seemed to work well involved establishing a group of scientific experts that all stakeholders agreed to; by working closely together through collaborative analysis, the scientists were able to understand the basis for the stakeholders' concerns and the stakeholders were able to understand the role that science could play and to participate in generating data. When the adversarial groups involved in a decision can jointly oversee and participate in the research needed to resolve scientific and other technical issues underlying a policy debate, they have the means to assure themselves that other stakeholders are not manipulating the analysis.

This report draws its conclusions from a few readily available case studies primarily because virtually all of the research that has sought to identify the determinants of successful public participation in environmental decision-making focuses on process-oriented social goals and does not evaluate the role of science. Not surprisingly, risk assessors have tended to focus on risk controversies and social scientists have focused on social dimensions; research in this area would benefit from teams comprising both risk assessors and social scientists. Research is needed that includes determinants of how science has been included in stakeholder-based decision-making and how its role has had an impact on process outcomes. An analysis of the social factors that contribute to differing interpretations of scientific information and how science weighs as a factor in decision-making is also worthy of more focused research. Finally, more rigorous study is needed to determine whether, as some cynics suspect, most risk management decisions are made on the basis of political expediency. The extent to which good science or efforts at stakeholder collaboration have any real influence remains to be determined.

1. Introduction and Background

Managing risks to health, safety, and the environment is evolving beyond being the sole purview of regulatory agencies. More and more risk management decisions are developed and implemented using collaborative processes involving consultation and cooperation among stakeholders, including regulators, regulated parties, advocacy-based organizations, and the general public. This trend constitutes a move away from the unilateral, technocratic, regulatory model of risk management decision-making toward more inclusive, democratic, non-regulatory processes, reflecting the democratic ideal that people should be involved in their own governance (English 1996). Growing stakeholder-based decision-making is thought to be a response to a lack of public trust in risk management decisions made by government and industry; expanded public awareness of environmental, health, and safety issues; increased social expectations for improved environmental quality; changes in information technology; and the desire by business and government to demonstrate responsiveness to public concerns (Yosie and Herbst 1998s). At the same time, it is a natural outgrowth of the interest group pluralism model of administrative action in which regulatory agencies act as brokers for the many relevant interests and perspectives on problems within their jurisdictions (Stewart 1975).

A number of organizations have made recommendations concerning the need for increased stakeholder involvement in decision-making. In its 1997 final report, the Commission on Risk Assessment and Risk Management (Risk Commission) concluded that a good risk management decision emerges from a process that elicits the views of those affected by the decision, so that differing technical assessments, public values, knowledge, and perceptions are considered (Risk Commission 1997). The Risk Commission's report also stated:

> Stakeholders bring to the table important information, knowledge, expertise, and insights for crafting workable solutions. Stakeholders are more likely to accept and implement a risk management decision they have participated in shaping. Stakeholder collaboration is particularly important for risk management because there are many conflicting interpretations about the nature and significance of

risks. Collaboration provides opportunities to bridge gaps in understanding, language, values, and perceptions. It facilitates an exchange of information and ideas that is essential for enabling all parties to make informed decisions about reducing risks.

In its 1996 report, *Understanding Risk*, the National Academy of Sciences carefully avoided using the term “stakeholder” but noted that risk management processes must have an appropriately diverse participation or representation of the spectrum of interested and affected parties, of decision-makers, and of specialists in risk analysis, at each step (NRC/NAS 1996). The report defined “affected parties” as people, groups, or organizations that may experience benefit or harm as a result of a hazard, or of the process leading to risk characterization, or of a decision about risk, noting that such parties need not be aware of the possible harm to be considered affected. “Interested parties” were defined as people, groups, or organizations that decide to become informed about and involved in a risk characterization or decision-making process (and who may or may not be affected parties).

The Western Center for Environmental Decision-making asserts that public involvement can help gather information; create forums for the exchange of technical information and public opinion; help participants make better decisions about environmental problems; accelerate (but not guarantee) change; and begin to reclaim the legitimacy of government by demonstrating a recommitment to public debate (Western Center for Environmental Decision-making 1997). The US Environmental Protection Agency (EPA) recommends building stakeholder partnerships for environmental improvement because doing so promotes voluntary environmental management, shifting the responsibility for environmental quality from government to a partnership that includes industry. It also opens up the evaluation and assessment process to those parties—customers, workers, and local communities—affected by the choices that industry makes (US EPA 1995). Building on that theme, the American Chemistry Council requires as part of its Responsible Care® program that member companies seek and incorporate public inputs into their products and operations (American Chemistry Council 1999). In addition to EPA and industry, states, municipalities, the governments of other industrialized nations, and the US

Departments of Energy and Defense, among others, all rely increasingly on stakeholder processes to help make decisions about their activities that have potential environmental health impacts.

Despite the common-sense appeal of stakeholder-based processes, they have been criticized for several reasons. These include the substantial investment of time and resources required; the likelihood that they will heighten, not alleviate, conflict; the difficulty in identifying and facilitating the inclusion of truly representative stakeholders; the possibility that they are actually counter-democratic due to increased representation of special interest groups; and the concern that when nontechnical people are included in decision-making, the scientific or technical and factual basis of a problem or solution will be distorted, trivialized, or ignored. The latter concern arises partly because of the difficulty scientists have communicating technical information as part of stakeholder deliberations and partly because decision-makers often perceive nontechnical stakeholders as being more legitimate representatives of social values (US EPA 1995). It can also be attributed to nontechnical stakeholders' suspicion that science can be distorted to support different stakeholders' points of view.

Assessing the impacts of stakeholder processes to date requires clarification of the many different types of processes that have been conducted and evaluated. Stakeholder involvement can range from national and multinational decision-making, such as that associated with implementing the Clean Air Act or the North American Free Trade Agreement, to community-based decision-making, such as that associated with the cleanup of contaminated sites. It can mean negotiated rulemaking efforts ("reg-negs"), such as that which created the microbial disinfectant by-products rule for drinking water, or comparative risk projects such as those conducted by states to help set risk management priorities. They can be directed towards setting exposure limits for chemicals, as were a number of attempts by the US Occupational Safety and Health Administration to set workplace Permissible Exposure Limits, or towards identifying the sources of public health problems in a disadvantaged urban area, like South Baltimore. Some types of stakeholder processes convened by regulatory agencies require consensus and some do not; some are binding and some are not. That is, some result in recommendations from the majority of participants that regulatory agencies are not required to implement, but may take into account when making the ultimate risk management decision. Stakeholder processes inform regulatory decision-making, but do not constitute decision-making; regulatory agencies may benefit from the outcome of a process but must, in the end, take the final, legal responsibility for a decision. As a result, evaluating the "success" of a stakeholder process can be somewhat difficult. Of course, stakeholder-based risk management does not have to be initiated or conducted by regulatory agencies. Regulated parties, for example, may initiate risk management efforts on their own in collaboration with other stakeholders, as the electric utility industry did when it invited Environmental Defense to help them identify cleaner power production technologies.

Much of the concern about how science is used in risk management decision-making results from how science is used or abused when risk management policies are debated by stakeholders in the absence of a formal process. For example, the global controversy over the safety of genetically modified organisms and the reactions in the UK to bovine spongiform encephalitis (BSE), in Belgium to dioxin in chicken feed, and in the US and Europe to phthalates in toys are all situations where stakeholders—government regulators, the media, advocacy organizations, industry, and consumers—are debating appropriate risk management actions in the absence of an organized framework. Deciding what risk management actions are appropriate generally depends on some agreement about the nature and extent of the risks; in those cases, stakeholders disagree about the nature and extent of the risks mostly because they disagree about the underlying science. Some stakeholders argue that because the science is uncertain and the risks potentially severe, extreme risk management actions are warranted. Those stakeholders assert that it is up to the proponents of a potential risk (e.g., toy manufacturers) to demonstrate its safety; they also tend to mistrust any proponent-sponsored scientific research or claims of safety. Other stakeholders argue that the science is not uncertain, or at least not uncertain enough, to warrant extreme actions; these stakeholders also tends to argue that the consequences of extreme risk management actions are disproportionate to their benefits. In either case, Paul Slovic argues that whoever controls the definition of risk controls the rational solution to the problem at hand; defining risk thus becomes an exercise in power (Slovic 1999).

In general, many decisions that people make about risk management in our daily lives are not made on the basis of science or facts, but on the basis of perceived fairness. If people made decisions on the basis of scientific facts or quantitative risk estimates alone, they would not smoke cigarettes or eat doughnuts, and would drive only reluctantly. Science and concepts of risk are not irrelevant; many people have stopped smoking, many who continue to smoke know that they are at increased risk of lung cancer, and people know that doughnuts are not good for them. However, risk is also a social construct, with most people making decisions about risk based on a complex set of perceptions that include familiarity, harm, benefit, values, dread, voluntariness, and other factors (Slovic 1987), and on what they hear from a few people quoted in the newspapers or on television. Newspaper and television reporters cover risk on the basis of rarity, novelty, commercial viability, and drama, not on the basis of relative risk (Graham 1998). In the absence of formal stakeholder processes in which nontechnical stakeholders work together with technical stakeholders so that the former come to understand the technical issues and the latter come to understand the nontechnical issues, the self-interest of all parties—described as the Rashomon effect, in which different parties give differing accounts of the same situation, suiting that party's interests (Mazur 1998)—will dominate risk debates.

Much of the literature on stakeholder processes focuses more on providing guidance for establishing and conducting them and less on evaluating their successes, failures, and impacts. While the emphasis on the former is not misplaced, more research is needed on the latter. Resources for the Future has a project underway that is identifying the successes, failures, and impacts of public participation in environmental decision-making by evaluating about 250 case studies (RFF 1999) using an evaluation framework based on social goals (Beierle 1999). More typical (but also valuable) is a report from the Western Governors' Association assessing the value of local stakeholder involvement efforts at two sites (Belsten 1996). The 1998 report by Yosie and Herbst, based on case studies and extensive interviews, is probably the most recent and comprehensive analytic evaluation of the issues and challenges associated with managing stakeholder processes (Yosie and Herbst 1998b). In general, the literature indicates that stakeholder processes vary substantially in terms of process quality and influence on policy outcomes. Most studies also agree that stakeholder processes are not a transitory phenomenon but an important development that reflects a fundamental change in the way environmental risk management decisions are made.

This report relies primarily on case examples. Although there is a good literature on science and decision-making and on stakeholder processes and decision-making, there is very little that examines all three aspects together. The report uses information from the case examples to draw conclusions and make recommendations about ways to improve or enhance the role of science in stakeholder processes. By focusing on science as part of a decision-making process and not solely as an outcome of a process, the report attempts to avoid the difficulties inherent in identifying objective measures of scientific or technical quality. It relies instead on whether stakeholders can resolve scientific conflicts as the basis for evaluation.

2. The Problem: Uncertainty, Credibility, and Communication

The root of most debates about the role of science in risk management decision-making is the fundamentally uncertain nature of science. Most highly subjective, contradictory, or incorrect scientific claims occur in the areas of uncertain knowledge, or in the application of well-established knowledge to novel or ambiguous situations (Mazur 1998). Uncertainty allows the participants in a debate to generate competing technical analyses to support their conflicting policy arguments (Mazur 1975). Surprisingly often, disagreements on key technical points remain unresolved and scientific uncertainties remain unaddressed, undermining opportunities for resolving policy debates (Adler et al. 2000).

The essential problem with the "dueling scientists" approach is that the adversaries recognize that each group can manipulate or distort its analysis to support its policy position. The resulting suspicions make it difficult for any one participant to generate technical information that will be credible to the other participants (Busenberg 1999). When no common ground of technical knowledge is achieved, its role and importance in deliberation can be diminished or eliminated.

Poor communication about the role of science in a risk management decision-making process also leads to misunderstanding and suspicion. It is often the quality of the communication—not the technical information itself—that stands in the way of finding common ground (Hance et al. 1988). Problems arise when participants misunderstand the extent to which science can and cannot provide answers to their concerns. If nontechnical stakeholders do not understand the science or the role it can play in decision-making, it is unlikely to play a significant role. If the scientists or technically oriented stakeholders do not understand what the real concerns of the other stakeholders are, then science—no matter how well deployed—will not solve the problem.

This section uses two case examples to illustrate the problem of resolving technical policy disputes. The first involves competing scientific knowledge claims and the second, conflicting goals and communication failure among the participants.

Case #1: Valdez, Alaska (Busenberg 1999). Large volumes of crude oil are shipped in the Prince William Sound region of Alaska, with oil loaded onto tankers at the port of Valdez at a terminal operated by the Alyeska Pipeline Service Company (Alyeska). Alyeska had supported the establishment of a Regional Citizens' Advisory Council (RCAC) to help oversee environmental management of the marine oil trade there. The RCAC and Alyeska engaged in two major disputes involving technically based policy issues. In the first, a suspicion that science was being distorted to support the industry's desired outcome led to a stalemate, with the technical issues ultimately ignored in the risk management decision-making process. The participants in the second dispute, perhaps learning from the lessons of the first, resorted to a collaborative process instead (see Section 4).

The first dispute involved the impact of crude oil vapors emitted by the oil terminal on air quality in the city of Valdez. Alyeska had commissioned a series of air quality studies that examined the levels and sources of airborne volatile organic compounds in Valdez and the RCAC convened a panel of scientists to evaluate the results of the studies. The panel agreed with the findings regarding the levels of ambient airborne benzene but disagreed with the method used to identify the source of the benzene emissions. The two groups of scientists then generated contradictory knowledge claims regarding the sources of benzene, with the RCAC concluding that 90% of it originated at the oil terminal and Alyeska concluding that only 25% originated there. The RCAC asked Alyeska to install vapor control systems and Alyeska refused, unless a significant health risk could be attributed to the terminal. Interviews revealed that the Alyeska scientists questioned the validity of the RCAC models and that RCAC scientists believed the Alyeska results had been manipulated to support the industry's arguments. Mutual suspicions of distorted communication arising from claims of mistaken and manipulated analyses led to an impasse, with neither party accepting the other's interpretation. In the absence of a common foundation of knowledge, further discussion stalled and the Valdez air quality debate remained deadlocked for two years.[1]

Case #2: Baltimore Community Environmental Partnership (US EPA 1999a). Southern Baltimore is an industrialized area with a large concentration of industrial, commercial, and waste treatment and disposal facilities. Major facilities include chemical manufacturers, petroleum storage facilities, a medical waste incinerator, the city landfill, and a municipal wastewater treatment plant, 11 of which report air emissions to the EPA Toxics Release Inventory. Additional facilities, such as the city waste incinerator, a large steel mill, and two utility power plants, are located nearby. Altogether, more than 175 chemicals are emitted from facilities in the area, leading residents to rank air quality first on their list of concerns at a community priority-setting meeting. In particular, community residents were concerned about the possible public health consequences of exposure to the combined emissions from all the industrial, commercial, and waste treatment and disposal facilities located in and around their

[1]Eventually, the debate was superseded by implementation of the 1990 Clean Air Act Amendments and an EPA draft rule requiring a 95% reduction in the emissions of all hazardous air pollutants from the Valdez terminal. Alyeska responded by installing vapor controls. Thus the risk management action taken was in response to impending regulatory requirements, not a result of any determination of potential health effects by a stakeholder process.

neighborhoods. A Community Environmental Partnership[2] had been started in southern Baltimore as a community-based approach to environmental protection and economic development. A subcommittee of the partnership comprising representatives of different community sectors was formed to address air quality, while a separate subcommittee was formed to address community health. The goals of the air quality subcommittee, co-chaired by one resident and one industry representative, were to determine whether current levels of air toxics resulting from industrial emissions in partnership neighborhoods might affect community health and to recommend actions to improve air quality. All decisions were made by consensus.

The air quality subcommittee chose to use a risk-based screening method to help provide information on the potential health risks associated with airborne chemicals in partnership neighborhoods. The approach used standard methods to identify chemicals from air pollution sources that might pose the greatest health risks. Three successive screens of the original 175 chemicals of potential concern identified four chemicals as being of most concern to the partnership neighborhoods. Of those four, only benzene emissions were estimated to result in airborne concentrations above the subcommittee's screening level, suggesting that local industrial emissions do not pose a threat to public health in that area. Petrochemical storage facilities in one neighborhood were identified as the primary source of the modeled benzene, but contributed only 12% of the measured ambient benzene concentrations in the area. Mobile sources were thought to account for most of the ambient benzene concentrations but mobile sources were not considered in the screening exercise, which looked only at point-source emissions.

The limited scope of the subcommittee's investigation produced a dilemma. The subcommittee wanted to focus on facility-related point-source chemical emissions and to develop concrete recommendations to improve community health. As it turned out, the study

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[2]The Community Environmental Partnership comprised community residents, businesses, organizations such as local schools and the Johns Hopkins School of Public Health, local governments (Baltimore City and Anne Arundel County), state government (Maryland Department of Environment), and federal government (US Environmental Protection Agency).

found that the point sources evaluated were not likely to be a significant contributing factor to community health concerns. By not including a potentially important source of air pollution—mobile sources—in the study, the subcommittee did not have enough information to develop the most effective recommendations. Thus it is possible that poor air quality does contribute to public health problems in South Baltimore, but by failing to look at the whole picture, the study could not answer the question. The relationship between the limited scope of the subcommittee's work and its ability to make recommendations for improving community air quality and health was not adequately discussed, understood, and agreed to at the beginning of the effort.

When the participants realized that the results of the study were not going to be able to show what some expected—that industrial air emissions posed risks to their health—the environmental advocacy group representatives resigned from the subcommittee. In a letter to EPA (timed to be released one day before the study results were made public), those who resigned (and others who had not been involved in the project at all) stated that they were "deeply committed to the Partnership's ultimate goal: the discovery of more effective ways to reduce pollution through the reinvention of traditional regulatory programs." That goal had not, in fact, been articulated and agreed to at the start of the effort. The letter authors went on to say that what they had sought by participating in the project was "a real opportunity [to develop] a new and deeper understanding of the environmental conditions *that threaten us* and [to debate] the best way to address those problems" [emphasis added]. Thus those who resigned had started with the assumption that the environmental conditions they were addressing posed risks to their health. When that assumption was not borne out by the results of a process they had agreed to and participated in from the start, they resigned in an attempt to discredit the process and findings and to maintain their adversarial position. In this way, the conflict became one less about what science was relevant and more about whether science was relevant. Scientific legitimacy was appealing when it suited the needs of the environmental advocacy participants; scientific information was sought as a means to buttress their beliefs, not to answer a question or solve a problem.

While the Baltimore Air Committee process did not exactly fail, its results did not have the support of all participating stakeholders. It was not able to use science to change views, solve a problem, or develop a consensus. One problem was that the environmental activists were the only community resident representatives involved. Broader community representation that did not rely on only one sector or viewpoint would have created better conditions for an effective deliberative process. The process should have clarified at the outset what the science would and would not allow the study to accomplish and how the science and the political agendas of some stakeholders conflicted. Involving participants in collecting actual data to verify the estimates of the air contaminant exposure models might have contributed to a shared understanding of the results of the study and improved its credibility. Finally, by taking a longer-term view of the deliberative process and an iterative approach to problem definition, the two subcommittees formed to address air quality and community health separately might have been combined. This study could have been one of several steps taken towards answering the larger question, What factors contribute to health problems in the community? By focusing on the narrow question it did, it could not answer the broader public health concerns of the community.

3. Science, Precaution, and Risk Analysis: The Challenge

The case examples in Section 2 illustrate some of the challenges and difficulties associated with using risk assessment as an input to decision-making by stakeholders when the credibility of the underlying science is either in doubt or inconsistent with stakeholder concerns. Despite such difficulties, risk assessment has emerged over the last two decades as the dominant paradigm in the US and elsewhere for including science in regulatory decision-making about the best ways to manage threats to health and the environment. Risk assessment is a way to organize scientific information in a form that is meant to provide a useful input—both qualitative and quantitative—to risk management decision-making. Risk assessment is not the only input to decision-making, of course; social, economic, feasibility, legal, equity, and political considerations also play important roles. The challenge is to maintain a role for risk assessment and to preserve the integrity of science when decision-making is influenced by many nontechnical factors. As the cases in the previous section show, doing so is particularly challenging when risk management decisions are conducted as collaborative efforts among stakeholders with differing technical knowledge levels, interests, goals, and world views.

3.1 Evolution of risk assessment as the scientific vehicle for informing risk management

Before risk assessment became a well-recognized and codified discipline, a precautionary approach often guided risk management decision-making in the US for many years. For example, in the 1950s the Delaney clause required the Food and Drug Administration to ban outright food and color additives that had been shown to produce tumors in humans or laboratory animals. In the 1970s, a legal basis for a precautionary approach was established when the Environmental Protection Agency was required by the *Ethyl* decision to proceed with its plans to ban leaded gasoline even if the science was not strong enough to be able to prove exactly what the benefits of removing lead would be (*Ethyl Corp. v. EPA*. 541 F.2d 1 (DC Cir.)(en banc), cert. denied, 426 US 941, 1976).

In 1980, however, the *Benzene* decision overturned the precautionary basis of the *Ethyl* decision and substituted a risk-based principle by establishing the need for some form of evaluation as a basis for deciding if a risk is "significant" enough to deserve regulation (*Industrial Union Dept., AFL-CIO v. American Petroleum Inst*., 448 US 607, 1980). A series of Executive Orders requiring cost-benefit analysis of proposed decisions also fueled the demand for risk assessment, because the benefit of environmental regulation is typically the risk reduction that it is predicted to achieve.

To a large extent, the body of US laws that seek to establish practices that will ensure safety—or at least mitigate risk—from chemical or other contaminant exposures were established before risk assessment emerged as a discipline. Most of the methodology of risk assessment was developed in reaction to the calls by these laws to define limits on exposure that will "protect the public health with an adequate margin of safety" or lead to "a reasonable certainty of no harm". That is, in passing the laws, the US Congress called on the regulatory agencies to develop means to assess risks so as to define exposure levels that would achieve the stated qualitative goals of health protection (Rhomberg 1997).

Thus, in response to the Executive orders, the Supreme Court, and Congress, the US has moved away from a precaution-based approach to regulation and risk management and substituted a risk-based approach, albeit one that incorporates precautionary assumptions. Until recently, however, little attention has been given to the complications of reconciling the scientific process of risk assessment with the needs of democratic procedure (Kasperson et al. 1999).

3.2 Role of science in risk management decision-making

Because both science and judgment play important roles, risk assessment is controversial. Often, the controversy arises from what we do not know and from what risk assessments cannot tell us, because our knowledge of human vulnerability and of environmental impacts is incomplete (Risk Commission 1997). Nonetheless, because of its scientific underpinnings, risk assessment generally constitutes the vehicle for including science in risk management decision-making. Thus, risk assessment is based on science to the extent possible and on judgment when necessary.

The importance of assuring a strong technical basis for risk management is well recognized. In *Understanding Risk*, the National Academy of Sciences acknowledged that reliable technical and scientific input is essential to making sound decisions about risk (NRC/NAS 1996). The report recognized scientific analysis as the best source of reliable, replicable information about hazards and exposures and as being essential for good risk characterization. Relevant analysis, in quantitative or qualitative form, strengthens the knowledge base for deliberations; without good analysis, stakeholder processes can arrive at agreements that are unwise, not feasible, or simply a reflection of who possesses greater political power. The chief challenges are to follow in practice analytic principles that are widely accepted and to recognize the limitations of analysis.

The Western Center for Environmental Decision-making concurs, stating that a "better environmental decision" is one that is based on a better understanding of the relevant science. Public attitudes can change public policies, but they cannot change the laws of nature, e.g., the chemistry of ozone depletion, the physics of air pollution, or the neurotoxicity of lead. The normal political processes of reaching decisions by compromise will produce bad results if they assume that a natural system or physical law can "compromise" as well. Risk managers have a special obligation to ensure that the public understands the technical constraints imposed by the natural world (Western Center for Environmental Decision-making 1997).

Scientific and technical experts bring substantive knowledge, methodological skills, experience, and judgment to the task of understanding risk. In addition to their specialized knowledge, scientists bring a capacity to build systematic and reliable ways of analyzing and interpreting information about new situations (NRC/NAS 1996). At the same time, the nontechnical public can contribute valuable knowledge and information to the factual basis of a decision. It is important to elicit and facilitate the incorporation of such knowledge in a valid scientific framework.

Although, to a great extent, science provides the factual basis for decision-making, it may not always be neutral and objective as a decision-making tool, even when it meets all the tests of scientific peer review. According to the National Academy of Sciences (NRC/NAS 1996):

> Good scientific analysis is neutral in the sense that it does not seek to support or refute the claims of any party in a dispute, and it is objective in the sense that any scientist who knows the rules of observation of the particular field of study can in principle obtain the same results. But science is not necessarily neutral and objective in its ways of framing problems [or] in its choice of assumptions . . . Evidence that science has been censored or distorted to favor particular interested parties has long been a source of conflict over risk characterizations.

Nonetheless, scientific data and knowledge form the building blocks necessary to ground consensus-seeking deliberations and to promote confidence in the process and its outcome (Adler et al. 2000). Objectivity and subjectivity are relative, not absolute, and scientific knowledge is considered more objective than other systems of belief about the natural world. And while science has its subjective elements, modern science does discover real features of nature—viruses, ions, planets, gravitational attraction, electromagnetic radiation, supernovas—in a way that other methods of knowing cannot (Mazur 1998).

Integrating science into a multifactorial decision-making process is challenging because science alone is not an adequate basis for a risk decision. Risk decisions are, ultimately, public policy choices. A specialist's role is to bring as much relevant knowledge as possible to participants in a decision, whose job it is to make the value-laden choices. Good science is a necessary—in fact, an indispensable—basis for good risk characterization, but it is not a sufficient basis (NRC/NAS 1996).

3.3 Science, judgment, and democracy

The role of experts and technical knowledge in a democracy is frequently debated, particularly in the context of environmental health and ecological risk management. The debate centers on conflicts between the "world of values, ethics, politics, and life philosophies" and the "world of information and technical expertise" (Yankelovich 1991). Scientists have been accused of failing to place their efforts in an adequate social context, believing that science is separate from social factors or that social factors play minimal roles (Brown and Mikkelsen 1990). Some describe the choice as one between "Almighty Science *versus* Nature" (Jackson 1999), where Nature represents all that is good and democratic and science is evil because it "subdues" nature, presumably through empiricism. Even Isaac Newton recognized that hypotheses about nature that are not based on empirical evidence "have no place" in science, however (Van Doren 1991). Others assert that "new frontiers of scientific knowledge developed not from a value-free forward march of science but from conscious decisions to examine data in a new light and to seek new sources of data" (Brown and Mikkelsen 1990); few, of course, would suggest that science is value-free and most would equate the re-examination of data and the search for more data with the scientific method itself.

Properly understood, the distinction is essentially one between information and judgment. As Daviel Yankelovich has somewhat tendentiously put it, “In its eagerness to exalt the truths of science, empiricism has, crudely and blindly, undermined other modes of knowing, including public judgment . . . American culture grossly overvalues the importance of information as a form of knowledge and undervalues the importance of cultivating good judgment. It assumes, falsely, that good information automatically leads to good judgment” (Yankelovich 1991).

There is a fallacy that people sometimes succumb to, which is to assume that if only the “right” science were known or generated, the “right” answer or course of action would become apparent. This belief arises in part due to misunderstanding science, in part due to attempts to mask needed judgment as science, and in part because of the legal tradition in the US that relies heavily on establishing a factual basis for decision-making. Regulatory decisions in the US have to be justified by an extensive factual record that is subject to judicial review. The factual basis for a risk management decision is highly valued because, in the absence of a complete factual basis or record, decisions are easily challengeable. As a consequence, the judgmental or less factually based component of risk management decision-making is perceived as being less highly valued, contributing to Yankelovich’s assertion that “In present-day America, a serious gap exists between the point of view of the experts and that of the general public” (Yankelovich 1991).

Nonetheless, both information and judgment are recognized as being essential components of decision-making (Yankelovich 1991):

> Although the struggle between experts and public has become adversarial, there can be no such thing as the “victory” of one side over the other. If the experts overreach themselves and further usurp the public’s legitimate role, we will have the formal trappings of democracy without the substance, and everyone will

> suffer. If the public dominates and pushes the experts out of the picture altogether, we will have demagoguery or disaster or both. A better balance of power and influence is needed, with each side performing its function in sympathy and support of the other.

The movement over the last several years towards more inclusive and democratic environmental health risk management decision-making processes reflects an attempt to develop better ways to integrate social, political, economic, and technical issues into fair risk management decisions; in effect, to balance the scientists' facts and the public's judgment. As Yankelovich put it, "When the proper balance exists between the public and the nation's elites, our democracy works beautifully. When that balance is badly skewed, the system malfunctions. The chief symptom of imbalance is the nation's inability to arrive at consensus on how to cope with its most urgent problems" (Yankelovich 1991). It is certainly the case that consensus on how best to manage risks to health and the environment is seldom achieved. It is also not surprising that, as we struggle to seek the right balance in order to achieve consensus, decisions often will be skewed, with scientific and factual knowledge playing roles of varying importance and influence.

Robert F. Kennedy, Jr. contends that the issues of environment and democracy are intertwined and inseparable, and that the environmental movement and the laws it spawned gave us "true democracy in this country for the first time" (Kennedy 1998). He argues that the body of 19 major federal environmental statutes passed since 1970 essentially re-enacts the ancient doctrines of nuisance and public trust and acknowledges that while we need industry, we also have a right to a clean environment. Risk assessment can play a role in helping us decide how much risk society will tolerate if it justifies the destruction of an absolute right.

Some argue against the wisdom of delegating environmental risk management decisions to either public stakeholders or experts, proposing market-based policies instead. Markets are considered truly democratizing means of decision-making due to the broad extent of public participation. However, few of us are willing to rely on "democratic participation" stakeholder processes to manage the financial risks associated with our savings and pensions, for example; we should be unwilling to do the same with regard to health and environmental risks (Shogren 1998).

4. Striking the Right Balance: Approaches to Solving the Problem

This section uses case examples to illustrate how different approaches to collaborative analysis have been used to overcome the problems of distorted analysis, credibility conflicts, and poor communication as stakeholders strive to give due consideration to both science and values. In each case, the disputing parties collaborated to generate a knowledge base that all stakeholders understood and trusted and that directly addressed their concerns.

Case #3: Prince William Sound. Following the dispute described in Case #1 (Section 2) between the oil industry and the residents of Valdez, Alaska over air quality, a second dispute took place (Busenberg 1999). The second dispute involved a debate over the capabilities of the tug vessels used to escort oil tankers in the Sound. The tug vessels' primary purpose was to help correct course errors that might otherwise lead to collisions and oil spills. The RCAC (citizens' group) proposed that the oil industry deploy highly maneuverable tractor tug vessels in one region of the Sound and an ocean rescue tug vessel with an enhanced propulsion system in another region of the Sound, on the basis that doing so would reduce the risk of oil spills. The oil industry opposed the proposal as an unnecessary expense given that existing studies did not demonstrate that those tug vessels would improve safety. The oil industry then proposed to resolve the dispute by performing a comprehensive risk assessment of the oil trade in the Sound. The risk assessment was to be jointly funded and managed through a steering committee comprising RCAC members, oil industry managers, and representatives of the two government regulatory agencies with the appropriate jurisdictions. To avoid "dueling scientists," the steering committee combined the industry's scientific experts with the RCAC's scientific experts to form a single research team. Later interviews found all parties agreeing that if the oil industry had conducted the risk assessment on its own, no one else would have believed the results. By having the participants in the dispute structure and perform the risk assessment jointly, collaborative analysis was used to resolve potentially adversarial technical disagreements.

There were several benefits to using the collaborative model. One benefit was mutual learning among the participants. Frequent meetings led the steering committee to gain a better understanding of the technical dimensions of maritime risk assessment and the research team to better understand the problem at issue and to gather data it would not have otherwise. Steering committee members actually participated in data gathering with the research team. Another benefit resulted from combining resources, making more money available to conduct the work. The results of the risk assessment were accepted as credible by all parties involved in the issue, who agreed that hidden agendas or conspiracies could not influence the collaborative process.

In response to the results of the assessment, the oil industry deployed an ocean rescue tug vessel in the Sound. The risk assessment was not able to determine whether tractor tug vessels would improve the safety provided by the conventional tug vessels already active, however. The governor of Alaska decided the issue by declaring that tractor tug vessels constituted the “best available technology” as required under state law and the oil industry responded with two such vessels on the basis of the policy decision. Thus both science and politics played roles in the outcome.

Case #4: MTBE and HEI. The 1990 amendments to the Clean Air Act established the Federal Reformulated Gasoline Program to make recommendations about reformulating gasoline in ways that reduce emissions of air pollutants from motor vehicles. One of the ways the program has tried to reduce carbon monoxide emissions is through the addition of chemicals that increase the oxygen content of gasoline, or “oxygenates.” Methyl tertiary butyl ether (MTBE) is an oxygenate that has caused some controversy because of disagreements about its effectiveness, its potential to cause human health effects, and its ability to contaminate ground and surface waters.

The introduction of reformulated gasoline containing MTBE had elicited a number of complaints from workers and the general public in some areas of the United States, including reports of unpleasant odor, headaches, burning of the eyes and throat, and other symptoms of discomfort. In response to those concerns, the Health Effects Institute (HEI) was asked by EPA and the Centers for Disease Control and Prevention to convene an expert panel to review the available scientific information on MTBE and other oxygenates and assess potential risks to health resulting from their use. HEI is an independent, nonprofit corporation supported jointly by EPA and industry to “provide high-quality, impartial, and relevant science on the health effects of pollutants from motor vehicles and from other sources in the environment” (HEI 2000).

HEI convened a panel of scientists to evaluate oxygenates but recognized that the scientists did not represent the stakeholders. Appreciating that credibility in a broader context was needed, HEI identified an advisory board comprising stakeholders to work with the scientists and to help formulate the questions of concern. The advisory board members were representatives of environmental advocacy organizations, industry, state health departments, other government agencies, unions, other scientists, and citizens. The first meeting included both the scientific panel and the advisory board so that the initial problem formulation was conducted by both scientists and stakeholders. Together, scientists and stakeholders clarified the scope of the evaluation and identified and interpreted the needed scientific information. A draft report describing the study’s conduct and conclusions was reviewed by both groups. Although the substance of the draft and final reports did not differ significantly, both groups considered the review valuable because it improved the way in which the report’s message was communicated. The report concluded that risks from gasoline containing MTBE were essentially the same as risks from gasoline alone because any potential risks from MTBE were offset by its benefits (HEI 1996). Involving stakeholders in the process that was used to reach that conclusion added time and expense but, according to HEI president Daniel Greenbaum, the effort was considered worthwhile by EPA and HEI because credibility was maintained and stakeholders were satisfied with the outcome (D. Greenbaum, personal communication).

A second inquiry into the impacts of oxygenates in gasoline benefitted from the lessons learned during the first review. The first review had flagged ground water contamination by MTBE as a potential issue of concern deserving further study. The second review was able to focus on that issue, putting the potential health risks issue aside. The second review was conducted by a “blue ribbon panel” convened by EPA and comprising representatives of all stakeholders (US EPA 1996). The challenge for that panel was separating the credible science from the science influenced by stakeholder interests. Because the panel was an effective blend of stakeholders and technically competent non-stakeholders, the technical people were able to keep the stakeholders honest, thereby maintaining the credibility of the process and its outcome. The panel concluded that while current levels of MTBE in ground water pose no health risk, they recommended dramatically curtailing its use due to potentially widespread water pollution problems.[3]

Thus both reviews of oxygenates in gasoline demonstrated the effectiveness of combining scientists and stakeholders in a manner that was able to maintain the integrity of the science while addressing stakeholder concerns and assuring stakeholder “buy-in.” The scope of the second review was guided by the outcome of the first, demonstrating how an iterative approach to problem definition can help focus stakeholder efforts.

Case #5: Savannah River and CRESP. The Consortium for Risk Evaluation with Stakeholder Participation (CRESP) began operation in 1995 in response to a conclusion by a National Academy of Sciences committee (NRC/NAS 1994):

> The Environmental Management Office of DOE [US Department of Energy] needs an independent institutional mechanism to develop data and methodology to make risk a key part of its decision making.

CRESP’s mission is to improve the scientific and technical basis of DOE’s environmental management decisions, leading to protective and cost-effective cleanup of the nation’s nuclear weapons while enhancing stakeholder understanding of nuclear weapons production facility

[3]EPA is currently exploring whether MTBE can be regulated, and possibly banned, under

waste sites (CRESP 2000). CRESP is organized to provide both guidance to and peer review of the evolving effort to use risk-based methods and evaluations to shape cleanup decisions at DOE sites.

One of the site cleanups that has involved CRESP is underway at DOE's Savannah River Site. The Savannah River Site was constructed during the early 1950s to produce the basic materials used in the fabrication of nuclear weapons, primarily tritium and plutonium-239. Today, the site both stores and is contaminated by high-level, low-level, and liquid radioactive wastes as well as by radioactive wastes, mixed with hazardous chemical wastes. Before CRESP was involved at Savannah River, DOE, EPA, and the states had performed different risk assessments, obtaining conflicting risk estimates due primarily to differences in assumptions about exposure to contaminants through fish consumption. When CRESP became involved, its researchers concluded that the many conflicting assumptions about fish consumption could be overcome by obtaining actual data to replace the assumptions, and proceeded to work with local residents to collect the data. Another risk assessment was performed, monitored closely by stakeholders, and a new risk estimate was obtained that was higher than previous estimates. Nonetheless, risks from the approximately 3-millirem radiation exposure occurring through contaminated fish were still considerably lower than risks from background radiation levels of 200-400 millirem. The new risk estimate appears to have been credible and accepted by the stakeholders who participated because it directly addressed their concerns and because they had been involved in both research planning and in its actual performance.

5. Conclusions and Recommendations

The limited case studies considered here suggest that a key to successful use of scientific information in collaborative decision-making is Democratic Science—using a broadly based deliberative process to help shape the technical analysis. Collaborative, Democratic Science-

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the Toxic Substances Control Act.

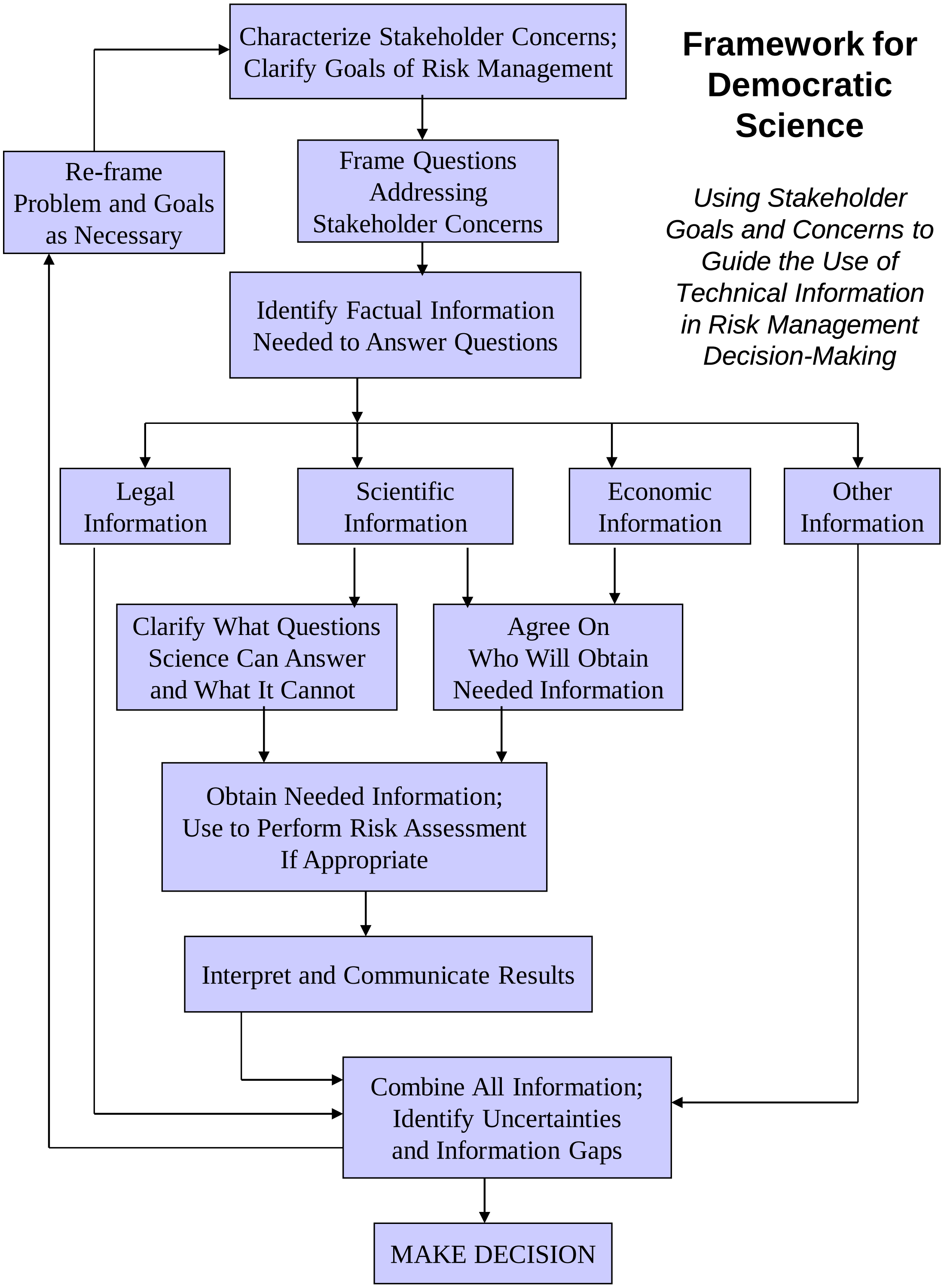
based decision-making can determine which analytic techniques and information are used, interpret analytic results, and use those results to guide decision-making or re-frame the risk management problem and goals, as necessary. What each of the successful case examples in Section 4 have in common is that stakeholders agreed to use one jointly overseen group of scientists and agreed on what that group of scientists would consider. In that way, stakeholders' choices were used to establish what the role of science would be in the risk management decision-making process. In each case, science played an important role, but a role that was shaped—through Democratic Science—by stakeholder values to address their concerns. Through Democratic Science, science was also able to inform an evolving understanding of the scope of the problem. The integrity of the science was maintained and its credibility assured because stakeholders were involved in deciding how science would be used to answer their questions and in obtaining the scientific information needed to answer those questions. In other words, the Democratic Science-based case studies described here demonstrate the effectiveness of implementing what the National Academy of Sciences report *Understanding Risk* called the "analytic-deliberative process" (NRC/NAS 1996) and what the Risk Commission outlined with its framework for stakeholder-based risk management decision-making (Risk Commission 1997).

5.1 Framework for Democratic Science: Combining science and values in decision-making

Page 27 depicts a Framework for Democratic Science, or a guide for using stakeholder goals and concerns to guide the use of technical information in risk management decision-making as part of an iterative analytic-deliberative process. In the first step, stakeholder concerns guide the identification of potential risks and clarify risk management goals. In the second step, the questions that must be answered to address stakeholder concerns are articulated. These two steps are critical to clearly understanding the problem *before* attempts to solve it are made. Next, the factual information needed to answer those questions is identified. Such information need not be solely scientific and might include information about economic impacts,

Framework for Democratic Science

Using Stakeholder Goals and Concerns to Guide the Use of Technical Information in Risk Management Decision-Making



statutory issues, and demographics, for example. Stakeholders then identify and agree on whom should be responsible for obtaining the needed factual information. In several of the case examples described here, a model that seemed to work well involved establishing a group of scientific experts that all stakeholders agreed to; by working closely together through collaborative analysis, the scientists were able to understand the basis for the stakeholders' concerns and the stakeholders were able to understand the role that science could play and to participate in generating data. After the needed scientific information is obtained, it is combined with other information and used either to re-frame the problem and risk management goals or to guide decision-making.

A similar model to the Framework for Democratic Science that is recommended here is the model of cooperative discourse, or three-step participation model (Renn et al. 1993, Schneider et al. 1998). In the first step of that model, values and criteria for judging different risk management options are elicited from stakeholders, which in turn are used by a group of technical experts in the second step to guide the development of indicators or measures for evaluating the performance of each option as compared to the evaluative criteria. For the second step, a group Delphi process is used to reconcile conflicts about factual evidence and reach an expert consensus via direct confrontation among experts representing diverse views (Renn and Kotte 1984). In the final step, citizens deliberate to evaluate and design policy options based on knowledge of the likely consequences of each option and on their own values and preferences, with input from the first two steps. The model of cooperative discourse has been implemented in Germany to address energy policies and waste disposal issues and in the US to develop sludge-disposal strategies, with mixed results.

It is important to acknowledge that science may not always be the sole basis for a decision; in many cases, it will be one—but not the overriding—consideration. The goal is to maintain the integrity and credibility of the science and to define a useful role for scientific information in decision-making. That goal can be achieved through collaborative analysis that generates a single body of knowledge that will be accepted by all the groups in a policy debate as a valid basis for negotiations and agreements (Ozawa 1991, Busenberg, 1999). When the adversarial groups involved in a policy debate jointly oversee the research needed to resolve the underlying scientific and other technical issues, they have the means to assure themselves that other stakeholders are not manipulating the analysis. This observation is consistent with the general principal established by other studies of decision-making processes, which have found that when people have an opportunity to participate in a process, they are more likely to view its results as fair and credible (Thibault and Walker 1975).[4]

The following guidelines will help implement Democratic Science in order to maintain a useful role for science in stakeholder-based decision-making.

1. Research and analysis should respond directly to stakeholders' concerns.
2. All stakeholders should be involved at the research planning stage.
3. Stakeholders should collaborate with scientists to obtain data and other information.
4. Decision-making should be iterative, with technical information used to guide either decision-making or problem re-evaluation, as necessary.

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[4] Interestingly, the thesis that participation increases credibility is also consistent with other cases, not discussed here, where community participation in scientific investigations improved the credibility of the results within an affected community, but not necessarily within the broader scientific community. For example, during the contentious debate that characterized the investigation and litigation associated with the Woburn, Massachusetts community's belief that trichloroethylene-contaminated drinking water was the cause of their leukemia cluster, the only scientific study that was credible to the community was "The Harvard Study". That study, performed by Harvard School of Public Health scientists, began with a cooperative agreement regarding the extent and nature of community involvement in the investigation itself (Brown and Mikkelsen 1990). It is possible, however, that if the Harvard Study had not supported the community's belief regarding a causal association between exposure and outcome, that it would not have retained its credibility with the community.

5.2 Suggestions for further research

Research teams comprising both risk assessors and social scientists are needed. By operating independently, risk assessors have tended to focus on science and decision-making while social scientists have focused on the social determinants of decision-making. More rigorous study of science in stakeholder-based decision-making would be facilitated by both types of scientists working together.

1. *The role of science in stakeholder processes*. Virtually all of the research that has sought to identify the determinants of successful public participation in environmental decision-making focuses on process-oriented social goals. While some perceive that science suffers in the hands of stakeholders, it is difficult to evaluate that perception objectively using the currently available data base because of the emphasis on social goals as evaluation metrics. Little work has been devoted to evaluating the role of science. Research is needed that includes determinants of how science has been included in stakeholder-based decision-making and how its role has had an impact on process outcomes.
2. *Policy disputes resulting from differing scientific interpretations*. This report has focused on the role of science in formal, convened, stakeholder decision-making processes. Much of the genesis of the concern over that role results from situations that do not involve formal stakeholder processes. Such disputes involve general disagreements among stakeholders that arise partly due to differences in interpretations of the science that underlies particular actions and partly due to differences in how science is weighed against the many other factors that contribute to decisions about managing risks. A rigorous analysis of the social factors that contribute to differing interpretations of scientific information and how science weighs as a factor in decision-making is beyond the scope of this analysis and worthy of more focused research.
3. *Politics versus science*. Some cynics argue that most risk management decisions are

made on the basis of political expediency and that neither good science nor efforts at stakeholder collaboration have any real influence. More rigorous study is needed to determine whether and to what extent that is indeed the case.

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Appendix M

Excerpt from textbook by Wilson & Crouch, 2001

Excerpt from

Wilson, R., and Crouch, E.A.C. (2001). Risk-Benefit Analysis. 2nd Edition. Center for Risk Analysis, Harvard University.

Risk-Benefit Analysis

Richard Wilson
Department of Physics
Center for Risk Analysis
Harvard University

and

Edmund A. C. Crouch
Cambridge Environmental Inc.

Published by the Center for Risk Analysis
Harvard University

Second Edition
Distributed by Harvard University Press

Table of Contents

7

Lists of Risks

"It is unquestionably true that [rail travel] is safer than traveling by coach or horseback...if one wants anything safer he must walk."

—H.G. Prout, (1892) The American Railway

New York, Charles Scribner and Son, p 191

The safety of technology-based systems improves with time. As will be seen below, most such systems have improved in the U.S. The first part of this quotation is still true in the year 2000. But expressed as deaths per mile traveled, train travel is now safer than walking.

Some Examples of Risk Calculations

As we said in the opening sentence of this book, life is a risky business. We went on to explain what this meant in qualitative terms, and then to describe how quantitative estimates may be made of the magnitudes of various measures of risk. The knowledge of such risk magnitudes from individual causes, however, may be of little use unless they can be related to the magnitudes of everyday risks. For otherwise one can obtain no sense of the importance of the risks, and how much notice should be taken of them.

This chapter is devoted to showing just how (quantitatively) risky are everyday life and actions by assigning numerical values to a collection of common actions which involve some element of risk. The object is to provide a background of values for familiar risks, against which the results of calculations of unfamiliar risks may be judged. Throughout the chapter we shall be specifically discussing risks of death, so that the risk measure used will be the probability of death—sometimes a population weighted average annual probability, at other times age specific annual average probabilities, and occasionally other averages. We do not claim, however, to present a complete list of risks. In order to present all the risks on as common a basis as possible, we have tried to arrange our examples so that we can specify some quantity or measure of activity which will give either a lifetime probability of 10^{-6} (one in a million) of dying from that activity, or an annual average probability of 10^{-6} of dying. Since the average expectation of life of a person in the U.S. is about 78 years (in the year 2000), for any given risk there will be a factor of about 78 difference between the numerical values of such measures. The annual average probability (that is, averaged over the lifetime of an individual) is about equal to the population average (that is, averaged over all ages according to the age structure of the population) provided the risks are small enough.

The Risk (of Death) in Living

The first risk (of death) to consider is that in living itself (i.e. the probability of dying). In case this sounds paradoxical, it must be realized that the sum total of all lifetime average risks (of death) must be one (absolute certainty) since everybody dies. From the risk analyst's point of view, we might say that the whole object of living is to die! Our efforts go into attempting to reduce annual risks, in order to make it more likely that the inevitable death will occur later, and longevity is increased. We look first at the probability of dying because it corresponds to the sum total of all the risks to which we are exposed. If we had a complete list of all activities undertaken by everybody, together with a list of the risks involved in such activities, and provided that we took care to avoid double counting, we could add all the risks together to obtain the total risk of dying. Evidently, for any individual or group, such a sum will vary from individual to individual or group to group, but if we average everything over the whole population we simply get the average risk

FIGURE 7-1

Time (in Hours) in Which Probability of Dying Is One in a Million, vs. Age (linear scale)

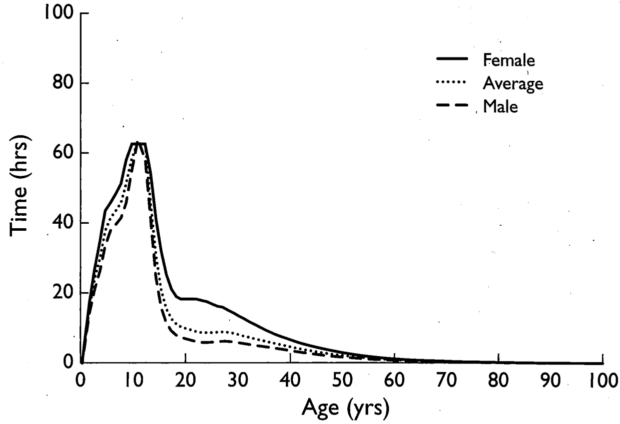
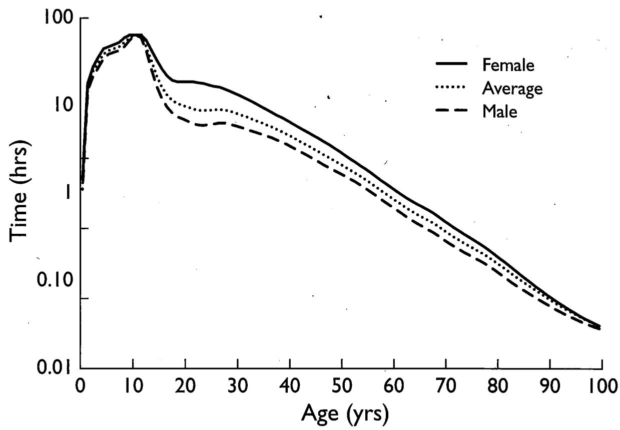


FIGURE 7-2

Time (in Hours) in Which Probability of Dying Is One in a Million, vs. Age (logarithmic scale)



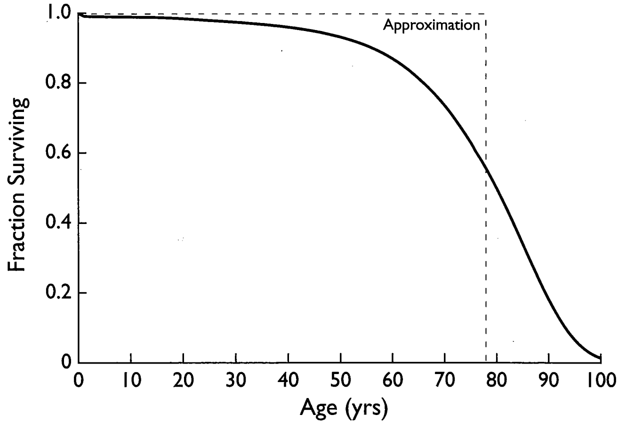
of dying for that population. Figures 7-1 and 7-2 show the time required to accumulate a probability of one in a million (10^{-6}) of dying at a given age for the U.S. population in 1998. This is a measure of the reciprocal of the total risk of living. Notice the linear scale in Figure 7-1 and the logarithmic scale in Figure 7-2.

The large range of times is better shown on the logarithmic scale of Figure 7-2, but Figure 7-1 may show the range more dramatically for those unfamiliar with logarithmic plots. The time required increases rapidly with age initially, reaching a maximum of 62 hours at age 10–11, and then falls rapidly. The dip in the curves near age 21–22, especially pronounced in males, is caused mainly by the risks of auto accidents. After age 30 the curves decrease steadily (this is especially obvious on Figure 7-2), reaching 7 minutes (males) to 11 minutes (females) at age 80. These curves are, of course, just the reciprocal of the age-specific death rate curves for the U.S. population, and convey the same information. If we know the number N of males aged 20 (for example) in the population, and the time to accumulate the one in a million (10–6) probability of dying for males aged 20 is 6.5 hours (from Figure 7-1), then in 1 year the probability of death is (8,760/6.5)/1,000,000 = 0.0013 (1.3×10^{-3}) and so 0.0013 N (1.3×10^{-3} N) males aged 20 die each year.

Life Expectancy

Figures 7-1 and 7-2 correspond to what occurred in the U.S. in 1997. From year to year the probabilities of dying change gradually as changes occur in our society, so they are not strictly applicable to other years, although the rate of change is small. If these probabilities were to remain constant, it is possible to calculate what the population age structure (represented, for example, by the fraction surviving to a given age) would be if the same number of children were born each year, and all grew up subject to the age specific risks of Figures 7-1 and 7-2 (and there was no immigration or emigration). The result is shown in Figure 7-3, where it was seen that most people would survive until their 60s, but there is a rapid drop off in survivors after age 75. The average age of the population shown in Figure 7-3 is known as the life expectancy or expectation of life (at birth) in 1998. It is not precisely the expected length of life of a child born in 1998. In actual fact, of course, such a child faces different risks—e.g., the actual risk for that child at age 5 is the 5-year-old's risk in 2004 (which is not yet measurable), not in 1998 (which *has* been measured). The expectation of life (at birth) is thus a form of

FIGURE 7-3
Age Structure of Static Population in 1997



average measure of the risk of dying at all ages, since the risks at all ages are taken into account in computing it, and is thus a measure which may be used to compare between years to see if risks have been increasing or decreasing on average. The variation of expectation of life (at birth) with time was shown for the U.S. in Figure 1-2 and for various other countries in Figure 1-3. The expectation of life has been increasing, mostly steadily, except in Russia, corresponding to a mostly steady decline in the average annual risk of death.

A Selection of Risks: Historically Calculated

In the tables and graphs that follow the text of this chapter, we present a diverse selection of risks variously calculated. It is often desirable to compare risks of the same type if possible, so we present lists where risks are grouped clearly into categories, within which intercomparison is easily justified and probably moderately accurate. But we also specifically introduce disparate risks to stimulate thought. Most of these tables apply to the U.S. We start in Table 7-1a with a set of occupational risks calculated from historical statistics. Many have been declining steadily over the years. The values given are derived from the statistics given in the various sources noted in the tables (and we include where applicable the table number of a particular source, e.g Statistical Abstract of the U.S. 1999 edition). The values given are crude rates rather than the age-adjusted rates. The calculation is especially simple. All that is required is a knowledge of the numbers who died in the past, and the

TABLE 7-1A

Occupational Risks

Deaths per Year of Risky Activity (Disabling Injuries Not Included Except When Stated)

Occupation or Industry	Annual per Capita Risk per 100,000	Annual Trend per 100,000	Source Based On	Ref, #
All Industries	7	-0.2	1955–98	4
Women in Industry	1	+0.1	1992–94	11
Women in industry (homicide)	0.4		1992–94	11
Colorado industry (average)	7		1982–94	10
Colorado industry (homicide)	0.6		1982–94	10
Manufacturing	3.2	–0.2	1955–98	3#705
Retail trade	1.7	–0.2	1955–98	3#705
Service	1.5	–0.3	1955–98	3#705
Government	1.7		1998	3#705
Transport and public utilities	12	–1.2	1955–98	3#705
Construction	14	–2.4	1955–97	3#710
Construction (women)	6		1992–94	11
Mining and quarrying	24	-7.5	1955–98	3#705
Coal mining (accidents)	24	-3	1977–99	5
Coal Mining (China)	500		2000	text
Metal mining and milling	56	–2.2	1959–98	5
Stone Quarries	40	–1	1959–98	5
Stone (underground)	9	1	1978–98	5
Nonmetal mining undergnd	46	–2	1979–98	5
Nonmetal mining surface	18	1	1978–98	5
Agriculture	23	–1.8	1955–98	7,3#716

continued

populations at risk. In Table 7-1a the risk (and rate of decline, where applicable) is as given for the last year in the range shown. In principle the rates of decline should be obtained by regressing the logarithm of the rate against time, and the variability is the year-to-year variability around this regression line. In many cases a simple visual approximation is used.

In the first edition of this book we presented tables such as Table 7-1a in "scientific notation" $1*10^{-5}$ or 1×10^{-5} instead of in "ordinary" notation, 1 in a hundred thousand. For a specialist risk assessor this can be useful, particularly for comparison of wide ranges of risks. However, here we are deliberately expressing the risks as fatalities per year per 100,000 persons at risk, so that

TABLE 7-1A

Occupational Risks *(continued)*

Deaths per Year of Risky Activity (Disabling Injuries Not Included Except When Stated)

Occupation or Industry	Annual per Capita Risk per 100,000	Annual Trend per 100,000	Source Based On	Ref, #
Tractor fatalities	10	–1	1969–98	7
Police officers killed in line of duty				
Total	32	+0.5	1975–98	3#355
By felons	15	+0.3	1975–97	4, text
Railroad employees	15	–0.4	1975–00	9
Steel workers (accidents only)	28		1969–72	2
Assassination, murder, or battle injury				
President of United States	1,900		1789–2000	text
President of Egypt	1,900		1948–2000	text
President of France	1,400		1848–2000	text
King/Queen of England	430		1066–2000	text
Spouse of King/Queen	210		1066–2000	text
Government office worker	9		1997	text
Airline pilot (accidents only)	10		1997	text
Frequent flying professor (accident only)	3		2000	text
Astronaut Space launch (per launch):				
From direct data (Including Challenger)	4,000		1975–86	text
O-ring failure at 31°F	13,000			text
O-ring failure at 60°F	2,000			text
Fire fighters (buildings)	40	-0.7	1972-99	8
Wildfire fighters				
Total	21		2000	6, 8
Per 12 months work	100		2000	6, 8

Sources: [Ref (1) #19 means table 19 of reference 1]

(1) Murphy (2000); also available on the web at: *www.cdc.gov/nchs/data/nvs48_11.pdf*

(2) Baldewiicz et al. (1974)

(3) Statistical Abstract of the United States 2000 edition (and earlier editions for the trends)

(4) NSC (Annual)

(5) Mine Safety and Health at www.msha.gov/centurystats/centurystats.htm

(6) Mangan (1999) see also *www.fs.fed.us/fire/safety/fatalities/*

(7) Runyan (1990) report on NM agriculture

(8) National Fire Data Center (1999) *www.usfa.fema.gov/nfdc*

(9) Federal Railroad Aministration (Office of Safety) *safetydata.fra.dot.gov/*)

(10)Vassalo et al. (1997) also: stats.bls.gov/opub/cwc/1997/spring/art5abs.htm/)

(11)Knestaut (1996) also at: stats.bls.gov/opub/cwc/1997/summer/brief3.htm/)

TABLE 7-1B

Occupational Risks

Deaths per Year of Risky Activity Involving Uncertain Dose-Response Relationship. These risks could be zero if there is a threshold. (Disabling injuries not included except when stated.)

Occupation	Annual Risk per 100,000	Uncertainty Factor	Year	Source
Coal miner with black lung disease	500	⅓ to 3	2000	text
Smoking asbestos worker at 0.1 fiber/ml	18	⅓ to 3	2000	text
Teacher (female age 25–55) in typical school with 0.0002 fibers/ml average asbestos level				
Total (smoker)	0.013		2000	text
Total (non smoker)	0.006		2000	text
Mesothelioma	0.005		2000	text
Lung cancer (smoker)	0.008		2000	text
Lung cancer (non smoker)	0.001		2000	text
Mesothelioma if risk reduced for chrysotile	0.0002		2000	text
Smoking (male) office worker with asbestos at 0.001 fiber/cc	0.1		2000	text
Nuclear power plant worker (exposed at NRC maximum)	20		2000	text
Airline pilot (cosmic ray exposure)	14		2000	text
Hospital X-ray technician (world average)	10		2000	text

the relative magnitude may be more easily seen, and negligible risks may be seen to be negligible. This approach also has the advantage that it is the standard notation used by the National Center for Health Statistics to present various risks.

Table 7-1b is a further set of estimates of occupational risks due to specific on-the-job exposures, all of which involve an uncertain dose response relationship. As noted in Chapter 2, the dose response is generally unknown when the risk is only a few percent above background risk. If there is a threshold in the dose response relationship, most of these risks could be zero. Even with the pessimism (conservatism) of a linear dose response relationship risk estimates for risks tend to be lower than the historically derived total occupational risks for which the relationship between years of "exposure" and death rate is clearly linear. Nonetheless the cancer risks arouse particularly strong emotions as noted in Chapter 4.

The number of persons who are exposed to the risk is obviously important both for deciding the total cost of reducing a risk, and the desirability of

TABLE 7-2A

Risks of Death Due to an Action

(Public Risks Historically Calculated)

Occupation or Industry	Annual per Capita Risk per 100,000	Annual Trend per 100,000	Source Based On	Ref, #
Total crude death rate (U.S.)	870	–79	1980–98	3#1355
Heart disease	271	–3.6	1980–98	1#B, 3#126
Diabetes mellitus	24	+0.4	1980–98	1#B, 3#126
Pneumonia and influenza	35	+0.5	1980–98	1#B, 3#126
Chronic pulmonary disease42	+0.9		1980–98	1#B, 3#126
Cigarette smoking (per smoker)	300			text
All fatal cancers	200	–4	1978–98	1#B, 3#126
Respiratory	59	-0.6	1978–98	3#126
Digestive Organs	47	–1.3	1978–98	3#126
Genital Organs	22	–0.5	1978–98	3#126
Breast	16	–0.7	1978–98	3#126
Cancer from arsenic at 500 ppb in water	140		2000	text
Motor vehicle accident (total)	15	–0.4	1972–98	1#19, 3#1036
Alcohol related (BAC>0.01)	6			9
Pedestrian deaths	2	–0.1	1972–98	1#19, 3#1035
Cyclist per total pop.	0.30	–0.01	1980–98	1#19, 3#1035
Cyclist at night	0.1		1985	6
Collision with animals	0.5		1998	
Using cell phone	0.15		2000	2
Motor vehicle accident (New Mexico)	35		2000	
Rail grade crossing acc. (total)	0.18		1996	8
Not involving automobiles	0.027		1996	8
Rail trespassing accidents	0.15		1999	10
All other accidents	19.	0	1990–97	3#126
Home accidents (all ages)	11	0	1978–98	4, 11, text
All toys (under 15)	0.027	-0.001	1985-99	6, 3#12
Garage door (age 2–14)	0.009		1982–89	6, 3#12
Toy chest lids (age 0.5–1.5)	0.06		1973–82	6, 3#12
Electrocution	0.18	–0.02	1980–96	3#135
Illegal drugs (per total population)	5.6	+0.1	1980–97	3#141
Alcohol (direct)	6.3	–0.1	1980–96	3#142
Cirrhosis of the liver (alcohol-related)	4	–0.4	1974–97	text
Objects inhaled and ingested	1.2	+0.001	1968–96	3#135
Misadventures during medical care, etc., complications	1.1	+0.001	1980–98	1, 3#135

continued

TABLE 7-2A
Risks of Death Due to an Action *(continued)*
(Public Risks Historically Calculated)

Occupation or Industry	Annual per Capita Risk per 100,000	Annual Trend per 100,000	Source Based On	Ref, #
Falls: (includes unidentified fractures)				
General population	6	−0.009	1977–98	11, 3#12
Over 70 years old	43		1998	11, 3#12
Drowning (unintentional)	1.6	+0.2	1963–98	1#19
Drowning (UK)	1		1998	7
Fires	1.4	−0.07	1963–77	1
Firearms (total)	11	−0.1	1968–98	1#19
Suicide	6.5		1968–98	1#19
Homicide	4.4		1968–98	1#19
Suicides (total)	11	−0.03	1980–98	1#B, 3#138
Homicide (victims) (total)	6.8	−0.4	1979–98	1#B, 3#126
Black males	56	−4.6	1995–7	3#139
Accidental Poisoning (total)	4		1998	1#19
Gases and vapors	0.24	−0.03	1977–96	3#135
Solids and liquids (not drugs or medicines)	0.16	−0.02	1977–96	3#135
Suffocation (total)	4.1		2000	1#19
Unintentional	1.7		2000	1#19
Babies in adult beds	0.24		1990–97	6
Suicide	2.1		2000	1#19
Yearly coast to coast flight (accident risk)	1		2000	text
Being hit by falling aircraft	0.004		1998	text
Being hit by meteorite	0.04		2000	text
Tornadoes	0.015		1950–2000	5, 3#405
Floods	0.045		1950–97	3#405
Lightning	0.016	−0.002	1977–97	3#405
Tropical cyclones and hurricanes	0.009		1952–98	3#405
Drought or heat wave	0.4		1980–00	3#406
Bites and stings by venomous	0.017		1998	11

Sources: [Ref 1#19 means Table 19 of reference 1]

(1) Murphy (2000); also available on the web at: *www.cdc.gov/nchs/data/nvs48_11.pdf*

(2) Harvard Center for Risk Analysis "Risk in Perspective" Summer 2000

(3) Statistical Abstract of the United States 2000 edition (and earlier references with different table numbers)

continued

TABLE 7-2A
Risks of Death Due to an Action *(continued)*
(Public Risks Historically Calculated)

(4) NSC (Annual)

(5) Storm reduction Center, NOAA also available on the web at: *www.spc.noaa.gov*

(6) Consumer Product Safety Commission reports: *www.cpsc.gov*

(7) Royal Society for Prevention of Accidents (UK) *www.rospa.co.uk*

(8) Bureau of Transportation Statistics: *www.bts.gov*

(9) Mothers Against Drunk driving: *www.madd.org*

(10) Operation Lifesaver: *www.oli.org*

(11) The risk for bites, stings and falls (and many other risks not listed here) is derived from the website. *www.cdc.gov/nchs/datawh/statab/unpubd/mortabs/gmwki.htm*

This includes all the ICD classifications E880-E888. This is 50% greater than the falls attributed in Table 1054 of the statistical abstracts. But classification E888 is for unidentified falls, and E887 for deaths by fracture not otherwise identified. For examining trends consistency is important. The risk of falls for those over 70 is the number of deaths by falls of those over 70 divided by the population over 70 and is 10 times the average risk.

* Factor of $^1/_{10}$ to 10.

doing so. The separation of occupational risks, where a limited number of people are exposed, in Table 7-1a and 7-1b and the public risks in Tables 7-2a and 7-2b is a partial recognition of this. It is noteworthy that most occupational risks have declined and the rate of decline is greater than it was in 1982. One of the ways that risks averaged over an occupation are being reduced is by searching out sub-groups at especially high risk and attending to them. Such attention is encouraged by various workers' protection laws.

The employer indifference of 1906 was exemplified in Upton Sinclair's novel, *The Jungle:* "In the beginning he had been fresh and strong, and he had gotten a job the first day; but now he was second-hand, a damaged article, so to speak, and they did not want him.... they had worn him out, with their speeding-up and their carelessness, and now they had thrown him away!" This probably still applies to developing countries, and to perhaps some small groups, particularly immigrants to the U.S.

Table 7-2a is a list of various commonplace public risks of death, also calculated from historical data. Most of these risks would be considered involuntary. There may be some overlapping between categories in this table (home accidents, for example, includes falls within the home).

Although these risk estimates seem very simple, there is often an ambiguity of the definition of the occupation or grout risk. Since the numerator and

TABLE 7-2B

Risks of (an) Action(s)

(Public Risks Involving an uncertain Dose-Response Relationship. Any of These Risks Could Be Zero if a Threshold Exists)

Occupation	**Annual Risk per 100,000**	**Uncertainty Factor**	**Source Year**	**Ref, #**
Coal miner with black lung disease	500	⅓ to 3	2000	text
Air pollution (average in U.S.)	25	1/∞ to 5	2000	text
Cancer from drinking:				
Arsenic in water at U.S. EPA level of 50 ppb	140		2000	text
Arsenic in water at Fresno levels	2.8		2000	text
Chloroform in water at EPA limit (100 ppb)	0.07		2000	text
Risk from potassium 40 normally in body	1		2000	text
Living in an ordinary southern California house with indoor air pollution (TEAM study)	0.77		2000	text
One way transatlantic flight (cosmic rays)	0.14		2000	text
One drink with alcohol per day:				
Cancer and other adverse	5			Ch. 2, p. 52
Cardiovascular (reduction)	–200			Ch. 2, p. 52
Living near a superfund site:				
Love Canal	500			text
Stringfellow (house)	0.6			text
Stringfellow (school)	35			text
Midvale (Utah) max estimate	4			text
Midvale (Utah) best estimate	0.01			text
Old EPA regulatory limit (10^{-6}/ lifetime pessimistically calculated)	0.0014		2000	text
Authors' estimate of real risk at *old* EPA regulatory limit	<0.0001		2000	text
Eating ice cream daily	19		1999	1

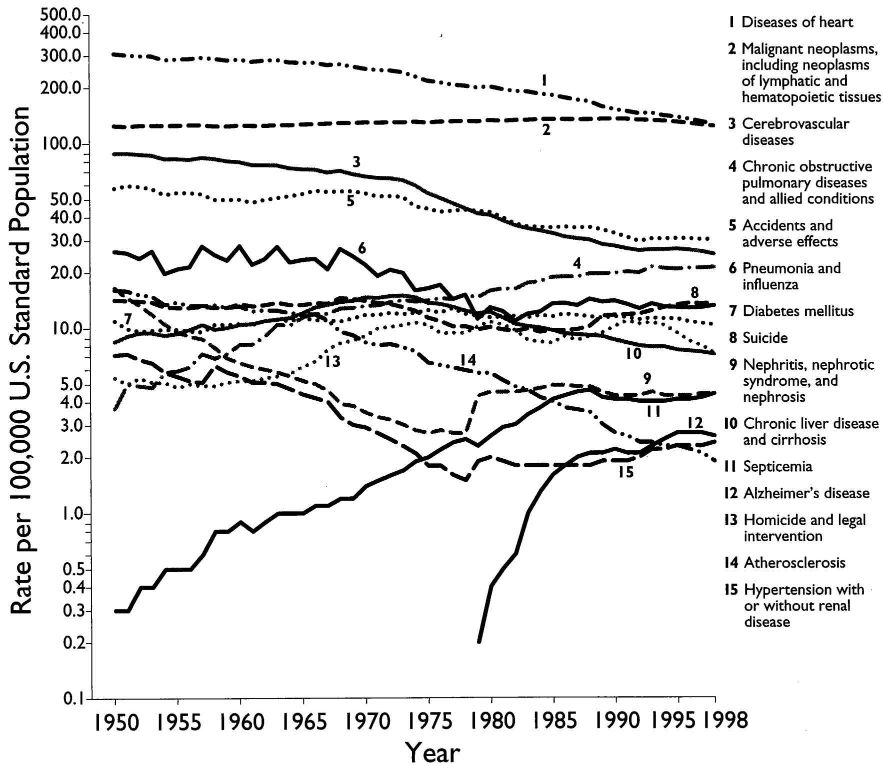
Source:

(1) Cancer risk from dioxin calculated by Gough, M. and S. Milloy, *http://www.junkscience.org/dec99/benjerry2.htm*

denominator often come from different sources, the definition can be different in the two cases leading to an error. For example the deaths in fighting fires includes helicopter crashes and crashing motor vehicles hurrying to the scene. The number of people fighting wildfires in the U.S. should therefore include not only the people registered but these auxiliary people. On the other hand, few if any people are employed for the full year. The choice of group at risk (discussed in Chapter 1 as the boundary of the problem) can

FIGURE 7-4

Age-Adjusted Death Rates for the 15 Leading Causes of Death: U.S., 1950–1998



lead to very different values of the risk estimate. This is illustrated in the specific example below of the risk of being killed by bear attack. In comparing risks from one year to the next great care must be taken in using the data to be sure there is consistency. This also applies when one presents, as here, a "raw" risk averaged over the population of all ages, and the age distribution of the population changes. Many risks vary with age. Then the "raw" risk becomes less useful and for purposes of studying the changes with time, an artificial "age adjusted" risk is often constructed valid for a society with a static age distribution (see Appendix III for the methods adopted). In Figure 7-4 we present from Murphy (2000) the age adjusted death rates for various

FIGURE 7-5

Annual Fatality in Various Occupations per 100,000 Persons Employed

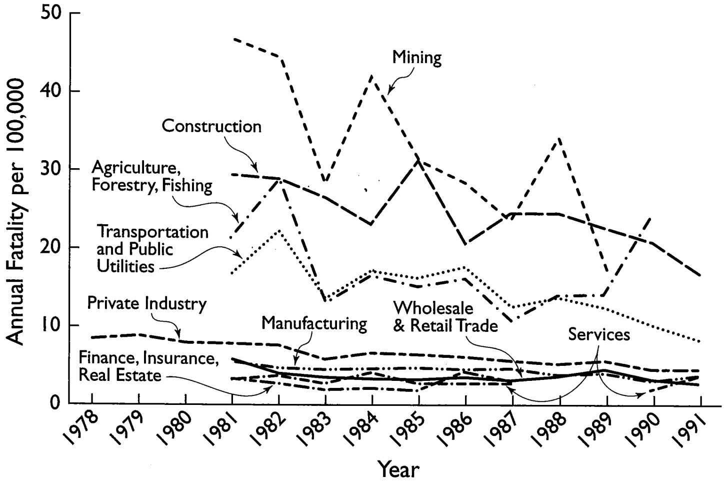


FIGURE 7-6

Risk of Cirrhosis of the Liver in U.S. States vs Average Alcohol Consumption

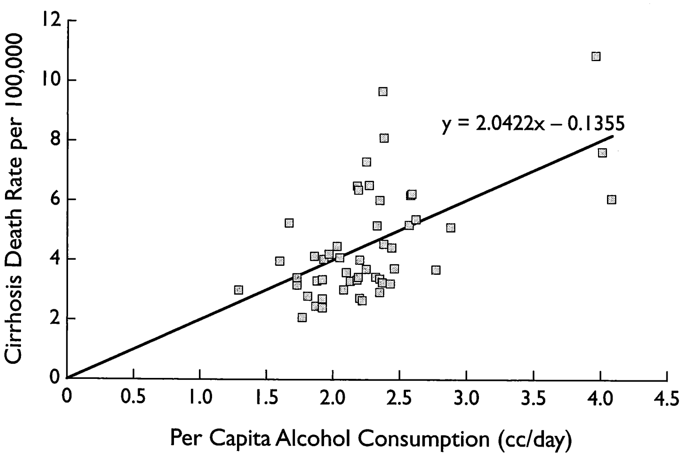


TABLE 7-2C

Lifetime Risk from Action Stated

Action	Lifetime Risk (Parts per 100,000)	Year	Source
Cancer from eating:			
1 tablespoon of peanut butter (if hepatitis B1)	0.0003	2000	text
1 tablespoon of peanut butter (NO hepatitis)	0.00001	2000	text
4 daily tablespoons of peanut butter (if suffering from hepatitis B1)	30	2000	test
4 daily tablespoons of peanut butter (NO hepatitis B1) (cancer risk)	1.3	2000	text
½ lb of charcoal broiled steak a week	3	2000	text
Mesothelioma in female exposed from ages 6–16 to asbestos in school at 0.0002 fibers/cc	0.24	2000	text
Mesothelioma in male school child (5 to 10 times smaller if chrysotile risk is reduced)	0.16	2000	text
Risk of deep space probe (approx.)	0.000001		text
Risk of deep space probe (NASA)	0.00000003		text
EPA regulation range			
Upper end	10	2000	text
Lower end	0.1	2000	text

diseases, showing the trends. This graph also shows breaks in the curves due to changes in definition of the diseases.

Most of the risks have been steadily going down in the 20 years since the first edition of this book. This is illustrated in Figure 7-5 where we plot trends. (OSHA, 1997) for a number of occupations. These trends generally continue those seen in earlier times (shown in the first edition). Figure 7-6 plots cirrhosis of the liver against alcohol consumption in various states showing how that risk is estimated.

Table 7-2b is a further set of everyday risks, expressed on an annual basis, which involve an uncertain- response relationship. They could be zero if there is a threshold.

Table 7-2c shows a set of everyday risks expressed on a lifetime basis. Note that they could be zero if there is a threshold in the relevant dose response relationship.

Table 7-3, in contrast, shows a set of voluntary risks of death—mostly those incurred in sports or in recreational activities. These are shown separately because they are voluntary risks. Most people will voluntarily engage in activities far more risky than activities imposed upon them by other members

TABLE 7-3
Recreational Risks

Sport	Average Annual Risk per 100,000	Average Annual Deaths	Estimated Population at Risk	Years of Coverage	Source
All children's toys	0.044	22	60,000	1985	CPSC
Aerial acrobatics (professional)	<~200	0.22	350	1970–78	1
Air show/air racing and acrobatics	500	4.9	1,000	1971–77	1
Flying amateur/home built aircraft	300	25	10,000	1970–77	1
Bicycle racing (registered)	1.4	0.33	10,000	1970–96	1, 5
Boating	5	815	300,000	1972–98	5, 6
Whitewater boating					
(Experienced)	270	27	10,000	1995–99	AWA
(Inexperienced)	70	36	50,000	1995–99	AWA
Waterskiing	47	47	100,000	1995	
Bob sledding	<~70	0	450	1970–78	1
Boxing	40	2	5,000	1995	5
Football (total)	0.6	6	1,000,000	1995	5
Sandlot	0.2	1.7	1,000,000	1970–78	1
Professional and semiprofessional	7	0.11	1,500	1970–78	1
High school	1.2	13	1,000,000	1970–96	1, 5
College	3	1.2	4,000	1970–96	1, 5
Basketball	0.4	4	1,000,000	1995	5
Glider flying	40	7	20,000	1970–77	1
Hang gliding	26	13	50,000	1995	1, 5
Hunting	3	600	2,000,000	1972	2, 3
Ice yachting	5	0.22	5,000	1970–78	1
Balloon flying	90	2.6	3,000	1970–77	1
Mountain recreation:					
Hiking	6.4			1996	5
Casual climbing	57			1996	5
Mountaineering	60	34	60,000	1951–78	1, 4
Dedicated climbing	600			1996	5
Himalayas per ascent	13000		~100	1920–99	text
Bear attack:					
Backpacker	1.3	0.13	10,000	1955–2000	text
Concession worker	10	0.07	500	1955–2000	text
Power boat racing	8	5.2	7,000	1970–78	1
Professional stunting	<~1000	1	200	1975–78	1
Rodeo	<~3	0.33	30,000	1970–78	1
Sail planing	59			1996	

continued

TABLE 7-3
Recreational Risks *(continued)*

Sport	Average Annual Risk per 100,000	Average Annual Deaths	Estimated Population at Risk	Years of Coverage	Source
Scuba diving	42	126	300,000	1970–96	1, 3
Ski racing	2.5	2	80,000	1970–96	1, 3
Sky diving (U.S.)	58	29	50,000	1995–00	
Sky diving (international)	30	74	250,000	1991	
Snow skiing	12	41	300,000	1995	
Snowmobiling	13	60	450,000	1995	5
Spelunking	<~1	44	10,000	1970–78	1
Snowboarding	0.25	5	2,000,000	1991–95	
Sport parachuting	200	41	20,000	1970–78	1
Horseracing (thoroughbred)	100	2.6	2,000	1970–78	1
Swimming	3	2,600	8,000,000	1972–78	2, 3
Tilting soda machines	2.5	5	50000	1985–87	5

Sources:

(1) "Statistical Bulletin" Metropolitan Life Insurance Company (1979) This was the principal source for this table in the first edition but it is no longer being issued. This makes the numbers somewhat less consistent than desirable and much more uncertain than the estimates in the previous two tables.

(2) Bureau of the Census

(3) National Safety Council (annual)

(4) Ferris (1963)

(5) Cosio (1992)

(6) National Boating against Drunk Driving (BADD)

of society. These risks are much harder to quantify. Often the number of deaths can be determined moderately well, but the number of persons engaged in the risky activity is uncertain. Moreover, the risks vary. Usually there is a small "professional" group intensely engaged in the activity with a high risk, and a much larger "amateur" or "non-professional" group, with a smaller one. The average risk is then often dominated by the small group with the high risk.

In general the recreational risks have not been reduced in the last 20 years as as much as occupational risks have. It seems that when a recreation is made safer, individuals begin to engage in hazardous activities that would have been considered too risky before.

TABLE 7-4A
Some Risks of "One in a Million"

Time (or Action) to Accumulate a Risk of One in a Million from the Cause Indicated (Historically Calculated)

Motor Vehicle Accident	100 miles
Falls (average over life)	6 days
Falls (average under 70)	15 hours
Drowning	19 days
Fires	13 dqays
Firearms	3 days
Electrocution	200 days
Tornadoes	5½ years
Floods	2 years
Lighting	6 years
Occupational Risks—Working in:	
Manufacturing	100 days
Government	10 days
Transport	3 days
Agriculture	1½ days
Construction	3 days
Coal mine accidents	1½ days
Black lung disease	2 hours
Police officer	1¼ days
Pilot	3 days
Frequent Flying Professor	10 days

Note: the larger risks have a *smaller* number in this table!

Time (or Action) to Reach One in a Million Risk

There are many other ways of presenting these risks, with different ways suited for various purposes. In Figures 7-1 and 7-2 we provided overall background by showing how long in normal life it takes to accumulate a risk of 10^{-6} (one in a million) of dying (depending on age) and given another yardstick to judge a one in a million (10^{-6}) risk, In Tables 7-4a and 7-4b, we list some of the risks that we face, as listed in Tables 7-1a, 7-1b, 7-2a, 7-2b, and 7-3 and put them into a form so that each corresponds to a risk of one in a million—10^{-6}. This table perhaps helps to place different risks in perspective, but some of the interpretations have to be strained a little to get them into this format, so that they are difficult to compare.

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