



**Estimates of the Probable Costs and Benefits
of the
Amendments
to the
Model Toxics Control Act
Cleanup Regulation
Chapter 173-340 WAC**

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Executive Summary

This report summarizes Ecology's analysis of the probable costs and probable benefits of the proposed amendments to the Model Toxics Control Act (MTCA) Cleanup Regulation (Chapter 173-340 WAC) and explains how those estimates were generated. After considering both the quantifiable and qualitative costs and benefits and the specific directives of the statute being implemented, Ecology has determined that the probable benefits exceed the probable costs.

Ecology conducted a comprehensive review of the proposed amendments to the MTCA Cleanup Regulation (Chapter 173-340 WAC) to identify those amendments that required further evaluation to determine whether the probable benefits of the proposed rule amendments exceed the probable costs. Based on this review, Ecology determined that the following amendments may have significant economic impacts and should be subject to further analysis.

- Changes to the Method A soil and ground water cleanup levels.
- Establishment of soil cleanup levels – consideration of land use.
- Establishment of soil cleanup levels – evaluation of the soil-to-ground water pathway.
- Establishment of soil cleanup levels – evaluation of the dermal exposure pathway.
- Establishment of soil cleanup levels – evaluation of the vapor exposure pathway.
- Establishment of soil cleanup levels – conducting a terrestrial ecological evaluation.
- Requirement of financial assurances.
- Creation of a citizen technical advisor.

The impact of each of these proposed rule amendments on costs and benefits was evaluated in Chapter 2. For each amendment, Ecology summarized the proposed rule amendment in comparison with the current rule and then estimated the general impact on costs and benefits.

The primary impact of the proposed rule amendments on costs and benefits is expected to result from changes in the cleanup levels established for a site. See Section 2.1, as well as Sections 2.2 through 2.6. Costs and benefits, though, are not directly related to the establishment of cleanup levels. Rather, the ultimate impact on costs and benefits of any change in cleanup levels is dependent on several site-specific factors, including (most importantly) the remedy selected. Technical analyses of the probable costs and probable benefits of the proposed Method A soil and ground water cleanup levels specified in Tables 720-1, 740-1 and 745-1 are presented in Chapter 3 and Chapter 4 respectively. The probable cost impact of the proposed cleanup levels, as well as the requirements for establishing soil cleanup levels, on petroleum contaminated sites was also analyzed. See Chapter 5. A technical analysis of the probable cost impact of conducting a terrestrial ecological evaluation was also conducted. See Chapter 6. Overall, Ecology determined that the probable benefits of the proposed cleanup levels, as well as the proposed requirements for establishing soil cleanup levels, exceeded the probable costs.

In addition to evaluating the potential impact of any change in cleanup levels, Ecology also evaluated the potential impact of amending the requirement of financial assurances. See Section 2.7. This evaluation included a technical analysis of the probable costs of requiring financial assurances at a site. See Chapter 7. Overall, Ecology determined that the probable benefits of the proposed rule amendment exceeded the probable costs.

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Chapter 1 Introduction

1.1 Purpose

The Washington Administrative Procedure Act requires that significant legislative rules be evaluated to “[d]etermine that the probable benefits of a rule are greater than its probable costs, taking into account both quantitative and qualitative benefits and costs and the specific directives of the statute being implemented.” RCW 34.05.328(1)(c). This determination must be documented prior to final rule adoption and included in the rulemaking record. This report summarizes Ecology’s analysis of the probable costs and probable benefits of the proposed amendments to the MTCA Cleanup Regulation (Chapter 173-340 WAC) and explains how the estimates of those costs and benefits were generated.

1.2 Background

The Model Toxics Control Act (Initiative 97), chapter 70.105D RCW, was passed by the voters of the State of Washington in November 1988 and became effective March 1, 1989. The law establishes the basic authorities and requirements for cleaning up contaminated sites in a manner that will protect human health and the environment.

As a general declaration of policy, the Model Toxics Control Act (MTCA), chapter 70.105D RCW, states that:

Each person has a fundamental and inalienable right to a healthful environment, and each person has a responsibility to preserve and enhance that right. The beneficial stewardship of the land, air, and waters of the state is a solemn obligation of the present generation for the benefit of future generations.

RCW 70.105D.010(1). The statute further states that:

A healthful environment is now threatened by the irresponsible use and disposal of hazardous substances. There are hundreds of hazardous waste sites in this state, and more will be created if current waste practices continue. Hazardous waste sites threaten the state’s water resources, including those used for public drinking water. Many of our municipal landfills are current or potential hazardous waste sites and present serious threats to human health and the environment.

RCW 70.105D.010(2). The purpose of MTCA is to prevent or remedy these threats to human health and the environment. As stated in MTCA’s general declaration of policy, “[t]he main purpose of this act is ... to clean up all hazardous waste sites and to prevent the creation of future hazards due to improper disposal of toxic wastes into the state’s land and waters.” Id.

To accomplish these statutory goals, MTCA requires Ecology to accomplish several objectives. The statute specifies those objectives in RCW 70.105D.030(2). In particular, MTCA requires

Ecology “to immediately implement all provisions of this chapter to the maximum extent practicable, including investigative and remedial actions where appropriate.” Id. Furthermore, MTCA requires Ecology to adopt, and thereafter enforce, rules under chapter 34.05 RCW to:

- (a) Provide for public participation...; [and]
- ...
- (e) Publish and periodically update minimum cleanup standards for remedial actions at least as stringent as the cleanup standards under section 121 of the federal cleanup law, 42 U.S.C. Sec. 9621, and at least as stringent as all applicable state and federal laws, including health-based standards under state and federal law[.]

Id. The federal cleanup law referenced in MTCA is the Comprehensive Environmental Response Compensation and Liability Act of 1980 as amended by the Superfund Amendments and Reauthorization Act of 1986.

MTCA also provides Ecology with the authority to accomplish several specific statutory objectives. These objectives are specified in RCW 70.105D.030(1) and include the following:

- (a) Investigate, provide for investigating, or require potentially liable persons to investigate any releases of hazardous substances, including but not limited to inspecting, sampling, or testing to determine the nature or extent of any release or threatened release...;
- (b) Conduct, provide for conducting, or require potentially liable persons to conduct remedial actions (including investigations under (a) of this subsection) to remedy releases or threatened releases of hazardous substances.... In conducting, providing for, or requiring remedial action, the department shall give preference to permanent solutions to the maximum extent practicable and shall provide for or require adequate monitoring to ensure the effectiveness of the remedial action;
- ...
- (d) Carry out all state programs authorized under the federal cleanup law and the federal resource, conservation, and recovery act, 42 U.S.C. Sec. 6901 et seq., as amended;
- (e) Classify substances as hazardous substances...;
- (f) Issue orders or enter into consent decrees or agreed orders that include deed restrictions where necessary to protect human health and the environment from a release or threatened release of a hazardous substance from a facility....;
- (g) Enforce the application of permanent and effective institutional controls that are necessary for a remedial action to be protective of human health and the environment;
- (h) Require holders to conduct remedial actions necessary to abate an imminent or substantial endangerment...;
- (i) Provide informal advice and assistance to persons regarding the administrative and technical requirements of this chapter.... As part of providing this advice for independent remedial actions, the department may prepare written opinions regarding whether the independent remedial actions or proposals for those actions meet the substantive requirements of this chapter or whether the department believes further remedial action is necessary at the facility....; and

- (j) Take any other actions as necessary to carry out the provisions of this chapter, including the power to adopt rules under chapter 34.05 RCW.

RCW 70.105D.030(1).

To achieve the general goals and specific objectives and requirements of MTCA, Ecology adopted the MTCA Cleanup Regulation, chapter 173-340 WAC. The rule was developed in two phases and adopted in 1990 and 1991 respectively.

In 1995, the legislature in HB 1810 established the MTCA Policy Advisory Committee (PAC) and directed it to provide advice to the legislature and Ecology on administrative and legislative actions to implement the goals and objectives of MTCA more effectively. The committee was comprised of 22 members representing a broad range of interests, including the interests of the Legislature, local government, large and small business, agriculture, environmental organizations, financing institutions, ports, the Department of Ecology, the Department of Health, the environmental consulting industry, the Science Advisory Board, and the public at large. The PAC provided its final report containing its recommendations in December 1996. The final report and related documentation is included in the rule-making file.

Ecology is currently proposing to adopt amendments to the MTCA Cleanup Regulation. These amendments reflect changes developed through a negotiated rulemaking process that began in 1997. The proposed rule amendments were developed in response to:

- The recommendations of the MTCA Policy Advisory Committee (PAC);
- The recommendations of the MTCA Science Advisory Board (SAB);¹
- The recommendations of the Duwamish Coalition's Total Petroleum Hydrocarbon (TPH) Project Oversight Group (POG);²
- The statutory requirement in RCW 70.105D.030(2)(d) that Ecology publish and periodically update minimum cleanup standards for remedial actions;
- The regulatory requirement in WAC 173-340-702(3) that Ecology review and, as appropriate, update cleanup standards every five years based on new scientific information and changes in other state and federal laws;
- The amendment of the Model Toxics Control Act;

¹ The MTCA Science Advisory Board (SAB) was established by Ecology pursuant to RCW 70.105D.030(4) to render advice to Ecology with respect to the hazard ranking system, cleanup standards, remedial actions, deadlines for remedial actions, monitoring, and the classification of hazardous substances.

² The purpose of the Duwamish Coalition's TPH Project was to provide recommendations to Ecology regarding the evaluation of risks and the selection of cleanup actions for sites affected by complex mixtures of contamination with a petroleum-compound base, or what is referred to under current state regulations as Total Petroleum Hydrocarbons (TPH). The TPH Project Oversight Group (POG), consisting of key staff from the Washington State Department of Ecology, the U.S. Environmental Protection Agency Region 10, King County, the Port of Seattle, and the Cities of Seattle and Tukwila, oversaw the project. Other participants included technical specialists from the Department of Ecology, the Pollution Liability Insurance Agency, industry, the Science Advisory Board, U.S. Naval Laboratories, project consultants, and others. An interagency Memorandum of Agreement governed the actions of the POG. The POG submitted its final report in April 1999. The final report and related documentation is included in the rule-making file.

- The statutory objective in the Administrative Procedure Act (RCW 34.05.230) that agencies convert long-standing interpretative and policy statements into rules; and
- The need to clarify and improve the readability of the rule

1.3 Scoping of the Analysis

Ecology conducted a comprehensive review of the proposed amendments to the MTCA Cleanup Regulation (Chapter 173-340 WAC) to identify those amendments that required further evaluation to determine whether the probable benefits of the proposed rule amendments exceed the probable costs. The review undertaken by Ecology considered several factors, including whether the amendment may have a significant economic impact, whether the amendment establishes requirements under optional methodologies, and whether the amendment only clarifies existing requirements. Based on this review, Ecology determined that the following amendments may have significant economic impacts and should be subject to further analysis.

- Changes to the Method A soil and ground water cleanup levels.
- Establishment of soil cleanup levels – consideration of land use.
- Establishment of soil cleanup levels – evaluation of the soil-to-ground water pathway.
- Establishment of soil cleanup levels – evaluation of the dermal exposure pathway.
- Establishment of soil cleanup levels – evaluation of the vapor exposure pathway.
- Establishment of soil cleanup levels – conducting a terrestrial ecological evaluation.
- Requirement of financial assurances.
- Creation of a citizen technical advisor.

Chapter 2 Evaluation of the Proposed Amendments

The primary impact of the proposed rule amendments on costs and benefits is expected to result from changes in the cleanup levels established for a site. Costs and benefits, though, are not directly related to the establishment of cleanup levels. Rather, the ultimate impact on costs and benefits of any change in cleanup levels is dependent on several site-specific factors, including (most importantly) the remedy selected. More permanent cleanup actions that remove contaminants from the soil or ground water typically cost more than less permanent cleanup actions that leave contamination at the site and rely on engineered and institutional controls. Consequently, the proposed rule amendments that affect the establishment of cleanup levels are expected to have a greater impact if a more permanent remedy that removed contaminants were selected than if a less permanent remedy that contained contamination were selected.

2.1 Method A Cleanup Levels for Soil and Ground Water³

The primary impact of the proposed rule amendments on costs and benefits is expected to result from the proposed changes to the soil and ground water Method A cleanup levels. The impact of the proposed Method A soil cleanup levels also reflects the impact of the proposed amendments regarding the evaluation of the leaching pathway (see Section 2.3) and the dermal pathway (see Section 2.4).

2.1.1 Summary of Proposed Rule Amendment

The proposed rule amendments include changes to some of the Method A cleanup levels for soil and ground water. These changes are identified in WAC 173-340-900 in Tables 720-1, 740-1, and 745-1. The basis for each of these changes and the resulting cleanup levels are provided in the applicable footnotes located at the end of each Method A table.

Table 2-1 below identifies the Method A ground water cleanup levels that have changed or been added as part of the proposed rule amendments. See Table 720-1 in WAC 173-340-900 for the complete Method A table and associated explanatory footnotes.

Table 2-1: Proposed Changes to Method A Ground Water Cleanup Levels

Hazardous Substance	Cleanup Level (ug/liter)		Basis for Change*
	Current Rule	Proposed Rule	
Benzo(a)pyrene	N/A	0.1	See Table 720-1 footnote.
DDT	0.1	0.3	Equation 720-2
Lead	5	15	See Table 720-1 footnote.
PAHs (carcinogenic)	0.1	N/A**	
TPH Mixtures			
Gasoline Range Organics			
• Benzene not present	1,000	1,000	See Table 720-1 footnote.

³ Unless otherwise indicated, the phrase “Method A cleanup levels” in this report refers to the values specified in Tables 720-1, 740-1, and 745-1 in WAC 173-340-900.

• Benzene present	1,000	800	See Table 720-1 footnote.
Diesel Range Organics	1,000	500	See Table 720-1 footnote.
Heavy Oils	1,000	500	See Table 720-1 footnote.
Mineral Oil	1,000	500	See Table 720-1 footnote.
TPH Components			
Toluene	40	1,000	See Table 720-1 footnote.
Ethylbenzene	30	700	See Table 720-1 footnote.
Xylenes	20	1,000	See Table 720-1 footnote.
MTBE	N/A	20	See Table 720-1 footnote.
Naphthalenes	N/A	5	Equation 720-1

* Please refer to Table 720-1 in WAC 173-340-900 for a more detailed description of the basis for the change.

** See benzo(a)pyrene and associated footnote in Table 720-1 in WAC 173-340-900.

Table 2-2 below identifies the Method A soil cleanup levels for unrestricted land uses that have changed or been added as part of the proposed rule amendments. See Table 740-1 in WAC 173-340-900 for the complete Method A table and associated explanatory footnotes.

Table 2-2: Proposed Changes to Method A Soil Cleanup Levels for Unrestricted Land Use

Hazardous Substance	Cleanup Level (mg/kg)		Exposure Pathway of Concern	Basis for Change*
	Current Rule	Proposed Rule		
Benzo(a)pyrene	N/A	0.1	Direct Contact	Equation 740-2
Chromium (Total)	100	N/A		
• Chromium VI	N/A	19	Ground Water	3-Phase Model
• Chromium III	N/A	2,000	Ground Water	3-Phase Model
DDT	1	3	Direct Contact	
EDB	0.001	0.005	Ground Water	3-Phase Model + PQL
Lindane	1.0	0.01	Ground Water	3-Phase Model + PQL
Methylene chloride	0.5	0.02	Ground Water	3-Phase Model
Mercury (inorganic)	1	2	Ground Water	3-Phase Model
PAHs (carcinogenic)	1.0	N/A**		
Tetrachloroethylene	0.5	0.05	Ground Water	3-Phase Model
1,1,1 Trichloroethane	20	2	Ground Water	3-Phase Model
Trichloroethylene	0.5	0.03	Ground Water	3-Phase Model
TPH Mixtures				
Gasoline Range Organics				
• Conditional	100	100	Ground Water	4-Phase Model
• Default	100	30	Ground Water	4-Phase Model
Diesel Range Organics	200	2,000	Ground Water	Residual Saturation
Heavy Oils	200	2,000	Ground Water	Residual Saturation
Mineral Oil	200	4,000	Ground Water	Residual Saturation
TPH Components				
Benzene	0.5	0.03	Ground Water	3- & 4-Phase Models
Toluene	40	7	Ground Water	3-Phase Model
Ethylbenzene	20	6	Ground Water	3-Phase Model
Xylenes	20	9	Ground Water	3-Phase Model
MTBE	N/A	0.1	Ground Water	3-Phase Model
Naphthalenes	N/A	5	Ground Water	3-Phase Model

* Please refer to Table 740-1 in WAC 173-340-900 for a more detailed description of the basis for the change. The 3-Phase Model and the 4-Phase Model refer the methods described in WAC 173-340-747 for establishing soil concentrations protective of ground water. "PQL" means that the cleanup level was adjusted based on the practical quantitation limit.

** See benzo(a)pyrene and associated footnote in Table 740-1 in WAC 173-340-900.

Table 2-3 below identifies the Method A soil cleanup levels for industrial properties that have changed or been added as part of the proposed rule amendments. See Table 745-1 in WAC 173-340-900 for the complete Method A table and associated explanatory footnotes.

Table 2-3: Proposed Changes to Method A Soil Cleanup Levels for Industrial Properties

Hazardous Substance	Cleanup Level (mg/kg)		Exposure Pathway of Concern	Basis for Change*
	Current Rule	Proposed Rule		
Arsenic	200	20	Ground Water	3-Phase Model + NB
Benzo(a)pyrene	N/A	2	Ground Water	3-Phase Model
Cadmium	10	2	Ground Water	3-Phase Model + PQL
Chromium (Total)	500	N/A		
• Chromium VI	N/A	19	Ground Water	3-Phase Model
• Chromium III	N/A	2,000	Ground Water	3-Phase Model
DDT	5	4	Ground Water	3-Phase Model
EDB	0.001	0.005	Ground Water	3-Phase Model + PQL
Lindane	1.0	0.01	Ground Water	3-Phase Model + PQL
Methylene chloride	0.5	0.02	Ground Water	3-Phase Model
Mercury (inorganic)	1	2	Ground Water	3-Phase Model
PAHs (carcinogenic)	20	N/A**		
Tetrachloroethylene	0.5	0.05	Ground Water	3-Phase Model
1,1,1 Trichloroethane	20	2	Ground Water	3-Phase Model
Trichloroethylene	0.5	0.03	Ground Water	3-Phase Model
TPH Mixtures				
Gasoline Range Organics				
• Conditional	100	100	Ground Water	4-Phase Model
• Default	100	30	Ground Water	4-Phase Model
Diesel Range Organics	200	2,000	Ground Water	Residual Saturation
Heavy Oils	200	2,000	Ground Water	Residual Saturation
Mineral Oil	200	4,000	Ground Water	Residual Saturation
TPH Components				
Benzene	0.5	0.03	Ground Water	4-Phase Model
Toluene	40	7	Ground Water	3-Phase Model
Ethylbenzene	20	6	Ground Water	3-Phase Model
Xylenes	20	9	Ground Water	3-Phase Model
MTBE	N/A	0.1	Ground Water	3-Phase Model
Naphthalenes	N/A	5	Ground Water	3-Phase Model

* Please refer to Table 745-1 in WAC 173-340-900 for a more detailed description of the basis for the change. The 3-Phase Model and the 4-Phase Model refer the methods described in WAC 173-340-747 for establishing soil concentrations protective of ground water. "PQL" means that the cleanup level was adjusted based on the practical quantitation limit. "NB" means that the cleanup level was adjusted based on the natural background concentration.

** See benzo(a)pyrene and associated footnote in Table 745-1 in WAC 173-340-900.

2.1.2 Consideration of Statutory Goals and Objectives

The proposed rule amendment is required to achieve the general goals and specific objectives of the statute, including the following:

- To protect human health (see RCW 70.105D.010 and .030); and
- To periodically update minimum cleanup standards for remedial actions based on new scientific information and changes to state and federal laws (see RCW 70.105D.030(2)(d) and WAC 173-340-702(3)).

The proposed rule amendment achieves these objectives by updating the Method A soil and ground water cleanup levels based on new scientific information and changes to state and federal laws. The establishment of Method A cleanup levels that are protective of human health requires an evaluation of the relevant exposure pathways. Evaluation of these exposure pathways requires consideration of the “degree of protection” or “acceptable level of risk” for carcinogens and non-carcinogens defined in the MTCA Cleanup Regulation.⁴

For an extensive discussion of whether the proposed rule amendment is the least burdensome alternative that will achieve the general goals and specific objectives of MTCA, please see the LBA Analysis

2.1.3 Analysis of Probable Costs

The impact of these proposed rule amendments on costs depends on whether the proposed Method A cleanup levels will increase or decrease the costs of site remediation. Whether the proposed Method A cleanup levels will increase or decrease the costs of site remediation depends on several factors.

First, the impact depends on whether the proposed Method A cleanup levels are more stringent or less stringent than under the current rule. More stringent cleanup levels may increase the total cost of site remediation while less stringent cleanup levels may decrease the total cost of site remediation (avoided cost).

⁴ The legislature in HB 1810 required the PAC to review, provide advice, and develop recommendations on “clean-up standards and clean-up levels, including the use of site-specific risk assessment.” In response, the PAC established the following priority issue for analysis that included consideration of costs and benefits:

Do allowable risk values in the MTCA cleanup regulations appropriately balance the public’s desire for protecting individuals with the need for cleanups to proceed at a reasonable cost? Should the allowable risk values for carcinogens in the MTCA cleanup regulations be amended, for example, to match federal risk range values under CERCLA (the federal superfund program) in the National Contingency Plan?

Final PAC Report, pp. 4-5. At the PAC’s request, the MTCA Science Advisory Board conducted a review of the target risk levels defined in the MTCA Cleanup Regulation. The SAB, however, did not recommend changing those levels (Final PAC Report, p. 28). The PAC also did not recommend changing the target risk levels (Final PAC Report, pp. 19, 28 and C-16 through C-17). Based on the lack of a recommendation from the PAC, amendment of the target risk levels was not included within the scope of this rule-making action.

Second, the impact depends on several site-specific factors, including the type of contaminants present, which contaminants are contaminants of concern, the type of media contaminated, the extent of contamination, and the physical properties of the site. These factors determine the nature and scope of the cleanup and whether the proposed cleanup levels have an impact.

Third, the impact depends on the remedy selected. More permanent cleanup actions that remove contaminants from the soil or ground water typically cost more than less permanent cleanup actions that leave contamination at the site and rely on engineered and institutional controls. The impact of the proposed cleanup levels would have the greatest impact on costs if a more permanent cleanup were selected because the proposed levels would require a change in the amount of contaminants requiring removal. However, the proposed cleanup levels might not have any impact on cleanup costs if a less permanent remedy were selected that left contamination at the site because the proposed levels might not require a change in the amount of contaminants requiring removal.

The impact of the proposed Method A soil and ground water cleanup levels on cleanup costs were estimated using two methodologies. First, the impact of the proposed Method A soil and ground water cleanup levels were estimated by applying those levels to a model site representative of most sites that use Method A to establish cleanup levels. **See Chapter 3.** Second, the particular impact of the proposed Method A soil and ground water cleanup levels on petroleum contaminated sites was estimated by applying those levels to a model site representative of a commercial gas station. **See Chapter 5.** The analysis of the impact of the proposed Method A soil cleanup levels also reflects the impact of the proposed amendments regarding the evaluation of the leaching pathway (**see Section 2.3**) and the dermal pathway (**see Section 2.4**).

2.1.4 Analysis of Probable Benefits

The impact of the proposed rule amendments on benefits also depends on several factors. First, as discussed above, the impact depends on whether the proposed Method A cleanup levels are more stringent or less stringent than under the current rule. More stringent cleanup levels would quantitatively reduce the risk of adverse health effects.

Second, the impact depends on several site-specific factors, including the type of contaminants present, which contaminants are contaminants of concern, the type of media contaminated, the extent of contamination, and the physical properties of the site. These factors determine the nature and scope of the cleanup and whether the proposed cleanup levels have an impact.

Third, the impact depends on the remedy selected. More permanent cleanup actions that remove contaminants from the soil or ground water typically would quantitatively reduce the risk of adverse health effects. Less permanent cleanup actions that leave contamination at the site and rely on engineered and institutional controls might not result in additional contaminant removal and, consequently, may not reduce the risk of adverse health effects.

The probable benefits of the proposed Method A soil and ground water cleanup levels are discussed in **Chapter 5**.

2.1.5 Conclusion

In conclusion, considering the probable impacts on costs and benefits of this proposed rule amendment, as discussed in **Section 2.1** (Method A Cleanup Levels for Soil and Ground Water) and further evaluated in the technical analyses discussed in **Chapters 3 – 5**, Ecology has determined that the probable benefits of this proposed rule amendment exceed the probable costs.

2.2 Soil Cleanup Levels – Consideration of Land Use

To establish soil cleanup levels that are protective of human health, consideration of the reasonable maximum exposure scenario and the land uses that form the basis of that scenario is required.

2.2.1 Summary of Proposed Rule Amendment

The following description of the proposed rule amendment includes a description of the current rule and a comparison of the proposed rule amendment with the current rule.

The current rule allows soil cleanup levels to be established using land uses other than residential and industrial as the basis for a reasonable maximum exposure (RME) scenario if certain specified conditions are met. Other land uses that could be considered include commercial, recreational, and agricultural. WAC 173-340-740(1).

The proposed rule amendments allow soil cleanup levels to be established using only residential and industrial land uses as the basis for a RME scenario. This means that other land uses (such as commercial, recreational, and agricultural) must use residential land use as the RME scenario for establishing cleanup levels. However, these other land uses may be used to establish remediation levels as part of remedy selection. WAC 173-340-708(3)(d)(ii); 173-340-740(1)(a). For example, if containment is the proposed remedy for contaminated soil at a commercial site, the RME scenario for evaluating the protectiveness of the containment system for the direct contact pathway could be changed from a child living on the site to a maintenance worker or child trespasser. See WAC 173-340-708(3)(d)(ii), (iii).

2.2.2 Consideration of Statutory Goal and Objectives

The proposed rule amendment is required to achieve the general goals and specific objectives of the statute, including the following:

- To protect human health (see RCW 70.105D.010 and .030);
- To provide industrial cleanup standards at industrial properties (see RCW 70.105D.030(2)(e)); and
- To periodically update minimum cleanup standards for remedial actions based on new scientific information and changes to state and federal laws (RCW 70.105D.030(2)(d) and WAC 173-340-702(3)).

The proposed rule amendment will more effectively achieve these objectives by allowing soil cleanup levels to be established using only residential and industrial land uses as the basis for a RME scenario, but allowing consideration of other land uses (such as commercial, recreational, and agricultural) to establish remediation levels as part of remedy selection. The amendment is based on a PAC recommendation and was determined by the PAC as necessary to more effectively achieve the goals and objectives of MTCA (see Final PAC Report, pp. 24-27). The intent of the amendment is to create a system of constrained flexibility whereby the rule would more effectively ensure the protection of human health while providing increased flexibility to use risk assessment for establishing cleanup levels and for selecting cleanup actions.

For an extensive discussion of whether the proposed rule amendment is the least burdensome alternative that will achieve the general goals and specific objectives of MTCA, please see the LBA Analysis.

2.2.3 Analysis of Probable Costs

The impact of this proposed amendment on costs depends on whether the amendment would increase the cleanup costs. The proposed rule amendment is not expected to result in any additional cleanup costs. This projection is based on several factors.

First, based on a comparison of the current and proposed rules, the proposed rule amendment is not expected to result in additional cleanup costs. Although land uses other than residential and industrial (such as commercial, recreational, and agricultural) may not be used to establish cleanup levels, these other land uses may be used to evaluate the protectiveness of remediation levels as part of remedy selection. WAC 173-340-708(3)(d)(ii); 173-340-740(1)(a). Ecology expects that if less stringent cleanup levels could have been established under the current rule using land uses other than residential and industrial as the basis for a reasonable maximum exposure (RME) scenario, then remediation levels based on those same scenarios could also be justified. Accordingly, while the proposed rule amendment could result in more stringent soil cleanup levels based on residential land use at a few sites, the amendment is not expected to result in additional cleanup actions at those sites.

Furthermore, if an alternative RME scenario (based on a commercial, recreational, or agricultural land use) was used under the current rule to establish soil cleanup levels, then institutional controls would be required. WAC 173-340-440(1); 173-340-740(1)(c)(iii) and (d)(ii)(C). Similarly, under the proposed rule amendments, if remediation levels based on those same RME scenarios were justified for a site, then institutional controls would also be required. WAC 173-340-440(2). Accordingly, the requirement of institutional controls under the proposed rule amendments would also not result in additional cleanup costs.

Second, the establishment of soil cleanup levels less stringent than residential soil cleanup levels under the current rule is limited in application and rarely used in practice. For commercial land uses, the current rule specifically provides that “soil cleanup levels **shall** be established in accordance with residential areas unless it can be clearly demonstrated that this is inappropriate.”

WAC 173-340-740(1)(c). To demonstrate that this is inappropriate, it must be clearly demonstrated that:

- (A) [t]he property is currently zoned for or otherwise officially designated for industrial/commercial use;
- (B) [t]he property is currently used for industrial/commercial purposes or has a history of use for industrial/commercial purposes;
- (C) [the] properties adjacent to and in the general vicinity of the property are used or are designated for use for industrial/commercial purposes; **and**
- (D) [t]he property and properties adjacent to and in the general vicinity are expected to be used for industrial/commercial purposes for the foreseeable future due to site zoning, statutory or regulatory restrictions, comprehensive plans, adjacent land use, and other relevant factors.”

WAC 173-340-740(1)(c)(i) (emphasis added). Furthermore, as emphasized in the current rule “[Ecology] expects that only industrial/commercial properties located in the interior portion of a large industrial/commercial area will qualify for other than method A or method B cleanup levels....” WAC 173-340-740(1)(c)(v). Because most sites cannot make these demonstrations, most properties are precluded from using land uses other than residential as the basis for a RME scenario. Even if a property qualifies, the current rule requires that “soil cleanup levels be established as close as practicable to the method B soil cleanup levels...and shall be at least as stringent as method C soil cleanup levels.” WAC 173-340-740(1)(c)(ii).

Third, even if a property qualifies for an alternative RME scenario, soil cleanup levels that are established for a site must be protective of the underlying ground water and must not cause an exceedance of the ground water cleanup level. Ground water cleanup levels are based on the potential productivity of the aquifer underlying a site, independent of the surface land use. Many commercial and industrial areas throughout the state are underlain by highly productive aquifers. Examples include the Airdustrial Park area in Tumwater, the Nalley Valley in Tacoma, Ponders Corner in Lakewood, the Spokane Valley sole source aquifer, and municipal water supply wells for the Cities of Vancouver, Richland and Union Gap. This is also apparent from the number of public water systems that have become contaminated by nearby industrial and commercial sites. Since most sites are underlain by aquifers that are classified as drinking water aquifers under MTCA, soil cleanup levels would often be established that are equivalent to the Method B cleanup level.

2.2.4 Analysis of Probable Benefits

The impact of this proposed rule amendment on benefits depends on whether the amendment would result in a cleanup that is more protective of human health and the environment. The protectiveness of a cleanup is based on both the established cleanup standards and the selected cleanup actions. While the proposed rule amendment could result in more stringent soil cleanup levels at a few sites, the amendment is not expected to result in additional cleanup actions at those sites. First, as discussed above, even though land uses other than residential (such as commercial, recreational, and agricultural) may not be used to establish less stringent soil cleanup levels, these other land uses may be used to establish remediation levels as part of

remedy selection. WAC 173-340-708(3)(d)(ii); 173-340-740(1)(a). Second, as discussed above, the establishment of soil cleanup levels less stringent than residential soil cleanup levels under the current rule is limited in application and rarely used in practice. Third, even if a property qualifies for an alternative RME scenario under the current rule, soil cleanup levels that are established for a site must still be protective of the underlying ground water and must not cause an exceedance of the ground water cleanup level. However, while the proposed rule amendment is not expected to result in additional cleanup actions, the amendment is expected to provide greater assurance that the cleanups actions selected for a site are protective of human health and the environment.

2.2.5 Conclusion

In conclusion, considering the probable impacts on costs and benefits of this proposed rule amendment as discussed in this section (**Section 2.2**), Ecology has determined that the probable benefits of this proposed rule amendment exceed the probable costs. In fact, the proposed rule amendment is not expected to result in any additional cost for the potentially liable person.

2.3 Soil Cleanup Levels – Consideration of the Leaching Pathway

To establish soil cleanup levels that are protective of human health, consideration of several different pathways of exposure is required, including the leaching of contaminants from soil into the ground water.

2.3.1 Summary of Proposed Rule Amendment

The following description of the proposed rule amendment includes a description of the current rule and a comparison of the proposed rule amendment with the current rule.

Evaluation of the leaching pathway (soil-to-ground water pathway) requires a determination that the soil concentration will not cause an exceedance of the ground water cleanup level established under WAC 173-340-720. Under the current rule, soil concentrations that meet this requirement are determined by multiplying the ground water cleanup level by 100. Under the proposed rule amendments, Ecology replaced this methodology with fate and transport models and other approaches. WAC 173-340-747. The following discussion provides a brief overview of the proposed rule amendment.

WAC 173-340-747(2) sets forth the general requirements (criteria) that soil concentrations must meet for those concentrations to be considered protective of human health. First, the soil concentrations must not cause an exceedance of the ground water cleanup levels established under WAC 173-340-720. To determine if this criterion is met, one of the methodologies specified in subsections (4) through (9) must be used. Second, to ensure that the first criterion is met, the soil concentration must not result in the accumulation of free product on or in ground water. To determine if this criterion is met, one of the methodologies specified in subsection (10) must be used.

WAC 173-340-747(3) provides an overview of the methods specified in subsections (4) through (10) for deriving soil concentrations that meet the criteria specified in subsection (2). Certain methods are tailored for particular types of hazardous substances or sites. Certain methods are more complex than others and certain methods require the use of site-specific data. The specific requirements for deriving a soil concentration under a particular method may also depend on the hazardous substance. Note, however, that the proposed rule amendment does not mandate the use of any particular methodology.

WAC 173-340-747(4) through (10) specifies the procedures and requirements for establishing soil concentrations that meet the criteria specified in subsection (2) under each of the specified methodologies.

The proposed Method A soil cleanup levels were established by evaluating each of the exposure pathways, including the soil-to-ground water pathway. The Method A soil cleanup levels that are based on the protection of ground water are identified in **Tables 2-2 and 2-3**. Derivation of these cleanup levels was based on the application of the three-phase and the four-phase equilibrium partitioning models and on the consideration of residual saturation. As indicated by **Tables 2-2 and 2-3**, each of the proposed changes to the Method A soil cleanup levels is based on protection of ground water, except for one – benzo(a)pyrene for unrestricted land use, which is based on direct contact.

2.3.2 Consideration of Statutory Goals and Objectives

The proposed rule amendment is required to achieve the general goals and specific objectives of the statute, including the following:

- To protect human health (see RCW 70.105D.010 and .030); and
- To periodically update minimum cleanup standards for remedial actions based on new scientific information and changes to state and federal laws (see RCW 70.105D.030(2)(d) and WAC 173-340-702(3)).

The proposed rule amendment will more effectively achieve these objectives by replacing the old “100x ground water” model with more accurate chemical and site-specific fate and transport models. The methodology proposed by Ecology more accurately quantifies the risk posed to ground water by hazardous substances within the soil and hence more accurately ensures the protection of human health and the environment. **See Section 2.3.4.**

For an extensive discussion of whether the proposed rule amendment is the least burdensome alternative that will achieve the general goals and specific objectives of MTCA, please see the LBA Analysis.

2.3.3 Analysis of Probable Costs

The impact of this proposed rule amendment on costs depends on whether the soil cleanup level is established based on the leaching pathway and, if so, whether evaluation of the leaching pathway results in a less or more stringent soil cleanup level.

This proposed rule amendment has resulted in a different Method A soil cleanup level for many hazardous substances. These hazardous substances are identified in **Tables 2-2 and 2-3**. Some of these hazardous substances have become more stringent and some have become less stringent. This proposed rule amendment may also result in different Method B or Method C soil cleanup levels.

More stringent cleanup levels may increase the total cost of site remediation while less stringent cleanup levels may decrease the total cost of site remediation (avoided cost). As discussed previously, the cost impact also depends on whether the hazardous substance(s) at issue will determine the nature and scope of the cleanup (i.e., whether the hazardous substance(s) are contaminants of concern at a site) and the remedy selected for the site.

The impact of the proposed leaching pathway amendment on cleanup costs was evaluated as part of the evaluation of the impact of the proposed Method A cleanup levels. **See Chapter 3**. The impact of the proposed leaching pathway amendment on cleanup costs was also evaluated as part of the evaluation of the impact of the proposed rule on petroleum contaminated sites. **See Chapter 5**.

2.3.4 Analysis of Probable Benefits

2.3.4.1 Health Benefits and Avoided Cleanup Costs

The impact of the proposed rule amendment on benefits also depends on several factors. First, as discussed above, the impact depends on whether the soil cleanup level is established based on the leaching (soil-to-ground water) pathway and, if so, whether evaluation of this pathway results in a less or more stringent soil cleanup level. While more stringent cleanup levels would quantitatively reduce the risk of adverse health effects, less stringent cleanup levels would reduce the cost of cleanup (avoided cost).

Second, the impact depends on whether the hazardous substance(s) at issue will determine the nature and scope of the cleanup (i.e., whether the hazardous substance(s) are contaminants of concern at a site) and the remedy selected for the site.

The probable benefits of the proposed leaching pathway amendment was evaluated as part of the evaluation of the impact of the proposed Method A cleanup levels. **See Chapters 3 and 4**.

2.3.4.2 Other Benefits

The proposed rule amendment will also more effectively achieve the statutory goals and objectives, including protection of human health, by replacing the current “100x ground water” model with more accurate chemical and site-specific fate and transport models. The methodology proposed by Ecology more accurately quantifies the risk posed to ground water by hazardous substances within the soil and hence more accurately ensures the protection of human health and the environment.

The proposal to replace the old “100 X ground water” model with the more accurate chemical and site-specific fate and transport models is based on an extensive review of new scientific and technical information. Although the 100 X ground water model was based on the best scientific and technical information available at the time, the old model does not adequately account for site or chemical-specific factors that control the movement of hazardous substances from soil into water. The movement of hazardous substances from soil into water is primarily controlled by two factors: the soil properties and the hazardous substance water solubility.

For example, some hazardous substances like benzene are relatively soluble in water. When gasoline is released to the soil, benzene will immediately start to partition from the gasoline into water that is held within the soil pores and then flow to the ground water. The 100 X ground water model does not adequately account for this mobility. All hazardous substances are treated the same, even if some are more mobile than others. Consequently, for hazardous substances that are highly mobile (e.g., benzene, gasoline and chlorinated organics), the 100 X model will predict a soil concentration that is too high and consequently not sufficiently protective of human health. Conversely, for hazardous substances that are less mobile (e.g., PCBs, metals and heavier petroleum products), the 100 X model will predict a soil concentration that is too low.

Based on new scientific and technical information developed since the adoption of the 100 X ground water methodology in 1991, Ecology developed two fate and transport models to account for the way hazardous substances behave when they are released to the soil. These models apply the same principle of equilibrium partitioning used for evaluating the leaching pathway in the ASTM Risk-Based Corrective Action protocol and the U.S. Environmental Protection Agency’s Soil Screening Guidance. The three-phase model accounts for partitioning of hazardous substances between the water, air and solid phases of a soil. The four-phase model accounts for partitioning between these same phases plus includes a non-aqueous liquid phase, a phase that commonly occurs when organic chemicals such as petroleum products are released to soils. Both of these models were subject to rigorous review by the MTCA Science Advisory Board and its Fate and Transport Subcommittee, which included members from the private consulting community and the University of Washington and Washington State University. Assumptions used in these models include extensive information extracted from the literature as well as information from contaminated sites in Washington State.

2.3.5 Conclusion

In conclusion, considering the probable impacts on costs and benefits of this proposed rule amendment, as discussed in **Section 2.3** (Soil Cleanup Levels – Consideration of the Leaching Pathway) and **Section 2.1** (Method A Cleanup Levels for Soil and Ground Water) and further evaluated in the technical analyses discussed in **Chapters 3 – 5**, Ecology has determined that the probable benefits of this proposed rule amendment exceed the probable costs.

2.4 Soil Cleanup Levels – Consideration of the Dermal Pathway

To establish soil cleanup levels that are protective of human health, consideration of several different pathways of exposure is required, including the direct contact (dermal + ingestion) pathway of exposure.

2.4.1 Summary of Proposed Rule Amendment

The following description of the proposed rule amendment includes a description of the current rule and a comparison of the proposed rule amendment with the current rule.

The current rule does not specifically require the evaluation of the dermal exposure pathway to establish soil cleanup levels. However, Ecology may establish soil cleanup levels that are more stringent than those otherwise required, when, based on a site-specific evaluation, Ecology determines that such levels are necessary to protect human health or the environment. See WAC 173-340-740(2)(c), (3)(b), (4)(c); and 173-340-745(3)(c), (4)(b) in the current rule.

The proposed rule specifically requires the evaluation of the dermal exposure pathway, concurrent with the ingestion exposure pathway, for certain hazardous substances and for other hazardous substances under certain conditions. Specifically, the dermal exposure pathway must be evaluated concurrently with the ingestion exposure pathway for all sites contaminated with petroleum mixtures. WAC 173-340-740(3)(b)(iii)(B)(III) and 173-340-745(5)(b)(iii)(B)(III). For all other contaminated sites, a concurrent exposure evaluation (dermal + ingestion) must be conducted only if the proposed changes to the default assumptions in the standard Method B or standard Method C equations “would result in a significantly higher soil cleanup level than would be calculated without the proposed changes.” WAC 173-340-740(3)(c)(iii) and 173-340-745(5)(c)(iii).

If an evaluation of the dermal exposure pathway concurrent with the ingestion exposure pathway is required, the proposed rule amendment specifies the equations and default assumptions that must be used to conduct that evaluation. See Equations 740-3 through 740-5 and Equations 745-3 through 745-5. Modification of the default assumptions is allowed to derive modified Method B or C soil cleanup levels. See WAC 173-340-740(3)(c)(ii) and (iii)(C); 173-340-745(5)(c)(ii) and (iii)(C).

2.4.2 Consideration of Statutory Goals and Objectives

The proposed rule amendment is required to achieve the general goals and specific objectives of the statute, including the following:

- To protect human health (see RCW 70.105D.010 and .030); and
- To periodically update minimum cleanup standards for remedial actions based on new scientific information and changes to state and federal laws (see RCW 70.105D.030(2)(d) and WAC 173-340-702(3)).

The proposed rule amendment will more effectively achieve these objectives by requiring an evaluation of the dermal exposure pathway, concurrent with the ingestion exposure pathway, for certain hazardous substances (petroleum mixtures) and for other hazardous substances under certain standardized conditions. The proposed rule amendment also achieves this objective by specifying how (through standard equations and default assumptions) that evaluation should be conducted. The amendment is based on a review of new scientific and technical information.

Review of this information demonstrates that soil cleanup levels established without evaluating the dermal pathway concurrent with the ingestion pathway may not be sufficiently protective of human health. The amendment was subject to rigorous review by the MTCA Science Advisory Board and is consistent with current trends across both state and federal agencies. The amendment is also consistent with the recommendations of the PAC regarding the evaluation of other potentially relevant pathways of exposure, including the dermal pathway, when modifications to default assumptions result in significantly higher soil cleanup levels than would be calculated without those modifications (see Final PAC Report, pp. 25-26 and C-10).

For an extensive discussion of whether the proposed rule amendment is the least burdensome alternative that will achieve the general goals and specific objectives of MTCA, please see the LBA Analysis.

2.4.3 Analysis of Probable Costs

The impact of this proposed rule amendment on costs depends on whether the dermal exposure pathway would be analyzed under the amendment and, if so, whether that analysis would result in a more stringent soil cleanup level than would otherwise have been established if that pathway had not been analyzed.

This proposed rule amendment does not result in any changes to the Method A soil cleanup levels specified in Tables 740-1 and 745-1.

This proposed rule amendment could result in changes to standard Method B or standard Method C soil cleanup levels for petroleum mixtures. As described previously, the dermal exposure pathway must be evaluated concurrently with the ingestion exposure pathway for all sites contaminated with petroleum mixtures. WAC 173-340-740(3)(b)(iii)(B)(III) and 173-340-745(5)(b)(iii)(B)(III). The actual impact of the proposed rule amendment on standard Method B and C cleanup levels, however, depends on several factors.

First, the impact depends on whether an evaluation of the dermal exposure pathway concurrent with the ingestion exposure pathway results in a lower soil concentration than would have been derived by evaluation of the ingestion exposure pathway alone. As can be seen in **Table 2-4**, inclusion of the dermal pathway in the direct contact soil calculation, using the default assumptions in the proposed rule amendments, has only a minor effect on soil concentrations for unrestricted land use. For industrial land use, including the dermal pathway decreases the soil concentration more, although the amount of difference varies considerably between hazardous substances.

Table 2-4: Comparison of Soil Direct Contact Concentrations for Petroleum Mixtures under the Current and Proposed Rules

Hazardous Substance	Soil Direct Contact Concentrations (mg/kg)			
	Unrestricted Land Use		Industrial Land Use	
	Current Rule (Ingestion)	Proposed Rule (Dermal + Ingest)	Current Rule (Ingestion)	Proposed Rule (Dermal + Ingest)
TPH Mixtures				

Gasoline Range Organics	4,700	4,700	210,000	150,000
Diesel Range Organics	3,900	3,000	170,000	39,000
Heavy Oils	3,900	3,000	170,000	39,000
Mineral Oil	7,800	5,800	340,000	70,000
TPH Components*				
Benzene	34	34	4,526	2,627
Toluene	16,000	15,000	700,000	297,309
Ethylbenzene	8,000	7,400	350,000	148,665
Xylenes	160,000	150,000	N/A	N/A
MTBE	N/A	N/A	N/A	N/A
Naphthalenes	1,600	1,200	70,000	16,613

* For the TPH components listed in this table, the assumption is that these occur as pure substances, not as a mixture. If they occur as a mixture, the individual TPH component cleanup levels must be adjusted downward for additive risk.

Second, the impact depends on whether the direct contact pathway determines the soil cleanup level or whether some other exposure pathway determines the soil cleanup level. If an exposure pathway other than direct contact determines the soil cleanup level, then the proposed rule amendment will have no impact, irrespective of whether the proposed rule amendment results in a more stringent direct contact soil concentration. As can be seen in **Table 2-5**, for sites where protection of ground water is a concern, none of the soil cleanup levels for petroleum mixtures and components is determined by the direct contact pathway. Rather, they are determined by the leaching pathway.

Table 2-5: Comparison of Soil Direct Contact Concentrations and Soil Cleanup Levels for Petroleum Mixtures under the Proposed Rule

Hazardous Substance	Soil Direct Contact Concentrations and Soil Cleanup Levels (mg/kg)			
	Unrestricted Land Use		Industrial Land Use	
	Direct Contact Concentration	Soil Cleanup Level	Direct Contact Concentration	Soil Cleanup Level
TPH Mixtures				
Gasoline Range Organics	4,700	100 or 30	150,000	100 or 30
Diesel Range Organics	3,000	2,000	39,000	2,000
Heavy Oils	3,000	2,000	39,000	2,000
Mineral Oil	5,800	4,000	70,000	4,000
TPH Components*				
Benzene	34	0.03	2,627	0.1
Toluene	15,000	7	297,309	7
Ethylbenzene	7,400	6	148,665	6
Xylenes	150,000	9	N/A	9
MTBE	N/A	0.1	N/A	0.1
Naphthalenes	1,200	5	16,613	5

* For the TPH components listed in this table, the assumption is that these occur as pure substances, not as a mixture. If they occur as a mixture, the individual TPH component cleanup levels must be adjusted downward for additive risk.

The impact of the proposed dermal pathway amendment on cleanup costs was evaluated as part of the evaluation of the impact of the proposed rule on petroleum contaminated sites. **See Chapter 5.**

As with standard Method B and C, this proposed rule amendment could result in changes to modified Method B or modified Method C cleanup levels. Again, however, the impact of the

proposed rule amendment on costs depends on several factors. In addition to the factors discussed above for petroleum mixtures, the impact also depends on whether an evaluation of the dermal pathway would even be required under the proposed rule amendment. As described previously, an evaluation would only be required if the proposed changes to the default assumptions in the standard Method B or standard Method C equations “would result in a significantly higher soil cleanup level than would be calculated without the proposed changes.” WAC 173-340-740(3)(c)(iii) and 173-340-745(5)(c)(iii). Since the establishment of site-specific soil cleanup levels under modified Method B or modified Method C is optional, further evaluation of the potential impact of this amendment on such site-specific cleanup levels has not been conducted.

2.4.4 Analysis of Probable Benefits

2.4.4.1 Health Benefits

The impact of the proposed rule amendment on benefits also depends on several factors. First, as discussed above, the impact depends on whether the soil cleanup level is established based on the direct contact pathway and, if so, whether evaluation of this pathway results in a more stringent soil cleanup level. More stringent cleanup levels would quantitatively reduce the risk of adverse health affects. Second, the impact depends on whether the hazardous substance(s) at issue will determine the nature and scope of the cleanup (i.e., whether the hazardous substance(s) are contaminants of concern at a site) and the remedy selected for the site.

2.4.4.2 Other Benefits

The proposed rule amendment will also more effectively achieve the statutory goals and objectives, including protection of human health, by requiring an evaluation of the dermal exposure pathway, concurrent with the ingestion exposure pathway, for certain hazardous substances (petroleum mixtures) and for other hazardous substances under certain standardized conditions. The proposed rule amendment also achieves this objective by specifying how (through standard equations and default assumptions) that evaluation should be conducted. Evaluation of the dermal exposure pathway under certain specified conditions ensures that the soil cleanup levels and the remedy established for a site are sufficiently protective of human health. Review of new scientific and technical information demonstrates that soil cleanup levels established without evaluating the dermal pathway concurrent with the ingestion pathway may not be sufficiently protective of human health. The amendment was subject to rigorous review by the MTCA Science Advisory Board and is consistent with current trends across both state and federal agencies. The amendment is also consistent with the recommendations of the PAC regarding the evaluation of other potentially relevant pathways of exposure, including the dermal pathway, when modifications to default assumptions result in significantly higher soil cleanup levels than would be calculated without those modifications (see Final PAC Report, pp. 25-26 and C-10). The amendment also attempts to combine the goals advanced by the MTCA Policy Advisory Committee of creating a rule that achieves a level of simplicity combined with a level of human health and environmental protection consistent with advances in scientific information.

2.4.5 Conclusion

In conclusion, considering the probable impacts on costs and benefits of this proposed rule amendment, as discussed in **Section 2.4** (Soil Cleanup Levels – Consideration of the Dermal Pathway) and **Section 2.1** (Method A Cleanup Levels for Soil and Ground Water) and further evaluated in the technical analyses discussed in **Chapters 3 – 5**, Ecology has determined that the probable benefits of this proposed rule amendment exceed the probable costs.

2.5 Soil Cleanup Levels – Consideration of the Vapor Pathway

To establish soil cleanup levels that are protective of human health, consideration of several different pathways of exposure is required, including the vapor pathway of exposure.

2.5.1 Summary of Proposed Rule Amendment

The following description of the proposed rule amendment includes a description of the current rule and a comparison of the proposed rule amendment with the current rule.

The current rule requires the evaluation of the vapor exposure pathway for protection of both ambient and indoor air under certain circumstances. WAC 173-340-740(3)(a)(iv) and (4)(b)(iv) and WAC 173-340-740(3)(b)(iv) and (4)(b)(iv).

The proposed rule amendments do not change how the pathway is evaluated; rather, the proposed amendments only change the circumstances for requiring an evaluation of the pathway. Furthermore, the proposed amendments do not mandate the use of any particular methodology for evaluating the pathway, if an evaluation is required.

The proposed rule amendments set forth the criteria for determining when to conduct an evaluation of the vapor exposure pathway. In general, the criteria identify those situations where the vapor pathway, rather than the direct contact or the leaching pathways, becomes the most significant exposure pathway (the exposure pathway of concern). The following discussion provides an overview of those criteria.

For standard Method B (soil cleanup levels for unrestricted land use) and for standard Method C (soil cleanup levels for industrial land use), the applicability of the vapor pathway evaluation is defined in WAC 173-340-740(3)(b)(iii)(C) and WAC 173-340-745(5)(b)(iii)(C) respectively. Specifically, the proposed rule amendments provide the following:

The soil to vapor pathway shall be evaluated for volatile organic compounds whenever any of the following conditions exist:

- (I) For gasoline range organics, whenever the total petroleum hydrocarbon (TPH) concentration is significantly higher than a concentration derived for protection of ground water for drinking water beneficial use under WAC 173-340-747(6) using default assumptions;

- (II) For diesel range organics, whenever the total petroleum hydrocarbon (TPH) concentration is greater than 10,000 mg/kg;
- (III) For other volatile organic compounds, including petroleum components, whenever the concentration is significantly higher than a concentration derived for protection of ground water for drinking water beneficial use under WAC 173-340-747(4).

For modified Method B (soil cleanup levels for unrestricted land use) and for modified Method C (soil cleanup levels for industrial land use), the applicability of the vapor pathway evaluation is defined in WAC 173-340-740(3)(c)(iv)(A) and WAC 173-340-745(5)(c)(iv)(A) respectively. Specifically, the proposed rule amendments provide the following:

The soil to vapor pathway shall be evaluated for volatile organic compounds whenever any of the following conditions exist:

- (I) For other than petroleum hydrocarbon mixtures, the proposed changes to the standard ... equations ... or default values would result in a significantly higher soil cleanup level than would be calculated without the proposed changes;
- (II) For petroleum hydrocarbon mixtures, the proposed changes to the standard ... equations ... or default values would result in a significantly higher soil cleanup level than would be calculated without the proposed changes;
- (III) For gasoline range organics, whenever the total petroleum hydrocarbon (TPH) concentration is significantly higher than a concentration derived for protection of ground water for drinking water beneficial use under WAC 173-340-747(6) using default assumptions;
- (IV) For diesel range organics, whenever the total petroleum hydrocarbon (TPH) concentration is greater than 10,000 mg/kg;
- (V) For other volatile organic compounds, including petroleum components, whenever the concentration is significantly higher than a concentration derived for protection of ground water for drinking water beneficial use under WAC 173-340-747(4).

2.5.2 Consideration of Statutory Goals and Objectives

The proposed rule amendment is required to achieve the general goals and specific objectives of the statute, including the following:

- To protect human health (see RCW 70.105D.010 and .030); and
- To periodically update minimum cleanup standards for remedial actions based on new scientific information and changes to state and federal laws (see RCW 70.105D.030(2)(d) and WAC 173-340-702(3)).

The proposed rule amendment will more effectively achieve these objectives by establishing standardized procedures and criteria for determining whether an evaluation of the vapor exposure pathway is required and by providing methods that may be used to conduct an evaluation if required. The amendment is based on a review of new scientific and technical information.

Review of this information demonstrates that soil cleanup levels established without evaluating the vapor pathway may not be sufficiently protective of human health. The amendment was subject to rigorous review by the MTCA Science Advisory Board and is consistent with current trends across both state and federal agencies. The amendment is also consistent with the recommendations of the PAC regarding the evaluation of other potentially relevant pathways of exposure, including the vapor pathway, when modifications to default assumptions result in significantly higher soil cleanup levels than would be calculated without those modifications (see Final PAC Report, pp. 25-26 and C-10).

For an extensive discussion of whether the proposed rule amendment is the least burdensome alternative that will achieve the general goals and specific objectives of MTCA, please see the LBA Analysis.

2.5.3 Analysis of Probable Costs

The impact of this proposed rule amendment on costs depends on whether the vapor exposure pathway would be analyzed under the amendment (but not under the current rule) and, if so, whether that analysis would result in a more stringent soil cleanup level than would otherwise have been established if that pathway had not been analyzed.

This proposed rule amendment does not result in any changes to the Method A soil cleanup levels specified in Tables 740-1 and 745-1.

This proposed rule amendment could result in more stringent standard Method B or standard Method C soil cleanup levels. The actual impact of the proposed rule amendment on costs, however, depends on several factors. First, the impact depends on whether an evaluation would be required under the proposed rule amendment. Under the proposed rule amendment, an evaluation would only be required under certain standardized conditions. See WAC 173-340-740(3)(b)(iii)(C) and 173-340-745(5)(b)(iii)(C).

Second, the impact depends on whether an evaluation of the vapor pathway would have been conducted under the current rule. If an evaluation of the vapor pathway would be conducted under both the current and proposed rules, then there would be no impact. This conclusion is based on the fact that the proposed rule does not change how the pathway is evaluated and does not mandate the use of any particular methodology for evaluating the pathway.

Third, the impact depends on whether an evaluation of the vapor exposure pathway would result in a lower soil cleanup level than would have been established without that evaluation. In other words, even if an evaluation were conducted under the proposed rule (but not under the current rule), the evaluation might not result in a more stringent soil cleanup level.

Therefore, only if an evaluation were conducted under the proposed rule (but not under the current rule) and that evaluation resulted in a more stringent soil cleanup level than would have been established without that evaluation could the proposed rule amendment have an impact on costs.

The impact of the proposed dermal pathway amendment on cleanup costs was evaluated as part of the evaluation of the impact of the proposed rule on petroleum contaminated sites. See **Chapter 5**.

As with standard Method B and C, this proposed rule amendment could also result in more stringent modified Method B or modified Method C soil cleanup levels. Again, however, the actual impact of the proposed rule amendment on costs depends on several factors. First, the impact depends on whether an evaluation would be required under the proposed rule amendment. Second, the impact depends on whether an evaluation of the vapor pathway would have been conducted under the current rule. Third, the impact depends on whether an evaluation of the vapor exposure pathway would result in a lower soil cleanup level than would have been established without that evaluation. Only if an evaluation were conducted under the proposed rule (but not under the current rule) and that evaluation resulted in a more stringent soil cleanup level than would have been established without that evaluation could the proposed rule amendment have an impact on costs. Since the establishment of site-specific soil cleanup levels under modified Method B or modified Method C is optional, further evaluation of the potential impact of this amendment on such site-specific cleanup levels has not been conducted.

2.5.4 Analysis of Probable Benefits

2.5.4.1 Health Benefits

The impact of this proposed rule amendment on benefits also depends on several factors. First, as discussed above, the impact depends on whether the vapor exposure pathway would be analyzed under the amendment (but not under the current rule) and, if so, whether that analysis would result in a more stringent soil cleanup level than would otherwise have been established if that pathway had not been analyzed. More stringent cleanup levels would quantitatively reduce the risk of adverse health affects. Second, the impact depends on whether the hazardous substance(s) at issue will determine the nature and scope of the cleanup (i.e., whether the hazardous substance(s) are contaminants of concern at a site) and the remedy selected for the site.

2.5.4.2 Other Benefits

The proposed rule amendment will also more effectively achieve the statutory goals and objectives, including protection of human health, by establishing standardized procedures and criteria for determining whether an evaluation of the vapor exposure pathway is required. Evaluation of the vapor exposure pathway under certain specified conditions ensures that the soil cleanup levels and the remedy established for a site are sufficiently protective of human health. Review of new scientific and technical information demonstrates that soil cleanup levels established without evaluating the vapor pathway may not be sufficiently protective of human health. The amendment was subject to rigorous review by the MTCA Science Advisory Board and is consistent with current trends across both state and federal agencies. The amendment is also consistent with the recommendations of the PAC regarding the evaluation of other potentially relevant pathways of exposure, including the vapor pathway, when modifications to default assumptions result in significantly higher soil cleanup levels than would be calculated

without those modifications (see Final PAC Report, pp. 25-26 and C-10). The amendment also attempts to combine the goals advanced by the MTCA Policy Advisory Committee of creating a rule that achieves a level of simplicity combined with a level of human health and environmental protection consistent with advances in scientific information.

2.5.5 Conclusion

In conclusion, considering the probable impacts on costs and benefits of this proposed rule amendment, as discussed in **Section 2.5** (Soil Cleanup Levels – Consideration of the Vapor Pathway) and **Section 2.1** (Method A Cleanup Levels for Soil and Ground Water) and further evaluated in the technical analyses discussed in **Chapters 3 – 5**, Ecology has determined that the probable benefits of this proposed rule amendment exceed the probable costs.

2.6 Soil Cleanup Levels – Consideration of Terrestrial Ecological Receptors

To establish soil cleanup levels that are protective of the environment, consideration of the impact of hazardous substances on terrestrial ecological receptors is required.

2.6.1 Summary of Proposed Rule Amendments

The following description of the proposed rule amendment includes a description of the current rule and a comparison of the proposed rule amendment with the current rule.

Under both the current and proposed rules, all cleanup actions must meet certain minimum requirements, including protection of human health and the environment. WAC 173-340-360(2). “Environment” is broadly defined in the rule to mean “any plant, animal, natural resource, surface water (including underlying sediments), ground water, drinking water supply, land surface (including tidelands and shorelands) or subsurface strata, or ambient air within the state of Washington or under jurisdiction of the state of Washington.” WAC 173-340-200.

The current rule requires, as appropriate, an investigation of the current and potential threats to plants and animals that may be posed by hazardous substances. Specifically, the current rule requires as part of the remedial investigation and feasibility study, as appropriate, “sufficient investigations to characterize the distribution of hazardous substances present at the site, and threat to human health **and the environment**,” including, as applicable to the site:

Information to determine the impact or potential impact of the hazardous substance from the facility on the natural resources and Ecology of the area such as: Sensitive environment, plant and animal species, and other environmental receptors.

WAC 173-340-350(6)(c) and (6)(c)(vi) (emphasis added). The current rule also requires, as appropriate, that the remedial investigation and feasibility study include:

A risk assessment characterizing the current and potential threats to human health **and the environment** that may be posed by hazardous substances. This assessment may not be required when [Ecology] determines that proposed cleanup standards are obvious and

undisputed and allow an adequate margin of safety for protection of human health **and the environment.**

WAC 173-340-350(6) and (6)(d) (emphasis added).

Under the current rule, Ecology may also establish cleanup levels more stringent than those otherwise required by the rule when, based on a site-specific evaluation, Ecology determines that such levels are necessary to protect human health and the environment. With respect to the terrestrial environment in particular, the current rule authorizes the following:

[Ecology] may establish method B cleanup levels that are more stringent than those required under (a) of this subsection, when, based on a site-specific evaluation, [Ecology] determines that such levels are necessary to protect human health or environment, including the following:

- (i) Concentrations which eliminate or substantially reduce the potential for food chain contamination;
- (ii) Concentrations which eliminate or substantially reduce the potential for damage to soils or biota in the soils which could impair the use of soils for agricultural or silvicultural purposes;
- (iii) Concentrations which eliminate or substantially reduce the potential for adverse effects on vegetation or wildlife;

...

WAC 173-340-740(3)(b). The current rule provides Ecology the same authority to establish more stringent soil cleanup levels under Method C. WAC 173-340-740(4)(c).

However, the current rule does not indicate how this site-specific evaluation should be conducted.

In summary, under the current rule, terrestrial ecological impacts are evaluated on a case-by-case basis. The current rule does not specify criteria for ecological protectiveness, whether a terrestrial ecological evaluation is required, or how a terrestrial ecological evaluation should be conducted.

The proposed rule amendments, in comparison, establish criteria for ecological protectiveness and define a tiered process for evaluating threats from soil contamination to terrestrial ecological receptors. The basic framework of the proposed rule amendment, including the tiered screening approach, is based on a PAC recommendation (see Final PAC Report, pp. 30-32). The requirements and procedures for determining whether a simplified or site-specific terrestrial ecological evaluation is required (exclusions) and, where an evaluation is required, how a simplified or site-specific evaluation may be conducted are set forth in WAC 173-340-7490 through 173-340-7494. The amendment provides significant flexibility in determining the type of ecological evaluation that is required for a particular site. In particular, the amendment provides significant flexibility in how one may conduct a site-specific evaluation. The

amendment does not require the use of any particular methodology for conducting a site-specific evaluation.

Based on a comparison of the current rule and the proposed rule amendments, Ecology has made the following determinations regarding the impact of the proposed rule amendments:

- Both the current rule and the proposed rule require all cleanup actions to protect human health and the environment. See WAC 173-340-360.
- Both the current rule and the proposed rule require, as appropriate, an investigation of the current and potential threats to terrestrial ecological receptors that may be posed by hazardous substances. See WAC 173-340-350.
- Under both the current rule and the proposed rule, Ecology may establish more stringent cleanup levels, including soil cleanup levels, to protect the environment. See WAC 173-340-720 through 173-340-750.
- The current rule does not provide clear direction as to when a terrestrial ecological evaluation is required or how an evaluation should be conducted. The proposed rule amendments specify those situations where a simplified or site-specific terrestrial ecological evaluation is not required (exclusions) and, where such an evaluation is required, how such an evaluation may be conducted. See WAC 173-340-350, 173-340-740 and 173-340-745 under both rules and WAC 173-340-7490 through 173-340-7494 under the proposed rule amendments.
- Neither the current rule nor the proposed rule requires the use of any particular methodology for conducting an evaluation.
- Under both the current rule and the proposed rule, a site-specific terrestrial ecological evaluation may not be required.
- Under both the current rule and the proposed rule, even if a site-specific terrestrial ecological evaluation is conducted, it may not result in lower soil cleanup levels or additional remedial actions.

2.6.2 Consideration of Statutory Goals and Objectives

The proposed rule amendment is required to achieve the general goals and specific objectives of the statute, including the following:

- To protect the environment (see RCW 70.105D.010 and .030);
- To periodically update minimum cleanup standards for remedial actions based on new scientific information and changes to state and federal laws (RCW 70.105D.030(2)(d) and WAC 173-340-702(3));
- To require potentially liable persons to conduct remedial actions (including investigations) to remedy releases or threatened releases of hazardous substances (see RCW 70.105D.030(1)(b));
- To give preference to permanent solutions to the maximum extent practicable (see RCW 70.105D.030(1)(b));
- To require adequate monitoring to ensure the effectiveness of the remedial action (see RCW 70.105D.030(1)(b)); and

- To enforce the application of permanent and effective institutional controls that are necessary for a remedial action to be protective of human health and the environment (see RCW 70.105D.030(1)(g)).

The proposed rule amendment will achieve these objectives by defining a tiered process for evaluating potential threats posed by soil contaminants to terrestrial ecological receptors and by establishing criteria for ecological protectiveness. The basic framework for the amendment, including the tiered screening approach, is based on a PAC recommendation and was determined by the PAC as necessary to more effectively achieve the goals and objectives of MTCA (see Final PAC Report, pp. 30-32). By ensuring that those sites that may pose a threat to the environment undergo a terrestrial ecological evaluation, the proposed rule amendment is expected to ensure that cleanup actions are protective not only of human health but also of the environment.

For an extensive discussion of whether the proposed rule amendment is the least burdensome alternative that will achieve the general goals and specific objectives of MTCA, please see the LBA Analysis.

2.6.3 Analysis of Probable Costs

The impact of the proposed rule amendment on costs depends on several factors. These factors include the following:

- First, whether a terrestrial ecological evaluation would be required under the proposed rule, but not under the current rule;
- Second, whether the site would qualify for an exclusion from conducting a simplified or site-specific terrestrial ecological evaluation under the proposed rule;
- Third, the type of terrestrial ecological evaluation conducted under the proposed rule;
- Fourth, whether the terrestrial ecological evaluation conducted under the proposed rule would result in lower soil cleanup levels or additional remedial actions;

The probable costs associated with this amendment include both the cost of any more thorough terrestrial ecological evaluation and the costs of any additional cleanup actions required based on such evaluations.

2.6.3.1 Is a terrestrial ecological evaluation required under the proposed rule, but not current rule?

First, the probable costs of the proposed rule amendment is dependent on whether a terrestrial ecological evaluation would be required under the proposed rule, but not under the current rule. If an evaluation were conducted under both the current and proposed rules, then no additional evaluation or cleanup costs would be expected. This conclusion is based in part on the assumption that the same analysis would be conducted under both rules. This assumption is based on the fact that neither the current nor the proposed rule mandates the use of any particular methodology for conducting the evaluation.

Ecology does not expect that for most sites a simplified or site-specific terrestrial ecological evaluation would be required under the proposed rule, but not under the current rule. This conclusion is based on a comparative analysis of the requirements of the current and proposed rules. This conclusion is also based on the expectation that most sites will obtain an exclusion from conducting a simplified or site-specific terrestrial ecological evaluation under the proposed rule. See the discussion below under **Section 2.6.2.2** and the Terrestrial Environmental Evaluation Pilot Study Report (Ecology, 1999). If a simplified or site-specific evaluation were not required under the proposed rule, the expectation is that such an evaluation would also not be required or conducted under the current rule.

2.6.3.2 Does the site qualify for an exclusion from conducting a simplified or site-specific terrestrial ecological evaluation under the proposed rule?

Second, the probable cost of the proposed rule amendment is dependent on whether a simplified or site-specific terrestrial ecological evaluation is even required. The proposed rule specifies those situations where a simplified or site-specific terrestrial ecological evaluation is not required (exclusions). WAC 173-340-7491. If a site qualifies for an exclusion, then further terrestrial ecological evaluations would not be required and additional site remediation would not be required to protect terrestrial ecological receptors. Accordingly, neither the costs of conducting an evaluation nor the costs of additional cleanup actions would be incurred.

Ecology expects that most sites will be able to obtain an exclusion from conducting a simplified or site-specific terrestrial ecological evaluation. This conclusion is based in part on the results of the Terrestrial Environmental Evaluation Pilot Study Report (Ecology, 1999). Of the 39 Voluntary Cleanup Program Sites selected for evaluation, ninety-five percent (95%) obtained an exclusion. Five percent (5%) were evaluated using a simplified evaluation. None were evaluated using a site-specific evaluation.

Even if a site qualifies for an exclusion, additional costs may be incurred. Qualifying for an exclusion requires some analysis, resulting in minor costs. Based on the results of the Terrestrial Environmental Evaluation Pilot Study (Ecology, 1999), conducting such an analysis would most likely require less than an hour.

Additional institutional controls may also be required to obtain an exclusion. This may increase the cost of cleanup. However, this additional cleanup cost would only be incurred if those institutional controls would not otherwise be required as part of the cleanup to protect human health. For example, if the selected cleanup action includes leaving residual contamination under a containment barrier (such as paving), then institutional controls would already be required. In addition, obtaining an exclusion is optional. Institutional controls and the associated cost could be avoided by conducting a site-specific terrestrial ecological evaluation.

Again, as discussed under **Section 2.6.2.1**, if a simplified or site-specific evaluation is not required under the proposed rule, the expectation is that an evaluation would also not be required under the current rule.

2.6.3.3 What type of evaluation is conducted?

Third, the probable cost of the proposed rule amendment is dependent on the type or method of evaluation conducted. The amendment provides significant flexibility in determining the type of ecological evaluation that is required for a particular site. In addition, the amendment provides significant flexibility in how one may conduct a site-specific evaluation. The proposed rule amendment does not mandate how a site-specific terrestrial ecological evaluation may be conducted. Consequently, the cost of conducting an evaluation may vary greatly from site to site.

2.6.3.4 Does the evaluation result in lower soil cleanup levels and additional remedial actions?

Fourth, the probable costs of the proposed rule amendment depends on whether the evaluation would result in lower cleanup levels and additional remedial actions. Conducting a simplified or site-specific terrestrial ecological evaluation may not result in lower soil cleanup levels or additional remedial actions. Either the existing soil concentrations or the soil cleanup levels based on human health may already be protective of terrestrial ecological receptors. If additional remedial actions would not be required, then no additional cleanup costs would be incurred. Only if the terrestrial ecological evaluation resulted in additional remedial actions would additional cleanup costs be incurred.

2.6.3.5 Summary

In summary, only if a simplified or site-specific terrestrial ecological evaluation were required under the proposed rule, but not under the current rule, and that evaluation resulted in additional remedial actions would the proposed rule result in additional cleanup costs. Considering the factors discussed above, Ecology does not expect that the proposed rule amendments will result in lower soil cleanup levels or additional cleanup actions being required at most sites. Consequently, Ecology does not expect that the proposed rule will result in additional cleanup costs at most sites. However, Ecology does expect that for a few sites, additional evaluation costs may be incurred as a consequence of conducting more involved terrestrial ecological evaluations than would have been conducted under the current rule. Most of these evaluations are expected to be simplified evaluations as opposed to site-specific evaluations. Ecology also expects that for a few sites, additional cleanup costs may be incurred as a consequence of the proposed rule. Those costs that are incurred are not expected to be significant.

The impact of the proposed rule amendment on costs was also evaluated as part of the evaluation of the impact of the proposed rule on petroleum contaminated sites. **See Chapter 5.** To further estimate the impact of the proposed rule amendment on evaluation costs, as well as cleanup costs, three case studies were also developed and evaluated. **See Chapter 6.**

2.6.4 Analysis of Probable Benefits

The beneficial impact of the proposed rule amendment results from any increased protection of the environment at a site; any reduction in the regulatory burden (avoided cost) of conducting an

evaluation at a site; and the increased assurance that the environment is sufficiently and consistently protected at every site.

2.6.4.1 Environmental Benefits

The impact of the proposed rule amendment on the protection of the environment is based on the same factors considered under **Section 2.6.3** to analyze the impact on costs. If a terrestrial ecological evaluation were required under the proposed rule, but not the current rule, and the terrestrial ecological evaluation resulted in additional remedial actions, then the proposed rule amendment would result in additional protection of the environment. Based on the factors discussed under **Section 2.6.3**, Ecology does not expect that the proposed rule amendment will result in lower soil cleanup levels or additional cleanup actions at most sites. Consequently, Ecology does not expect that the proposed rule amendment will provide additional environmental protection (in the form of additional cleanup actions) at most sites. However, by ensuring that those sites that may pose a threat to the environment undergo a terrestrial ecological evaluation, the proposed rule amendment is expected to ensure that cleanup actions are protective not only of human health but also of the environment. At a few sites, though, Ecology does expect that additional cleanup actions may be required. For those sites, the proposed rule amendment will provide additional environmental protection (in the form of additional cleanup actions).

For those sites where a simplified or site-specific terrestrial ecological evaluation is conducted, Ecology expects that the proposed rule amendment to expedite and facilitate cleanups by providing a clear and consistent process for ensuring the potential ecological threats from soil contamination are adequately considered in site cleanups. While the current rule results in uncertainty regarding the criteria for ecological protectiveness, when an ecological risk assessment should be conducted, and how an ecological risk assessment should be conducted, the proposed rule provides considerably more specificity. In particular, the proposed rule amendment establishes criteria for ecological protectiveness and defines a tiered process for evaluating potential threats from soil contamination to terrestrial ecological receptors.

2.6.4.2 Reduction in Regulatory Burden (Avoided Cost)

As discussed more thoroughly in the LBA Analysis, the proposed rule amendment is the least burdensome alternative that will achieve the general goals and specific objectives of MTCA. In fact, by establishing criteria for ecological protectiveness and defining a tiered process for evaluating potential threats from soil contamination to terrestrial ecological receptors, the proposed rule amendment is expected to reduce the regulatory burden or cost of conducting an evaluation at many sites.

Examples of measures that may reduce the regulatory burden of protecting terrestrial ecological receptors include the following:

- (1) Site-specific terrestrial ecological evaluations may not be required if soil concentrations at a site do not exceed specified criteria. The proposed rule specifies soil concentrations for hazardous substances (Table 749-3) that Ecology considers highly likely to be safe at

any site without any further evaluation of site conditions. If these concentrations are not exceeded, then these concentrations can be used to show, without any further site-specific evaluation, that there is no potential threat to terrestrial plants and animals. If only some hazardous substances exceed these concentrations, the table can also be used to exclude the remaining substances from further consideration and thus narrow the focus of the evaluation.

- (2) Site-specific terrestrial ecological evaluations may not be required if it is known that planned future actions to be taken at a site will eliminate exposure pathways (WAC 173-340-7493(1)(d)(i) and 173-340-7493(2)(a)(ii)).
- (3) Site-specific terrestrial ecological evaluations may not be required if a site qualifies for an exclusion under WAC 173-340-7491(1). The proposed rule amendment sets forth criteria for determining whether a site qualifies for an exclusion. These criteria rely on readily available information and do not require specialized expertise to evaluate. Consequently, these criteria can be applied to a site with minor evaluation costs.
- (4) A site-specific terrestrial ecological evaluation may not be required if the site qualifies for a simplified evaluation under WAC 173-340-7492. This "simplified evaluation procedure" is based on a higher level of acceptable risk and consequently expected to be easier and less costly. For example:
 - Soil concentrations considered safe without further evaluation of the site (Table 749-2) are higher than those used in the site-specific evaluation procedure (Table 749-3).
 - Only those substances listed in Table 749-2 need be considered in a simplified evaluation. At a site where TCE is the only hazardous substance, for example, the evaluation could be terminated because this substance is not listed in the table.
 - Specialized expertise in ecology and toxicology is not required to perform a simplified evaluation.
 - Ecology staff need not be involved in conducting a simplified evaluation because the procedure is more prescriptive. This is expected to facilitate voluntary cleanups, since most sites that do not qualify for an exclusion under WAC 173-340-7491(1) are expected to be eligible for a simplified evaluation.
 - Allowance for a higher level of acceptable risk is based on the principle that the consequences of an underprotective cleanup are constrained by excluding sites from using this procedure where there are potential threats to more important ecological communities or species. The determination of whether a simplified evaluation may be conducted relies on criteria using readily available information and does not require specialized expertise to apply (WAC 173-340-7491(2)).
- (5) Land use may be used to limit the range of terrestrial species to be considered in a simplified or site-specific evaluation (WAC 173-340-7490(3)(b)). Threats from contaminated soil to plants and soil biota need not be evaluated at industrial or commercial sites.

2.6.5 Conclusion

In conclusion, considering the probable impacts on costs and benefits of this proposed rule amendment, as discussed in **Section 2.6** (Soil Cleanup Levels – Consideration of Terrestrial Ecological Receptors) and further evaluated in the technical analyses discussed in **Chapters 5 and 6**, Ecology has determined that the probable benefits of this proposed rule amendment exceed the probable costs.

2.7 Financial Assurances

2.7.1 Summary of Proposed Rule Amendment

The following description of the proposed rule amendment includes a description of the current rule and a comparison of the proposed rule amendment with the current rule.

Under the current rule, Ecology may require the potentially liable person to provide financial assurances under certain circumstances and using specified or approved mechanisms. See WAC 173-340-440(7) under the current rule.

The proposed rule amendments on financial assurances revise the current rule in the following ways:

- First, the proposed rule changes Ecology's authority and duty to require the potentially liable person to provide financial assurances. Specifically, the amendment provides that "Ecology shall, as appropriate, require financial assurance mechanisms at sites where the cleanup action selected includes engineered and/or institutional controls." WAC 173-340-440(11). Based on this amendment, Ecology expects that financial assurances will be required in practice under the proposed rule where they may not have been required under the current rule.
- Second, the proposed rule provides potentially liable persons increased flexibility in the selection of financial assurance mechanisms that meet the requirements of the rule. See WAC 173-340-440(11)(a).
- Third, the proposed rule provides a specific exemption for financial hardship. See WAC 173-340-440(11)(b).
- Fourth, the proposed rule provides a specific exemption for potentially liable persons that can demonstrate that sufficient financial resources are available and in place to provide for the long-term effectiveness of engineered and institutional controls adopted. See WAC 173-340-440(11).

The proposed rule amendment is based on a PAC recommendation (see Final PAC Report, pp. 32-34).

2.7.2 Consideration of Statutory Goals and Objectives

The proposed rule amendment is required to achieve the general goals and specific objectives of the statute, including the following:

- To protect human health and the environment (see RCW 70.105D.010 and .030);
- To require potentially liable persons to conduct remedial actions (including investigations) to remedy releases or threatened releases of hazardous substances (see RCW 70.105D.030(1)(b));
- To give preference to permanent solutions to the maximum extent practicable (see RCW 70.105D.030(1)(b));
- To require adequate monitoring to ensure the effectiveness of the remedial action (see RCW 70.105D.030(1)(b)); and
- To enforce the application of permanent and effective institutional controls that are necessary for a remedial action to be protective of human health and the environment (see RCW 70.105D.030(1)(g)).

The proposed rule amendment will achieve these objectives by requiring, as appropriate, "financial assurance mechanism at sites where the cleanup action selected includes engineered and/or institutional controls." See WAC 173-340-440(11). The amendment is based on a PAC recommendation and was determined by the PAC as necessary to more effectively achieve the goals and objectives of MTCA (see Final PAC Report, pp. 32-34).

For an extensive discussion of whether the proposed rule amendment is the least burdensome alternative that will achieve the general goals and specific objectives of MTCA, please see the LBA Analysis.

2.7.3 Analysis of Probable Costs

The impact of the proposed rule amendment on costs depends on each of the four factors discussed above. Most notably, the impact depends on whether and to what extent financial assurances will be required in practice under the proposed rule where they may not have been required under the current rule. If financial assurances were required under both the current and proposed rules, a potentially liable person would not incur additional costs as a consequence of the proposed rule amendment. Overall, though, Ecology expects that financial assurances will be required in practice under the proposed rule where they may not have been required under the current rule. However, the number of sites and potentially liable persons that may be impacted is uncertain.

Even if financial assurances will be required in practice under the proposed rule where they may not have been required under the current rule, other factors may mitigate the impact on costs. First, the impact depends on whether a potentially liable person would qualify for an exemption based on financial hardship. Second, the impact depends on whether a potentially liable person would qualify for an exemption based on a demonstration that sufficient financial resources are available and in place to provide for the long-term effectiveness of engineered and institutional controls adopted. Third, even if the potentially liable person does not qualify for an exemption,

the impact may be mitigated by the increased flexibility provided by the proposed rule in the selection of financial assurance mechanisms that meet the requirements of the rule.

The selection of cleanup actions under the MTCA Cleanup Regulation may also limit the impact of the proposed rule amendment. If a less permanent remedy requiring financial assurances is more costly than a more permanent remedy that would not require financial assurances, then the more permanent remedy will be selected, thereby limiting the total impact of the proposed rule amendment. The disproportionate cost analysis, conducted as part of the remedy selection process, accounts for the total cost of the cleanup action, including any long-term costs such as operation and maintenance costs, monitoring costs, equipment replacement costs, and the cost of maintaining institutional controls. WAC 173-340-360(3).

To the extent that the proposed rule amendment has an impact, the amendment is expected to impact larger, more complex sites (industrial site) rather than smaller, less complex sites (commercial gas station). Smaller, less complex sites (e.g., commercial gas stations) are less likely to require institutional or engineered controls that would require financial assurances. Such sites typically use Method A to establish cleanup levels and use permanent remedies to cleanup the site. As reflected by Ecology's Statewide Leaking Fuel Tank Study (see **Chapter 5**), over 60% of commercial gas stations sites cleanup to below applicable cleanup levels. Even if such sites were impacted, the financial assurances required would reflect the simplicity of the site. Larger, more complex sites are more likely to contain multiple contaminants, to involve multiple pathways, to use site-specific information to develop modified Method B or C cleanup levels and/or remediation levels, and to use more complex, less-permanent remedies requiring long-term maintenance and monitoring.

In summary, based on the factors discussed above, the proposed rule amendment is not expected to impact most sites. Those sites that are impacted are expected to be the larger, more complex sites instead of the smaller, less complex sites. For those sites that may be impacted, Ecology estimated the potential cost of financial assurances. That analysis is presented in **Chapter 7**. That analysis is based on a larger, more complex site and, accordingly, represents an upper-bound estimate on costs.

2.7.4 Analysis of Probable Benefits

The impact of this proposed rule amendment on benefits also depends on each of the four factors discussed above. Most notably, the impact depends on whether and to what extent financial assurances will be required in practice under the proposed rule where they may not have been required under the current rule. To the extent that financial assurances will be required in practice under the proposed rule where they may not have been required under the current rule, the proposed rule amendment will increase the protectiveness of the cleanup. The increased protection of human health and the environment is difficult to estimate quantitatively.

Financial assurances are safeguards (an insurance policy) to ensure the protectiveness of the cleanup over the long-term. More specifically, financial assurances may be required to cover the long-term operation and maintenance costs, long-term monitoring costs, equipment replacement

costs, and the long-term cost of maintaining institutional controls. Financial assurances may also be required to cover any failure of the implemented remedy.

Financial assurances also ensure that the potentially liable persons, not the taxpayers, are required to pay for the cleanup, as directed by the Model Toxics Control Act. Ensuring that the potentially liable persons, not the taxpayers, are required to pay for the cleanup is an issue of fairness and equity. Without such financial assurances, taxpayers would be required to pay for the long-term operation and maintenance of a less than permanent remedy. Without such financial assurances, taxpayers would be subsidizing the selection and implementation of less permanent cleanups.

Note that both the proposed and current rules provide a person conducting the cleanup with the option of conducting a more permanent cleanup action that does not require financial assurances. For site cleanups that are dependent upon financial assurances for long-term protectiveness of the final remedy, the person conducting the cleanup derives an economic benefit by either delaying, or avoiding, the costs associated with meeting cleanup standards.

2.7.5 Conclusion

In conclusion, considering the probable impacts on costs and benefits of this proposed rule amendment, as discussed in this section (**Section 2.7**) and further evaluated in the technical analysis discussed in **Chapter 7**, Ecology has determined that the probable benefits of this proposed rule amendment exceed the probable costs.

2.8 Citizen Technical Advisor

2.8.1 Summary of Proposed Rule Amendment

The proposed rule amendments include a funding mechanism for the addition of a citizen technical advisor position at the Department of Ecology. WAC 173-340-550. This amendment is based on a PAC recommendation (see Final PAC Report, pp. 47-48). The citizen technical advisor will increase the resources available to citizens, enabling citizens to more effectively participate in the cleanup process. The proposed rule amendment includes the cost of the citizen technical advisor as an overhead program support cost. As a type of remedial action cost, program support costs are recoverable from a potentially liable person.

2.8.2 Consideration of Statutory Goals and Objectives

The proposed rule amendment is required to achieve the general goals and specific objectives of the statute, including the following:

- To protect human health and the environment (See RCW 70.105D.010 and .030);
- To provide for public participation (See RCW 70.105D.030(2)(a)); and
- To recover remedial action costs from potentially liable persons (See RCW 70.105D.050(3)).

To provide for more meaningful public participation and to more effectively protect human health and the environment, Ecology has established the citizen technical advisor. The citizen technical advisor will help citizens participate more effectively in the cleanup process by enhancing their understanding of the Model Toxics Control Act and the implementing regulations, as well as site investigations and feasibility studies. The proposed rule amendment is based on a PAC recommendation and was determined by the PAC as necessary to more effectively achieve the goals and objectives of MTCA (Final PAC Report, pp. 47-48).

For an extensive discussion of whether the proposed rule amendment is the least burdensome alternative that will achieve the general goals and specific objectives of MTCA, please see the LBA Analysis.

2.8.3 Analysis of Probable Costs

The impact of this proposed amendment on costs is based on any increase in the program support costs that are recoverable due to the addition of the citizen technical advisor.

Program support costs (PSC) are established by multiplying the direct staff costs (DSC) by the program support cost multiplier (PSCM).

$$\text{PSC} = \text{DSC} \times \text{PSCM}$$

The program support cost multiplier (PSCM) is established by dividing the program support costs (PSC) by the direct staff costs (DSC).

$$\text{PSCM} = \text{PSC} / \text{DSC}$$

The MTCA Cleanup Regulation limits program support costs to the amount of direct staff costs by providing that the program support cost multiplier (PSCM) “shall not exceed 1.0 (one).” WAC 173-340-550(2)(c). The regulation further provides that this multiplier shall be evaluated at least biennially. Biennial audit results since the establishment of the multiplier have not resulted in any adjustments (increases) to the multiplier since program support costs already exceed direct staff costs, resulting in a multiplier greater than 1.0. Under the most recent audit in 1998, the program support cost multiplier was calculated to be 1.37.

The cost of the citizen technical advisor is estimated to be \$95,480 per year, based on the projected cost of one FTE (Full Time Equivalent). However, since the current multiplier (1.37) already exceeds 1.0 (i.e., program support costs > direct staff costs), additional program support costs, including those attributable to the citizen technical advisor, cannot be recovered. Based on its experience since the inception of the cost multiplier, Ecology further anticipates that current program support costs will not decrease. Therefore, the program support costs recoverable under the proposed rule amendments is estimated to be the same as under the current rule.

2.8.4 Analysis of Probable Benefits

The probable benefits associated with the availability of a citizen technical advisor are not quantifiable. Nevertheless, the benefits associated with the establishment of a citizen technical advisor are significant. The citizen technical advisor will help citizens participate more effectively in the cleanup process by enhancing their understanding of the Model Toxics Control Act and the implementing regulations, as well as site investigations and feasibility studies. The citizen technical advisor is intended to augment, not replace, resources available to citizens now provided by Ecology site staff. Effective citizen participation contributes to efficient and protective cleanups by helping decision-makers develop remedies that consider community values. Effective citizen participation also enhances the protectiveness of a remedy by increasing the knowledge and understanding of citizens of the cleanup and the risks associated with any residual contamination.

Ecology anticipates that the duties of the citizen technical advisor will include the following:

- Help the public identify and focus on key issues at a site and to understand the implications of assumptions in site-specific risk assessments, at the request of citizens or Ecology.
- Answer questions from the public related to risk assessment, remedial actions, and site cleanup processes.
- Explain technical documents, including site-specific risk assessments, in non-technical language at the request of citizens.
- Prepare generic explanatory documents and presentations.
- Track contacts and resulting referrals/actions (for program evaluation).

2.8.5 Conclusion

In conclusion, considering the probable impacts on costs and benefits of this proposed rule amendment as discussed in this section (**Section 2.8**), Ecology has determined that the probable benefits of this proposed rule amendment exceed the probable costs. In fact, the proposed rule amendment is not expected to result in any additional cost for the potentially liable person.

Chapter 3 Technical Analysis – Probable Costs of the Proposed Method A Soil and Ground Water Cleanup Levels

3.1 Introduction

The primary impact of the proposed rule amendments on cost results from the proposed changes to the soil and ground water cleanup levels in the Method A tables. The proposed changes to the Method A soil cleanup levels, and the basis for those changes, are described in **Table 3-1 and Table 3-2**. The proposed changes to the Method A ground water cleanup levels, and the basis for those changes, are described in **Table 3-12**. Further description of the proposed changes and the potential impact of those proposed changes is presented in **Chapter 2**.

The potential impact of the proposed Method A cleanup levels on costs depends on whether the proposed Method A cleanup levels will increase or decrease the cleanup cost at a site. Whether the proposed Method A cleanup levels will increase or decrease the cleanup cost at a site depends on several factors. First, the impact depends on whether the proposed Method A cleanup levels are more stringent or less stringent than under the current rule. More stringent cleanup levels may increase the total cleanup cost while less stringent cleanup levels may decrease the total cleanup cost. Second, the impact depends on several site-specific factors, including the type of contaminants present, the type of media contaminated, the extent of contamination, the contaminants of concern, and the physical properties of the site. Third, the impact depends on the remedy selected.

3.2 Impact of Proposed Method A Soil Cleanup Levels

3.2.1 Methodology

To estimate the potential impact of the proposed Method A soil cleanup levels on cleanup costs, the proposed cleanup levels were applied to a model site that is representative of most sites that use Method A to establish cleanup levels. Description of that model site is provided in **Section 3.2.2**.

The impact of the proposed Method A soil cleanup levels on soil cleanup costs depends on whether the proposed levels are more stringent or less stringent than under the current rule and on the type of remedy selected. For this analysis, Ecology assumed that a more permanent cleanup action that removes contaminants from the soil was selected. Based on this assumption, the estimated change in cost of contaminant removal (soil cleanup) for each contaminant was calculated by multiplying the unit cost of contaminant removal by the change in the amount of contaminants requiring removal. While more stringent cleanup levels are expected to increase soil cleanup costs, less stringent cleanup levels are expected to decrease soil cleanup costs (avoided cost). **See Section 3.2.3**.

Even if the more stringent Method A soil cleanup levels result in an increase in soil cleanup costs, those cleanup costs may be offset by a corresponding decrease in ground water cleanup

costs. For this analysis, Ecology assumed that because the more stringent Method A soil cleanup levels are based on protection of ground water, the removal of additional contaminants from the soil will reduce the amount of contaminants reaching and requiring removal from the ground water. The estimated avoided cost of contaminant removal (ground water cleanup) for each contaminant was calculated by multiplying the unit cost of contaminant removal by the differential amount of contaminants requiring removal. **See Section 3.2.4.**

3.2.2 Description of Model Site

The model site is based on the following basic assumptions:

- The extent of contamination at the site is $\frac{1}{4}$ acre to a depth of 25 feet.
- Soil contamination is uniform across the site and at depth.
- The soil density at the site is 1.5 kilograms per liter or 42.45 kilograms per cubic foot.
- Potable ground water is present at a depth of 25 feet below the ground surface.
- Each contaminant is a contaminant of concern at the site driving the nature and scope of the cleanup.

The size of the area of contamination is based on a review of site files, the lot size of small commercial properties, and the scope of cleanups typical for such sites. The $\frac{1}{4}$ acre size is on the upper end of the size of many Method A cleanups and thus should provide a conservative (high) estimate of increased soil cleanup costs.

The soil density of 1.5 kilograms per liter is the default density used in the three- and four-phase equilibrium partitioning models that are used to derive soil concentrations protective of ground water under WAC 173-340-747. The value is based on the EPA soil screening guidance (U.S. EPA, 1995) and published information on soil density.

The depth to ground water of 25 feet was based on a review of site files. This value is expected to be representative of sites both west and east of the Cascades. Shallow ground water is common at west-side contaminated sites due to the high annual amount of precipitation. In the dryer areas of the state, primarily east of the Cascades, most contaminated sites are located in urbanized areas that developed near surface water or are in heavily irrigated areas and thus tend to also have relatively shallow ground water. Also, in both areas of the state, the source of the contamination is often buried at depth beneath the ground surface. Thus, the estimate of 25 feet is probably a reasonable upper bound estimate of the depth to ground water at most Method A sites and should result in a conservative (high) estimate of cleanup costs.

This analysis assumes that each of the proposed Method A cleanup levels is the contaminant of concern at the model site and, thus, determines the nature and scope of the cleanup. This assumption is based on the fact that Method A sites tend to be smaller sites with only a few or only one contaminant driving the cleanup. However, the assumption is a conservative assumption since the hazardous substances may not be contaminants of concern at a particular site. For example, other contaminants whose cleanup levels have not changed could actually drive the cleanup at a site.

3.2.3 Cost of Soil Cleanup

The cost of soil cleanup depends on the remedy selected. More permanent cleanup actions that remove contaminants from the soil typically cost more than less permanent cleanup actions that leave contamination at the site and rely on engineered and institutional controls. For this analysis, Ecology assumed that a more permanent cleanup action that removes contaminants from the soil was selected. This assumption is a conservation assumption that provides a high bound estimate of the potential differential in cleanup costs under the current and proposed rules. Assumption of a less permanent remedy that leaves contamination at the site might not result in any additional cleanup or cost.

3.2.3.1 *Estimated Differential Mass of Contaminant Removal (kg)*

To estimate the change in the cost of soil cleanup, Ecology first calculated the change in the amount of contamination requiring removal from the soil at the model site for each contaminant. These calculations were based on the change in the Method A soil cleanup levels and the model site assumptions regarding the area and depth of contamination. More stringent cleanup levels require an increase in the amount of contaminant removal. Less stringent cleanup levels allow for a reduction in the amount of contaminant removal. The change in the mass of soil contaminants requiring removal is presented in **Table 3-3** for unrestricted land use and in **Table 3-4** for industrial land use.

3.2.3.2 *Estimated Unit Cost for Contaminant Removal (\$/kg)*

To estimate the change in the cost of soil cleanup, Ecology next estimated the unit cost of removing an additional kilogram of contaminant from the soil. The estimated unit cost of soil cleanup depends on the remedial technology used to remove the soil contamination. The remedial technology selected depended on the type of contaminant and the available technologies for treating those contaminants. The selection was based on review of federal reports and on the best professional judgment of environmental engineers. The estimated unit cost for each of the treatment technologies was based on actual data from reports available from the federal government (Federal Remediation Technologies Roundtable: Cost and Performance Reports, <http://clu-in.org/remed1.htm>), the only readily available source found for this type of information. The cost estimates include both capital and operating expenses. The estimated unit costs of soil cleanup are expressed as the cost per kilogram of contamination removed (\$/kg). The unit cost estimates can be thought of as the increase (or decrease) in the operating costs for a treatment remedy at a site.

- For volatile hazardous substances, soil vapor extraction (SVE) was selected. The unit cost is based on the median cost at 13 sites. **See Table 3-7.**
- For semi-volatile hazardous substances and pesticides, excavation and treatment using low temperature thermal desorption was selected. The unit cost is based on the median cost at 15 sites. **See Table 3-8.**

- For metals, excavation and treatment using soil washing was selected. The unit cost is based on the cost at one site. **See Table 3-9.**
- For all hazardous substances, for comparison purposes, the cost of excavating and off-site disposal was calculated based on bids and actual invoices from sites in Washington State. **See Table 3-10.**

3.2.3.3 Results – Estimated Differential Cost of Contaminant Removal (\$)

The estimated change in the cost of contaminant removal (soil cleanup) for each contaminant was calculated by multiplying the unit cost of contaminant removal by the change in the amount of contaminants requiring removal. More stringent cleanup levels require an increase in the amount of contaminant removal, resulting in an increase in cleanup costs. Less stringent cleanup levels allow for a reduction in the amount of contaminant removal, resulting in a decrease in cleanup costs. These calculations are presented in **Table 3-5** for unrestricted land use and in **Table 3-6** for industrial land use.

- **Increased Cost for More Stringent Soil Cleanup Levels**

As illustrated in **Tables 3-5 and 3-6**, adopting more stringent soil cleanup levels could result in small increases in soil cleanup costs for sites contaminated with benzene, cPAHs, cadmium, DDT, ethylbenzene, methylene chloride, tetrachloroethylene, trichloroethylene, or xylene. The increased costs ranged from about **\$250 to \$8,000**.

Adopting more stringent soil cleanup levels could result in moderate increases in soil cleanup costs for sites contaminated with lindane, toluene, 1,1,1 TCE and fresh and weathered gasoline. The increased costs ranged from about **\$11,000 to \$50,000**.

Adopting more stringent soil cleanup levels could result in substantial increases in soil cleanup costs for sites contaminated with hexavalent chromium and for industrial properties contaminated with arsenic. The increased costs ranged from about **\$50,000 to \$300,000**.

- **Decreased (Avoided) Cost for Less Stringent Soil Cleanup Levels**

As also illustrated in **Tables 3-5 and 3-6**, adopting less stringent soil cleanup levels could result in small decreases (savings) in soil cleanup costs for sites contaminated with DDT (unrestricted land use), EDB, mercury, or naphthalene. The decreased costs ranged from about **\$2 to \$3,000**.

Adopting less stringent soil cleanup levels could result in substantial decreases (savings) in soil cleanup costs for sites contaminated with trivalent chromium, diesel fuel, heavy oils or electrical insulating mineral oil. The decreased costs range from about **\$900,000 to \$2 million**.

3.2.4 Avoided Cost of Ground Water Cleanup

Even if the more stringent Method A soil cleanup levels result in an increase in soil cleanup costs, those cleanup costs may be offset by a corresponding decrease in ground water cleanup costs. For this analysis, Ecology assumed that because the more stringent Method A soil cleanup levels are based on protection of ground water, the removal of additional contaminants from the soil will reduce the amount of contaminants reaching and requiring removal from the ground water.

3.2.4.1 Estimated Reduction in Mass of Contaminant Removal (kg)

To estimate the reduction in ground water cleanup costs, Ecology first calculated the change in the amount of contamination requiring removal from the ground water at the model site for each contaminant. To make this calculation, Ecology first determined the reduction in the soil concentration under the proposed rule. This concentration was then converted to a mass based on site size, depth to ground water, and soil density. This is the mass that, if not removed from the soil, would eventually reach the ground water and require removal. These calculations are provided in **Table 3-3** for unrestricted land use and **Table 3-4** for industrial land use.

3.2.4.2 Estimated Unit Cost of Contaminant Removal (\$/kg)

To estimate the reduction in ground water cleanup costs, Ecology next estimated the unit cost of removing an additional kilogram of contaminant from the ground water. The estimated unit cost of ground water cleanup depends on the remedial technology used to remove the ground water contamination. The remedial technology selected for all of the contaminants was a pump and treat system. To determine the unit cost of a pump and treat system, cost information was compiled from an EPA report on 28 ground water pump and treat systems (U.S. EPA, 1999), the only readily available source found for this type of information. The median of this data, expressed as a cost per kilogram of contamination removed from the ground water, was used as the unit cost. Universal application of this unit cost estimate is considered reasonable because these sites represent a wide range of site conditions and contaminants and no pattern, based on type of contamination, could be discerned from the data. **See Table 3-11.**

3.2.4.3 Results – Estimated Avoided Cost of Contaminant Removal (\$)

The estimated avoided cost of contaminant removal (ground water cleanup) for each contaminant was calculated by multiplying the unit cost of contaminant removal by the change in the amount of contaminants requiring removal. These calculations are presented in **Table 3-5** for unrestricted land use and in **Table 3-6** for industrial land use.

As illustrated in these tables, the savings in ground water remediation costs could be substantial, from about **\$10,000 to over \$10 million**. These savings more than offset any increase in soil remediation costs.⁵ This confirms what is common knowledge in site remediation – it is

⁵ In fact, based on the estimated unit costs of soil remediation (\$51.64/kg) and ground water remediation (\$2,108.27/kg), the cost of soil remediation is only 2.4% of the cost of ground water remediation. Hence, even if it were assumed that only a small fraction of the contaminants in the soil reached the ground water, the savings in ground water remediation costs would still offset the increase in soil remediation costs.

substantially less expensive to remove contamination from the soil before it reaches the ground water than it is to remove the contamination from the ground water.

3.3 Impact of Proposed Method A Ground Water Cleanup Levels

3.3.1 Methodology

To estimate the potential impact of the proposed Method A ground water cleanup levels on cleanup costs, the proposed cleanup levels were applied to a model site that is representative of most sites that use Method A to establish cleanup levels. Description of that model site is provided in **Section 3.3.2**.

The impact of the proposed Method A ground water cleanup levels on ground water cleanup costs depends on whether the proposed levels are more stringent or less stringent than under the current rule and on the type of remedy selected. For this analysis, Ecology assumed that a more permanent cleanup action that removes contaminants from the ground water was selected. Based on this assumption, the estimated differential cost of contaminant removal (ground water cleanup) for each contaminant was calculated by multiplying the unit cost of contaminant removal by differential amount of contaminants requiring removal. While more stringent cleanup levels are expected to increase ground water cleanup costs, less stringent cleanup levels are expected to decrease ground water cleanup costs (avoided cost). **See Section 3.3.3.**

3.3.2 Description of Model Site

The model site is based on the following basic assumptions:

- The extent of ground water contamination is one acre to a depth of 20 feet.
- The contamination is uniform across the site and at depth.
- The soil porosity at the site is 0.43.
- Each contaminant is a contaminant of concern at the site driving the nature and scope of the cleanup.

The extent of ground water contamination is based on a review of site files and the scope of ground water cleanups typical for Method A sites. The soil porosity of 0.43 is the default porosity used in the three- and four-phase equilibrium partitioning models that are used to derive soil concentrations protective of ground water under WAC 173-340-747. The value is based on the EPA soil screening guidance (U.S. EPA, 1995) and experience at sites in Washington State.

This analysis assumes that each of the proposed Method A cleanup levels is the contaminant of concern at the model site and, thus, determines the nature and scope of the cleanup. This assumption is based on the fact that Method A sites tend to be smaller sites with only a few or only one contaminant driving the cleanup. However, the assumption is a conservative assumption since the hazardous substances may not be contaminants of concern at a particular site. For example, other contaminants whose cleanup levels have not changed could actually drive the cleanup and cost at a site.

3.3.3 Cost of Ground Water Cleanup

The cost of ground water cleanup depends on the remedy selected. More permanent cleanup actions that remove contaminants from the ground water typically cost more than less permanent cleanup actions that leave contamination at the site and rely on engineered and institutional controls. For this analysis, Ecology assumed that a more permanent cleanup action that removes contaminants from the ground water was selected. This assumption is a conservation assumption that provides a high bound estimate of the potential differential in cleanup costs under the current and proposed rules. Assumption of a less permanent remedy that leaves contamination at the site might not result in any additional cleanup or cost.

3.3.3.1 *Estimated Differential in Mass of Contaminant Removal (kg)*

To estimate the change in ground water cleanup costs, Ecology first calculated the change in the amount of contamination requiring removal from the ground water at the model site for each contaminant. These calculations were based on the change in the Method A ground water cleanup levels and the model site assumptions regarding the area and depth of contamination. More stringent cleanup levels require an increase in the amount of contaminant removal. Less stringent cleanup levels allow for a reduction in the amount of contaminant removal. The change in the mass of contaminants requiring removal from the ground water for each contaminant are presented in **Table 3-13**.

3.3.3.2 *Estimated Unit Cost of Contaminant Removal (\$/kg)*

To estimate the change in ground water cleanup costs, Ecology next estimated the unit cost of removing an additional kilogram of contaminant from the ground water for each contaminant. The estimated unit cost of ground water cleanup depends on the remedial technology used to remove the ground water contamination. The remedial technology selected was a pump and treat system. To determine the unit cost of a pump and treat system, cost information was compiled from an EPA report on 28 ground water pump and treat systems (U.S. EPA, 1999), the only readily available source found for this type of information. The median of this data, expressed as a cost per kilogram of contamination removed from the ground water, was used as the unit cost. Universal application of this unit cost estimate is considered reasonable because these sites represent a wide range of site conditions and contaminants and no pattern, based on type of contamination, could be discerned from the data. **See Table 3-11**.

3.3.3.3 *Estimated Differential Cost of Contaminant Removal (\$)*

The estimated change in cost of contaminant removal (ground water cleanup) for each contaminant was calculated by multiplying the unit cost of contaminant removal by the change in the amount of contaminants requiring removal. More stringent cleanup levels require an increase in the amount of contaminant removal, resulting in an increase in cleanup costs. Less stringent cleanup levels allow for a reduction in the amount of contaminant removal, resulting in a decrease in cleanup costs. The calculations are presented in **Table 3-13**.

- **Increased Cost for More Stringent Ground Water Cleanup Levels**

As illustrated in **Table 3-13**, adopting more stringent cleanup levels could result in moderate increases in ground water cleanup costs for sites contaminated with gasoline range organics with benzene, diesel range organics, heavy oils, and mineral oil. The increased costs ranged from about **\$4,500 to \$11,000**.

- **Decreased (Avoided) Cost for Less Stringent Ground Water Cleanup Levels**

As illustrated in **Table 3-13**, adopting less stringent cleanup levels could result in small decreases (savings) in ground water cleanup costs ranging from about **\$2 to \$3,600** for sites contaminated with for benzo(a)pyrene, trivalent chromium, DDT, lead, MTBE, and naphthalene.

Adopting less stringent cleanup levels could result in moderate decreases (savings) in ground water cleanup costs ranging from about **\$15,000 to \$22,000** for sites contaminated with ethylbenzene, toluene, and xylene.

3.4 Conclusion

In summary, adopting more stringent Method A soil cleanup levels could result in small increases in soil cleanup costs ranging from about **\$250 to \$300,000**, depending on the hazardous substance. **See Tables 3-5 and 3-6**. Even if the more stringent soil cleanup levels resulted in an increase in soil cleanup costs, those cleanup costs may be offset by a corresponding decrease in ground water cleanup costs. Specifically, the avoided cost of ground water cleanup could be substantial, ranging from about **\$10,000 to over \$10 million**. **See Table 3-13**. These savings more than offset any increase in soil cleanup costs. This confirms what is common knowledge in site remediation – it is substantially less expensive to remove contamination from the soil before it reaches the ground water than it is to remove the contamination from the ground water.

Adopting more stringent Method A ground water cleanup levels could result in moderate increases in ground water cleanup costs for sites contaminated with gasoline range organics with benzene, diesel range organics, heavy oils, and mineral oil. The increased costs ranged from **about \$4,500 to \$11,000**, depending on the hazardous substance. **See Table 3-13**.

Adopting less stringent Method A soil cleanup levels could result in small to more substantial decreases in soil cleanup costs ranging from only a **few dollars to \$2 million**, depending on the hazardous substance. **See Tables 3-5 and 3-6**. Adopting less stringent Method A ground water cleanup levels could result in small to moderate decreases in ground water cleanup costs ranging from only a **few dollars to \$22,000**, depending on the hazardous substance. **See Table 3-13**.

3.5 Calculations

Table 3-1: Summary of Method A Soil Cleanup Levels for Unrestricted Land Use

Hazardous Substance	CAS Number	Current Method A Cleanup Level (mg/kg)	Proposed Method A Cleanup Level (mg/kg)	Basis for Standard
Arsenic	7440-38-2	20.0	20	Soil ingestion using equation 740-2, and leaching using 3-phase model, adjusted for natural background (1).
Benzene	71-43-2	0.5	0.03	Protection of drinking water -- based on both 3 and 4 phase models.
Benzo(a)Pyrene	50-32-8	none	0.1	Soil ingestion using equation 740-2. Can also be used as the total toxic equivalents for all cPAHs. See WAC 173-340-708(8).
Cadmium	7440-43-9	2	2	Protection of drinking water, adjusted for PQL.
Chromium (total)	7440-47-3	100.0	none	Replaced by values for Cr III and Cr VI.
Chromium VI	18540-29-9		19	Protection of drinking water--3 phase model.
Chromium III	16065-83-1		2000	Protection of drinking water--3 phase model.
DDT	50-29-3	1	3	Soil ingestion using equation 740-2.
Ethylbenzene	100-41-4	20.0	6	Protection of drinking water--3 phase model.
Ethylene dibromide (EDB)	106-93-4	0.001	0.005	Protection of drinking water--3 phase model, adjusted for PQL.
Lead	7439-92-1	250.0	250	Soil ingestion. See 1991 responsiveness summary for explanation of calculation. (1)
Lindane	58-89-9	1	0.01	Protection of drinking water--3 phase model, adjusted for PQL.
Methylene chloride	75-09-2	0.5	0.02	Protection of drinking water--3 phase model.
Mercury (inorganic)	7439-97-6	1	2	Protection of drinking water--3 phase model.
MTBE	1634-04-4	none	0.1	Protection of drinking water--3 phase model.
Naphthalenes	91-20-3	none	5	Protection of drinking water--3 phase model. Total of all naphthalene, 1-methyl naphthalene and 2-methyl naphthalene.
PAHs (carcinogenic)		1.0	none	Replaced by Benzo(a)Pyrene, above.
PCB Mixtures	1336-36-3	1	1	ARAR. This is a total value for all PCBs in the soil sample.
Tetrachloroethylene	127-18-4	0.5	0.05	Protection of drinking water--3 phase model.
Toluene	108-88-3	40.0	7	Protection of drinking water--3 phase model.
1,1,1 Trichloroethane	71-55-6	20	2	Protection of drinking water--3 phase model.
Trichloroethylene	79-01-5	0.5	0.03	Protection of drinking water--3 phase model.
Xylenes	1330-20-7	20.0	9	Protection of drinking water--3 phase model. Total of all m, o & p xylene.
GRO with benzene		100	30	Protection of drinking water--4 phase model, assuming weathered gasoline composition.
GRO w/o benzene		100	100 (3)	Protection of drinking water--4 phase model, assuming highly weathered gasoline composition.
Diesel Range Organics		200	2000	Protection of drinking water--residual saturation
Heavy Oils		200	2000	Protection of drinking water--residual saturation for diesel.
Mineral Oil		200 (2)	4000	Protection of drinking water--residual saturation

(1) Ecology decision not to change at this time. Ecology intends to review and, if appropriate, update these values in a future rulemaking.

(2) Ecology has also issued a fact sheet (#95-157-TCP) allowing the use of 2000 mg/kg at electrical substations and switchyards.

(3) To use this value no benzene must be present in the soil and the aromatic EC 8 to EC 16 fractions must be less than 20% of the gasoline mixture.

Table 3-2: Summary of Method A Soil Cleanup Levels for Industrial Land Use

Hazardous Substance	CAS Number	Current Method A Cleanup Level mg/kg	Proposed Method A Cleanup Level (mg/kg)	Basis for Standard
Arsenic	7440-38-2	200	20	Protection of drinking water, adjusted for background (1)
Benzene	71-43-2	0.5	0.03	Protection of drinking water--based on both 3 and 4 phase models.
Benzo(a)Pyrene	50-32-8	none	2	Protection of drinking water--3 phase model.
Cadmium	7440-43-9	10	2	Protection of drinking water, adjusted for background
Chromium (total)	7440-47-3	500.0	none	Replaced by values for Cr III and Cr VI.
Chromium VI	18540-29-9		19	Protection of drinking water--3 phase model.
Chromium III	16065-83-1		2000	Protection of drinking water--3 phase model.
DDT	50-29-3	5	4	Protection of drinking water--3 phase model.
Ethylbenzene	100-41-4	20	6	Protection of drinking water--3 phase model.
Ethylene dibromide (EDB)	106-93-4	0.001	0.005	Protection of drinking water, adjusted for PQL
Lead	7439-92-1	1000.0	1000	Ingestion (3)
Lindane	58-89-9	20	0.01	Protection of drinking water, adjusted for PQL
Methylene chloride	75-09-2	0.5	0.02	Protection of drinking water--3 phase model.
Mercury (inorganic)	7439-97-6	1	2	Protection of drinking water--3 phase model.
MTBE	1634-04-4	none	0.1	Protection of drinking water--3 phase model.
Naphthalenes	91-20-3	none	5	Protection of drinking water--3 phase model. Total of naphthalene, 1-methyl naphthalene & 2-methyl naphthalene
PAHs (carcinogenic)		20	none	Replaced by benzo(a)pyrene.
PCB Mixtures	1336-36-3	10.0	10	ARAR. This is a total value for all PCBs in the soil sample.
Tetrachloroethylene	127-18-4	0.5	0.05	Protection of drinking water--3 phase model.
Toluene	108-88-3	40	7	Protection of drinking water--3 phase model.
1,1,1 Trichloroethane	71-55-6	20	2	Protection of drinking water--3 phase model.
Trichloroethylene	79-01-5	0.5	0.03	Protection of drinking water--3 phase model.
Xylenes	1330-20-7	20	9	Protection of drinking water--3 phase model. Total of all m, o & p xylene.
GRO with benzene		100	30	Protection of drinking water--4 phase model, assuming weathered gasoline composition.
GRO w/o benzene		100	100 (5)	Protection of drinking water--4 phase model, assuming highly weathered gasoline composition.
Diesel Range Organics		200	2000	Protection of drinking water--residual saturation
Heavy Oils		200	2000	Protection of drinking water--residual saturation for diesel.
Mineral Oil		200 (4)	4000	Protection of drinking water--residual saturation

- (1) Based on background value in table 740-1. Ecology intends to review and, if appropriate, update this value in a future rulemaking.
- (2) This can also be used as the total toxic equivalents for all cPAHs. See WAC 173-340-708(8).
- (3) Ecology decision not to change at this time. Ecology intends to review and, if appropriate, update this value in a future rulemaking.
- (4) Ecology has also issued a fact sheet (#95-157-TCP) allowing the use of 2000 mg/kg at electrical substations and switchyards.
- (5) To use this value no benzene must be present in the soil and the aromatic EC 8 to EC 16 fractions must be less than 20% of the gasoline mixture.

Table 3-3: Method A Soil Cleanup Levels for Unrestricted Land Use - Calculation of Change in Mass Removed

Hazardous Substance	CAS Number	Current Method A Cleanup Level (mg/kg) (1)	Proposed Method A Cleanup Level (mg/kg) (2)	Difference (mg/kg) (3)	Change in mass removed from soil at a site (kg) (4)	Change in mass needing removal from GdH2O at site (kg) (5)
Arsenic	7440-38-2	20.0	20	0	0.0	0.0
Benzene	71-43-2	0.5	0.03	0.47	5.4	-5.4
Benzo(a)Pyrene	50-32-8	0.1	0.1	0.0	0.0	0.0
Cadmium	7440-43-9	2	2	0	0.0	0.0
Chromium (total)	7440-47-3	100.0	none			
Chromium VI	18540-29-9		19	81	936	-936
Chromium III	16065-83-1		2,000	-1,900	-21,958	0.0
DDT	50-29-3	1	3	-2	-23	0.0
Ethylbenzene	100-41-4	20.0	6	14	162	-162
Ethylene dibromide (EDB)	106-93-4	0.001	0.005	-0.004	-0.046	0.0
Lead	7439-92-1	250.0	250	0	0.0	0.0
Lindane	58-89-9	1	0.01	0.99	11	-11
Methylene chloride	75-09-2	0.5	0.02	0.48	5.5	-5.5
Mercury (inorganic)	7439-97-6	1	2	-1	-11.6	0.0
MTBE	1634-04-4	0.005 & 2.0	0.1	(-0.095) & 1.9	(-1.1) & 22	0 & -22
Naphthalene	91-20-3	0.5 & 0.4	5	(-4.5) & -4.6	(-52) & -53	0
PAHs (carcinogenic)		1.0	none	see B(a)P		
PCB Mixtures	1336-36-3	1	1	0	0.0	0.0
Tetrachloroethylene	127-18-4	0.5	0.05	0.45	5.2	-5.2
Toluene	108-88-3	40.0	7	33	381	-381
1,1,1 Trichloroethane	71-55-6	20	2	18	208	-208
Trichloroethylene	79-01-5	0.5	0.03	0.47	5.4	-5.4
Xylenes	1330-20-7	20.0	9	11	127	-127
GRO with benzene		100	30	70	809	-809
GRO w/o benzene		100	100	0	0.0	0.0
Diesel Range Organics		200	2000	-1800	-20,803	0.0
Heavy Oils		200	2000	-1800	-20,803	0.0
Mineral Oil		200	4000	-3800	-43,917	0.0

Footnotes:

- (1) From current MTCA table 2. Exceptions: B(a)P = cPAH total divided by 7 (number of cPAHs). For MTBE first value assumes MTBE = PQL as per WAC 173-340-704(2)(c) ; second value assumes MTBE resnet at 2% in gas* and a cleanup level of 100 mg/kg. For naphthalene first value assumes naphthalene = PQL as per WAC 173-340-740(2)(c); second value assumes present in diesel fuel at 0.2%** and a cleanup level of 200 mg/kg).
- (2) From table 740-1 in MTCA rule revisions proposed in August 2000.
- (3) Column 1 minus column 2.
- (4) Mass calculated assuming 1/4 acre site with uniform contamination, 25 feet between source of release and ground water and soil dry density of 1.5 kg/l or 42.45 kg/cf. This is the change in mass of contamination that would have to be removed from the soil at a site to meet the proposed cleanup level. Equals [10890 (ft²) * 25 (ft) * 42.45 (kg/ft³) * value in column 3 (mg/kg)] / [1,000,000 (mg/kg)].
- (5) Decrease in mass needing removal from ground water to achieve ground water cleanup level as a result of new soil cleanup levels. For sites with the more stringent soil cleanup levels being driven by ground water protection concerns, this is equal to the additional mass of contamination needing removal from the soil. A value of zero means no ground water remediation would be needed for either soil cleanup level as ground water would meet drinking water standard under both cleanup levels.

* Source: Oregon DEQ

** Source: TPH-National Criteria Working Group; Ecology site files.

Table 3-4: Method A Soil Cleanup Levels for Industrial Land Use – Calculation of Change in Mass Removed

Hazardous Substance	CAS Number	Current Method A Cleanup Level (mg/kg) (1)	Proposed Method A Cleanup Level (mg/kg) (2)	Difference (mg/kg) (3)	Change in mass removed from soil at a site (kg) (4)	Change in mass needing removal from GdH2O at a site (kg) (5)
Arsenic	7440-38-2	200	20	180	2,080	-2080.3
Benzene	71-43-2	0.5	0.03	0.47	5.4	-5.4
Benzo(a)Pyrene (3)	50-32-8	2.8	2	0.8	9.2	-9.2
Cadmium	7440-43-9	10	2	8	92.5	-92.5
Chromium (total)	7440-47-3	500.0	none			
Chromium VI	18540-29-9		19	481	5,559	-5,559
Chromium III	16065-83-1		2,000	-1,500	-17,336	0.0
DDT	50-29-3	5	4	1	12	-12
Ethylbenzene	100-41-4	20	6	14	162	-162
Ethylene dibromide (EDB)	106-93-4	0.001	0.005	-0.004	-0.046	0.0
Lead	7439-92-1	1000.0	1000	0	0.0	0.0
Lindane	58-89-9	20	0.01	19.99	231	-231
Methylene chloride	75-09-2	0.5	0.02	0.48	5.5	-5.5
Mercury (inorganic)	7439-97-6	1	2	-1	-11.6	0.0
MTBE (4)	1634-04-4	0.005 & 2.0	0.1	(-0.095) & 1.9	(-1.1) & 22	0 & -22
Naphthalene (5)	91-20-3	0.5 & 0.4	5	(-4.5) & -4.6	(-52) & -53	0
PAHs (carcinogenic)		20	none	see B(a)P		
PCB Mixtures	1336-36-3	10.0	10	0	0.0	0.0
Tetrachloroethylene	127-18-4	0.5	0.05	0.45	5.2	-5.2
Toluene	108-88-3	40	7	33	381	-381
1,1,1 Trichloroethane	71-55-6	20	2	18	208	-208
Trichloroethylene	79-01-5	0.5	0.03	0.47	5.4	-5.4
Xylenes	1330-20-7	20	9	11	127	-127
GRO with benzene		100	30	70	809	-809
GRO w/o benzene		100	100	0	0.0	0.0
Diesel Range Organics		200	2,000	-1,800	-20,803	0.0
Heavy Oils		200	2,000	-1,800	-20,803	0.0
Mineral Oil		200	4,000	-3,800	-43,917	0.0

Footnotes:

- (1) From current MTCA table 2. Exceptions: B(a)P = cPAH total divided by 7 (number of cPAHs). For MTBE first value assumes MTBE = PQL as per WAC 173-340-704(2)(c); second value assumes MTBE resented at 2% in gas* and a cleanup level of 100 mg/kg. For naphthalene first value assumes naphthalene = PQL as per WAC 173-340-740(2)(c); second value assumes present in diesel fuel at 0.2%** and a cleanup level of 200 mg/kg).
- (2) From table 740-1 in MTCA rule revisions proposed in August 2000.
- (3) Column 1 minus column 2.
- (4) Mass calculated assuming 1/4 acre site with uniform contamination, 25 feet between source of release and ground water and soil dry density of 1.5 kg/l or 42.45 kg/cf. This is the change in mass of contamination that would have to be removed from the soil at a site to meet the proposed cleanup level. Equals [10890 (ft²) * 25 (ft) * 42.45 (kg/ft³) * value in column 3 (mg/kg)] / [1,000,000 (mg/kg)].
- (5) Decrease in mass needing removal from ground water to achieve ground water cleanup level as a result of new soil cleanup levels. For sites with the more stringent soil cleanup levels being driven by ground water protection concerns, this is equal to the additional mass of contamination needing removal from the soil. A value of zero means no ground water remediation would be needed for either soil cleanup level as ground water would meet drinking water standard under both cleanup levels.

* Source: Oregon DEQ

** Source: TPH-National Criteria Working Group; Ecology site files.

Table 3-5: Method A Soil Cleanup Levels for Unrestricted Land Use – Calculation of Change in Cost of Cleanup

Hazardous Substance	CAS Number	Current Method A Cleanup Level (mg/kg) (1)	Proposed Method A Cleanup Level (mg/kg) (2)	Difference (mg/kg) (3)	Change in Mass removed from soil (kg) (4)	Unit Cost of Soil Treatment (\$/kg) (5)	Difference in Cost of Soil Remediation (\$) (6)	Unit Cost of Soil Excav. & Off-Site Disposal (\$/kg) (7)	Difference in Cost of Soil Remediation (\$) (8)	Δ Mass needing Removal From GW (kg) (9)	Unit Cost of GW Remediation (\$/kg) (10)	Difference in Cost of GW Remediation (\$) (11)
Arsenic	7440-38-2	20.0	20	0	0	238.96	\$0	51.64	\$0	0	2108.27	\$0
Benzene	71-43-2	0.5	0.03	0.47	5.4	16.58	\$90	51.64	\$280	-5.4	2108.27	-\$11,452
Benzo(a)Pyrene	50-32-8	0.1	0.1	0.0	0	186.04	\$0	51.64	\$0	0	2108.27	\$0
Cadmium	7440-43-9	2	2	0	0	238.96	\$0	51.64	\$0	0	2108.27	\$0
Chromium (total)	7440-47-3	100.0	none									
Chromium VI	18540-29-9		19	81	936	238.96	\$223,695	51.64	\$48,341	-936	2108.27	-\$1,973,590
Chromium III	16065-83-1		2,000	-1,900	-21,958	238.96	-\$5,247,161	51.64	-\$1,133,928	0	2108.27	\$0
DDT	50-29-3	1	3	-2	-23.1	186.04	-\$4,300	51.64	-\$1,194	0	2108.27	\$0
Ethylbenzene	100-41-4	20.0	6	14	162	16.58	\$2,683	51.64	\$8,355	-162	2108.27	-\$341,114
Ethylene dibromide (EDB)	106-93-4	0.001	0.005	-0.004	-0.046	16.58	-\$1	51.64	-\$2	0	2108.27	\$0
Lead	7439-92-1	250.0	250	0	0	238.96	\$0	51.64	\$0	0	2108.27	\$0
Lindane	58-89-9	1	0.01	0.99	11.4	186.04	\$2,129	51.64	\$591	-11.4	2108.27	-\$24,122
Methylene chloride	75-09-2	0.5	0.02	0.48	5.5	16.58	\$92	51.64	\$286	-5.5	2108.27	-\$11,695
Mercury (inorganic)	7439-97-6	1	2	-1	-11.6	238.96	-\$2,762	51.64	-\$597	0	2108.27	\$0
MTBE	1634-04-4	0.005 & 2.0	0.1	(-0.095) to 1.9	(-1.1) to 22	16.58	\$-18 to \$32	51.64	\$-56.8 to \$1136	up to -22	2108.27	up to -\$46,382
Naphthalene	91-20-3	0.5 & 0.4	5	(-4.5) to -4.6	(-52) to -53	16.58	(-\$862) to -\$879	51.64	(-\$2685) to -\$2737	0	2108.27	\$0
PAHs (carcinogenic)		1.0	none	see B(a)P		186.04	\$0	51.64	\$0	0	2108.27	\$0
PCB Mixtures	1336-36-3	1	1	0	0	186.04	\$0	51.64	\$0	0	2108.27	\$0
Tetrachloroethylene	127-18-4	0.5	0.05	0.45	5.2	16.58	\$86	51.64	\$269	-5.2	2108.27	-\$10,964
Toluene	108-88-3	40.0	7	33	381	16.58	\$6,323	51.64	\$19,695	-381	2108.27	-\$804,055
1,1,1 Trichloroethane	71-55-6	20	2	18	208	16.58	\$3,449	51.64	\$10,742	-208	2108.27	-\$438,575
Trichloroethylene	79-01-5	0.5	0.03	0.47	5.4	16.58	\$90	51.64	\$280	-5.4	2108.27	-\$11,452
Xylenes	1330-20-7	20.0	9	11	127	16.58	\$2,108	51.64	\$6,565	-127	2108.27	-\$268,018
GRO with benzene		100	30	70	809	16.58	\$13,413	51.64	\$41,776	-809	2108.27	-\$1,705,571
GRO w/o benzene		100	100	0	0	16.58	\$0	51.64	\$0	0	2108.27	\$0
Diesel Range Organics		200	2,000	-1,800	-20,803	16.58	-\$344,907	51.64	-\$1,074,247	0	2108.27	\$0
Heavy Oils		200	2,000	-1,800	-20,803	186.04	-\$3,870,120	51.64	-\$1,074,247	0	2108.27	\$0
Mineral Oil		200	4,000	-3,800	-43,917	186.04	-\$8,170,253	51.64	-\$2,267,856	0	2108.27	\$0

Table 3-5 Footnotes.

- (1) From current MTCA table 2. Exceptions: B(a)P = cPAH total divided by 7 (number of cPAHs). For MTBE first value assumes MTBE = PQL as per WAC 173-340-704(2)(c); second value assumes MTBE present at 2% in gas and a cleanup level of 100 mg/kg. For naphthalene first value assumes naphthalene = PQL as per WAC 173-340-704(2)(c); second value assumes present in diesel fuel at 0.2% and a cleanup level of 200 mg/kg).
- (2) From table 740-1 in MTCA rule revisions proposed in August 2000.
- (3) Column 1 minus column 2.
- (4) Mass calculated assuming 1/4 acre contaminated area with uniform contamination extending 25 feet to ground water and soil dry density of 1.5 kg/l or 42.45 kg/cf. This is the change in mass of contamination that would have to be removed from the soil at a site to meet the proposed cleanup level (**see Table 3-3**).
- (5) For volatile organics based on median cost of soil vapor extraction reported at 13 federal cleanup sites (**see Table 3-7**). For metals based on cost of soil washing reported at 1 federal cleanup site (**see Table 3-9**). For semi volatile organics and pesticides based on the median cost of thermal desorption at 15 federal cleanup sites (**see Table 8**).
- (6) Change in mass removed from soil (column 4) times unit cost of cleanup (column 5). Positive number is increase in soil cleanup costs, negative number is savings in soil cleanup costs.
- (7) Disposal at a landfill based on data from Ecology site files (**Table 3-10**).
- (8) Change in mass removed from soil (column 4) times unit cost of cleanup (column 7). Positive number is increase in soil cleanup costs, negative number is savings in soil cleanup costs.
- (9) Decrease in mass needing removal from ground water to achieve ground water cleanup level as a result of new soil cleanup levels (**see Table 3-3**).
- (10) Based on median cost of ground water cleanup at 26 sites, expressed as a cost per kg of contaminants removed (**see Table 3-11**).
- (11) Change in mass removed from ground water times unit cost of cleanup. This is the savings in ground water cleanup costs.

Table 3-6: Method A Soil Cleanup Levels for Industrial Land Use – Calculation of Change in Cost of Cleanup

Hazardous Substance	CAS Number	Current Method A Cleanup Level (mg/kg)	Proposed Method A Cleanup Level (mg/kg)	Difference (mg/kg)	Change in Mass removed from Soil in Kg (kg) (1)	Unit Cost of Soil Remediation (\$/kg) (2)	Difference in Cost of Soil Remediation (\$) (3)	Unit Cost of Soil Excav. & Off-Site Disposal (\$/kg) (7)	Difference in Cost of Soil Remediation (\$) (8)	Change in Mass needing Removal from GW (kg) (4)	Unit Cost of GW Remediation (\$/kg) (5)	Difference in Cost of GW Remediation (\$) (6)
Arsenic	7440-38-2	200	20	180	2,080	238.96	\$497,099	51.64	\$107,425	-2,080	2108.27	-\$4,385,754
Benzene	71-43-2	0.5	0.03	0.47	5.4	16.58	\$90	51.64	\$280	-5.4	2108.27	-\$11,452
Benzo(a)Pyrene	50-32-8	2.8	2	0.8	9.2	186.04	\$1,720	51.64	\$477	-9.2	2108.27	-\$19,492
Cadmium	7440-43-9	10	2	8	92	238.96	\$22,093	51.64	\$4,774	-92	2108.27	-\$194,922
Chromium (total)	7440-47-3	500.0	none									
Chromium VI	18540-29-9		19	481	5,559	238.96	\$1,328,360	51.64	\$287,063	-5,559	2108.27	-\$11,719,711
Chromium III	16065-83-1		2,000	-1,500	-17,336	238.96	-\$4,142,496	51.64	-\$895,206	0	2108.27	\$0
DDT	50-29-3	5	4	1	11.6	186.04	\$2,150	51.64	\$597	-11.6	2108.27	-\$24,365
Ethylbenzene	100-41-4	20	6	14	162	16.58	\$2,683	51.64	\$8,355	-162	2108.27	-\$341,114
Ethylene dibromide	106-93-4	0.001	0.005	-0.004	0.0	16.58	-\$1	51.64	-\$2	0	2108.27	\$0
Lead	7439-92-1	1000.0	1000	0	0	238.96	\$0	51.64	\$0	0	2108.27	\$0
Lindane	58-89-9	20	0.01	19.99	231	186.04	\$42,980	51.64	\$11,930	-231.0	2108.27	-\$487,062
Methylene chloride	75-09-2	0.5	0.02	0.48	5.5	16.58	\$92	51.64	\$286	-5.5	2108.27	-\$11,695
Mercury (inorganic)	7439-97-6	1	2	-1	-11.6	238.96	-\$2,762	51.64	-\$597	0	2108.27	\$0
MTBE	1634-04-4	0.005 & 2.0	0.1	(-0.095) & 1.9	(-1.1) & 22	16.58	\$-18 to \$32	51.64	\$-56.8 to \$1136	up to -22	2108.27	up to -\$46,382
Naphthalene	91-20-3	0.5 & 0.4	5	(-4.5) & -4.6	(-52) & -53	16.58	(-\$862) to -\$879	51.64	(-\$2685) to -\$2737	0	2108.27	\$0
PAHs (carcinogenic)		20	none	see B(a)P		186.04	\$0	51.64	\$0	0	2108.27	\$0
PCB Mixtures	1336-36-3	10.0	10	0	0	186.04	\$0	51.64	\$0	0	2108.27	\$0
Tetrachloroethylene	127-18-4	0.5	0.05	0.45	5.2	16.58	\$86	51.64	\$269	-5.2	2108.27	-\$10,964
Toluene	108-88-3	40	7	33	381	16.58	\$6,323	51.64	\$19,695	-381	2108.27	-\$804,055
1,1,1 Trichloroethane	71-55-6	20	2	18	208	16.58	\$3,449	51.64	\$10,742	-208	2108.27	-\$438,575
Trichloroethylene	79-01-5	0.5	0.03	0.47	5.4	16.58	\$90	51.64	\$280	-5.4	2108.27	-\$11,452
Xylenes	1330-20-7	20	9	11	127	16.58	\$2,108	51.64	\$6,565	-127	2108.27	-\$268,018
GRO with benzene		100	30	70	809	16.58	\$13,413	51.64	\$41,776	-809	2108.27	-\$1,705,571
GRO w/o benzene		100	100	0	0	16.58	\$0	51.64	\$0	0	2108.27	\$0
DRO		200	2,000	-1,800	-20,803	16.58	-\$344,907	51.64	-\$1,074,247	0	2108.27	\$0
Heavy Oils		200	2,000	-1,800	-20,803	186.04	-\$3,870,120	51.64	-\$1,074,247	0	2108.27	\$0
Mineral Oil		200	4,000	-3,800	-43,917	186.04	-\$8,170,253	51.64	-\$2,267,856	0	2108.27	\$0

Table 3-6 Footnotes:

- (1) From current MTCA table 3. Exceptions: B(a)P = cPAH total divided by 7 (number of cPAHs). For MTBE first value assumes MTBE = PQL as per WAC 173-340-704(2)(c) ; second value assumes MTBE present at 2% in gas and a cleanup level of 100 mg/kg. For naphthalene first value assumes naphthalene = PQL as per WAC 173-340-704(2)(c); second value assumes present in diesel fuel at 0.2% and a cleanup level of 200 mg/kg).
- (2) From table 745-1 in MTCA rule revisions proposed in August 2000.
- (3) Column 1 minus column 2.
- (4) Mass calculated assuming 1/4 acre contaminated area with uniform contamination extending 25 feet to ground water and soil dry density of 1.5 kg/l or 42.45 kg/cf. This is the change in mass of contamination that would have to be removed from the soil at a site to meet the proposed cleanup level (**see Table 3-3**).
- (5) For volatile organics based on median cost of soil vapor extraction reported at 13 federal cleanup sites (**see Table 3-7**). For metals based on cost of soil washing reported at 1 federal cleanup site (**see Table 3-9**). For semi volatile organics and pesticides based on the median cost of thermal desorption at 15 federal cleanup sites (**see Table 3-8**).
- (6) Change in mass removed from soil (column 4) times unit cost of cleanup (column 5). Positive number is increase in soil cleanup costs, negative number is savings in soil cleanup costs.
- (7) Disposal at a landfill based on data from Ecology site files (**Table 3-10**).
- (8) Change in mass removed from soil (column 4) times unit cost of cleanup (column 7). Positive number is increase in soil cleanup costs, negative number is savings in soil cleanup costs.
- (9) Decrease in mass needing removal from ground water to achieve ground water cleanup level as a result of new soil cleanup levels (**see Table 3-3**).
- (10) Based on median cost of ground water cleanup at 26 sites, expressed as a cost per kg of contaminants removed (**see Table 3-11**).
- (11) Change in mass removed from ground water times unit cost of cleanup. This is the savings in ground water cleanup costs.

Table 3-7: Cost of Soil Vapor Extraction (SVE) – Compiled from Federal Cleanup Sites

	Site Name & Location	Contaminants	Contaminant Mass Removed (Pounds)	Capitol Cost Dollars	Operating Cost Dollars	Months of Operation	Total Capitol & Operating Costs (\$)	Cost per Pound of Mass Removed (\$)	Cost per Kilogram of Mass Removed (\$)
1	Basket Creek, GA	TCE, PCE, toluene,xylene, methyl ethyl ketone, methyl isobutyl ketone	1,571	na	na	6	660,000	9.20	4.17
2	Davis-Monthan AFB, AZ	JP-4	585,700	162,000	45,000	16	207,000	0.35	0.16
3	Fairchild Semiconductor, CA	TCA, 1,1,1 TCE, 1,1,DCE, PCE, xylene, freon 113, acetone, isopropyl alcohol	16,000	2,100,000	1,800,000	16	3,900,000	243.75	110.56
4	Hastings Well #3, NB	Carbon Tet	600	210,378	159,250	12	369,628	616.05	279.43
5	Hill AFB, UT	JP-4	211,000	335,000	132,000	24	335,024	1.59	0.72
6	Intersil/Siemens, CA	TCE	3,000	550,000	220,000	60	770,000	256.67	116.42
7	Luke AFB, AZ	TPH (JP-4 and lub oils), BTEX, MEK	12,000	297,017	210,168	6	507,185	42.27	19.17
8	Rocky Mt Arsenal, OU 18	TCE, PCE, toluene,xylene, methyl ethyl ketone, methyl isobutyl ketone	70	75,600	88,490	5	164,090	2,344.14	1,063.29
9	Sacramento Army Depot, CA	TCE,PCE, 1,2 DCE	138	231,127	439,384	14	670,511	4,858.78	2,203.91
10	Sand Creek, CO	Chloroform, methylene chloride, TCE, PCE, TPH	176,500	na	na	6	2,058,000	11.70	5.31
11	Shaw AFB, SC	JP-4, BTEX	518,000	1,800,000	568,500	19	2,368,500	4.57	2.07
12	Texas Tower Site, Fort Greely, AK	Diesel	1,300	178,530	117,230	24	295,760	227.51	103.20
13	Verona Well Field, MI	19 contaminants including 1,1,1 TCE, PCE	45,000	na	na	54	1,645,281	36.56	16.58
	All projects		Median	264,072		16	Median	42.27	19.17
	All projects		Average	593,965		20	Average	665.63	301.92
						Without projects 8 & 9 (1)	Median	36.56	16.58
						Without projects 8 & 9 (1)	Average	131.84	59.80
						TPH sites only (8, 11, 17, 18)	Median	3.08	1.40
						TPH sites only (8, 11, 17, 18)	Average	58.51	26.54

Source:

Federal Remediation Technologies Roundtable: Cost and Performance Reports. Web-Site: [Http://clu-in.org/remed1.htm](http://clu-in.org/remed1.htm)

Footnote:

(1) Projects 8 & 9 appear to be outliers. This median value was used in subsequent calculations. Note that TPH only projects have a much lower cost.

Table 3-8: Cost of Soil Cleanup Using Low Temperature Thermal Desorption – Compiled from Federal Cleanup Sites

Site Name & Location	Contaminants	Soil or Waste Treated Tons	Capitol Cost	Operating Cost	Total Costs	Cost per Ton of Soil or Waste	Notes		
1 Arlington Blending and Packaging, TN	pesticides, PCP, arsenic	41,431	\$4,293,893	\$62,351	\$4,356,244	\$105.14	1996		
2 FCX Washington, NC	pesticides	13,591			\$1,696,800	\$124.85	1995-96		
3 Ft. Lewis Coal Pilot Plant, WA	cPAHs	104,336			\$7,100,000	\$68.05	1996		
4 Letterkenny Army Depot, PA	VOCs, metals, heavy TPH	22,378			\$5,402,801	\$241.43	1993-94 Results reported as 13,986 cy. Converted using 1.6 ton/cy.		
5 Longhorn Army Ammo Plant, TX	Methylene Chloride, TCE	51,669			\$4,886,978	\$94.58	1997 Reported soil density of 1.6 ton/cy.		
6 McKin Company, ME	BTEX, PAHs	18,400			\$2,900,000	\$157.61	1986-87 Results reported as 11,500 cy. Converted using 1.6 ton/cy.		
7 NAS Cecil Field, FL	BTEX, TPH	11,768			\$1,986,122	\$168.77	1995		
8 Outboard Marine, IL	PCB s	12,755			\$2,474,000	\$193.96	1992		
9 Port Moller, AK	BTEX, GRO, DRO	15,200			\$3,325,000	\$218.75	1995 Results reported as 9,500 cy. Converted using 1.6 ton/cy.		
10 Re-Solve, MA	PCBs	44,000			\$6,800,000	\$154.55	1993-94 Reported soil density of 1.2 ton/cy.		
11 Rocky Flats Trenches T-3 & T-4, CO	VOCs, BTEX, ketones	6,074			\$1,804,337	\$191,144	\$1,328,600	\$218.74	1996 Results reported as 3,796 cy. Converted using 1.6 ton/cy.
12 Sand Creek, CO	pesticides	13,000					\$1,995,481	\$153.50	1994 Reported soil density of 1.6 ton/cy.
13 TH Agriculture & Nutrition, GA	pesticides	4,300					\$849,996	\$197.67	1993 Reported soil density of 1.7 tons/cy.
14 Waldrick Aerospace, NJ	BTEX, VOCs, TPH	5,520					\$3,610,086	\$654.00	1993 Results reported as 3,450 cy. Converted using 1.6 ton/cy.
15 Wide Beach, NY	PCBs	42,000					\$11,600,000	\$276.19	1991
					Median Average	\$168.77	Per ton of soil		
						\$201.85	Per ton of soil		
					Median Average	\$186.04	Per kg of contamination (1)		
						\$222.50	Per kg of contamination (1)		

Source:
Federal Remediation Technologies Roundtable: Cost and Performance Reports. Web-Site: [Http://clu-in.org/remed1.htm](http://clu-in.org/remed1.htm)

Footnote:
(1) Assuming contaminant concentration is 1000 mg/kg, a typical average concentration based on available data at these and other federal sites.

Table 3-9: Cost of Soil Cleanup Using Soil Washing – Compiled from Federal Cleanup Sites

	Site Name & Location	Contaminants	Soil or Waste Treated (Tons)	Mass Treated (Kg)	Total Costs (\$)	Cost per Ton of Soil or Waste (\$/ton)	Cost per Kg of Contaminants (\$/kg)	Notes
1	King of Prussia, NJ	Metals (avg. total metals 1,850 mg/kg)	19,200	32,223	\$7,700,000	\$401.04	\$238.96	1993

Source:
Federal Remediation Technologies Roundtable: Cost and Performance Reports. Web-Site: <http://clu-in.org/remed1.htm>

Table 3-10: Cost of Soil Cleanup Using Excavation and Off-Site Disposal in a Landfill – Compiled from Ecology Bid Data

Site Name & Location	Contaminants	Cost per Ton of Soil \$/Ton	Cost per Kg of Contaminants \$/kg (2)	Notes
Asarco Everett (1)	Metals (arsenic & lead)			
Bidder #1		\$38.00	\$41.89	
Bidder #2		\$44.06	\$48.57	
Bidder #3		\$46.85	\$51.64	
Bidder #4		\$40.00	\$44.09	
Bidder #5		\$52.50	\$57.87	
Bidder #6		\$47.97	\$52.88	
Bidder #7		\$39.00	\$42.99	
Bidder #8		\$60.00	\$66.14	
Bidder #9		\$51.67	\$56.96	
	Median	\$46.85	\$51.64	
	Average	\$46.67	\$51.45	
Other Sites (3)				
K Mart, Everett	TPH	\$30.28		
Vilander Property, Battleground	TPH	\$47.00		
Sequim Bay State Park	TPH	\$45.00		

Footnotes:

- (1) Source: Year 2000 bids on Asarco Everett soil excavation and disposal, Everett WA.
- (2) Assuming 1000 mg/kg, a typical average contaminant concentration at the federal cleanup sites reported in previous tables.
- (3) Ecology site files. Based on this data the Everett bid median appears appropriate to use for a cost estimate.

Table 3-11: Cost of Ground Water Cleanup Using Pump and Treat Systems – Compiled from Federal Cleanup Sites

Site Name & Location	Contaminants	Volume of GW Extracted (Million Gallons)	Contaminant Mass Removed Pounds	Capitol Cost Dollars	Annual Operating Cost Dollars	Years of Operation	Total Operating Costs Dollars
1 Baird and McGuire, MA	VOCs, SVOCs, Pesticides, metals	80	2,100	11,000,000	2,000,000	3.8	7,600,000
2 City Industries, FL	VOCs	151.7	2,700	1,200,000	170,000	3.0	510,000
3 Des Moines, IA	VOCs	4900	30,000	1,600,000	110,000	8.8	968,000
4 Firestone, CA	VOCs	1800	500	4,100,000	1,300,000	6.8	8,840,000
5 French Ltd. TX	VOCs	306	510,000	15,000,000	3,400,000	4.0	13,600,000
6 Gold Coast, FL	VOCs	80	2,000	250,000	120,000	3.7	444,000
7 Intersil, CA	VOCs	36	120	330,000	140,000	7.3	1,022,000
8 JMT Facility RCRA, NY	VOCs	50.1	840	880,000	150,000	9.6	1,440,000
9 Keefe, NH	VOCs	46	68	1,600,000	240,000	4.1	984,000
10 King of Prussia, NJ	VOCs, Metals	151.5	5,400	2,000,000	390,000	2.7	1,053,000
11 La Salle, IL	VOCs, PCBs	23	130	5,300,000	190,000	4.4	836,000
12 Libby, MT	VOCs, SVOCs	15.1	37,000	3,000,000	500,000	5.3	2,650,000
13 Moffett, CA	VOCs	0.284	?				
14 MSWP, AR	VOCs, SVOCs	100.6	800	470,000	91,000	8.3	755,300
15 Mystery Bridge, WY	VOCs	192.8	21	310,000	170,000	3.6	612,000
16 Odessa I, TX	Metals	125	1,100	2,000,000	190,000	4.2	798,000
17 Odessa IIS, TX	Metals	121	130	2,000,000	140,000	4.1	574,000
18 Old Mill, OH	VOCs	13	120	210,000	210,000	7.8	1,638,000
19 SCRDI Dixiana, SC	VOCs	20.6	7	94,000	94,000	4.6	432,400
20 Site A, NY	VOCs	8.4	5,300	290,000	290,000	1.3	377,000
21 Sol Lynn, TX	VOCs	13	5,000	150,000	150,000	3.0	450,000
22 Solid State, MO	VOCs	257	2,700	370,000	370,000	4.2	1,554,000
23 Solvent Recovery Service, CT	VOCs, Metals	32.5	4,300	400,000	400,000	2.9	1,160,000
24 Sylvester/Gilson Road, NH	VOCs, Pesticides, Metals	1200	430,000	1,900,000	1,900,000	9.5	18,050,000
25 US Aviox, MI	VOCs	329	660	180,000	180,000	3.4	612,000
26 United Chrome, OR	Metals	62	31,000	3,300,000	96,000	8.6	825,600
27 USCG Center, NC	VOCs, Metals	2.6	?				
28 Western Processing, WA	VOCs, Metals	974	100,000	15,000,000	4,400,000	8.2	36,080,000

Source:

Groundwater Cleanup: Overview of Operating Experience at 28 Sites. EPA 542-R-99-006, September 1999.

Table 3-11: Cost of Ground Water Cleanup Using Pump and Treat Systems – Compiled from Federal Cleanup Sites (continued)

Site Name & Location	Total Capital & Operating Costs (\$)	Cost per Pound of Mass Removed (\$)	Cost per Kg of Mass Removed (\$)
1 Baird and McGuire, MA	18,600,000	\$8,857.14	\$19,526.63
2 City Industries, FL	1,710,000	\$633.33	\$1,396.26
3 Des Moines, IA	2,568,000	\$85.60	\$188.72
4 Firestone, CA (1)	12,940,000	\$25,880.00	\$57,055.57
5 French Ltd. TX	28,600,000	\$56.08	\$123.63
6 Gold Coast, FL (1)	694,000	\$347.00	\$765.00
7 Intersil, CA	1,352,000	\$11,266.67	\$24,838.72
8 JMT Facility RCRA, NY	2,320,000	\$2,761.90	\$6,088.95
9 Keefe, NH	2,584,000	\$38,000.00	\$83,775.56
10 King of Prussia, NJ	3,053,000	\$565.37	\$1,246.43
11 La Salle, IL	6,136,000	\$47,200.00	\$104,058.06
12 Libby, MT	5,650,000	\$152.70	\$336.65
13 Moffett, CA			
14 MSWP, AR	1,225,300	\$1,531.63	\$3,376.65
15 Mystery Bridge, WY	922,000	\$43,904.76	\$96,793.32
16 Odessa I, TX	2,798,000	\$2,543.64	\$5,607.75
17 Odessa IIS, TX	2,574,000	\$19,800.00	\$43,651.48
18 Old Mill, OH	1,848,000	\$15,400.00	\$33,951.15
19 SCRDI Dixiana, SC	526,400	\$75,200.00	\$165,787.42
20 Site A, NY	667,000	\$125.85	\$277.45
21 Sol Lynn, TX	600,000	\$120.00	\$264.55
22 Solid State, MO	1,924,000	\$712.59	\$1,571.00
23 Solvent Recovery Service, CT	1,560,000	\$362.79	\$799.82
24 Sylvester/Gilson Road, NH	19,950,000	\$46.40	\$102.28
25 US Aviex, MI	792,000	\$1,200.00	\$2,645.54
26 United Chrome, OR	4,125,600	\$133.08	\$293.40
27 USCG Center, NC			
28 Western Processing, WA	51,080,000	\$510.80	\$1,126.12
	Median	\$956.30	\$2,108.27
	Average	\$11,438.36	\$25,217.24

Table 3-12: Summary of Method A Ground Water Cleanup Levels

Hazardous Substance	CAS No.	Method A Cleanup Level (ug/l)		Basis for Proposed Cleanup Level
		Current	Proposed	
Arsenic	7440-38-2	5	5	Natural background--MCL exceeds allowable risk.
Benzene	71-43-2	5	5	MCL
Benzo(a)Pyrene	50-32-8	none	0.1	MCL adjusted to 1 X 10 ⁻⁵ risk. This can also be used as the total toxic equivalents for all cPAHs. See WAC 173-340-708(8).
Cadmium	7440-43-9	5	5	MCL
T Chromium	7440-47-3	50	50	Method B--based on Chromium VI. (1)
Chromium VI	18540-29-9	none	none	
Chromium III	16065-83-1	none	none	
DDT	50-29-3	0.1	0.3	Method B (current Method A value appears to be in error)
1,2 Dichloroethane	107-06-2	5	5	MCL
Ethylbenzene	100-41-4	30	700	MCL
Ethylene dibromide	106-93-4	0.01	0.01	Method B adjusted to PQL--MCL exceeds allowable risk.
Lead	7439-92-1	5	15	MCL
Lindane	58-89-9	0.2	0.2	MCL
Methylene chloride	75-09-2	5	5	MCL
Mercury (inorganic)	7439-97-6	2	2	MCL
MTBE	1634-04-4	none	20	Lower limit of EPA Advisory level
Naphthalenes	91-20-3	none	160	Method B for naphthalene. This is a total of all naphthalene, 1-Methyl naphthalene & 2-Methyl Naphthalene in the water.
PAHs(carcinogenic)(1)	na	0.1	none	Replaced by Benzo(a)Pyrene, above.
PCB mixtures	1336-36-3	0.1	0.1	Method B adjusted to PQL (MCL exceeds MTCA allowable HQ and cancer risk). This is a total for all PCBs.
Tetrachloroethylene	127-18-4	5	5	MCL
Toluene	108-88-3	40	1000	MCL
TPH (total)	14280-30-9	1,000	none	Replaced with TPH for specific products.
Gasoline	6842-59-6		1,000	Equation 720-3, assuming no benzene is present in gasoline contaminated water.
GRO w/o benzene			800	Equation 720-3, assuming benzene restored to 5 ug/l.
GRO with benzene			500	Equation 720-3.
Diesel			500	Equation 720-3.
Heavy Oils			500	Equation 720-3.
Electrical Insulating Oil			500	Equation 720-3.
1,1,1 Trichloroethane	71-55-6	200	200	MCL
Trichloroethylene	79-01-6	5	5	MCL
Vinyl Chloride	75-01-4	0.2	0.2	MCL adjusted to 1 X 10 ⁻⁵ risk.
Xylene (total)	1330-20-7	20	1000	Not to exceed total TPH for gasoline & aesthetic considerations (odor)
Gross Alpha Particle Act.		15 pCi/l	15 pCi/l	MCL.
Gross Beta Particle Act.		4 mrem/yr	4 mrem/yr	MCL (4 mrem/yr equals 50 pCi/l)
Radium 226 & 228		5 pCi/l	5 pCi/l	MCL
Radium 226		3 pCi/l	3 pCi/l	MCL

(1) If just chromium III is present at site, may use MCL of 100 ug/l.

Table 3-13: Method A Ground Water Cleanup Levels – Calculation of Change in Cleanup Costs

Hazardous Substance	CAS Number	Method A Cleanup Levels (ug/l)		Difference (ug/l)	Change in Mass Removed from GW at a site (kg) (1)	Unit Cost of GW Remediation (\$/kg) (2)	Increase in Cost OR (Savings) for GW Remediation (\$) (3)
		Current Rule	Proposed Rule				
Arsenic	7440-38-2	5.0	5	0	0	2,108.27	-
Benzene	71-43-2	5	5	0	0	2,108.27	-
Benzo(a)Pyrene (4)	50-32-8	0.01	0.1	0.09	-0.00095	2,108.27	(2.01)
Cadmium	7440-43-9	5	5	0	0	2,108.27	-
Chromium (total)	7440-47-3	50.0	50	0	0	2,108.27	-
Chromium VI	18540-29-9	None	50	0	0	2,108.27	-
Chromium III	16065-83-1	None	100	50	-0.53	2,108.27	(1,118.22)
DDT	50-29-3	0.1	0.3	0.2	-0.0021	2,108.27	(4.47)
1,2 Dichloroethane	107-06-2	5	5	0	0	2,108.27	-
Ethylbenzene	100-41-4	30.0	700	670	-7.11	2,108.27	(14,984.16)
Ethylene dibromide (EDB)	106-93-4	0.01	0.01	0	0	2,108.27	-
Lead	7439-92-1	5.0	15	10	-0.106	2,108.27	(223.64)
Lindane	58-89-9	0.2	0.2	0	0	2,108.27	-
Methylene chloride	75-09-2	5	5	0	0	2,108.27	-
Mercury (inorganic)	7439-97-6	2	2	0	0	2,108.27	-
MTBE (5)	1634-04-4	1	20	19	-0.20	2,108.27	(424.92)
Naphthalene (6)	91-20-3	1	160	159	-1.69	2,108.27	(3,555.94)
PAHs (carcinogenic)		0.1	none	see B(a)P			
PCB Mixtures	1336-36-3	0.1	0.1	0	0	2,108.27	-
Tetrachloroethylene	127-18-4	5.0	5	0	0	2,108.27	-
Toluene	108-88-3	40.0	1000	960	-10.18	2,108.27	(21,469.84)
TPH (total)	14280-30-9	1000	none	see below			
Gasoline range organics	6842-59-6						
GRO with benzene		1000	800	-200	2	2,108.27	4,472.88
GRO w/o benzene		1000	1000	0	0.00	2,108.27	-
Diesel Range Organics		1000	500	-500	5.30	2,108.27	11,182.21
Heavy Oils		1000	500	-500	5.30	2,108.27	11,182.21
Electrical Insulating Mineral Oil		1000	500	-500	5.30	2,108.27	11,182.21
1,1,1 Trichloroethane	71-55-6	200	200	0	0	2,108.27	-
Trichloroethylene	79-01-5	5.0	5	0	0	2,108.27	-
Vinyl Chloride		0.2	0.2	0	0	2,108.27	-
Xylenes	1330-20-7	20.0	1000	980	-10.40	2,108.27	(21,917.12)
Gross Alpha Particle Activity		15 pCi/l	15 pCi/l	0	0	2,108.27	-
Gross Beta Particle Activity		4 mrem/yr	4 mrem/yr	0	0	2,108.27	-
Radium 226 & 228		5 pCi/l	5 pCi/l	0	0	2,108.27	-
Radium 226		3 pCi/l	3 pCi/l	0	0	2,108.27	-

Footnotes:

- (1) Mass calculated assuming 1 acre site with uniform ground water contamination, an aquifer thickness of 20 ft. and soil porosity of 0.43. This is the change in mass of contamination that would have to be removed from the ground water at a site to meet the proposed cleanup level.
- (2) Source: Ground Water Cleanup: Overview of Operating Experience at 28 Sites, EPA 542-R-99-006, September 1999.
- (3) Current concentration is PAH value of 1 divided by 7 (number of cPAHs).
- (4) Current concentration is based on PQL as per WAC 173-340-704(1)(c).
- (5) Current concentration is based on PQL as per WAC 173-340-704(1)(c).

Chapter 4 Technical Analysis – Probable Benefits of the Proposed Method A Soil and Ground Water Cleanup Levels

4.1 Introduction

The primary impact of the proposed rule amendments on benefits results from the proposed changes to the soil and ground water cleanup levels in the Method A tables. The proposed changes to the Method A soil cleanup levels, and the basis for those changes, are described in **Table 3-1 and Table 3-2**. The proposed changes to the Method A ground water cleanup levels, and the basis for those changes, are described in **Table 3-12**. Further description of the proposed changes and the potential impact of those proposed changes is presented in **Chapter 2**.

The impact of the proposed rule amendments on benefits depends on several factors. First, the impact depends on whether the proposed Method A cleanup levels are more stringent or less stringent than under the current rule. Less stringent cleanup levels are expected to reduce the cost of cleanup. **See Section 4.2**. More stringent cleanup levels are expected to improve the quality of ground water and, thereby, enhance the value of the ground water (maintain the most beneficial uses) and reduce the risk of adverse health effects associated with exposure to contaminated ground water. **See Section 4.3**.

Second, the impact is dependent on the remedy selected. Neither the costs nor the benefits of cleanup are directly related to the establishment of cleanup levels. Rather, the costs and benefits of cleanup are dependent on the remedy selected. For this analysis, as with the cost analysis, Ecology assumed that a more permanent cleanup action that removes contaminants from the soil or ground water was conducted. This assumption is a conservative assumption that provides a high bound estimate of the potential differential in the costs and benefits of cleanup.

4.2 Less Stringent Cleanup Levels

The primary benefit of less stringent soil and ground water cleanup levels is the expected reduction in the cost of cleanup. Less stringent cleanup levels are expected to require less contaminant removal, resulting in a decrease in the cost of cleanup. This decrease is an avoided cost or savings.

4.2.1 Soil Cleanup Levels

Less stringent soil cleanup levels are expected to require less contaminant removal, resulting in a decrease in the cost of soil cleanup. This decrease is an avoided cost or savings. The impact of less stringent Method A soil cleanup levels on cleanup costs was analyzed **Chapter 3**. The results of this analysis are presented in **Section 3.2.3.3**.

4.2.2 Ground Water Cleanup Levels

Less stringent ground water cleanup levels are expected to require less contaminant removal, resulting in a decrease in the cost of ground water cleanup. This decrease is an avoided cost or savings. The impact of less stringent Method A ground water cleanup levels on cleanup costs was analyzed **Chapter 3**. The results of this analysis are presented in **Section 3.3.3.3**.

4.3 More Stringent Cleanup Levels

The primary benefit of more stringent soil and ground water cleanup levels is the expected reduction in the amount of contaminants in the ground water. Several independent approaches were used to quantify the probable benefits of the more stringent cleanup levels. First, because more stringent soil cleanup levels could result in less ground water cleanup, the potential avoided cost or savings in ground water cleanup was calculated. **See Section 4.3.1**. Second, the benefit of less ground water contamination was estimated by calculating the potential avoided cost of municipal ground water treatment. **See Section 4.3.2**. Third, the benefit of less ground water contamination was estimated by calculating the value of ground water based on water rates charged by municipalities and the value of the water rights. **See Section 4.3.3**. Fourth, the health benefit of less ground water contamination was estimated by calculating the reduced risk of adverse health effects (including cancer) and the avoided costs associated with avoiding those adverse health effects. **See Section 4.3.4**.

4.3.1 Avoided Cost of Ground Water Cleanup – Soil Cleanup Levels ONLY

The impact of more stringent Method A soil cleanup levels on cleanup costs may be offset by a corresponding decrease in the cost of ground water cleanup. For this analysis, Ecology assumed that because the more stringent Method A soil cleanup levels are based on protection of ground water, the removal of additional contaminants from the soil will reduce the amount of contaminants reaching and requiring removal from the ground water. The impact of more stringent soil cleanup levels on the costs of ground water cleanup was analyzed in **Chapter 3**. The results of this analysis are presented in **Section 3.2.4.3**.

4.3.2 Avoided Municipal Ground Water Treatment Costs

Another approach to quantifying the benefits of less ground water contamination is to estimate the avoided cost of ground water treatment at municipal water wells. To estimate the potential avoided cost, Ecology considered the cost of ground water treatment at three municipal water treatment systems found in Washington State. **See Table 4-1**. Using this approach, it appears a reasonable range of capital costs for such systems is between **\$2 million and \$4 million** with annual operating expenses expected to be about **\$100,000 per year**. This estimate of probable benefits exceeds the increased probable cost of soil cleanup described in **Section 3.2** and the increased probable cost of ground water cleanup described in **Section 3.3**.

4.3.3 Avoided Reduction in Value of Ground Water

Another approach to quantifying the benefits of less ground water contamination is to estimate the avoided reduction in the value of ground water. To estimate the potential avoided reduction in value, water rates charged by municipalities and the value of the water rights were examined.

See **Tables 4-2 and 4-3**. The same model site described under **Section 3.3** and used to evaluate the cost of ground water cleanup was used for this calculation.

Based on water rates charged by municipalities, the **annual** value or benefit of the ground water would be **\$7,800** for this model site. Based on the value of water rights, the **annual** value or benefit of the ground water would be **\$10,320 to \$12,900** for this model site.

The total value or benefit is based on the value lost during the restoration time. Experience to date has shown that it can take 10 to 20 years or longer to restore ground water once it has become contaminated. Based on this time estimate for ground water restoration, the value or benefit of ground water lost during this restoration time would be in the range of **\$78,000 to \$258,000** at the model site. This range of probable benefits exceeds the estimated increased probable cost of soil cleanup described in **Section 3.2** and the increased probable cost of ground water cleanup described in **Section 3.3**.

4.3.4 Health Benefits

Another approach to quantifying the benefits of less ground water contamination is to estimate the benefits of a reduction in the risk of adverse health effects associated with exposure to contaminated ground water. To quantify the health benefits, Ecology calculated the reduced risk of adverse health effects (including cancer) for each hazardous substance of concern, determined the range of adverse health effects attributable to those hazardous substances, and calculated the cost of a single incidence (unit cost) of those adverse health effects. Based on assumptions regarding the exposed population, Ecology also attempted to calculate the number of avoided incidences of cancer. Based on this further estimate, Ecology also attempted to calculate the value of reducing risks of excess cancer mortality.

4.3.4.1 Estimates of Reduced Health Risks

For Method A soil cleanup levels, ground water contaminant concentrations resulting from the current and proposed Method A soil cleanup levels were first predicted for both unrestricted land use and industrial land use using the methods described in WAC 173-340-747 of the proposed rule. See **Tables 4-7 through 4-14**.

The hazard quotient and cancer risk at these concentrations were then calculated. This calculation assumes that the ground water is used or has the potential to be used as a source of drinking water. See **Tables 4-15 through 4-22**.

The reduction in cancer risks and hazard quotients resulting from the adoption of the more stringent soil cleanup levels were then calculated. See **Table 4-5** for unrestricted land use and **Table 4-6** for industrial land use.

The proposed Method A ground water cleanup level for several hazardous substances also result in significant reductions in the risk of non-cancer health effects. These include gasoline with benzene, diesel range organics, and heavy oils.

4.3.4.2 Estimates of Reduced Morbidity: Cancer Health Effects

For carcinogens, the calculations show that adopting the proposed more stringent soil cleanup levels will decrease the risk of cancer incidence by anywhere from 0.3×10^{-6} to $5,283 \times 10^{-6}$. **See Table 4-4.** In other words, adoption of the more stringent soil cleanup levels will reduce the potential that a person drinking ground water will contract cancer.

The reduction in risk is significant because in Washington State an estimated **3.1 million persons** rely on ground water as their source of drinking water (OFM, 1999a). Based on the assumption that 3.1 million persons have the potential to be exposed to contaminated drinking water during their lifetime, the reduction in risk could result in anywhere from about **21 to 1,469 fewer persons** contracting some form of cancer, depending on the hazardous substance. **See Table 4-4.** This estimate is based on the assumption that most sites establish cleanup levels based on unrestricted land use instead of industrial land use.

The assumption that 3.1 million persons have the potential to be exposed to contaminated ground water during their lifetime is based on several considerations. First, 3.1 million persons already rely on ground water as their source of drinking water and a certain percentage of them are exposed to contaminated ground water. Second, exposure to contaminated ground water is expected to increase as the population of the state increases. Third, exposure to contaminated ground water is expected to increase as development density increases, resulting in more water supply wells being subjected to an increased risk of contamination. Fourth, exposure to contaminated ground water is impacted by the mobility of an increasing population over time.

The range of adverse health effects or cancers attributable to exposure to the hazardous substances with more stringent cleanup levels is significant. **See Table 4-23.** The estimated **cost of a single incidence** is about **\$22,000** for all cancers (non-fatal) and **\$41,000** for lung cancer (non-fatal).

4.3.4.3 Estimates of Reduced Morbidity: Non-Cancer Health Effects

For non-carcinogens, the calculations show that adopting the proposed more stringent soil cleanup levels will significantly decrease the risk of non-cancer health effects (hazard quotient). **See Tables 4-5 and 4-6.** The proposed Method A ground water cleanup level for several hazardous substances also result in significant reductions in the risk of non-cancer health effects.

In other words, adoption of the more stringent soil cleanup levels will reduce the potential that a person drinking ground water will experience adverse health effects. The reduction in risk is significant because in Washington State an estimated **3.1 million persons** rely on ground water as their source of drinking water (OFM, 1999a).

The range of adverse health effects attributable to exposure to the hazardous substances with more stringent cleanup levels is significant. Attributable adverse health effects include adverse effects on the nervous system, respiratory system, cardiovascular system, liver, and kidney. **See Table 4-23.**

The estimated **cost of a single incidence** of these adverse health effects ranges from about **\$6,000 to \$200,000**. Two methods were used to estimate the avoided cost of the identified adverse health effects – the cost of illness approach and the willingness to pay or contingent valuation approach. **See Table 4-23.**

The cost of illness (COI) approach accounts for the direct costs of medical treatment and the foregone output (measured by income) of affected persons who are unable to work due to illness. This approach has the advantage of utilizing regularly collected and available data, but tends to underestimate the total avoided cost by either underestimating or failing to account for several costs. The costs not accounted for include the following:

- The COI approach underestimates the cost of illness for persons not conventionally employed (e.g., housekeepers, the young, retired persons and others not earning income from current economic activity).
- The COI approach does not account for the “disutility of illness” (i.e., pain and suffering).
- The COI approach does not account for averting or defensive expenditures (e.g., home water filtration systems).
- The COI approach does not account for productivity losses (e.g., affected person goes to work but is not as efficient as when healthy).
- The COI approach does not account for “quality of life” effects. These effects may include reduced ability to engage in occupational or recreational activities or reductions in general enjoyment of leisure time.

The willingness to pay approach, by contrast, elicits or infers values for reductions in or avoidance of ill health in ways that – in principle – incorporate some or all of the above. Methods used typically include surveys, labor market studies, and others.

4.3.4.4 Estimates of Reduced Mortality – Cancer

Many of the adverse health effects attributable to the hazardous substances of concern could result in death. Principally among those is cancer. Based on statistics obtained from the National Cancer Institute, the overall mortality rate of a person who has contracted cancer is 43% (NCI, 2000). Consequently, to quantify the benefits of less ground water contamination, Ecology also estimated the societal benefits of projected reductions in cancer mortality resulting from the reduced risks of cancer incidence attributable to the hazardous substances of concern. To quantify those societal benefits, Ecology attempted to calculate the value of reducing risks of excess mortality on a per person basis. This calculation is based on information obtained from several sources, including application of the results of a previously published contingent valuation study. The resulting average (best) estimate of the social value of reducing excess cancer mortalities is **\$47 million**. This average (best) estimate is bounded by a **range from \$16 million to \$99 million**.

The following discussion provides a summary of the methodology used and assumptions made in calculating the value of reducing risks of excess mortalities on a per person basis. Further discussion of the methodology employed to generate these results, as well as a description of

alternative approaches examined by Ecology and tests of the sensitivity of the results to varying assumptions about parameter values can be found in **Chapter 8**.

- (1) **Exposed Population:** Ecology assumed that 3.1 million persons have the potential to be exposed to contaminated drinking water during their lifetime. This assumption is based on several considerations. **See Section 4.3.4.2.**
- (2) **Reduction in Cancer Risk:** The reduction in cancer risk for each hazardous substance of concern was calculated by determining the cancer risk at the current and proposed cleanup levels. **See Tables 4-5 and 4-6.** The calculations show that adopting the proposed more stringent cleanup levels will decrease the risk of cancer incidence by anywhere from 0.3×10^{-6} to $5,283 \times 10^{-6}$. **See Table 4-4.** In other words, adoption of the more stringent cleanup levels will reduce the potential that a person drinking ground water will contract cancer.
- (3) **Reduction in Cancer Incidence:** The reduction in cancer incidence for each hazardous substance of concern was calculated by multiplying the exposed population (3.1 million persons) by the cancer risk at the current and proposed cleanup levels. The calculations show that the reduction in the number of persons contracting cancer ranged from 21 to 1,469 (based on the changes to the soil cleanup levels for unrestricted land use) and 0.8 to 16,377 (based on the changes to the soil cleanup levels for industrial land use). **See Table 4-4.**
- (4) **Mortality Rate:** The overall mortality rate of a person who has contracted cancer (all sites/both sexes/all races) is estimated to be 43%. This estimate is based on cancer incident and mortality statistics obtained from the National Cancer Institute (NCI, 2000). Other studies have cited cancers of the colon, rectum, and bladder as most likely outcomes from consumption of contaminated ground water. However, the conditional mortality rates for these cancers are very close to the overall rate (weighted average of 36.9 percent), and it was judged that the small difference versus the overall rate would serve to pick up other cancer sites not covered by colo/rectal and bladder cancers.
- (5) **Reduction in Cancer Mortality:** The reduction in cancer mortality was calculated by multiplying the number of cancer incidences by the mortality rate of 43%. Since most sites establish soil cleanup levels based on unrestricted instead of industrial land use, estimates of cancer incidence used in this calculation were based only on the proposed soil cleanup levels for unrestricted land use. **See Table 4-24.**
- (6) **Per Unit Benefit Estimates – Central Tendency Analysis:** The calculated reductions in excess deaths were then converted to death rates per 100,000 relevant to the potentially exposed population of 3.1 million in order to facilitate application of a contingent valuation study. The analysis of excess mortalities avoided employed a “central tendency” approach. The central value was determined by calculating the average of potential excess mortalities avoided across all hazardous substances of concern. Ranges about such central values are generally derived via calculation of conventional statistical confidence intervals. However, the extent and nature of the data set available for this

analysis did not permit this. Instead, the end points on the range used here are the calculated 5th and 95th percentile values of the available data. A valuation mechanism derived from research by duVair and Loomis (described below) was then used to assign monetary values (1998 dollars per death averted per year) to the central value and the end points of the range described here. The results are an average (best) estimate of **\$2.2 million**, a low-end range value of **\$0.74 million**, and a high-end range value of **\$4.6 million** when extrapolated over all Washington households. See **Table 4-24**.

The study by duVair and Loomis, entitled “Household’s Valuation of Alternative Levels of Hazardous Waste Risk Reduction: An Application of the Referendum Format Contingent Valuation Method,” (duVair and Loomis, 1993) used a referendum format in which survey respondents registered a “yes” or “no” response to payment of a preselected amount for a specified result. The study used a single class of pollutant exposure (heavy metals) as the contingent event. The reported results also allowed for the derivation of a (theoretically well-behaved) “willingness to pay” function generalizable to excess death reductions other than those specifically considered in their analysis.

(7) **Discounting and Income Elasticity Adjustments:** The results derived from the central tendency analysis described above were further adjusted in the following ways:

- **Discounting Adjustment:** It was judged that a discounted present value of the streams of annual benefits derived above would more closely correspond, temporally and conceptually, to the costs incurred in a typical cleanup at a model site as described in Chapter 3. This adjustment used a discount rate of 5.5 percent (reflecting a modest degree of risk tolerance) and a time horizon of 35 years. The former is based on the rate of return on treasury securities. The latter is based on an assumed average affected population life expectancy of 70 years. Hence, a typical individual would have a remaining life expectancy of 35 years. The resulting lump sum discounted present values for all Washington households are an average value of **\$33.3 million** with **\$11.3 million** and **\$70.4 million** at the low and high ends of the range described above. See **Table 4-25**.
- **Income Elasticity Adjustment:** There appears to be substantial evidence that willingness to pay for reduced risks to life and health varies directly with income, although there is less agreement about the magnitude of this effect. The benefit estimates described here are, of course, in constant 1998 dollars. However, both history and best available forecasts indicate that real income has risen over time and will continue to do so. Thus, it seems appropriate to take this relationship into account. This adjustment, applied to the results described above, uses a projected 2.5 percent growth rate for Washington real personal income (Office of the Forecast Council, 2000) and an income elasticity coefficient equal to 1.0 (Viscusi, 1993, p. 1930). (This assumes that willingness to pay for reduced risks change at the same rate as real income.) The results are an average (best) estimate of **\$47.0 million** (discounted, elasticity adjusted present value) bracketed by low and high estimates of **\$16.0 million** and **\$99.3 million** respectively. See **Table 4-26**.

In addition to the approach just discussed, Ecology also estimated the value of reducing risks of excess mortality on a per person basis using an alternative approach. This approach was developed for and discussed in the October 2000 draft of this document. That approach was based on the incremental undiscounted dollars of avoided mortalities per year for Washington State households with each substance evaluated independently and the resulting values aggregated over all substances. This approach and subsequent sensitivity analysis resulted in a range of values from **\$10 million to 32 million** with an average or best estimate of **\$18 million**.⁶

4.3.4.5 Conclusions

Based on quantitative estimates of (1) the reduction in risk of adverse health effects, (2) the range of adverse health effects attributable to the hazardous substances of concern, (3) the cost of even a single incidence of these adverse health effects, and (4) the exposed population, Ecology has determined that the probable benefits of adopting the more stringent cleanup levels are significant in comparison with the probable costs. The probable avoided cost of even a single incidence of these adverse health effects range from **\$6,000 to \$200,000**. If these adverse health effects should result in even a single death, the probable avoided cost increases to about **\$47 million**, the value of reducing risks of excess mortality on a per person basis (discounted present value based on the results of the central tendency analysis and adjusted for income growth).

4.3.5 Other Benefits

In addition to the health-related benefits considered previously, additional benefits potentially accrue to the proposed more stringent soil and ground water cleanup levels. Although these were not quantified in monetary terms in this analysis, it is useful to be aware of their existence. Examples (but far from an exhaustive listing) include:

- Ecological benefits – protection of fish and other aquatic life, especially when ground and surface waters are connected, as well as terrestrial wildlife.
- Public perceptions and acceptance of drinking water.
- Property values – the market values of property in proximity to contaminated sites may be adversely affected and, conversely enhanced when sites are cleaned up.
- Active use values – protection/enhancement of general recreational use of water and land.
- Aesthetics – elimination of adverse sensory effects of contamination.

⁶ The best estimate of \$18 million is the estimate included in the Draft Report (October 2000) and assumes mortalities from substances earlier in the analysis sequence are already accounted for. Extrapolation over all Washington households allows for generalized altruism. The high-end estimate of \$32 million assumes that cancer mortality estimates for each substance are valued independently and completely by all Washington households. The benefit estimate is sum of estimated benefits for all substances considered. This evaluation assumes a distinction between initial deaths for each substance and generalized altruism. The low-end estimate of \$10 million assumes that households not using groundwater have low or zero willingness to pay to avoid risks of mortality. Benefit estimates are derived by extrapolation over households in a potentially exposed population of 3.1 million. Benefits are aggregated over all substances considered. Altruism is assumed to exist only within the potentially exposed population.

- “Bequest” benefits – satisfaction of knowing that the environment is protective of current generations and protected for future generations.
- Passive use values – option value, etc. (in addition to benefits accruing to active use).

Further discussion of ecological benefits and the public perceptions and acceptance of drinking water is provided below.

4.3.5.1 Ecological Effects

Ecological effects are not quantified in this benefits assessment. However, they are anticipated to occur at levels of severity that are in proportion to the levels of soil and ground water contamination that occur. The avoidance of ecological effects resulting from the proposed rule constitutes a non-quantified benefit of the proposed rule.

The hazardous substances of concern have numerous ecological effects on multiple biological systems, as indicated in **Table 4-23**. While there are differences in the function and disease introduction between humans and animals, there are also striking similarities. The anatomy and physiology of most animal systems share many common elements, including most of the basic organ systems and biochemical processes. Effects observed in humans are generally assumed to be similar to those observed in animals, with the exception of higher cognitive functions. This is the basis for the extensive animal laboratory testing programs and requirements that are used to evaluate the toxicity of chemicals on humans.

It is likely that most of the effects observed in humans will also be observed in animals. There are also numerous animal studies that have demonstrated effects in various species. Some of the hazardous substances bioaccumulate and can move through the food chain through a variety of pathways. In addition to damage caused directly on ecological systems, ecological effects may indirectly cause adverse effects in humans, through ingestion of contaminated plants and animals.

4.3.5.2 Drinking Water Quality and Public Perception

It is well established that the public often avoids the use of tap water that is suspected of being contaminated. In this context, contamination may suggest biological, chemical, or other water quality issues. When public perception of water quality declines, consumers purchase bottled water if they have the means to do so. In addition or as an alternative, they may avoid the use of tap water, ingesting and cooking with other liquids, substituting pre-mixed baby formula, and using other strategies to limit ingestion. Consumer avoidance of tap water sources usually results in costs to the consumers, either in the cost of obtaining substitute fluids or potential health impacts of reduced fluid intake. In addition, there are numerous cases where government agencies have provided bottled water due to biological or chemical contamination. The levels of contamination at which the government activities occur vary depending on a variety of factors.

The relationship between contaminants in tap water and changes in consumer behavior or government interventions is a complex one. Factors that impact the choice to avoid tap water depends on public information that is provided on levels of contamination, potential health

effects, individual aversions to risk taking, and other considerations. A quantitative evaluation of these responses and the potential benefits of avoiding associated costs to the consumer or governments is not included in this benefits assessment. However, it is clear that many consumers purchase bottled water (a multimillion dollar industry) or invest in other methods of improving drinking water quality, such as point-of-use (POU) devices, specifically to avoid ingestion of contaminants. Thus, it is reasonable to conclude that a reduction in contamination will have the long-term effect of restoring some level of consumer confidence in the water supply.

4.4 Conclusion

The primary benefit of less stringent soil and ground water cleanup levels is the expected reduction in the cost of cleanup. Less stringent cleanup levels are expected to require less contaminant removal, resulting in a decrease in the cost of cleanup. This decrease is an avoided cost or savings. **See Section 4.2.** Adopting less stringent Method A soil cleanup levels could result in small to more substantial decreases in soil cleanup costs ranging from only a **few dollars to \$2 million**, depending on the hazardous substance. **See Tables 3-5 and 3-6.** Adopting less stringent Method A ground water cleanup levels could result in small to moderate decreases in ground water cleanup costs ranging from only a **few dollars to \$22,000**, depending on the hazardous substance. **See Table 3-13.**

The primary benefit of more stringent soil and ground water cleanup levels is the expected reduction in the amount of contaminants in the ground water. Several independent approaches were used to quantify the probable benefits of the more stringent cleanup levels. First, because more stringent soil cleanup levels could result in less ground water cleanup, the potential avoided cost or savings in ground water cleanup was calculated. **See Section 4.3.1.** Second, the benefit of less ground water contamination was estimated by calculating the potential avoided cost of municipal ground water treatment. **See Section 4.3.2.** Third, the benefit of less ground water contamination was estimated by calculating the value of ground water based on water rates charged by municipalities and the value of the water rights. **See Section 4.3.3.** Fourth, the health benefit of less ground water contamination was estimated by calculating the reduced risk of adverse health effects (including cancer) and the avoided costs associated with avoiding those adverse health effects. **See Section 4.3.4.** Based on each of these approaches, Ecology determined that the probable benefits of the more stringent cleanup levels exceeded the probable costs.

4.5 Calculations

Table 4-1: Capital and Operating Costs for Contaminated Municipal Well Treatment Systems

Site	Contaminant	Treatment Method	Capital Cost (\$)	Annual Operating Cost (\$)	Year
Well 12 A	VOCs	Air Stripping	1,000,000	100,000	1983
Lakewood	VOCs	Air Stripping	1,290,000	90,000	1985
Tumwater	VOCs	Air Stripping	3,770,478	60,000	1999

Table 4-2: Calculation of Value of Ground Water Based on Value of Water Right

Typical range = \$1200 to \$1500 per acre-ft/year (1)

Assuming a 1 acre area of ground water contamination and a 20 ft thick aquifer with a porosity of 0.43, the **one year** value of this ground water would be calculated as follows.

1 acre X 20 ft thickness X 0.43 porosity X \$1200/acre ft = \$10,320/year

1 acre X 20 ft thickness X 0.43 porosity X \$1500/acre ft = \$12,900/year

Assuming it would take 10 years to restore the ground water to useable quality, the value is:

10 year value: **\$103,200 to \$129,000**

Assuming it would take 20 years to restore the ground water to useable quality, the value is:

20 year value: **\$206,400 to \$258,000**

(1) Source: Personnal communication with Kathy Callison, City of Tumwater Public Works Department.

Table 4-3: Calculation of Value of Ground Water Based on Water Rates

Another measure of the value of clean water is how much is charged by water utilities for this water. This includes well development, water treatment, storage and distribution costs as well as administrative costs. Thus, it could be viewed as the value if the water system had to be replaced due to contamination.

Based on the water rates charged in 15 Washington communities (1), this gives the following range of value:

City	Rate / 1000 cf
Aberdeen	\$26.80
Bellevue	\$21.07
Chehalis	\$27.59
Kelso	\$21.58
Kirkland	\$24.55
Lacey	\$15.01
Long Beach	\$31.74
Mtlake Terrace	\$21.60
Olympia	\$16.91
Port Townsend	\$23.45
Seattle	\$19.30
Shelton	\$19.14
Spokane	\$9.55
Tacoma	\$13.95
Tumwater	\$20.15
Average	\$20.83
Median	\$21.07

(1) Source: City of Tumwater Year 2000 budget report.

Thus, one acre-ft of ground water has an average value of:

$$(43,560 \text{ cf})(\$20.83) / 1,000 \text{ cf} = \$907.36$$

and, one pore volume of ground water at the site has a value of:

$$(1 \text{ acre})(20 \text{ ft})(0.43)(\$907.36/\text{acre-ft}) = \$7,803.25$$

Assuming a 10 year ground water restoration timeframe, the value is:

$$\$7,803.25 * 10 = \mathbf{\$78,032}$$

Assuming a 20 year ground water restoration timeframe, the value is:

$$\$7,803.25 * 20 = \mathbf{\$156,065}$$

Table 4-4: Number of Persons with Potential to Contract Cancer due to Ground Water Ingestion

Hazardous Substance	CAS No.	Method A Soil Cleanup Levels for Unrestricted Land Use		Method A Soil Cleanup Levels for Industrial Land Use	
		Incremental Cancer Risk @ Predicted Concentration (1) (unitless)	Number of persons in WA with Potential to Contract Cancer (2) (persons)	Incremental Cancer Risk @ Predicted Concentration (1) (unitless)	Number of persons in WA with Potential to Contract Cancer (2) (persons)
Arsenic	7440-38-2			5283	16377
Benzene	71-43-2	55	171	55	171
Cadmium	7440-43-9				
T Chromium	7440-47-3				
Chromium III	16065-83-1				
Chromium VI	18540-29-9				
DDT	50-29-3			0.3	0.8
1,2 Dichloroethane	107-06-2				
Ethylbenzene	100-41-4				
Ethylene dibromide (EDB)	106-93-4				
Lead	7439-92-1				
Lindane	58-89-9	474	1469	474	1469
Methylene chloride	75-09-2	19	58	19	58
MTBE	1634-04-4				
Naphthalene	91-20-3				
cPAH Mixtures	na				
PCB mixtures	1336-36-3				
Tetrachloroethylene (PCE)	127-18-4	49	153	49	153
Toluene	108-88-3				
1,1,1 Trichloroethane	71-55-6				
Trichloroethylene	79-01-6	18	55	18	55
Vinyl Chloride	75-01-4				
Xylenes	1330-20-7				
Gasoline range organics	6842-59-6	7	21	7	21

Calculation made only for carcinogens and for soil cleanup levels proposed to become more stringent due to ground water protection concerns.

Footnotes:

- (1) From **Table 4-5**. Expressed in terms of 10⁻⁶ risk, that is, a value of 55 is a risk of 55 X 10⁻⁶. This is the additional risk posed by drinking ground water beneath a site cleaned up to the current Method A soil cleanup levels instead of the proposed method A soil cleanup levels.
- (2) Column 1 multiplied by 3.1 million persons. This is the total excess cancer risk for a population of 3.1 million (the number of persons estimated to rely on ground water for drinking water in WA State*).
- (3) From **Table 4-6**. Expressed in terms of 10⁻⁶ risk, that is, a value of 55 is a risk of 55 X 10⁻⁶. This is the additional risk posed by drinking ground water beneath a site cleaned up to the current Method A soil cleanup levels instead of the proposed Method A soil cleanup levels.
- (4) Column 1 multiplied by 3.1 million persons. This is the total excess cancer risk for a population of 3.1 million (the number of persons estimated to rely on ground water for drinking water in WA State*).

*Source: WA State OFM Environmental Chartbook, June 1999.

Footnotes for Table 4-5:

- (1) From current MTCA table 2. Exceptions: B(a)P = cPAH/7; MTBE first value is PQL and second is assuming 2% MTBE in gasoline contaminated soil cleaned up to 100 mg/kg; naphthalene = PQL as per WAC 173-340-704(2)(c).
- (2) From table 740-1 in MTCA rule revisions proposed in August 2000.
- (3) Column 1 minus column 2. Further calculations only address contaminants with soil cleanup level proposed to decrease due to ground water considerations.
- (4) Predicted using 3 phase model (see **Table 4-7**). For TPH gas, average value predicted using 4-phase model (see **Tables 4-11 and 4-13**)
- (5) Hazard quotient of predicted ground water concentration (see **Table 4-15**).
- (6) Cancer risk at predicted ground water concentration. Expressed in terms of 10⁻⁶ risk, that is, a value of 55 is a risk of 55 X 10⁻⁶ (see **Table 4-17**).
- (7) Predicted using 3 phase model (see **Table 4-8**). For TPH gas, average value predicted using 4-phase model (see **Tables 4-12 and 4-14**)
- (8) Hazard quotient of predicted ground water concentration (see **Table 4-16**).
- (9) Cancer risk at predicted ground water concentration. Expressed in terms of 10⁻⁶ risk, that is, a value of 55 is a risk of 55 X 10⁻⁶ (see **Table 4-18**).
- (10) Column 5 minus column 8.
- (11) Column 6 minus column 9.

Footnotes for Table 4-6:

- (1) From current MTCA table 3. Exceptions: B(a)P = cPAH/7; MTBE first value is PQL and second is assuming 2% MTBE in gasoline contaminated soil cleaned up to 100 mg/kg; naphthalene = PQL as per WAC 173-340-704(2)(c).
- (2) From table 745-1 in MTCA rule revisions proposed in August 2000.
- (3) Column 1 minus column 2. Further calculations only address contaminants with soil cleanup level proposed to decrease due to ground water considerations.
- (4) Predicted using 3 phase model (see **Table 4-9**). For TPH gas, average value predicted using 4-phase model (see **Tables 4-11 and 4-13**)
- (5) Hazard quotient of predicted ground water concentration (see **Table 4-19**).
- (6) Cancer risk at predicted ground water concentration. Expressed in terms of 10⁻⁶ risk, that is, a value of 55 is a risk of 55 X 10⁻⁶ (see **Table 4-21**).
- (7) Predicted using 3 phase model (see **Table 4-10**). For TPH gas, average value predicted using 4-phase model (see **Tables 4-12 and 4-14**).
- (8) Hazard quotient of predicted ground water concentration (see **Table 4-20**).
- (9) Cancer risk at predicted ground water concentration. Expressed in terms of 10⁻⁶ risk, that is, a value of 55 is a risk of 55 X 10⁻⁶ (see **Table 4-22**).
- (10) Column 5 minus column 8.
- (11) Column 6 minus column 9.

Table 4-7: Calculation of Predicted Ground Water Concentration Resulting from Current Method A Soil Cleanup Levels for Unrestricted Land Use using the 3-Phase Model

3-Phase Model Results	CAS No.	Resulting GW Conc (mg/l) (1)	Bulk Density (g/cc) (2)	Soil Water (cc/cc) (2)	Soil Air (cc/cc) (2)	H' (cc/cc) (3)	Koc (ml/g) (3)	Foc (%) (4)	Kd (cc/g) (5)	Dilution Factor (dimensionless)	Current Soil Cleanup Level (mg/kg) (6)
Arsenic	7440-38-2		1.5	0.3	0.13	0	-	-	29	20	
Benzene	71-43-2	0.0888	1.5	0.3	0.13	0.228	61.7	0.1%	0.062	20	0.500
Cadmium	7440-43-9		1.5	0.3	0.13	0	-	-	6.7	20	
Chromium (total)	7440-47-3										
Chromium VI	18540-29-9	0.260416	1.5	0.3	0.13	0	-	-	19	20	100.000
Chromium III	16065-83-1		1.5	0.3	0.13	0	-	-	1000	20	
DDT	50-29-3		1.5	0.3	0.13	0.000332	677,934	0.1%	678	20	
Ethyl Benzene	100-41-4	2.3148	1.5	0.3	0.13	0.323	204	0.1%	0.204	20	20.000
Ethylene dibromide (EDB)	106-93-4		1.5	0.3	0.13	0.0336	66	0.1%	0.066	20	
Lead	7439-92-1		1.5	0.3	0.13	0	-	-	10000	20	
Lindane	58-89-9	0.03222	1.5	0.3	0.13	0.000574	1,352	0.1%	1.4	20	1.000
Methylene Chloride	75-09-2	0.1148	1.5	0.3	0.13	0.0898	10	0.1%	0.010	20	0.500
Mercury (inorganic)	7439-97-6		1.5	0.3	0.13	0.467	-	-	52	20	
MTBE	1634-04-4	0.4705	1.5	0.3	0.13	0.018	11	0.1%	0.011	20	2.000
Naphthalene	91-20-3		1.5	0.3	0.13	0.0198	1,191	0.1%	1.191	20	
cPAH Mixtures	na										
Benzo[a]anthracene	56-55-3		1.5	0.3	0.13	0.000137	357,537	0.1%	358	20	
Benzo[b]fluoranthene	205-99-2		1.5	0.3	0.13	0.00455	1,230,000	0.1%	1,230	20	
Benzo[k]fluoranthene	207-08-9		1.5	0.3	0.13	0.000034	1,230,000	0.1%	1,230	20	
Benzo[a]pyrene	50-32-8		1.5	0.3	0.13	0.0000463	968,774	0.1%	969	20	
Chrysene	218-01-9		1.5	0.3	0.13	0.00388	398,000	0.1%	398	20	
Dibenzo[a,h]anthracene	53-70-3		1.5	0.3	0.13	6.03E-07	1,789,101	0.1%	1,789	20	
Indeno[1,2,3-cd]pyrene	207-08-9		1.5	0.3	0.13	0.0000656	3,470,000	0.1%	3470.00	20	
PCB Mixtures	1336-36-3										
Arochlor 1016	12674-11-2		1.5	0.3	0.13	0.119	107,285	0.1%	107	20	
Arochlor 1260			1.5	0.3	0.13	0.189	822,422	0.1%	822	20	
Tetrachloroethylene (PCE)	127-18-4	0.0471	1.5	0.3	0.13	0.754	265	0.1%	0.265	20	0.500
Toluene	108-88-3	5.501	1.5	0.3	0.13	0.272	140	0.1%	0.140	20	40.000
1,1,1 Trichloroethane	71-55-6	2.5246	1.5	0.3	0.13	0.705	135	0.1%	0.135	20	20.000
Trichloroethylene	79-01-6	0.0756	1.5	0.3	0.13	0.422	94	0.1%	0.094	20	0.500
Xylenes	1330-20-7	2.1873	1.5	0.3	0.13	0.279	233	0.1%	0.233	20	20.000
m-xylene	108-38-3		1.5	0.3	0.13	0.301	196	0.1%	0.196	20	
o-xylene	95-47-6		1.5	0.3	0.13	0.213	241	0.1%	0.241	20	
p-xylene			1.5	0.3	0.13	0.314	311	0.1%	0.311	20	

Footnotes for Table 4-7:

- (1) Predicted ground water concentration from current Method A soil cleanup level. Determined by adjusting value until soil cleanup level matches current rule. No value has been calculated for contaminants with a proposed soil cleanup level that is equal to or higher than the current Method A soil cleanup level.
- (2) From equation 747-1. Based on Soil Screening Guidance: Technical Background Document. EPA/540/R-95/12B. May 1996.
- (3) Source: Soil Screening Guidance: Technical Background Document. EPA/540/R-95/12B. May, 1996. Exceptions are:
 - EDB values from ATSDR Toxicological Profile (TP 91/13);
 - MTBE from USGS final draft report on fuel oxygenates (March, 1996)
 - Arochlor values for Henry's constant and solubility limit from ATSDR Toxicological Profile (Dec, 1998); Arochlor Koc from EPA 1994 draft of soil screening guidance
 - Values for total xylenes are a weighted average of m,o & p xylene based on gasoline composition data from TPH Criterial Working Group--Volume 2 (May 1998). That is: m = 51% of total xylene; o = 28% of total xylene; and , p = 21% of total xylene.
 - H' for all metals except mercury assumed = zero. Mercury H' from EPA Soil Screening Guidance.
- (4) Based on review of data available from the literature and WA State sites.
- (5) From equation 747-2 for organics. For metals, based on review of data available from the literature and WA State sites.
- (6) Current MTCA soil cleanup level. Calculated using equation 747-1 (3-phase model) with model defaults (as shown in this table) and ground water cleanup level shown in this table. For MTBE this is the estimated soil concentration assuming cleanup to 100 ppm TPH-G and 2% MTBE.
- (7) Pore water concentration = ground water cleanup level X dilution factor.
- (8) There is NAPL in the soil if the pore water concentration exceeds the solubility limit.
- (9) C sat is the soil concentration above which there is NAPL in the soil. It is calculated by substituting the solubility limit for the [ground water cleanup level X DF] in equation 747-1.
- (10) Water mass = [Pore water concentration X soil water fraction] / soil bulk density. This is the mass of contaminant in the water phase.
- (11) Vapor concentration = Pore water concentration X Henry's Constant X 1000.
- (12) Vapor mass = [Vapor concentration X soil air fraction] / soil bulk density. This is the mass of contaminant in the vapor phase.
- (13) Soil concentration = Pore water concentration X Kd
- (14) Soil mass = [Pore water concentration X Kd X soil bulk density] / soil bulk density. This is the mass of contaminant in the soil phase.
- (15) Sum mass = water mass + vapor mass + soil mass. This value equals the soil cleanup level.

Table 4-8: Calculation of Predicted Ground Water Concentration Resulting from Proposed Method A Soil Cleanup Levels for Unrestricted Land Use using the 3-Phase Model

3-Phase Model Results	CAS No.	Resulting GW Concentration (mg/l) (1)	Bulk Density (g/cc) (2)	Soil Water (cc/cc) (2)	Soil Air (cc/cc) (2)	H' (cc/cc) (3)	Koc (ml/g) (3)	Foc (%) (4)	Kd (cc/g) (5)	Dilution Factor (dimensionless)	Proposed Soil Cleanup Level (mg/kg) (6)
Arsenic	7440-38-2		1.5	0.3	0.13	0	-	-	29	20	
Benzene	71-43-2	0.0054	1.5	0.3	0.13	0.228	61.7	0.1%	0.062	20	0.030
Cadmium	7440-43-9		1.5	0.3	0.13	0	-	-	6.7	20	
Chromium (total)	7440-47-3										
Chromium VI	18540-29-9	0.05	1.5	0.3	0.13	0	-	-	19	20	19
Chromium III	16065-83-1		1.5	0.3	0.13	0	-	-	1000	20	
DDT	50-29-3		1.5	0.3	0.13	0.000332	677,934	0.1%	678	20	
Ethyl Benzene	100-41-4	0.695	1.5	0.3	0.13	0.323	204	0.1%	0.204	20	6.00
Ethylene dibromide (EDB)	106-93-4		1.5	0.3	0.13	0.0336	66	0.1%	0.066	20	
Lead	7439-92-1		1.5	0.3	0.13	0	-	-	10000	20	
Lindane	58-89-9	0.000325	1.5	0.3	0.13	0.000574	1,352	0.1%	1.4	20	0.0101
Methylene Chloride	75-09-2	0.0047	1.5	0.3	0.13	0.0898	10	0.1%	0.010	20	0.020
Mercury (inorganic)	7439-97-6		1.5	0.3	0.13	0.467	-	-	52	20	
MTBE	1634-04-4	0.0236	1.5	0.3	0.13	0.018	11	0.1%	0.011	20	0.100
Naphthalene	91-20-3		1.5	0.3	0.13	0.0198	1,191	0.1%	1.191	20	
cPAH Mixtures	na										
Benzo[a]anthracene	56-55-3		1.5	0.3	0.13	0.000137	357,537	0.1%	358	20	
Benzo[b]fluoranthene	205-99-2		1.5	0.3	0.13	0.00455	1,230,000	0.1%	1,230	20	
Benzo[k]fluoranthene	207-08-9		1.5	0.3	0.13	0.000034	1,230,000	0.1%	1,230	20	
Benzo[a]pyrene	50-32-8		1.5	0.3	0.13	0.0000463	968,774	0.1%	969	20	
Chrysene	218-01-9		1.5	0.3	0.13	0.00388	398,000	0.1%	398	20	
Dibenzo[a,h]anthracene	53-70-3		1.5	0.3	0.13	6.03E-07	1,789,101	0.1%	1,789	20	
Indeno[1,2,3-cd]pyrene	207-08-9		1.5	0.3	0.13	0.0000656	3,470,000	0.1%	3470.00	20	
PCB Mixtures	1336-36-3										
Arochlor 1016	12674-11-2		1.5	0.3	0.13	0.119	107,285	0.1%	107	20	
Arochlor 1260			1.5	0.3	0.13	0.189	822,422	0.1%	822	20	
Tetrachloroethylene (PCE)	127-18-4	0.0047	1.5	0.3	0.13	0.754	265	0.1%	0.265	20	0.050
Toluene	108-88-3	0.964	1.5	0.3	0.13	0.272	140	0.1%	0.140	20	7.01
1,1,1 Trichloroethane	71-55-6	0.253	1.5	0.3	0.13	0.705	135	0.1%	0.135	20	2.00
Trichloroethylene	79-01-6	0.0045	1.5	0.3	0.13	0.422	94	0.1%	0.094	20	0.030
Xylenes	1330-20-7	0.984	1.5	0.3	0.13	0.279	233	0.1%	0.233	20	9.00
m-xylene	108-38-3		1.5	0.3	0.13	0.301	196	0.1%	0.196	20	
o-xylene	95-47-6		1.5	0.3	0.13	0.213	241	0.1%	0.241	20	
p-xylene			1.5	0.3	0.13	0.314	311	0.1%	0.311	20	

Table 4-8 continued.

3-Phase Model Results	CAS No.	Pore Water Concentration (mg/l) (7)	Solubility (mg/l) (3)	NAPL in Soil? (8)	Csat (mg/kg) (9)	Pore Water Concentration (mg/l) (7)	Water Mass (mg/kg) (10)	Vapor Concentration (mg/m ³) (11)	Vapor Mass (mg/kg) (12)	Soil Conc. (mg/kg) (13)	Soil Mass (mg/kg) (14)	Sum Mass (mg/kg) (15)
Arsenic	7440-38-2	-	-	n/a	-	0.00	0.000	-	-	0.00	0.00	0.00
Benzene	71-43-2	0.11	1,750	No	493	0.11	0.022	24.624	0.0021	0.0067	0.0067	0.030
Cadmium	7440-43-9	0.00	-	n/a	-	0.00	0.000	-	-	0.00	0.00	0.00
Chromium (total)	7440-47-3											
Chromium VI	18540-29-9	1.0	-	n/a	-	1.0	0.20	-	-	19	19	19
Chromium III	16065-83-1	0.0	-	n/a	-	0.0	0.00	-	-	0	0	0
DDT	50-29-3	0.0000	0.0250	No	17	0.0000	0.0000	0.0000	0.00E+00	0.00	0.00	0.00
Ethyl Benzene	100-41-4	14	169	No	73	14	2.8	4489.7	0.39	2.84	2.84	6.00
Ethylene dibromide (EDB)	106-93-4	0.00000	4,000	No	1,076	0.00000	0.000000	0.0000	0.00E+00	0.000000	0.000000	0.000000
Lead	7439-92-1	0.00	-	n/a	-	0.00	0.000	-	-	0	0	0
Lindane	58-89-9	0.0065	6.8	No	11	0.0065	0.00130	0.0037	3.23E-07	0.0088	0.0088	0.010
Methylene Chloride	75-09-2	0.09	13,000	No	2,831	0.09	0.019	8.4	0.00073	0.0009	0.0009	0.020
Mercury (inorganic)	7439-97-6	0.000	-	n/a	-	0.000	0.000	0	0.0000	0.00	0.00	0.00
MTBE	1634-04-4	0.47	50,000	No	10,628	0.47	0.094	8.5	0.00074	0.0052	0.0052	0.100
Naphthalene	91-20-3	0.0	31	No	43	0.0	0.00	0	0.0000	0.00	0.00	0.00
cPAH Mixtures	na											
Benzo[a]anthracene	56-55-3	0.00000	0.0094	No	3.4	0.00000	0.000000	0.00E+00	0.00E+00	0.00	0.000	0.00
Benzo[b]fluoranthene	205-99-2	0.00000	0.0015	No	1.8	0.00000	0.000000	0.00E+00	0.00E+00	0.00	0.00	0.00
Benzo[k]fluoranthene	207-08-9	0.00000	0.0008	No	1.0	0.00000	0.000000	0.00E+00	0.00E+00	0.00	0.00	0.00
Benzo[a]pyrene	50-32-8	0.00000	0.00162	No	1.6	0.00000	0.000000	0.00E+00	0.00E+00	0.00	0.00	0.00
Chrysene	218-01-9	0.00000	0.0016	No	0.64	0.00000	0.000000	0.00E+00	0.00E+00	0.00	0.000	0.00
Dibenzo[a,h]anthracene	53-70-3	0.00000	0.00249	No	4.5	0.00000	0.000000	0.00E+00	0.00E+00	0.00	0.00	0.00
Indeno[1,2,3-cd]pyrene	207-08-9	0.00000	0.0000022	No	0.076	0.00000	0.000000	0.00E+00	0.00E+00	0.00	0.00	0.00
PCB Mixtures	1336-36-3											
Arochlor 1016	12674-11-2	0.0000	0.42	No	45	0.0000	0.00000	0.00	0.00E+00	0.00	0.00	0.00
Arochlor 1260		0.0000	0.08	No	66	0.0000	0.00000	0.00	0.00E+00	0.00	0.00	0.00
Tetrachloroethylene (PCE)	127-18-4	0.09	200	No	106	0.09	0.019	71	0.0061	0.0249	0.0249	0.050
Toluene	108-88-3	19	526	No	191	19	3.9	5244.16	0.45	2.70	2.70	7.0
1,1,1 Trichloroethane	71-55-6	5.1	1,330	No	527	5.1	1.01	3567.3	0.31	0.68	0.68	2.00
Trichloroethylene	79-01-6	0.09	1,100	No	364	0.09	0.018	38	0.0033	0.0085	0.0085	0.030
Xylenes	1330-20-7	20	171	No	78	20	3.9	5490.72	0.48	4.59	4.59	9.0
m-xylene	108-38-3	0	161	No	68	0	0.0	0	0.00	0.00	0.00	0.0
o-xylene	95-47-6	0	178	No	82	0	0.0	0	0.00	0.00	0.00	0.0
p-xylene		0	185	No	100	0	0.0	0	0.00	0.00	0.00	0.0

Table 4-8 Footnotes:

- (1) Predicted ground water concentration from current Method A soil cleanup level. Determined by adjusting value until soil cleanup level matches current rule. No value has been calculated for contaminants with a proposed soil cleanup level that is equal to or higher than the current Method A soil cleanup level.
- (2) From equation 747-1. Based on Soil Screening Guidance: Technical Background Document. EPA/540/R-95/12B. May 1996.
- (3) Source: Soil Screening Guidance: Technical Background Document. EPA/540/R-95/12B. May, 1996. Exceptions are:
 - EDB values from ATSDR Toxicological Profile (TP 91/13);
 - MTBE from USGS final draft report on fuel oxygenates (March, 1996)
 - Arochlor values for Henry's constant and solubility limit from ATSDR Toxicological Profile (Dec, 1998); Arochlor Koc from EPA 1994 draft of soil screening guidance
 - Values for total xylenes are a weighted average of m,o & p xylene based on gasoline composition data from TPH Criterial Working Group--Volume 2 (May 1998). That is: m = 51% of total xylene; o = 28% of total xylene; and , p = 21% of total xylene.
 - H' for all metals except mercury assumed = zero. Mercury H' from EPA Soil Screening Guidance.
- (4) Based on review of data available from the literature and WA State sites.
- (5) From equation 747-2 for organics. For metals, based on review of data available from the literature and WA State sites.
- (6) Current MTCA soil cleanup level. Calculated using equation 747-1 (3-phase model) with model defaults (as shown in this table) and ground water cleanup level shown in this table.
- (7) Pore water concentration = ground water cleanup level X dilution factor
- (8) There is NAPL in the soil if the pore water concentration exceeds the solubility limit.
- (9) C sat is the soil concentration above which there is NAPL in the soil. It is calculated by substituting the solubility limit for the [ground water cleanup level X DF] in equation 747-1.
- (10) Water mass = [Pore water concentration X soil water fraction] / soil bulk density. This is the mass of contaminant in the water phase.
- (11) Vapor concentration = Pore water concentration X Henry's Constant X 1000.
- (12) Vapor mass = [Vapor concentration X soil air fraction] / soil bulk density. This is the mass of contaminant in the vapor phase.
- (13) Soil concentration = Pore water concentration X Kd
- (14) Soil mass = [Pore water concentration X Kd X soil bulk density] / soil bulk density. This is the mass of contaminant in the soil phase.
- (15) Sum mass = water mass + vapor mass + soil mass. This value equals the soil cleanup level.

Table 4-9: Calculation of Predicted Ground Water Concentration Resulting from Current Method A Soil Cleanup Levels for Industrial Land Use using the 3-Phase Model

3-Phase Model Results	CAS No.	Resulting GW Conc. (mg/l) (1)	Bulk Density (g/cc) (2)	Soil Water (cc/cc) (2)	Soil Air (cc/cc) (2)	H' (cc/cc) (3)	Koc (ml/g) (3)	Foc (%) (4)	Kd (cc/g) (5)	Dilution Factor (dimensionless)	Current Soil Cleanup Level (mg/kg) (6)
Arsenic	7440-38-2	0.342466	1.5	0.3	0.13	0	-	-	29	20	200.000
Benzene	71-43-2	0.0888	1.5	0.3	0.13	0.228	61.7	0.1%	0.062	20	0.500
Cadmium	7440-43-9	0.07247	1.5	0.3	0.13	0	-	-	6.7	20	10.001
Chromium (total)	7440-47-3										
Chromium VI	18540-29-9	1.30209	1.5	0.3	0.13	0	-	-	19	20	500.003
Chromium III	16065-83-1		1.5	0.3	0.13	0	-	-	1000	20	
DDT	50-29-3	0.0003687	1.5	0.3	0.13	0.000332	677,934	0.1%	678	20	5.001
Ethyl Benzene	100-41-4	2.3148	1.5	0.3	0.13	0.323	204	0.1%	0.204	20	20.000
Ethylene dibromide (EDB)	106-93-4		1.5	0.3	0.13	0.0336	66	0.1%	0.066	20	
Lead	7439-92-1		1.5	0.3	0.13	0	-	-	10000	20	
Lindane	58-89-9	0.64432	1.5	0.3	0.13	0.000574	1,352	0.1%	1.4	20	20.000
Methylene Chloride	75-09-2	0.1148	1.5	0.3	0.13	0.0898	10	0.1%	0.010	20	0.500
Mercury (inorganic)	7439-97-6		1.5	0.3	0.13	0.467	-	-	52	20	
MTBE	1634-04-4	0.471	1.5	0.3	0.13	0.018	11	0.1%	0.011	20	2.000
Naphthalene	91-20-3		1.5	0.3	0.13	0.0198	1,191	0.1%	1.191	20	
cPAH Mixtures	na										
Benzo[a]anthracene	56-55-3		1.5	0.3	0.13	0.000137	357,537	0.1%	358	20	
Benzo[b]fluoranthene	205-99-2		1.5	0.3	0.13	0.00455	1,230,000	0.1%	1,230	20	
Benzo[k]fluoranthene	207-08-9		1.5	0.3	0.13	0.000034	1,230,000	0.1%	1,230	20	
Benzo[a]pyrene	50-32-8	0.0001445	1.5	0.3	0.13	0.0000463	968,774	0.1%	969	20	2.800
Chrysene	218-01-9		1.5	0.3	0.13	0.00388	398,000	0.1%	398	20	
Dibenzo[a,h]anthracene	53-70-3		1.5	0.3	0.13	6.03E-07	1,789,101	0.1%	1,789	20	
Indeno[1,2,3-cd]pyrene	207-08-9		1.5	0.3	0.13	0.0000656	3,470,000	0.1%	3470.00	20	
PCB Mixtures	1336-36-3										
Arochlor 1016	12674-11-2		1.5	0.3	0.13	0.119	107,285	0.1%	107	20	
Arochlor 1260			1.5	0.3	0.13	0.189	822,422	0.1%	822	20	
Tetrachloroethylene (PCE)	127-18-4	0.0471	1.5	0.3	0.13	0.754	265	0.1%	0.265	20	0.500
Toluene	108-88-3	5.501	1.5	0.3	0.13	0.272	140	0.1%	0.140	20	40.000
1,1,1 Trichloroethane	71-55-6	2.5246	1.5	0.3	0.13	0.705	135	0.1%	0.135	20	20.000
Trichloroethylene	79-01-6	0.0756	1.5	0.3	0.13	0.422	94	0.1%	0.094	20	0.500
Xylenes	1330-20-7	2.1873	1.5	0.3	0.13	0.279	233	0.1%	0.233	20	20.000
m-xylene	108-38-3		1.5	0.3	0.13	0.301	196	0.1%	0.196	20	
o-xylene	95-47-6		1.5	0.3	0.13	0.213	241	0.1%	0.241	20	
p-xylene			1.5	0.3	0.13	0.314	311	0.1%	0.311	20	

Table 4-9 Continued.

3-Phase Model Results	CAS No.	Pore Water Concentration (mg/l) (7)	Solubility (mg/l) (3)	NAPL in Soil? (8)	Csat (mg/kg) (9)	Pore Water Concentration (mg/l) (7)	Water Mass (mg/kg) (10)	Vapor Concentration (mg/m ³) (11)	Vapor Mass (mg/kg) (12)	Soil Conc. (mg/kg) (13)	Soil Mass (mg/kg) (14)	Sum Mass (mg/kg) (15)
Arsenic	7440-38-2											
Benzene	71-43-2	1.78	1,750	No	493	1.78	0.355	404.928	0.0351	0.1096	0.1096	0.500
Cadmium	7440-43-9											
Chromium (total)	7440-47-3											
Chromium VI	18540-29-9	26.0	-	n/a	-	26.0	5.21	-	-	495	495	500
Chromium III	16065-83-1											
DDT	50-29-3											
Ethyl Benzene	100-41-4	46	169	No	73	46	9.3	14953.608	1.30	9.44	9.44	20.00
Ethylene dibromide (EDB)	106-93-4											
Lead	7439-92-1											
Lindane	58-89-9	12.8864	6.8	Yes	11	12.8864	2.57728	7.3968	6.41E-04	17.4224	17.4224	20.000
Methylene Chloride	75-09-2	2.30	13,000	No	2,831	2.30	0.459	206.2	0.01787	0.0230	0.0230	0.500
Mercury (inorganic)	7439-97-6											
MTBE	1634-04-4	9.41	50,000	No	10,628	9.41	1.882	169.4	0.01468	0.1035	0.1035	2.000
Naphthalene	91-20-3											
cPAH Mixtures	na											
Benzo[a]anthracene	56-55-3											
Benzo[b]fluoranthene	205-99-2											
Benzo[k]fluoranthene	207-08-9											
Benzo[a]pyrene	50-32-8	0.0029	0.00162	Yes	2	0.0029	0.001	0.00013	1.16E-08	2.7998	2.7998	2.800
Chrysene	218-01-9											
Dibenzo[a,h]anthracene	53-70-3											
Indeno[1,2,3-cd]pyrene	207-08-9											
PCB Mixtures	1336-36-3											
Arochlor 1016	12674-11-2											
Arochlor 1260												
Tetrachloroethylene (PCE)	127-18-4	0.94	200	No	106	0.94	0.188	710	0.0616	0.2496	0.2496	0.500
Toluene	108-88-3	110	526	No	191	110	22.0	29925.44	2.59	15.40	15.40	40.0
1,1,1 Trichloroethane	71-55-6	50.5	1,330	No	527	50.5	10.10	35596.86	3.09	6.82	6.82	20.00
Trichloroethylene	79-01-6	1.51	1,100	No	364	1.51	0.302	638	0.0553	0.1421	0.1421	0.500
Xylenes	1330-20-7	44	171	No	78	44	8.7	12205.134	1.06	10.19	10.19	20.0

Table 4-9 Footnotes:

- (1) Predicted ground water concentration from current Method A soil cleanup level. Determined by adjusting value until soil cleanup level matches current rule. No value has been calculated for contaminants with a proposed soil cleanup level that is equal to or higher than the current Method A soil cleanup level.
- (2) From equation 747-1. Based on Soil Screening Guidance: Technical Background Document. EPA/540/R-95/12B. May, 1996
- (3) Source: Soil Screening Guidance: Technical Background Document. EPA/540/R-95/12B. May 1996. Exceptions are:
 - EDB values from ATSDR Toxicological Profile (TP 91/13);
 - MTBE from USGS final draft report on fuel oxygenates (March 1996)
 - Arochlor values for Henry's constant and solubility limit from ATSDR Toxicological Profile (Dec, 1998); Arochlor Koc from EPA 1994 draft of soil screening guidance
 - Values for total xylenes are a weighted average of m,o & p xylene based on gasoline composition data from TPH Criterial Working Group--Volume 2 (May 1998). That is: m = 51% of total xylene; o = 28% of total xylene; and , p = 21% of total xylene.
 - H' for all metals except mercury assumed = zero. Mercury H' from EPA Soil Screening Guidance.
- (4) Based on review of data available from the literature and WA State sites.
- (5) From equation 747-2 for organics. For metals, based on review of data available from the literature and WA State sites.
- (6) Current MTCA soil cleanup level. Calculated using equation 747-1 (3-phase model) with model defaults (as shown in this table) and ground water cleanup level shown in this table. For MTBE this is the estimated soil concentration assuming cleanup to 100 ppm TPH-G and 2% MTBE.
- (7) Pore water concentration = ground water cleanup level X dilution factor
- (8) There is NAPL in the soil if the pore water concentration exceeds the solubility limit.
- (9) C sat is the soil concentration above which there is NAPL in the soil. It is calculated by substituting the solubility limit for the [ground water cleanup level X DF] in equation 747-1.
- (10) Water mass = [Pore water concentration X soil water fraction] / soil bulk density. This is the mass of contaminant in the water phase.
- (11) Vapor concentration = Pore water concentration X Henry's Constant X 1000.
- (12) Vapor mass = [Vapor concentration X soil air fraction] / soil bulk density. This is the mass of contaminant in the vapor phase.
- (13) Soil concentration = Pore water concentration X Kd
- (14) Soil mass = [Pore water concentration X Kd X soil bulk density] / soil bulk density. This is the mass of contaminant in the soil phase.
- (15) Sum mass = water mass + vapor mass + soil mass. This value equals the soil cleanup level.

Table 4-10: Calculation of Predicted Ground Water Concentration Resulting from Proposed Method A Soil Cleanup Levels for Industrial Land Use using the 3-Phase Model

3-Phase Model Results	CAS No.	Resulting GW Conc. (mg/l) (1)	Bulk Density (g/cc) (2)	Soil Water (cc/cc) (2)	Soil Air (cc/cc) (2)	H' (cc/cc) (3)	Koc (ml/g) (3)	Foc (%) (4)	Kd (cc/g) (5)	Dilution Factor (dimensionless)	Current Soil Cleanup Level (mg/kg) (6)
Arsenic	7440-38-2	0.0343	1.5	0.3	0.13	0	-	-	29	20	20.03
Benzene	71-43-2	0.0054	1.5	0.3	0.13	0.228	61.7	0.1%	0.062	20	0.030
Cadmium	7440-43-9	0.015	1.5	0.3	0.13	0	-	-	6.7	20	2.00
Chromium (total)	7440-47-3										
Chromium VI	18540-29-9	0.05	1.5	0.3	0.13	0	-	-	19	20	19
Chromium III	16065-83-1		1.5	0.3	0.13	0	-	-	1000	20	
DDT	50-29-3	0.000296	1.5	0.3	0.13	0.000332	677,934	0.1%	678	20	4.01
Ethyl Benzene	100-41-4	0.695	1.5	0.3	0.13	0.323	204	0.1%	0.204	20	6.00
Ethylene dibromide (EDB)	106-93-4		1.5	0.3	0.13	0.0336	66	0.1%	0.066	20	
Lead	7439-92-1		1.5	0.3	0.13	0	-	-	10000	20	
Lindane	58-89-9	0.000325	1.5	0.3	0.13	0.000574	1,352	0.1%	1.4	20	0.0101
Methylene Chloride	75-09-2	0.0047	1.5	0.3	0.13	0.0898	10	0.1%	0.010	20	0.020
Mercury (inorganic)	7439-97-6		1.5	0.3	0.13	0.467	-	-	52	20	
MTBE	1634-04-4	0.0236	1.5	0.3	0.13	0.018	11	0.1%	0.011	20	0.100
Naphthalene	91-20-3		1.5	0.3	0.13	0.0198	1,191	0.1%	1.191	20	
cPAH Mistures	na										
Benzo[a]anthracene	56-55-3		1.5	0.3	0.13	0.000137	357,537	0.1%	358	20	
Benzo[b]fluoranthene	205-99-2		1.5	0.3	0.13	0.00455	1,230,000	0.1%	1,230	20	
Benzo[k]fluoranthene	207-08-9		1.5	0.3	0.13	0.000034	1,230,000	0.1%	1,230	20	
Benzo[a]pyrene	50-32-8		1.5	0.3	0.13	0.0000463	968,774	0.1%	969	20	
Chrysene	218-01-9		1.5	0.3	0.13	0.00388	398,000	0.1%	398	20	
Dibenzo[a,h]anthracene	53-70-3		1.5	0.3	0.13	6.03E-07	1,789,101	0.1%	1,789	20	
Indeno[1,2,3-cd]pyrene	207-08-9		1.5	0.3	0.13	0.0000656	3,470,000	0.1%	3470.00	20	
PCB Mixtures	1336-36-3										
Arochlor 1016	12674-11-2		1.5	0.3	0.13	0.119	107,285	0.1%	107	20	
Arochlor 1260			1.5	0.3	0.13	0.189	822,422	0.1%	822	20	
Tetrachloroethylene (PCE)	127-18-4	0.0047	1.5	0.3	0.13	0.754	265	0.1%	0.265	20	0.050
Toluene	108-88-3	0.964	1.5	0.3	0.13	0.272	140	0.1%	0.140	20	7.01
1,1,1 Trichloroethane	71-55-6	0.253	1.5	0.3	0.13	0.705	135	0.1%	0.135	20	2.00
Trichloroethylene	79-01-6	0.0045	1.5	0.3	0.13	0.422	94	0.1%	0.094	20	0.030
Xylenes	1330-20-7	0.984	1.5	0.3	0.13	0.279	233	0.1%	0.233	20	9.00
m-xylene	108-38-3		1.5	0.3	0.13	0.301	196	0.1%	0.196	20	
o-xylene	95-47-6		1.5	0.3	0.13	0.213	241	0.1%	0.241	20	
p-xylene			1.5	0.3	0.13	0.314	311	0.1%	0.311	20	

Table 4-10 Continued.

3-Phase Model Results	CAS No.	Pore Water Concentration (mg/l) (7)	Solubility (mg/l) (3)	NAPL in Soil? (8)	Csat (mg/kg) (9)	Pore Water Concentration (mg/l) (7)	Water Mass (mg/kg) (10)	Vapor Concentration (mg/m ³) (11)	Vapor Mass (mg/kg) (12)	Soil Conc. (mg/kg) (13)	Soil Mass (mg/kg) (14)	Sum Mass (mg/kg) (15)
Arsenic	7440-38-2	-	-	n/a	-	0.69	0.137	-	-	19.89	19.89	20.03
Benzene	71-43-2	0.11	1,750	No	493	0.11	0.022	24.624	0.0021	0.0067	0.0067	0.030
Cadmium	7440-43-9	0.29	-	n/a	-	0.29	0.058	-	-	1.94	1.94	2.00
Chromium (total)	7440-47-3											
Chromium VI	18540-29-9	1.0	-	n/a	-	1.0	0.20	-	-	19	19	19
Chromium III	16065-83-1	0.0	-	n/a	-	0.0	0.00	-	-	0	0	0
DDT	50-29-3	0.0059	0.0250	No	17	0.0059	0.0012	0.0020	1.70E-07	4.01	4.01	4.01
Ethyl Benzene	100-41-4	14	169	No	73	14	2.8	4489.7	0.39	2.84	2.84	6.00
Ethylene dibromide (EDB)	106-93-4	0.00000	4,000	No	1,076	0.00000	0.000000	0.0000	0.00E+00	0.000000	0.000000	0.000000
Lead	7439-92-1	0.00	-	n/a	-	0.00	0.000	-	-	0	0	0
Lindane	58-89-9	0.0065	6.8	No	11	0.0065	0.00130	0.0037	3.23E-07	0.0088	0.0088	0.010
Methylene Chloride	75-09-2	0.09	13,000	No	2,831	0.09	0.019	8.4	0.00073	0.0009	0.0009	0.020
Mercury (inorganic)	7439-97-6	0.000	-	n/a	-	0.000	0.000	0	0.0000	0.00	0.00	0.00
MTBE	1634-04-4	0.47	50,000	No	10,628	0.47	0.094	8.496	0.00074	0.0052	0.0052	0.100
Naphthalene	91-20-3	0.0	31	No	43	0.0	0.00	0	0.0000	0.00	0.00	0.00
cPAH Mistures	na											
Benzo[a]anthracene	56-55-3	0.00000	0.0094	No	3.4	0.00000	0.000000	0.00E+00	0.00E+00	0.00	0.000	0.00
Benzo[b]fluoranthene	205-99-2	0.00000	0.0015	No	1.8	0.00000	0.000000	0.00E+00	0.00E+00	0.00	0.00	0.00
Benzo[k]fluoranthene	207-08-9	0.00000	0.0008	No	1.0	0.00000	0.000000	0.00E+00	0.00E+00	0.00	0.00	0.00
Benzo[a]pyrene	50-32-8	0.00000	0.00162	No	1.6	0.00000	0.000000	0.00E+00	0.00E+00	0.00	0.00	0.00
Chrysene	218-01-9	0.00000	0.0016	No	0.64	0.00000	0.000000	0.00E+00	0.00E+00	0.00	0.000	0.00
Dibenzo[a,h]anthracene	53-70-3	0.00000	0.00249	No	4.5	0.00000	0.000000	0.00E+00	0.00E+00	0.00	0.00	0.00
Indeno[1,2,3-cd]pyrene	207-08-9	0.00000	0.0000022	No	0.076	0.00000	0.000000	0.00E+00	0.00E+00	0.00	0.00	0.00
PCB Mixtures	1336-36-3											
Arochlor 1016	12674-11-2	0.0000	0.42	No	45	0.0000	0.00000	0.00	0.00E+00	0.00	0.00	0.00
Arochlor 1260		0.0000	0.08	No	66	0.0000	0.00000	0.00	0.00E+00	0.00	0.00	0.00
Tetrachloroethylene (PCE)	127-18-4	0.09	200	No	106	0.09	0.019	71	0.0061	0.0249	0.0249	0.050
Toluene	108-88-3	19	526	No	191	19	3.9	5244.16	0.45	2.70	2.70	7.0
1,1,1 Trichloroethane	71-55-6	5.1	1,330	No	527	5.1	1.01	3567.3	0.31	0.68	0.68	2.00
Trichloroethylene	79-01-6	0.09	1,100	No	364	0.09	0.018	38	0.0033	0.0085	0.0085	0.030
Xylenes	1330-20-7	20	171	No	78	20	3.9	5490.72	0.48	4.59	4.59	9.0
m-xylene	108-38-3	0	161	No	68	0	0.0	0	0.00	0.00	0.00	0.0
o-xylene	95-47-6	0	178	No	82	0	0.0	0	0.00	0.00	0.00	0.0
p-xylene		0	185	No	100	0	0.0	0	0.00	0.00	0.00	0.0

Table 4-10 Footnotes:

- (1) Predicted ground water concentration from current Method A soil cleanup level. Determined by adjusting value until soil cleanup level matches current rule. No value has been calculated for contaminants with a proposed soil cleanup level that is equal to or higher than the current Method A soil cleanup level.
- (2) From equation 747-1. Based on Soil Screening Guidance: Technical Background Document. EPA/540/R-95/12B. May, 1996
- (3) Source: Soil Screening Guidance: Technical Background Document. EPA/540/R-95/12B. May, 1996. Exceptions are:
 - EDB values from ATSDR Toxicological Profile (TP 91/13);
 - MTBE from USGS final draft report on fuel oxygenates (March, 1996)
 - Arochlor values for Henry's constant and solubility limit from ATSDR Toxicological Profile (Dec, 1998); Arochlor Koc from EPA 1994 draft of soil screening guidance
 - Values for total xylenes are a weighted average of m,o & p xylene based on gasoline composition data from TPH Criterial Working Group--Volume 2 (May 1998). That is: m = 51% of total xylene; o = 28% of total xylene; and , p = 21% of total xylene.
 - H' for all metals except mercury assumed = zero. H' for mercury from EPA Soil Screening Guidance.
- (4) Based on review of data available from the literature and WA State sites.
- (5) From equation 747-2 for organics. For metals, based on review of data available from the literature and WA State sites.
- (6) Current MTCA soil cleanup level. Calculated using equation 747-1 (3-phase model) with model defaults (as shown in this table) and ground water cleanup level shown in this table.
- (7) Pore water concentration = ground water cleanup level X dilution factor
- (8) There is NAPL in the soil if the pore water concentration exceeds the solubility limit.
- (9) C sat is the soil concentration above which there is NAPL in the soil. It is calculated by substituting the solubility limit for the [ground water cleanup level X DF] in equation 747-1.
- (10) Water mass = [Pore water concentration X soil water fraction] / soil bulk density. This is the mass of contaminant in the water phase.
- (11) Vapor concentration = Pore water concentration X Henry's Constant X 1000.
- (12) Vapor mass = [Vapor concentration X soil air fraction] / soil bulk density. This is the mass of contaminant in the vapor phase.
- (13) Soil concentration = Pore water concentration X Kd
- (14) Soil mass = [Pore water concentration X Kd X soil bulk density] / soil bulk density. This is the mass of contaminant in the soil phase.
- (15) Sum mass = water mass + vapor mass + soil mass. This value equals the soil cleanup level.

Table 4-11: Ground Water Concentration Using the 4-Phase Model and BP Gasoline Composition #4 Using 100 PPM in Soil (Current TPH-G Method A Soil Cleanup Level)

Solid:	32.9%
Air:	6.4%
Water:	5.5%
NAPL:	55.2%
	100.0%

	Equilibrium Composition %	Soil Concentration ppm	Predicted G.W. ug/l
Aliphatics	BP # 4		
EC >5-6	2.640%	2.64	27.49
EC >6-8	14.131%	14.13	43
EC >8-10	9.935%	9.94	3.0
EC >10-12	13.808%	13.81	0.31
EC >12-16		0.00	0.00
EC >16-21		0.00	0.00
Aromatics			
Benzene	0.127%	0.127	21.09
Toluene	2.003%	2.00	229
Ethylbenzene	1.135%	1.14	81
Xylenes	6.427%	6.43	450
EC >8-10	10.248%	10.25	197
EC >10-12	20.242%	20.24	206
EC >12-16	16.106%	16.11	50
EC >16-21	0.000%	0.00	0
EC >21-35	0.000%	0.00	0
Naphthalene	3.198%	3.20	57
MTBE		0.00	0
Total	100.000%	100.00	1,366

Total soil porosity: default is 0.43 n 0.430 Unitless
 Volumetric water content: default is 0.3 Qw 0.300 Unitless
 Initial volumetric air content: default is 0.13 Qa 0.130 Unitless
 Soil bulk density measured: default is 1.5 rb 1.500 kg/l
 *or, use soil bulk density computed @solid density=2.65kg/l: 1.811 kg/l
 Fraction Organic Carbon: default is 0.001 foc 0.0010 Unitless
 Dilution Factor: default is 20 DF 20.0 Unitless

Soil Concentration: **100.00**
 Predicted Ground Water TPH (ug/l): **1,366**
HI @ Predicted G.W. Concentration: 2.60

Volumetric NAPL Content, QNAPL : 0.000099
 NAPL Saturation (%), QNAPL/n: 0.02%
 Type of model used for computation: 4-Phase Model
 Computation completed? **Yes!**

Soil Concentration = 100.00

NOTE: This is a reprint of summary output only. The complete model run can be found in the rule file.

Table 4-12: Ground Water Concentration Using the 4-Phase Model and BP Gasoline Composition #4 Using 30 PPM in Soil (Proposed TPH-G Method A Soil Cleanup Level)

Solid:	75.4%
Air:	12.1%
Water:	8.8%
NAPL:	3.7%
	100.0%

	Equilibrium Composition %	Soil Concentration ppm	Predicted G.W. ug/l
Aliphatics	BP # 4		
EC >5-6	2.640%	0.79	10.23
EC >6-8	14.131%	4.24	24
EC >8-10	9.935%	2.98	3.6
EC >10-12	13.808%	4.14	0.69
EC >12-16		0.00	0.00
EC >16-21		0.00	0.00
Aromatics			
Benzene	0.127%	0.038	6.74
Toluene	2.003%	0.60	82
Ethylbenzene	1.135%	0.34	39
Xylenes	6.427%	1.93	209
EC >8-10	10.248%	3.07	84
EC >10-12	20.242%	6.07	110
EC >12-16	16.106%	4.83	45
EC >16-21	0.000%	0.00	0
EC >21-35	0.000%	0.00	0
Naphthalene	3.198%	0.96	44
MTBE		0.00	0
Total	100.000%	30.00	658

Total soil porosity: default is 0.43 n 0.430 Unitless
 Volumetric water content: default is 0.3 Qw 0.300 Unitless
 Initial volumetric air content: default is 0.13 Qa 0.130 Unitless
 Soil bulk density measured: default is 1.5 rb 1.500 kg/l
 *or, use soil bulk density computed @solid density=2.65kg/l: 1.811 kg/l
 Fraction Organic Carbon: default is 0.001 foc 0.0010 Unitless
 Dilution Factor: default is 20 DF 20.0 Unitless

Soil Concentration: **30.00**

Predicted Ground Water TPH (ug/l): **658**

HI @ Predicted G.W. Concentration: 1.23

Volumetric NAPL Content, QNAPL : 0.000002
 NAPL Saturation (%), QNAPL/n: 0.00%
 Type of model used for computation: 4-Phase Model
 Computation completed? **Yes!**

Soil Concentration = 30.00

NOTE: This is a reprint of summary output only. The complete model run can be found in the rule file.

Table 4-13: Ground Water Concentration Using the 4-Phase Model and ARCO Gasoline Composition #5 Using 100 PPM in Soil (Current TPH-G Method A Soil Cleanup Level)

Solid:	36.0%
Air:	5.9%
Water:	7.2%
NAPL:	50.9%
	100.0%

	Equilibrium Composition %	Soil Concentration ppm	Predicted G.W. ug/l
Aliphatics	ARCO # 5		
EC >5-6	1.36%	1.36	14.29
EC >6-8	13.4%	13.37	42
EC >8-10	12.8%	12.83	4.0
EC >10-12	10.8%	10.77	0.25
EC >12-16		0.00	0.00
EC >16-21		0.00	0.00
Aromatics			
Benzene	0.066%	0.066	11.06
Toluene	2.8%	2.84	328
Ethylbenzene	1.8%	1.82	134
Xylenes	10.0%	10.04	718
EC >8-10	11.6%	11.64	228
EC >10-12	26.3%	26.27	274
EC >12-16	7.7%	7.73	25
EC >16-21		0.00	0
EC >21-35		0.00	0
Naphthalene	1.27%	1.27	24
MTBE		0.00	0
			0
Total	100.00%	100.00	1,801

Total soil porosity: default is 0.43 n 0.430 Unitless
 Volumetric water content: default is 0.3 Qw 0.300 Unitless
 Initial volumetric air content: default is 0.13 Qa 0.130 Unitless
 Soil bulk density measured: default is 1.5 rb 1.500 kg/l
 *or, use soil bulk density computed @solid density=2.65kg/l: 1.811 kg/l
 Fraction Organic Carbon: default is 0.001 foc 0.0010 Unitless
 Dilution Factor: default is 20 DF 20.0 Unitless

Soil Concentration: **100.00**

Predicted Ground Water TPH (ug/l): **1,801**

HI @ Predicted G.W. Concentration: 2.33

Volumetric NAPL Content, QNAPL : 0.000093
 NAPL Saturation (%), QNAPL/n: 0.02%
 Type of model used for computation: 4-Phase Model
 Computation completed? **Yes!**

Soil Concentration = 100.00

NOTE: This is a reprint of summary output only. The complete model run can be found in the rule file.

Table 4-14: Ground Water Concentration Using the 4-Phase Model and ARCO Gasoline Composition #5 Using 30 PPM in Soil (Current TPH-G Method A Soil Cleanup Level)

Solid:	77.2%
Air:	11.8%
Water:	11.1%
NAPL:	NONE
	100.0%

	Equilibrium Composition %	Soil Concentration @ 30 PPM' ppm	Predicted G.W. ug/l
Aliphatics	ARCO # 5		
EC >5-6	1.36%	1.36	5.28
EC >6-8	13.4%	13.37	24
EC >8-10	12.8%	12.83	5.0
EC >10-12	10.8%	10.77	0.62
EC >12-16		0.00	0.00
EC >16-21		0.00	0.00
Aromatics			
Benzene	0.066%	0.066	3.53
Toluene	2.8%	2.84	117
Ethylbenzene	1.8%	1.82	63
Xylenes	10.0%	10.04	330
EC >8-10	11.6%	11.64	96
EC >10-12	26.3%	26.27	145
EC >12-16	7.7%	7.73	22
EC >16-21		0.00	0
EC >21-35		0.00	0
Naphthalene	1.27%	1.27	18
MTBE		0.00	0
Total	100.00%	100.00	829

Total soil porosity: default is 0.43 n 0.430 Unitless
 Volumetric water content: default is 0.3 Qw 0.300 Unitless
 Initial volumetric air content: default is 0.13 Qa 0.130 Unitless
 Soil bulk density measured: default is 1.5 rb 1.500 kg/l
 *or, use soil bulk density computed @solid density=2.65kg/l: 1.811 kg/l
 Fraction Organic Carbon: default is 0.001 foc 0.0010 Unitless
 Dilution Factor: default is 20 DF 20.0 Unitless

Soil Concentration: **30.00**

Predicted Ground Water TPH (ug/l): **829**

HI @ Predicted G.W. Concentration: 1.09

Volumetric NAPL Content, QNAPL : NAPL phase is not existing!
 NAPL Saturation (%), QNAPL/n: N/A
 Type of model used for computation: 3-Phase Model
 Computation completed? **Yes!**

Soil Concentration = 30.00

NOTE: This is a reprint of summary output only. The complete model run can be found in the rule file.

Table 4-15: Calculation of Ground Water Hazard Quotient Resulting from Current Method A Soil Cleanup Levels for Unrestricted Land Use

Risk Calculations – Noncarcinogenic Effects of Drinking Water Ingestion

Hazardous Substance	CAS No.	Reference Dose (1) (mg/kg)	Avg. Body Weight (kg)	Unit Conv. Factor (ug/mg)	Hazard Quotient (unitless)	Drinking H2O Ing. Rate (liters/day)	Inhalation Corr. Factor (unitless)	Drinking H2O Fraction (unitless)	Method B Noncarcin (2) (ug/l)	Predicted Concentration (3) (ug/l)	HQ @ Predicted Concentration (4) (unitless)
Arsenic	7440-38-2	0.0003	16	1,000	1	1.0	1	1.0	4.8		
Benzene	71-43-2	0.003	16	1,000	1	1.0	2	1.0	24	88.8	3.70
Cadmium	7440-43-9	0.0005	16	1,000	1	1.0	1	1.0	8.0		
T Chromium	7440-47-3	not available									
Chromium III	16065-83-1	1.5	16	1,000	1	1.0	1	1.0	24,000		
Chromium VI	18540-29-9	0.003	16	1,000	1	1.0	1	1.0	48	260.416	5.43
DDT	50-29-3	0.0005	16	1,000	1	1.0	1	1.0	8.0		
Ethylbenzene	100-41-4	0.1	16	1,000	1	1.0	2	1.0	800	2314.8	2.89
Ethylene dibromide (EDB)	106-93-4	not available									
Lead	7439-92-1	not available									
Lindane	58-89-9	0.0003	16	1,000	1	1.0	1	1.0	4.8	32.22	6.71
Methylene chloride	75-09-2	0.06	16	1,000	1	1.0	2	1.0	480	114.8	0.24
Mercury (inorganic)	7439-97-6	0.0003	16	1,000	1	1.0	1	1.0	4.8		
MTBE	1634-04-4	not available							20.0	407	20.35
Naphthalene	91-20-3	0.02	16	1,000	1	1.0	2	1.0	160		
cPAH Mixtures	na	not available									
Benzo[a]anthracene	56-55-3	not available									
Benzo[b]fluoranthene	205-99-2	not available									
Benzo[k]fluoranthene	207-08-9	not available									
Benzo[a]pyrene	50-32-8	not available									
Chrysene	218-01-9	not available									
Dibenzo[a,h]anthracene	53-70-3	not available									
Ideno[1,2,3-cd]pyrene	207-08-9	not available									

Footnotes:

- (1) Source of RfDs is EPA's IRIS database except for benzene which is from EPA's NCEA.
- (2) Value calculated using equation 720-1 and default assumptions in that equation.
- (3) Concentration in ground water predicted with 3 phase model if current Method A soil cleanup level is used. Values not calculated for soil cleanup levels equal to or greater than current Method A soil cleanup level.
- (4) Predicted ground water concentration divided by Method B value. Bolded values indicate predicted concentration exceeds MTCA requirement that HQ not exceed 1.0. MTBE does not have an RfD or CPF. Value shown is predicted concentration divided by health advisory concentration.

Table 4-15 Continued.

Risk Calculations – Noncarcinogenic Effects of Drinking Water Ingestion

Hazardous Substance	CAS No.	Reference Dose (1) (mg/kg)	Avg. Body Weight (kg)	Unit Conv. Factor (ug/mg)	Hazard Quotient (unitless)	Drinking H2O Ing. Rate (liters/day)	Inhalation Corr. Factor (unitless)	Drinking H2O Fraction (unitless)	Method B Noncarcin (2) (ug/l)	Predicted Concentration (3) (ug/l)	HQ @ Predicted Concentration (4) (unitless)
PCB mixtures	1336-36-3	not available									
High Risk & Persistence		not available									
Low Risk & Persistence		not available									
Lowest Risk & Persistence		not available									
Aroclor 1016	12674-11-2	0.00007	16	1,000	1	1.0	1	1.0	1.1		
Aroclor 1248	12672-29-6	not available									
Aroclor 1254	11097-69-1	0.00002	16	1,000	1	1.0	1	1.0	0.32		
Aroclor 1260		not available									
Tetrachloroethylene (PCE)	127-18-4	0.01	16	1,000	1	1.0	2	1.0	80	47.1	0.59
Toluene	108-88-3	0.2	16	1,000	1	1.0	2	1.0	1,600	5,501	3.44
1,1,1 Trichloroethane	71-55-6	0.9	16	1,000	1	1.0	2	1.0	7,200	2524.6	0.35 & 12.6
Trichloroethylene	79-01-6	not available								75.6	
Xylenes	1330-20-7	2.0	16	1,000	1	1.0	2	1.0	16,000	2,187.3	0.14 & 2.2
m-Xylene	108-38-3	not available									
o-xylene	95-47-6	not available									
p-xylene		not available									
Gasoline (5)										1366 & 1801	2.6 & 2.3

Footnotes:

- (1) Source of RfDs is EPA's IRIS database except for 1,1,1 TCE, which is from HEAST
- (2) Value calculated using equation 720-1 and default assumptions in that equation.
- (3) Concentration in ground water predicted with 3 phase model if current Method A soil cleanup level is used. Values not calculated for soil cleanup levels equal to or greater than current Method A soil cleanup level.
- (4) Predicted ground water concentration divided by Method B value. For 1,1,1 TCE the first value is the HQ, the second is the ratio of the predicted concentration to the MCL of 200 ug/l. For xylene the first value is the HQ, the second is the ratio of the predicted concentration to odor threshold of 1000 ug/l.
- (5) First value for BP composition #4, second value for ARCO composition #5. Both results obtained using 4 phase model to predict ground water impact at a soil gasoline conc. of 100 PPM.

Table 4-16: Calculation of Ground Water Hazard Quotient Resulting from Proposed Method A Soil Cleanup Levels for Unrestricted Land Use

Risk Calculations – Noncarcinogenic Effects of Drinking Water Ingestion

Hazardous Substance	CAS No.	Reference Dose (1) (mg/kg)	Avg. Body Weight (kg)	Unit Conv. Factor (ug/mg)	Hazard Quotient (unitless)	Drinking H2O Ing. Rate (liters/day)	Inhalation Corr. Factor (unitless)	Drinking H2O Fraction (unitless)	Method B Noncarcin (2) (ug/l)	Predicted Concentration (3) (ug/l)	HQ @ Predicted Concentration (4) (unitless)
Arsenic	7440-38-2	0.0003	16	1,000	1	1.0	1	1.0	4.8		
Benzene	71-43-2	0.003	16	1,000	1	1.0	2	1.0	24	5.40	0.2
Cadmium	7440-43-9	0.0005	16	1,000	1	1.0	1	1.0	8.0		
T Chromium	7440-47-3	not available									
Chromium III	16065-83-1	1.5	16	1,000	1	1.0	1	1.0	24,000		
Chromium VI	18540-29-9	0.003	16	1,000	1	1.0	1	1.0	48	50	1.0
DDT	50-29-3	0.0005	16	1,000	1	1.0	1	1.0	8.0		
Ethylbenzene	100-41-4	0.1	16	1,000	1	1.0	2	1.0	800	695	0.9
Ethylene dibromide (EDB)	106-93-4	not available									
Lead	7439-92-1	not available									
Lindane	58-89-9	0.0003	16	1,000	1	1.0	1	1.0	4.8	0.325	0.1
Methylene chloride	75-09-2	0.06	16	1,000	1	1.0	2	1.0	480	4.7	0.01
Mercury (inorganic)	7439-97-6	0.0003	16	1,000	1	1.0	1	1.0	4.8		
MTBE	1634-04-4	not available							20.0	23.6	1.2
Naphthalene	91-20-3	0.02	16	1,000	1	1.0	2	1.0	160		
cPAH Mixtures	na	not available									
Benzo[a]anthracene	56-55-3	not available									
Benzo[b]fluoranthene	205-99-2	not available									
Benzo[k]fluoranthene	207-08-9	not available									
Benzo[a]pyrene	50-32-8	not available									
Chrysene	218-01-9	not available									
Dibenzo[a,h]anthracene	53-70-3	not available									
Ideno[1,2,3-cd]pyrene	207-08-9	not available									

Footnotes:

- (1) Source of RfDs is EPA's IRIS database except for benzene which is from EPA's NCEA.
- (2) Value calculated using equation 720-1 and default assumptions in that equation.
- (3) Concentration in ground water predicted with 3 phase model if current Method A soil cleanup level is used. Values not calculated for soil cleanup levels equal to or greater than current Method A soil cleanup level.
- (4) Predicted ground water concentration divided by Method B value. Bolded values indicate predicted concentration exceeds MTCA requirement that HQ not exceed 1.0. MTBE does not have an RfD or CPF. Value shown is predicted concentration divided by health advisory concentration.

Table 4-16 Continued.

Risk Calculations – Noncarcinogenic Effects of Drinking Water Ingestion

Hazardous Substance	CAS No.	Reference Dose (1) (mg/kg)	Avg. Body Weight (kg)	Unit Conv. Factor (ug/mg)	Hazard Quotient (unitless)	Drinking H2O Ing. Rate (liters/day)	Inhalation Corr. Factor (unitless)	Drinking H2O Fraction (unitless)	Method B Noncarcin (2) (ug/l)	Predicted Concentration (3) (ug/l)	HQ @ Predicted Concentration (4) (unitless)
PCB mixtures	1336-36-3	not available									
High Risk & Persistence		not available									
Low Risk & Persistence		not available									
Lowest Risk & Persistence		not available									
Aroclor 1016	12674-11-2	0.00007	16	1,000	1	1.0	1	1.0	1.1		
Arochlor 1248	12672-29-6	not available									
Arochlor 1254	11097-69-1	0.00002	16	1,000	1	1.0	1	1.0	0.32		
Arochlor 1260		not available									
Tetrachloroethylene (PCE)	127-18-4	0.01	16	1,000	1	1.0	2	1.0	80	4.7	0.1
Toluene	108-88-3	0.2	16	1,000	1	1.0	2	1.0	1,600	964	0.6
1,1,1 Trichloroethane	71-55-6	0.9	16	1,000	1	1.0	2	1.0	7,200	253	0.04
Trichloroethylene	79-01-6	not available									
Xylenes	1330-20-7	2.0	16	1,000	1	1.0	2	1.0	16,000	984	0.06 & 1.0
m-Xylene	108-38-3	not available									
o-xylene	95-47-6	not available									
p-xylene		not available									
Gasoline (5)										658 & 829	1.23 & 1.09

Footnotes:

- (1) Source of RfDs is EPA's IRIS database except for 1,1,1 TCE, which is from HEAST.
- (2) Value calculated using equation 720-1 and default assumptions in that equation.
- (3) Concentration in ground water predicted with 3 phase model if current Method A soil cleanup level is used. Values not calculated for soil cleanup levels equal to or greater than current Method A soil cleanup level.
- (4) Predicted ground water concentration divided by Method B value. For xylene the first value is the HQ, the second is the ratio of the predicted concentration to odor threshold of 1000 ug/l.
- (5) First value for BP composition #4, second value for ARCO composition #5. Both results obtained using 4 phase model to predict ground water impact at a soil gasoline conc. of 30 PPM.

Table 4-17: Calculation of Ground Water Cancer Risk Resulting from Current Method A Soil Cleanup Levels for Unrestricted Land Use

Risk Calculations – Carcinogenic Effects of Drinking Water Ingestion

Hazardous Substance	CAS No.	Risk (unitless)	Avg. Body Weight (kg)	Lifetime (years)	Unit Conv. Factor (ug/mg)	Potency Factor (kg-day/mg)	Drinking H ₂ O Ing. Rate (liters/day)	Duration of Exposure (years)	Inhalation Corr. Factor (unitless)	Drinking H ₂ O Fraction (unitless)	Method B Carcinogen (ug/l)	Predicted Concentration (3) (ug/l)	Risk @ Predicted Concentration (4) (unitless)
Arsenic	7440-38-2	1E-06	70	75	1,000	1.5	2.0	30	1	1.0	0.058		
Benzene	71-43-2	1E-06	70	75	1,000	0.029	2.0	30	2	1.0	1.51	88.8	58.86
Cadmium	7440-43-9					not available							
T Chromium	7440-47-3												
Chromium III	16065-83-1					not available							
Chromium VI	18540-29-9					not available						260.416	
DDT	50-29-3	1E-06	70	75	1,000	0.34	2.0	30	1	1.0	0.26		
Ethylbenzene	100-41-4					not available						2314.8	
Ethylene dibromide (EDB)	106-93-4	1E-06	70	75	1,000	85	2.0	30	2	1.0	0.00051		
Lead	7439-92-1					not available							
Lindane	58-89-9	1E-06	70	75	1,000	1.3	2.0	30	1	1.0	0.067	32.22	478.70
Methylene chloride	75-09-2	1E-06	70	75	1,000	0.0075	2.0	30	2	1.0	5.8	114.8	19.68
Mercury (inorganic)	7439-97-6					not available							
MTBE	1634-04-4					not available						3529	
Naphthalene	91-20-3					not available							
cPAH Mixtures	na												
Benzo[a]anthracene	56-55-3					not available							
Benzo[b]fluoranthene	205-99-2					not available							
Benzo[k]fluoranthene	207-08-9					not available							
Benzo[a]pyrene	50-32-8	1E-06	70	75	1,000	7.3	2.0	30	1	1.0	0.012		
Chrysene	218-01-9					not available							
Dibenzo[a,h]anthracene	53-70-3					not available							
Ideno[1,2,3-cd]pyrene	207-08-9					not available							

Footnotes:

- (1) Source of Cancer Potency Factor is the oral slope factors from EPA's IRIS database, except for Lindane which is from HEAST.
- (2) Value calculated using equation 720-2 and default assumptions in that equation.
- (3) Concentration in ground water predicted with 3 phase model if current Method A soil cleanup level is used. Values not calculated for soil cleanup levels equal to or greater than current Method A soil cleanup level.
- (4) Predicted ground water concentration divided by Method B value. This value is expressed in terms of 10⁻⁶ risk, that is a value of 58.9 is a risk of 58.9 X 10⁻⁶ or 5.89 X 10⁻⁵.

Table 4-17 Continued.

Risk Calculations – Carcinogenic Effects of Drinking Water Ingestion

Hazardous Substance	CAS No.	Risk (unitless)	Avg. Body Weight (kg)	Lifetime (years)	Unit Conv. Factor (ug/mg)	Potency Factor (kg-day/mg)	Drinking H ₂ O Ing. Rate (liters/day)	Duration of Exposure (years)	Inhalation Corr. Factor (unitless)	Drinking H ₂ O Fraction (unitless)	Method B Carcinogen (ug/l)	Predicted Concentration (3) (ug/l)	Risk @ Predicted Concentration (4) (unitless)
PCB mixtures	1336-36-3												
High Risk & Persistence		1E-06	70	75	1,000	2.0	2.0	30	1	1.0	0.044		
Low Risk & Persistence		1E-06	70	75	1,000	0.4	2.0	30	1	1.0	0.22		
Lowest Risk & Persistence		1E-06	70	75	1,000	0.07	2.0	30	1	1.0	1.25		
Aroclor 1016	12674-11-2					not available							
Aroclor 1248	12672-29-6					not available							
Aroclor 1254	11097-69-1					not available							
Aroclor 1260						not available							
Tetrachloroethylene (PCE)	127-18-4	1E-06	70	75	1,000	0.051	2.0	30	2	1.0	0.86	47.1	54.91
Toluene	108-88-3					not available						5,501	
1,1,1 Trichloroethane	71-55-6					not available						2524.6	
Trichloroethylene	79-01-6	1E-06	70	75	1,000	0.011	2.0	30	2	1.0	4.0	75.6	19.01
Xylenes	1330-20-7					not available						2,187.3	
m-Xylene	108-38-3					not available							
o-xylene	95-47-6					not available							
p-xylene						not available							
Gasoline (5)											1.51	11.1 & 20.1	7.35 & 13.31

Footnotes:

- (1) Source of Cancer Potency Factor is the oral slope factors from EPA's IRIS database, except for tetrachloroethylene, trichloroethylene and vinyl chloride which are from HEAST.
- (2) Value calculated using equation 720-2 and default assumptions in that equation.
- (3) Concentration in ground water predicted with 3 phase model if current Method A soil cleanup level is used. Values not calculated for soil cleanup levels equal to or greater than current Method A soil cleanup level.
- (4) Predicted ground water concentration divided by Method B value. This value is expressed in terms of 10⁻⁶ risk, that is a value of 58.9 is a risk of 58.9 X 10⁻⁶ or 5.89 X 10⁻⁵.
- (5) First value for BP composition #4, second value for ARCO composition #5. Both results obtained using 4 phase model to predict benzene conc. at a soil gasoline conc. of 100 PPM. All values based on benzene. Risk calculated by dividing predicted benzene concentration by Method B benzene value.

Table 4-18: Calculation of Ground Water Cancer Risk Resulting from Proposed Method A Soil Cleanup Levels for Unrestricted Land Use

Risk Calculations – Carcinogenic Effects of Drinking Water Ingestion

Hazardous Substance	CAS No.	Risk (unitless)	Avg. Body Weight (kg)	Lifetime (years)	Unit Conv. Factor (ug/mg)	Potency Factor (kg-day/mg)	Drinking H ₂ O Ing. Rate (liters/day)	Duration of Exposure (years)	Inhalation Corr. Factor (unitless)	Drinking H ₂ O Fraction (unitless)	Method B Carcinogen (ug/l)	Predicted Concentration (3) (ug/l)	Risk @ Predicted Concentration (4) (unitless)
Arsenic	7440-38-2	1E-06	70	75	1,000	1.5	2.0	30	1	1.0	0.058		
Benzene	71-43-2	1E-06	70	75	1,000	0.029	2.0	30	2	1.0	1.51	5.4	3.58
Cadmium	7440-43-9					not available							
T Chromium	7440-47-3												
Chromium III	16065-83-1					not available							
Chromium VI	18540-29-9					not available							
DDT	50-29-3	1E-06	70	75	1,000	0.34	2.0	30	1	1.0	0.26		
Ethylbenzene	100-41-4					not available							
Ethylene dibromide (EDB)	106-93-4	1E-06	70	75	1,000	85	2.0	30	2	1.0	0.00051		
Lead	7439-92-1					not available							
Lindane	58-89-9	1E-06	70	75	1,000	1.3	2.0	30	1	1.0	0.067	0.325	4.83
Methylene chloride	75-09-2	1E-06	70	75	1,000	0.0075	2.0	30	2	1.0	5.8	4.7	0.81
Mercury (inorganic)	7439-97-6					not available							
MTBE	1634-04-4					not available						23.6	
Naphthalene	91-20-3					not available							
cPAH Mixtures	na												
Benzo[a]anthracene	56-55-3					not available							
Benzo[b]fluoranthene	205-99-2					not available							
Benzo[k]fluoranthene	207-08-9					not available							
Benzo[a]pyrene	50-32-8	1E-06	70	75	1,000	7.3	2.0	30	1	1.0	0.012		
Chrysene	218-01-9					not available							
Dibenzo[a,h]anthracene	53-70-3					not available							
Ideno[1,2,3-cd]pyrene	207-08-9					not available							

Footnotes:

- (1) Source of Cancer Potency Factor is the oral slope factors from EPA's IRIS database, except for Lindane which is from HEAST.
- (2) Value calculated using equation 720-2 and default assumptions in that equation.
- (3) Concentration in ground water predicted with 3 phase model if current Method A soil cleanup level is used. Values not calculated for soil cleanup levels equal to or greater than current Method A soil cleanup level.
- (4) Predicted ground water concentration divided by Method B value. This value is expressed in terms of 10⁻⁶ risk, that is a value of 58.9 is a risk of 58.9 X 10⁻⁶ or 5.89 X 10⁻⁵.

Table 4-18 Continued:

Risk Calculations – Carcinogenic Effects of Drinking Water Ingestion

Hazardous Substance	CAS No.	Risk (unitless)	Avg. Body Weight (kg)	Lifetime (years)	Unit Conv. Factor (ug/mg)	Potency Factor (kg-day/mg)	Drinking H ₂ O Ing. Rate (liters/day)	Duration of Exposure (years)	Inhalation Corr. Factor (unitless)	Drinking H ₂ O Fraction (unitless)	Method B Carcinogen (ug/l)	Predicted Concentration (3) (ug/l)	Risk @ Predicted Concentration (4) (unitless)
PCB mixtures	1336-36-3												
High Risk & Persistence		1E-06	70	75	1,000	2.0	2.0	30	1	1.0	0.044		
Low Risk & Persistence		1E-06	70	75	1,000	0.4	2.0	30	1	1.0	0.22		
Lowest Risk & Persistence		1E-06	70	75	1,000	0.07	2.0	30	1	1.0	1.25		
Aroclor 1016	12674-11-2					not available							
Arochlor 1248	12672-29-6					not available							
Arochlor 1254	11097-69-1					not available							
Arochlor 1260						not available							
Tetrachloroethylene (PCE)	127-18-4	1E-06	70	75	1,000	0.051	2.0	30	2	1.0	0.86	4.7	5.48
Toluene	108-88-3					not available							
1,1,1 Trichloroethane	71-55-6					not available							
Trichloroethylene	79-01-6	1E-06	70	75	1,000	0.011	2.0	30	2	1.0	4.0	4.5	1.13
Vinyl Chloride	75-01-4	1E-06	70	75	1,000	1.9	2.0	30	2	1.0	0.023		
Xylenes	1330-20-7					not available							
m-Xylene	108-38-3					not available							
o-xylene	95-47-6					not available							
p-xylene						not available							
Gasoline (5)											1.51	6.74 & 3.53	4.5 & 2.3

Footnotes:

- (1) Source of Cancer Potency Factor is the oral slope factors from EPA's IRIS database, except for tetrachloroethylene, trichloroethylene and vinyl chloride which are from HEAST.
- (2) Value calculated using equation 720-2 and default assumptions in that equation.
- (3) Concentration in ground water predicted with 3 phase model if current Method A soil cleanup level is used. Values not calculated for soil cleanup levels equal to or greater than current Method A soil cleanup level.
- (4) Predicted ground water concentration divided by Method B value. This value is expressed in terms of 10⁻⁶ risk, that is a value of 58.9 is a risk of 58.9 X 10⁻⁶ or 5.89 X 10⁻⁵.
- (5) First value for BP composition #4, second value for ARCO composition #5. Both results obtained using 4 phase model to predict benzene conc. at a soil gasoline conc. of 30 PPM. All values based on benzene. Risk calculated by dividing predicted benzene concentration by Method B benzene value.

Table 4-19: Calculation of Ground Water Hazard Quotient Resulting from Current Method A Soil Cleanup Levels for Industrial Land Use

Risk Calculations – Noncarcinogenic Effects of Drinking Water Ingestion

Hazardous Substance	CAS No.	Reference Dose (1) (mg/kg)	Avg. Body Weight (kg)	Unit Conv. Factor (ug/mg)	Hazard Quotient (unitless)	Drinking H2O Ing. Rate (liters/day)	Inhalation Corr. Factor (unitless)	Drinking H2O Fraction (unitless)	Method B Noncarcinogen (2) (ug/l)	Predicted Concentration (3) (ug/l)	HQ @ Predicted Concentration (4) (unitless)
Arsenic	7440-38-2	0.0003	16	1,000	1	1.0	1	1.0	4.8	342.466	71.3
Benzene	71-43-2	0.003	16	1,000	1	1.0	2	1.0	24	88.8	3.7
Cadmium	7440-43-9	0.0005	16	1,000	1	1.0	1	1.0	8.0	72.47	9.1
T Chromium	7440-47-3	not available									
Chromium III	16065-83-1	1.5	16	1,000	1	1.0	1	1.0	24,000		
Chromium VI	18540-29-9	0.003	16	1,000	1	1.0	1	1.0	48	1302.09	27.1
DDT	50-29-3	0.0005	16	1,000	1	1.0	1	1.0	8.0	0.3687	0.05
Ethylbenzene	100-41-4	0.1	16	1,000	1	1.0	2	1.0	800	2314.8	2.9
Ethylene dibromide (EDB)	106-93-4	not available									
Lead	7439-92-1	not available									
Lindane	58-89-9	0.0003	16	1,000	1	1.0	1	1.0	4.8	644.32	134.2
Methylene chloride	75-09-2	0.06	16	1,000	1	1.0	2	1.0	480	114.8	0.2
Mercury (inorganic)	7439-97-6	0.0003	16	1,000	1	1.0	1	1.0	4.8		
MTBE	1634-04-4	not available							20.0	407	20.4
Naphthalene	91-20-3	0.02	16	1,000	1	1.0	2	1.0	160		
cPAH Mixtures	na	not available									
Benzo[a]anthracene	56-55-3	not available									
Benzo[b]fluoranthene	205-99-2	not available									
Benzo[k]fluoranthene	207-08-9	not available									
Benzo[a]pyrene	50-32-8	not available								0.1445	
Chrysene	218-01-9	not available									
Dibenzo[a,h]anthracene	53-70-3	not available									
Ideno[1,2,3-cd]pyrene	207-08-9	not available									

Footnotes:

- (1) Source of RfDs is EPA's IRIS database except for benzene which is from EPA's NCEA.
- (2) Value calculated using equation 720-1 and default assumptions in that equation.
- (3) Concentration in ground water predicted with 3 phase model if current Method A soil cleanup level is used. Values not calculated for soil cleanup levels equal to or greater than current Method A soil cleanup level.
- (4) Predicted ground water concentration divided by Method B value. Bolded values indicate MCL exceeds MTCA requirement that HQ not exceed 1.0. MTBE does not have an RfD or CPF. Value shown is predicted concentration divided by health advisory concentration.

Table 4-19 Continued:

Risk Calculations – Noncarcinogenic Effects of Drinking Water Ingestion

Hazardous Substance	CAS No.	Reference Dose (1) (mg/kg)	Avg. Body Weight (kg)	Unit Conv. Factor (ug/mg)	Hazard Quotient (unitless)	Drinking H2O Ing. Rate (liters/day)	Inhalation Corr. Factor (unitless)	Drinking H2O Fraction (unitless)	Method B Noncarcinogen (2) (ug/l)	Predicted Concentration (3) (ug/l)	HQ @ Predicted Concentration (4) (unitless)
PCB mixtures	1336-36-3	not available									
High Risk & Persistence		not available									
Low Risk & Persistence		not available									
Lowest Risk & Persistence		not available									
Aroclor 1016	12674-11-2	0.00007	16	1,000	1	1.0	1	1.0	1.1		
Arochlor 1248	12672-29-6	not available									
Arochlor 1254	11097-69-1	0.00002	16	1,000	1	1.0	1	1.0	0.32		
Arochlor 1260		not available									
Tetrachloroethylene (PCE)	127-18-4	0.01	16	1,000	1	1.0	2	1.0	80	47.1	0.6
Toluene	108-88-3	0.2	16	1,000	1	1.0	2	1.0	1,600	5,501	3.4
1,1,1 Trichloroethane	71-55-6	0.9	16	1,000	1	1.0	2	1.0	7,200	2524.6	0.35 & 12.6
Trichloroethylene	79-01-6	not available								75.6	
Xylenes	1330-20-7	2.0	16	1,000	1	1.0	2	1.0	16,000	2,187.3	0.14 & 2.2
m-Xylene	108-38-3	not available									
o-xylene	95-47-6	not available									
p-xylene		not available									
Gasoline (5)										1366 & 1801	2.6 & 2.3

Footnotes:

- (1) Source of RfDs is EPA's IRIS database except for 1,1,1 TCE, which is from HEAST.
- (2) Value calculated using equation 720-1 and default assumptions in that equation.
- (3) Concentration in ground water predicted with 3 phase model if current Method A soil cleanup level is used. Values not calculated for soil cleanup levels equal to or greater than current Method A soil cleanup level.
- (4) Predicted ground water concentration divided by Method B value. Bolded values indicate predicted concentration exceeds MTCA requirement that HQ not exceed 1.0. For 1,1,1 TCE the first value is the HQ, the second is the ratio of the predicted concentration to the MCL of 200 ug/l. For xylene the first value is the HQ, the second is the ratio of the predicted concentration to odor threshold of 1000 ug/l.
- (5) First value for BP composition #4, second value for ARCO composition #5. Both results obtained using 4 phase model to predict ground water impact at a soil gasoline conc. of 100 PPM.

Table 4-20: Calculation of Ground Water Hazard Quotient Resulting from Proposed Method A Soil Cleanup Levels for Industrial Land Use

Risk Calculations – Noncarcinogenic Effects of Drinking Water Ingestion

Hazardous Substance	CAS No.	Reference Dose (1) (mg/kg)	Avg. Body Weight (kg)	Unit Conv. Factor (ug/mg)	Hazard Quotient (unitless)	Drinking H2O Ing. Rate (liters/day)	Inhalation Corr. Factor (unitless)	Drinking H2O Fraction (unitless)	Method B Noncarcinogen (2) (ug/l)	Predicted Concentration (3) (ug/l)	HQ @ Predicted Concentration (4) (unitless)
Arsenic	7440-38-2	0.0003	16	1,000	1	1.0	1	1.0	4.8	34.3	7.1
Benzene	71-43-2	0.003	16	1,000	1	1.0	2	1.0	24	5.40	0.2
Cadmium	7440-43-9	0.0005	16	1,000	1	1.0	1	1.0	8.0	15.0	
T Chromium	7440-47-3	not available									
Chromium III	16065-83-1	1.5	16	1,000	1	1.0	1	1.0	24,000		
Chromium VI	18540-29-9	0.003	16	1,000	1	1.0	1	1.0	48	50	1.0
DDT	50-29-3	0.0005	16	1,000	1	1.0	1	1.0	8.0	0.296	0.04
Ethylbenzene	100-41-4	0.1	16	1,000	1	1.0	2	1.0	800	695	0.9
Ethylene dibromide (EDB)	106-93-4	not available									
Lead	7439-92-1	not available									
Lindane	58-89-9	0.0003	16	1,000	1	1.0	1	1.0	4.8	0.325	0.1
Methylene chloride	75-09-2	0.06	16	1,000	1	1.0	2	1.0	480	4.7	0.01
Mercury (inorganic)	7439-97-6	0.0003	16	1,000	1	1.0	1	1.0	4.8		
MTBE	1634-04-4	not available							20.0	23.6	1.2
Naphthalene	91-20-3	0.02	16	1,000	1	1.0	2	1.0	160		
cPAH Mixtures	na	not available									
Benzo[a]anthracene	56-55-3	not available									
Benzo[b]fluoranthene	205-99-2	not available									
Benzo[k]fluoranthene	207-08-9	not available									
Benzo[a]pyrene	50-32-8	not available									
Chrysene	218-01-9	not available									
Dibenzo[a,h]anthracene	53-70-3	not available									
Ideno[1,2,3-cd]pyrene	207-08-9	not available									

Footnotes:

- (1) Source of RfDs is EPA's IRIS database except for benzene which is from EPA's NCEA.
- (2) Value calculated using equation 720-1 and default assumptions in that equation.
- (3) Concentration in ground water predicted with 3 phase model if current Method A soil cleanup level is used. Values not calculated for soil cleanup levels equal to or greater than current Method A soil cleanup level.
- (4) Predicted ground water concentration divided by Method B value. Bolded values indicate predicted concentration exceeds MTCA requirement that HQ not exceed 1.0. MTBE does not have an RfD or CPF. Value shown is predicted concentration divided by health advisory concentration.

Table 4-20 Continued:

Risk Calculations – Noncarcinogenic Effects of Drinking Water Ingestion

Hazardous Substance	CAS No.	Reference Dose (1) (mg/kg)	Avg. Body Weight (kg)	Unit Conv. Factor (ug/mg)	Hazard Quotient (unitless)	Drinking H2O Ing. Rate (liters/day)	Inhalation Corr. Factor (unitless)	Drinking H2O Fraction (unitless)	Method B Noncarcinogen (2) (ug/l)	Predicted Concentration (3) (ug/l)	HQ @ Predicted Concentration (4) (unitless)
PCB mixtures	1336-36-3	not available									
High Risk & Persistence		not available									
Low Risk & Persistence		not available									
Lowest Risk & Persistence		not available									
Aroclor 1016	12674-11-2	0.00007	16	1,000	1	1.0	1	1.0	1.1		
Arochlor 1248	12672-29-6	not available									
Arochlor 1254	11097-69-1	0.00002	16	1,000	1	1.0	1	1.0	0.32		
Arochlor 1260		not available									
Tetrachloroethylene (PCE)	127-18-4	0.01	16	1,000	1	1.0	2	1.0	80	4.7	0.1
Toluene	108-88-3	0.2	16	1,000	1	1.0	2	1.0	1,600	964	0.6
1,1,1 Trichloroethane	71-55-6	0.9	16	1,000	1	1.0	2	1.0	7,200	253	0.04
Trichloroethylene	79-01-6	not available									
Xylenes	1330-20-7	2.0	16	1,000	1	1.0	2	1.0	16,000	984	0.06 & 1.0
m-Xylene	108-38-3	not available									
o-xylene	95-47-6	not available									
p-xylene		not available									
Gasoline (5)											

Footnotes:

- (1) Source of RfDs is EPA's IRIS database except for 1,1,1 TCE, which is from HEAST
- (2) Value calculated using equation 720-1 and default assumptions in that equation.
- (3) Concentration in ground water predicted with 3 phase model if current Method A soil cleanup level is used. Values not calculated for soil cleanup levels equal to or greater than current Method A soil cleanup level.
- (4) Predicted ground water concentration divided by Method B value. For xylene the first value is the HQ, the second is the ratio of the predicted concentration to odor threshold of 1000 ug/l.
- (5) First value for BP composition #4, second value for ARCO composition #5. Both results obtained using 4 phase model to predict ground water impact at a soil gasoline conc. of 30 PPM.

Table 4-21: Calculation of Ground Water Cancer Risk Resulting from Current Method A Soil Cleanup Levels for Industrial Land Use

Risk Calculations – Carcinogenic Effects of Drinking Water Ingestion

Hazardous Substance	CAS No.	Risk (unitless)	Avg. Body Weight (kg)	Lifetime (years)	Unit Conv. Factor (ug/mg)	Potency Factor (kg-day/mg)	Drinking H ₂ O Ing. Rate (liters/day)	Duration of Exposure (years)	Inhalation Corr. Factor (unitless)	Drinking H ₂ O Fraction (unitless)	Method B Carcinogen (ug/l)	Predicted Concentration (3) (ug/l)	Risk @ Predicted Concentration (4) (unitless)
Arsenic	7440-38-2	1E-06	70	75	1,000	1.5	2.0	30	1	1.0	0.058	342.466	5,870.8
Benzene	71-43-2	1E-06	70	75	1,000	0.029	2.0	30	2	1.0	1.51	88.8	58.9
Cadmium	7440-43-9					not available							
T Chromium	7440-47-3												
Chromium III	16065-83-1					not available							
Chromium VI	18540-29-9					not available							
DDT	50-29-3	1E-06	70	75	1,000	0.34	2.0	30	1	1.0	0.26	0.3687	1.4
1,2 Dichloroethane	107-06-2	1E-06	70	75	1,000	0.091	2.0	30	2	1.0	0.48		
Ethylbenzene	100-41-4					not available						2314.8	
Ethylene dibromide (EDB)	106-93-4	1E-06	70	75	1,000	85	2.0	30	2	1.0	0.00051		
Lead	7439-92-1					not available							
Lindane	58-89-9	1E-06	70	75	1,000	1.3	2.0	30	1	1.0	0.067	644.32	9,572.8
Methylene chloride	75-09-2	1E-06	70	75	1,000	0.0075	2.0	30	2	1.0	5.8	114.8	19.7
Mercury (inorganic)	7439-97-6					not available							
MTBE	1634-04-4					not available						3529	176.5
Naphthalene	91-20-3					not available							
cPAH Mixtures	na												
Benzo[a]anthracene	56-55-3					not available							
Benzo[b]fluoranthene	205-99-2					not available							
Benzo[k]fluoranthene	207-08-9					not available							
Benzo[a]pyrene	50-32-8	1E-06	70	75	1,000	7.3	2.0	30	1	1.0	0.012	0.144500	12.1
Chrysene	218-01-9					not available							
Dibenzo[a,h]anthracene	53-70-3					not available							
Ideno[1,2,3-cd]pyrene	207-08-9					not available							

Footnotes:

- (1) Source of Cancer Potency Factor is the oral slope factors from EPA's IRIS database, except for Lindane which is from HEAST.
- (2) Value calculated using equation 720-2 and default assumptions in that equation.
- (3) Concentration in ground water predicted with 3 phase model if current Method A soil cleanup level is used. Values not calculated for soil cleanup levels equal to or greater than current Method A soil cleanup level.
- (4) Predicted ground water concentration divided by Method B value. This value is expressed in terms of 10⁻⁶ risk, that is a value of 19.7 is a risk of 19.7 X 10⁻⁶ or 1.97 X 10⁻⁵.

Table 4-21 Continued:

Risk Calculations – Carcinogenic Effects of Drinking Water Ingestion

Hazardous Substance	CAS No.	Risk (unitless)	Avg. Body Weight (kg)	Lifetime (years)	Unit Conv. Factor (ug/mg)	Potency Factor (kg-day/mg)	Drinking H ₂ O Ing. Rate (liters/day)	Duration of Exposure (years)	Inhalation Corr. Factor (unitless)	Drinking H ₂ O Fraction (unitless)	Method B Carcinogen (ug/l)	Predicted Concentration (3) (ug/l)	Risk @ Predicted Concentration (4) (unitless)
PCB mixtures	1336-36-3												
High Risk & Persistence		1E-06	70	75	1,000	2.0	2.0	30	1	1.0	0.044		
Low Risk & Persistence		1E-06	70	75	1,000	0.4	2.0	30	1	1.0	0.22		
Lowest Risk & Persistence		1E-06	70	75	1,000	0.07	2.0	30	1	1.0	1.25		
Aroclor 1016	12674-11-2					not available							
Aroclor 1248	12672-29-6					not available							
Aroclor 1254	11097-69-1					not available							
Aroclor 1260						not available							
Tetrachloroethylene (PCE)	127-18-4	1E-06	70	75	1,000	0.051	2.0	30	2	1.0	0.86	47.1	54.9
Toluene	108-88-3					not available							
1,1,1 Trichloroethane	71-55-6					not available							
Trichloroethylene	79-01-6	1E-06	70	75	1,000	0.011	2.0	30	2	1.0	4.0	75.6	19.0
Xylenes	1330-20-7					not available							
m-Xylene	108-38-3					not available							
o-xylene	95-47-6					not available							
p-xylene						not available							
Gasoline (5)											1.5	11.1 & 20.1	7.35 & 13.31

Footnotes:

- (1) Source of Cancer Potency Factor is the oral slope factors from EPA's IRIS database, except for tetrachloroethylene, trichloroethylene and vinyl chloride which are from HEAST.
- (2) Value calculated using equation 720-2 and default assumptions in that equation.
- (3) Concentration in ground water predicted with 3 phase model if current Method A soil cleanup level is used. Values not calculated for soil cleanup levels equal to or greater than current Method A soil cleanup level.
- (4) Predicted ground water concentration divided by Method B value. This value is expressed in terms of 10⁻⁶ risk, that is a value of 58.9 is a risk of 58.9 X 10⁻⁶ or 5.89 X 10⁻⁵.
- (5) First value for BP composition #4, second value for ARCO composition #5. Both results obtained using 4 phase model to predict benzene conc. at a soil gasoline conc. of 100 PPM. All values based on benzene. Risk calculated by dividing predicted benzene concentration by Method B benzene value.

Table 4-22: Calculation of Ground Water Cancer Risk Resulting from Proposed Method A Soil Cleanup Levels for Industrial Land Use

Risk Calculations – Carcinogenic Effects of Drinking Water Ingestion

Hazardous Substance	CAS No.	Risk (unitless)	Avg. Body Weight (kg)	Lifetime (years)	Unit Conv. Factor (ug/mg)	Potency Factor (kg-day/mg)	Drinking H ₂ O Ing. Rate (liters/day)	Duration of Exposure (years)	Inhalation Corr. Factor (unitless)	Drinking H ₂ O Fraction (unitless)	Method B Carcinogen (ug/l)	Predicted Concentration (3) (ug/l)	Risk @ Predicted Concentration (4) (unitless)
Arsenic	7440-38-2	1E-06	70	75	1,000	1.5	2.0	30	1	1.0	0.058	34.3	588.00
Benzene	71-43-2	1E-06	70	75	1,000	0.029	2.0	30	2	1.0	1.51	5.4	3.58
Cadmium	7440-43-9					not available							
T Chromium	7440-47-3												
Chromium III	16065-83-1					not available							
Chromium VI	18540-29-9					not available							
DDT	50-29-3	1E-06	70	75	1,000	0.34	2.0	30	1	1.0	0.26	0.296	1.15
Ethylbenzene	100-41-4					not available							
Ethylene dibromide (EDB)	106-93-4	1E-06	70	75	1,000	85	2.0	30	2	1.0	0.00051		
Lead	7439-92-1					not available							
Lindane	58-89-9	1E-06	70	75	1,000	1.3	2.0	30	1	1.0	0.067	0.325	4.83
Methylene chloride	75-09-2	1E-06	70	75	1,000	0.0075	2.0	30	2	1.0	5.8	4.7	0.81
Mercury (inorganic)	7439-97-6					not available							
MTBE	1634-04-4					not available						23.6	
Naphthalene	91-20-3					not available							
cPAH Mixtures	na												
Benzo[a]anthracene	56-55-3					not available							
Benzo[b]fluoranthene	205-99-2					not available							
Benzo[k]fluoranthene	207-08-9					not available							
Benzo[a]pyrene	50-32-8	1E-06	70	75	1,000	7.3	2.0	30	1	1.0	0.012		
Chrysene	218-01-9					not available							
Dibenzo[a,h]anthracene	53-70-3					not available							
Ideno[1,2,3-cd]pyrene	207-08-9					not available							

Footnotes:

- (1) Source of Cancer Potency Factor is the oral slope factors from EPA's IRIS database, except for Lindane which is from HEAST.
- (2) Value calculated using equation 720-2 and default assumptions in that equation.
- (3) Concentration in ground water predicted with 3 phase model if current Method A soil cleanup level is used. Values not calculated for soil cleanup levels equal to or greater than current Method A soil cleanup level.
- (4) Predicted ground water concentration divided by Method B value. This value is expressed in terms of 10⁻⁶ risk, that is a value of 58.9 is a risk of 58.9 X 10⁻⁶ or 5.89 X 10⁻⁵.

Table 4-22 Continued:

Risk Calculations – Carcinogenic Effects of Drinking Water Ingestion

Hazardous Substance	CAS No.	Risk (unitless)	Avg. Body Weight (kg)	Lifetime (years)	Unit Conv. Factor (ug/mg)	Potency Factor (kg-day/mg)	Drinking H ₂ O Ing. Rate (liters/day)	Duration of Exposure (years)	Inhalation Corr. Factor (unitless)	Drinking H ₂ O Fraction (unitless)	Method B Carcinogen (ug/l)	Predicted Concentration (3) (ug/l)	Risk @ Predicted Concentration (4) (unitless)
PCB mixtures	1336-36-3												
High Risk & Persistence		1E-06	70	75	1,000	2.0	2.0	30	1	1.0	0.044		
Low Risk & Persistence		1E-06	70	75	1,000	0.4	2.0	30	1	1.0	0.22		
Lowest Risk & Persistence		1E-06	70	75	1,000	0.07	2.0	30	1	1.0	1.25		
Aroclor 1016	12674-11-2					not available							
Aroclor 1248	12672-29-6					not available							
Aroclor 1254	11097-69-1					not available							
Aroclor 1260						not available							
Tetrachloroethylene (PCE)	127-18-4	1E-06	70	75	1,000	0.051	2.0	30	2	1.0	0.86	4.7	5.48
Toluene	108-88-3					not available							
1,1,1 Trichloroethane	71-55-6					not available							
Trichloroethylene	79-01-6	1E-06	70	75	1,000	0.011	2.0	30	2	1.0	4.0	4.5	1.13
Xylenes	1330-20-7					not available							
m-Xylene	108-38-3					not available							
o-xylene	95-47-6					not available							
p-xylene						not available							
Gasoline (5)											1.51	6.74 & 3.53	4.5 & 2.3

Footnotes:

- (1) Source of Cancer Potency Factor is the oral slope factors from EPA's IRIS database, except for tetrachloroethylene, trichloroethylene and vinyl chloride which are from HEAST.
- (2) Value calculated using equation 720-2 and default assumptions in that equation.
- (3) Concentration in ground water predicted with 3 phase model if current Method A soil cleanup level is used. Values not calculated for soil cleanup levels equal to or greater than current Method A soil cleanup level.
- (4) Predicted ground water concentration divided by Method B value. This value is expressed in terms of 10⁻⁶ risk, that is a value of 58.9 is a risk of 58.9 X 10⁻⁶ or 5.89 X 10⁻⁵.
- (5) First value for BP composition #4, second value for ARCO composition #5. Both results obtained using 4 phase model to predict benzene conc. at a soil gasoline conc. of 30 PPM. All values based on benzene. Risk calculated by dividing predicted benzene concentration by Method B benzene value.

Table 4-23: Estimated Cost of Adverse Health Effects

Condition	Cost per Case (\$)	Measure
Cancer Health Effects		
• All Cancers (non-fatal)	\$21,733 (1)	Cost of illness
• Lung Cancer (non-fatal)	\$41,184 (1)	Cost of illness
Non-Cancer Health Effects		
• Effects on nervous system	\$6,467 (1)	Willingness to pay / contingent valuation
• Effects on respiratory system	\$34,228 (1)	Willingness to pay / contingent valuation
• Effects on cardiovascular system	\$5,668 (1)	Cost of illness
• Effects on the kidneys	\$24,250 (2),(3)	Cost of illness
• Effects on the liver	\$222,077 (2),(3)	Cost of illness

Footnotes:

- (1) Source: Tolley, G., D. Kenkel, and R. Fabian, *Valuing Health for Policy: An Economic Approach*, The University of Chicago Press (1994).
- (2) Source: Cooper, B.S., and D.P. Rice, *The Economic Cost of Illness Revisited*, Social Security Bulletin, pp. 21-36, Feb. 1976.
- (3) The estimated costs of illness for effects on the kidneys and liver are based on aggregated values obtained from the source in footnote (2). These aggregated figures were adjusted for a single case based on national statistics obtained from a different source. Accordingly, these figures may not be as reliable.

Notes:

- Values have been adjusted for inflation and converted (when necessary) to an annual basis.
- Values are shown on a per-case basis since available information does not allow application of incidence rates to potentially affected populations.
- Annualization of values originally derived and reported on a daily, weekly, or monthly basis was done in order to provide a common time dimension. However, these rather broad categories of health effects include conditions (e.g., headaches, nausea) that may typically run their course in less than a year. In such cases, the values shown should be adjusted accordingly.
- The reported values are drawn from information generated using different measurement frameworks – the cost of illness approach versus willingness to pay contingent value studies. The further reduces the direct comparability of values for different health effects categories.

Table 4-24: Value of Reducing Risks of Excess Mortality – Central Tendency Analysis

Hazardous Substance	Cancer Incidence (1)	Estimated Cancer Deaths (2)	Deaths per 100,000	WTP (\$) Per hh Per yr (3, 4, 5)	WTP (\$) Per Death Per hh Per yr (3, 5)	Value of Risk Reduction (\$/yr) (3, 5)	
Gasoline range organics	21	9	0.291	46	5.06	\$11,789,508	
Trichloroethylene	55	24	0.763	66	2.78	\$6,488,781	
Methylene chloride	58	25	0.805	67	2.69	\$6,278,531	
Tetrachloroethylene	153	66	2.122	97	1.48	\$3,440,254	
Benzene	171	74	2.372	101	1.38	\$3,210,938	
Lindane	1,469	632	20.376	229	0.36	\$845,959	
	average	138	4.455	129	0.93	\$2,172,010	average
	5th percentile	41	1.336	81	1.97	\$4,583,015	high
	95th percentile	787	25.393	249	0.32	\$738,020	low

Footnotes:

- (1) See Table 4-4.
- (2) Based on a mortality rate of 43%. Mortality rate derived from statistics obtained from the National Cancer Institute (NCI, 2000).
- (3) Values in 1998 dollars; not discounted.
- (4) Based on duVair, P. and Loomis, J., *Household's Valuation of Alternative Levels of Hazardous waste Risk Reduction: An Application of the Referendum Format Contingent Valuation Method*, Journal of Environmental Management, Vol. 39, pp. 143-55, 1999.
- (5) Based on the size and number of households in Washington State. Washington State Office of Financial Management, Forecasting Division, *1999 Population Trends*, September 1999.

Table 4-25: Value of Reducing Risks of Excess Mortality – Discounted to Present Values

These estimates are based on the central tendency estimates (see Table 4-24) using constant 1998 dollars discounted to a present lump sum value for all Washington households. The discount rates used for these benefit estimates are as follows:

- 3.770% yield to maturity, 30 year inflation indexed treasury securities;
- 5.520% yield to maturity, 30 year treasury securities
- 1.287% yield to maturity, 10 year high yield privately issued corporate bonds

These discount rates were published in the December 7, 2000 issue of the Wall Street Journal.

Rate	Low Present Value	Average Present Value	High Present Value
3.770%	\$14,215,534	\$41,836,638	\$88,276,717
5.520%	\$11,330,957	\$33,347,262	\$70,363,848
12.870%	\$5,651,538	\$16,632,735	\$35,095,632

Table 4-26: Value of Reducing Risks of Excess Mortality – Income Elasticity Adjustment

These estimates are based on the discounted present value results (see Table 4-25). These estimates use constant 1998 dollars and assume a 2.5% per year, long term real income growth (Office of the Forecast Council, 2000) and an income elasticity for a willingness to pay function of 1.0 (Viscusi, 1993, p. 1930). The resulting estimates are shown below.

Rate	Low Present Value	Average Present Value	High Present Value
3.770%	\$20,855,789	\$61,379,056	\$129,511,878
5.520%	\$15,982,963	\$47,038,221	\$99,252,234
12.870%	\$7,044,707	\$20,732,733	\$43,746,766

Chapter 5 Technical Analysis – Probable Cost Impact on Petroleum Contaminated Sites

5.1 Introduction

5.1.1 Conceptual Approach

To assess the impact of the proposed rule amendments on costs, an analysis of the impact of the proposed rule amendments on petroleum contaminated sites was conducted. This analysis includes an analysis of the impacts of the following proposed rule amendments:

- Changes to the Method A soil and ground water cleanup levels.
- Establishment of soil cleanup levels – evaluation of the soil-to-ground water pathway.
- Establishment of soil cleanup levels – evaluation of the dermal exposure pathway.
- Establishment of soil cleanup levels – evaluation of the vapor exposure pathway.
- Establishment of soil cleanup levels – conducting a terrestrial ecological evaluation.

Petroleum contaminated sites were selected for this analysis for the following reasons:

- Petroleum contaminated sites represent the largest percentage of cleanup sites.
- Petroleum contaminated sites represent the largest percentage of cleanup sites that use Method A cleanup levels.
- Petroleum hydrocarbons are the most commonly detected hazardous substances at all cleanup sites.

This analysis supplements the generic approach used for estimating the impact of the proposed rule amendments on costs discussed in **Chapter 3**.

5.1.2 Study Design

To assess the impact of the proposed rule amendments on costs, the impact of the current rule (the baseline) must first be evaluated. To assess that impact, Ecology conducted a statewide study of leaking fuel tank sites. A description of that study and the results of that study are presented in **Section 5.2**.

To assess the impact of the proposed rule amendments on petroleum contaminated sites, three “typical” petroleum contaminated sites were developed for analysis based on actual cleanup sites in Washington State. These three site scenarios are as follows:

- **Site “A”** – Commercial gas station with no ground water contamination. This scenario was used to assess the impact of excavating soil to Method A soil cleanup levels.
- **Site “B”** – Commercial gas station with soil and ground water contamination. This scenario was used to assess the impact of treating soil and ground water to Method B cleanup levels.

- **Site “C”** – Industrial facility with soil and ground water (non-potable) contamination.

Analysis of the impact of the proposed rule amendments on these three “typical” sites is presented in **Sections 5.3 through 5.5**.

5.2 Statewide Leaking Fuel Tank Study

5.2.1 Methodology

For the statewide leaking fuel tank site study, Ecology randomly selected twenty nine (29) sites from the January 5, 2000, version of Ecology’s Leaking Underground Storage Tank (LUST) list that have received a “No Further Action” letter from Ecology. Specifically, ten (10) sites were selected from Ecology’s Northwest and Central Regions, with nine (9) sites selected from Ecology’s Southwest Region.

The following data was then collected and compiled for each site:

- The site name, address, city and county;
- BTEX⁷, TPH-Gasoline and TPH-Diesel concentrations in both soil and ground water;
- The depth to ground water;
- The type of laboratory analysis used for petroleum constituents; and
- The number of cubic yards of soil removed during cleanup.

Once this information was compiled, the post-cleanup data for each region was sorted and tabulated according to the following six (6) categories:

- Sites where it was not clear what was done (i.e., unknown);
- Sites where petroleum hydrocarbon soil levels were non-detect (ND);
- Sites where petroleum hydrocarbon soil levels were greater than non-detect (ND) but less than the *current* Method A levels;
- Sites where petroleum hydrocarbon soil levels were greater than non-detect (ND) but less than the *proposed* Method A levels;
- Sites where petroleum hydrocarbon soil levels were greater than the *current* Method A levels; and
- Sites where petroleum hydrocarbon soil levels were greater than the *proposed* Method A levels.

In order for a site to qualify as a “non-detect,” all the samples had to be non-detect for all petroleum constituents. For sites where soil levels were somewhere between non-detect and existing or proposed Method A, best professional judgement was used to determine a “representative” petroleum hydrocarbon concentration for the site. This type of assessment was necessary because in most situations multiple soil samples from different depths and locations were collected and reported. Best professional judgment was also used to determine

⁷ BTEX = benzene, toluene, ethyl benzene and xylene.

representative concentrations for sites where the petroleum hydrocarbon soil concentrations exceeded either current or proposed Method A levels.

5.2.2 Study Results

Compilation and analysis of the data acquired as part of the statewide leaking fuel tank study revealed the following:

- 62% of the sites (18 of 29 sites) were cleaned up to either non-detect (ND) or to levels less than the *current* Method A soil cleanup levels, with 24% of the sites (7 sites) exceeding *current* Method A cleanup levels (**Figure 5-1**).
- Applying the *proposed* Method A cleanup levels the same data set, 49% of the sites were cleaned up to either non-detect (ND) or levels less than the *proposed* Method A cleanup levels, with 38% of the sites (11 sites) exceeding the *proposed* Method A cleanup levels **Figure 5-2**).
- Thus, applying the *proposed* instead of the *current* Method A cleanup levels to the data set resulted in a 14% increase in the number of sites exceeding the applicable cleanup level (i.e., at *current* Method A, seven (7) sites exceeded; at *proposed* Method A, eleven (11) sites exceeded).

A more detailed analysis of the data set also found the following:

- TPH-gasoline was the most frequently detected contaminant (12 of 29 sites or 41%; **Table 5-1**).
- The impact of the *proposed* Method A standards for TPH-gasoline and benzene was more significant than other hazardous substances (toluene, ethylbenzene, and xylene). Specifically, 9 of 12 (75%) sites exceeded the *proposed* TPH-G standard of 30 ppm, while 4 of 4 sites (100%) exceed the *proposed* benzene standard of 0.03 ppm. Conversely, the proposed standards for TPH-diesel, T, E and X had less impact, i.e. 2 of 5 sites (40%) exceeded the proposed standard (7 ppm) for toluene; 3 of 8 sites (37.5%) exceeded the proposed standard (6 ppm) for ethyl benzene and 4 of 9 (44%) sites exceeded the proposed standard (9 ppm) for xylene.
- Benzene and toluene (B & T) were detected in soil less frequently than ethyl benzene and xylene (E & X). This is probably an artifact of water solubility (i.e., B and T are more soluble in water, while E and X are less soluble and are therefore less mobile).
- Even though gasoline was the most frequently detected hazardous substance in soil, 69% of the sites (20 of 29) did not test the ground water for benzene.
- The median amount of petroleum contaminated soil removed (16 sites) was 125 cubic yards; the mean was 713 cubic yards.

- The average ground water depth for 13 sites was 13 feet below ground surface (bgs).

5.2.3 Conclusions

Based on the statewide leaking fuel tank study, Ecology determined that the proposed changes to the Method A cleanup levels under the proposed rule amendments would likely impact only 51% of the sites evaluated. This is based on the fact that 49% of the sites surveyed cleaned up soil to either non-detect or to levels that are below both the current and proposed Method A cleanup levels.

5.3 Site “A” – Commercial Gas Station with Contaminated Soil and No Ground Water Contamination

5.3.1 Site “A” Description

A description of the site is as follows:

- The property is ¼ acre in size (100 x 100 feet) and either paved or covered with buildings.
- The property is zoned for commercial land use.
- The site contains nine fuel tanks (7 gasoline, 1 heating oil and 1 waste oil).
- The soil is contaminated with a gasoline mixture.
- A TPH-gasoline soil concentration of 1,700 ppm was measured at the site.
- The remedy selected for the site consisted of tank removal and excavation and disposal of contaminated soil. Approximately 500 cubic yards of soil was removed during the excavation, stockpiled on site and eventually transported to an in-state facility for disposal. The size of the tank pit area was 30 feet wide, 50 feet long and 12 feet deep (5,400 cubic feet).
- After the soil was excavated, seven (7) samples were collected from the bottom of the tank pit (12 feet deep) and analyzed for TPH-gasoline. The range of gasoline concentrations detected was non-detect (ND) to 12 ppm.
- Ground water was not encountered during the excavation and the site soil was comprised of brown silty-sandy clay.

5.3.2 Site “A” Analysis

The impact of the proposed rule amendments on this “typical” site depends on several factors, including the gasoline composition, the method for establishing soil cleanup levels, the remedy selected for the site, and the volume of contaminated soil.

5.3.2.1 Gasoline Composition

Ecology also derived a representative gasoline composition for this site. This composition was derived using actual data and the four-phase equilibrium partitioning model. First, Ecology derived the composition of fresh gasoline by having one sample of British Petroleum (BP) brand

gasoline sent to a laboratory and analyzed for Volatile Petroleum Hydrocarbons (VPH)⁸ and volatile organics (VOA's).⁹

The composition of fresh gasoline was then used as the initial composition in the four-phase model which was encoded in an Excel™ spreadsheet. A soil TPH-gasoline concentration of 100 mg/kg¹⁰ was then selected as the initial soil concentration for each fuel composition. Specifically, once the fresh composition has been entered into the spreadsheet, a simulation was done at 100 mg/kg TPH-gasoline. Each subsequent composition was then determined by summing the amount of gasoline adsorbed to soil plus the amount of gasoline present as a non-aqueous phase liquid (NAPL). That is, the amount of fuel in the air (vapor) and water (soil pore water) was subtracted from the system to simulate weathering of the fresh fuel. This represents the parts of the fuel removed by volatilization and leaching/biodegradation.

This iterative modeling process resulted in the fuel compositions provided in **Table 5-2**. The median BTEX composition of this data set was then compared to the modeled compositions. This analysis found that composition No. 4 most closely resembled actual field data (**Table 5-3 and Figures 5-3 and 5-4**).

5.3.2.2 Cleanup Levels

For Site "A," Ecology assumed that soil cleanup levels were established under Method A. Method A soil cleanup levels for TPH-G (TPH-gasoline) and BTEX (benzene, toluene, ethyl benzene and xylene) established under the proposed rule were compared against those established under the current rule. **See Table 5-5.**

Note that soil cleanup levels may only be established using Method A if those levels are protective of terrestrial ecological receptors. For Site "A," Ecology determined that both the current and proposed cleanup levels are protective.

As discussed in Chapter 2, the terrestrial ecological rule amendments will only impact cleanup costs if a terrestrial ecological evaluation were required under the proposed rule, but not the current rule, and that evaluation resulted in additional remedial actions being required. Considering the factors discussed in Chapter 2, Ecology does not consider this likely for most sites.

⁸ Volatile Petroleum Hydrocarbons (VPH) are defined as all hydrocarbon compounds eluting just prior to n-pentane through 1-methylnaphthalene. VPH is comprised of C5 through C6, >C6 through C8, >C8 through C10 and >C10 through C12 Aliphatic Hydrocarbons, as well as >C8 through C10, >C10 through C12 and >C12 through C13 Aromatic Hydrocarbons as well as benzene and toluene.

⁹ Volatile Organics (VOA's). Includes BTEX and MTBE, per Ecology's Manchester Laboratory Method (EPA Method 8020, GC/PID).

¹⁰ 100 ppm was selected because it is a convenient number to work with when dealing with percentages. As it turns out, Ecology found that it really does not matter what number you start with. That is, if you select a higher starting concentration, all it means is that it will take that much longer to redistribute or partition the various gasoline components.

For Site “A,” the terrestrial ecological evaluation could end by comparing the ecological indicator soil concentrations in Table 749-3 under WAC 173-340-900 against soil concentrations protective of human health. Specifically, the 30 ppm human health cleanup level is less than the 100 ppm ecological indicator soil concentration for TPH-G. The 100 ppm concentration is expected to be protective at any MTCA site. The selected remedy will not result in residual contamination in excess of that ecological indicator concentration.

Alternatively, Ecology expects that the site could qualify for an exclusion from conducting a terrestrial ecological evaluation. Specifically, the site should qualify for an exclusion under WAC 173-340-7491(1)(b) because the site is, or will be, covered by buildings, paved roads, pavement, or other physical barriers that will prevent plants or wildlife from being exposed to soil contamination. Institutional controls would not be required to obtain this exclusion because the remedy selected will not result in residual contamination in excess of that ecological indicator soil concentrations.

5.3.2.3 Remedy Selection

For Site “A,” Ecology assumed that a more permanent remedy would be selected. Assumption of a more permanent remedy is a conservative assumption that highlights the potential cost differential. Assumption of a less permanent remedy that includes engineered and/or institutional controls (such as containment) and results in residual contamination at the site may not result in any cost differential. For this site, Ecology assumed that soil excavation and removal was the selected remedy. This assumption is based on the common use of soil excavation and removal at leaking fuel tank sites in Washington State.

5.3.2.4 Cleanup Costs

For Site “A,” the impact of the proposed rule on cleanup costs is based on the amount of soil requiring removal under the proposed rule as compared with current rule. The cleanup cost is based on the volume of soil excavated (cubic yards) multiplied by the unit cost of excavating one cubic yard of soil.

- **Volume of Remediated Soil:** To estimate the amount of soil that would have to be remediated under proposed rule compared to the current rule. Ecology first plotted measured TPH-gasoline soil concentrations¹¹ against depth (**Figure 5-5**). The data in this plot were then fitted to a linear regression and a slope of the line through these points was derived. The slope of the straight line ($m = 0.0035$) through the measured data points was then used to construct hypothetical X,Y data pairs by using the straight line equation $y = mx + b$. This process resulted in the values specified in **Table 5-4**.

Hypothetical concentration versus depth profiles for TPH-G and BTEX were then constructed using an assumed composition (No. 4) and the information from the linear regression through the measured data points (**Figure 5-6; Figure 5-7**).

¹¹ According to the site report, the highest measured soil TPH-gasoline concentration (1,700 ppm) was detected at 6 feet; with 6.3 – 12 ppm TPH-gasoline detected at 12 feet depth (based of tank excavation).

Once the concentration versus depth profiles were constructed, it was then possible to precisely estimate how much soil would need to be excavated to meet both the current and proposed Method A table soil values (column labeled “y” depth in **Table 5-4**). This analysis assumed that the length (50 feet) and width (30 feet) of the excavation pit remained constant and the only variable was depth.

If TPH-G determined the volume of soil that required remediation, then the proposed rule would require excavation and removal of 14 additional cubic yards of soil. If benzene, and not TPH-G, determined the volume of soil that required remediation, then the proposed rule would require excavation and removal of 73 additional cubic yards of soil. **See Table 5-5.**

- **Unit Cost:** The unit cost was estimated to be **\$75 per cubic yard**. This estimation is based on the best professional judgment of site managers and a review of site cleanups.
- **Total Cost:** If TPH-G determined the volume of soil that required remediation, the proposed rule would increase the cleanup cost from \$48,667 to \$49,668, resulting in a cost differential of **\$1,021 or 2.1%**. **See Table 5-5.**

If benzene, not TPH-G, determined the volume of soil that required remediation, the proposed rule would increase the cleanup cost from \$44,292 to \$49,883, resulting in a cost differential of **\$5,542 or 11.1%**. **See Table 5-5.**

5.3.2.5 Evaluation Costs

Under this scenario, Ecology does not expect additional evaluation costs to be incurred under the proposed rule at most sites since additional or more complicated analyses would not be required. To the extent that additional analyses would be required, such as for MTBE, the costs are expected to be minor.

5.3.3 Site “A” Summary

For this site, the impact of the proposed rule amendments on costs is relatively minor. The proposed rule would not result in additional evaluation costs. The proposed rule could result in an increase in cleanup costs of anywhere from **\$1,021 to \$5,542 (2.1% to 11.1%)**.

5.4 Site “B” – Commercial Gas Station with Soil and Ground Water Contamination

5.4.1 Site “B” Description

The description of Site “B” is the same site as Site “A,” described in **Section 5.3**, except that the release at the site is assumed to have caused contamination of potable ground water. Specifically, because of the duration of the release and because the base of leaking fuel tanks were in close proximity to the ground water table, the release is assumed to have resulted in the mass of gasoline in the ground water being larger than in the soil. In addition, the release was

assumed to have resulted in a ground water plume larger in area than the area of soil contamination. The following specific assumptions were also made:

- The ground water is classified as potable under WAC 173-340-720.
- A 30 ft. wide x 50 ft. long x 12 ft. deep (18,000 cubic feet) area of soil is uniformly contaminated with 1,700 ppm TPH-gasoline.
- A 15 ft. wide x 50 ft. long x 1.5 ft. deep (1,125 cubic feet) light non-aqueous phase liquid (gasoline) layer is present on the ground water table. It was assumed that the gasoline LNAPL has concentration of 764,000 mg/kg, which is based on a laboratory measurement of fresh gasoline (**Table 5-6**).
- A dissolved-phase (gasoline components) ground water plume with a uniform concentration of 2.3 mg/l (see **Table 5-12**) is also present beneath the site. The plume has the following dimensions: 30 ft. wide x 100 x long x 12 feet deep.

5.4.2 Site “B” Analysis

The impact of the proposed rule amendments on this “typical” site depends on several factors, including the gasoline composition, the method for establishing soil and ground water cleanup levels, the remedy selected for the site, and the volume or mass of contaminated soil and ground water.

5.4.2.1 Gasoline Composition

The gasoline composition assumed for Site “B” is the same as for Site “A”. See **Section 5.3**.

5.4.2.2 Method B Ground Water Cleanup Levels

For Site “B,” standard Method B ground water cleanup levels were established under both the current and proposed rules. The current and proposed Method B ground water cleanup levels are presented in **Table 5-7**.

- Under the current rule, the standard Method B ground water cleanup levels are 1,000 ppb for TPH-G and 1.3 ppb for benzene.
- Under the proposed rule, the standard Method B ground water cleanup levels are 490 ppb for TPH-G and 5 ppb for benzene.

5.4.2.3 Method B Soil Cleanup Levels

For Site “B,” standard Method B soil cleanup levels were established under both the current and proposed rules. Derivation of the standard Method B soil cleanup levels included consideration of the direct contact, leaching and vapor pathways for protection of human health. Derivation of soil cleanup levels also included consideration of terrestrial ecological receptors. Under both rules, the cleanup levels are determined by the leaching pathway. The current and proposed Method B soil cleanup levels are presented in **Table 5-7**.

- Under the current rule, the standard Method B soil cleanup levels are 100 ppm for TPH-G and 0.13 ppm for benzene.

- Under the proposed rule, the standard Method B soil cleanup levels are 22 ppm for TPH-G and 0.03 ppm for benzene.

Consideration of each of the exposure pathways is discussed below.

- **Direct Contact Pathway:** Under the current rule, evaluation of the direct contact pathway requires consideration of only the ingestion pathway. Protective soil concentrations were derived using the Interim TPH Policy and the gasoline composition. None of the existing soil concentrations at the site (TPH-G and BTEX) exceeded the protective soil concentrations derived under the current rule. **See Table 5-8.** Under the proposed rule, evaluation of the direct contact pathway for petroleum mixtures requires consideration of both the dermal and ingestion pathways. Protective soil concentrations were derived using Equation 740-3 and the gasoline composition. The protective soil concentrations derived under the proposed rule were greater than those derived under the current rule. However, none of the existing soil concentrations at the site (TPH-G and BTEX) exceeded the protective soil concentrations derived under the proposed rule. **See Table 5-8.** Since the existing soil concentrations are protective under both rules, evaluation of this pathway under the proposed rule would not result in additional cleanup costs. To the extent that the contaminants evaluated are the same, the evaluation costs are expected to be the same.
- **Leaching Pathway:** Under the current rule, the Interim TPH Policy was used to determine whether the existing soil concentrations were protective of ground water. Ecology determined that the existing soil concentrations were not protective, finding that the existing 1,700 ppm TPH-G soil concentration would result in a TPH-G ground water concentration of 2.46 mg/l, which exceeds the criteria of 1 mg/l. **See Table 5-11.** Protective soil concentrations were then derived using the “100 x ground water cleanup level” methodology. **See Table 5-9.** Application of this approach resulted in a protective soil concentration of 100 ppm for TPH-G and 0.13 for benzene. **See Table 5-8.**

Under the proposed rule, the 4-phase equilibrium partitioning model was used to determine whether the existing soil concentrations were protective of ground water. Ecology determined that the existing soil concentrations were not protective, finding that the existing 1,700 ppm TPH-G soil concentration would result in a TPH-G ground water concentration of 2.3 mg/l, which exceeds the criteria of 0.49 mg/l. **See Table 5-12.** Protective soil concentrations were then derived using the 4-phase model. **See Table 5-13.** Application of this model resulted in a protective soil concentration of 22 ppm for TPH-G and 0.03 for benzene. **See Table 5-8.**

- **Vapor Pathway:** As discussed in Chapter 2, the proposed rule amendment will only impact cleanup costs if an evaluation of the vapor pathway were required under the proposed rule, but not the current rule, and that evaluation resulted in a more stringent soil cleanup level than would have been established without that evaluation. Considering the factors discussed in Chapter 2, Ecology does not consider this likely at most sites. At this site, Ecology assumed that an evaluation of this pathway would not be required under either the current or proposed rule because the concentration derived under the leaching pathway would not likely

cause a concern regarding soil vapors. Thus, additional evaluation or cleanup costs would not be incurred as a consequence of this pathway.

- **Terrestrial Ecological Evaluation:** As discussed in Chapter 2, the proposed rule amendment will only impact cleanup costs if a terrestrial ecological evaluation were required under the proposed rule, but not the current rule, and that evaluation resulted in additional remedial actions being required. Considering the factors discussed in Chapter 2, Ecology does not consider this likely for most sites.

For Site “B,” the terrestrial ecological evaluation could end by comparing the ecological indicator soil concentrations in Table 749-3 under WAC 173-340-900 against soil concentrations protective of human health. Specifically, the 22 ppm human health cleanup level is less than the 100 ppm ecological indicator soil concentration for TPH-G. The 100 ppm concentration is expected to be protective at any MTCA site. The selected remedy will not result in residual contamination in excess of that ecological indicator concentration.

Alternatively, Ecology expects that the site could qualify for an exclusion from conducting a terrestrial ecological evaluation. Specifically, the site should qualify for an exclusion under WAC 173-340-7491(1)(b) because the site is, or will be, covered by buildings, paved roads, pavement, or other physical barriers that will prevent plants or wildlife from being exposed to soil contamination. Institutional controls would not be required to obtain this exclusion because the remedy selected will not result in residual contamination in excess of the ecological indicator soil concentration.

5.4.2.4 Remedy Selection

For Site “B,” Ecology assumed that a more permanent remedy would be selected. Again, assumption of a permanent remedy is a conservative assumption that highlights the potential cost differential. Assumption of a less permanent remedy that included engineered and/or institutional controls (such as containment) and resulted in residual contamination at the site may not result in any cost differential. For this site, Ecology assumed that “dual-phase extraction” would be used to cleanup the soil and ground water simultaneously to meet applicable cleanup standards. Dual-phase extraction consists of soil vapor extraction (SVE) and air sparging of ground water.

5.4.2.5 Cleanup Costs

For Site “B,” the cleanup cost is based on the cost of using “dual-phase extraction” to cleanup the soil and ground water to meet the applicable cleanup standards. The mass of soil or ground water contamination that must be removed under either rule is based on the difference between the existing mass of contamination and the mass of contamination at the applicable cleanup level. The cost differential is based on the mass of contamination in the soil and ground water that must be removed under the proposed rule as compared with the current rule.

- **Mass of Contamination:** The existing mass of soil contamination is 1,300 kilograms. This estimate is based on the assumption that the site (50 x 30 x 12 feet) was uniformly contaminated with TPH-G at a concentration of 1,700 ppm. The change in the mass of soil contamination requiring removal is 69.7 kilograms. **See Table 5-14.**

The existing mass of ground water contamination is 17,761 kilograms. This estimate is based on the assumption that the depth to ground water is 12 feet, the soil is uniformly contaminated with TPH-G at a concentration of 1,700 ppm, and the affected aquifer is 100 x 30 x 15 feet. The estimate is also based on assumption that a layer of non-aqueous phase liquid (LNAPL) is present on the ground water table and is 15 x 50 x 1.5 feet. The change in mass of ground water contamination requiring removal is less than 1 kilogram. **See Table 5-14.**

Thus, the total increase in the mass of TPH-G contamination requiring removal from the soil and ground water is **70 kilograms**. **See Table 5-14.**

Note that the change in the mass of benzene requiring removal from the soil was calculated to be less than 1 kilogram. Note also that there would be no change in the differential mass of benzene requiring removal from the ground water. **See Table 5-14.**

- **Unit Cost of Soil and Ground Water Cleanup (Dual-Phase Extraction):** The unit cost of conducting dual-phase extraction was estimated to be **\$65.20 per kilogram**. This estimate is based on the median cost of the costs at four commercial gas stations (**Table 5-15**).
- **Total Cost:** The impact of the proposed rule on cleanup costs was calculated by multiplying the unit cost of dual-phase extraction by the differential mass of soil and ground water contamination that must be removed. That amount was calculated to be **\$4,564**, representing an increase of **0.37%**. **See Table 5-14.**

5.4.2.6 Evaluation Costs

Under this scenario, Ecology does not expect additional evaluation costs to be incurred under the proposed rule since additional or more complicated analyses would not generally be required. In a few circumstances, relatively small increases in the cost of evaluating the leaching or ecological pathways might be incurred.

5.4.3 Site “B” Summary

For Site “B,” the impact of the proposed rule amendments on costs is expected to be small. The proposed rule could result in an increase in cleanup costs at Site “B” of **\$4,560**, representing an increase of **less than 1%** in cleanup costs. The proposed rule is not expected to result in any significant increase in the costs of conducting any evaluations.

5.5 Site “C” – Industrial Facility with Soil and Non-Potable Ground Water Contamination

5.5.1 Site “C” Description

A description of the site is as follows:

- The property is 5 acres in size and zoned for industrial land use.
- Both the soil and ground water are contaminated with a gasoline mixture.
- The maximum TPH-G soil concentration measured at the site is 10,000 ppm.
- The ground water is demonstrated to be non-potable under WAC 173-340-720.

5.5.2 Site “C” Analysis

The impact of the proposed rule amendments on this “typical” site depends on several factors, including the gasoline composition, the method for establishing soil and ground water cleanup levels, the remedy selected for the site, and the volume or mass of contaminated soil and ground water.

5.5.2.1 Gasoline Composition

The gasoline composition assumed for Site “C” is the same as for site A. **See Section 5.3.**

5.5.2.2 Method C Ground Water Cleanup Levels

For Site “C,” Ecology assumed that the ground water was not classified as potable under WAC 173-340-720 under both the current and proposed rules. Under both the current and proposed rule, ground water cleanup levels for ground water that is not classified as potable may be established on a site-specific basis. Consequently, the proposed rule is not expected to result in either additional evaluation costs or lower cleanup levels.

5.5.2.3 Method C Soil Cleanup Levels

For Site “C,” Ecology assumed that soil cleanup levels for industrial land use (standard Method C) could be established under both the current and proposed rules. Derivation of standard Method C soil cleanup levels included consideration of the direct contact, leaching and vapor pathways for protection of human health. Derivation of soil cleanup levels also includes consideration of terrestrial ecological receptors.

- **Direct Contact Pathway:** Under the current rule, evaluation of the direct contact pathway requires consideration of only the ingestion pathway. Protective soil concentrations would be derived using the Interim TPH Policy and the Method C equations. The measured TPH-G and benzene concentrations would not exceed the protective soil concentrations derived under the current rule. Under the proposed rule, evaluation of the direct contact pathway for petroleum mixtures requires consideration of both the dermal and ingestion pathways. Protective soil concentrations would be derived using Equations 745-3, 745-4 and 745-5. While the protective soil concentrations derived under the proposed rule would be lower than under the current rule, the measured TPH-G and benzene concentrations would not exceed the protective soil concentrations derived under the proposed rule. Since the existing soil concentrations are protective, evaluation of this pathway under the proposed rule would not result in additional cleanup costs. To the extent that the contaminants evaluated are the same, the evaluation costs are expected to be the same.
- **Leaching Pathway:** Derivation of a soil concentration that is protective of ground water depends on the applicable ground water cleanup level. In this case, the ground water cleanup levels were based on a site-specific analysis and are unknown. Hence, the protective soil

concentrations are unknown. The protective soil concentrations derived under the proposed rule are expected to be relatively similar to those under the current rule. Because similar analyses would be conducted, the proposed rule is not expected to result in additional evaluation costs.

- **Vapor Pathway:** As discussed in Chapter 2, the proposed rule amendment will only impact cleanup costs if an evaluation of the vapor pathway were required under the proposed rule, but not the current rule, and that evaluation resulted in a more stringent soil cleanup level than would have been established without that evaluation. Considering the factors discussed in Chapter 2, Ecology does not consider this likely for most sites. Depending on the evaluation of the leaching pathway, an analysis of the vapor pathway may be required. Evaluation of the pathway may not even require a lower cleanup level. Even if a lower cleanup level were required, Ecology expects that if an evaluation were required under the proposed rule, such an evaluation would also be required under the current rule and would result in the same conclusion. Thus, additional evaluation or cleanup costs would not be incurred as a consequence of this pathway.
- **Terrestrial Ecological Evaluation:** As discussed in Chapter 2, the proposed rule amendment will only impact cleanup costs if a terrestrial ecological evaluation were required under the proposed rule, but not the current rule, and that evaluation resulted in additional remedial actions being required. Considering the factors discussed in Chapter 2, Ecology does not consider this likely for most sites.

For Site “C,” the site might qualify for an exclusion from conducting a terrestrial ecological evaluation. Specifically, the site could qualify for an exclusion under WAC 173-340-7491(1)(b) if the site is, or will be, covered by buildings, paved roads, pavement, or other physical barriers that will prevent plants or wildlife from being exposed to soil contamination. Such containment measures are typical at industrial sites. Institutional controls would be required to obtain this exclusion. However, implementation of these institutional controls would not increase cleanup costs because institutional controls would already be required because Method C was used to establish cleanup levels at the site.

Alternatively, if the site qualifies for a simplified evaluation, the analysis could end by comparing the priority contaminant soil concentration for industrial sites in Table 749-2 under WAC 173-340-900 against the measured soil concentration. For gasoline, the maximum soil concentration of 10,000 ppm measured at the site is less than the priority contaminant concentration of 12,000 ppm. To end the analysis, an institutional control is required. Again, implementation of these institutional controls would not increase cleanup costs because institutional controls would already be required because Method C was used to establish cleanup levels at the site.

5.5.2.4 Remedy Selection

For Site “C,” Ecology assumed that a less permanent remedy would be selected under both the current and proposed rules. More specifically, Ecology assumed that remedy selected would consist of soil treatment and containment and remediation levels to define when those two components are used. Residual contamination above the soil cleanup levels would remain at the

site. Institutional and engineered controls would also be required. Because the ground water cleanup levels are expected to be the same, the cost of cleaning up ground water is expected to be same, irrespective of the remedy selected.

5.5.2.5 Cleanup Costs

For Site “C,” the proposed rule is not expected to result in additional cleanup costs. The cost of remediating ground water is not expected to change. Because the ground water cleanup levels are expected to be the same, the cost of cleaning up ground water is expected to be same, irrespective of the remedy selected. The cost of remediating soil is also not expected to change. If a more permanent remedy consisting of soil excavation or treatment were selected for the site, Ecology would expect cleanup costs to increase. However, because a less permanent remedy was selected for this site, the costs are not expected to increase. This is based on the fact that the same engineered and institutional controls would be implemented and the cleanup would result in the same amount of residual contamination.

5.5.3 Site “C” Summary

For Site “C,” neither cleanup nor evaluation costs are expected to increase. This conclusion is based in part on the assumption that a less permanent remedy would most likely be selected at such a site. Though unlikely, any increase in costs would be relatively minor, particularly in comparison with the total cost.

5.6 Conclusion

Based on the statewide leaking fuel tank study, Ecology determined that the proposed changes to the Method A cleanup levels under the proposed rule amendments would likely impact only 51% of the sites evaluated. This is based on the fact that 49% of the sites surveyed cleaned up soil to either non-detect or to levels that are below both the current and proposed Method A cleanup levels.

For Site “A,” the impact of the proposed rule amendments on costs is expected to be small. The proposed rule would not result in additional evaluation costs. The proposed rule could result in an increase in cleanup costs of anywhere from about **\$1,000 to \$5,600**, representing an increase in cleanup costs of about **2% to 11%**.

For Site “B,” the impact of the proposed rule amendments on costs is also expected to be small. The proposed rule could result in an increase in cleanup costs at Site “B” of **\$4,560**, representing an increase of **less than 1%** in cleanup costs. The proposed rule is not expected to result in any significant increase in the costs of conducting any evaluations.

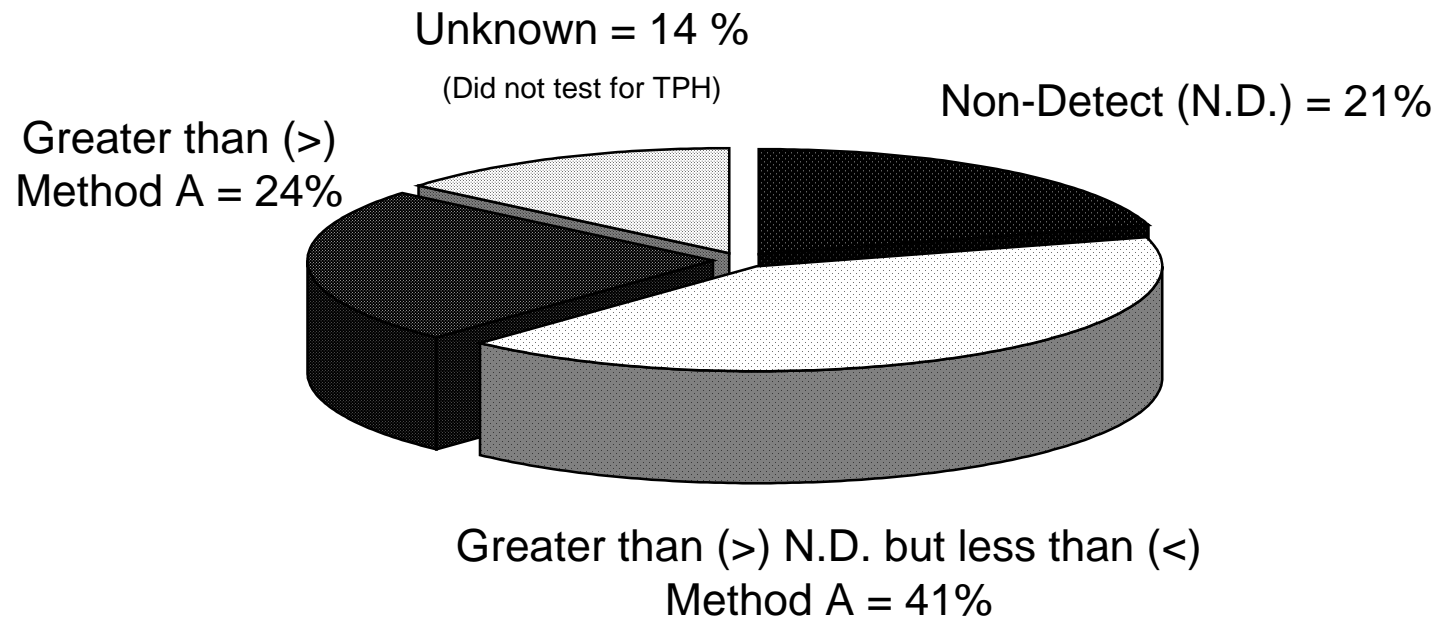
For Site “C,” neither cleanup nor evaluation costs are expected to increase. This conclusion is based in part on the assumption that a less permanent remedy would most likely be selected at such a site. Though unlikely, any increase in costs would be relatively minor, particularly in comparison with the total cost.

5.7 Calculations

Figure 5-1: Leaking Fuel Tank Study – Impact of Current Method A Soil Cleanup Levels

Impact of Current Method A Soil Cleanup Levels

62% of All Sites Cleaned-Up to Less than Current Method A Soil Values

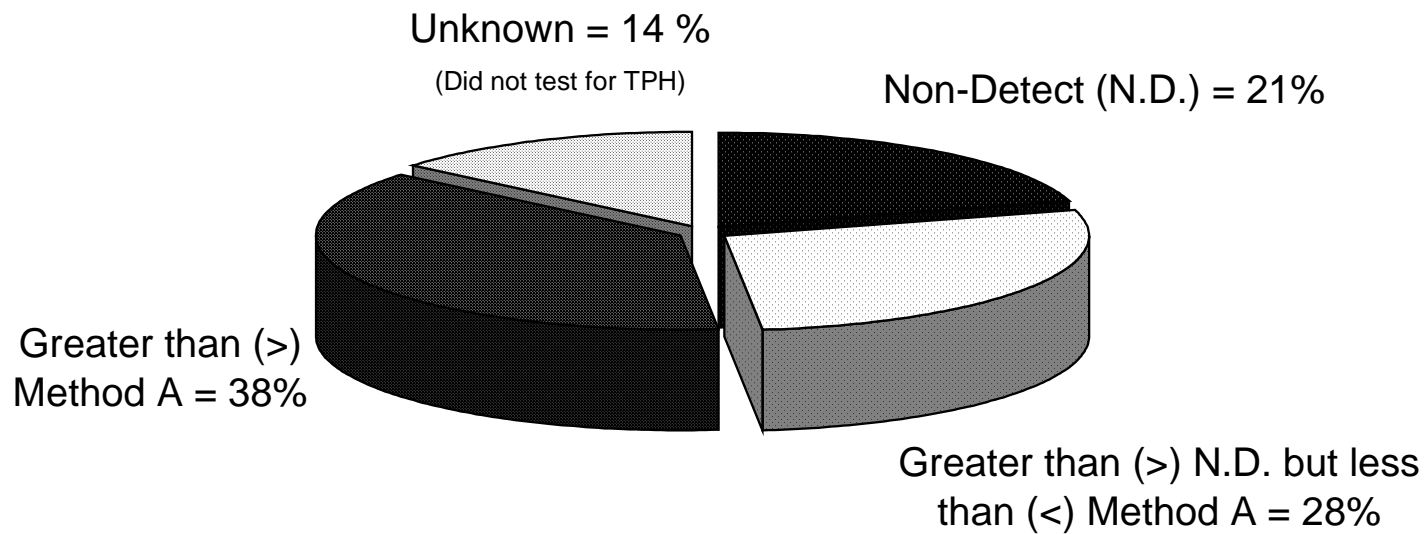


N.D. = Non-Detect in Soil

Figure 5-2: Leaking Fuel Tank Study – Impact of Proposed Method A Soil Cleanup Levels

Impact of Proposed Method A Soil Cleanup Levels

49% of All Sites Would be Less than Method A, 38% Greater than Method A



N.D. = Non-Detect in Soil

Table 5-1: Leaking Fuel Tank Site Study – Residual Soil Concentrations (12 of 29 Sites)

Site	TPH-G ppm	TPH-D ppm	B ppm	T Ppm	E ppm	X ppm
1	14	655	0.366	0.19	0.009	0.06
2	43	11,000	0.15	4.7	0.3	0.1
3	306	82	7.1	0.23	0.15	0.832
4	110	45	5.3	160	5.35	0.11
5	1,210	39	-	41	0.055	247
6	100	-	-	-	8.3	4.5
7	41	-	-	-	100	78.0
8	730	-	-	-	82	610
9	26	-	-	-	-	250
10	5,900	-	-	-	-	-
11	2,800	-	-	-	-	-
12	9	-	-	-	-	-
Number of Detects (n)	12	5	4	5	8	9
Current Method A	100	200	0.5	40	20	20
Proposed Method A	30	2,000	0.1	7	6	9
Mean Value Detected	869	1,971	3.4	35.2	22.7	120
Median Value Detected	105	82	2.8	4.7	2.8	4.5

Table 5-2: Gasoline Composition Derivation – Fuel Compositions

Equivalent Carbon (EC) Group	Gasoline Fuel Compositions						
	1	2	3	4	5	6	7
AL >5-6	28.48%	14.18%	6.4%	2.640%	1.09%	0.44%	0.18%
AL >6-8	17.2%	18.1%	16.7%	14.131%	11.58%	9.3%	7.29%
AL >8-10	4.6%	6.9%	8.6%	9.935%	10.79%	11.4%	11.8%
AL >10-12	5.5%	8.7%	11.5%	13.808%	15.59%	17.1%	18.4%
B	2.9%	1.2%	0.4%	0.127%	0.04%	0.011%	0.003%
T	7.7%	5.6%	3.5%	2.003%	1.11%	0.6%	0.32%
E	1.7%	1.7%	1.4%	1.135%	0.87%	0.6%	0.5%
X	8.9%	9.1%	8.0%	6.427%	5.00%	3.8%	2.8%
AR >8-10	5.5%	7.9%	9.4%	10.248%	10.55%	10.5%	10.4%
AR >10-12	9.2%	13.9%	17.6%	20.242%	21.97%	23.2%	24.0%
AR >12-16	6.6%	10.4%	13.5%	16.106%	18.04%	19.6%	20.9%
EC >16-21	0.0%	0.0%	0.0%	0.000%	0.00%	0.0%	0.0%
EC >21-35	0.0%	0.0%	0.0%	0.000%	0.00%	0.0%	0.0%
Naphthalene	1.6%	2.4%	2.9%	3.198%	3.37%	3.4%	3.5%
	100%	100%	100%	100%	100%	100%	100%

Note: Composition #4 is the most representative of weathered gasoline and was selected based on a comparison with field data. See [Table 5-3](#). Composition #4 was selected as the composition for all three sites – Site “A,” Site “B,” and Site “C.”

Table 5-3: Gasoline Composition Derivation – Soil BTEX Composition Ratios

	Median (16 Sites)	Ecology Comp. No. 4	Site	Site	Site	Site	Site	Site
			1	2	3	4	5	6
B	0.14%	0.13%	0.06%	0.12%	0.01%	0.80%	0.02%	0.09%
T	1.85%	2.00%	2.82%	2.29%	1.45%	9.81%	0.16%	1.42%
E	1.15%	1.14%	1.64%	0.69%	0.65%	0.00%	0.43%	1.20%
X	7.22%	6.43%	12.14%	4.83%	10.05%	0.00%	3.66%	7.68%
	Site	Site	Site	Site	Site	Site	Site	Site
	7	8	9	10	11	12	13	14
B	0.08%	0.03%	0.16%	0.03%	0.27%	0.18%	0.37%	0.33%
T	1.53%	0.44%	2.17%	0.32%	2.91%	2.50%	3.14%	3.08%
E	1.02%	0.48%	1.25%	0.49%	1.55%	1.37%	1.20%	1.42%
X	8.47%	4.80%	7.33%	3.66%	7.64%	7.12%	8.00%	7.92%
	Site	Site						
	15	16						
B	0.25%	0.20%						
T	0.30%	0.98%						
E	1.46%	1.09%						
X	6.63%	5.29%						

Figure 5-3: Gasoline Composition Derivation – Gasoline Weathering Profile

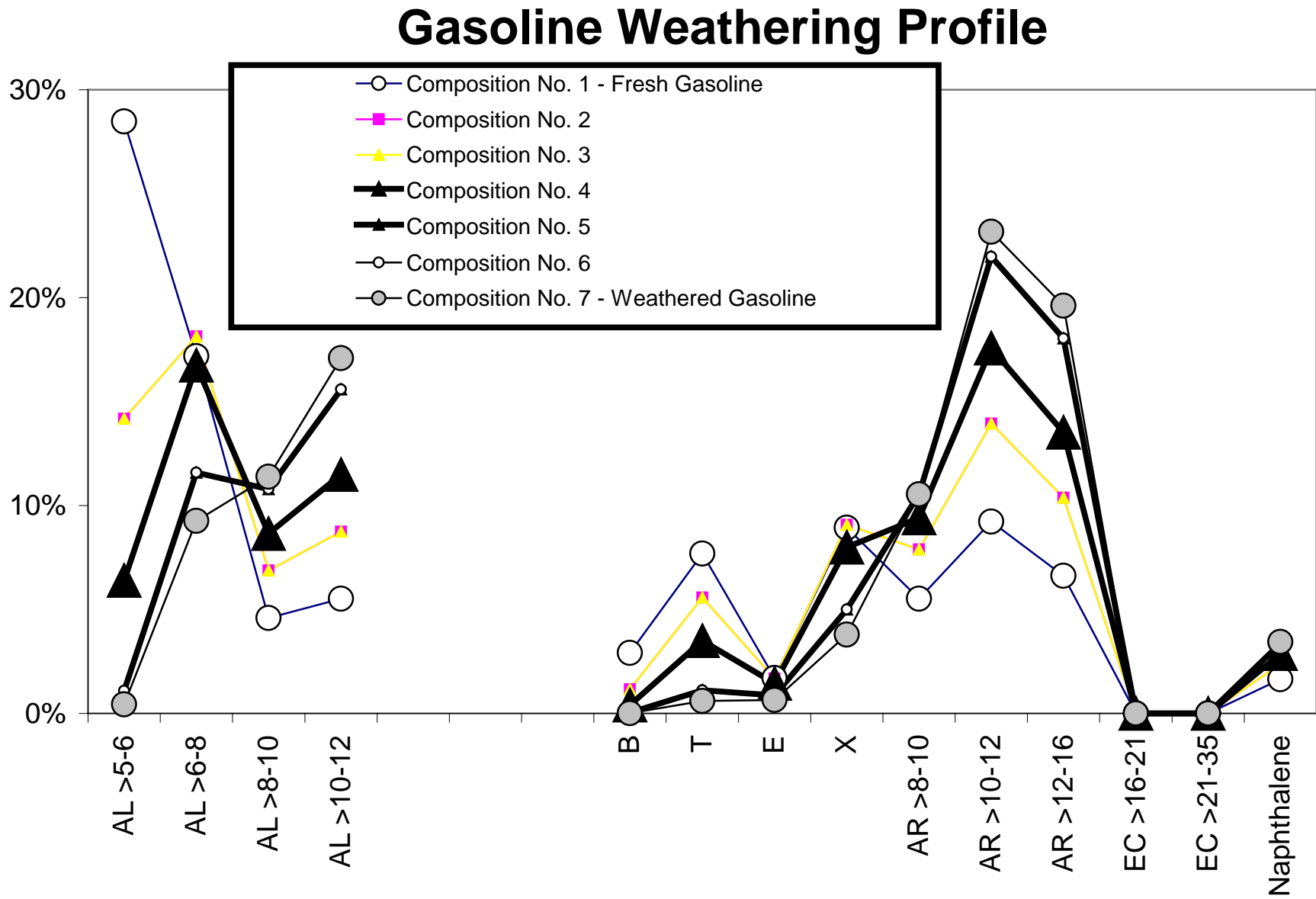


Figure 5-4: Gasoline Composition Derivation – Measured vs. Predicted Soil BTEX Composition Ratios

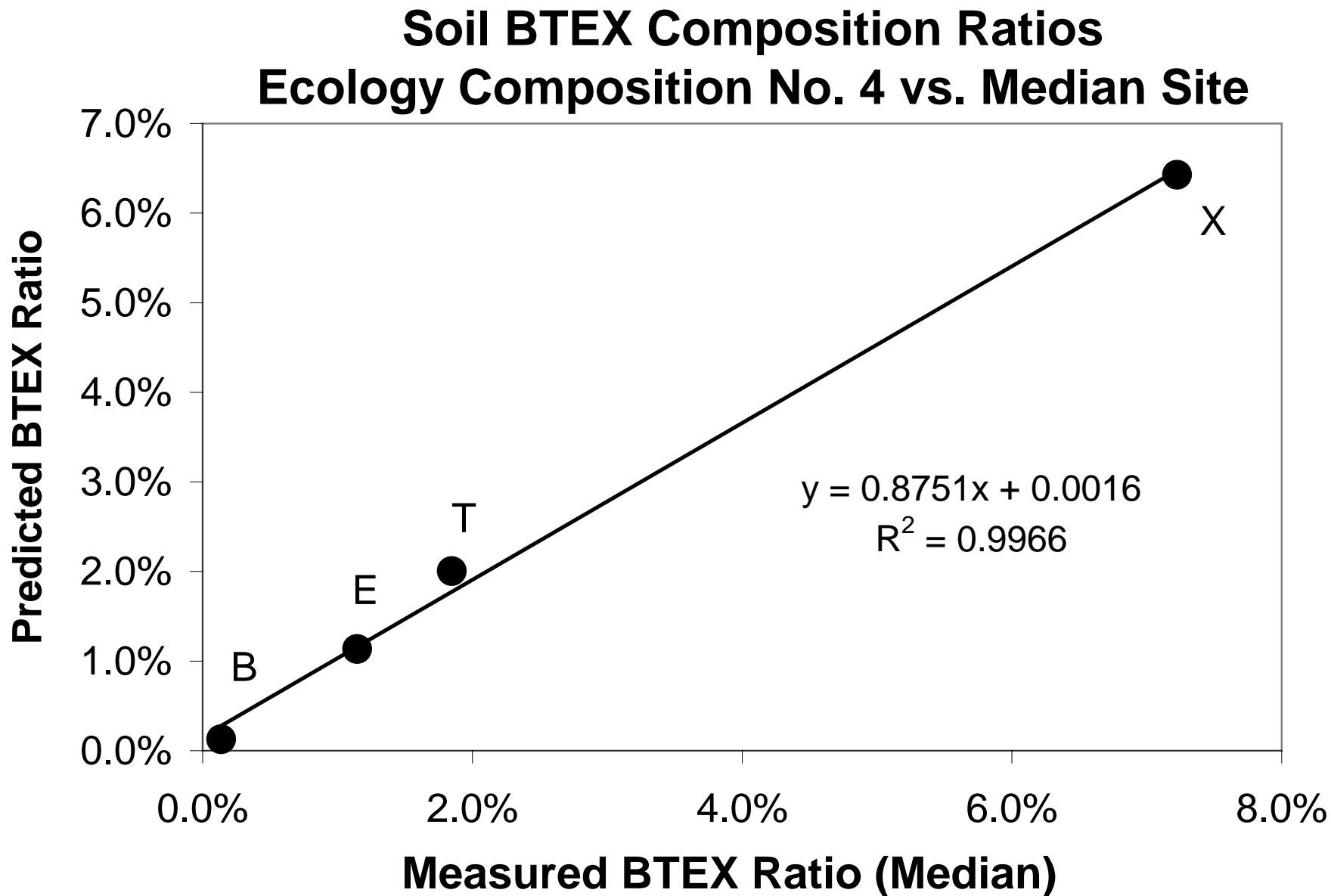


Figure 5-5: Site "A" – Measured Gasoline Soil Concentrations vs. Depth

Site "A" - Concentration vs. Depth

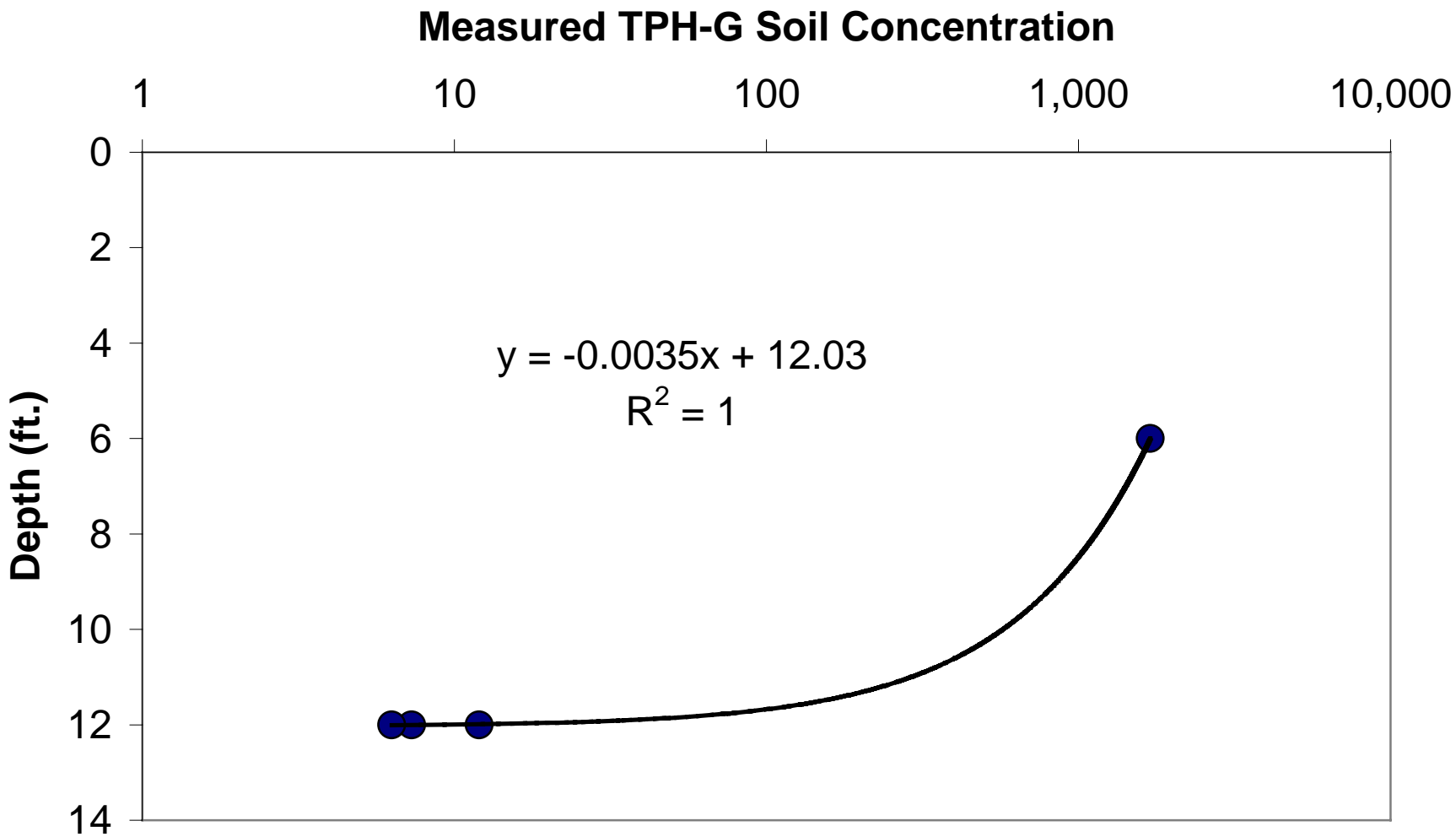


Table 5-4: Site "A" – Hypothetical Soil Data

TPH-G (ppm)	B (ppm)	T (ppm)	E (ppm)	X (ppm)	y (Depth ft)	m (Slope)	b (y-intercept)
10	0.0127	0.200	0.113512	0.6427	11.995	-0.0035	12.03
20	0.0254	0.401	0.227025	1.2854	11.96	-0.0035	12.03
30	0.0381	0.601	0.340537	1.9282	11.925	-0.0035	12.03
40	0.0469	0.801	0.45405	2.5709	11.89	-0.0035	12.03
50	0.0507	1.001	0.567562	3.2136	11.855	-0.0035	12.03
60	0.0634	1.202	0.681075	3.8563	11.82	-0.0035	12.03
70	0.0761	1.402	0.794587	4.4991	11.785	-0.0035	12.03
80	0.0888	1.602	0.908099	5.1418	11.75	-0.0035	12.03
90	0.1015	1.803	1.021612	5.7845	11.715	-0.0035	12.03
100	0.1142	2.003	1.135124	6.4272	11.68	-0.0035	12.03
140	0.1268	2.804	1.589174	9.00	11.54	-0.0035	12.03
200	0.2537	4.006	2.270249	12.854	11.33	-0.0035	12.03
300	0.3805	6.009	3.405373	19.282	10.98	-0.0035	12.03
350	0.5074	7.010	3.972935	22.495	10.805	-0.0035	12.03
400	0.6342	8.012	4.540497	25.709	10.63	-0.0035	12.03
500	0.7611	10.015	5.675621	32.136	10.28	-0.0035	12.03
600	0.8879	12.018	6.810746	38.563	9.93	-0.0035	12.03
700	1.0148	14.021	7.94587	44.991	9.58	-0.0035	12.03
800	1.1416	16.024	9.080994	51.418	9.23	-0.0035	12.03
900	1.2685	18.027	10.21612	57.845	8.88	-0.0035	12.03
1,000	1.3953	20.030	11.35124	64.272	8.53	-0.0035	12.03
1,100	1.5222	22.033	12.48637	70.7	8.18	-0.0035	12.03
1,200	1.649	24.036	13.62149	77.127	7.83	-0.0035	12.03
1,300	1.7759	26.039	14.75662	83.554	7.48	-0.0035	12.03
1,400	1.9027	28.042	15.89174	89.981	7.13	-0.0035	12.03
1,500	2.0296	30.045	17.02686	96.409	6.78	-0.0035	12.03
1,600	2.1564	32.048	18.16199	102.84	6.43	-0.0035	12.03
1,700	2.2833	34.051	19.29711	109.26	6.08	-0.0035	12.03
1,800	2.4101	36.054	20.43224	115.69	5.73	-0.0035	12.03
1,900	2.537	38.057	21.56736	122.12	5.38	-0.0035	12.03
2,000	2.6638	40.060	22.70249	128.54	5.03	-0.0035	12.03
2,100	2.7907	42.063	23.83761	134.97	4.68	-0.0035	12.03
2,200	2.9175	44.066	24.97273	141.4	4.33	-0.0035	12.03
2,300	3.0444	46.069	26.10786	147.83	3.98	-0.0035	12.03
2,400	3.1712	48.072	27.24298	154.25	3.63	-0.0035	12.03
2,500	3.2981	50.075	28.37811	160.68	3.28	-0.0035	12.03
2,600	3.4249	52.078	29.51323	167.11	2.93	-0.0035	12.03
2,700	3.5518	54.081	30.64836	173.54	2.58	-0.0035	12.03
2,800	3.6786	56.084	31.78348	179.96	2.23	-0.0035	12.03
2,900	3.8055	58.087	32.9186	186.39	1.88	-0.0035	12.03
3,000	3.9323	60.090	34.05373	192.82	1.53	-0.0035	12.03
3,100	4.0592	62.093	35.18885	199.24	1.18	-0.0035	12.03
3,200	4.186	64.096	36.32398	205.67	0.83	-0.0035	12.03
3,300	4.3129	66.099	37.4591	212.1	0.48	-0.0035	12.03
3400	4.313	68.102	38.59423	218.53	0.13	-0.0035	12.03

Figure 5-6: Site "A" – Gasoline and Benzene Soil Concentrations vs. Depth

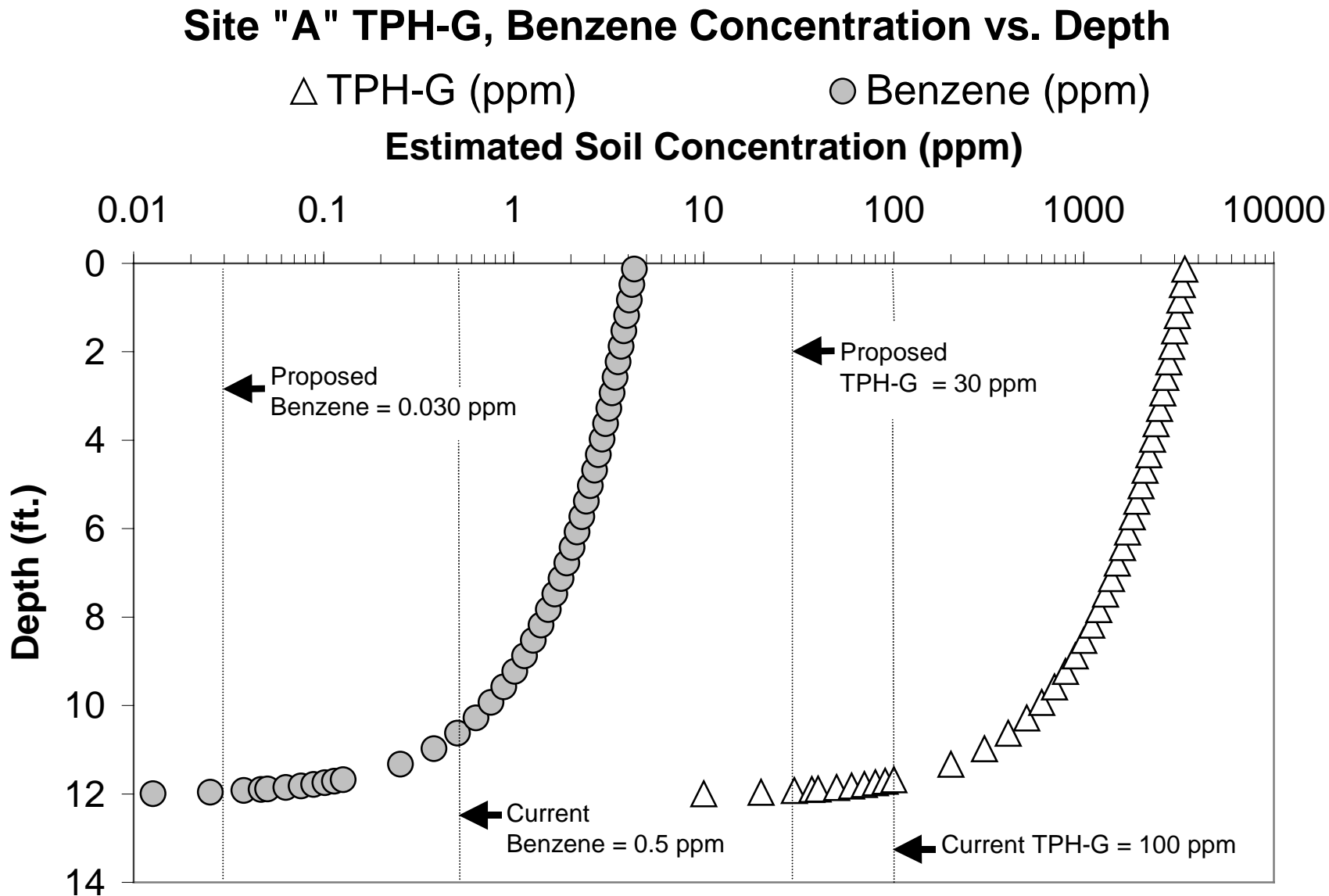


Figure 5-7: Site "A" – Toluene, Ethylbenzene & Xylene Soil Concentrations vs. Depth

Site "A" Concentration vs. Depth

△ Toluene (ppm) ✕ Ethyl Benzene (ppm) ○ Xylene (ppm)

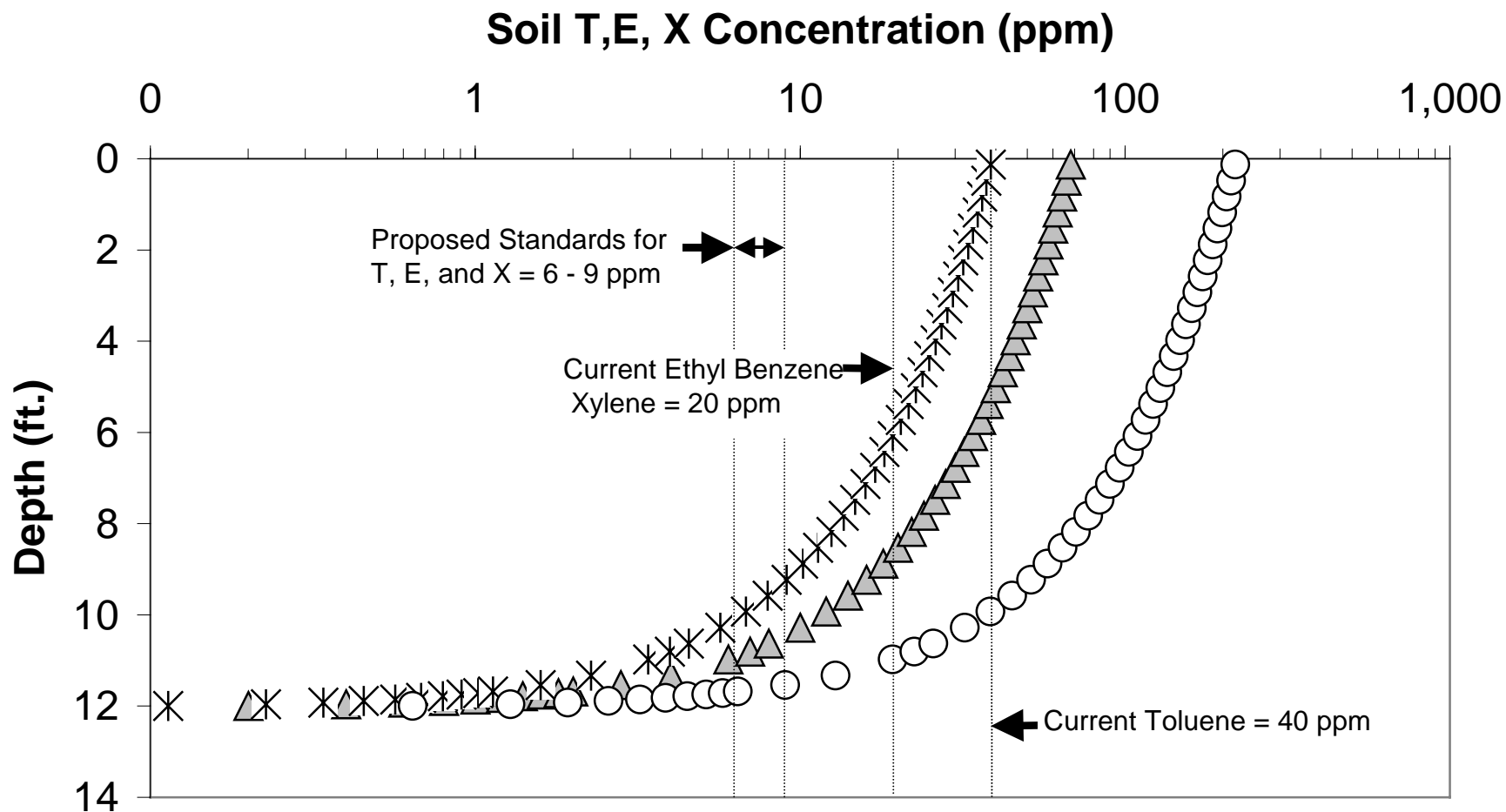


Table 5-5: Site "A" – Cost Estimates for Excavation of Soil to Method A Cleanup Levels

Hazardous Substance	Current Rule			Proposed Rule			Change	
	Cleanup Level (ppm)	Cubic Yards	Cleanup Cost	Cleanup Level (ppm)	Cubic Yards	Cleanup Cost	Δ Cost	% Δ
TPH-G	100	649	\$ 48,667	30	663	\$ 49,688	\$1,021	2.1%
B	0.5	591	\$ 44,292	0.03	664	\$ 49,833	\$5,542	11.1%
T	40	279	\$ 20,958	7	600	\$ 45,021	\$24,063	53.4%
E	20	318	\$ 23,875	6	571	\$ 42,833	\$18,958	44.3%
X	20	610	\$ 45,750	9	641	\$ 48,083	\$2,333	4.9%

Table 5-6: Existing Ground Water Concentrations based on NEAT (Pure) Gasoline Composition

BP Gasoline (NEAT)	Analytical Method	Concentration (mg/kg)	Weight (%)
Aliphatics			
AL 5-6	VPH	194,000	25.4%
AL > 6 – 8	VPH	117,000	15.3%
AL > 8 – 10	VPH	31,300	4.1%
AL > 10 – 12	VPH	37,600	4.9%
Aromatics			
Benzene	GC/PID	19,800	2.6%
Toluene	GC/PID	52,400	6.9%
Ethyl Benzene	GC/PID	11,600	1.5%
Xylene	GC/PID	60,800	7.9%
AR > 8 – 10	VPH	110,000	14.4%
AR > 10 – 12	VPH	74,000	9.7%
Naphthalene	GC/PID	11,200	1.5%
AR > 12 – 13	VPH	45,100	5.9%
TPH-G (sum)		764,800	100%

Source: Ecology Fuel / Water Mixing Experiment.

Table 5-7: Site "B" – Soil and Ground Water Cleanup Levels

Hazardous Substance	Ground Water Cleanup Levels (ppb)		Soil Cleanup Levels (ppm)	
	Current Rule (1)	Proposed Rule (2)	Current Rule (3)	Proposed Rule (4)
TPH-G	1,000	490	100	22
B	1.3	5	0.13	0.03
T	20	61	2	0.4
E	11	29	1.1	0.3
X	64	155	6.4	1.4

Footnotes:

- (1) TPH-G based on interim TPH policy; other values based on % composition in fuel.
- (2) Based on 4-phase model results.
- (3) TPH-G based on 100 X ground water; other values based on % composition in fuel.
- (4) Based on 4-phase model results.

Table 5-8: Site "B" – Protective Soil Concentrations: Direct Contact Pathway

Hazardous Substance	Existing Concentrations (ppm)	Protective Soil Concentrations (ppm)	
		Current Rule (1)	Proposed Rule (2)
TPH-G	1,700	3,380	3,870
B	2.2	4.3	4.9
T	34.0	68	77
E	19.3	38	44
X	109.3	217	249

Footnotes:

- (1) First value based on interim TPH policy; other values based on % composition in fuel.
- (2) First value based on Equation 740-3, others based on % composition in fuel.

Table 5-9: Site "B" – Protective Soil Concentrations: Leaching Pathway

Hazardous Substance	Existing Concentrations (ppm)	Protective Soil Concentrations (ppm)	
		Current Rule (1)	Proposed Rule (2)
TPH-G	1,700	100	22
B	2.2	0.13	0.03
T	34.0	2	0.4
E	19.3	1.1	0.3
X	109.3	6.4	1.4

Footnotes:

- (1) First value based on 100 X ground water; other values based on % composition in fuel.
- (2) Based on 4-phase model results.

Table 5-10: Site "B" – Calculation of Ground Water Cleanup Levels (Proposed Rule)

Hazardous Substance	Predicted Ground Water Concentration based on the 4-Phase Model (ug/l)	Composition of Predicted Ground Water (%)	Reference Dose (RfD) (mg/kg-day)	Hazard Quotient (HQ) (unitless)	Composition of HQ (%)
Aliphatics					
AL_EC >5-6	8	1.54%	5.7	1.65E-04	0.02%
AL_EC >6-8	18	3.73%	5.7	4.00E-04	0.04%
AL_EC >8-10	3	0.58%	0.03	1.18E-02	1.28%
AL_EC >10-12	1	0.12%	0.03	2.42E-03	0.26%
AL_EC >12-16	0	0.00%	0.03	0.00E+00	0.00%
AL_EC >16-21	0	0.00%	2	0.00E+00	0.00%
AL_EC > 21-34	0	0.00%	2	0.00E+00	0.00%
Aromatics					
Benzene (EC5-7)	5	1.01%	0.003	2.06E-01	22.50%
Toluene (EC>7-8)	61	12.38%	0.2	3.79E-02	4.13%
Ethylbenzene	29	5.90%	0.1	3.61E-02	3.94%
Xylenes	155	31.58%	2	9.67E-03	1.05%
AR_EC >8-10	62	12.64%	0.05	1.55E-01	16.88%
AR_EC >10-12	82	16.71%	0.05	2.04E-01	22.31%
AR_EC >12-16	34	6.94%	0.05	4.25E-02	4.63%
AR_EC >16-21	0	0.00%	0.03	0.00E+00	0.00%
AR_EC >21-35	0	0.00%	0.03	0.00E+00	0.00%
Naphthalene	34	6.87%	0.02	2.10E-01	22.94%
TPH-G (sum)	490	100%		* 0.92	100%

* The reason why the Hazard Index (HI) is less than 1 is because at a soil concentration of 22 mg/kg TPH-G, the predicted ground water benzene concentration is 5 ppb, which is the drinking water Maximum Contaminant Level (MCL). Thus, in this case, the limiting factor is the predicted concentration for benzene and not the HI of 1.

Table 5-11: Site "B" – Protective Soil Concentrations: Leaching Pathway Calculations #1

Under the current rule, the measured TPH-G soil concentration of 1,700 ppm is not protective of ground water because the predicted ground water concentration of 2,464 ppb exceeds the ground water cleanup level of 1,000 ppb and a hazard index of 1.

Hazardous Substance	Gasoline Comp. (%)	Existing Soil Concentration (mg/kg)	Predicted Ground Water Concentration based on I-TPH policy (ug/l)	MW (g/mol)	Moles (mmol/kg)	Mole Fraction	Solubility (mg/l)	Effective Solubility (mg/l)	DF
Aliphatics									
AL > 5-6	2.64%	44.88	59	81.0	5.5E-01	4.2E-02	2.80E+01	1.2E+00	20
AL > 6-8	14.13%	240.22	38	100.0	2.4E+00	1.8E-01	4.20E+00	7.6E-01	20
AL > 8-10	9.94%	168.90	2	130.0	1.3E+00	9.80E-02	3.30E-01	3.2E-02	20
AL > 10-12	13.81%	234.73	0.1	160.0	1.5E+00	1.11E-01	2.60E-02	2.9E-03	20
Aromatics									
B	0.13%	2.16	187.7	78.0	2.8E-02	2.1E-03	1.80E+03	3.8E+00	20
T	2.00%	34.05	726	92.0	3.7E-01	2.8E-02	5.20E+02	1.5E+01	20
E	1.14%	19.30	116	106.2	1.8E-01	1.4E-02	1.69E+02	2.3E+00	20
X	6.43%	109.26	664	106.2	1.0E+00	7.8E-02	1.71E+02	1.3E+01	20
AR > 8-10	10.25%	174.22	356	120.0	1.5E+00	1.1E-01	6.50E+01	7.1E+00	20
AR > 10-12	20.24%	344.11	250	130.0	2.6E+00	2.0E-01	2.50E+01	5.0E+00	20
AR > 12-16	16.11%	273.80	40	150.0	1.8E+00	1.4E-01	5.80E+00	8.0E-01	20
N	3.20%	54.36	27	240.0	2.3E-01	1.7E-02	3.20E+01	5.5E-01	20
TPH-G (sum)	100%	1,700	2,464		13.25516	1.0			

Table 5-12: Site “B” – Protective Soil Concentrations: Leaching Pathway Calculations #2

Under the proposed rule, the measured TPH-G soil concentration of 1,700 ppm is not protective of ground water because the predicted ground water concentration of 2,302 ppb exceeds the ground water cleanup level of 490 and a hazard index of 1.

Hazardous Substance	Predicted Ground Water Concentration (ug/l)	Composition of Predicted Ground Water	Reference Dose (Rfd) (mg/kg-day)	Hazard Quotient (HQ) (Unitless)	Composition of HQ
Aliphatics					
AL_EC >5-6	67	5.22%	5.7	1.47E-03	0.02%
AL_EC >6-8	48	5.91%	5.7	1.05E-03	0.01%
AL_EC >8-10	2	0.43%	0.03	8.77E-03	0.12%
AL_EC >10-12	0	0.06%	0.03	7.87E-04	0.01%
AL_EC >12-16	0	0.00%	0.03	0.00E+00	0.00%
AL_EC >16-21	0	0.00%	2	0.00E+00	0.00%
AL_EC > 21-34	0	0.00%	2	0.00E+00	0.00%
Aromatics					
Benzene (EC 5-7)	124	1.08%	0.003	5.18E+00	68.45%
Toluene (EC >7-8)	639	12.89%	0.2	4.00E-01	5.28%
Ethylbenzene	111	5.76%	0.1	1.39E-01	1.83%
Xylenes	646	30.72%	2	4.04E-02	0.53%
AR_EC >8-10	334	12.19%	0.05	8.34E-01	11.03%
AR_EC >10-12	242	14.99%	0.05	6.05E-01	8.00%
AR_EC >12-16	40	5.26%	0.05	4.96E-02	0.66%
AR_EC >16-21	0	0.00%	0.03	0.00E+00	0.00%
AR_EC >21-35	0	0.00%	0.03	0.00E+00	0.00%
Naphthalene	49	5.48%	0.02	3.06E-01	4.05%
TPH-G (Sum)	2,302	100%		7.56	100%

Table 5-13: Site "B" – Protective Soil Concentrations: Leaching Pathway Calculations #3

Under the proposed rule, the 4-phase equilibrium partitioning model was used to derive soil concentrations that are protective of ground water (i.e., will not cause an exceedance of the ground water cleanup level). The model results indicate that a TPH-G soil concentration of 22 mg/kg will not cause an exceedance of the TPH-G ground water cleanup level of 490 ug/l or a HQ of 1.

Hazardous Substance	Protective Soil Concentration (mg/kg)	Ground Water Composition @ HI = 1 (ug/l)	Reference Dose (RfD) (mg/kg-day)	Hazard Quotient (HQ) (unitless)	Composition of HQ (%)
Aliphatics					
AL_EC >5-6	0.58	8	5.7	1.65E-04	0.02%
AL_EC >6-8	3.11	18	5.7	4.00E-04	0.04%
AL_EC >8-10	2.19	3	0.03	1.18E-02	1.28%
AL_EC >10-12	3.04	1	0.03	2.42E-03	0.26%
AL_EC >12-16	0.00	0	0.03	0.00E+00	0.00%
AL_EC >16-21	0.00	0	2	0.00E+00	0.00%
AL_EC > 21-34	0.00	0	2	0.00E+00	0.00%
Aromatics					
Benzene (EC5-7)	0.03	5	0.003	2.06E-01	22.50%
Toluene (EC>7-8)	0.44	61	0.2	3.79E-02	4.13%
Ethylbenzene	0.25	29	0.1	3.61E-02	3.94%
Xylenes	1.41	155	2	9.67E-03	1.05%
AR_EC >8-10	2.25	62	0.05	1.55E-01	16.88%
AR_EC >10-12	4.45	82	0.05	2.04E-01	22.31%
AR_EC >12-16	3.54	34	0.05	4.25E-02	4.63%
AR_EC >16-21	0.00	0	0.03	0.00E+00	0.00%
AR_EC >21-35	0.00	0	0.03	0.00E+00	0.00%
Naphthalene	0.70	34	0.02	2.10E-01	22.94%
TPH-G (sum)	22.0	490		0.92	100%

Table 5-14: Site "B" – Mass and Cleanup Cost Calculations: TPH-G

	Existing Concentration (mg/kg)	Mass @ Existing Level (kg)	Mass @ Cleanup Level (kg)		Δ Mass (kg)		Δ Total Mass (kg)
			Current Rule	Proposed	Current Rule	Proposed Rule	
TPH-G							
• Soil	1,700	1,300	76.5	6.7	1,223	1,293	69.7
• Ground Water	*764,800	17,761	0.5	0.3	17,761	17,761	0.3
Total		19,061	77.0	7	18,984	19,054	70
Benzene							
• Soil	2.2	1.6	0.11	0.030	1.53	1.62	0.08
• Ground Water	*19,800	460	0.00082	0.00082	460	460	0
Total		461	0.12	0.031	461	461	0.08

* A 15 ft. wide x 50 ft. long x 1.5 ft deep (1,125 cubic feet) LNAPL (gasoline) layer is present on the ground water table. "LNAPL" means light non-aqueous phase liquid. It was assumed that the gasoline LNAPL has a concentration of 764,000 mg/kg, which is based on a laboratory measurement of fresh gasoline (Table 5-6). Note also that the dissolved-phase ground water plume with a concentration of 2.3 mg/l results in an existing mass of 1.26 kg and does not affect the calculation of the differential mass.

The increased cost of soil and ground water cleanup is then equal to the change in mass of contaminants requiring removal from the soil and ground water x unit cost of removal = 70 kg x \$65.20/kg = **\$4,564** (an increase of **0.37%**)

Table 5-15: Site "B" – Unit Cost of Dual-Phase Extraction

Site	Soil	Soil TPH (mg/kg)	Ground Water TPH-G + BTEX (mg/l)	LNAPL?	Contamination Removed		Removal Time (Days)	Total Cost (\$)	Unit Cost (\$/kg)	Year
					Pounds	Kg				
Houston, TX Gasoline Station	Silty-Clay	-	> 30	Yes	36,000	16,329	290	\$380,000	\$23.27	1994
UST Release, Car Rental Lot, Los Angeles, CA	Silty-Clay	1,400 avg 100	-	Yes – 3 ft.	17,000	7,711	196	\$600,000	\$77.81	1991
Gasoline Station, Indiana	Clay	1,000 – 10,000	1 - 16	Thin layer 1 well	2,500	1,134	407	\$331,000	\$292.42	1995
Amcor Precast, Ogden UT Gas and diesel	Silty Sand	555 avg.	51 avg	unk	9643	4,374	425	\$230,015	\$52.59	1992-93
All four sites:								Average	\$111.52	
								Median	\$65.20	
Excluding Indiana Site:								Average	\$51.22	
								Median	\$52.59	

Sources:

- (1) U.S. Environmental Protection Agency, Analysis of Selected Enhancements for Soil Vapor Extraction, EPA-542-R-97-007, 1997.
- (2) Federal Remediation Technologies Roundtable: Cost and Performance Reports. Web Site: <http://clu-in.org/remed1.htm>

Chapter 6 Technical Analysis – Probable Costs of Conducting a Terrestrial Ecological Evaluation

6.1 Introduction

To clarify how potential impacts were considered, this analysis describes the terrestrial ecological evaluation process. Following the description of each step in the process, a brief analysis is provided of the potential impacts. To further estimate the impact of the proposed rule amendment on evaluation costs, as well as cleanup costs, three typical site scenarios or case studies were developed and evaluated.

6.2 Case Studies

6.2.1 Commercial Gas Station

The impact of the proposed rule amendment on the cleanup of a commercial gas station is also discussed in **Chapter 5**.

6.2.1.1 Site Description

Soil has been contaminated by a release from an underground storage tank at a gas station location in a town's commercial area. All of the property is paved and all of the soil contamination is beneath this paved area.

6.2.1.2 Analysis

Part 1 – Simple Exclusions (WAC 173-340-7491(1)):

Evaluation of the site to establish whether it qualifies for an exclusion is optional. Instead of attempting to qualify for an exclusion, a site-specific evaluation may be conducted or the criteria in WAC 173-340-7491(2) may be used to decide whether the site qualifies for a simplified evaluation.

The exclusion criteria can be evaluated in any order. If the site meets any one of the criteria it is not necessary to evaluate the other criteria.

- (a) WAC 173-340-7491(1)(a): This site does not qualify under this exclusion because surface soil is contaminated.

Making this determination does not require special information needs.

- (b) WAC 173-340-7491(1)(b): This site qualifies for an exclusion under this provision because the contaminated soil is covered by paving.

Making this determination does not require special information needs. To obtain an exclusion under this provision, an institutional control is required to ensure that the paving is maintained in the future. If residual contamination above health-based cleanup levels remains after cleanup, an institutional control would also be required to protect human health. Thus, no additional cleanup costs would be incurred.

- (c) WAC 173-340-7491(1)(c): This site qualifies for an exclusion under this provision because there is less than 1.5 acres of contiguous undeveloped land within 500 feet of the site.

A city or county planning department map and ground-truthing may be used to decide whether the site qualifies for this exclusion. Alternatively, an aerial photograph could be used. Aerial photographs are available from sources such as the Washington Department of Natural Resources Division of Photo and Map Sales, which also provides information on other aerial photograph resources. Estimated cost is \$30. Information is available at <http://www.wa.gov/dnr/htdocs/ger/specmate.htm>

6.2.2 Industrial Site

6.2.2.1 Site Description

The site consists of soil contaminated at a former metal plating facility located in an industrial area of a large city. The site covers about 3 acres (450 ft by 300 ft) and borders on a multiple lane highway. Contaminants found throughout the site include cadmium, chromium, lead, nickel and zinc.

6.2.2.2 Analysis

Part 1 – Determining whether the site qualifies for a simple exclusion under WAC 173-340-7491(1):

Evaluation of the site to establish whether it qualifies for an exclusion is optional. Instead of attempting to qualify for an exclusion, a site-specific evaluation may be conducted or the criteria in WAC 173-340-7491(2) may be used to decide whether the site qualifies for a simplified evaluation.

The exclusion criteria can be evaluated in any order. If the site meets any one of the criteria it is not necessary to evaluate the other criteria.

- (a) WAC 173-340-7491(1)(a): This site does not qualify under this exclusion because surface soil is contaminated.

Making this determination does not require special information needs.

- (b) WAC 173-340-7491(1)(b): This site does not qualify for an exclusion under this provision because the contaminated soil is not covered.

Making this determination does not require special information needs.

- (c) WAC 173-340-7491(1)(c): This site could qualify for an exclusion under this provision if there is less than 1.5 acres of contiguous undeveloped land within 500 feet of the site.

A city or county planning department map and ground-truthing may be used to decide whether the site qualifies for this exclusion. Alternatively, an aerial photograph could be used. Aerial photographs are available from sources such as the Washington Department of Natural Resources Division of Photo and Map Sales, which also provides information on other aerial photograph resources. Estimated cost is \$30. Information is available at <http://www.wa.gov/dnr/htdocs/ger/specmate.htm>

Part 2 – Determining whether a site-specific terrestrial ecological evaluation is required or whether a simplified evaluation may be conducted under WAC 173-340-7491(2)(a):

For sites that do not qualify for a simple exclusion, the criteria under WAC 173-340-7491(2) are used to identify sites where ecological values require a site-specific evaluation. For all other sites, the less conservative and easier to use simplified evaluation procedure may be used.

- (a) WAC 173-340-7491(2)(a)(i): Areas where management or land use plans will maintain or restore native or semi-native vegetation.

These may include, for example, areas set aside as open space, green belts, or environmentally sensitive areas. There is a high potential for future ecological exposure in these areas, which may increase over time where surrounding areas become developed.

This criteria does not apply to this site because the adjoining land is intensively used for industrial activities.

At some sites evaluation of this condition may require consultation with adjacent property owners and local city or county planning departments. (Note that the condition applies to the site, not the boundary of the property where the site is located. A property adjoining a greenbelt, for example, would not necessarily trigger a requirement for a site-specific terrestrial ecological evaluation unless the site was located adjacent to the greenbelt.)

- (b) WAC 173-340-7491(2)(a)(ii): Sites used by listed species.

Listed species include threatened or endangered species designated by the Washington State Department of Fish and Wildlife as “priority species” or “species of special concern;” or a plant species listed in the Washington State Department of Natural Resources Natural Heritage Program’s “Endangered, Threatened, and Sensitive Vascular Plants of Washington” publication.

This criteria does not apply to this site.

In this case, the location in an industrial area and the nature of the site provides sufficient information for a decision. For a site where there was some uncertainty, the evaluator could contact the Washington Department of Fish and Wildlife and the Washington Department of Natural Resources to consult their GIS databases. Cost would be about \$70. Information to assist in making an enquiry is available at <http://www.wa.gov/wdfw/hab/phspage.htm> and <http://www.wa.gov/dnr/htdocs/fr/nhp/order/fsorder.htm>

- (c) WAC 173-340-7491(2)(a)(iii): Areas of 10 or more acres of native vegetation within 500 feet of the site.

Area and plant community characteristics are used as operational predictors of ecological exposure (frequency, duration, number of individuals and taxa potentially exposed). In general, a larger block of vegetation is expected to attract more use than a smaller block, and native plant communities are similarly expected to support higher biotic diversity than plant communities composed of exotic, weedy plant species.

This criteria does not apply to this site.

There are no special information needs for this analysis. The property is less than 10 acres and there is one tree on the property.

Based on this analysis, this site is eligible for a simplified terrestrial ecological evaluation under WAC 173-340-7492.

Part 3 – Simplified Terrestrial Ecological Evaluation under WAC 173-340-7492:

The Simplified Evaluation for this site ends under WAC 173-340-7492(2)(a)(ii), with a determination that substantial wildlife exposure is unlikely.

Table 749-1 must be used to make this determination. The table requires an estimation of the area of contiguous land on the site or within 500 feet of any area on the site to the nearest half acre. A city or county planning department map and ground-truthing may be used to make this determination. Alternatively, an aerial photograph could be used. Aerial photographs are available from sources such as the Washington Department of Natural Resources Division of Photo and Map Sales, which also provides information on other aerial photograph resources. Estimated cost is \$30. Information may be obtained at the following web site: <http://www.wa.gov/dnr/htdocs/ger/specmate.htm>. The table also requires a determination of the habitat quality of the site. While this evaluation should be undertaken by an experienced field biologist, a conservative estimate may be used as indicated in the table. Only a few hours of a biologist's time would be expected. The table also requires knowledge of the contaminants on the site. This information should already be available as part of the remedial investigation of the site.

6.2.3 City Park Site

6.2.3.1 Site Description

The site consists of soil contaminated by a former wood treating facility and is now part of a 24 acre city park. The site covers about 0.7 acres and is located within the park. The park is maintained as mown lawn for sports activities such as baseball and soccer. Contaminants of concern at the site include benzo(a)pyrene and pentachlorophenol.

6.2.3.2 Analysis

Part 1 – Determining whether the site qualifies for a simple exclusion under WAC 173-340-7491(1):

Evaluation of the site to establish whether it qualifies for an exclusion is optional. Instead of attempting to qualify for an exclusion, a site-specific evaluation may be conducted or the criteria in WAC 173-340-7491(2) may be used to decide whether the site qualifies for a simplified evaluation.

The exclusion criteria can be evaluated in any order. If the site meets any one of the criteria it is not necessary to evaluate the other criteria.

- (a) WAC 173-340-7491(1)(a): This site does not qualify under this exclusion because surface soil is contaminated.

Making this determination does not require special information needs.

- (b) WAC 173-340-7491(1)(b): This site does not qualify for an exclusion under this provision because the contaminated soil is not covered.

Making this determination does not require special information needs.

- (c) WAC 173-340-7491(1)(c): This site does not qualify for an exclusion under this provision because there is more than 1.5 acres of contiguous undeveloped land within 500 feet of the site.

A city or county planning department map and ground-truthing may be used to decide whether the site qualifies for this exclusion. Alternatively, an aerial photograph could be used. Aerial photographs are available from sources such as the Washington Department of Natural Resources Division of Photo and Map Sales, which also provides information on other aerial photograph resources. Estimated cost is \$30. Information is available at <http://www.wa.gov/dnr/htdocs/ger/specmate.htm>

Part 2 – Determining whether a site-specific terrestrial ecological evaluation is required or whether a simplified evaluation may be conducted under WAC 173-340-7491(2)(a):

For sites that do not qualify for a simple exclusion, the criteria under WAC 173-340-7491(2) are used to identify sites where ecological values require a site-specific evaluation. For all other sites, the less conservative and easier to use simplified evaluation procedure may be used.

- (a) WAC 173-340-7491(2)(a)(i): Areas where management or land use plans will maintain or restore native or semi-native vegetation.

These may include, for example, areas set aside as open space, green belts, or environmentally sensitive areas. There is a high potential for future ecological exposure in these areas, which may increase over time where surrounding areas become developed.

This criteria does not apply to this site because the site is part of a park maintained for intensive sport activities such as baseball and soccer. Although there are greenbelts bordering the park, the site is not directly adjacent to these areas.

At some sites evaluation of this condition may require consultation with adjacent property owners and local city or county planning departments. (Note that the condition applies to the site, not the boundary of the property where the site is located. A property adjoining a greenbelt, for example, would not necessarily trigger a requirement for a site-specific terrestrial ecological evaluation unless the site was located adjacent to the greenbelt.)

- (b) WAC 173-340-7491(2)(a)(ii): Sites used by listed species.

Listed species include threatened or endangered species designated by the Washington State Department of Fish and Wildlife as “priority species” or “species of special concern;” or a plant species listed in the Washington State Department of Natural Resources Natural Heritage Program’s “Endangered, Threatened, and Sensitive Vascular Plants of Washington” publication.

This criteria does not apply to this site.

In this case, the nature of the site (an area of mown lawn within a sports park) provides sufficient information for a decision. For a site where there was some uncertainty, the evaluator could contact the Washington Department of Fish and Wildlife and the Washington Department of Natural Resources to consult their databases for this property. Cost would be about \$70. Information to assist in making an enquiry is available at <http://www.wa.gov/wdfw/hab/phspage.htm> and <http://www.wa.gov/dnr/htdocs/fr/nhp/order/fsorder.htm>

- (c) WAC 173-340-7491(2)(a)(iii): Areas of 10 or more acres of native vegetation within 500 feet of the site.

Area and plant community characteristics are used as operational predictors of ecological exposure (frequency, duration, number of individuals and taxa potentially exposed). In general, a larger block of vegetation is expected to attract more use than a smaller block,

and native plant communities are similarly expected to support higher biotic diversity than plant communities composed of exotic, weedy plant species.

This criteria does not apply to this site.

A city or county planning department map, and ground-truthing, may be used to decide whether the site meets this criterion. Alternatively, an aerial photograph could be used. Aerial photographs are available from sources such as the Washington Department of Natural Resources Division of Photo and Map Sales, which also provides information on other aerial photograph resources. Estimated cost is \$30. Information is available at <http://www.wa.gov/dnr/htdocs/ger/specmate.htm>

Based on this analysis, this site is eligible for a simplified terrestrial ecological evaluation under WAC 173-340-7492.

Part 3 – Simplified Terrestrial Ecological Evaluation under WAC 173-340-7492:

The Simplified Evaluation also provides options for terminating the evaluation without any additional cleanup requirements. The options can be evaluated in any order and the evaluation can be terminated if any one of the criteria apply to the site. For this site, the evaluation ends under WAC 173-340-7492(2)(a)(ii), with a determination that substantial wildlife exposure is unlikely.

Table 749-1 must be used to make this determination. The table requires an estimation of the area of contiguous undeveloped land on the site or within 500 feet of any area on the site to the nearest half acre. A city or county planning department map and ground-truthing may be used to make this determination. Alternatively, an aerial photograph could be used. Aerial photographs are available from sources such as the Washington Department of Natural Resources Division of Photo and Map Sales, which also provides information on other aerial photograph resources. Estimated cost is \$30. Information may be obtained at the following web site: <http://www.wa.gov/dnr/htdocs/ger/specmate.htm>. The table also requires a determination of the habitat quality of the site. While this evaluation should be undertaken by an experienced field biologist to derive a score, the conservative estimate (score) provided in the table may be used instead. If a field evaluation is conducted, only a few hours of a biologist's time would be expected. The table also requires knowledge of the contaminants on the site. This information should already be available as part of the remedial investigation of the site.

If the site had been one acre in size, then it would not have met this criterion. However, this would not result in more stringent soil cleanup levels or additional remedial actions since the Method A and Method B cleanup levels for benzo(a)pyrene and pentachlorophenol are more stringent than Table 749-2 ecologically-based values.

6.3 Conclusion

In summary, based on the impact analysis in Chapter 2 (see Section 2.6) and the evaluation of case studies in this chapter, Ecology has made the following determinations. First, only if a

simplified or site-specific terrestrial ecological evaluation were required under the proposed rule, but not under the current rule, and only if that evaluation resulted in additional remedial actions would the proposed rule result in additional cleanup costs. Considering the factors discussed in Chapter 2 and the results of the three case studies, Ecology does not expect that the proposed rule amendments will result in lower soil cleanup levels or additional cleanup actions being required at most sites. Consequently, Ecology does not expect that the proposed rule will result in additional cleanup costs at most sites.

Second, the cost of conducting a terrestrial ecological evaluation under the proposed rule is expected to be small at most sites, irrespective of whether such an evaluation were conducted under the current rule. This conclusion is based on two factors. One, as demonstrated by these case studies and the Terrestrial Environmental Evaluation Pilot Study (Ecology, 1999), most sites are expected to either obtain an exclusion or conduct a simplified evaluation. Two, as demonstrated by both these case studies and the Pilot Study, the cost of either obtaining an exclusion or conducting a simplified evaluation is small.

Third, even if the proposed rule amendment does not require additional cleanup actions, Ecology expects that the proposed rule amendment will expedite and facilitate cleanups at most sites by providing a clear and consistent process for ensuring the potential ecological threats from soil contamination are adequately considered in site cleanups. Furthermore, by establishing criteria for ecological protectiveness and defining a tiered process for evaluating potential threats from soil contamination to terrestrial ecological receptors, the proposed rule amendment provides the most cost-effective approach to meeting the statutory requirement that cleanup actions not only protect human health, but also the environment.

Chapter 7 Technical Analysis – Probable Cost Impact of Financial Assurances

7.1 Introduction

The purpose of this chapter is to estimate the cost of requiring financial assurances at a site. This analysis assumes that financial assurances would be required under the proposed rule, but not the current rule. Whether financial assurances would actually be required under the proposed rule, but not the current rule, is discussed in Chapter 2.

The analysis first identifies the types of remedial actions that may require coverage. Second, the analysis estimates the potential cost of obtaining that type of coverage under various mechanisms. Third, the analysis examines the potential cost of financial assurances for a single, more complex site to determine a high-end estimate of probable costs.

7.2 Coverage

The purpose of this section is to identify the categories of remedial action activities where the site could be required to “assure” resources are available and in place to provide for the long-term effectiveness of engineering and institutional controls. Financial assurances may be required to cover one or more of the following three categories: operation and maintenance, compliance monitoring, and corrective measures.

- **Operation and Maintenance**

First, financial assurances may be required to cover the cost of operation and maintenance activities. These activities may include routine facility inspections; maintenance of the function and integrity of the containment system; continuation of processes necessary for waste degradation on-site; maintenance of a monitoring system for run-on and run-off control; maintaining a ground water and soil monitoring system; operating and maintaining a leak detection system, if a double liner system is present; providing for an unsaturated zone soil monitoring system; operating a leachate collection, detection and removal system; and operating and maintaining a security system such as fencing or warning signs. The frequency of these activities should rely on past experience and sound engineering practices.

- **Compliance Monitoring**

Second, financial assurances may be required to cover the cost of compliance monitoring. Monitoring activities could include ground water monitoring, soil monitoring, leak detection monitoring, gas monitoring, and long-term monitoring for on-site disposal, isolation, or containment. Where the cleanup action includes engineered controls or institutional controls, the monitoring will be required until residual hazardous substance concentrations no longer exceed site cleanup levels.

- **Corrective Measures**

Third, financial assurances may be required to cover the cost of corrective measures. While it may be difficult to predict, the extent to which the final cover will require replacement should be a contingency cost estimate based on damages caused by severe storms or other periodic natural events that could be predicted to occur during the time that contamination will remain on site. Capital replacement costs, such as the cost of replacing a geomembrane or liner for capped contamination, are included in this category.

7.3 Cost of Coverage

The purpose of this section is to estimate the potential cost of financial assurances. The cost is dependent on the type and amount of coverage required, which is dependent on many site-specific factors. The cost is also dependent on the mechanism selected.

7.3.1 Methodology for Estimating Costs

The estimated cost of financial assurances is based on the following:

- The cost of selecting a financial assurance mechanism (administrative cost);
- The cost of establishing a financial assurance mechanism (administrative cost); and
- The cost of the financial assurance mechanism.

The cost of establishing a financial assurance mechanism and the cost of that mechanism are dependent on the mechanism selected.

The first step in estimating the costs of compliance was to identify the specific activities necessary for compliance. Those activities may depend on the site and the financial assurance mechanism selected. The second step is to determine the amount and type of labor needed (e.g., facility engineer and consultant) to accomplish each task. The third step is to develop unit cost estimates for each unit of labor. The costs or prices presented in this document are based on cost information obtained through vendor contacts; a review of background documentation used to support specific MTCA activities; professional journals; technical reports; and best professional judgment. The final step is to estimate the total costs by multiplying the unit cost by the number of units. Throughout this section, all dollar values have been presented in 1997 dollars.

Labor rates and hourly estimates were developed based on "Estimating Costs for the Economic Benefits of RCRA Noncompliance," dated September 1997 and a December 1997 update, prepared for EPA's RCRA Enforcement Division by Science Applications International Corporation with initial drafting by DPRA, Incorporated under EPA contracts. DPRA is an environmental engineering consulting. Depending on the circumstances, the "typical" hour amount may consist of the median, the mean, or an estimated derived from best professional judgment. The "typical" cost estimate is derived from information obtained from professional sources. Labor rates are "burdened;" that is, the hourly rate includes wages, fringe benefits, overhead and profit.

The cost estimates are also based on the following assumptions:

- The same financial assurance mechanism(s) throughout the period.
- The cost estimates for the amount of assured costs will not significantly change.
- A consulting firm will be used to estimate the assured costs.
- The trustee fees represent the average trustee fee over the pay-in period. During that time, the trust fund will increase steadily from zero to full value of the assured costs. A trust funds average size will be 50% of the assured costs and the annual trustee fees are 1% of the value of the trust fund. Therefore, over the pay-in period, the average annual trustee fee will equal 0.5% of assured costs (50% x 1.0% x assured costs). If a person has been noncompliant for a period of time greater than the pay-in period, this estimate will tend to underestimate the value of the annual trustee fees. If the period of noncompliance is less than the pay-in period, this estimate will tend to overestimate the value of the annual fees. In such instances, more detailed estimates of the annual trustee fees may be beneficial.
- The annual taxes on interest earned represent the average amount a firm will pay in taxes over the pay-in period.
- A stand-by trust will have no costs until it is utilized.
- A local government guarantee will have no additional costs since this analysis is done annually for a bond rating.

7.3.2 Cost Estimates

7.3.2.1 Administrative Costs of Selecting and Establishing Financial Assurance Mechanisms

The administrative costs are based on the costs of selecting and establishing a financial assurance mechanism. Selecting a financial assurance mechanism is estimated to cost **\$499**. See **Table 7-1**. The cost of establishing a financial assurance mechanism is dependent on the mechanism. The estimated cost ranges from **\$182 to \$2,602**. See **Table 7-2**.

Table 7-1: Estimated Cost of Selecting a Financial Assurance Mechanism

Activity	Type of Personnel	Labor (hours)	Unit Labor Cost (\$/hour)	Total Cost (\$)
Select Financial Assurance Mechanism	Manager	1	\$118	\$118
	Accountant	2	81	162
	Attorney	2	99	198
	Clerical	1	21	21
TOTAL				\$499

Table 7-2: Estimated Cost of Establishing a Financial Assurance Mechanism

Activity	Type of Personnel	Labor (hours)	Unit Labor Cost (\$/hour)	Total Cost (\$)
Establish	Manager	0.25	\$118	\$30

Financial Test	Attorney	1.0	99	99
	Accountant	10.0	81	810
	Clerical	1.75	21	37
TOTAL				\$976
Establish Corporate Guarantee from Parent Company	Manager	0.5	\$118	\$59
	Attorney	0.5	99	50
	Accountant	0.5	81	41
	Clerical	1.5	21	32
TOTAL				\$182
Establish Letter of Credit	Manager	1.75	\$118	\$207
	Attorney	5.25	99	520
	Accountant	2.0	81	162
	Clerical	1.5	21	32
TOTAL				\$921
Establish Surety Bond	Manager	1.5	\$118	\$177
	Attorney	4.0	99	396
	Accountant	2.0	81	162
	Clerical	1.0	21	21
TOTAL				\$756
Establish Trust Fund	Manager	1.5	\$118	\$177
	Attorney	4.0	99	396
	Accountant	2.0	81	162
	Clerical	5.5	21	116
TOTAL				\$851
Establish Insurance Policy	Manager	1.5	\$118	\$177
	Attorney	4.0	99	396
	Accountant	2.0	81	162
	Clerical	1.0	21	21
	Admin. Fee			\$1,846
TOTAL				\$2,602

7.3.2.2 Cost of a Financial Assurance Mechanisms

The cost of a financial assurance mechanism is dependent on the mechanism, the coverage, and site-specific factors. Because the cost is dependent on site-specific factors, generic cost estimates could not be derived for most mechanisms. In the absence of site-specific estimates, the method for deriving a cost is presented. See Table 7-3.

Table 7-3: Estimated Cost of Financial Assurance Mechanisms

Activity	Type of Personnel	Labor (hours)	Unit Labor Cost (\$/hour)	Total Cost (\$)
Maintain Financial Test	Accountant	8 hour	\$81	\$648
	Clerical	4 hour	21	84
TOTAL				\$732
Maintain Corporate Guarantee	Clerical	4 hour	\$21	\$84
TOTAL				\$84

Activity	Cost Type	Method of Calculation
Maintain Letter of Credit	Credit Fee	Approximately 1.5% of assured costs (0.5 to 2.0% depending on firm's credit).
Maintain Surety Bond	Surety Fee	Approximately 1.5% of assured costs (0.5 to 3.0% depending on firm's credit).
Maintain Trust Fund	Payment into a Trust Fund	Total assured costs divided by number of years for pay-in period.
	Trustee Fee	Approximately 0.5% of assured costs.
	Taxes on Interest Earned on Trust Fund	50% of assured costs multiplied by trust fund rate of return and marginal tax rate (federal and state).
Maintain Insurance	Insurance Premium	Total assured costs divided by estimated facility life.

7.4 High-End Cost Estimate

The cost of a financial assurance mechanism is dependent on the mechanism, the coverage, and many site-specific factors. The coverage required may include one or more of the following: operation and maintenance, compliance monitoring, and corrective measures. Site-specific factors determine the coverage required. These factors include the remedy selected for the site. The remedy selected determines the type of engineering and/or institutional controls that is required at the site. For example, if containment is included as part of the remedy at a hazardous waste management facility, the cost of financial assurances are expected to be relatively high because they would have to cover significant operation and maintenance, compliance monitoring, and corrective measures. Remedies at other sites would not be expected to require as much coverage and, hence, financial assurances.

To estimate the probable high-end cost of financial assurances, Ecology reviewed a random sampling of six (6) sites where hazardous wastes were managed under the state dangerous waste rules and where financial assurances were required for post-closure care (operation and maintenance, compliance monitoring, and corrective measures). Hazardous waste management facilities are considered representative of more complex sites and cleanups that result in the containment of large volumes of highly contaminated substances. Typically, containment rather than complete off-site disposal is a component of the cleanup action at these sites. Ecology believes that these sites (where hazardous wastes are managed) require the greatest coverage (and hence cost) and are not representative of most sites that might require financial assurances under the MTCA Cleanup Regulation.

Based on its review, Ecology found that the coverage requiring financial assurances at the six facilities averaged \$1.2 million, after discounting the low and high values as anomalies. Again, the cost of a financial assurance mechanism depends not only on the coverage required, but also the mechanism selected. Based on the method of calculation for the different mechanisms shown in **Table 7-3**, Ecology determined that the probable cost of financial assurance mechanisms for these sites could range from **\$6,000 to \$40,000**. Again, this estimate of probable costs is based on a complex site where hazardous wastes are managed and is not representative of most sites where financial assurances may be required. Accordingly, this estimate is a high-end estimate of probable costs.

7.5 Conclusion

In summary, the cost of financial assurance is dependent on the type and amount of coverage required, which is dependent on many site-specific factors, and the mechanism selected. The estimated cost of financial assurances is based on the administrative cost of selecting and establishing a financial assurance mechanism and the cost of the mechanism. The estimated **administrative costs** ranged from **\$681 to \$3,101**, depending on the mechanism selected. The cost of a financial assurance mechanism is dependent on the mechanism, the coverage, and site-specific factors. Because the cost is dependent on site-specific factors, generic cost estimates could not be derived for all sites. To estimate the probable high-end cost of financial assurances, Ecology reviewed a random sampling of six sites where hazardous wastes were managed under the state dangerous waste rules and where financial assurances were required for post-closure care. Based on that review, Ecology determined that the **probable high-end cost of financial assurance mechanisms** could range from **\$6,000 to \$40,000**. Again, this high-end estimate of probable costs is based on a complex site where hazardous wastes are managed and is not representative of all or most sites where financial assurances may be required.

Chapter 8 Consideration of Uncertainty and Variability

8.1 Background

The topics of uncertainty and variability, particularly as uncertainty and variability relates to risk assessment, have been extensively examined in the literature (NRC, 1994; EPA, 1997). Uncertainty represents a lack of knowledge. Variability arises from the heterogeneity of populations, places and time. Although variability and uncertainty are conceptually quite different, they can complement or confound one another.

There are several different types of uncertainty associated with a lack of knowledge. Although specifically related to risk assessment, the types of uncertainty have application beyond risk assessment. The gaps in our knowledge, uncertainty, may be classified as parameter uncertainty and model uncertainty. The NRC, 1994, details a description of both these two types of uncertainty.

Distinguishable from uncertainty, variability may involve variations in people's behavior, attitudes, location, and activity. Variability may also involve variations in contaminant concentrations among sites and migration within a site. Variability, for example, may involve changes over time in individual and aggregate real purchasing power. Willingness to pay to avoid mortality and morbidity may vary directly with real income. This variability also contributes to a level of uncertainty because available empirical research does not yield general agreement as to the magnitude of this effect. The income elasticity factor of 1.0 used in the discussion below is based on research by Viscusi and Evans, 1990, and cited in Viscusi, 1993. Uncertainty can lead to inaccurate or biased estimates, whereas variability can affect the precision of the estimates and the degree to which they can be generalized.

The following discussion provides an overview of some of the more significant sources of uncertainty and variability in the analysis.

Ecology recognizes the inherent uncertainty and variability in the methodologies used and assumptions made to evaluate the probable costs and probable benefits of the proposed rule amendments and has evaluated the sources of that uncertainty and variability. Based on that evaluation, Ecology believes that the methodologies used and assumptions made adequately address that variability and uncertainty and result in reasonably bounded estimates that reflect the potential differential in costs and benefits of the proposed rule amendments. The following discussion provides a brief overview of some of the more significant sources of uncertainty and variability.

8.2 Estimates of Probable Costs and Avoided Costs

While the primary impact of the proposed rule amendments on cleanup costs is expected to result from changes in the cleanup levels established for a site, the actual measure of those cleanup costs is not directly related to the establishment of cleanup levels. Rather, the ultimate impact on

cleanup costs of any change in cleanup levels is dependent on several site-specific factors, including (and perhaps most importantly) the cleanup action selected.

Therefore, to estimate the probable costs (or avoided costs) of the proposed Method A soil and ground water cleanup levels (Chapter 3) and the probable cost impact of the proposed rule amendments on petroleum contaminated sites (Chapter 5), basic assumptions had to be made regarding several site-specific factors that are subject to significant variability and uncertainty. These assumptions include, but are not limited to, the selection of representative site models, the selection of cleanup actions, and the selection of remedial technologies.

8.2.1 Selection of Representative Site Models

To estimate the impact of the proposed rule amendments on cleanup costs at a site, Ecology had to first develop representative site models. These site models are based on many site-specific factors or parameters that are subject to substantial variability and uncertainty. For the analyses in Chapter 3, Ecology developed site models that conservatively reflect the majority of sites that use Method A to establish soil and ground water cleanup levels. For the analyses in Chapter 5, Ecology developed site models that reflect the majority of petroleum contaminated sites. The development of these site models required assumptions regarding several important site parameters, including the following:

- The nature of soil and ground water contamination;
- The extent of soil and ground water contamination;
- The uniformity of the contamination;
- The soil density;
- The depth to ground water;
- The potability of ground water;
- The land use; and
- Whether the hazardous substance(s) at the site are contaminants of concern determining the nature and scope of the cleanup.

Conservative estimates of each of these site parameters were made to provide a high-end estimate of the potential differential in cleanup costs under the current and proposed rules. The basis for each of these model parameters is described in the relevant sections of this report and includes review of site files and the best professional judgment of engineers and site managers.

8.2.2 Selection of Permanent Cleanup Actions

To estimate the impact of the proposed rule amendments on cleanup costs at a site, Ecology next had to select the cleanup action for the site. More permanent or active cleanup actions that remove contaminants from the soil or ground water typically cost more than less permanent cleanup actions that leave contamination at the site and rely on engineered and institutional controls. Consequently, any change to cleanup levels resulting from the proposed rule amendments is expected to have a greater impact if a more permanent remedy that removed

contaminants were selected than if a less permanent remedy that contained contamination using engineered and institutional controls were selected.

For the analyses in both Chapter 3 and Chapter 5, Ecology assumed that a more permanent cleanup action that removes contaminants from the soil and ground water would be used at the model site. While this assumption reflects the statutory and regulatory requirement that cleanup actions use permanent solutions to the maximum extent practicable (see RCW 70.105D.030(1)(b) and WAC 173-340-360(2)), this assumption does not necessarily result from that requirement. In fact, the selection of a cleanup action that meets each of the requirements in WAC 173-340-360 is dependent on many site-specific factors that are subject to significant variability, including the nature and scope of contamination. Consequently, the assumption of a permanent remedy is a conservative assumption that provides a high-end estimate of the potential differential in cleanup costs under the current and proposed rules. Assumption of a less permanent or active remedy that leaves contamination at the site might not result in any additional cleanup or cost.

8.2.3 Selection of Remedial Technologies

To estimate the impact of the proposed rule amendments on cleanup costs at a site, Ecology finally had to select the remedial technology that would implement the selected cleanup action. The remedial action selected depends on the contaminants of concern and the available technologies for treating those contaminants. Both the selection of remedial technologies and the unit cost of those technologies are subject to variability among sites and uncertainty. For the purposes of this analysis, the selection was based on review of site reports and on the best professional judgment of an environmental engineer. The estimated unit costs for each of the remedial technologies was based on available data from site reports.

8.3 Estimates of Probable Benefits

8.3.1 Quantitative Estimates of Health Benefits – Morbidity

To quantitatively estimate the benefits of a reduction in the risk of adverse health effects associated with exposure to contaminated ground water, Ecology had to calculate the reduced risk of adverse health effects (including cancer) for each hazardous substance of concern, determine the range of adverse health effects attributable to those hazardous substances, calculate the cost of a single incidence (unit cost) of those adverse health effects, and determine the exposed population. Each of the factors, however, is subject to variability and uncertainty. The calculations of reduced risk are based on equations and default assumptions specified in the regulation.¹² Assumptions were made regarding the range of adverse health effects attributable to the hazardous substances of concern and the cost of a single incidence of those health effects.

¹² There are a large range of adverse health effects, non-cancer and cancer, not evaluated in the development of toxicity criteria associated with hazardous substances and the development of cleanup levels. For some hazardous substances, for example, toxicity criteria are developed based on a single biological endpoint when the chemical actually causes multiple adverse health effects. The choice of a single biological endpoint for the development of toxicity criteria is a judgment call. While this choice is guided by the best available science, it introduces uncertainty.

The basis for those assumptions is described in Chapter 4. The estimate of the exposed population is also subject to significant uncertainty, as well as variability over time. As a consequence of this uncertainty and variability, the exposed population estimate was not used to calculate quantitatively an estimate of the total health benefits (avoided health costs) of the more stringent cleanup levels. However, the estimate of the exposed population was used for the limited purpose of calculating the number of avoided incidences of cancer to enable the further calculation of the value of reducing risks of excess cancer mortality.

8.3.2 Quantitative Estimates of Health Benefits – Mortality

In addition to the factors described above, to quantitatively estimate the benefits of reducing the risk of excess cancer mortality, Ecology also had to calculate the number of avoided incidences of cancer, determine the mortality rate, and calculate the value of reducing risks of excess cancer mortality. Again, each of these factors is subject to uncertainty and variability. For example, the number of incidences is dependent on risk assessments and the size of the exposed population, both of which are also subject to uncertainty and variability. The mortality rate varies dependent upon the characteristics of the exposed population and the particular form of cancer. Estimates of both of these factors were made to provide a best estimate of the potential differential in health benefits. The basis for each of these estimates is described in the relevant sections of this report.

The value of reducing risks of excess cancer mortality is itself dependent on several economic factors that are themselves subject to uncertainty and variability. These include, but are not limited to, the value of households based on a contingent valuation study, the discounting of that value to a present value, and the income elasticity adjustment. To address this uncertainty and variability, Ecology utilized different approaches, based on the following:

- Incremental undiscounted dollars of avoided mortalities per year for households in Washington State with each substance evaluated independently and the resulting values aggregated over all substances;
- Undiscounted dollars per life per year of excess mortalities avoided based on a central tendency analysis of potential risk and risk reduction (i.e., not substance-specific); and
- Discounted lump sum estimates based on the results of the central tendency analysis, with and without real income elasticity adjustments, per life required to pay an estimated average value of excess mortalities avoided for 35 years.

To further address the uncertainty and variability, sensitivity analyses were conducted on each of these different approaches. For example, adjustments to the discount rate and income growth were made.

These different approaches and sensitivity analyses are described more thoroughly in Chapter 4.

8.3.3 Qualitative Benefits

Strict parity between monetized probable costs and benefits is neither required under the Administrative Procedure Act nor justified in consideration of the number of non-monetized

benefits associated with this rule-making action. Although not quantified in monetary terms in this analysis, these non-monetized benefits are significant. Examples include, but are not limited to, the following:

- Ecological benefits – protection of fish and other aquatic life, especially when ground and surface waters are connected, as well as terrestrial wildlife.
- Public perceptions and acceptance of drinking water.
- Property values – the market values of property in proximity to contaminated sites may be adversely affected and, conversely enhanced when sites are cleaned up.
- Active use values – protection/enhancement of general recreational use of water and land.
- Aesthetics – elimination of adverse sensory effects of contamination.
- “Bequest” benefits – satisfaction of knowing that the environment is protective of current generations and protected for future generations.
- Passive use values – option value, etc. (in addition to benefits accruing to active use).

Further discussion of ecological benefits and the public perceptions and acceptance of drinking water is provided in Chapter 4.

8.4 Conclusion

Ecology recognizes the inherent uncertainty and variability in the methodologies used and assumptions made to evaluate the probable costs and probable benefits of the proposed rule amendments. However, Ecology believes that those methodologies and assumptions adequately address that variability and uncertainty and result in reasonably bounded estimates that reflect the potential differential in costs and benefits of the proposed rule amendments. The Department of Ecology will continue to make decisions in the face of such uncertainty and variability to protect human health and the environment in Washington State. Recognizing and having addressed the uncertainty and variability associated with this analysis, Ecology determined that the probable benefits of the proposed rule amendments exceed the probable costs.

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