

Guidance for Managing Hazardous Substance Air Discharges From Remedial Systems

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DISCLAIMER

This document provides information and technical assistance to the public and to employees of the Department of Environmental Quality (DEQ) regarding DEQ's Cleanup Program. The information in this document should be interpreted and used in a manner consistent with Oregon's environmental cleanup law (ORS 465.200 et. seq.) and implementing rules. This DEQ guidance does not constitute rulemaking by the Environmental Quality Commission and may not be relied upon to create a right or benefit, substantive or procedural, enforceable at law or in equity, by any person. DEQ may take action at variance with this document.

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Table of Contents

1. Introduction	1
1.1 Application.....	1
1.2 Regulatory Authority	1
1.3 Summary of Required Actions.....	3
2. Managing Air Discharges from Remedial Systems	4
2.1 Pilot Testing.....	4
2.1.1 Pilot Test Guidelines.....	4
2.1.2 Sample Analyses.....	6
2.2 Evaluating Pilot Test Results	7
2.3 Air Dispersion Modeling	7
2.3.1 Model Input Requirements	7
2.3.2 Interpreting the Model’s Output	8
3. Remedial System Operation	10
3.1 Off-Gas Treatment Technologies	10
3.2 Monitoring System Performance	10
3.3 Summary of Suggested Milestones for Remedial System Operation.....	11
4. References	12
Appendix 1	1
A.1 Calculation of Effective RfDi for gasoline and diesel	1
A.2 Calculating Permissible Concentration Increases for Non-Carcinogens	2
A.3 Calculating Permissible Concentration Increases (PCIs) for Carcinogens	2
A.4 Conversion Factor for PRG to Permissible Air Concentrations	3
A.5 Screening Criteria for Petroleum Remediation Systems	3

List of Figures and Tables

Figure 2.1 Flowchart of Suggested Off-Gas Discharge Management Process.....	5
Table 2.1: Summary of Recommended Analytical Methods.....	6
Table 2.2: Input Parameters Needed to Model a Point Source Using SCREEN3	8
Table 2.3: Permissible Concentration Increases	9

Acronyms

BTEX	benzene, toluene, ethylbenzene, and xylenes
CAP	Corrective Action Plan
DEQ	(Oregon) Department of Environmental Quality
EPA	U.S. Environmental Protection Agency
EQC	(Oregon) Environmental Quality Commission
FID	flame-ionization detector
FS	feasibility study
ICP	Independent Cleanup Pathway
MTBE	methyl tertiary-butyl ether
NIOSH	National Institute of Occupational Safety and Health
OAR	Oregon Administrative Rules
ORS	Oregon Revised Statutes
PID	photo-ionization detector
SVE	soil vapor extraction
TPH	total petroleum hydrocarbons
UST	underground storage tank
VOCs	volatile organic compounds

1. Introduction

Cleanup of sites contaminated with volatile organic compounds (VOCs) such as gasoline and solvents, often requires purging of the volatile components from groundwater or soil gas -- and discharging the VOCs into the atmosphere. If left untreated, this discharge can create unacceptable health risks to people living or working in the area. Removing the contaminants from soil and groundwater may be a critical step to protect human health and the environment over the long term, but transferring these contaminants to the air may actually increase exposures in the short term. Oregon's environmental cleanup rules require DEQ to consider not only the effectiveness of a proposed site remedy, but also the potential risks posed by implementation of the remedy itself on human health and the environment.

This guidance document is designed to help: 1) evaluate “off-gas” air discharges associated with remedial actions; and 2) determine under what circumstances off-gas treatment is appropriate. This guidance provides information on assessment methods, compliance point locations, and screening criteria for evaluating potential impacts from discharges of *hazardous substances* [for definition see ORS 465.200(16)] to the air.

1.1 Application

This guidance applies to the remediation of contaminated soil or groundwater under the *Cleanup Rules for Leaking Petroleum Underground Storage Tank Systems* (UST Cleanup Rules, OAR 340-122-0205 through 340-122-0360) and *Hazardous Substance Remedial Action Rules* (OAR 340-122-0010 through 340-122-0115). This guidance applies only to active remediation systems that discharge hazardous substances into the atmosphere; examples include active soil vapor extraction (SVE), air stripping, and dual-phase extraction systems, but not passive soil-venting systems.

1.2 Regulatory Authority

When DEQ selects and approves cleanup remedies for UST sites and other hazardous substance release sites, the agency must consider “[a]ny short term risk from implementing the remedy posed to the community, to those engaged in the implementation of the remedy and to the environment” [ORS 465.315 (1)(d)]. The Oregon Environmental Quality Commission (EQC) has adopted administrative rules to implement this statutory requirement. For cleanups conducted under UST Program rules:

- **OAR 340-122-0250 (5):** *The Department shall approve the corrective action plan only after ensuring that implementation of the plan, including any applicable remediation levels, will adequately protect human health, safety, and welfare and the environment, and after providing any public notice consistent with the requirements of OAR 340-122-0260.*
- **OAR 340-122-0250 (11):** *A responsible party may begin remediation of soil and groundwater before corrective action plan approval provided that the responsible party: (a) Notifies the Department of its intention to begin remediation; (b) Complies with any conditions imposed by the Department including halting remediation or mitigating adverse consequences from remedial activities.*

For cleanups conducted under UST Program rules, DEQ recognizes the importance of allowing site remediation to begin before DEQ approves the Corrective Action Plan (CAP). However, the UST Program rules require DEQ to pre-approve remedial activities that could cause air

discharges of hazardous substances.

For cleanups conducted under Hazardous Substance Remedial Action rules:

- ***OAR 340-122-0090 (3)(d): Implementation Risk.*** *Each remedial action alternative shall be assessed for the risk from implementing the remedial action, by considering the following, as appropriate:*
 - (A) Potential impacts on the community during implementation of the remedial action and the effectiveness and reliability of protective or mitigative measures;*
 - (B) Potential impacts on workers during implementation of the remedial action and the effectiveness and reliability of protective or mitigative measures;*
 - (C) Potential impacts on the environment during implementation of the remedial action and the effectiveness and reliability of protective or mitigative measures;*
 - (D) Time until the remedial action is complete; and*
 - (E) Any other information related to implementation risk.*

In adopting both the UST and Remedial Action rules, the EQC gave DEQ the authority to evaluate the impact of remedial actions and assure they do not pose an unacceptable risk to human health and the environment. The Legislature set and the EQC implemented risk-based standards to protect human health and the environment. This guidance provides a process that, if followed, will ensure compliance with the statutes and rules on a case-by-case basis. However, this guidance should not be interpreted as rule or requirement. The project sponsor may propose alternative approaches to comply with these statutes and rules.

It is important to note that DEQ's Air Quality Program has rules pertaining to discharge of VOCs from a wide range of facilities (OAR 340, Division 216); they are intended to manage concentrations of ozone (a by-product of VOC photolysis) on an *airshed* scale. As a result, the rules have not required assessments of *localized air quality impacts* from small-scale sources of hazardous substances. Air discharge sources that emit over 10 tons per year of a criteria pollutant, including VOCs, may require an air quality permit from DEQ prior to system operation. Permits may also be required if there is an "air quality concern" [OAR 340-216-0020 Table 1, Part B, #74]. This may arise in some communities for a variety of reasons. Contact air quality staff in the appropriate DEQ regional office if you have questions about air quality permitting requirements.

The DEQ Air Quality Program developed an approach to reducing the public's exposure to toxic air pollutants and the EQC adopted rules to implement that strategy in October 2003. As a next step, health protective ambient air concentrations are now being considered by the department-appointed Air Toxics Science Advisory Committee. As these concentrations are developed and formalized in rule, the Air quality and Cleanup Programs will consult about how best to achieve consistency of implementation.

1.3 Summary of Required Actions

In accordance with rule, DEQ requires individuals conducting projects under DEQ oversight covered by this guidance to submit an evaluation of implementation risks before full-scale remediation begins. Typically, this evaluation is based on the results of a *pilot test* of the remediation system (see Section 2.1), and includes a determination of the need for off-gas treatment and the rationale for that decision. Note: DEQ will evaluate the need for treatment of emissions during pilot-testing, depending on the anticipated hazardous substance discharge, pilot test length, and the project's proximity to people.

For cleanups conducted under UST rules, the evaluation referred to in the paragraph above should be included as part of the Corrective Action Plan (CAP). The remediation system may not be operated until DEQ has approved the CAP. The only exception is when performing effective off-gas treatment (Section 3), after obtaining prior written approval from DEQ to perform such treatment.

For cleanups conducted under Hazardous Substance Remedial Action rules, this evaluation should be included in the feasibility study (FS) – or in a removal action plan, if treatment starts before the FS is completed. For projects without real-time DEQ oversight, project documentation should demonstrate that acceptable risk levels are met during implementation of the remedy.

If there is any possibility of system emissions requiring an air quality discharge permit contact air-quality staff in the appropriate DEQ regional office prior to the pilot-testing phase.

2. Managing Air Discharges from Remedial Systems

The following actions and decision points are suggested to manage VOC discharges from a remediation system:

- Run a pilot test (see Section 2.1 below).
- If the system is remediating petroleum contamination only, screen pilot test data to determine if emissions meet the five screening criteria for petroleum remediation systems in Section 2.2.
- If pilot test data fail the screening or the system is remediating VOCs other than petroleum hydrocarbons, the options are: 1) treat the off-gases; 2) run a computer model based on site-specific data to analyze the potential risk posed by off-gases; or 3) change to a remediation technology that does not produce off-gases.
- If modeling results at receptor locations still exceed the risk-based permissible concentration increases in Table 2.3, treat the off-gases or change to a remediation technology that does not produce off-gases.
- If off-gas emissions do not pose an unacceptable risk either based on the initial generic screening or the subsequent site-specific computer model evaluation, there is no need to treat the off-gases.
- Monitor system operations to document and evaluate system performance.

Figure 2.1, on the following page, illustrates these steps in a flowchart format. Each step in the flowchart is described in more detail below.

2.1 Pilot Testing

Typically, VOC emission estimates and risk modeling are based on data from stack discharge samples or influent concentrations collected from a pilot test on the treatment system. Complete a pilot test before beginning full-scale, continuous operation of the treatment system, and after any significant expansion or redesign of the system.

Pilot test results are indicative of VOC emission rates at the start of the cleanup. While emission rates may vary over time as VOCs are removed from soil or groundwater, and as groundwater levels fluctuate, it is difficult to estimate accurately how these rates will change over time. Therefore, use pilot test results to make initial exposure estimates and to assess the need for off-gas treatment. Once the system is operational, monitor its performance and re-evaluate the need for treatment if influent concentrations change.

2.1.1 Pilot Test Guidelines

2.1.1.1 Testing Vapor Extraction and Dual-Phase Extraction Systems

For the best estimate of emission rates, vapor samples should be collected from all recovery wells/trenches expected to be used in the full-scale cleanup. Alternatively, a sample from a single extraction well or trench will suffice for the pilot test as long as it is in the region of highest contamination. Use this sample result and the maximum anticipated airflow for the full-scale system to estimate total emissions.

Before collecting any samples, the system should be purged by maintaining the air flow rate expected for the full-scale cleanup for at least 12 hours (unless site conditions allow pressure equilibrium to be reached more quickly).

After purging, two samples should be collected from an in-line sampling port, into either Tedlar bags or Summa canisters. (The second sample is a quality-control duplicate.) As mentioned above, samples should be collected from either: 1) all recovery wells/trenches expected to be used in the full-scale cleanup; or 2) only from the region of highest contamination. All samples should be stored, preserved, and analyzed within acceptable holding times as specified by the EPA-approved analytical method.

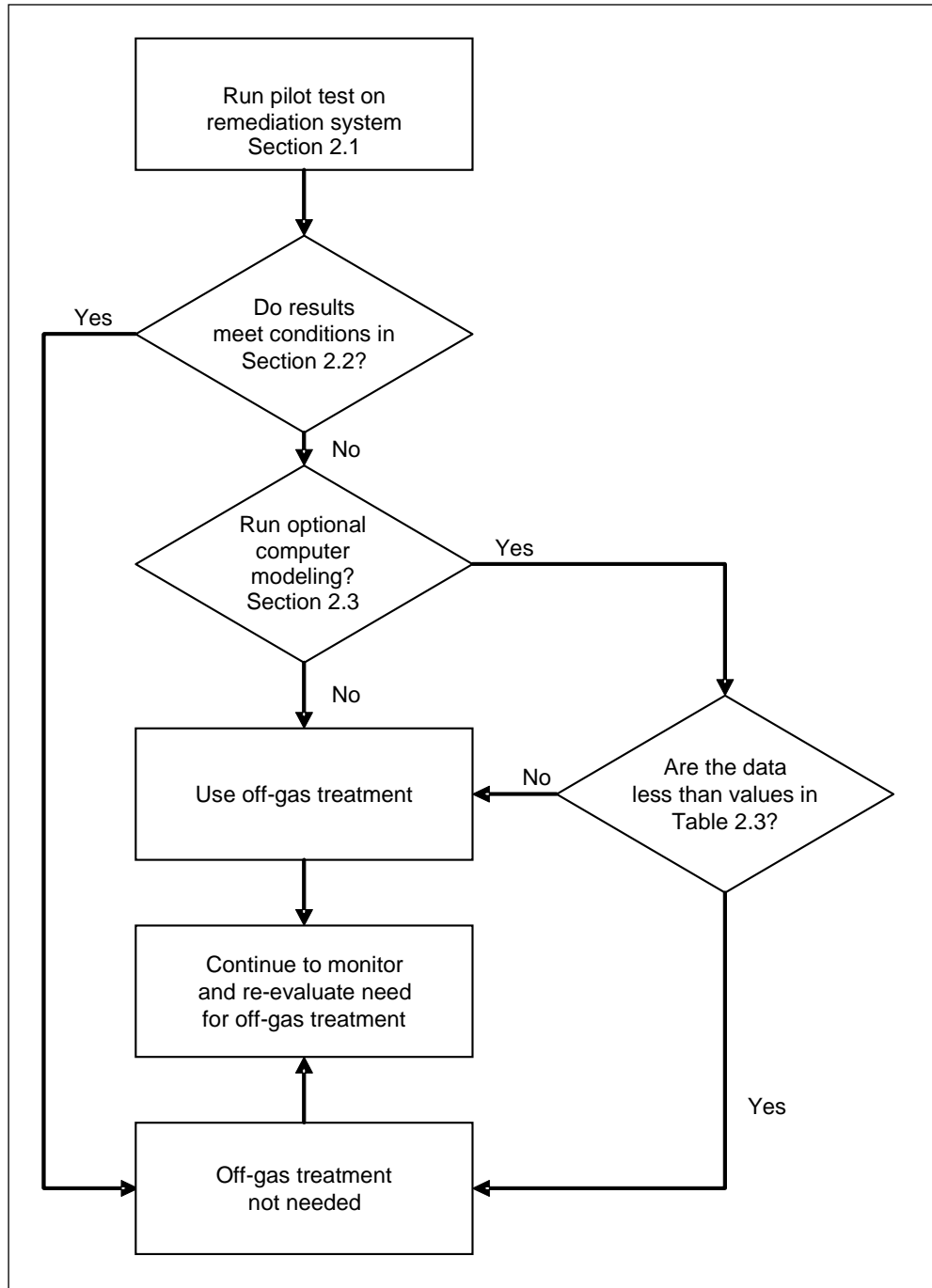


Figure 2.1 Flowchart of Suggested Off-Gas Discharge Management Process

2.1.1.2 Testing Groundwater Extraction/Air Stripping Systems

Prior to operating a groundwater extraction/air stripping system, groundwater monitoring data can be used to estimate vapor emission rates and determine the need for off-gas treatment. However, these estimates and determinations must be validated through routine sampling once the system begins operation. For operating systems, emissions from an air-stripping tower can be estimated using data from influent water samples alone (assuming a 100% contaminant removal efficiency). Alternatively, it is acceptable to collect both influent and effluent water samples and determine the stripping efficiency from the difference between influent and effluent contaminant concentrations. Before collecting samples, the pumping system should be operated continuously at the maximum design flow rate for at least 24 hours. There may be permitting requirements for discharging treated groundwater. Discuss the disposal options and permitting requirements with the DEQ project manager.

2.1.2 *Sample Analyses*

Off-Gas. For gasoline or diesel contamination, test off-gas samples for TPH, BTEX, and MTBE. For gasoline, measure TPH, BTEX, and MTBE levels using EPA Method TO-3. There are no approved EPA methods specifically developed for quantifying diesel-range hydrocarbons in air samples, but laboratories performing air analyses indicate quantification of vapor-phase diesel levels can be accomplished using NIOSH Method 1550 or a modified EPA Method TO-13. Quantify BTEX levels in diesel using EPA Method TO-3, TO-14a, or TO-15.

For sites with chlorinated solvents or other non-petroleum VOCs, use EPA Method TO-14a, TO-15, or other EPA approved analytical methods¹ that provide a method reporting limit (MRL) low enough to evaluate the risk to people.

Table 2.1: Summary of Recommended Analytical Methods

<u>Contaminant</u>	<u>TPH-Gasoline</u>	<u>TPH-Diesel</u>	<u>BTEX, MTBE</u>	<u>Non-Petroleum VOCs</u>
Medium				
Off-Gas Samples	EPA Method TO-3	NIOSH Method 1550 or a modified EPA Method TO-13	EPA Methods TO-3, TO-14a or TO-15	EPA Method TO-14a, TO-15, or other appropriate methods
Groundwater Influent Samples	NWTPH-Gx	NWTPH-Dx	EPA Methods 8021 or 8260	EPA Method 8260 or other appropriate methods

Influent Water. For a groundwater treatment system where off-gas discharge estimates will be based on concentrations in the influent water, test groundwater samples for TPH using NWTPH-Gx and/or NWTPH-Dx, and for BTEX/MTBE using EPA Methods 8021 or 8260. Use EPA Method 8260 or other EPA approved analytical methods for chlorinated solvents or other non-petroleum VOCs.

¹ DEQ's Tanks and Cleanup Programs generally require the use of analytical methods from *Test Methods for Evaluating Solid Waste*, SW-846 (U.S. EPA).

2.2 Evaluating Pilot Test Results

If emissions from the remediation system are low enough to present no unacceptable risk to human health or the environment, the system can be “screened out” of this process and will not need off-gas treatment. The treatment system does not present an unacceptable risk if; 1) the results of dispersion modeling indicate VOC levels do not exceed the concentrations in Table 2.3 of this document at receptor locations/compliance points; or 2) the system meets all five of the screening criteria listed below. Otherwise, there is the choice of either treating off-gas, using computer modeling to calculate a more site-specific result (Section 2.3), or selecting a treatment technology that does not produce air discharges.

Screening Criteria for Petroleum Remediation Systems

1. The system is treating only *petroleum-contaminated* soil and/or groundwater; and
2. The emission rate of benzene is less than 0.25 lbs/day; and
3. The emission rate of gasoline-range TPH is less than 23 lbs/day; and
4. The emission rate of diesel-range TPH is less than 4.3 lbs/day; and
5. The discharge stack is located at least 100 feet from the nearest residence, and 66 feet from the nearest occupied commercial structure or manned work station.

Calculation of allowable emission levels in items 2 – 4 above assumed: 1) relatively flat terrain around the site; 2) a discharge stack of at least 15 feet in height and no more than 4 inches in diameter; and 3) no nearby buildings large enough to interfere with the mixing of off-gases and air. If any of these criteria do not apply to a specific system, site-specific modeling should be performed to determine whether to treat the discharge. See Appendix 1 for more detailed information.

2.3 Air Dispersion Modeling

If pilot test results indicate that a system will not meet the generic screening criteria listed in Section 2.2, the project sponsor may choose either to implement off-gas treatment or to use computer modeling to calculate a more site-specific result. SCREEN3² or another EPA-approved dispersion model may be used to estimate the impact on site-specific ambient air concentrations. SCREEN3 is a conservative model that calculates 1-hour average vapor concentrations at specified distances from a discharge stack. The model output is subsequently converted into longer term averages and risk assessment methods are then applied to evaluate the potential impact to people.

2.3.1 Model Input Requirements

Before modeling the effects of a treatment system, certain information must be collected and input into the model. This information is typically related to operating parameters of the remediation system and the surrounding land use and terrain. Data needs include locations and distances from the discharge stack to residential and commercial structures, workstations, and sensitive receptors such as day-care centers, schools, and hospitals. Table 2.2 lists the information needed for SCREEN3.

² SCREEN3 is available free from EPA’s website: <https://www.epa.gov/scram/air-quality-dispersion-modeling-screening-models>. Consult the SCREEN3 user’s manual for a description and discussion of the model and its input parameters.

Table 2.2: Input Parameters Needed to Model a Point Source Using SCREEN3

Emission Rate (g/s)	
Stack Height (m)	
Stack Gas Exit Velocity (m/s) or Volumetric Flow Rate (ACFM, m ³ /s)	
Stack Gas Temperature (K)	
Ambient Temperature (K)	
Receptor Height Above Ground (m)	
Receptor Distance from Source (m)	[discrete distance or automated array]
Land Type	[rural or urban]
Terrain Type	[simple or complex based on surrounding topography]
Meteorology	[option "1" (full meteorology) is normally selected]
<i>In addition, for building downwash calculations</i>	
Building Height (m)	
Minimum Horizontal Dimension (m)	
Maximum Horizontal Dimension (m)	

2.3.2 Interpreting the Model's Output

One of the model's input parameters listed in Table 2.2 is "Receptor Distance from Source." This is more commonly known as the point of compliance, where contaminant concentrations released from the system must meet acceptable risk levels. For the purpose of this guidance, this compliance point is *the distance from the discharge stack to the nearest location where people live and/or work*. A compliance point may be a residence, school, commercial building, or outdoor work station. It is appropriate to measure the distance from the base of the discharge stack to the nearest occupied structure or work station.³

After running the model with site-specific input data, the maximum 1-hour average concentration for carcinogens at the compliance point can be converted to an annual average by multiplying the model output by 0.1. For non-carcinogens, multiply the maximum 1-hour average output by 0.4 to convert to a 24-hour average concentration. (See EPA's SCREEN3 Model User's Guide for background information on these conversion factors.) If the resulting averages are less than or equal to the risk-based values listed in [Table 2.3](#) below, off-gas treatment is not needed. Otherwise, off-gas treatment is needed to reduce VOC concentrations to acceptable levels. Alternatively, select a treatment technology that does not produce air discharges.

The concentrations listed in [Table 2.3](#) represent a life-time excess cancer risk of one-in-a-million from exposure to each carcinogen for five years, and a hazard quotient of one from exposure to non-carcinogens. If the treatment system will operate for more than five years, or if the number of carcinogenic compounds emitted exceeds 10, or the sum of the hazard quotients for compounds with similar toxicological end-point exceeds 1, off-gas treatment may be necessary to maintain adequate protection of nearby workers and residents. Occupants of residential properties are assumed to be children for the duration of the exposure, while individuals working at commercial/industrial properties are assumed to be adults. For the purpose of this guidance, use residential standards for sensitive receptors such as schools, day-care facilities, and hospitals.

³ For receptors located at distances less than the point of calculated maximum pollutant concentration, the maximum concentration should be compared to Table 2.3 values to see if off-gas treatment is needed.

Table 2.3: Permissible Concentration Increases*

Contaminant	Risk Type	Residential (ug/m ³)	Occupational (ug/m ³)
Acrolein	noncarcinogen	0.01	0.08
Benzene	carcinogen	0.98	7.6
1,3-Butadiene	carcinogen	0.044	0.34
Carbon tetrachloride	carcinogen	0.49	3.9
Chloroform	carcinogen	0.33	2.52
1,2-Dibromoethane (EDB)	carcinogen	0.013	0.10
1,1-Dichloroethylene	noncarcinogen	110	830
1,2-Dichloroethylene (cis)	noncarcinogen	19	150
1,2-Dichloroethylene (trans)	noncarcinogen	38	290
1,2-Dichloroethane (EDC)	carcinogen	0.29	2.2
1,4-Dioxane	carcinogen	2.4	19
Ethylbenzene	noncarcinogen	550	4200
Methyl tertiary-butyl ether (MTBE)	carcinogen	15	110
Perchloroethylene (PCE)	carcinogen	1.3	9.7
1,1,1-Trichloroethane (TCA)	noncarcinogen	1200	9200
Trichloroethylene (TCE)	carcinogen	0.07	0.51
Vinyl chloride (child)	carcinogen	0.84	Not applicable
Vinyl chloride (adult)	carcinogen	Not applicable	13
TPH – Diesel Range	noncarcinogen	63	490
TPH – Gasoline Range	noncarcinogen	340	2600
Other Contaminants	noncarcinogen	Multiply EPA Region 9 Ambient Air PRG by 0.52	Multiply EPA Region 9 Ambient Air PRG by 4.0
Other Contaminants	carcinogen	Multiply EPA Region 9 Ambient Air PRG by conversion factor for child 3.9	Multiply EPA Region 9 Ambient Air PRG by conversion factor for occupational exposure 30

*DEQ may revise the values in this table as new information becomes available or regulations change.

Note: Regardless of the measured or calculated rate of discharge, the remediation system should not create nuisance conditions (noise, odors) for people living or working in the vicinity of the project.

⁴ Risk calculations in this guidance are based on a 5-year minimum exposure duration. For remediation systems expected to operate longer than 5 years, adjust exposure duration factors accordingly. These calculations can be carried out using the DEQ risk-based decision making spreadsheets, *Risk-Based Concentrations for Individual Chemicals* (DEQ, 2003) and *Calculating RBCs for Total Petroleum Hydrocarbons* (DEQ, 2003). To obtain occupational values, set the occupational exposure duration to 5 years (or longer if needed, as discussed above) and recalculate RBCs. Since the spreadsheets are not set up to calculate residential exposures only for children, the spreadsheets must be adjusted to provide correct residential values for this guidance document. To do this, set the adult body weight to 15 kg and the adult inhalation rate to 8.3 m³/day, which makes them equal to values for a child. Then set both the adult and child exposure duration to 5 years (or higher value as needed) and recalculate RBCs.

3. Remedial System Operation

3.1 Off-Gas Treatment Technologies

If off-gas treatment is needed, use of treatment technologies capable of achieving VOC removal efficiencies of at least 95% is recommended. The following technologies meet this performance standard:

- Thermal oxidation;
- Catalytic oxidation;
- Vapor-phase carbon adsorption; and
- Internal combustion.

Biofiltration systems can also be used to treat off-gases. Their performance efficiency, however, can be more variable.

3.2 Monitoring System Performance

Once full-scale, continuous operation of the remediation system begins, pre-treatment and stack discharge samples (or water samples for groundwater extraction/air stripping systems) should be collected and analyzed monthly, or at some other mutually agreed upon frequency, to:

- Make sure that emission rates remain below acceptable levels;
- Determine when off-gas treatment can be discontinued, or should be installed;
- Monitor system efficiency and progress in achieving cleanup goals; and
- Determine when it is appropriate to shut down the remediation system.

Regular sampling should occur whether or not the system includes off-gas treatment. In addition to monthly sampling, trends in system performance can also be monitored with field screening tools such as an appropriately calibrated PID or FID. Once a good correlation between PID or FID readings and laboratory results is established, some of the samples can be replaced by PID or FID monitoring. However, at least one sample should be submitted to the laboratory monthly, or other mutually agreed to frequency.

If the system DOES NOT include off-gas treatment: Routine sampling should be conducted as described above, both to demonstrate that VOC discharges remain within acceptable limits and to track overall performance of the remediation system. While monthly sampling is recommended, as remediation of the site progresses, data on emission rates may support less frequent sampling. DEQ should be notified if monitoring events indicate emission rates are increasing significantly. If two consecutive sampling events show that emissions have increased above acceptable risk values at receptor locations, an off-gas treatment technology should be installed.

If the system DOES include off-gas treatment: Monthly discharge sampling should be conducted as described above to verify treatment system effectiveness. When two consecutive months of pre-treatment (treatment system influent) sampling show that influent concentrations have declined below Table 2.3 values at receptor locations, **and** there is a consistent trend of stable or declining influent concentrations, off-gas treatment can be discontinued. In such situations, the project sponsor should consult with DEQ about discontinuing off-gas treatment.

Note: To ensure off-gas treatment units are operating at a minimum 95% removal efficiency, it is

appropriate for the project sponsor to monitor emissions regularly with an appropriately calibrated PID or FID, and to report monitoring results to DEQ.

3.3 Summary of Suggested Milestones for Remedial System Operation

- Evaluate the need for off-gas treatment.
- If off-gas treatment is not (or no longer) in place, sample off-gas at regular intervals and share results with DEQ, to confirm emission levels and to document trends that may support remedial system shutdown.
- If off-gas is being treated, sample influent concentrations and system emissions monthly (or other mutually agreed to frequency) and share results with DEQ, to verify treatment effectiveness and to document trends that may support discontinuing treatment.
- Consult with DEQ at all key decision points related to remedial system operation.

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Appendix 1

A.1 Calculation of Effective RfDi for gasoline and diesel

As applied in risk assessments, exposure models are used with site-specific concentration data, scenario-specific intake data, and chemical-specific toxicity data to yield estimates of risk that could result from exposure to the chemical(s) of concern. A more detailed explanation of such models can be found in the Department's *Guidance for Conduct of Deterministic Human Health Risk Assessments* (DEQ, 2000b).

$$\text{Risk} = \text{Concentration} \times \text{Exposure Factors} \times \text{Toxicity}$$

To calculate permissible (i.e. exposure results in an increase in the hazard quotient/index by less than one) increases in ambient levels of total petroleum hydrocarbons requires that inhalation reference doses (RfDi) be established for diesel and gasoline as whole products. These "effective" RfDi s were derived by back calculating from ambient air RBCs for gasoline and diesel developed by the DEQ Petroleum Hydrocarbons working group. For a discussion on how those RBCs were established, consult the DEQ September 2003 *Risk-Based Decision Making for the Remediation of Petroleum Contaminated Sites* document.

<http://www.oregon.gov/deq/FilterDocs/RBDMGuidance.pdf>

$$\text{RfD}_i = \frac{\text{RBC}_{air} \cdot \text{IRA}_o \cdot \text{ED}_o \cdot \text{EF}}{\cdot \text{ARL}_n \cdot \text{AT}_{no} \cdot 365 \text{ d/yr} \cdot \text{BW}_a \cdot 10^3 \mu\text{g/mg}_o}$$

Where:

RfDi = Noncancer reference dose – inhaled (mg/kg-d) = **Chemical Specific**

IRA_o = Inhalation rate, air – adult, occupational (m³/d) = **7 m³/day**

ED_o = Exposure duration – adult, occupational (yr) = **5 years**

EF_o = Exposure frequency – adult, occupational (d/yr) = **250 days/year**

ARL_n = Acceptable Risk Level for Noncarcinogens (unitless) = **Hazard Index of 1**

AT_{no} = Averaging time – noncarcinogens-occupational (yr) = **5 years**

BW_a = Body weight – adult (kg) = **70 kg**

RBC_{air} = Risk-based concentration (ug/m³)

And,

Whole product gasoline RBC_{air (Occupational)} = **2600 ug/m³**

Whole product diesel RBC_{air (Occupational)} = **490 ug/m³**

These calculations yield effective RfDi values for diesel and gasoline (weighted average of RfDis for the TPH fractions composing each product):

Whole Product Gasoline RfDi = .178 mg/kg-d
Whole Product Diesel RfDi = .034 mg/kg-d

A.2 Calculating Permissible Concentration Increases for Non-Carcinogens

Non-Carcinogens – Residential

$$PCI_{air} (\mu\text{g}/\text{m}^3) = \frac{ARL_n \cdot AT_{nr} \cdot 365 \text{ d/yr} \cdot BW_c \cdot 10^3 \mu\text{g}/\text{mg}}{ED_r \cdot EF_r \cdot IRAc \cdot (1/RfD_i)}$$

Non-Carcinogens – Occupational

$$PCI_{air} (\mu\text{g}/\text{m}^3) = \frac{ARL_n \cdot AT_{no} \cdot 365 \text{ d/yr} \cdot BW_a \cdot 10^3 \mu\text{g}/\text{mg}}{(1/RfD_i) \cdot IRA_o \cdot ED_o \cdot EF_o}$$

Where:

PCI = Permissible concentration increase ($\mu\text{g}/\text{m}^3$) = **Chemical Specific**

ARL_n = Acceptable Risk Level for Noncarcinogens (unitless) = **Hazard Index of 1**

AT_{nr} = Averaging time – noncarcinogens-residential (yr) = **5 years**

AT_{no} = Averaging time – noncarcinogens-occupational (yr) = **5 years**

BW_a = Body weight – adult (kg) = **70 kg**

BW_c = Body Weight – residential, child = **15 kg**

ED_r = Exposure duration – residential (yr) = **5 years**

ED_o = Exposure duration – adult, occupational (yr) = **5 years**

EF_r = Exposure frequency – residential (d/yr) = **350 days/year**

EF_o = Exposure frequency – adult, occupational (d/yr) = **250 days/year**

IRA_c = Inhalation rate, air -child (m^3/d) = **8.3 m^3/day**

IRA_a = Inhalation rate, air – adult, occupational (m^3/d) = **7 m^3/day**

A.3 Calculating Permissible Concentration Increases (PCIs) for Carcinogens

Carcinogens – Residential

$$PCI_{air} (\mu\text{g}/\text{m}^3) = \frac{ARL_c \cdot AT_c \cdot 365 \text{ d/yr} \cdot BW_c \cdot 10^3 \mu\text{g}/\text{mg}}{EF_r \cdot IRA_c \cdot SF_i \cdot ED}$$

Carcinogens – Occupational

$$PCI_{air} (\mu\text{g}/\text{m}^3) = \frac{ARL_c \cdot AT_c \cdot 365 \text{ d/yr} \cdot BW_a \cdot 10^3 \mu\text{g}/\text{mg}}{SF_i \cdot IRA_a \cdot ED \cdot EF_o}$$

Where:

ARL_c = Acceptable Risk Level for Carcinogens (unitless) = **1 x 10⁻⁶**

AT_c = Averaging time – carcinogens (yr) = **70 years**

BW_a = Body weight – adult (kg) = **70 kg**

BW_c = Body Weight – residential, child = **15 kg**

ED = Exposure duration – (yr) = **5 years**

EF_r = Exposure frequency – residential (d/yr) = **350 days/year**

Exposure Frequency – Occupational (d/yr) = **250 days/year**

IRA_c = Inhalation rate, air – residential (child), (m^3/d) = **8.3 $\text{m}^3 \text{ day}$**

IRA_a = Inhalation rate, air – occupational (m^3/d) = **7 m^3/d**

SF_i = Cancer slope factor – inhaled ($\text{mg}/\text{kg-d}$)⁻¹ = **Chemical Specific**

A.4 Conversion Factor for PRG to Permissible Air Concentrations

$$\text{Conversion factor} = \text{PCI} / \text{PRG}$$

Conversion Factor for Carcinogens (residential) = PCIres/PRG = approximately 3.9

Conversion Factor for Carcinogens (occupational) = PCIocc/PRG = approximately 30

Conversion Factor for Non-Carcinogens (residential) = PCIres/PRG = approximately 0.52

Conversion Factor for Non-Carcinogens (occupational) = PCIocc/PRG = approximately 4

Where:

PCI = Permissible Concentration Increase

PRG = Preliminary Remediation Goal (EPA Region 9)

A.5 Screening Criteria for Petroleum Remediation Systems

The screening criteria are based on a lbs per day approach to establish the de minimis emission rates. De minimis being defined as: an emission rate that has a negligible impact on air quality at a prescribed distance (minimum setback from residences and commercial businesses).

Reviewing the results of dispersion modeling for discharges from hypothetical indicates that for a given system configuration and volumetric flow rate, air impacts are directly proportional (have a linear relationship) to vapor concentration. For a given daily emission rate, low flow systems with high vapor concentrations produced more significant air quality impacts (and associated health risks) than did high flow-low concentration discharges. As a result, low flow systems were focused on in identifying de minimis emission rates.

The next step in identifying de minimis emission rates was to examine information on soil and groundwater treatment systems currently or previously operated at tank cleanup sites to identify what typically is the minimum-size system employed. Based on this work, systems having a volumetric flow rate of 50 cubic feet per minute were identified as a representing a reasonable minimum size.

Dispersion modeling results for 50 CFM systems were examined to determine what vapor concentrations produced acceptable/not acceptable air quality impacts'. Linear interpolation was then used to determine a specific vapor concentration/daily emission rate that produced an increase in average annual ambient air concentration at a distance of 30 meters (approx. 100 feet) that corresponds to the calculated permissible concentration increase (PCI).

Interpolation calculations are presented below:

$$ER_{DEM} = \frac{PCI \cdot ER_{30}}{CI_{30}}$$

Where:

ER_{DEM} = De Minimis Emission Rate (lbs/day)

PCI = Permissible Concentration Increase at (ug/m³) =

ER₃₀ = Emission Rate producing CI₃₀ (lbs/day)

CI₃₀ = Annual Average HAPs Concentration Increase at a distance of 30 meters (ug/m³) {50 CFM System}

For Benzene:

$$PCI_B = .97 \text{ ug/m}^3$$

$$CI_{30,B} = 1.12 \text{ ug/m}^3$$

$$ER_{30,B} = .29 \text{ lbs/day}$$

$$ER_{DEM,B} = \frac{.9 \text{ ug/m}^3 \times .29 \text{ lbs/day}}{1.12 \text{ ug/m}^3} = .25 \text{ lbs/day}$$

For Gasoline Range TPH

$$PCI_G = 336 \text{ ug/m}^3$$

$$CI_{30,G} = 560 \text{ ug/m}^3$$

$$ER_{30,G} = 38 \text{ lbs/day}$$

$$ER_{DEM,G} = \frac{336 \text{ ug/m}^3 \times 38 \text{ lbs/day}}{560 \text{ ug/m}^3} = 22.8 \text{ lbs/day}$$

For Diesel Range TPH

Since, for a given system configuration, there is a linear relationship between emissions rate and ambient air concentration, the diesel range TPH ER_{DEM} can be calculated from the following equation:

$$ER_{DEM,D} = PCI_D / PCI_G * ER_{DEM,G} \text{ lbs/day}$$

Where:

$$PCI_D = 64 \text{ ug/m}^3$$

$$PCI_G = 336 \text{ ug/m}^3$$

$$ER_{DEM,G} = 22.8 \text{ lb/day}$$

$$ER_{DEM,D} = \frac{64 \text{ ug/m}^3 \times 22.8 \text{ lbs/day}}{336 \text{ ug/m}^3} = 4.3 \text{ lbs/day}$$