

Tiered Approach to Corrective Action Objectives (TACO)

Fact Sheet 1: Introduction

What is TACO?

TACO is the Illinois EPA's method for developing remediation objectives for contaminated soil and groundwater. These remediation objectives protect human health and take into account site conditions and land use. Remediation objectives generated by TACO are risk-based and site-specific.

How can TACO help me?

Previously, the Illinois EPA's Bureau of Land (BOL) used conservative "one-size-fits-all" remediation objectives at nearly every site. Baseline remediation objectives still exist, but other options also protective of human health have been added.

TACO provides flexibility to site owners and operators in developing site-specific remediation objectives. It's now the site owners and operators who decide how best to manage their sites within TACO guidelines. However, this determination of site-specific remediation objectives is subject to Illinois EPA review and approval.

By exercising these new choices, site owners and operators may reduce remediation costs, return more sites to productive use, hasten property redevelopment, and still fully comply with environmental laws and regulations.

Under TACO, a site may qualify to receive a No Further Remediation Letter acknowledging the site owner or operator has satisfied the applicable BOL program requirements (*See Fact Sheet 3*).

Does TACO apply to my site?

Yes, you will use TACO if your site is regulated by one of the following BOL programs:

- Leaking Underground Storage Tank (LUST) Program
- Site Remediation Program
- RCRA Closure and Corrective Action

Are there any limitations to TACO?

TACO works in cooperation with the existing laws and regulations. If you participate in one of the BOL programs listed above, TACO can only be used in conjunction with that program's requirements.

Because of the wide range of programs in which TACO can be applied, TACO itself does not provide procedures for characterizing a site and the potential contamination at the site. Such characterization is a critical step in the overall TACO process, but is program specific.

Consistent with the regulations of other programs, and as approved by the Illinois EPA, TACO may also be used to develop remediation objectives to protect surface waters, sediments or ecological concerns.

Any TACO procedure that delays an owner's or operator's response during an environmental emergency cannot be used.

TACO does not consider any person's liability, culpability, or legal, moral or ethical responsibility to address a release of a regulated substance into the environment.

Can I use TACO to update my existing remediation objectives?

Yes.

How does TACO work?

TACO offers site owners and operators the following choices:

- Exclusion of exposure routes
- Use of area background concentrations as screening tools or remediation objectives
- Three tiers for selecting remediation objectives.

Selection of an option or combination of options to use in developing remediation objectives depends on the

site-specific conditions and the site owner's or operator's remediation goals.

Exposure Route Evaluations

Human exposure route(s) can be excluded from further consideration provided the requirements in Subpart C of TACO are met. The human exposure routes are: inhalation, soil ingestion and groundwater ingestion (including migration to groundwater). Exclusion of an exposure route will require an institutional control (*See Fact Sheets 4 & 8*).

Determining Area Background

When contaminant concentrations do not exceed background concentrations for soil and/or groundwater, evaluation under any of the other tiers may not be required. The procedures for determining area background concentrations are contained in Subpart D of TACO (*See Fact Sheet 9*).

Tier 1

In Tier 1, the site owner or operator compares site sample analytical results to baseline remediation objectives, contained in "look-up" tables. These objectives are based on simple, conservative models (*See Fact Sheet 6*).

To complete a Tier 1 evaluation, the site owner or operator must know:

- The extent and concentrations of the contaminants of concern,
- The groundwater classification as defined in Illinois Administrative Code, Part 620, and
- The intended land use at the site (either residential or industrial/commercial).

If remediation objectives are based on an industrial/commercial land use, then an institutional control prohibiting the property from residential use will be imposed.

Tier 2

A Tier 2 evaluation is not required for those contaminants of concern that meet the Tier 1 remediation objectives (*See Fact Sheets 7 & 10*). A Tier 2 evaluation is also not required for exposure routes excluded under Subpart C of TACO.

Under Tier 2, a site owner or operator considers:

- Data previously gathered for Tier 1,
- The physical and chemical properties of the contaminants,
- The site-specific soil and groundwater parameters (e.g., soil type, soil organic carbon content, hydraulic conductivity), and

- The application of institutional controls and engineered barriers.

The additional Tier 2 information can allow for calculation of less stringent but equivalently protective remediation objectives. These calculations are derived from simple analytical models and standardized equations.

Tier 3

Site owners and operators can use Tier 3 to address those situations which they choose not to handle or cannot handle under the first two tiers. These situations can range from simple sites where physical barriers limit remediation, to complex sites where full-scale risk assessments or alternative modeling are applied. A Tier 3 review and evaluation draws on expertise beyond the immediate BOL project manager.

Do I have to use all three tiers?

No. The tier(s) you select to develop remediation objectives will depend on multiple factors, including the actual amount and extent of contamination present, the cost of remediating that contamination, and the cost of obtaining the information necessary to conduct a Tier 2 or Tier 3 analysis. The tiers do not need to be used in sequence.

What happens next?

After remediation objectives are established using TACO procedures, a site owner or operator may:

- Reduce contaminant concentrations to meet established objectives through active remediation (e.g., dig and haul, or treatment in place),
- Restrict exposure to contaminated soil or groundwater or both by using engineered barriers or institutional controls,
- Take no action, if contaminant concentrations present at the site do not exceed remediation objectives, or
- Use any combination of the options above.

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Fact Sheet 2: Risk

The Use of Risk in TACO

Risk can be defined as the likelihood (or probability) of an undesirable occurrence under specific circumstances. In TACO, the circumstances (often called a scenario) are environmental contamination and its possible adverse effects on human health and/or the environment.

The concept of risk is incorporated into TACO to provide adequate protection to human health and the environment while incorporating site-specific information to allow for more cost-effective remediation.

Risk Basics

In determining environmental risk there are three basic components; all must be present for a risk to exist:

1. Contaminant(s) i.e., chemicals,
2. Exposure route(s) e.g., air or drinking water, and
3. Receptor(s) i.e., people, plants or animals.

When using TACO, all three factors must be considered. The contaminants of concern are identified based on products released on site and program-specific site investigation requirements. At a minimum, the exposure routes of inhalation, ingestion of soil and ingestion of groundwater as drinking water must be evaluated. The potential of contaminants to migrate to groundwater is evaluated as part of the migration to groundwater route. It may also be necessary to evaluate exposure from chemicals crossing the skin in some circumstances. The receptors (those populations possibly exposed) are identified through the determination of present and post remediation land use.

Risk under TACO is quantified in two separate ways:

1. For non-carcinogenic effects, risk is expressed as a hazard quotient or the ratio of the expected exposure to the regulatory limit, and
2. For carcinogenic effects, risk is associated with

the probability of an individual developing cancer over a lifetime.

Remediation objectives for carcinogens and non-carcinogens are derived using different assumptions about their effect on the human body. It is important to note that carcinogenic contaminants may have non-carcinogenic toxic effects which are also considered in Tiers 2 and 3 of TACO. The frequency and duration of the exposure along with the concentration of the contaminant determine the health effects.

Non-Cancer Risk

For non-carcinogenic contaminants, the measure used to describe the potential for non-carcinogenic toxicity in an individual is not expressed as a probability. Instead, the potential for effects is evaluated by comparing an exposure level (E) over a specified time period (e.g., lifetime) with a reference dose (RfD) derived for a similar exposure period. This ratio of predicted exposure to acceptable exposure is called the hazard quotient (HQ).

In the development of a RfD, the upper bound of the human tolerance range must first be identified or estimated. Called the threshold, this upper bound represents a level that, if exceeded, could cause the protective mechanisms that exist in the body to be overcome and an adverse effect could occur.

Next, based on a "subthreshold" level, the "no observed adverse effect level" (NOAEL) is identified. The NOAEL is then divided by one or more uncertainty factors (usually multiples of ten) to account for such things as sensitive sub-populations and extrapolation from animal studies to humans. The RfD values are provided by the U.S. EPA.

An example of the determination of HQs follows:

<u>Contaminant</u>	<u>E</u>	<u>RfD</u>
Acetone	0.01	0.1
Dalapon	0.02	0.03

$$\text{HQ (acetone)} = 0.01 \text{ mg/kg-day} / 0.1 \text{ mg/kg-day} = 0.1$$

$$\text{HQ (dalapon)} = 0.02 \text{ mg/kg-day} / 0.03 \text{ mg/kg-day} = 0.7$$

The HQ assumes that there is a level of exposure (i.e., a threshold) below which it is unlikely that adverse health effects would occur. If the exposure level exceeds this threshold (i.e., if $E/RfD > 1$) there is a concern for potential noncancer effects. It is important not to interpret HQ ratios as statistical probabilities; a ratio of 0.01 does not mean that there is a 1 in 100

chance of an effect occurring.

TACO also requires that if contaminants of concern are known to have the same target organ (e.g., liver, kidney) the HQ's for those contaminants must be added to form a Hazard Index (HI). This HI must be below one (1.0) to assume no adverse health effects on the target organ. For example:

HQ (acetone) = 0.1

HQ (dalapon) = 0.7

HI = 0.8 (target organ kidney)

Cancer Risk

For carcinogens, risks are estimated as the probability of an individual developing cancer over a lifetime as a result of exposure to a contaminant.

A risk evaluation based on the presumption of a threshold is inappropriate for carcinogens. The underlying presumption for carcinogens is that the introduction of even one molecule of the contaminant can cause cancer in an individual even if the probability is very low. This conservative, "nonthreshold" concept is used because it is presumed that there is no level of exposure to a carcinogen that does not pose a certain level of risk.

Because the threshold concept is not acceptable for carcinogens, a value different from a RfD that quantifies the relationship between dose and response must be developed. This value is known as a slope factor (SF), and it converts daily intakes of a carcinogen averaged over a lifetime directly to the upper bound risk of an individual developing cancer. That is, risk is equal to chronic daily intake (CDI) averaged over 70 years (lifetime) multiplied by the SF.

The SF is derived through the plotting of a curve that compares dose to response. Statistical procedures usually calculate the SF as the upper 95th percent confidence limit of the slope of the dose-response curve (i.e., there is only a 5% chance that the cancer risk could be greater). Because this is the upper bound risk, the actual risk is between that value and zero. The SF is roughly equivalent to the risk per unit dose, expressed as (mg/kg/d)⁻¹. As with the RfD, the SF is provided by the U.S. EPA.

An example of the determination of cancer risk follows:

<u>Contaminant</u>	<u>CDI</u>	<u>SF</u>
Benzene	0.0005	0.03

Risk = 0.0005 mg/kg-day x 0.03 (mg/kg-day)⁻¹
Risk = 1.5 x 10⁻⁵

The risk of cancer due to exposure to a contaminant is commonly expressed in exponential terms, e.g., 10⁻⁶ and 10⁻⁴. These terms equate to a risk of 1 in 1,000,000 and 1 in 10,000 respectively. In the benzene example, the risk estimate of 1.5 x 10⁻⁵ means that 1.5

additional cases of cancer above background might occur among 100,000 exposed persons (or 15 cases in 1,000,000 persons) as a result of benzene exposure. The background cancer rate is 1 in 3, meaning that over a lifetime, an American's probability of getting cancer is 0.333333. Adding a 10⁻⁶ risk would increase the probability of an individual getting cancer to 0.333334. With the addition of a 10⁻⁴ risk, the probability of an individual getting cancer would be 0.333433.

Point of Human Exposure

For both carcinogenic and non-carcinogenic contaminants, it is important to identify the location of the risk on a site. Essentially the risk is at the point of human exposure, because without exposure there is no risk. In the TACO procedure, it is assumed that the point of human exposure, i.e., the risk, is at the contaminant source. If, however, an institutional control or an engineered barrier is in place (*see Fact Sheets 4 & 5*), the point of human exposure is moved to the edge of such controls.

Risk Management

The goal of risk management is to reduce risk to an acceptable level while balancing the benefits of corrective action with its associated costs.

TACO provides several options for risk management if there is a need for risk reduction. The three most common options are:

1. Active remediation,
2. Engineered barriers, and
3. Institutional controls.

Active remediation would include any cleanup activities which would reduce contaminant levels to either an acceptable risk level or to a level that would allow the use of one of the other options. Engineered barriers and institutional controls serve to prevent exposure to the remaining contaminants.

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Fact Sheet 3: No Further Remediation Letters

What is a No Further Remediation (NFR) letter?

A No Further Remediation (NFR) letter, issued by the Illinois EPA's Bureau of Land (BOL), acknowledges that a site owner or operator has satisfied the respective BOL laws and regulations. A site qualifies to receive an NFR letter once the owner or operator meets all program requirements and the applicable TACO remediation objectives.

Why isn't there a generic NFR letter?

TACO changes remediation requirements in two ways:

1. Responsibility for choosing among remediation objectives lies with the site owner or operator instead of the Illinois EPA.
2. The remediation objectives can be tailored to the intended post remediation land use.

Because of this, it is not feasible to issue a single generic letter for all situations.

What's the difference between each BOL program's NFR letter?

Each BOL program's authorization to issue an NFR letter comes from separate laws and regulations.

Under the Leaking Underground Storage Tank program (35 IAC 732), an NFR letter signifies that no further corrective action is required in response to a LUST release.

Under the Site Remediation Program (35 IAC 740), a comprehensive NFR letter signifies that a site is protective of human health and the environment. A focused NFR letter signifies that either the remediation area is only a portion of a larger parcel of property, or that the site owner has elected to limit the environmental investigation and related contaminants of concern to be remediated, or both.

Under Section 4(y) of the Environmental Protection Act, the Illinois EPA may issue a letter signifying that a person is no longer responsible for preventive or corrective action at a site.

Under RCRA Subtitle C, an Acceptance of Certification of Closure for a specific RCRA Unit may be obtained. Also, a determination of no further remediation may be obtained for solid waste management units investigated and/or remediated under the RCRA corrective action requirements of RCRA permits issued by the Illinois EPA.

Must I participate in an Illinois EPA BOL program to obtain an NFR letter?

Yes.

Is there any other way I can get an NFR letter?

No. However, a site undergoing a voluntary cleanup may not need an NFR letter. For example, during a property transaction a buyer and seller can agree to manage a site using TACO without the BOL's Site Remediation Program oversight and approval.

Can the NFR letter serve as an institutional control?

Yes. The NFR letter can restrict land use to prevent exposure to the remaining contaminants. An institutional control is a legal mechanism for imposing limits on land use, such as a deed restriction or local ordinance (*See Fact Sheet 4*). We anticipate many persons will opt for less stringent cleanup objectives and accept the restrictions.

What are the conditions of an NFR letter?

The conditions vary by site depending on the intended post remediation land use, remaining contamination, and the risk level posed by the remaining contamination.

For example, the conditions of an institutional control may prohibit groundwater beneath a site from being used as drinking water. Or, another condition could prohibit a site from residential use. Any violation of a site-specific restriction would be grounds for voidance of the NFR determination.

Why do I need to record an NFR letter with the county recorder?

You must record the NFR letter to ensure current and future users of the property will be informed of conditions of the institutional controls and protected from unwitting exposure to environmental health risks. The NFR letter provides a chain of notification when filed with the local county recorder's office, and becomes indexed to the property.

Do I have to pay a separate fee to obtain the NFR letter ?

Only those sites in the Site Remediation Program pay a fee. Sites in the LUST and RCRA programs do not.

How can an NFR letter be voided?

The validity of the NFR letter depends on the continued observance of institutional controls to protect human health.

The Illinois EPA may seek to void an NFR letter if any of the following occurs:

- violation of the land use restriction,
- failure to operate and maintain preventive or engineering controls,
- improper disturbance or removal of contamination,
- failure to comply with recording requirements,
- obtaining the NFR letter by fraud or misrepresentation,
- subsequent discovery of contaminants not identified as part of the investigation upon which the NFR letter was based, or
- failure to pay the NFR Assessment Fee or Site Remediation Program fees (both applicable only to the Site Remediation Program).

Can I obtain a supplemental NFR letter?

Yes. For example, if a site originally received an NFR letter restricting the land use to industrial/ commercial, an owner or operator can later enter the Site Remediation Program to receive a new NFR. Upon successful completion of appropriate remedial activities, the BOL will issue a new NFR letter that

supersedes the initial NFR letter and allows an alternative land use.

What is an environmental cover letter?

The Illinois EPA, with the assistance of county recorders, has developed a one page cover letter that simplifies the recording process. The cover letter is provided by the Illinois EPA at the time it issues the NFR letter. The owner or operator files the NFR letter by recording both the cover letter and NFR letter with the county recorder.

Can I transfer my LUST site into the Site Remediation Program? And, if I do, would the NFR letter from the SRP satisfy my LUST requirements?

Yes, a site may be transferred from LUST to the Site Remediation Program providing the proper application is made to the SRP. It is important to note, however, that once an agreement is signed with the SRP, the owner/operator is no longer eligible for reimbursement from the UST Fund.

The NFR letter from the SRP will state whether or not you have satisfied the requirements of the LUST program. If the LUST requirements have not been met under the SRP, you must continue remediation under the LUST program. Any subsequent corrective action performed to meet the LUST requirements is not eligible for reimbursement either.

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Fact Sheet 4: Institutional Controls

What are institutional controls?

Institutional controls are legal mechanisms for imposing restrictions and conditions on land use. These restrictions and conditions are contained in an Illinois EPA No Further Remediation (NFR) letter, and may include:

- Restrictive covenants and deed restrictions
- Negative easements
- Ordinances adopted and administered by a unit of local government
- Agreements between a property owner and a highway authority

Why are institutional controls required?

Land use restrictions and conditions are necessary when remaining (post remediation) contaminants pose a risk to human health or the environment.

Institutional controls protect people from harmful exposure to contaminants that are left in place. For example, the conditions of an institutional control may prohibit groundwater beneath a site from being used as drinking water, or require the maintenance of an engineered barrier to prevent exposure to contaminants. Violation of these conditions could pose an unacceptable health and safety risk.

How will I know if my site needs an institutional control?

You will need an institutional control when the remediation objectives used at your site are based on any of the following:

- Industrial/commercial land use
- Engineered barriers
- Pathway exclusion
- The point of human exposure is located at a place other than at the source
- Any combination of the above

You will not need an institutional control if your site

meets the residential remediation objectives.

How do institutional controls work?

The language of the institutional control(s) is found in the NFR letter (*see Fact Sheet 3*). The NFR letter may include copies of ordinances and deed restrictions in addition to maps showing the areas where remaining contaminants exceed the residential remediation objectives.

After approval by the Illinois EPA, the NFR letter must be filed by the site owner with the local county recorder's office to be effective. By indexing the letter to the property, users of the property will be made aware of contaminants left in place. This ensures current and future users of the property will be informed of the conditions of the institutional controls and/or protected from unwitting exposure to environmental health risks.

Are institutional controls permanent land use restrictions?

Yes. However, the site owner may conduct additional investigative and/or remedial activities in the future to reduce or eliminate the remaining contaminants posing a risk to human health or the environment. Once such work is completed, a request can be made to the Illinois EPA to obtain a new NFR letter.

What conditions may be imposed by institutional controls?

Conditions imposed by institutional controls could:

- restrict land use to industrial/commercial,
- prohibit installation of potable wells on site,
- require three feet of clean cover to remain over contamination left in place,
- require a site safety plan to be implemented if any intrusive activities occur in a contaminated area, and/or
- require maintenance of a parking lot or other engineered barrier.

The conditions or restrictions found in institutional controls all serve to prevent human exposure to

remaining contaminants, but are site-specific and depend on multiple factors. These factors include:

- amount of contamination left behind
- location of contamination
- nature or type of contamination
- potential migration pathways or routes of exposure
- geology of the site
- location of site and population at risk

The Bureau of Land (BOL) can assist you in identifying your site's options.

My property is already zoned commercial, so do I need an institutional control from the Illinois EPA restricting the property to commercial/industrial use?

An institutional control from the Illinois EPA is not the same as a local commercial zoning ordinance. Local zoning does not offer the same health protection because residential use of commercially zoned property is not necessarily prohibited. Restricting the land use to commercial/industrial property under TACO means that the property cannot be used for residential purposes.

TACO defines "residential property" as any real property that is used for habitation by individuals or properties where children have the opportunity for exposure to contaminants through ingestion or inhalation at educational facilities, health care facilities, child care facilities or playgrounds.

Contaminants from my site migrated to an adjacent property. I want to resolve any concerns about off-site contamination. If I need an institutional control for my property, does that mean my next door neighbor's property needs one too?

Yes, if the levels off-site exceed residential remediation objectives and your neighbor agrees to the land use restriction.

What if my neighbor will not accept an institutional control?

Without your neighbor's consent, the Illinois EPA will not issue the NFR letter specifying off-site institutional controls. You must either re-negotiate with your neighbor to gain consent, or clean up the off-site contamination to residential remediation objectives.

I heard that if a city ordinance limits the community's drinking water source to a public water supply, then the ordinance can serve as an

institutional control. Is this true?

Yes, it can serve as an institutional control if the ordinance effectively prohibits the use of private wells for drinking water, and the procedural requirements specified in 742.1015 are met -- including a memorandum of understanding between the city and the Illinois EPA.

One condition of my institutional control requires three feet of clean soil to be placed over the contamination. However, I need to put in a foundation for a new office building which will disturb the three feet of cover. What can I do?

A building foundation can be constructed, but the construction workers must be adequately protected from exposure to the contaminants pursuant to OSHA regulations and safe worker practices. If contaminated soil is to be excavated as part of the foundation construction, it must be managed accordingly. Contaminated soils not excavated or disturbed still require an equivalently protective cover.

If my contamination extends beneath a highway, what can I do?

Since roadways can be acceptable engineered barriers, a site owner can enter into an agreement with the highway authority (state, county or local) for the purposes of developing remediation objectives. This agreement can then serve as an institutional control.

Point of Human Exposure

In TACO, it is assumed that the point of human exposure, i.e., the risk, is at the contaminant source. If, however, an institutional control or an engineered barrier is in place, the point of human exposure is moved to the edge of such controls.

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Fact Sheet 5: Engineered Barriers

What is an engineered barrier?

An engineered barrier as defined in TACO limits exposure and/or controls migration of contaminants. A barrier may be natural or human-made, but its effectiveness must be verified by engineering practices.

For an exposure (and therefore, a risk) to occur, three factors must be present:

1. Contaminants,
2. An exposure route, and
3. A receptor.

The purpose of an engineered barrier is to limit exposure by “cutting off” the route. The use of an engineered barrier is an option in situations where contaminant concentrations exceed the applicable Tier 1 or Tier 2 remediation objectives.

The type of barrier used is based on the exposure route being intercepted and the barrier’s effectiveness in doing so.

Requirements

If an engineered barrier is used, it must be accompanied by an institutional control (*see Fact Sheet 4*) which assures the proper maintenance of the barrier. This institutional control is transferrable with the property and must provide procedures to be followed if intrusive work (breaching of the barrier) is necessary.

An engineered barrier will only be approved by the Bureau of Land (BOL) if the barrier, as part of the final corrective action, is intended to be permanent. That is, barriers will not be approved as part of the final corrective action if they are only intended for temporary use.

Examples of unacceptable engineered barriers include natural attenuation, fencing, and point of use water treatment.

When “cutting off” an exposure route, the soil must not exceed the soil attenuation capacity (742.215) and the soil saturation limit (742.220); exhibit reactivity (742.305(c)); exhibit a pH less than or equal to 2.0 or greater than or equal to 12.5 (742.305(d)); or, exhibit toxicity for inorganic chemicals or their salts (742.305(e)).

Migration to Groundwater Barriers

For the migration to groundwater route, the goal of a barrier is to prevent the leaching of contaminants out of the soil and into the groundwater by reducing the infiltration rate (742.905). The two types of barriers discussed in TACO are caps and permanent structures. Using engineered barriers to impede contaminant migration to groundwater may be more feasible under a Tier 3 exposure route review (742.925).

A cap is a horizontal barrier that covers the entire area of contamination to prevent infiltration of water. A cap must be constructed of compacted clay, asphalt, concrete, or other materials capable of producing similar results.

Permanent structures are acceptable barriers due to their capping effects. A roadway, for example, may represent an adequate cap, as could a building.

Soil Ingestion and Inhalation Barriers

For both the soil ingestion and inhalation exposure routes, barriers can prevent human exposure to contaminated media.

The two types of barriers acceptable for both of these routes are caps and permanent structures. A clean soil cover is also acceptable for the soil ingestion route.

Caps used to prevent soil ingestion and/or inhalation are similar to those required for the migration to groundwater pathway, and may be constructed with the same materials. Caps for this use, however, are intended to prevent the upward migration of soil and

vapors instead of the downward infiltration of water.

Permanent structures may provide adequate protection from contamination in instances where the contaminants have migrated beneath the structure or when a structure is built above the contamination.

A clean soil cover may be used to prevent the ingestion of contaminated soil provided that the clean cover is at least three feet thick. Clean cover consists of materials that have contaminant levels not exceeding the applicable Tier 1 residential remediation objectives.

Ingestion of Groundwater Barriers

For the ingestion of groundwater route, two barriers accepted under TACO are slurry walls and hydraulic control of groundwater.

A slurry wall is a vertical barrier constructed of a material that will prevent or impede the horizontal movement of soil or groundwater contamination. A slurry wall may be used in conjunction with a cap to prevent the migration of the contaminated groundwater.

Hydraulic groundwater control is used to:

- prevent groundwater from coming in contact with contaminated soil, and
- prevent contaminated groundwater from migrating.

Other Proposals

The engineered barriers discussed here are all acceptable options. TACO, however, also allows the proposal of other types of barriers. Other barriers will be considered by the BOL if it can be demonstrated that the proposed barrier is as effective as those described here.

Point of Human Exposure

For both carcinogenic and non-carcinogenic contaminants, it is important to identify the location of the risk on a site. Essentially the risk is at the point of human exposure, because without exposure there is no risk. In the TACO procedure, it is assumed that the point of human exposure, i.e., the risk, is at the contaminant source. If, however, an institutional control or an engineered barrier is in place, the point of human exposure is moved to the edge of such controls.

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Tiered Approach to Corrective Action Objectives (TACO)

Fact Sheet 6: Tier 1

What is Tier 1?

A Tier 1 evaluation compares the concentrations of contaminants of concern detected at a site to baseline remediation objectives. Tier 1 enables site owners to choose between residential and industrial/commercial use of a site; however, institutional controls are required whenever remediation objectives are based on an industrial/commercial land use.

Tier I provides the following pre-calculated “Look Up” Tables:

- Residential Soil Remediation Objectives (Appendix B, Table A)
- Industrial/Commercial Soil Remediation Objectives (Appendix B, Table B)
- Groundwater Remediation Objectives (Appendix B, Table E)
- pH specific Soil Remediation Objectives for Inorganics and Ionizing Organics for the Migration to Groundwater Portion of the Groundwater Ingestion Route (Appendix B, Tables C & D)

It is important to check the footnotes in the Tier 1 tables. For instance, footnote “e” means the chemical is a carcinogen; footnote “b” means the chemical is not a carcinogen. Footnote “m” means the objective is expressed as a TCLP or SPLP value.

When do I use Tier 1?

After you’ve completed a site investigation or characterization, you should compare your sample results to the Tier 1 “Look Up” Tables. Tier 1 can serve as a screening tool, or can be used as your remediation objectives.

Note: Before beginning a Tier 1 analysis, you may want to consider a pathway exclusion evaluation (*See Fact Sheet 8*).

How do I use Tier 1?

For soil, a Tier 1 remediation objective is obtained

from the “Look Up” Tables for:

- Inhalation,
- Ingestion, and
- Migration to Groundwater (also called the Soil Component of the Groundwater Ingestion Exposure Route)

Of the three exposure routes, the most restrictive becomes your site’s soil objective -- unless that particular route has been excluded from further consideration under the requirements of 742, Subpart C (*see Fact Sheet 8*).

For groundwater, the Tier 1 remediation objectives for your site correspond to the site’s groundwater classification, either Class I or Class II. If no site-specific information is available, then the groundwater at the site is assumed to be Class I.

A contaminant is not of concern if the concentration of the contaminant is below the Tier 1 objective for the most restrictive route.

Is my site Residential or Industrial/ Commercial?

“Residential Property” is any real property that is used for habitation by individuals or properties where children have the opportunity for exposure to contaminants through ingestion or inhalation at educational facilities, health care facilities, child care facilities or playgrounds.

“Industrial/Commercial Property” is any real property that does not meet the definition of residential property, conservation property or agricultural property.

Whenever using the industrial/commercial scenario, the Construction Worker Scenario must also be evaluated. If the construction worker objectives are more stringent than the industrial/commercial objectives, the construction worker objectives apply.

The construction worker scenario is designed for workers performing demolition, earth moving or construction activities, as well as routine and emergency utility installation or repair.

Sites that meet Tier 1 residential remediation objectives

do not need to be evaluated for the construction worker population.

What if my contaminant is not listed in the Tier 1 tables?

For contaminants not listed in the Tier 1 tables, you may request site-specific soil and groundwater remediation objectives from the BOL, or you can propose remediation objectives for BOL approval.

How many analytical samples do I need to collect for a Tier 1 evaluation? What do I analyze these samples for?

Site investigation and characterization requirements are program- and site-specific. Any averaging and/or compositing used in such an investigation must be consistent with the approach described in Section 742.225 (*see Fact Sheet 10*)

For Leaking Underground Storage Tank (LUST) sites, the indicator contaminants for unleaded

environmental conditions and their related contaminants of concern. A comprehensive determination usually requires sampling analyses for volatiles, semi-volatiles, and metals, but may also include agrichemicals, PCBs, and dioxins (*See Fact Sheet 12*).

For RCRA sites, the sampling analysis is usually determined by the constituents of the wastes managed in the RCRA unit and their degradation products. However, in certain cases, expanded lists of hazardous constituents must also be analyzed for.

What does it mean if my site's sample results are all below the Tier 1 values?

If you have met the Tier 1 values as well as all program specific requirements, including proper characterization of the site, then you qualify to receive a No Further Remediation letter (*See Fact Sheet 3*).

gasoline are benzene, ethylbenzene, toluene and xylene.

For Site Remediation Program (SRP) sites, either a focused or comprehensive determination can be requested. A focused determination is designed for only a limited number of chemical(s). A comprehensive determination is for all recognized

Tier 1 Example - Application of the Tier 1 Residential Table

In this example, the groundwater classification at the residential site is Class I. Assume no routes are excluded from consideration, pursuant to 742, Subpart C. The benzene and benzo(a)pyrene soil and groundwater remediation objectives obtained from Part 742, Appendix B, Tables A and E are:

	Ingestion (mg/kg)	Inhalation (mg/kg)	Migration to Groundwater (mg/kg)	Groundwater (mg/L)
Benzene	22	0.8	0.03	0.005
Benzo(a)Pyrene	0.09	---	8	0.002

The benzene soil remediation objective is 0.03 mg/kg, which is the most restrictive soil remediation objective. The groundwater remediation objective is 0.005 mg/L, due to the groundwater classification.

The benzo(a)pyrene soil remediation objective is 0.09 mg/kg, which is the most restrictive soil remediation objective. For contaminants such as benzo(a)pyrene, under Tier 1, the lack of an inhalation remediation objectives is not likely to underestimate risks. The benzo(a)pyrene groundwater remediation objective is 0.002 mg/L, due to the groundwater classification.

In another example, assume the ingestion of groundwater is excluded from consideration, pursuant to Subpart C. The benzene remediation objectives from Appendix B, Table C for Industrial/Commercial and Construction Worker Populations are: 200 mg/kg Ind/Com Ingestion, 4,300 mg/kg Construction Ingestion, 1.5 mg/kg Ind/Com Inhalation, and 1.7 mg/kg Construction Inhalation. The benzene soil remediation objective at this industrial/commercial site is 1.5 mg/kg because it is the most restrictive.

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Tiered Approach to Corrective Action Objectives (TACO)

Fact Sheet 7: Tier 2

What is Tier 2?

Under Tier 2, site owners and operators can develop remediation objectives applying site-specific data to pre-established modeling equations provided in Appendix C (Tier 2 Tables).

When do I use Tier 2?

When your contaminant concentrations exceed Tier 1 objectives, Tier 2 may be used to develop remediation objectives that are based on the actual site conditions and are still protective of human health.

How do I obtain data for a Tier 2 equation?

Tier 2 allows the use of information on the physical and chemical properties of individual chemicals along with site-specific physical and groundwater properties. Any field data used must conform to standard practice in the geological and engineering industry. Many of the parameters in the equations can use either a default value (i.e., standardized values) or actual site-specific data. Appendix C, Tables B and D provide the default values (labeled “parameter values”) and identify when site-specific data may be used. Methods for determining physical soil parameters are provided in Appendix C, Table F.

Where do I find a chemical’s physical and toxicological properties?

Physical parameters can be found in Appendix C, Table E. If a contaminant’s physical properties are not listed in Appendix C, Table E, properties can be proposed for Illinois EPA review and approval. Justification for the use of the values will need to be provided.

The U.S. EPA’s Integrated Risk Information System (IRIS) should be consulted for toxicological parameters. Toxicological parameters may be requested from a BOL project manager, or values may

be proposed for Illinois EPA review.

Are carcinogens and noncarcinogens calculated differently?

Yes. Fundamental to the use of Tier 2 equations is the determination of whether a contaminant is a carcinogen or a noncarcinogen. Appendix B, Tables A and B identify which chemicals are carcinogens (footnoted “e”) and noncarcinogens (footnoted “b”). For carcinogenic effects, risk is associated with the probability of an individual developing cancer over a lifetime. For non-carcinogenic effects, risk is expressed as a hazard quotient (*See Fact Sheet 2*). It is important to note that a Hazard Quotient is not a statistical probability that can be related to a 10^{-6} risk. There are separate equations for carcinogens and for noncarcinogens.

Section 742.505(b)3 and 742.720 address chemicals with cumulative noncarcinogenic effects for a specific target organ(s). If a contaminant poses a risk of both cancer and noncarcinogenic effects, remediation objectives must be derived for the most health-sensitive effect.

What is a default value?

A default value is a standardized value that when factored into the equations produces a conservative, health protective remediation objective. For many parameters, site-specific values can be used in lieu of the default values. Not all parameters have default values, in which case a site-specific value must be obtained.

Should I use the SSL or RBCA equations?

Either the SSL or RBCA equations can be used. Both sets of equations are health protective. However, the RBCA and SSL equations themselves are different; their respective parameter values cannot be

interchanged. Also, the Tier 2 equation models cannot be altered (except as provided in Tier 3).

Furthermore, RBCA models ingestion, inhalation, and dermal exposure pathways all together in one equation, while SSL models them separately. This means that you must calculate the ingestion and inhalation objectives for a particular contaminant using the same set of equations, either SSL or RBCA.

Either the SSL or RBCA approach can model the migration to groundwater portion of the groundwater ingestion route. Since both sets of equations are scientifically defensible, either approach may be used for the development of remediation objectives.

That is, if the SSL equation determines one migration to groundwater remediation objective and the RBCA equation determines a less restrictive migration to groundwater remediation objective, the less restrictive objective may be used.

Do the soil attenuation and soil saturation constraints factor into a Tier 2 evaluation?

Yes. When developing Tier 2 remediation objectives, the total organic concentrations of all the contaminants from a single sampling point (whether they exceed the Tier 1 objectives or not) must not exceed the soil attenuation capacity.

The soil saturation limit cannot be exceeded for individual organic chemicals. A pre-calculated soil saturation limit is provided in Appendix A, Table A, or a site-specific value can be calculated using equation S29.

Tier 2, Example 1 - Application of the Tier 1 Tables in a Tier 2 Analysis

In this example, the groundwater classification at the site is Class II. Using Appendix B, Table A (Tier 1, Residential) as a screening tool, here are the contaminant concentrations at the site and their respective Tier 1 residential remediation objectives:

	Site Contaminant Concentration (mg/kg)	Ingestion (mg/kg)	Inhalation (mg/kg)	Migration to Groundwater (mg/kg)
Benzene	3.0	22	0.8	0.15
Ethylbenzene	200	7,800	400	19
Toluene	7.0	16,000	650	30
Chrysene	250	88	-- c	800

Benzene: The level of contamination (3.0 mg/kg) is less than the ingestion remediation objective (22 mg/kg), but greater than the inhalation and migration to groundwater remediation objectives listed in Table A (0.8 mg/kg and 0.15 mg/kg, respectively). Therefore, a Tier 2 evaluation for benzene could be calculated for the migration to groundwater exposure route and the inhalation exposure route. The most restrictive of these two objectives will be the soil remediation objective for benzene.

Ethylbenzene: The level of contamination (200 mg/kg) is less than the ingestion and inhalation remediation objectives, but greater than the migration to groundwater remediation objective; therefore, the only Tier 2 objective to be calculated is for the migration to groundwater route.

Toluene: The level of contamination (7 mg/kg) is less than the Tier 1 ingestion, inhalation, and migration to groundwater remediation objectives; therefore, no further remediation objectives for toluene are needed.

Chrysene: The level of contamination (250 mg/kg) is less than the migration to groundwater remediation objective, but greater than the ingestion remediation objective. Therefore, a Tier 2 remediation objective need only be evaluated for ingestion. Note: the inhalation objective has footnote "c" indicating no toxicity data is provided. In fact, for chrysene, the soil saturation limit is protective for the inhalation route.

Tier 2, Example 2 - Calculating a Tier 2 Migration to Groundwater Soil Remediation Objective

This example uses the SSL Partition Equation for Migration to Groundwater for protection of Class 1 groundwater from benzene contamination. S17 is the equation that determines the remediation objective, but S18 and S19 are needed to determine inputs into S17. In this example all default variables are used, except for the site-specific organic content (f_{oc}). The site-specific f_{oc} value is 0.05. The Illinois EPA has found that the two most sensitive variables in the model are the GW_{obj} and the f_{oc} , and recommends that the default values be used for the remaining parameters.

Step 1: Determine the soil leachate concentration using Equation S18

$$C_w = DF \cdot GW_{obj} \quad \Rightarrow \quad (20) \cdot (0.005 \text{ mg/L}) = 0.100 \text{ mg/L}$$

GW_{obj} (0.005 mg/L) was obtained from Appendix B, Table E.

Step 2: Determine the soil-water partition coefficient using Equation S19

$$K_d = K_{oc} \cdot f_{oc} \quad \Rightarrow \quad (58.9 \text{ L/kg}) \cdot (0.05 \text{ g/g}) = 2.945 \text{ L/kg}$$

K_{oc} (58.9 L/kg) was obtained from Appendix C, Table E.

Step 3: Use Equation S17 to determine the remediation objective

S17 can only be used for a contaminant of concern located above the water bearing unit

$$C_w \cdot \left\{ K_d + \frac{(\theta_w + \theta_a \cdot H')}{pb} \right\}$$

$$\text{Remediation Objective} = (0.100 \text{ mg/L}) \cdot \left\{ 2.945 \text{ L/kg} + \frac{(0.30 \text{ L/l}) + [(0.13 \text{ L/l}) \cdot (0.22)]}{1.5 \text{ kg/L}} \right\}$$

$$= (0.100 \text{ mg/L}) \cdot [(2.945 \text{ L/kg}) + (0.219 \text{ L/kg})] = (0.100 \text{ mg/L}) \cdot (3.16 \text{ L/kg}) = 0.316 \text{ mg/kg}$$

Note: 0.316 mg/kg reflects the site-specific conditions versus the Tier 1 remediation objective of 0.03 mg/kg.

Are there any limits to using Tier 2?

Yes. Both the SSL and RBCA equations presume that the assumptions on which the models are based are true at your specific site.

1. When modeling groundwater concentrations, there can be no layers confining the contaminated groundwater. That is, there can be no stratigraphic unit restricting the groundwater plume to a narrow seam and preventing vertical migration. This would result in a more concentrated flow occurring horizontally than the equations predict.
2. Sites in fractured bedrock or karst settings cannot be modeled because the dilution

factor for groundwater does not adequately address such aquifer flow patterns.

3. The TACO equations do not model contaminant concentrations for indoor air. The U.S. EPA and Illinois EPA decided against modeling remediation objectives for indoor air due to the sensitivity of models to parameters which do not lend themselves to standardization on a statewide basis (i.e., building ventilation rates and the number and size of cracks in foundations or basement walls).
4. Toxicological and physical parameters may not be varied. A chemical's physical parameters may be obtained from Appendix

C, Table E. Note: Some chemicals do not have default physical parameters. For instance, nitrate does not have a partition coefficient (k_{oc}) or degradation constant (λ).

Hence, Tier 2 equations will not be applicable for all chemicals.

Is the organic content of the soil important?

Yes, it is a measure of the capacity of the soil to adsorb organic contaminants. The organic carbon content (f_{oc}) is to be measured in the native soil where the organic contaminant is expected to migrate through to reach either the groundwater or the atmosphere.

For modeling migration to groundwater, the soil sample submitted for f_{oc} laboratory analysis is usually collected several feet below the ground surface. For modeling the inhalation exposure route, the soil sample submitted for f_{oc} laboratory analysis is usually collected within the top foot of the ground surface.

If sampled from fill areas with cinders, leaves, wood chips, slag, etc., the site-specific f_{oc} measurement cannot be used.

When calculating the Tier 1 migration to groundwater remediation objectives, the Illinois EPA used an f_{oc} value of 0.002. This default value is

However, it has been the Illinois EPA's experience that the organic carbon content may commonly range from two to five percent (0.02 to 0.05). The laboratory test methods to determine a soil's organic carbon content are provided in Appendix C, Table F.

Can I use models or equations different than those presented in TACO to calculate remediation objectives?

Yes. This would be a Tier 3 evaluation. Tier 3 considers other fate and transport models and any modifications or updates to exposure and toxic criteria.

How can I use SSL mass-limiting equations S26, S27 and S28?

S26 and S27 are used to determine a volatilization objective and S28 is used to find the soil component of the groundwater ingestion exposure route. These equations may be useful when the soil contamination is less than seven feet deep. The primary parameters to obtain are f_{oc} and the depth of contamination; for the remaining equation parameters, the default values will suffice.

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protective in soils containing little organic content where contaminants may migrate freely.

Tiered Approach to Corrective Action Objectives (TACO)

Fact Sheet 8: Pathway Exclusion

Introduction

Pathway exclusion is optional under TACO.

Pathway exclusion allows for the exclusion of an exposure route based on incompleteness of the route. Incompleteness means that the pathway is unable to transport contaminants to potential receptors. When the pathway exclusion requirements are met, you no longer need remediation objectives for that particular pathway. Exclusion of any exposure route requires an institutional control (*See Fact Sheet 4*) and may also require an engineered barrier (*See Fact Sheet 5*).

Minimum Requirements

The following two requirements, if applicable, must be met before pathway exclusion can be considered at a site:

1. The attenuation capacity of the soil and the soil saturation limit cannot be exceeded. This prevents free product and potentially unacceptable risks from either single or multiple contaminants from remaining in the soil. The attenuation determination is made by comparing the sum of all remaining organic contaminants from a single sample to the site-specific or default values for naturally occurring organic carbon of the soil (f_{oc}). The soil saturation limit is determined by using either Appendix A, Table A or by calculating a specific value from equation S29.
2. To prevent leaving behind materials with the potential impact of hazardous waste, soils cannot exhibit characteristics of reactivity or have a pH equal to or less than 2.0 or a pH greater than or equal to 12.5. Also, soil containing the following inorganics or their salts must not exhibit characteristics of toxicity: arsenic, barium, cadmium, chromium, lead, mercury, selenium, or silver.

Pathway Exclusion

Subpart C sets forth the requirements for

demonstrating that an exposure route is incomplete.

The three routes addressed in this Subpart are inhalation, soil ingestion and groundwater ingestion (which includes migration to groundwater). The "pathway exclusion" option in TACO can take into account natural conditions and/or engineered barriers and institutional controls.

Although Subpart C presents prescriptive requirements to pathway exclusion, Tier 3 is also an option for pathway exclusion under site-specific conditions not addressed in Subpart C.

Before any pathways can be excluded, the extent and concentrations of the contaminants of concern above the Tier 1 residential objectives must be known. The requirements for this characterization may vary by program within the BOL.

Excluding the Inhalation Pathway

To exclude the inhalation pathway, the contaminants of concern must not exceed the Tier 1 inhalation objectives within ten feet of the land surface or within ten feet of any man-made migration pathways (e.g., utility conduit). The ten foot requirement can, however, be modified by the BOL if an adequate engineered barrier is utilized.

If the inhalation pathway is to be excluded, an institutional control must be in place which satisfies all of the following:

- Soils exceeding Tier 1 levels will not be located or relocated to positions within ten feet of the surface or within ten feet of any man-made pathway,
- Safety precautions will be taken for future construction worker populations if the remaining levels exceed the construction worker scenario objectives for inhalation, and
- The engineered barrier will be maintained when it is relied upon for the objectives used.

Excluding the Ingestion Pathway

To exclude the ingestion pathway, the contaminants of concern must not exceed the Tier 1 ingestion objectives within three feet of the land surface. This three foot requirement can, however, be modified by the BOL if an adequate engineered barrier is utilized.

If the ingestion pathway is to be excluded, an institutional control must be in place which satisfies all of the following:

- Soils exceeding Tier 1 levels will not be located or relocated to positions within three feet of the land surface,
- Safety precautions will be taken for future construction worker populations if the remaining levels exceed the construction worker scenario objectives for ingestion, and
- The engineered barrier will be maintained when it is relied upon for the objectives used.

Excluding the Ingestion of Groundwater Pathway

To exclude the groundwater ingestion pathway, you must demonstrate that the groundwater in the area of the release will not be consumed as drinking water, and that contamination will not migrate to a location where it could be consumed. This demonstration must show the following:

- Free product has been removed to the extent practicable,
- The source of the release is not within a setback zone or a regulated recharge area of a potable water supply well,
- All areas within 2,500 feet of the source of the release are governed by an ordinance adopted by a unit of local government that prohibits the use of groundwater as a potable water supply,
- Using equation R26 in Appendix C, Table C, all contaminants will meet the Tier 1 objective at the nearest setback zone, and
- Using equation R26, any contaminated groundwater discharging to a surface water body will meet the surface water quality standards under 35 IAC 302.

Can I exclude the migration to groundwater pathway?

Yes. Under Tier 3, if you can't exclude the ingestion of groundwater pathway as discussed above, you can demonstrate that there is no actual or potential impact of contaminants to receptors from the migration to groundwater route. Or, you can propose to exclude the

migration to groundwater route. Such a proposal must contain the following information:

- Description of the route,
- Descriptions of the chemical and physical properties of the contaminants,
- Contaminant migration properties,
- Descriptions of the site and its physical characteristics,
- Discussion of why the route is unlikely to become active in the future, and
- Any modeling or engineered barriers, if applicable.

Can pathway exclusion be used in the LUST Program?

Yes. Subpart C of TACO may be applied in two ways under the LUST Program:

1. You may use the exposure pathway exclusion under 732.312 as site classification Method Three, or
2. If your site is classified as high priority under Method One or Method Two, you may use Subpart C of TACO in developing a corrective action approach.

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Tiered Approach to Corrective Action Objectives (TACO)

Fact Sheet 9: Background Determination

Introduction

Background determinations are optional under TACO.

A background determination may demonstrate that the level of contamination at a site is typical of area wide levels of that contaminant. Once background levels for a particular contaminant are established, that level may effectively be used as the remediation objective unless the Bureau of Land (BOL) determines that the level poses an acute threat to human health or the environment with regard to the post remediation land use.

Use of Area Background

You may request to use an area background approach to determine remediation objectives. Such a request must include information on the pathways which allowed the existence or the migration of the off-site contamination onto your site, the physical and chemical properties of the contaminants, and the location and justification of all background sampling points.

Once the background level has been properly determined, that level may be used to support a request to exclude that particular contaminant from further consideration, or it may be used as the remediation objective.

Background Determinations for Soil

The area background determination for soil may be approached in two ways:

1. Use of statewide background data (metropolitan or non-metropolitan), or
2. Use of statistically valid site-specific data.

Appendix A, Table G provides the values of inorganic contaminant concentrations found in both metropolitan and non-metropolitan areas. If these predetermined levels are exceeded, a further background investigation may be conducted or one of the other TACO options must be used to determine remediation objectives.

Any statistically valid approach approved by the BOL may also be used to develop site-specific background values. This approach must be appropriate for the characteristics of the data set collected. Objectives developed in this manner may be used as remediation objectives.

Samples for determining background concentrations in soil must be collected from areas not affected by the subject release. These samples must be collected from depths similar to each other and similar to those where on-site contamination was discovered.

Any averaging and/or compositing used in such an investigation must be consistent with the approach described in Section 742.225 (*See Fact Sheet 10*).

Background Determinations for Groundwater

To determine area background for groundwater, sampling must be conducted for a minimum of one year in four consecutive quarters unless another schedule is approved by the BOL. The wells used in the background determination must be:

- Located in areas unaffected by the subject release,
- Screened in the same geologic unit that is exhibiting contamination on site,
- Located upgradient from the subject release unless the BOL approves otherwise,
- Sufficient in number to account for all possible off-site releases; and
- Sufficient in number to adequately address the hydrogeologic setting.

Once the samples are collected, an appropriate statistical approach should be used to analyze the data set. The BOL has provided a prescriptive approach for a statistical analysis in Section 742.410, but other statistically valid approaches may be used if approved by the BOL.

Can I use a background determination for metals?

Yes. A site-specific background concentration can be calculated using an Illinois EPA approved statistical method. The background determination may then be used as the remediation objective. Appendix A, Table G provides the concentrations of inorganic chemicals in background soils. Also, in Appendix B, Table A, the footnote “t” is used for certain chemicals to indicate that the table value is likely to be less than the background concentration for the chemical. In those instances, screening or remediation concentrations using the procedures for determining area background may be more appropriate.

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Tiered Approach to Corrective Action Objectives (TACO)

Fact Sheet 10: Compliance with Remediation Objectives

Groundwater

To determine if a site meets the groundwater remediation objectives, the contaminant concentrations of discrete samples are compared to the applicable groundwater remediation objective(s). A discrete sample is a sample collected from only one point.

You will have achieved compliance if the analytical results from each sample do not exceed the applicable remediation objective(s).

Soil

When determining whether a site meets the soil remediation objectives, you may choose among three methods of compliance, depending on the type of contaminant and the potential human receptors.

You may reach compliance with soil remediation objectives in three ways:

1. Compare the contaminant concentrations of discrete samples to the applicable soil remediation objective(s),
2. Composite the soil samples by physically mixing the soil from more than one location prior to laboratory analysis. Next, compare the composite analytical result to the applicable soil remediation objective(s), and
3. Mathematically average individual analytical sample results, then compare the average to the applicable soil remediation objectives(s).

Whichever method or combination of methods you choose to use, you will have achieved compliance if the analytical results of the samples do not exceed the applicable remediation objective(s). There are, however, guidelines to follow when compositing and averaging.

Guidelines for soil compositing and averaging

You can neither composite nor average soil samples for determining compliance with ingestion and inhalation objectives for the construction worker population. This is because construction workers are normally exposed to a specific location and not to the site as a whole. Construction worker exposure must be evaluated at all sites that depend on an industrial/commercial land use for remediation objectives. The term “construction worker population” means people engaged on a temporary basis to perform work involving invasive construction activities such as earth-moving, building, and utility installation and repair during post remediation land use.

You may not composite soil samples if your contaminants of concern are volatile organic compounds (VOCs). Compositing of VOCs is prohibited because the compositing process itself provides a mechanism for the contaminants to escape into the atmosphere. Consequently, composite samples submitted for laboratory analysis underestimate the amount of VOCs actually present at the site.

How many samples do I need to collect at my site to determine compliance with the remediation objectives?

The number of samples you collect depends on the specific program requirements under which the remediation is performed (LUST, Site Remediation Program, RCRA Closure and Corrective Action).

If any of my laboratory sample results come back as “non-detect” or “below detection limits” how do I average my soil samples?

Laboratory sample results reported as “non-detect” or “below detection limits” should be included in the averaging calculation at a value equal to one-half the reported detection limit for that contaminant.

The first two charts below summarize the guidelines for soil sample compositing and averaging.

Migration to Groundwater Route¹

Sample Type	Number of Samples	Sample Compositing	Sample Averaging ²	Comments
Sampling for non-VOCs	At a minimum, 2 borings per 0.5 acre. The samples are to be collected every 2 feet, beginning from 6 inches below the ground surface.	Yes	Yes	All compositing or averaging must be done within the same borehole. At least one sample must be collected from the zone of contamination, and samples are to be collected through the zone of contamination. Samples obtained at or below the water table cannot be used for compositing or averaging.
Sampling for VOCs		No	Yes	

Inhalation and Ingestion Routes¹

Sample Type	Number of Samples	Sample Compositing	Sample Averaging ²	Comments
Sampling for non-VOCs	Program and site specific.	Yes ³	Program and site specific.	Samples must be collected within the contaminated area.
Sampling for VOCs		No		

¹These guidelines are not intended to prescribe a sampling protocol for a site investigation.

²Laboratory sample results reported as “non-detect” or “below detection limits” must be included in the averaging calculation at a value equal to one-half of the reported analytical detection limit for the contaminant.

³Neither sample compositing nor averaging are allowed under the construction worker scenario.

When does the mixture rule apply?

Depending on your contaminants, the mixture rule may or may not apply as the table below demonstrates. The mixture rule is designed to protect against harmful effects from multiple contaminants which attack the same target organ or have similar modes of action. Tables E and F of Part 742, Appendix A provide a list of chemicals which have noncarcinogenic effects (Table E) and carcinogenic effects (Table F). For example, at a typical gasoline LUST site, the multiple contaminants of concern would be ethylbenzene and toluene which both attack the kidney with noncarcinogenic effects.

The table below, when used in conjunction with Tables E and F, will show you when the rule applies to either groundwater or soil or both.

Application of the Mixture Rule

	Tier 1	Tier 2	Tier 3
Carcinogens	Groundwater	Groundwater	Groundwater Soil
Noncarcinogens	Groundwater	Groundwater Soil	Groundwater Soil

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Tiered Approach to Corrective Action Objectives (TACO)

Fact Sheet 11: Metals

How do I develop migration to groundwater remediation objectives for metals (inorganics)?

Three separate procedures for developing soil remediation objectives for the migration to groundwater pathway exist. For many inorganics, either a toxic characteristic leaching procedure (TCLP) test, a synthetic precipitation leaching procedure (SPLP), or a "totals" metal laboratory analysis may be used. To use the totals objectives, the pH of the soil that the metal is expected to migrate through must be obtained. It is useful to analyze for totals because the soil ingestion and inhalation remediation objectives are also measured in totals. For metals in groundwater, investigative samples should be unfiltered.

Can I use a background determination for metals?

Yes. A site specific background concentration can be calculated using an Illinois EPA approved statistical method. The background determination may then effectively be used as the remediation objective (*See Fact Sheet 9*). Also, Appendix A, Table G provides a look up table of values of concentrations of inorganic chemicals in background soils.

Also, in Appendix B, Table A, the footnote "t" is used for certain chemicals to indicate that the table value is likely to be less than the background concentration for the chemical. In those instances, screening or remediation concentrations using the procedures for determining area background may be more appropriate.

Any averaging and/or compositing of soil samples for a background determination must be consistent with the approach described in Section 742.225 (*See Fact Sheet 10*).

What are the remediation objectives for lead?

Appendix A, Table G provides background concentrations. The Tier 1 lead background objective is 20.9 mg/kg outside metropolitan areas and 36.0 mg/kg within metropolitan areas. The Tier 1 ingestion remediation objective for lead is 400 mg/kg. Concentrations exceeding 400 mg/kg generally require

either: 1) remediation, or 2) engineered barriers and institutional controls.

Can I use the Tier 2 equations for metals?

Yes. The SSL equations may be used for metals. For example, to determine a migration to groundwater remediation objective you can use Appendix C, Table J, which provides Soil Water Sorption Coefficients (k_s) values for eleven metals and nine ionizing organics. These values depend on the soil pH. Also, for all metals other than mercury, set Henry's Law Constant equal to zero.

How do I obtain the pH of the soil?

For Appendix B, Tables C and D and some Tier 2 groundwater equations, pH is a necessary component. Soil pH is a common laboratory test, and you can request it when submitting soil samples for analysis. Or, if using proper techniques, pH can be measured in the field. pH is based upon a logarithmic scale; therefore, pH sample results can not be averaged.

It is important to submit a sample for pH analysis that is representative of the soil that the contamination is expected to migrate through. Therefore, for evaluating the migration to groundwater pathway, the soil pH sample should be collected several feet below the surface in an uncontaminated area. For example, at a LUST site, the soil sample would be collected at a depth at or below the tank invert. For sites less than 0.5 acres, usually only one soil pH measurement is warranted.

For several metals, if the soil pH exceeds 8.0, a request can be made to the Bureau of Land to use the remediation objectives that correspond to a pH value of 7.75 to 8.0.

Metals, Example 1 - Application of the Industrial/Commercial Tables

In this example, a site is requesting industrial/commercial soil remediation objectives, and the groundwater classification is Class II. Assume no routes are excluded from consideration, pursuant to Subpart C. The pH of the subsurface soil is 7.5. The barium and chromium soil remediation objectives for ingestion and inhalation, from Appendix B, Table B (Tier 1 Soil Remediation Objectives for Industrial /Commercial Properties) are:

	Ingestion (mg/kg)	Inhalation (mg/kg)	Ingestion Construction (mg/kg)	Inhalation Construction (mg/kg)
Barium	140,000	910,000	14,000	870,000
Chromium	10,000	420	4,100	8,800

The barium and chromium soil remediation objectives for migration to groundwater from Appendix B, Table B are:

	<u>Soil Objective for the Migration to Class II Groundwater Route (mg/liter)</u>
Barium	2.0 (TCLP/SPLP)
Chromium	1.0 (TCLP/SPLP)

Also, the migration to groundwater objectives can be obtained from Appendix B, Table D, which gives pH specific objectives expressed in totals (mg/kg). This table shows 1,800 mg/kg for barium; no data is provided for chromium.

Therefore, the barium soil remediation objective is either:

- (1) 1,800 mg/kg (which is protective for migration to groundwater, ingestion and inhalation), or
- (2) 2.0 mg/l (which accounts for migration to groundwater) and 14,000 mg/kg (which accounts for ingestion and inhalation).
- (3) Also, for barium, the background soil concentration is 110 mg/kg for metropolitan areas, according to Appendix A, Table F.

Either 1, 2 or 3 above, may be used.

The chromium soil remediation objective is both 420 mg/kg and 1.0 mg/l. According to Appendix B, Tables C and D for chromium, a pH dependent value to determine the migration to groundwater remediation objective is not determined, so a TCLP or SPLP test must be used in addition to a totals test for ingestion and inhalation. However, the chromium background soil concentration is 16.2 mg/kg. Therefore, if all the on-site chromium soil sample results are less than 16.2 mg/kg, no further evaluation may be necessary, and you may not need to analyze by a TCLP or SPLP method.

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Tiered Approach to Corrective Action Objectives (TACO)

Fact Sheet 13: Mixture Rule

Introduction

The Illinois Pollution Control Board finalized a “mixture rule” by adopting Dockets B and C, which amended the TACO regulations (35 IAC Part 742). This amendment provides rules for developing remediation objectives when two or more contaminants of concern at a particular site have the same target organ or mode of action (i.e., they are similarly acting chemicals).

The mixture rule has been developed to meet the mandate set forth in Section 8 of the Illinois Groundwater Protection Act and in 35 IAC Part 620.601 and 620.615. For the Site Remediation Program, Section 58.5 of the Illinois Environmental Protection Act also requires the mixture rule.

Background

In general, the remediation objectives developed by TACO for a single contaminant are calculated to pose no more than either a non-carcinogenic hazard quotient of 1 or a carcinogenic risk of 1 in 1,000,000 (*See Fact Sheet #2*). If multiple chemicals present at a site affect the same target, the potential exists for an unacceptable exposure. To safeguard against this, an analysis of the contaminants’ mode of action is warranted during the development of risk-based remediation objectives for both carcinogens and non-carcinogens. It is important to understand not only the pathway into the body but also the toxic or carcinogenic endpoint.

For carcinogens, some protection against unacceptable exposure is built in. Even if ten carcinogens at a site have the same target (an unlikely event), the cumulative cancer risk for that target would be 1 in 100,000. This would be well within the acceptable risk range of 1 in 10,000 to 1 in 1,000,000. For noncarcinogens, there is no “acceptable range,” and therefore, no safeguard for cumulative effects. Two noncarcinogenic contaminants, each at the acceptable hazard quotient of 1, would result in an unacceptable hazard quotient of 2.

The Tables

Three tables in TACO are pertinent to the mixture rule:

- Appendix A, Table E, Similar-Acting Noncarcinogenic Chemicals
- Appendix A, Table F, Similar-Acting Carcinogenic Chemicals
- Appendix A, Table H, Chemicals Whose Tier 1 Class I Groundwater Remediation Objective Exceeds the 1 in 1,000,000 Cancer Risk Concentration

Tables E and F contain similar acting chemicals listed by endpoint of concern. If a site has two or more contaminants affecting the same target, (i.e., listed in Table E or F) the mixture may require analysis (see Application Table below).

Table H lists those Tier 1 groundwater objectives that are not based on a 1 in 1,000,000 risk factor. The majority of these groundwater objectives are adjusted upward due to laboratory detection limitations. Therefore, these contaminants’ Tier 1 objectives cannot be used when determining if the cumulative cancer risk lies within the acceptable risk range. The actual 1 in 1,000,000 risk concentration (as provided in the third column of Table H) must be used in mixture calculations.

Tier 1

The mixture rule does not apply to carcinogens or noncarcinogens in soil because of the inherent conservative nature of the Tier 1 objectives provided for noncarcinogens and the acceptable risk range for carcinogens. In addition, human exposure to soil contaminants for inhalation or ingestion is not direct; that is, the vapors or particulates must first become airborne for inhalation and soil must be disturbed and transported for ingestion. These factors offer another layer of safety.

Groundwater for carcinogens must be evaluated in Tier 1 whenever one of the COCs is listed in

continued

Appendix A, Table H, regardless of whether or not the Tier 1 objective is met. If none of the COCs are listed in Table H, the mixture rule does not apply. Groundwater for noncarcinogens must be evaluated when one contaminant exceeds its Tier 1 objective. At this point, all contaminants attacking the same target that are present at the site are brought into the mixture evaluation.

Tier 2

Soil is exempt from the mixture rule for carcinogens because of the allowable risk range. This range does not exist for noncarcinogens, consequently, the mixture rule must be applied to noncarcinogens in soil under Tier 2. Carcinogens in groundwater must be evaluated in the mixture rule if one of the contaminants is listed in Table H. Noncarcinogens in soil or groundwater must always be addressed in Tier 2 if two or more COC's have the same target or mode of action.

Tier 3

All scenarios in Tier 3 must use the mixture rule since so many possibilities for remediation and contaminant management exist. Therefore, with any Tier 3 proposal, a demonstration must be made that cumulative effects have been adequately addressed.

Adjusting the Remediation Objectives

For noncarcinogens two methods are available:

1. A weighted average may be calculated using the following equation:

$$W_{ave} = \frac{X_1}{CUO_v} + \frac{X_2}{CUO_v} + \frac{X_3}{CUO_v} + \dots + \frac{X_n}{CUO_v}$$

In this equation the original remediation objective for each contaminant is represented by *CUO*. The maximum level of each contaminant detected at the site is represented by the corresponding *X*.

Because the original noncarcinogenic objectives are based on a hazard quotient of 1, the weighted average must also be 1 or less to be equally protective for a particular target. If the weighted average is greater than 1, additional corrective action must be conducted for those contaminants which have exceedances.

2. You may divide each contaminant's original objective by the number of contaminants detected at the site that attack the same target. For example, if there are three contaminants that affect the kidney (e.g. acetone, toluene, and pyrene), the objective for acetone would be adjusted as follows:

$$\frac{COU_{Acetone}}{3} = \text{Adjusted COU for Acetone}$$

The same exercise would then be conducted for toluene and pyrene. Each of the contaminant's on-site levels is then compared to its respective adjusted objective. If any of the contaminants exceed their adjusted remediation objective, further corrective action will be required for those COCs which have exceedances.

For carcinogens:

The cumulative risk of carcinogenic contaminants attacking the same target must not exceed 1 in 10,000. Therefore, the risk from all on-site similar acting carcinogens must be added together. If this cumulative risk level is greater than 1 in 10,000, corrective action must be taken to reach an acceptable risk level.

Application

The table below outlines the scenarios in which the mixture rule must be used.

	Tier 1	Tier 2	Tier 3
Carcinogens	Groundwater*	Groundwater*	Groundwater Soil
Noncarcinogens	Groundwater	Groundwater Soil	Groundwater Soil

* Mixture rule applies if a carcinogenic COC listed on Appendix A, Table H is detected.

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