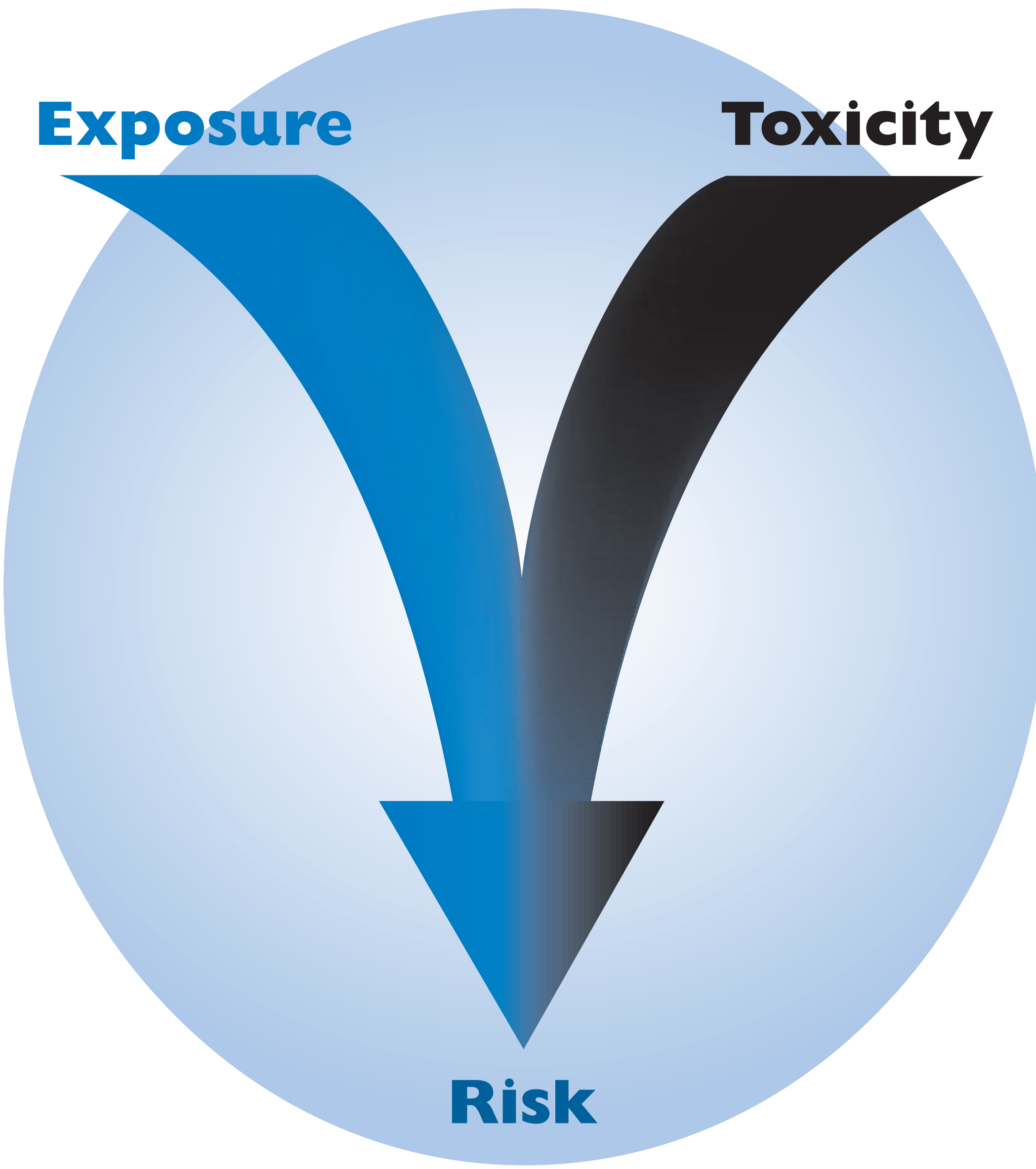
A Plain-Language Guide to Human Health Risk Assessment in the West Virginia Voluntary Remediation Program



Disclaimer

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Acknowledgement

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Purpose

The purpose of this guide is to present an overview of the use of risk assessment in the Voluntary Remediation Program (VRP) in West Virginia.

Risk Assessment—A Definition
The estimation of the risk of harm to human health posed by chemicals that are present at, or that may have moved away from, hazardous waste sites.

Math and science are used in carrying out risk assessment, and sometimes they can make risk assessment look complex. However, the basic principles involved are simple and can be expressed clearly and in a way that everyone can understand. This guide discusses these risk assessment principles in everyday language so that interested citizens can understand and participate in decisions involving Voluntary Remediation Program sites.

In This Guide

Estimating Risk—Knowledge, Judgment, and Uncertainty

There is no meter or instrument that measures risk at a hazardous waste site. Since we can't measure the risk, we can never say exactly what the risk posed by a site is. We must use our best professional judgment and our understanding about chemicals and their hazards to *estimate* the risks. Risk assessment is only as good as the judgment and understanding that go into it. Since our judgment and understanding of risk assessment are not perfect, the resulting estimation of risk cannot be absolutely certain. While risk assessment is often discussed in terms of numbers, it is important to always remember that these numbers, no matter how technical they may sound, are not exact. Understanding the *uncertainty* that is a part of *every* risk assessment is important. Some of the major sources of uncertainty in risk assessment are discussed in this guide.

Remediation Remedy Cleanup

The words "remediation" and "remedy" appear throughout this guide. They refer to the cleanup or control of chemicals that have been released to the environment at hazardous waste sites. The words "remediation," "remedy," and "cleanup" are often used interchangeably. "Cleanup" suggests that hazardous waste has been completely removed or destroyed. At some sites the risk caused by hazardous waste can be reduced or eliminated by *controlling* the waste without removing or destroying it. In this guide the words "remediation," "remedy," and "cleanup" all mean the removal, destruction *or* control of hazardous waste.

Risk Assessment in the Voluntary Remediation Program

Risk assessment is used to make two important decisions about what is done at sites in the Voluntary Remediation Program (VRP). First, risk assessment is used to decide whether a site needs to be cleaned up to reduce risk to human health. Second, if cleanup is needed, risk assessment helps determine how much cleanup is needed.

The Voluntary Remediation and Redevelopment Act was passed by the West Virginia legislature in 1996. The purpose of the law is to encourage the voluntary cleanup of sites contaminated with hazardous chemicals and to redevelop abandoned or underutilized properties. The law and its associated regulations were cooperatively developed by a diverse group of stakeholders including representatives from the general public, public health groups, industry, environmental groups, colleges and universities, and local governments. This process led to a strong program that is protective of communities and the environment while promoting economic development in West Virginia.

Voluntary Remediation Program Steps

A series of steps is involved in carrying out the VRP at a site. These steps are:

- Site Investigation/Characterization
- Conceptual Site Model Development
- ***Risk Assessment***
- Remedy Evaluation
- Remedy Selection
- Remedy Design
- Remedy Implementation
- End of Remedy/Certificate of Completion

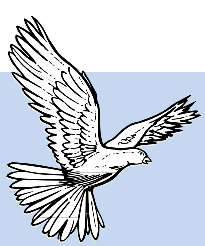
The focus of this guide is risk assessment. The steps listed after risk assessment are not discussed in this guide. More information about all of the steps in the VRP can be found in the *West Virginia Voluntary Remediation and Redevelopment Act Guidance Manual.* Information about this and other helpful documents can be found at the end of this guide.

VRP Standards

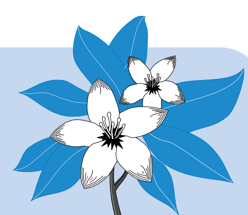
The VRP describes three standards that can be used in risk assessment to determine whether a site needs to be cleaned up and, if so, to what level. These are known as DeMinimis Standards, Uniform Standards, and Site-Specific Standards. These standards are discussed below after the overview of risk assessment principles.

Licensed Remediation Specialists

The VRP provides that technical experts called Licensed Remediation Specialists (LRSs) supervise the investigation and the risk assessment at VRP sites on behalf of site owners. The overriding duty of the LRS is to protect the safety, health, and welfare of the public. LRSs are certified by the State of West Virginia and are required to carry out their work in accordance with the VRP law and regulations.



What about Risks to Animals and Plants?



Human Health Risk Assessment and Environmental Risk Assessment

The VRP law requires that site cleanups be protective of both human health and the environment. The phrase "…and the environment" means animals and plants. The assessment of risk to animals and plants is known as "environmental risk assessment" or "ecological risk assessment" (sometimes simply called "ecorisk"). Environmental risk assessment uses many of the same principles described below for human health risk assessment. Environmental risk assessments are sometimes more complicated than human health risk assessments because many types of animals and plants have to be considered and evaluated. Also, the interactions between animals and plants and the environment where they live (for example, rivers and wetlands) are complex. Although the focus of this guide is human health risk assessment, understanding the principles described here can help in understanding environmental risk assessments. The VRP *Guidance Manual* provides a more complete discussion of environmental risk assessment.

How Do We Estimate Risk?

The Basic Risk Equation

Risk = Exposure × Toxicity

All risk assessment comes down to this one simple equation.

This risk equation shows that the level of risk is dependent on two things, exposure and toxicity. **Exposure** deals with how much chemical we come in contact with and how we come in contact with it. **Toxicity** deals with how harmful (poisonous) the chemical is and what type of harm it causes. Together, these two factors determine the level of risk. Because exposure and toxicity are so important to risk, they are discussed further in the sections below.

Exposure and toxicity are sometimes measured directly. At other times it may not be possible to measure them directly, and in those cases they are estimated. The estimation of exposure and toxicity often involves complex mathematical equations. However, no matter how complex the exposure and toxicity estimations are, the risk from the exposure and toxicity always comes down to the basic risk equation.

How Do We Describe Risk?

Decisions about what to do about risk are based on how big or small the risk is. This means we need to express or describe risk as a number. There are two ways used to describe risk as a number. The first way is used for chemicals that cause cancer. It describes risk as the *odds* (*chances*) that cancer will be caused by contaminants at a site. For example, the risk (chances, or likelihood) of getting cancer could be one in a million.

The second way of describing risk as a number is used for chemicals that are harmful but do not cause cancer. In this case, the risk is described as some *part* or *portion* of the level that is considered safe. For example, the risk could be one tenth of a safe level.

These ways of describing risk are discussed further in the section called "Putting It All Together" beginning on page 9.

Risk Is Made Up of Two Things—Exposure and Toxicity

We Must Always Think about Both

Because risk involves both exposure and toxicity, either one can affect the level of risk—sometimes, very much. For example, if there is no exposure to a chemical, that is, Exposure = 0, then no matter how toxic the chemical is, there is no risk (Risk = 0). If we never come in contact with the chemical (Exposure = 0), there can never be harm caused by it.

Risk = Exposure × Toxicity
If there is no contact, then Exposure = 0 and
Risk = 0 × Toxicity = 0

On the other hand, if a chemical has no toxicity (is not poisonous), then Toxicity = 0, and no matter how much of the chemical we are exposed to, there is no risk (Risk = 0). While all chemicals have some toxicity, for some chemicals the level of toxicity is so low that virtually no matter how much we come in contact with, there is no harm caused.

Risk = Exposure × Toxicity
If Toxicity = 0, then
Risk = Exposure × 0 = 0

In trying to understand risk assessment at a hazardous waste site, we should always ask about both exposure and toxicity. That is, how much chemical might I come in contact with (exposure)? And, how harmful is the chemical (toxicity)? Focusing on just one or the other will not answer questions about risk. Only by considering both exposure and toxicity together can risk be understood.

Exposure and Its Role in Risk Assessment

What Are Chemicals of Concern?

One of the most important steps in estimating risk at hazardous waste sites is estimating how much chemical people will come in contact with. Often there is more than one chemical contaminant at a site. In order to carry out a complete risk assessment, it is necessary to estimate the risks coming from all of the contaminants that people may come in contact with. Contaminants at the site that people can come in contact with now, or in the future, are called "chemicals of concern." As discussed above, there is no risk from chemicals which people are not exposed to. Therefore, chemicals at the site which people do not (or will not in the future) come in contact with are not chemicals of concern for human health risk.

What Types of Chemicals Are of Concern?

Hundreds of chemicals are usually looked for when a site is investigated. These chemicals can be grouped into classes based on their similarity to one another. There are three classes of chemicals frequently of concern at most VRP sites. Each of the three classes can have many individual chemicals. Often it is easier to refer to the classes instead of the individual chemicals. Therefore, you might hear these classes mentioned in discussions of risk assessment. The three most common classes of chemicals of concern at VRP sites are:

- Volatile organic compounds (VOCs)
- Semivolatile organic compounds (SVOCs)
- Metals

Volatile Organic Compounds (VOCs)

Volatile organic compounds are liquid chemicals that evaporate (volatilize) easily. They are often used as solvents to dissolve things. They are used in making chemicals, in manufacturing electronics, and in numerous other industries. They are widely used in both industry and at home to dissolve grease and paint and to clean surfaces. Gasoline and diesel fuel are made up of many chemicals, most of which are VOCs. Many chemicals are considered VOCs. A few that are often found at VRP sites include:

Benzene
Toluene
Vinyl chloride
Trichloroethylene (TCE)
Perchloroethylene (PCE)
Acetone
Xylene
Chloroform

Because VOCs evaporate easily, they are of concern because they can be breathed from the air.

Semivolatile Organic Compounds (SVOCs)

Semivolatile organic compounds are chemicals that evaporate slowly, or not at all. Many by-products and wastes from the production of chemicals contain SVOCs. Soot and ash left over after things are heated or burned often contain SVOCs. Pesticides used in agriculture and around the home are SVOCs. SVOCs that may be found at VRP sites include:

Dioxin
Polychlorinated biphenyls (PCBs)
Polyaromatic hydrocarbons (PAHs)
Pesticides
Phenol

Some SVOCs remain in the environment for a long time. As a result, there may be a greater chance of coming in contact with them.

Metals

Many industrial and commercial products contain metal compounds. Many waste materials contain metals as well. Some metals occur widely in nature and are essential for life. Other metals, often called "heavy metals", are very toxic. Some metals that are likely to be of concern at hazardous waste sites include:

Lead
Mercury
Cadmium
Arsenic

Unlike most VOCs and SVOCs, metals do not break down in the environment.

How Are Chemicals of Concern Identified?

There are many ways to identify chemicals that might be of concern at VRP sites. Records of activities and operations carried out over the years at the site are reviewed. People who have worked at or lived near the site are interviewed. An inspection of the site is carried out to look for evidence (labeled drums, boxes, storage tanks, etc.) of chemicals at the site. Samples of soil, debris, and water may be collected and submitted for chemical analysis. All of these activities are part of the step called "site investigation/characterization" in the VRP process listed above. Collecting samples for chemical analysis is a key part of the site investigation. The site investigation determines what contaminants are present at the site, where the contaminants are located, and how much is there.

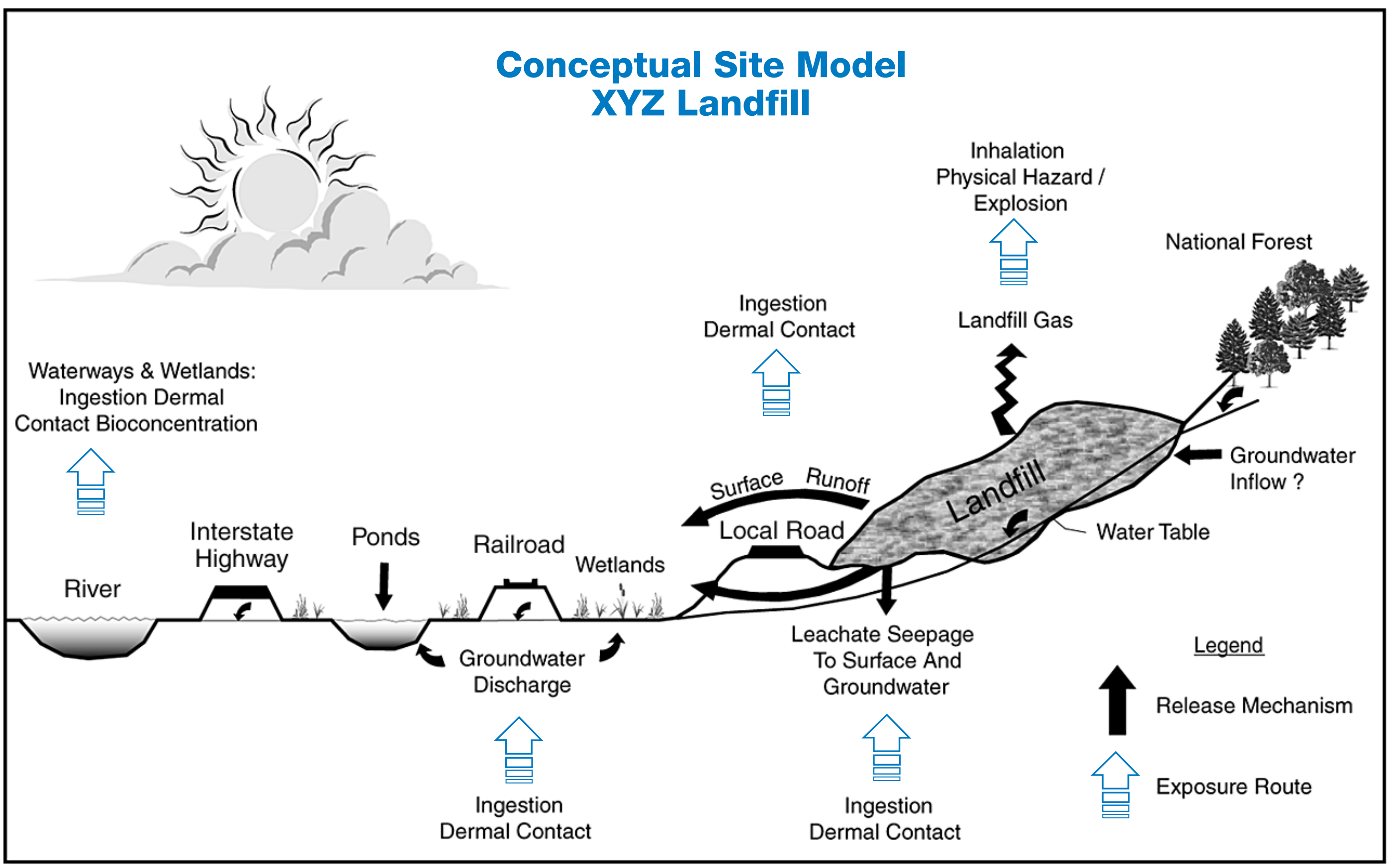
The Conceptual Site Model—A Picture of How We Come in Contact with Contaminants

The Conceptual Site Model (CSM) is a drawing that shows how chemicals are released from a hazardous waste site. The CSM also shows how people are likely to come in contact with chemicals that are released. A CSM must be developed for all sites in the VRP. The CSM is very important for the risk assessment because it helps focus attention on the routes of exposure that need to be considered in the risk assessment. The initial CSM for a site may be a very simple drawing. As the site investigation moves forward, more information about the site is collected. This additional information often causes the CSM drawing to be changed and improved. When it is time for the risk assessment to be started, the CSM drawing should be complete and accurate. The figure below is an example of a CSM.

The final CSM should describe all ways that people might come in contact with chemicals at the site and with chemicals that have moved away from the site. The VRP *Guidance Manual* provides a checklist to help the LRS develop the CSM drawing. A copy of the checklist is provided at the end of this guide to help you see the types of questions and answers that are used to develop the CSM.

How Chemicals May Reach Us—Directly and Indirectly

Chemicals that are released to the environment may stay where they are released or may move away from the place of release while leaving a trail of chemical behind. If the chemicals are released to the



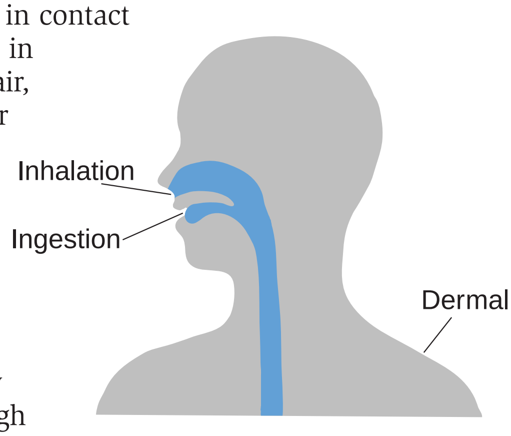
soil surface or to water on the surface (e.g., lakes or streams), then it is possible for people to come directly in contact with the contaminated surface soil or surface water.

If chemicals are released below the soil surface, people may still come in contact with them. If the chemicals move down through the soil, they may eventually reach groundwater. If people use the contaminated groundwater for drinking or bathing, then they may come in contact with the chemicals in the groundwater. If the chemicals released below the surface are VOCs, they may evaporate below the surface and move as a gas toward the surface, where they may reach the air or move into buildings. Thus, chemicals may reach people indirectly from the place where they are released.

A complete CSM should consider all ways, direct and indirect, that chemicals at a site may reach people.

How Do Chemicals Enter Our Body?

Once we come in contact with chemicals in soil, water, or air, they must enter our body to cause a toxic effect. There are three main ways that chemicals can enter our body. They can pass through our skin. They can be eaten or swallowed. They can be breathed in. These routes of entry have the following names:



- Passage through the skin—**Dermal**
- Eaten or swallowed—**Ingestion**
- Breathed—**Inhalation**

The VRP requires that all of these ways that chemicals enter the body be considered in a risk assessment. Therefore, you will often find the words "dermal," "ingestion," and "inhalation" used in the discussion of risk assessment results.

Knowing the Complete Exposure Picture Can Be Difficult

Modeling—Assumptions—Uncertainty

Knowing the type and amount of exposure is very important to estimating risk. Unfortunately, determining the amount of contact with contaminants at a site can be very difficult. In the case where people come directly in contact with the contaminated soil or water, the level of contamination can be measured. However, when the chemicals move through the environment from where they are released and reach us indirectly, then measuring their levels can be difficult. Once the chemicals have reached us, it is important to know how much actually gets into our bodies. This is also hard to measure.

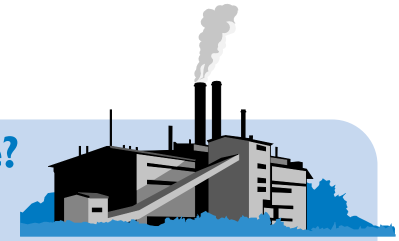
In many cases the amount of exposure to chemicals at a site cannot be measured. In these cases it is necessary to *estimate* the amount of exposure. The amount of exposure is estimated using *exposure models*. Exposure models are simply groups of equations that describe mathematically how we believe chemicals in the environment reach us and enter our bodies. The equations produce an exposure number that can be used in the basic risk equation to estimate risk.

Our current knowledge and understanding of how chemicals move through the environment and enter our bodies is not perfect. In order to create exposure models, it is necessary to make *assumptions* about the behavior of contaminants in the environment and how people come in contact with contaminated soil, water, and air. The types of things that are assumed include:

- how contamination moves underground,
- how tightly chemicals stick to soil,
- how much water people drink, and
- how much air people breathe.

These and many other factors go into estimating the exposure to chemicals at VRP sites. While the use of these factors in risk assessment is based on common experience and scientific research, their exact role in the actual exposure to contaminants is uncertain. This *uncertainty* in the understanding of people's contact with contaminants at VRP sites is a major cause of uncertainty in the risks estimated for a site.

What about a Site's Future Use?



The Important Role of Land Use

The VRP requires that risks be evaluated for how the site is currently used and how it might be used in the future. If all contaminants are removed from the site, then there is no risk now or in the future. However, often it is not possible or practical to remove all of the contamination from a site. If some contamination is left at the site, then the amount of risk caused by the contamination that remains at the site will depend on how the site is used because how the site is used will affect how much contact there might be with the remaining contamination. As the basic risk equation tells us, the more contact (exposure), the greater the risk. The VRP requires that the risk of all reasonable future uses of the site be considered. The risk arising from these future uses must not be greater than acceptable levels. The VRP requires that two types of land use, *residential* and *industrial*, be considered when estimating both current and future risks for a site. Industrial site uses includes commercial and retail businesses.

Toxicity and Its Role in Risk Assessment

Toxicity—The Second Key Part of Risk

Toxicity is the actual harm to human health caused by chemicals. It is the actual damage or injury caused to the body's organs and tissues. There are two questions that we seek to understand about toxicity:

- ***What type*** of harmful effect does the chemical cause to the body?
- ***How much*** harm can the chemical cause?

The answers to these two questions tell us what we need to know about toxicity in order to estimate risk using the basic risk equation.

Risk and Toxicity

Two Different Things

Sometimes people think of toxicity and risk as the same thing. While they are related, they really are two different things. It is important to be careful not to confuse the two when talking about risk assessment. Toxicity is the harm a chemical does to the human body. If you accidentally swallow a powerful pesticide and have a seizure as a result, that is an example of toxicity—that is, a toxic effect.

Risk relates to either the chance (probability) that a toxic effect will occur or how extreme (severe) the toxic effect will be. Risk is not the toxic effect itself but rather the *chances* of a toxic effect occurring. We talk about the risk of getting cancer. The toxic effect is cancer. The risk is the odds of getting cancer (toxicity) from coming in contact (exposure) with a cancer-causing chemical. That is why the basic risk equation is:

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

The Two Major Types of Toxicity

There are many harmful effects that a chemical can have on a person. These effects are broken into two classes—those that result in cancer and those that do not. Chemicals are grouped into two classes based on their toxic effect.

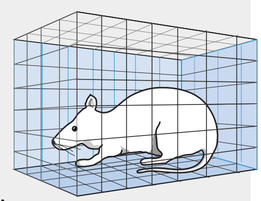
- Chemicals that cause cancer are called **carcinogens**.
- Chemicals that cause toxic effects other than cancer are called **noncarcinogens**. They may damage the nervous system, liver, lungs, kidneys, or other organs and tissues.

How Is Toxicity Measured?

Toxicity is measured by testing chemicals on laboratory animals—usually mice or rats. These laboratory tests answer the two key toxicity questions: "What type of harmful effect does the chemical cause to the body?" and "How much harm can the chemical cause?" The tests show whether the chemical causes cancer or some other effect. They also show how powerful the chemical is in causing the toxic effect. This information provides a toxicity number that can be used in the basic risk equation.

Measuring Toxicity: Of Mice and Men

Modeling—Assumptions—Uncertainty



Since it is not ethical to test toxic chemicals directly on people, it is necessary to use animals for toxicity testing. Most often mice are chosen. In this regard, mice are used as a toxicity model for humans. As with the exposure models described above, the use of mice as models for humans involves making some assumptions. It is assumed that chemicals will have the same toxic effect on humans as they do on mice. It is also assumed that mice are as sensitive to chemicals as humans. Since we can't be sure these assumptions are correct, the results of the toxicity testing are somewhat uncertain. Like the uncertainty about exposure, this uncertainty about toxicity contributes to the uncertainty in the estimated risk.

Putting It All Together—
Risk from Exposure and Toxicity

By measuring the level of contaminants at a site and knowing something about how people come in contact with contaminants in the soil, water, and air, we can develop a number that represents the exposure to chemicals at a site. From laboratory testing of chemicals, we can come up with a number that represents the toxicity of chemicals found at a site. As the basic risk equation shows, these two numbers are multiplied to produce an estimation of the risk posed by a site.

The Estimated Risk Number—What Does It Mean?

As mentioned in "How Do We Describe Risk?" on page 3, the way risk is described for a chemical at a site depends on whether the chemical causes cancer (carcinogen) or not (noncarcinogen). The risk numbers for carcinogens and noncarcinogens mean slightly different things.

Carcinogenic Risk—Risk Numbers for Cancer-Causing Chemicals

The risk numbers for chemicals that cause cancer (carcinogens) describe the *odds,* or *chances,* that a person will develop cancer as a result of coming in contact with contaminants at a VRP site. This chance or probability of developing cancer is expressed like the odds in a horse race or lottery. For example, we may say the risk of developing cancer from contact with chemicals at a site is one in a million or one in ten thousand.

You may see carcinogen risk odds expressed several different ways when risk assessment results are discussed. They may look different, but they really are just different ways of saying the same thing. Take, for example, the odds of one in a million. They may be expressed using the words—"one in a million." A million is one followed by six zeros (1,000,000). One in a million can also be written as a fraction, that is, one divided by a million:

$$\text{One in a million} = \frac{1}{1{,}000{,}000}$$

If we show the results of dividing one by a million, we get a third way to represent one in a million:

$$\text{One in a million} = \frac{1}{1{,}000{,}000} = 0.000001$$

Scientists often write numbers containing a lot of zeros in a shorthand way. In this shorthand, one in a million is written like this:

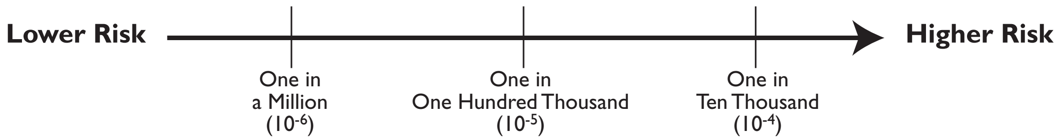
$$\text{One in a million} = \frac{1}{1{,}000{,}000} = 0.000001 = 10^{-6}$$

When this shorthand terminology is used in risk assessments, you will hear the one-in-a-million chance of getting cancer spoken of as "*ten to the minus six*" risk, meaning 10^{-6}. Other important cancer odds that you may often hear in risk assessment are:

$$\text{one in one hundred thousand} = \frac{1}{100{,}000} = 10^{-5} \text{ “\textit{ten to the minus five}”}$$

$$\text{one in ten thousand} = \frac{1}{10{,}000} = 10^{-4} \text{ “\textit{ten to the minus four}”}$$

Risk odds are in the following order:



VRP policy is that sites with cancer risk above one in ten thousand (above 10^{-4}) generally require some type of cleanup or control of contaminants at the site. Sites with a cancer risk less than one in a million (below 10^{-6}) do not require remediation. Sites with cancer risks between one in a million (above 10^{-6}) and one in ten thousand (below 10^{-4}) are evaluated on a case-by-case basis with site-specific factors considered in the decision of whether remediation is necessary.

An Important Point about Cancer Risks

The risks of cancer calculated in a risk assessment are risks in addition to the risk that occurs from all other causes of cancer in the general population. Cancer is a common disease. Current information indicates that 1 in 2 men and 1 in 3 women will develop some type of cancer *in their lifetime**. These odds are based on studies of the general population. Not everyone who develops cancer dies from it. Some cancers are not life-threatening. These are called “benign cancers.” Cancers that are life-threatening are called “malignant cancers.” There are many causes of cancer. While some are known (smoking, for example), most are not.

If a VRP site has an estimated cancer risk of one in a million, that one-in-a-million risk is *in addition* to the risk of that occurs from all causes of cancer in the general population. As an example, the total cancer risk for men exposed to a one-in-a-million cancer risk VRP site is:

$$\text{Cancer risk for men in the general population} = 1 \text{ in } 2 = \frac{1}{2} = 0.5$$

$$\text{A one-in-a-million cancer risk from a VRP site} = \frac{1}{1{,}000{,}000} = 0.000001$$

$$\text{Cancer Risk for Men in General Population} + \text{VRP Site Cancer Risk} = \text{Total Cancer Risk}$$

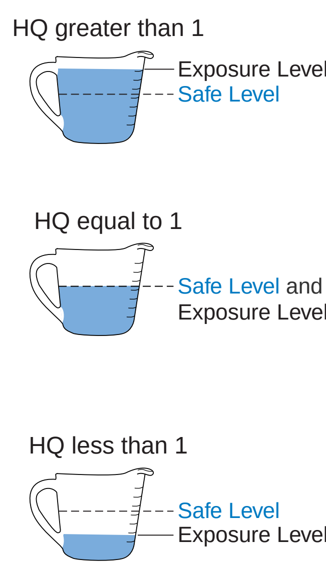
$$0.5 + 0.000001 = 0.500001$$

*These cancer statistics may be found under the heading *Who Is at Risk of Developing Cancer?* at the American Cancer Society Web site http://www.cancer.org/statistics/cff2000/basicfacts.html.

Noncarcinogenic Risk—Risk Numbers for Chemicals That Do Not Cause Cancer

The risk numbers for chemicals that do not cause cancer (noncarcinogens) are expressed differently than those for chemicals that cause cancer. For noncarcinogens, risk is expressed as a Hazard Quotient. The Hazard Quotient is a comparison between the amount of contact with the noncarcinogenic chemical and the “safe level” for that chemical. The “safe level” is determined by testing the chemical on laboratory animals. (In technical discussions of risk the “safe level” is called the “reference dose.”)

- A Hazard Quotient above 1 means that the amount of contact is above the “safe level” and that the site may need further study or remediation.
- A Hazard Quotient of 1 (HQ = 1) means that the amount of contact is equal to the “safe level” and is considered to be an acceptable level of risk.
- A Hazard Quotient less than 1 means the amount of contact is below the “safe level” and that the site does not pose an unacceptable level of risk and does not need remediation.



Conservative/Protective

Dealing with Uncertainty

Sometimes you may hear risk assessment referred to as "being conservative." In this case, "conservative" means protective. That is, the type of exposure and toxicity models used and the assumptions made were selected to produce a risk estimation that protects (conserves) human health. It has been stated elsewhere in this guide that there can be significant uncertainty associated with estimating risk. *Making sure that this uncertainty does not result in unexpected harm to the public is a major goal of risk assessment*. The way this is done is to design the exposure and toxicity models and to select the assumptions used in a way that *ensures that the resulting estimated risk, even with its uncertainty, is protective of human health*.

VRP Standards

The Voluntary Remediation Program has standards that are used to decide whether a site represents an unacceptable risk. The standards are developed based on the principles of risk assessment described in this guide. The detailed exposure and toxicity equations used to evaluate risk under these standards can be found in the VRP *Guidance Manual*. The *Guidance Manual* describes three standards: DeMinimis Standards, Uniform Standards, and Site-Specific Standards.

DeMinimis and Uniform Standards are similar to each other and differ mainly in the assumptions used to create them. Both the DeMinimis and Uniform Standards represent the amount (concentration) of a contaminant that could be present at a site without causing an unacceptable risk. These concentrations are calculated for individual contaminants in the various media (soil, water, or air) where they may occur. The DeMinimis and Uniform Standards are derived by running the basic risk equation in reverse. That is, starting with an acceptable risk level (for example, 10^{-6} for carcinogens or a Hazard Quotient of 1 for noncarcinogens) and the known toxicity of a chemical, risk accessors calculate an exposure concentration for that chemical that corresponds to the acceptable risk. This exposure concentration is the standard. If the concentration of a chemical at a site is below its standard, then its risk is acceptable. Having the DeMinimis and Uniform Standards expressed as concentrations allows for a quick comparison of measured levels of contamination at a site with the standards to determine whether the site represents a risk.

Site-Specific Standards are calculated by running the basic risk equation in the traditional way. That is, measured amounts of chemicals at the site are used to produce an exposure value. The exposure value for each chemical at the site, along with its known toxicity value, is used to calculate a level of risk for each chemical everywhere that it is found (soil, water, or air). The resulting level of risk is then compared to the acceptable risk levels. As stated above, the acceptable risk level for carcinogens is 10^{-6} or less. Cancer risk levels above 10^{-4} require remediation. Cancer risk levels between 10^{-6} and 10^{-4} are evaluated for acceptability on a case-by-case basis. The acceptable risk level for noncarcinogens is a Hazard Quotient of 1 or less.

Summary

Decisions about how to deal with sites in the West Virginia Voluntary Remediation Program are made based on the risks the sites pose to human health and the environment. Risk assessment is the process used to estimate site risks. In risk assessment both the amount of contact with hazardous chemicals at a site (exposure) and the poisonous hazard the chemicals pose (toxicity) are considered in determining the level of risk. The legislative rule that created the VRP describes the levels of risk for VRP sites that are protective of human health. Using the principles of risk assessment outlined in this guide, these protective risk levels are converted to levels of contaminants that must not be exceeded at VRP sites. These contaminant levels represent the risk-based standards that guide decisions about how VRP sites are handled.

assumptions When data necessary to calculate the risk at a site are not available, it is sometimes necessary to make *assumptions* about what the data values should be. Most often, assumptions are made about the type and amount of contact with hazardous chemicals at the site. It is the practice in risk assessment to make assumptions that result in a risk level that protects human health.

carcinogen A chemical that causes cancer.

chemicals of concern Chemicals whose presence at a site may cause a risk that needs to be evaluated in a risk assessment. The chemical's location at the site, how much of it is present, and its toxicity are factors that go into deciding whether it should be "of concern."

Conceptual Site Model A drawing that shows where chemicals are at a site and how people may come in contact with them.

conservative In risk assessment, "conservative" means protective of human health. A *conservative* risk assessment is one that is designed to make sure that human health is protected, regardless of the uncertainty that may be associated with the risk assessment.

DeMinimis Standard A standard in the VRP that allows a quick and easy determination of whether levels of hazardous chemicals at a site represent a risk that requires further investigation. Its use requires limited knowledge about the site. It is considered a "screening" standard. Because it is used to screen sites for further evaluation, the assumptions used to develop the standard are selected to be very protective of human health.

dermal exposure The passage of chemicals into the body through the skin.

exposure Contact with hazardous chemicals and their movement into the body.

Hazard Quotient The description of risk for noncarcinogens. It is a comparison of the amount of contact with a hazardous chemical to the safe level for that chemical.

ingestion exposure The entry of hazardous chemicals into the body by eating contaminated food, accidentally swallowing contaminated soil, or drinking contaminated water.

inhalation exposure The movement of hazardous chemicals into the body by breathing contaminated air.

land use How a site is currently used or how it will be used in the future. Land use is important in risk assessment because how people come in contact with hazardous chemicals at a site depends on how the site is used. The Voluntary Remediation Program groups land uses into two categories: residential and industrial. Industrial land uses include retail and business establishments.

Licensed Remediation Specialist (LRS) A person certified by the State of West Virginia to supervise the activities necessary for a site to undergo a voluntary remediation. The LRS works for the site owner. The LRS oversees the risk assessment and assists in investigating the site and making cleanup decisions. The overriding duty of the LRS is to protect the safety, health, and welfare of the public. LRSs are required to carry out their work according to the VRP laws and regulations.

metals A class of chemicals often found at Voluntary Remediation Program sites. Examples include, but are not limited to, lead, mercury, cadmium, and arsenic. Metals do not break down in the environment. (See the "Metals" discussion box on page 4.)

models Mathematical equations used to make predictions or estimations. The use of models (modeling) is often necessary in risk assessment to predict the amount of contact with hazardous chemicals or to estimate the toxicity of hazardous chemicals.

noncarcinogen A chemical that causes a harmful or toxic effect other than cancer. The harmful effect can be to either organs or tissues in the body. Noncarcinogens may affect the nervous system, immune system, reproductive system, or other important body functions.

remediation The removal, destruction, or control of hazardous chemicals at Voluntary Remediation Program sites. The words "cleanup" and "remediation" mean the same thing.

risk The probability, or likelihood, that harm will occur as a result of contact with hazardous chemicals.

risk assessment The estimation of the risk of harm posed by chemicals that are present at, or that may have moved away from, hazardous waste sites. Risk assessment can evaluate the risk to human health or the risk to animals and plants. *Human health* risk assessment is the focus of this guide. The evaluation of risks to animals and plants is known as *environmental* risk assessment or *ecological* risk assessment. The Voluntary Remediation Program requires that both human health and environmental risk assessments be carried out at VRP sites.

risk equation Risk = Exposure x Toxicity, the basic risk equation that shows that risk is equal to the amount of exposure multiplied by the level of toxicity.

safe level The amount of a noncarcinogen that a person can be exposed to over his or her life that will not produce a harmful effect. In technical discussions of risk assessment, the safe level is sometimes called a "reference dose."

semivolatile organic compounds (SVOCs) A class of chemicals often found at Voluntary Remediation Program sites. They are hazardous chemicals that evaporate slowly, or not at all. (See the "Semivolatile Organic Compounds" discussion box on page 4.)

Site-Specific Standard A standard in the Voluntary Remediation Program that uses widely accepted equations to combine exposure information and toxicity information to calculate levels of risk at VRP sites.

toxicity The harmful effect that a chemical causes to the body. The effect may be cancer or some other type of harm. (See *carcinogen* and *noncarcinogen*.)

Uniform Standard A standard in the Voluntary Remediation Program that is used to calculate levels of contaminants at a site that do not pose an unacceptable risk to human health. The Uniform Standard allows for exposure information that is collected from a site to be used to calculate an acceptable risk level. The use of site-specific information to calculate the Uniform Standard means that it relies on fewer assumptions than the *DeMinimis Standard*.

volatile organic compounds (VOCs) A class of chemicals often found at Voluntary Remediation Program sites. They are chemicals that evaporate quickly. (See the "Volatile Organic Compounds" discussion box on page 4.)

Voluntary Remediation Program (VRP) A program to encourage companies, communities, and other citizens to voluntarily clean up sites that have been polluted in the past. These sites can then be used for new development projects. The program was developed by a wide group of people including representatives from the general public, public health groups, industry, environmental groups, colleges and universities, and local governments.

Checklist for Conceptual Site Model Development

This checklist is to be submitted with the application and should incorporate information available at the time of submittal.

Step 1. Define Site Characteristics

1.1 Check geologic setting characteristics that apply ("yes" situation found at/near site)
❑ fractured rock ❑ fill material ❑ none as listed above
❑ alluvial aquifer ❑ karst

1.2 Depth to groundwater: _________ feet.
Is the underlying aquifer
❑ confined ❑ perched ❑ unconfined ❑ don't know

1.3 General direction of groundwater flow across the site:
❑ NW ❑ N ❑ NE ❑ E ❑ SE ❑ W

1.4 Local surface water bodies:
❑ wetlands ❑ spring/seep ❑ stream ❑ river ❑ lake ❑ pond/impoundment
Surface water distance(s) from site: ________ mile(s)

1.5 Are there known discharge points/springs from the underlying aquifer?
❑ yes ❑ no
Distance from site to known discharge points: _______ mile(s)

1.6 Determine average soil characteristics for usual site conditions:
1. Soil type (check appropriate)
❑ clay ❑ silt ❑ sand ❑ gravel
2. Is the average soil or water pH less than or equal to 3 or greater than or equal to 9?
❑ yes ❑ no

1.7 Have any of the following activities occurred at the site?
❑ surface mining ❑ deep mining ❑ injection or extraction wells ❑ monitoring wells

Step 2. Define the Contaminant Characteristics

2.1 Basic Contaminant Information

Contaminant Category	Petroleum	Metals	Other Inorg.	SVOCs	VOCs	PCBs	Pests.	Other
Surface impoundments	❑	❑	❑	❑	❑	❑	❑	❑
Aboveground drums	❑	❑	❑	❑	❑	❑	❑	❑
Buried drums	❑	❑	❑	❑	❑	❑	❑	❑
AST	❑	❑	❑	❑	❑	❑	❑	❑
UST	❑	❑	❑	❑	❑	❑	❑	❑
Piles	❑	❑	❑	❑	❑	❑	❑	❑
Landfill	❑	❑	❑	❑	❑	❑	❑	❑
Open dump	❑	❑	❑	❑	❑	❑	❑	❑
Other______	❑	❑	❑	❑	❑	❑	❑	❑

2.2 Indication of Suspected Contamination
❑ unusual level of vapors ❑ erratic behavior of product-dispensing equipment
❑ release detection results indicate a release ❑ discovery of holes in a storage tank
❑ spill/release ❑ other (specify) ________________________________

2.3 Visible Evidence of Contamination (check all that apply):
❑ contaminant-stained or contaminant-saturated soil or backfill
❑ ponded contaminants
❑ free product or sheen on ponded water
❑ free product or sheen on the groundwater surface
❑ free product or sheen surface water
❑ visual evidence of stressed biota (fish kills, stressed vegetation, etc.)
❑ visible presence of oil, tar, or other nonaqueous-phase contaminant > = 1,000 ft^2
❑ other (specify) ______________________

2.4 Are there any interim remedial actions that have or will take place?
❑ yes ❑ no (if "yes," fill out 2.5)

2.5 Interim remedial actions (check all that apply):

	Planned	Initiated	Completed	Not Applicable
Regulated substance removed from storage tanks	❑	❑	❑	❑
Containment of contamination	❑	❑	❑	❑
Contaminated soil excavated	❑	❑	❑	❑
Free product recovered	❑	❑	❑	❑
Temporary water supplies provided	❑	❑	❑	❑
Other (specify) ____________________	❑	❑	❑	❑

Step 3. Define Exposure Media and Transport Pathways

3.1 Identify media affected (or potentially affected by contaminants):

Contaminant						
__________	❑ air	❑ groundwater	❑ surface water	❑ soil	❑ sediments	❑ biota
__________	❑ air	❑ groundwater	❑ surface water	❑ soil	❑ sediments	❑ biota
__________	❑ air	❑ groundwater	❑ surface water	❑ soil	❑ sediments	❑ biota

3.2 Identify contaminant release mechanisms (check all that apply):

Contaminant				
__________	❑ leaching	❑ volatilization	❑ fugitive dust	❑ erosion/runoff
__________	❑ leaching	❑ volatilization	❑ fugitive dust	❑ erosion/runoff
__________	❑ leaching	❑ volatilization	❑ fugitive dust	❑ erosion/runoff

3.3 Groundwater use:

Is the groundwater connected to or part of an aquifer that serves as a source of drinking water?
❑ yes ❑ no (if "yes," groundwater is of concern)

Are there reasonably expected future groundwater uses based on state or local planning?
❑ yes ❑ no (if "yes," groundwater is of concern)

3.4 Local water supplies:

Industrial/municipal	❑ surface	❑ well
Residential	❑ surface	❑ well
Agricultural	❑ surface	❑ well

Water supply distance from site: _________________mile(s)

3.5 Local surface water (check all that apply):

Use			
Domestic supply	❑	Not currently used	❑
Recreation	❑	Fisheries	❑
Irrigation/stock watering	❑	Other __________	❑
Industrial supply	❑		

3.6 Local groundwater use (check all that apply):

Use	
Domestic supply	❑
Irrigation/stock watering	❑
Industrial supply	❑
Not currently used	❑
Other ___________	❑

3.7 Check if the following exposure pathways are applicable under foreseeable use of the site:

❑ soil ingestion
❑ inhalation of soil particles/vapors
❑ dermal contact with soil
❑ consumption of plants
❑ consumption of aquatic organisms
❑ inhalation of vapors released from groundwater
❑ surface water ingestion
❑ dermal contact with surface water
❑ groundwater ingestion
❑ consumption of terrestrial animals
❑ other ____________

For More Information

If you have questions about risk assessment in the VRP, call or write:

Office of Environmental Remediation
West Virginia Division of Environmental Protection

601 57th Street, SE
Charleston, WV 25304

Telephone: (304) 926-0499
Web site: http: http://www.wvdep.org/item.cfm?ssid=18

The technical details for carrying out risk assessments in the Voluntary Remediation Program can be found in two documents: the *West Virginia Voluntary Remediation and Redevelopment Act Guidance Manual (Version 1.1)* and the *User Guide for Risk Assessment of Petroleum Releases (Version 1.0)*. Both of these documents are available from the West Virginia Division of Environmental Protection (DEP) and are posted at the Web site http: //www.dep.org

A discussion of how you can contribute information to the risk assessment process can be found in a document prepared by the U.S. Environmental Protection Agency (EPA) titled *Superfund Today—Focus on Risk Assessment: Involving the Community*. The document can be obtained for free from EPA by calling 1-800-424-9346. The document number is EPA 540-K-98-004. It is also available at the EPA Web address http://www.epa.gov/superfund/tools/today.

WEST VIRGINIA
Division of Environmental Protection

WVDEP Mission Statement

Use all available resources to protect and restore West Virginia's environment in concert with the needs of present and future generations.