Risk Communication as a Key Component of a Successful Remediation Project

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Decisions made during the course of investigating and remediating a contaminated site, as well as the technology used, are most often driven exclusively by physical, technical, and health-based concerns. Additionally, in both determining and managing the potential risks posed by a remediation project, the focus tends to be placed primarily on health risks. However, a contaminated site and its remediation are neither static over time nor do they exist in a vacuum. Other elements of risk associated with the site and remedial activities include continuing regulatory oversight and compliance, public and agency relations, remedial technology costs, current and future land-use issues, and future technological/regulatory risks. Agencies, consultants, contractors, and facility management must consider these other non-health-related elements of risk. Additionally, efforts made to communicate a project's decisions, technologies, and risks are often made in a defensive or reactive posture, resulting in ineffective communication and an alienated, angry, or distrustful public. Proactive risk communication, as well as public involvement in the remedial process, are critical to the success of any remedial activity.

The field of environmental remediation has mushroomed over the past decade in response to both regulatory-driven requirements and the demands of the marketplace. Land uses and demographics change; industrial and commercial sites close or are subject to internal investigations, and agencies and the public are becoming more aggressive in identifying potentially contaminated sites. Accordingly, more and more contaminated sites are being discovered, and a much more aware and politically active public is demanding rapid, permanent, and lower-risk solutions. In response, investigators and inventors have teamed to develop a plethora of new remediation techniques and/or adapt existing technology to new situations.

Investigation and remediation projects for soil and groundwater are conducted for a variety of reasons that include but are not limited to

- Protection of public health and the environment (e.g., exposure to contaminated soils)
- Permit and regulatory compliance (e.g., air emissions or water discharges)

- Future use of the site (e.g., facility closure or relocation)
- Financial (e.g., satisfying potential purchasers)
- Secondary issues (e.g., treating contamination excavated for construction purposes)

In determining the most appropriate remediation approach, the remedial objective of the project is first defined. As there are various reasons driving a mitigation project, so can there be various objectives. These objectives may vary dramatically from one project to another and at times the variation involves subtleties. After a clear objective has been established, an engineering solution is usually then developed to meet that objective with clear and measurable (numeric) goals.

There are usually numerous options available to mitigate a site where hazardous material issues are present. The choices are chemical-, media-, and objective-specific. Usually, those in charge of evaluating and selecting remedial options view the alternatives as varying primarily with regard to implementation time, cost, efficiency, and regulatory acceptance. Recently, though, a major determinant of the propriety of a remedial alternative is the risk associated with the technology and the potential reduction in the risk remaining at the site after the technology has been applied.

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FOCUSING ON RISK

Dramatic changes have occurred during the past twenty years concerning the understanding and perception of various actual and potential threats to public health, safety, and environmental quality. These changes have significantly affected not only the public health and environmental communities, but society's understanding and perceptions as well. The political reaction to these concerns and perceptions has been the enactment of laws and regulations that, in many instances, regulate or restrict emissions of and exposure to environmental agents to below a preset (and in some cases arbitrary) incremental human health risk value. In response to these risk-based laws, industry and the regulatory agencies rely heavily on quantitative chemical health risk assessments for the generation of a risk "number," which is then compared to the appropriate statutory or agency-accepted risk limit. If the calculated risk value associated with a certain remedial technology or other site remediation activities is too high, the use or application of that technology and/or site operations may be significantly restricted or deemed inappropriate. If the calculated risk value is below the limit, the risk is usually judged insignificant or acceptable and that technology and site operations are allowed (provided that the risk value stays within agency-accepted boundaries).

However, many of these risk assessment-generated numbers are used as the sole risk endpoint or risk determinant in selecting remedial alternatives and managing the technological, chemical, and health risks associated with remediation technology and site operations. Attention is focused mainly on whether the use of that technology and performance of site mitigation operations is in compliance with the risk-based statute, permit, or other agency sanction. In other words, as long as the health risk assessment indicates less than a 1×10^{-6} incremental cancer risk (for example), the agency, site management, and consultant/contractor generally believe that the technology and site operation pose an insignificant risk. Accordingly, decisions are made regarding the potential or continued use of that technology, and performance and management of site operations are based primarily, or in large part, on that magical target or safe-harbor risk number.

Facility, project, and agency managers must take a broader perspective and understand that the risk assessment process is only an analytic tool, regardless of the importance given to the resulting number by regulators and the public. Health risk assessments are simply a technical assessment of the nature and magnitude of a certain specific and narrowly defined risk. The technical assessment and resulting risk number cannot and should not be used as the final element or sole driver in the remedial risk management process. The health risk assessment and risk number comprise only one of the considerations that should be used for management of a wide range of risks associated with remedial technology selection and site operations.

An essential prerequisite of a proper risk management program is a thorough understanding of how various risk-related terms are defined and applied.

RISK MANAGEMENT VERSUS RISK ASSESSMENT

One of the major problems in using risk numbers as a risk management tool is how hazards, risks, and risk assessments are defined, understood, and perceived by site or project management. A completed health risk assessment is often wrongly assumed to indicate that all significant risks associated with a particular site or technology have been properly identified and quantified and all information needed to properly apply the technology has been considered. An essential prerequisite of a proper risk management program is a thorough understanding of how various risk-related terms are defined and applied. As indicated below, many commonly used terms have, at the same time, a very broad range of coverage and exceptionally narrow application.

Basic Definitions

In broad terms, *risk assessment* refers to the technical assessment of the nature and magnitude of a risk. The focus and utility of a risk assessment depend on exactly which hazards are being assessed and how the term *risk* is defined. In recent years, one primary application of risk assessment work has been the long-term health risk posed by community exposure to emissions of carcinogenic air contaminants from a particular remedial technology. Other common applications of risk assessments include establishing health-based cleanup levels for a contaminated site and determining the health risk impacts of managing a particular site mitigation operation. In such cases, it would be more accurate to use the term *health risk assessment,* which is the process or procedure used to estimate the likelihood that humans or ecological systems will be adversely affected by a physical or chemical agent under a specific set of conditions.

It is important to note, for example, that the health risk evaluated under the California toxic air contaminant statutes and regulations and the related

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sections of the federal Clean Air Act Amendments are primarily human cancer risk, although other specified adverse health endpoints may be included. *Risk management*, on the other hand, uses information generated during the health and other risk assessment processes together with information about management, economic, and technical resources, internal/external economic, social, and regulatory priorities, and control or response options in a continuous process to determine the best methods of controlling, reducing, or eliminating various risks. One key distinction between risk assessment and risk management, aside from the obvious differences in objectives and scope, is that the risk management process is a continuous process, whereas risk assessments are usually one-time, situation-specific activities.

Three Models of Risk

In discussing health risk assessments or risk management, the terms risk and hazard are frequently used. As used in health risk assessments, these terms are very narrowly defined. Because a comprehensive site mitigation risk *management* program addresses the control of a variety of risks and hazards associated with a particular remedial option and site operation, these same narrow definitions cannot be used. *Risk,* as used in health risk assessments, is the probability or likelihood that an adverse outcome will occur in a person or group exposed to a particular concentration or dose of a particular hazardous agent. *Hazard* in this context is the particular adverse health outcome (e.g., cancer).

In terms of overall management of risks, far broader definitions must be used. In this context, risk can be expressed in at least three models:

1. *Risk = Hazard x Severity (and/or Probability),* where risk is a qualitative or quantitative judgment of the potential hazards associated with a remedial technology or site activity as modified by the severity and/or probability of the potential adverse impacts
2. *Risk = Hazard/Management and Technical Controls,* where risk is a qualitative or quantitative judgment of the potential hazards associated with a remedial technology or site activity as reduced and controlled by the presence and adequacy of the technical or management controls in place
3. *Risk = Hazard x Outrage,* where risk is a qualitative or quantitative judgment of the potential hazards associated with a remedial technology or site activity multiplied by the "outrage factor" (or public, agency, worker, or management perceptions and risk beliefs)

In an example using the first model, the risks associated with using an extractive physical remedial technology increase with the severity or probability of possible collateral physical damage or impacts (e.g., remediating a remote waste storage area versus an underground storage tank adjacent to an occupied building). Another example would be the increased risk of using a high-temperature thermal process that might emit a listed toxic air contaminant as opposed to a biological or chemical process that will have little or no air emissions (e.g., the risk of permit noncompliance, liability, and adverse financial and community relations impacts associated with the process and emissions of the listed chemical is greater simply because the process and listed chemical are more heavily regulated and the legal and social consequences of misuse or process failure are greater).

In the second model, as greater technical and engineering-based controls and administrative management mechanisms are used in the operation of the technology and management of the site, the risks associated with the technology and site operations will decrease. It should be noted that in the management systems control model, so long as a hazard is present (such as waste storage at the site), a risk will exist—no matter how good the control mechanisms. Unless the specific hazard itself is eliminated, one cannot obtain zero risk with even the most sophisticated controls.

The final model summarizes the concept that for a given hazard (which is broadly defined below), the risk associated with that hazard will be increased according to its outrage factor. *Outrage factor* is a concept associated with perception and communication of risk; and how a given individual perceives, rates, and reacts to a risk depends on several factors. The more risky a person (or the public) *perceives* an activity or emission to be (or the worse a risk is communicated), the higher the outrage factor and therefore the higher the actual risk to be managed. Risk perception, risk communication, and outrage factors are discussed in detail in the second part of this article.

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A Broader Definition of Hazard

In each of these definitions, one should note the importance of the term *hazard.* Although health risk assessments view hazard as a particular adverse health impact, the appropriate and safe selection of remedial technology and site operation and management can be adversely affected by a wide range of harms. In the risk management context, hazard should be broadly defined as anything (e.g., object, material, activity, situation) with the inherent potential to cause harm. These harms include (in addition to public carcinogenesis) health or safety harm to site workers, inability to accurately forecast long-term costs, adverse public relations or perceptions, public acceptance or rejection, perception of a health risk (which may have consequences as real as actual health risk), increased cost and required staff resources of compliance oversight and compliance assurance, costs of noncompliance and operational interruptions, and inability to operate if a permit is revoked, not approved, or modified with cumbersome restrictions. By expanding the view of the hazard(s) associated with a listed chemical beyond simply the community cancer hazard, it can be readily seen that the risks associated with the selection of a technology and operation of the site are still potentially significant—even though the probabilistic numerical cancer risk may be below a certain regulatory or agency-accepted limit.

Health risk assessments are typically broken down into four conceptually distinct but related steps.

THE RISK ASSESSMENT PROCESS

In order to understand why risk assessments cannot take the place of a formal risk management program, it is helpful to understand the specific health risk assessment process. Health risk assessments are typically broken down into four conceptually distinct but related steps. In terms of evaluating the risk of exposure to toxic air (or other media) contaminants, a preliminary step is conducted prior to the formal risk assessment.

Source/Release Assessment (Preliminary Step)

The source/release assessment estimates the amounts, frequencies, and locations of the emission, release, or escape of contaminants from specific sources (e.g., processes, stacks, discharge lines, groundwater) into occupational, residential, or outdoor environments. This evaluation typically involves measuring or calculating the discharge or emissions of chemicals from a particular activity or operation and modeling the environmental transport, dispersion, and deposition of the chemicals.

Hazard Identification (Step 1)

Hazard identification involves the collection and evaluation of toxicity data on the specific type of adverse health effects (e.g., cancer) that may be produced by the chemical and on the conditions of exposure under which the adverse health effect may be produced. The purpose of this step is to determine whether to infer that toxic effects observed in one setting (or species) will occur in other settings and to what degree it is scientifically correct to do so.

Dose-Response Assessment (Step 2)

Dose-response assessment quantitatively characterizes the relationship between the dose or amount of exposure to a chemical and the anticipated incidence or extent of the adverse health effect. Data are primarily derived from animal studies. Additionally, a particular chemical may have a different dose-response relationship depending on the specific conditions of exposure.

Exposure Assessment (Step 3)

Exposure assessment quantitatively measures or describes the specific nature and size of the various populations exposed to a chemical and the intensity, frequency, and duration of their particular exposures. These exposure assessments utilize the information developed in the source/release assessment.

Risk Characterization (Step 4)

The final step in the process integrates the results of the previous steps to calculate a quantitative probability that the population of interest will experience the particular form of adverse health effect associated with the chemical under known or anticipated conditions of exposure. The ultimate product of the risk characterization step is typically the well-known, but less understood, 10^{-6} incremental cancer risk.

MAJOR ELEMENTS OF RISK MANAGEMENT

Risk management uses the information from the source/release assessment, the risk assessment, and the risk number itself together with information about project and agency management, economic, and technical resources; internal/external social, economic, regulatory, and political values/priorities; and control or response options to determine the best methods of reducing or eliminating multiple risks. As noted earlier, in the overall risk management context, the risks (and hazards) to be reduced or eliminated include far more than a single specific health effect. Risk management includes the development, implementation, and ongoing evaluation of policies, strategies, and activities that result from this decision process.

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A common mistake of project and agency management is to assume that so long as the health risks associated with particular toxic chemicals or a particular remedial technology fall and remain below the regulatory risk threshold (10^{-6} or 10^{-5}), the risks associated with ongoing remedial actions are insignificant. However, the example potential risks and hazards noted below may cause significant adverse impact to the overall remediation project.

- Occupational exposures and health impacts can be significantly different from the health impact and risk to the general public. Although a contaminant or remedial technology poses no significant risk to the community, it should not automatically be inferred that project and site personnel are not at some risk (or are at risk for different hazards). Although the OSHA Hazardous Waste Operation and Emergency Response (HAZWOPER) forty-hour health and safety training addresses many of these hazards, most generic training courses that many consultants/contractors rely on must be supplemented with site- and project-specific training and oversight.
- Should the emissions from a site or remedial technology pose an "insignificant" risk, as determined by the health risk assessment, site and project management may believe that the continued use of the technology or site operation poses no hazard or risk. In such a case, site and project management may rank ongoing oversight of the remedial operations as a low priority. However, emissions and site activities are still heavily regulated, even though emissions are below the set risk limit. Accordingly, if minor changes to technology, operations, or emissions are not anticipated and evaluated in a timely manner, project management could face noncompliance or a crisis-management situation should emissions be discovered to have crept over the risk limit.
- Public and agency views of the risks associated with the contaminants, remedial technology, or site operations may be widely inconsistent with the measured scientific health risk. Accordingly, even though usage and emissions of a chemical may not pose a significant health risk (as determined by a risk assessment), the

mere *perception* of a significant risk (which may have nothing to do with the health risks) by the public or agency personnel creates serious problems for a remediation project.

- Even though the calculated health risks of the contaminants, remedial technology, or site operations may be below (or even above) a regulatory or other threshold, that calculated risk will usually be health risk (or dispersion) model-specific. Several hundred to several thousand different combinations of dose-response, exposure assessment, emission estimation/dispersion and deposition models, defaults, and assumptions are possible. If a new risk assessment would be required at a later time and any different combination of models or assumptions is used, a vastly different risk number may result. A risk management program must take these possible variations into account.
- Although residual soil contaminants may be left in place according to agency-approved health-based cleanup levels, the mere presence of contaminants in the soil may lower the value of the property for future use. This is another instance of risk perception; however, there is a real dollar value associated with the philosophical, social, cultural, and behavioral dimensions to risk.

RISK COMMUNICATION AND ITS IMPORTANCE IN RISK MANAGEMENT

Decisions involving selection of remedial technology, designing and managing site operations, establishing cleanup levels, and determining regulatory and permit requirements are more frequently being based on an assessment and evaluation of risk. These risks include (in addition to health risk) regulatory, financial, logistic, and technical risks. In order to make these determinations and decisions, the risks must be communicated to various regulatory, project, and client/facility personnel, and the general public. The manner in which risk decisions are generally made by these parties and the specific manner in which these particular risks are communicated will have a substantial impact on how these risks are viewed, evaluated, and acted on.

Another critical but often overlooked or misjudged element of the site remediation process is communicating project and technology risks to the public.

In obtaining approval or consensus from appropriate regulatory agencies for the use of a remedial technology and/or health-based cleanup level, the health and environmental risks are routinely discussed with agency personnel. Depending on how remediation technology and site operation risks and hazards are communicated to the agency, project hazards can be ranked as posing a far greater risk (and therefore being less acceptable) by agency personnel than they are by project designers and managers. Another critical but often overlooked or misjudged element of the site remediation process is communicating project and technology risks to the public. Although risk communication and public involvement are an integral and legally required part of CERCLA and state-directed remedial actions, effective communication of project and site risks is rarely performed at other remedial sites. In fact, even at CERCLA and similar sites, true risk communication is often ineffectual due to the agency's misunderstanding of basic risk communication principles and techniques. If risk communication is attempted at all at these other sites, it is often attempted only *after* significant public or agency risk interpretation and communication problems occur. Even then, these attempts are little more than public relations, presenting the agencies' or consultants' views or simplifying the data in an attempt to gain public acceptance, rather than real two-way communication.

Because of the significant impact of risk communication, both positive and negative depending on whether and how properly it is done, *all* parties involved in site remediation have a responsibility to ensure that risks are properly communicated. Risk communication activities (including public and agency involvement in the risk decision-making process) are not the sole responsibility (discretionary or not) of an agency, consultant/contractor, facility, media, or the public and should not be seen as an activity to be performed or overseen by only one of these parties. If left to only one, and risk communication is poorly accomplished, all responsible and affected parties will suffer as a result. It must be remembered that successful remedial action projects are measured by far more than just compliance with cleanup level goals; success is also measured by the trust and support gained during the project from the public and regulatory agencies.

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DEFINITION OF RISK COMMUNICATION

Most risk communication literature and studies are directed toward communicating risk to the public and understanding the public's perception of risk. However, these same principles apply whether communicating risk to the general public, agency personnel, facility/client management or workers, consultant/contractor personnel and project management, attorneys, or others. It is important to remember that regardless of a person's affiliation or level of education, that person's cognitive and decision-making processes are determined by subjective (personal history, biases, cultural and societal pressures, background) as well as by objective means (technical and scientific).

Risk communication is a process used by agencies, industry, and the public to discuss environmental and health hazards, their impacts, and how they should be addressed. This process includes

- Understanding people's perceptions of risk and their emotions and concerns
- Empathizing with those emotions and concerns
- Dealing with concerns for which agencies or project/site management have control and identifying how other concerns will be managed
- Advising people of environmental and public health risk assessments in language that they understand
- Informing the public, project/site management and agencies about current and proposed actions
- Providing opportunities for public involvement in risk management decisions

Risk communication is a two-way communication process that addresses the different perceptions of risk held by agency personnel, their constituents, and the regulated community. Risk perceptions will differ because they are determined by two factors that vary in importance depending on how one is personally affected by a hazardous situation.

1. The *hazard*—The potential that a chemical release, technology, or situation presents a danger to the public or the environment.
2. The *outrage*—The personal inequities, emotions, or concerns that the discovery of a hazard invokes.

The purpose of conducting risk communication is to inform and advise the public and agencies on health risk assessment information and to involve them in risk management. As a result of this process, the public can better decide on actions to protect its interests, and agencies and project managers can make effective risk management decisions. Such decisions may not always be viewed as ideal to all parties, but successful risk communication will help engender public, agency, and regulated community trust and credibility.

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Common Notions of Risk Communication

To help clarify the definition, some common notions of risk communication are offered:

Risk communication is *not*:

- Co-opting the public (i.e., simply trying to make them feel good without truly addressing their concerns)
- Simply selling the agency or consultant decisions to the public or the agency (i.e., public relations)
- Making decisions that cannot be adjusted
- Using jargon that people do not understand
- Listening passively without providing feedback
- Patronizing the public
- A reactive "fire fighting" process
- Just about risk assessment
- Only the responsibility of the agency in general, or the community relations, public relations, or external affairs offices
- Easy

Risk communication *is*:

- A two-way give-and-take process
- Active listening and legitimizing emotions
- Understanding that people can direct their anger at you even though it may be a manifestation of frustration about their situation
- Showing compassion when people are emotional
- Stating what is considered safe for the individual

- Explaining risk assessments
- Using nontechnical language
- Empowering people and other responsible parties to act in their best interest
- Recognizing that all affected and responsible parties (the public, agencies, and consultants/ contractors) have useful input that may not have been considered
- Telling people what is planned to be done
- Acting on what is heard and not ignoring or dismissing it
- Being considerate to the needs of an audience
- Practicing U.S. EPA's "seven cardinal rules of risk communication"

THE SEVEN RULES OF RISK COMMUNICATION

As part of EPA's effort to foster proper risk communication during CERCLA projects and to enhance the risk communication and public involvement activities of other public agencies involved in environmental matters, it developed the following "seven cardinal rules of risk communication." Although these rules were targeted toward EPA and other agency personnel in communicating and interacting with the general public, most (if not all) also have applicability in communications from and between other agencies, consultants/contractors, and site/facility management and personnel.

1. **Accept and involve the public as a legitimate partner**. All parties that have an interest or stake in the issue should be involved as early as possible in the risk decision-making process (including site and technology evaluation and design). No party in the remediation process should view the public (or the agency or consultant) in an us-versus-them fashion. All parties have a legitimate stake and therefore have a legitimate part in the process.
2. **Plan carefully and evaluate your performance**. Clear and explicit objectives should be developed for any formal risk communication activity. Even informal communication activities should be conducted with an underlying goal or objective and the specific messages needing communicating should be well practiced. Information regarding risks should be evaluated and all communicators should know its strengths and weaknesses. All project personnel and staff (including technical staff) should also be trained in general communication skills; however, communication skills are not the same as media or public relations training. Last, all communication efforts should be evaluated and mistakes learned from.
3. **Listen to the public's specific concerns**. If you do not listen to people, you cannot expect them to listen to you; communication is a two-way activity. Agency and/or project management personnel should not make assumptions about what people and each other know, think, or want done. All parties must take the time to find out what people are thinking. It is also important to keep in mind that people are more often concerned about trust, credibility,

competence, control, voluntariness, and fairness than mortality statistics or quantitative risk assessments. Although this statement is a broad generality, it is a natural human emotion and applies to interactions with agency staff, project personnel and management, facility or client management as well as to the general public.

> ***One should lean toward sharing more information, not less—otherwise people may think that something is being hidden.***

4. **Be honest, frank, and open**. In discussing the various issues and concerns of a project, technology, or risk assessment, both sides of the issue should be discussed. In other words, the whole truth should be told, and all parties should talk about and admit that there are differing opinions (and admit mistakes when discovered). Risk levels should not be minimized or exaggerated and risk information should be disclosed as soon as possible. One should lean toward sharing more information, not less—otherwise people may think that something is being hidden. Qualifications and credentials should be presented, but do not expect or ask to be trusted; trust and credibility are difficult to obtain, and once lost are almost impossible to regain completely.
5. **Coordinate and collaborate with other credible sources**. As noted earlier, no remediation project occurs in a vacuum or behind an impenetrable wall; other groups and individuals will have some involvement and impact (invited or not). Few things make risk communication more difficult than conflicts or public disagreements with other credible sources. This includes public interest or neighborhood groups that are just as credible to their public audience as Ph.D./DABT toxicologists/risk assessors are to their project audience. Project managers must therefore take the time to involve and coordinate with other organizations or groups. Whenever communications or notifications are issued, these should be issued jointly with other credible sources.
6. **Meet the needs of the media**. Even though in most cases, the media will be more interested in CERCLA, state-coordinated, or other high-profile or high-cost projects, all parties must anticipate and plan for media interest or involvement in any scale remediation. The media are frequently more interested in politics than risk, simplicity than complexity, danger than safety. However, the media are a real and legitimate partner. Be open with and accessible to reporters, respect their deadlines, and do not hesitate to follow up on stories with praise or criticism. Risk information tailored to the needs of each type of media (print, radio, television) should be provided. When dealing with complex issues, all parties should prepare in advance and provide background material.
7. **Speak clearly and with compassion**. Technical language and jargon are barriers to successful communication with the public. Communicators should be sensitive to norms, such as speech and dress. Simple, nontechnical language should be used; however, it is important to avoid the perception that the audience is being patronized. Risk comparisons should be used whenever possible to put risks into perspective, but comparisons that ignore distinctions

In any communication, always try to include a discussion of actions that are under way or that can be undertaken.

that people consider important should be avoided at all costs. Emotions that people express—anxiety, fear, anger, outrage, helplessness—should be acknowledged and responded to both in words and with actions. In any communication, always try to include a discussion of actions that are under way or that can be undertaken. People should be informed when something is not possible, and only actions that can be taken should be promised.

RISK PERCEPTION, THE OUTRAGE FACTOR, AND REDUCTION OF RISK THROUGH PLANNING

Some risk communication and judgment situations are more difficult than others, usually for reasons having little to do with the actual degree of hazard at a site. If a list is made of environmental health risks in order of how many people suffer health damage, and this list is compared to the same risks ordered according to how upsetting they are to the general public, the two lists will be very different. Consulting, industry, and agency risk managers have traditionally (and erroneously) believed the reason for this disparity is that the general public just does not or cannot understand the hazard or that the public's perception of risk is ignorant or irrational. The traditional risk communication response has been either to "educate" the public to understand the industry/agency-based science and engineering through public relations and media training or, should risk managers believe that the public's perceptions are irrational or ignorant, to ignore or disregard the public altogether. However, the problem is not the public's level of education or ability to understand complex issues. The problem that risk managers face and may not realize is that the public defines risk far more broadly than the risk assessment profession.

Professional risk assessors and many risk managers such as regulatory agencies and consultants view risk and risk levels as primarily relating to a numerical probability of an adverse health outcome (even though their personal risk decision-making processes are based in part on outrage components). Attempts to address the issues through public relations and risk science education do not address the root causes of public outrage and the public's broad definition of risk. Ignoring or disregarding the public will cause the outrage and view of risk to soar even higher. This is not to say that the public ignores all scientific or technical information but that outrage factors combine with an understanding of scientific information to produce public opinion. Conversely, agencies do not ignore outrage factors (although they may not be cognizant of them), and their opinions and decisions are based on a combination of their scientific and technical understanding and outrage factors.

Again, though, it is important to keep in mind that in discussing outrage and the public's definitions and views of risk that there are many "publics" to be considered. Regulatory agencies are usually the party that primarily interacts with the various general publics (individuals, citizen or neighborhood groups, environmental groups, and the media), and most risk communication principles are designed for these relationships. But consultants/contractors will interact and communicate risks with the facility, client, and/or regulatory agency. The facility or client will interact with the consultant and regulatory agency. The regulatory agency may interact and communicate to elected officials or boards. All of these parties may interact and communicate with the general public. Regardless of the level of education, training, experience, or job affiliation or responsibilities, however, every individual involved in making risk evaluations and decisions will make these evaluations and decisions in part based on their personal outrage factors. However, not all components of outrage will have the same degree of impact or importance to all parties. It is important to take the time to understand each party's stake in the risk decision to gain some insight into which components of outrage are more of a factor and how these components can be managed. Risks that are high in outrage factors are high risks, even if they are not especially hazardous. Efforts to explain or communicate the hazard (or make the hazard "acceptable") are unlikely to succeed so long as the outrage remains high. To decrease public/agency/consultant/facility concern about small hazards, the outrage must be diminished.

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Twelve Principal Outrage Components

The twelve principal components of outrage are listed in **Table 1** and discussed in detail below.

1. Voluntary versus involuntary or coerced

Any given activity, such as the decision to isolate waste in place or the operation of a thermal destruction technology, is viewed as approximately three orders of magnitude more risky if the public had no part in the selection process or feels it was coerced into accepting the decision or technology. Additionally, *coercion* does not imply any overt, sinister act or determination on an agency's or consultant's part. If the public was not consulted, had no say or active role in the issue, or was not presented with a true opportunity to negotiate and agree to the issue, the public will feel coerced and the risk value increases exponentially. It should be noted that a public hearing or public workshop discussing the issue or decision does not reduce the feeling of coercion and may (depending on what point in the remedial process the hearing or workshop is held) actually increase the feeling of coercion. Many public hearings or workshops are designed to inform the public or obtain public testimony about what has already been developed, selected, drafted, or evaluated. Even though the agency or consultant honestly believes that the decision or draft can and will be modified if sufficient or pertinent public input is received, the public feels that the decision has already been cast in stone, the industry or agency has already spent the money developing the decision and will not spend more to change what has already been decided, and that the hearing or workshop is merely a formality. In fact, at most public hearings, the public's concerns or testimony are not addressed during the hearing at all but much later in the administrative record.

This outrage component is not limited to the public. When preparing a health risk assessment, technology selection, remedial action plan, and

Table 1. The Twelve Principal Components of Outrage.

"SAFE"	"RISKY"
Voluntary	Coerced/Involuntary
Natural	Industrial/Man-made
Familiar	Exotic
Not Memorable	Memorable
Not Dreaded	Dreaded
Chronic	Catastrophic
Knowable	Unknowable
Individually Controlled	Controlled by Others
Fair	Unfair
Morally Irrelevant	Morally Relevant
Trustworthy Sources	Untrustworthy Sources
Responsive Process	Unresponsive Process

the like, a consultant or contractor who does not actively solicit agency input and involvement before and during the process itself will find that the agency views the risk assessment results, the technology, or action plan as considerably less acceptable on its face than if the agency were involved from the beginning. To simply provide the agency with a draft of a completed work product without involving them in developing the draft triggers the same component of outrage that occurs in the general public—the agency personnel feel somewhat coerced and respond by viewing the risk as much greater—even though there may be agreement on a numeric health risk level. The result is that the agency will most likely require additional work or studies to be conducted in an attempt to further reduce the risks to a level the agency will accept. Without this component of outrage, the agency may view the existing risks as acceptable and not require additional work or additional operational site management requirements.

To reduce this component of outrage, all parties must be given a real opportunity to develop the solution or options, determine and evaluate the technology, conduct the risk assessment, or develop the remedial action plan. This opportunity for cooperation and input does not mean, however, that control and all decision authority is transferred to another party. There is a middle ground on voluntarism and consensus, and all parties must strive to find this middle ground. The final selection, methodology, or plan is negotiated and agreed on; it is not forced. It is critical that this opportunity for input be real and tangible, and not simply implied with no true authority. If an agreement on an issue cannot be reached, there should be no action or unilateral decision on that issue (i.e., there is no coercion). This type of joint, cooperative, and collaborative means of making remediation decisions is nontraditional and difficult to make work. However, if it is done properly and honestly, it will result in a two to three order of magnitude reduction in risk level for a given issue.

The general public judges natural risks far differently than industrial or man-made risks.

2. Natural versus industrial

The general public judges natural risks far differently than industrial or man-made risks. So much so that when an industrial risk, such as accident risk from site remediation operations, is compared to a natural risk, such as being struck by lightning, the public will judge the industrial risk as being higher, even if the probabilistic risk is identical. This concept becomes critical in risk communication and public education efforts, during which health risk levels from a remediation site or technology are often compared to such publicly familiar risks as smoking, UV radiation and skin cancer, cancer from a lifetime of eating peanut butter, and so on. Because these efforts involve comparing what the public sees as being an industrial or man-made risk to a natural risk, however, such risk comparisons will fail and the public will view the industrial risk as higher.

Risk comparisons that ignore factors that influence public perceptions of risk and acceptability, such as voluntariness, fairness, benefits, alternatives, and control, should be avoided. Further limitations in comparisons that ignore factors that influence public perceptions of risk and acceptability should be acknowledged. Risk comparisons should be focused on classes of substances, processes, activities, or technologies that are similar or related in their characteristics, such as activities that serve the same function and whose benefits tend to be similar. Risk comparison communications must be specific about the intent of the comparison and caution against unwarranted conclusions; and relevant and important assumptions and uncertainties in the calculation of risk estimates should be explicitly acknowledged, disclosed, and explained.

3. Familiar versus exotic

People are less concerned with risk from household cleaners than with minor releases of the same chemicals from an industrial or remedial site. Additionally, even though no member of the public wants to live with a contaminated site, the longer the site exists, or the more frequently people see the site, the more familiar that site becomes. The site or facility may be an eyesore, but people in the neighborhood see it every day and become familiar with it. After site remediation or investigation activities commence, however, people will observe site workers in personal protective clothing (from level A to D), sampling or drilling equipment and operations, remedial technology being constructed, and other unfamiliar, high-tech or exotic activities occurring at the once-familiar site. Even if a barrier fence is erected around the site, the media will most likely cover site activities and focus even more attention on these unfamiliar, but strongly affecting visuals. The site may appear secretive and alien. Accordingly, the site ceases to be familiar to people and becomes exotic, and the public's judgment of site risks increases significantly—even though the actual health risks are being reduced. The same notion applies to seeking agency approval of new or innovative technology. Agency personnel, though quite educated, reasonable, and competent, will tend to judge new, innovative, or otherwise unfamiliar technology or operations as being riskier than more familiar traditional technology.

The solution to both problems is the same, although to a different degree of technical detail. Project and agency personnel must demystify the risk and familiarize and educate the public (and agency personnel) in the specific chemicals, technology, and operations. Equipment and operations displays in nearby shopping malls or at public meetings, pre-site activity media events and stories, hands-on demonstrations of the technology (such as letting people wear the protective suits or see and touch drill rigs and sampling/monitoring equipment) will significantly demystify the technology and reduce the public's view of the risks posed by that technology or activity. Agency personnel should be invited to visit other sites where the innovative technology is being used or demonstrated (as opposed to an in-office presentation). In familiarizing and educating the public or the agency, it is important to resist the natural instinct to sell or convince anyone on the benefits of the technology or site activity; all that should be done is to make the technology and activities more familiar and less exotic. Another instinct to avoid is to downplay the hazards and risks by keeping the technology or site activities hidden from the public or not providing information. Not being open and level with people will simply increase the outrage factor even further.

Another instinct to avoid is to downplay the hazards and risks by keeping the technology or site activities hidden from the public . . .

4. Not memorable versus memorable

As a result of fiction, news media, and personal experiences, technological or toxic risks are very memorable to the public, and activities involving technology and toxics are viewed as more risky. Additionally, certain symbols are viewed as very memorable, especially when linked to a technological or toxic risk. For example, the media coverage several years ago of the risks of the pesticide Alar (diaminozide) used on apples was extremely memorable to the public because of the pure imagery and symbolism associated with apples (e.g., wholesome food eaten by children, apples associated with schools). The risks therefore were judged to be extremely high. If the same pesticide exhibited the same risks, but through eating of pork, the images of hogs and pork would have been less symbolic, less memorable, and therefore less risky. In site remediation, memorability may be increased if the site or affected area is near a school or residential area rather than in an industrial zone where there is no pure symbolism.

Addressing memorability issues is relatively imprecise. The existing sources of memorability or symbolism need to be recognized and acknowledged. The agency and other parties must voluntarily recognize and discuss the specific things the public finds symbolic (such as the proximity of the school) as early in the remediation process as possible. By early acknowledgment and open discussion of these issues, the issues slowly become less memorable, the outrage factor decreases, and the risk is viewed as less.

5. Not dreaded versus dreaded

Operations, contaminants, and emissions that are associated with cancer or hazardous wastes are viewed as more risky because cancer is a dreaded disease and hazardous wastes are a dreaded environmental issue. Contaminants and emissions associated with acute illnesses or chemicals are not viewed with dread. Addressing these issues is similar to that for memorable risks; early acknowledgment and open discussion of the issues and taking the public's dread seriously will, over time, reduce the outrage factor.

6. Chronic versus catastrophic

Risks of a catastrophic potential are less acceptable than those with death or injuries spread over time and space. The image that a thermal treatment operation will suffer a process upset and result in the emission of a large toxic cloud is viewed as far more risky than the image of an operation that results in repeated or continuous long-term hazard (such as a long-term excavation and off-site transfer). Although the numerical risks may be greater for the second case, the public (or the agency) will most likely view the first case as more risky. Accordingly, activities and operations should be discussed using *both* acute, catastrophic risks and hazards, as well as the chronic risks. A comparison between the catastrophic risks of one alternative (which may be easier for the public to visualize) and the chronic risks of another is inappropriate and will increase the risk.

Because risk assessment is an inexact science, ... there will always be uncertainty in the result or process and disagreements among experts.

7. Knowable versus unknowable

Because risk assessment is an inexact science, subject to various assumptions and model applications, there will always be uncertainty in the result or process and disagreements among experts. The public tends to apply greater importance to the fact that uncertainty exists and the range or magnitude of the uncertainty than to the risk numbers themselves. In addition, from the public as well as the agency perspective, disagreement among experts is interpreted as an inability to know for certain, rather than a valid scientific range. Accordingly, these disagreements or differences of opinion regarding the data or risk will increase the view of risk associated with the data. For example, two different risk assessments quantifying the same health risk at 10^{-5} and 10^{-7} will be perceived as being in disagreement, and the real risk therefore will be deemed unknowable (or seen as the larger 10^{-5} number). This unknowable risk will be viewed as far more risky than if the differences in these same two risk assessments were acknowledged and the results reported as a range. In the latter case, the true risk will most likely be viewed by the public or agency as being in the middle of the range—a difference of one order of magnitude. All parties should recognize and acknowledge that there are valid uncertainties and expert disagreements. Between the two, expert disagreement is perceived as far riskier than uncertainty. Expert disagreement can be converted into the more acceptable uncertainty by reporting differences as a range (even while crediting the opposing references), rather than separate reporting of discrete and different values.

With other hazards, undetectable risks are more alarming than those that can be seen or detected. Operations or technology involving radioactivity or colorless and odorless gases or vapors are more risky than those with hazards that are readily seen or detected. Groundwater contaminants associated with the site and reported at one-half of the limit of detection (with the range being acknowledged) will generally be perceived as less risky than a report stating that site contaminants are below the limit of detection. One of the reasons the public is fearful of certain remedial technologies is the fact that the public has no real way of knowing if the technology is working correctly. At one site using thermal destruction technology, an instrument panel containing all appropriate operating parameters along with out-of-range alarms was installed in the lobby of the main public building of a community. Because the community could readily and immediately know if the technology was operating properly, the risks associated with that technology were reduced.

8. Individually controlled versus controlled by others

This component is different from the voluntary versus coerced/ involuntary component. Whereas voluntary versus coerced/involuntary essentially means "who decides?" the controlling-controlled component refers to "who implements?" A clear analogy illustrating the importance of control on judgment of risk is to imagine carving a roast with a sharp knife, but holding the roast in place with your hand—rather than with a fork. If you were holding the roast *and* carving with the knife, you would feel comfortable with your fingers relatively close to the knife edge. However, if someone else were carving, you would feel extremely uncomfortable with your fingers that close and you would move your hand much further away. In other words, so long as we control the hazard ourselves, the risk is viewed as relatively small; when the hazard is controlled by others, the risk becomes very large. This natural reaction occurs regardless of whether the carver is a close relative, a close friend, or someone else who is credible and trusted. Now imagine how the risk would be viewed if the knife is in the hand of a multinational corporation, faceless bureaucrat, or large governmental agency.

The more operational or investigatory control each party can share, the lower the risk will be judged by each party.

With regard to remediation activities, the more control over site activities and operations is vested with an agency or company, and less with the community the higher the site risks will be viewed by the community. The same holds true for relations among the agency, consultant, contractor, and facility site activity. The more operational or investigatory control each party can share, the lower the risk will be judged by each party. The impact of control on risk and outrage is exceptionally large. Unfortunately, the typical attitude of agencies, industry, and consultants has been to adopt the opposite position when dealing with the public and each other, each party sending out two messages. The first message is "*We're* the agency/facility/expert consultant. *We* have the jurisdiction, mandate or responsibility. *We're* in charge here. *We* have the expertise and trained personnel. *We're* providing the funding. Therefore, butt out and leave us to do our job." The second message given is "But don't worry. Trust us." The problem lies in the fact that one cannot simultaneously disempower people and reassure them.

The solution to this issue is to share control. For any remedial project or program, power sharing is relatively straightforward and can be achieved by establishing community advisory boards or inviting representatives from the community, community groups, and/or the agency/facility/consultant to serve on the project review and management team. These additional individuals must be given the same decision-making authority as the other board or team members; their participation should not be an information-only exercise. Even though these solutions are straightforward, however, the release and sharing of control and authority can be very difficult for an institution. Nonetheless, such collaboration and sharing are critical to the success of any remediation project.

9. Fair versus unfair

Although somewhat related to the first outrage component, this component is a question of equity, relating to the distribution of risk versus the distribution of benefit. Many agencies and facilities attempt to convince the public and each other that the benefits outweigh the risks. However, this risk-benefit claim is irrelevant if the risk and the benefit are going to two different places. Although this component may seem less an issue in site remediation where the public that suffers the risk also receives the benefit of a clean site, the community may view the majority of the benefit as going to the responsible industrial parties who will no longer have responsibility for the site or who will be spending less on the particular remedial option. If the community views the risk as unfair, the risk will be perceived as a much larger risk.

In solution, attempts to add local benefit commensurate to the local risk must not appear to be bribes to the community. The issues of fairness and individual control should be bracketed. Rather than an agency or facility unilaterally providing some form of compensation or benefit to the community (which will appear to be a bribe offer), the community should be given control over the benefit. The community should be told that whereas efforts are being made to reduce the risks, to the extent that the risks cannot be eliminated, the agency/facility is obliged to compensate the community for the remaining risks. The community is then asked what it wants in return (such as a park, increased monitoring, bottled water, or school program funding, for instance).

10. Morally irrelevant versus morally relevant

Issues that the public and agencies view as being morally relevant (e.g., morally wrong) are viewed as inherently riskier than morally irrelevant issues. In general, environmental pollution or contamination of ecosystems is viewed as morally objectionable. Therefore any attempt to justify continued or residual contamination is judged as risky and unacceptable. These attempts are often made by agencies, consultants, and facilities in trying to convince the public and each other that detectable residual contamination is an acceptable and just goal because of risk assessment results, cost-effectiveness, or comparison to previous levels of contamination. On a purely technical basis, there may be validity to that argument.

In general, environmental pollution or contamination of ecosystems is viewed as morally objectionable.

From the outrage perspective, what is occurring is that the agency or facility is attempting to justify performing an activity that is morally wrong.

To correct this, the moral relevancy of the residual contamination issue should be accepted, as well as the notion that the only morally acceptable and proper concentration or residual pollution goal is zero. Although zero may not be achievable in reality, and should not be stated as technically possible if it is not, adopting the morally proper zero level as a goal (versus a measure of success) reduces the moral outrage of the position and therefore reduces the risk. Agencies and facilities do not have to get to zero risk, but they have to want to. The general public is outraged by the smugness of technical personnel who state that zero risk is impossible and is therefore an unworthy goal. The *ability* to reach zero risk is not the issue; the issue is the *desire* to reach zero risk.

11. Trustworthy (or trusted) sources versus untrustworthy sources

Large numbers of people believe that business and industry are willing and capable of endangering human health and the environment, and that governmental agencies are either unable or unwilling to stop them. Although the current reality may belie that impression, it is accurately based on the past history of industrial environmental management and, in many widely publicized instances, current events. Agency-industry relationships are also viewed with mistrust by each party—the agency being viewed by industry as an institution that demands everything without regard to practicality or necessity; industry being viewed by the agency as a dollar-fixated polluter that will try to get away with doing the bare minimum. Consultants and attorneys are viewed by all as hired guns who will tailor their opinions and determinations to suit their client of the moment.

Until . . . trust can be earned, the main issue is not trust, it is accountability.

The long-term solution is to build credibility and trust through specific experiences and interactions. The short-term solution is not to ask to be trusted. As stated previously, credentials and qualifications can be provided, but trust and credibility must be earned. The natural reaction to those asking to be trusted is mistrust. Until that trust can be earned, the main issue is not trust, it is accountability. The mechanisms of accountability are much like the mechanisms of control discussed earlier. By involving other credible sources, such as the public or environmental representatives on the project management team or elsewhere in the decision-making process, the facility or agency does not need to be trusted initially, because the other credible sources will ensure the accountability of the agency or facility.

12. Responsive process versus unresponsive process

There are three major aspects of the responsive process: (1) Admit bad or unfavorable news of data in a timely and voluntary fashion—even if in draft or unsophisticated form (versus keeping the information secret or being forced by a party to reveal the information through legal means). Our society is tolerant of bad news, but very intolerant of bad news kept secret. (2) Apologize for misbehavior. Our society also has a tradition of forgiving the *repentant* sinner. (3) Respond to people's concerns with compassion (versus technocratic distraction). Responsive institutions and agencies will find that their actions will be viewed as less risky.

Additional Components of Outrage

In addition to the twelve principal components of outrage identified above, eight secondary and somewhat less important components include (safe versus risky):

- Affects average populations versus vulnerable populations
- Immediate effects versus delayed effects
- No risk to future generations versus substantial risk to future generations
- Victims statistical versus victims identifiable
- Preventable versus not preventable (only reducible)
- Substantial benefits versus few benefits
- Little media attention versus substantial media attention
- Little opportunity for collective action versus much opportunity for collective action

Conclusions about Hazard and Outrage

The problem is that outraged people do not pay much attention to hazard data.

There are several conclusions one can draw regarding hazards and outrage. In general, the public responds more to outrage than to hazard. Unfortunately, industry and agencies primarily attempt to address the hazard and hazard data. The problem is that outraged people do not pay much attention to hazard data. Outrage is not just a distraction from hazard. Both hazard and outrage are legitimate, measurable, and important. Finally, regardless of the demonstrated importance of proper risk communication, companies and agencies usually cannot reduce outrage much until they change their own organizations. Organizational barriers include restrictive job descriptions, the performance appraisal process (which may punish communication risk-takers), the internal climate of opinion and organizationally related cultural barriers, and perceived importance of internal policies. ■

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