APEGGA

Guideline for Management of Risk in Professional Practice

V1.0
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The Association of Professional Engineers, Geologists and Geophysicists of Alberta

FOREWORD

An APEGGA guideline presents procedures and practices that are recommended by APEGGA. Variations may be made to accommodate special circumstances if they do not detract from the intent of the guideline.

Guidelines use the word *should* to indicate that among several possibilities, one is recommended as particularly suitable without necessarily mentioning or excluding others; or that a certain course of action is preferred but not necessarily required; or that (in the negative form) a certain course of action is disapproved of but not prohibited *(should* equals *is recommended that)*. The word *shall* is used to indicate requirements that must be followed (s*hall* equals *is required to*). The word *may* is used to indicate a course of action permissible within the limits of the guideline *(may* equals *is permitted)*.

This guideline is an update and replacement of the APEGGA document *Management of Risk in Professional Practice - A Guideline* first published in 1989, to give a more thorough and up to date summary of the identification, assessment, and management of *risk*s associated with the practice of engineering, geology, and geophysics.

PARTICIPANTS

APEGGA's Practice Standards Committee (PSC) publishes practice standards and guidelines to achieve uniformly high standards of *professional practice*, which meet the intent of the *Engineering, Geological and Geophysical Professions Act* and which identify what the public should expect from any *professional member* of APEGGA. The goal of the committee is also to achieve an atmosphere in which a competent and effective consulting industry can thrive and produce direct benefits to the public. A subcommittee of the PSC was established to revise this guideline with the following membership:

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1 OVERVIEW

APEGGA's *professional members* hold diverse occupations and responsibilities. They explore resources and design economic and sustainable methods of developing them. They develop new projects and public infrastructure and keep existing facilities operating effectively. They touch every industrial sector in Alberta.

Why do *professional members* need to understand the principles of *risk*? Professional engineers, geologists, and geophysicists deal with the management of *risk* on a continual and ongoing basis. *Professional* members make *risk* trade-off decisions on a daily basis; yet these decisions are usually implicit.

If a *professional practice* does not properly assess, evaluate, and manage *risk*s, there may be serious occupational health and safety, environmental, legal/financial, and social/reputation *consequence*s. For example in Alberta in 2005, there were 143 fatalities and 35,460 workplace injuries with a median of seven workdays lost per injury.[1] Most of these losses could have been avoided with an appropriate *risk management* program.

Professional members are ethically, legally, and morally responsible to uphold the protection of the public, employees, and environment as paramount - regardless of their area of practice. The first rule of the *Code of Ethics* states that: "Professional engineers, geologists, and geophysicists shall, in their areas of practice, hold paramount the health, safety, and welfare of the public, and have regard for the environment." This responsibility is not reduced or diminished when the *professional member* provides service to the public through an employer.

In some organizations, *professional members* are the only employees who have a legal obligation to protect the public interest. Employers must encourage professional employees to come forward with the potential *consequences* if other authorities overrule professional judgment on technical or ethical issues.[2] If *professional members* explicitly analyze, evaluate, and appropriately manage *risk*s, then losses can be avoided and they have acted ethically and with due diligence.

1.1 SCOPE

This guideline focuses on what *professional members* can do to assess and manage the *risks* associated with their *professional practices.* First, this guideline outlines the generic *risk assessment* process including: identification of project scope, *stakeholder* involvement, planned reviews, *hazard identification*, and *risk assessment*. The various types of *risks* that *professional member*s may affect and/or be affected by are presented. *Risk evaluation* principles are discussed. Then, this guideline focuses on the management of *risk* by *professional members* in their *professional practice*. Standard of care and due diligence are discussed.

Specific *risk management* principles are presented, including: commitment from leadership; *risk assessment* and *management*, community awareness and emergency preparedness; incident investigations; continuous improvement; project design; construction and start-up; management of change; employee and contractor training;

1 Occupational Injuries and Diseases in Alberta Lost-Time Claims and Claim Rates 2005 Summary, July 2006, Alberta Human Resources and Employment.
2 Guideline for Ethical Practice. APEGGA, 2003.

and operations/facility management. Lastly, the *risk* transfer via contractual agreements or insurance, *risk* retention, and the need for continuous *risk* monitoring are discussed.

1.2 PURPOSE

The purpose of this guideline is to introduce *professional members* to the assessment and management of the *risk*s specific to their *professional practice*. Whether the *professional member* is a consultant and sole proprietor or a vice-president of operations for an oil and gas company – the *risk management* principles are the same. To illustrate the concepts, examples are given in textboxes throughout. This is not a guideline for completing a comprehensive *risk assessment* or evaluating *risk management*. Although some methodology is developed, the guideline is limited in this regard and *professional members* are directed to the references provided in Appendix A.

The purpose is also to remind *professional members* of their ethical and legal obligations: they cannot allow any retention, transfer, or externalization of *risk* that would harm the public, their employees, or the environment. In conveying the knowledge of appropriate, effective *risk management* processes to *professional members*, ethical behaviour and good judgment are reinforced.

1.3 DEFINITIONS

For the purposes of this guideline, the following terms and definitions apply and are italicized throughout. Definitions drawn from other references are marked (ISO)[3] or (CSA)[4] and have been supplemented.

Acceptable level of risk
The level of *risk* that is considered by *stakeholders* to pose minimal potential for adverse effects.

Code of Ethics
Scheduled *Code of Ethics* established pursuant to section 19(1)(j) of the *Engineering, Geological and Geophysical Professions (EGGP) Act*.

***Consequence* (ISO)**
Outcome of an *event.* There can be more than one *consequence* from one *event*. *Consequences* can range from positive to negative. However, *consequences* are always negative for occupational safety and health *risks*. *Consequences* can be expressed qualitatively or quantitatively.

***Decision maker* (CSA)**
A *person* or group of *persons* given the accountability and authority to make decisions. *Decision makers* are also *stakeholders*. In most cases, the *decision makers* will include senior management of the *professional practice*.

***Event* (ISO)**
An occurrence of a particular set of circumstances. The *event* can be certain or uncertain. The *event* can be a single occurrence or a series of occurrences. The *probability* associated with the *event* can be estimated for a given period of time.

3 ISO Guide 73 – Risk Management Vocabulary – Guidelines for Use in Standards, 2002.
4 *Risk Management Guideline for* Decision *Makers*, CAN/CSA-Q850-97 (Reaffirmed 2002), A National Standard for Canada.

***Hazard* (CSA)**
A *source* of potential harm, or an *event* with a potential for causing harm, in terms of human injury; damage to health, property, the environment and other things of value; or some combination of these. Equivalent terms are incident, accident, and near failure. The term 'near miss' is also used by industry, which is inaccurate – a miss is a miss, near or otherwise. For this reason, currently the term "near hit" is more often used.

***Hazard identification* (CSA)**
The systematic process of using information to recognize *hazards* and define their characteristics.

Likelihood
A general expression used for *probability* or frequency, can be expressed qualitatively or quantitatively.

Objective
Applied to *risk* analysis, this implies that any analyst would reach an identical prediction, so absolute objectivity must be free of any individual judgment.

Person
An individual, corporation, company, association, firm, partnership, society, or other entity/organization.

***Probability* (ISO)**
The extent to which an *event* is likely to occur. ISO 3534-1: 1993, definition 1.1, gives the mathematical definition of *probability* as "a real number in the scale 0 to 1 attached to a random event. It can be related to the long–run relative frequency of occurrence or to a degree of belief that an event will occur. For a high degree of belief, the *probability* is near 1." Frequency rather than *probability* may be used in describing risk. Degrees of belief about *probability* can be chosen as classes or ranks, such as:

- rare/unlikely/moderate/likely/almost certain
- incredible/improbable/remote/occasional/probable/frequent
- In civil proceedings, if something is probable, the likelihood of it occurring is greater than 50%. Whereas, if something is possible, the likelihood of it occurring is less than 50%.

Professional member
A professional engineer, professional geologist, professional geophysicist, registered professional technologist (engineering), registered professional technologist (geological), registered professional technologist (geophysical), or licensee entitled to engage in the practice of engineering, geology, and geophysics under the *EGGP Act*.

Professional practice
A professional corporation, company, association, firm, partnership, society, or other organization entitled to engage in the practice of engineering, geology and geophysics under the *EGGP Act*.

***Risk* (ISO)**
Combination of the *probability* of an *event* and its *consequences*. The term "*risk*" is generally used only when there is at least a possibility of negative *consequences*. In some situations, *risk* arises from the possibility of deviation from the expected outcome

or *event*. This guideline focuses on negative *consequences* and minimizing the possibility of loss.

Risk assessment
The overall process of *risk* analysis (process of identifying *hazards* and estimating their *probability* and *consequences*), *risk* estimation (process of combining the *probabilities* and *consequences*), and *risk* evaluation (process of evaluating the *risk* to determine if it can be *tolerated* or *accepted*).

***Risk management* (ISO)**
Coordinated activities to direct and control an organization with regard to *risk*. *Risk* management generally includes *hazard identification*, *risk assessment*, risk control or treatment, *risk* acceptance and *risk* communication.

Severity
The seriousness, magnitude, or degree of impact from an event occurring.

***Source* (ISO)**
Item or activity having a potential for a *consequence*. In the context of safety, *source* is a *hazard*.

***Stakeholder* (CSA)**
A *person*, group, organization, company, etc. able to affect, be affected by, or believing it might be affected by a decision or activity related to the *risk assessment*. *Decision makers* are also *stakeholders*.[5] *Stakeholders* may include senior management of the *professional practice*, project managers, technical experts, regulatory agencies, special interest groups, etc. In the context of a project or other engineering/geoscience related initiatives the *stakeholders* also typically include the owner(s), users and the public at large who may be impacted by the *consequences* of the *risks*.

Subjective
Applied to *risk* analysis, this indicates that individual judgment is applied which includes elements of prejudice, bias, or interest. At the negative extreme, such individual judgment would be based on no evidence, only personal opinion. As the judgment is increasingly based on evidence and less on personal opinion, it is said to become less *subjective* and more *objective*.

Tolerable level of risk
Expressing the *tolerable level of risk* is usually based on a variety of benchmarks including industry standards, local and foreign government regulations, practices of industry partners, and a qualitative assessment by *stakeholders* of what is fair and reasonable. "*Tolerability* does not mean *acceptability*. It refers to the willingness to live with a *risk* to secure certain benefits and in the confidence that it is being properly controlled. To tolerate a *risk* means that we do not regard it as negligible or something we might ignore, but rather as something we need to keep under review and reduce still further if and as we can."[6]

5 *Risk* Management *Guideline for Decision Makers*, CAN/CSA-Q850-97 (Reaffirmed 2002), A National Standard for Canada.

6 Paragraph No. 10, *The Tolerability of Risk from Nuclear Power Stations* U.K. Health and Safety Executive (HSE), 1992.

Vulnerability
Inability to absorb *consequences*.

2 INTRODUCTION TO RISK MANAGEMENT

What is *risk, risk assessment,* and *risk management? Risk is a c*ombination of the *probability* of an *event* and its *consequence*s, usually when there is at least a possibility of negative *consequences*. *Risk assessment* includes *risk* analysis (process of identifying *hazards* and estimating their *consequences* and *probability*), *risk* estimation (process of combining the *probabilities* and *consequences*), and *risk* evaluation (process of evaluating the *risk* to determine if it can be tolerated or accepted). *Risk management* is systematic application of management policies, procedures, and practices to the tasks of analyzing evaluating, controlling, and communicating *risks.*

> For some, the ordering of lunch can be a life threatening decision due to a medical condition, while for most it is a simple matter of personal preference.

Risk assessment and *risk management* must be part of every *professional member's* decisions, whether it is as simple as driving to work or as complex as a multi-million dollar business decision. It is this range of types of *risk*s, coupled with the factors that affect the outcomes from decisions made by the *professional practice* and the tolerance to those outcomes that make the discussion of *risk* so difficult. Every decision is based on the personal perspective, the understanding of the information available, and the familiarity with the tasks performed. This will vary depending on the situation, the *person* or *persons* involved and the specific point in time that the decision must be made.

The definitions in Section 1.3 provide a rigorous foundation for addressing *risk*, but these definitions by themselves do not communicate a full appreciation of the scope of *risk* and how it may affect a *professional member*. Accordingly, a functional description of *risk* that is entirely consistent with the rigorous definition is offered.[7,8] *Risk assessment* may be considered as the set of answers to the following five questions:

1. **What can go wrong? *(hazard identification)***
   - Operational factors
   - Organizational/ institutional factors
   - Human factors
   - Economic factors
   - Natural factors
2. **What are the consequences? *(consequence assessment)***
   - Occupational health and safety – i.e., effect to workers
   - Environmental and public health – i.e., effect on land, air, water, flora, fauna, and cultural heritage, effect to individual members of the public, societal (overall effect on the general public)

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7 S. Kaplan and B. Garrick. "On the Quantitative Definition of Risk", *Risk Analysis*, 1: pp. 11-27, 1991.
8 W. Leiss and S.E. Hrudey. "On Proof and Probability", pp. 1-19. In: *Law and Risk*. Law Commission of Canada. UBC Press, 2005.

- Legal, Financial, and other – i.e., damage to property or assets, economic losses (lost production, penalties, etc.), liability, incarceration
- Reputation/Societal – i.e., public perception, client perception

3. **How likely is it? *(probability assessment)***
   - Probability
   - Estimation of probability – i.e., professional judgment, historical data, etc.
4. **Over what time frame? *(probability assessment)***
   - Immediate or delayed
   - Short term (days, weeks, months)
   - Medium term (years)
   - Long term (life or lifecycle)
5. **What matters to those who are affected? *(risk evaluation)***
   - How do *stakeholders* evaluate the *risks* and benefits?
   - Are the *risks acceptable* when compared to the benefits?

What can go wrong is the *source* or *hazard*, which often results in an *event*. The *probability* of the *event* is often estimated on the basis of historical frequency or as a judgment reflecting a degree of belief in the *likelihood* of the hazardous *event* occurring. The *consequences* are outcomes arising from hazardous *event*(s) and what is affected by these *consequences* is vital to the effective management of *risk*. A time frame is necessary to give perspective to the estimates of *probability*. It is important to consider the probability of an event in the context of a particular timeframe or as a part of a life cycle analysis.

Finally, the issue of what matters to those affected is vital to the effective management of *risk*. *Professional member*s who are used to dealing with tangible, physical details in their practice may misjudge the reactions of those affected. Those reactions will often determine the range of difficulties that may arise from management of any *risk*. Failure to carefully consider this very real aspect of *risk* can lead to substantial expense or responsibility that might otherwise be readily avoided.

Risk management may be considered as the set of answers to a sixth question:

6. **What can be done to manage the *probability* or *consequences* associated with a *risk*? *(risk management)***
   - What options are available to prevent, eliminate, mitigate, transfer or retain the risk?
   - What are the associated trade-offs in terms of all costs and benefits?
   - What are the impacts of current management decisions on the future?

In business, *risk management* is usually viewed as means of minimizing the *probability* or *consequences* associated with the *event*s or circumstances that can lead to a loss. For total *risk management*, the *hazards* must first be identified, the *risk* with the associated outcomes estimated and evaluated and, the methods to address these risks assessed. Only then can the *risk* be considered to be managed.

2.1 OVERVIEW OF RISK MANAGEMENT PROCESS

These six *risk* management questions are operationalized as a flow chart (refer to Figure 1).

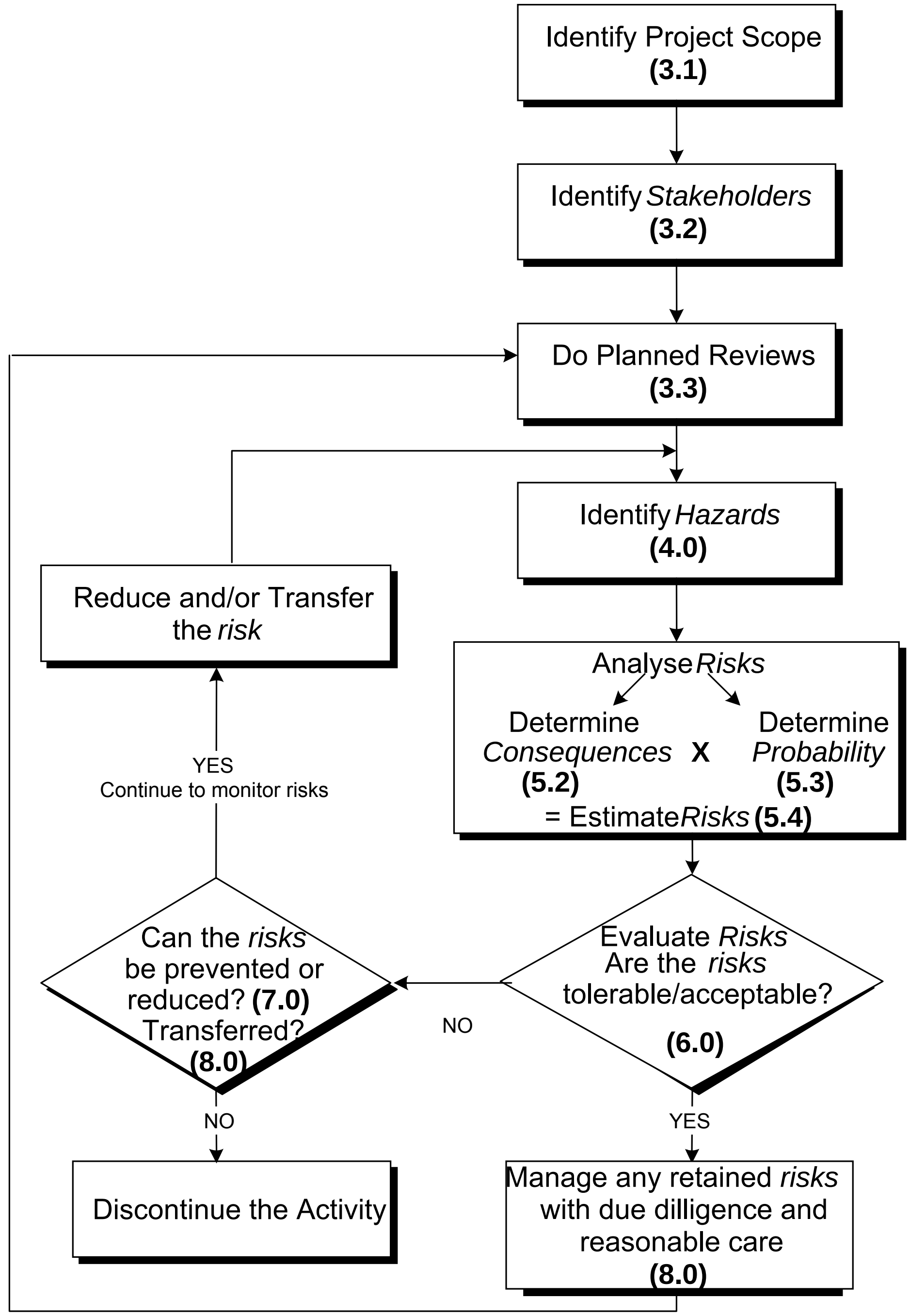

Figure 1 – *Risk management* flow chart

This flow chart is typically used for hazardous industries but is also applicable to other industries or organizations. Its purpose is to provide a general approach to *risk* and provide a method for ensuring unintended outcomes have been considered. By approaching projects in this manner, well considered approaches can be used to minimize the *risks* of negative outcomes.

This *risk management* process promotes explicit and appropriate decision making and meets the criteria for *due diligence*. *Risk management* does not necessarily require a formal, complex analysis. Often *risk management* can be based on simple, common-sense approaches. However, the identification of *hazards*, assessment of *risk*, *risk management*, and rationale for decisions must be documented. For those doing work internationally, there may be additional *risk management* requirements imposed by those authorities having jurisdiction. It is important to understand that once a *risk* is determined to be *acceptable*, it does not go away. It must be continually monitored and managed.

This figure serves as an outline for the remainder of this guideline. Section 3 discusses problem identification and scope, *stakeholder* identification, and doing planned reviews. Section 4 discusses *hazard identification.* Section 5 presents *risk analysis* - determining *consequences* and *probability,* estimation methods and various *risk* types. Section 6 discusses *risk evaluation* to determine the *tolerability/acceptability* of the *risk.* Section 7 reviews approaches for a *professional practice* to prevent, reduce and otherwise manage *risks*. And, lastly, Section 8 discusses the transfer, retention, and monitoring of *risk*.

2.2 BENEFITS OF RISK MANAGEMENT

For some industries and in some jurisdictions, *risk* management is a regulatory requirement. However, for those who must be convinced of its utility, there are numerous benefits of *risk management* to a *professional practice* including the following:[9,10]

- The control of *risks* is improved by identifying and minimizing the associated *probability* and *severity* of *consequences*.
- The explicit consideration of *risk* improves return on investment and allocation of resources by helping the *professional practice* to avoid harm, minimize losses, and save time. *Risk management* may indicate that the *professional practice* should back out of an overly risky project.
- The use of a comprehensive, documented, transparent approach to *risk management* demonstrates due diligence.
- There are fewer surprises. *Risk management* may help to uncover hidden *risk*s in situations that appear straightforward at first glance.
- *Risk management* and communication promotes of two-way dialogue with *stakeholders* regarding new operations, products, policies, or decisions; allowing them to understand and be part of the process.
- Investors, lenders, insurers, clients, and customers are increasingly drawn to *professional practices* that are able to manage *risks* effectively.

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9 *Risk Management* Guideline for Decision Makers, CAN/CSA-Q850-97 (Reaffirmed 2002), A National Standard for Canada.

10 Handbook to Risk Management Guidelines Companion to AS/NZS 4360:2004. © 2004 Standards Australia/Standards New Zealand.

2.3 APPLICATIONS OF RISK MANAGEMENT

The *risk management* process can be applied, either informally or formally, to any *professional practice* or organization, at any level, to any decision. It is typically used when making decisions about significant issues such as: changing policy, introducing new strategies or procedures, managing projects, spending large amounts of money, managing organizational differences or managing politically sensitive issues.[11] Specific applications of *risk management* include the following:

- Strategic, operational and business planning
- Asset management and resource planning
- Design and product liability
- Environmental and public health issues
- Public *risk* and general liability
- Compliance
- Occupational health and safety
- Operations and maintenance systems
- Project management
- Purchasing and contract management

3 PRELIMINARY ASSESSMENT

The first three boxes in Figure 1 describe how *professional members* must be constantly reviewing problems, identifying *stakeholders,* and doing planned reviews to identify possible *hazards*.

3.1 IDENTIFICATION OF PROJECT SCOPE

The first step is to assess the activity or project. This project will have a particular scope associated with it and may either be similar to previous projects or activities or mayhave some novel aspect about it.

Depending upon the nature of the work, formal risk management review may be required or a more informal approach may be sufficient. Is it the type of activity that can have the review done once and applied to many instances or does it require a separate approach for each project or activity? Can the *risk assessment* be dealt with in a simple manner? Using a formal, extensive *risk management* process for straightforward problems would be overly complicated and inefficient. For example, if customer relations or communication processes are inadequate, then improve those processes. If contractual disputes are seen as a *risk*, tighten up contract language.

3.2 IDENTIFICATION OF STAKEHOLDERS

Stakeholder identification includes determining who should be involved in the *risk assessment, evaluation,* and *management* processes; what degree of involvement is required; and how should dialogue be initiated and sustained.

11 Handbook to Risk Management Guidelines Companion to AS/NZS 4360:2004. © 2004 Standards Australia/Standards New Zealand.

Those involved in estimating and evaluating *risk* will need to develop a list of *stakeholders* based on the anticipated issues, required decisions, etc. *Stakeholders* are any *person*, group, organization, or company that are able to affect, be affected by, or believe it might be affected by a decision or activity related to the *risk assessment*. *Stakeholder*s may include *decision maker*s[12] such as senior management of the *professional practice*, project managers, technical experts, regulatory agencies, special interest groups, as well as the public at large. The process of identifying s*takeholder* must be documented in writing.

Levels of participation and responsibilities of *decision maker*s and *stakeholders* will vary depending on the nature of the *risk* being evaluated, the level of complexity, and the degree of expertise within the *professional practice*. The levels of participation should consider the following:

- Is this a concern with *stakeholders*?
- Is direct involvement in the problem identification, *risk assessment*, and *risk management* required?
- Does participation involve consultation during the investigation and validation of the results?
- Does participation involve an approval or decision?

Communication with *stakeholders* is critical during the scope investigation stage, as well as throughout the *risk assessment* and evaluation. Initial communication with *stakeholders* may result in additional or different *stakeholders* being identified.[13] There is much literature on *risk* communication, which discusses effective interaction and relaying of information (refer to Appendix A). It is as much an art as a science; it is recommended that *professional member*s refer to this literature, as required.

3.3 DOING PLANNED REVIEWS

The purpose of doing reviews on a regular, scheduled basis is to proactively gather data, do statistical and trend analyses, and foresee and manage potential problems for the *professional practice*. This ensures that the *risk management* for activities or projects is maintained as current. It entails the development of a database for the *professional practice*'s occupational health and safety system – to guide ongoing operations or new project designs. It would include documentation on incident investigations, insurance company reviews, regulatory activities (e.g., pressure vessel inspections, environmental reporting, asset renewal needs, changes to laws, code updates, etc.). It would also include the regular data collected on business operations and maintenance activities. Doing planned reviews is the responsibility of the *professional practice*'s management.

4 HAZARD IDENTIFICATION

The purpose of *hazard identification* is the process of recognizing that one or more *hazards* exist and defining the characteristics. This determines which failures or *hazards* may affect the project or activity and the possible *consequences*. It is important to note that if *professional members* do identify *hazards,* they have a legal obligation under the

12 *Risk* Management Guideline for Decision Makers, CAN/CSA-Q850-97 (Reaffirmed 2002), A National Standard for Canada.

13 Risk Management Guideline for Decision Makers, CAN/CSA-Q850-97, Risk Management: Guideline for Decision-Makers.

Occupational Health and Safety Act and the *Code of Ethics* to communicate the associated *risks* to those possibly affected and to take measures to eliminate or reduce the *risks* to an *acceptable* level.

An overview of *hazard identification* methods and types of *hazards* is given in this section. A detailed discussion of *hazard identification* methods, is provided elsewhere.[14]

4.1 HAZARD IDENTIFICATION METHODS

There are different methods of determining possible *hazards* and assessing the *consequences* of planned or existing processes. The choice of method depends upon the scope of the project or activity, the resources available, and the potential *hazards* and *severity* of *consequences* from those *hazards*. An informal or ad hoc method may be used by an individual for a straightforward, simple process while a more formal, structured method may be used by a larger organization with a complex operation for a larger-scale *risk*. These methods are listed in order of increasing complexity and formality:[15]

- **Personal observations** may be as informal as taking a walk around the site or more formal through planned task observations/analysis or workplace audits.
- **Check-lists** can be used during a workplace audit, to draw attention to where conditions deviate from standards. The checklists may be based on previous accident analysis, allowing the *risk* manager to identify symptoms that point to a *hazard*. Care must be taken in constructing the checklists to ensure that they are reasonably comprehensive for the activity or operation.[16]
- **Professional judgments of internal or external panel of experts** to do audits, which can be very effective in identifying *hazards*. Past experience is a powerful means of identifying a *hazard* since the *consequences* and actions may be already known. Although the knowledge can be judged as accurate, decisions can be affected by that past experience. A very negative experience can create a very cautious atmosphere while a positive experience can create carelessness.
- **Review of previous near-failure, close-call, or incident information** to determine the underlying causes. By recording and investigating unsafe behaviours/conditions, conclusions can be drawn regarding the causes of accidents or near accidents and proactive management of the causes same to prevent more serious consequences from occurring. Serious injuries and accidents, as defined by the *Occupational Health and Safety (OHS) Act*, must be reported to the OHS Council. Figure 2 shows the potential outcomes of a *hazard* with some estimates as to the *consequences*, to illustrate the relative *probability* of *consequences*. By learning from unsafe behaviours, a *professional practice* can avoid the more serious incidents from occurring.

14 Guidelines for Hazard Evaluation Procedures. A.I.Ch.E., Center for Chemical Process Safety (CCPS), 1992, N.Y. ISBN 0-8169-0491-X.

15 *Risk Management Guideline for Decision Makers*, CAN/CSA-Q850-97 (Reaffirmed 2002), A National Standard for Canada.

16 The creation of operation specific checklists is presented in *Practical Loss Control Leadership – Revised Edition* by Frank E. Bird Jr. & Robert G. Loftus, 1996.

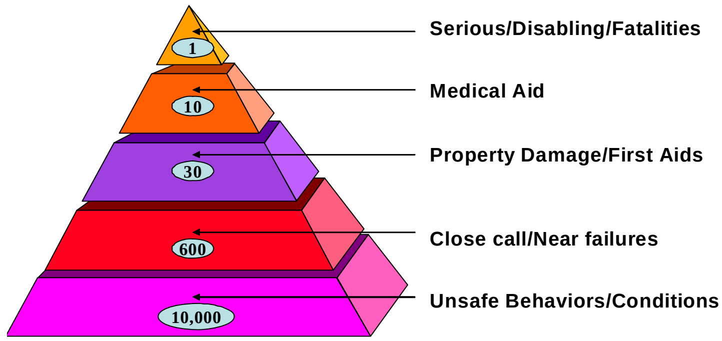

Figure 2 – Incident pyramid portraying relative *probability* of *consequences*[17]

- **Analysis of historical accident data** from comparable activities or projects to determine a general level of *risk* for a particular activity. Similarly, if it is available, the historical record for comparable organizations or industries can provide benchmark assessments of *risks*. Some insurers will provide technical support for the assessment of *risk* for particular activities.
- **Hazard and operability study (HAZOP**) is a structured, systematic technique for identifying *hazards* and operating problems throughout an area or entire facility. This type of study is particularly useful in identifying unforeseen *hazards* designed into facilities due to lack of information, or introduced into existing facilities due to changes in process conditions or operating procedures. It is important to note that the HAZOP process may only identify the *hazards* or concerns needing immediate attention. It is not a comprehensive *risk assessment* but the first step leading into the *risk* analysis where *consequence* and *probability* for the identified *hazards* are determined. HAZOPs are mandatory for many facilities in many jurisdictions.

The following methods may be used for *hazard identification* and also for estimating *probability*, bridging into the analysis of the associated *risks*.

- **Failure modes and effects analysis (FMEA**) is a technique, primarily qualitative although it can be quantified, by which the effects or *consequences* of individual component failure modes are systematically identified. FMEA can be used for both *hazard identification* and *probability* estimation.
- **Fault-tree analysis (FTA**) is a technique, either qualitative or quantitative, by which conditions and factors that can contribute to a specified undesired *event* (called the top event) are deductively identified, organized in a logical manner, and represented pictorially. FTA may be used for *hazard identification*, although it is primarily used in *risk* analysis as a tool to provide estimates of failure *probabilities*. It is also an effective method for incident investigations (referred to as "Root Cause Analysis") and can be used as a follow-up from a HAZOP study.
- **Event-tree analysis (ETA)** is a technique, either qualitative or quantitative, that is used to identify the possible outcomes and, when used quantitatively, their *probabilities*, given the occurrence of an initiative *event*. ETA can be used for *hazard identification* and for *probability* estimation of a sequence of *events* leading to hazardous situations.

17 Figure from *Loss Control Management* by Frank E. Bird Jr. & Robert G. Loftus, 1976 ISBN o-88061-000-X

4.2 TYPES OF HAZARDS

Hazards may be grouped into five general categories: operational failure, organizational/institutional failure, human failure, economic failure, and natural failures. These groups are not mutually exclusive and are often compounding.

Operational factors

- Substandard quality or design
- Equipment/mechanical failure, worn equipment, obsolescence
- Hardware/software failure
- Noise, vibration
- Toxic materials, carcinogens, radiation, or noxious materials release (pesticides, herbicides, pharmaceuticals, corrosives)
- Electrocution
- Flammable materials/explosion
- Objects with high potential energy
- Objects with high kinetic energy

Organizational/ institutional factors

- Substandard practices or conditions
- Insufficient training
- Personnel or job factors
- Security breach

Human factors

- Worker fatigue, distraction[18,19]
- Substandard compliance
- Political or legal issues

Economic factors

- Inflation
- Depression
- Changes in tax levies

Natural factors

- Floods
- Windstorms, hurricanes, tornadoes
- Earthquakes
- Rockfalls, avalanches, landslides

> The levees and coastline around New Orleans have been continually deteriorating. Since the 1980s, the systems had been deemed insufficient to withstand anything greater than a category three hurricane. The cost to prevent failure by rebuilding the marshes and/or upgrading the levees to handle a category five storm was estimated to be $10 - $50 billion U.S. On August 29, 2005, Hurricane Katrina hit New Orleans, causing the levees surrounding the city to fail. Most of the city was flooded. This flood has cost thousands of lives and an estimated $200 billion in damages.

18 Trevor Kletz. *An Engineer's View of Human Error,* 3rd Edition. 2001. Taylor & Francis, New York, 281pp. ISBN 1-56032-910-6. The theme of the book is ‘try to change situations, not people’

19 James Reason. *Managing the Risks of Organizational Accidents*. Ashgate, Aldershot, 252pp. ISBN 1 84014 105 0

- Biological *hazards,* dangerous microbiological substances, and other natural phenomena

5 RISK ANALYSIS AND ESTIMATION

Upon identifying the *hazards*, then the associated *risks* are determined by assessing the *probability* of the *events* occurring and the potential *consequences*. This section presents an overview of estimation methods and considerations in the estimation of *probability* and *consequences*. For a detailed discussion of *risk estimation* methods, refer elsewhere.[20]

Risk assessment may include model building to simplify the analysis. However, *professional members* must not rely on an over simplified approach.

5.1 ESTIMATION METHODS

The *risk estimation* method used can be qualitative or quantitative. The choice of method and the level of detail in the implementation must be compatible with the available information, the magnitude of the *risk*, and the resources available to perform the analysis. In some cases, the analysis can be phased, starting with simplified, general methods to screen *risks*, and progressing to more detailed methods for *risks* identified as significant. Both qualitative and quantitative *risk* estimation methods must be rational, with assumptions clearly stated using a transparent process.

Risk quantification may be useful for decisions regarding whether or not to provide services to a particular client, project or type of project. If the exposure to *risk* is significant in comparison to the benefit, the choice to not perform the work is always an option.

By examining a cross-section of typical owners, contractors, contracts, project types and staff available for an assignment, the *professional member* can assess the degree of *risk* in a relative or *subjective* manner. The *risks* can then be examined with respect to the potential for losses on a specific project.

5.1.1 Qualitative Risk Estimation

In the qualitative approach *risk* is represented by qualitative descriptors, on a user-defined, relative *risk* scale. Examples would be to classify *risk*s as low, medium or high; or to represent the *risk* by an index that varies between 1 and 10. The *risk* descriptor or index is typically defined *subjectively*. *Risk* indices can also be calculated from individual *likelihood* and *consequence* indices using simplified *subjective* formulae.

Qualitative *risk* estimation typically involves a significant degree of *subjective* judgment and produces relative (rather than absolute) *risk* estimates. For high level estimations, and in the absence of the data and resources required for quantitative analyses, qualitative *risk* analyses provide a structured and rational approach to reflect personal experience and expert opinion

> An example of applying judgment to frequency data is the use of motor vehicle fatality statistics to determine the specific *risk* of death to an individual. Given the average fatality *risk* in Canada, the *risk* to an individual would depend upon: the driver's gender, age, years of driving experience, wearing of a seatbelt, tendency to speed, mileage driven, urban/rural, season, etc.

20 CSA has developed guidance documents to address risk analysis (CSA Standard CAN/CSA-Q634) and environmental risk assessment (CSA Standard Z763).

in the decisions made. Qualitative evaluations are often used as a screening tool to determine whether more quantified forms of analyses are justified.

Qualitative methods are generally easy to use; however, the significant *subjective* input they require could lead to inaccuracies in the *risk* rankings. Consequently, a qualitative *risk* estimate may be difficult to defend to *stakeholders*, especially if they are overly technical. Defensibility should be improved if the *risk* estimate is tied directly to evidence. Because the *risk* scale is typically arbitrary, qualitative *risk* estimates for engineering or geoscience projects are not easily compared to other common *risk*s.

5.1.2 Quantitative Risk Estimation

In the quantitative approach *risk* is estimated on a physical quantified scale. This is typically achieved by estimating *likelihood* by the *probability* of occurrence, and *consequences* by a quantifiable attribute such as cost in dollars. The *risk* is therefore estimated in terms of such quantities as the expected cost in dollars (for financial *risk*) or the expected rate of fatality (for safety *risk*s).

Depending on the method used to estimate *probabilities* and *consequences*, quantitative methods will range from very *subjective* to very *objective* (see definitions). For example, *probability* estimates can be made purely on the basis of judgment, in which case the result would be quantified but *subjective*. The more that judgment can be grounded on evidence and critiqued by external review, the more it leads towards the *objective* end of the spectrum. Alternatively, *probabilities* may be quantified based on statistical or design data, in which case the outcome would appear to be more *objective*.

When quantitative methods are used, there is generally an attempt to make them as *objective* as possible by using relevant data and engineering/ geoscience models to define the underlying *probabilities* and *consequences*. It should be understood that any quantitative risk analysis is only as good as the data it is based on. The "garbage in – garbage out" adage is very applicable to this type of analysis. Also note that no method is purely *objective* as some *subjective* judgment is inevitably required to establish relevance of the statistical data and models used. It should also be recognized that there are many cases in which data and model deficiencies exist that make it necessary to use some *subjective* judgment in the *risk* estimation process. Statistical analyses of data that demand major assumptions to establish their relevance may produce increasingly *subjective*, but quantitative results.

> It is often erroneously assumed that quantitative methods are always precise and *objective*. In reality, the key feature of quantitative methods is that they use probabilities and quantified *consequence* estimates, resulting in quantified *risk* estimates (e.g., expected costs or fatalities). While quantitative methods are typically associated with the use of *objective* data, it is necessary in many cases to supplement the data with *subjective* (but quantitative) judgment. The degree of *subjectivity* or *objectivity* of the quantitative approach depends on the available data and how they are used. Numbers do not assure *objectivity*.

While quantitative methods typically require a higher level of effort, they have the potential to resolve some of the limitations associated with qualitative methods. The results are more easily interpreted because they are comparable to common *risk*s (i.e., the *risk* of fatality or the *risk* of losing money), and are well suited to cost optimization analyses. The results of quantitative methods can be easier to defend provided they are established on a more factual basis.

The use of quantitative *probability* also provides an opportunity to improve communication regarding the level of uncertainty. *Objective* or unbiased data may be blended with *subjective* judgment to determine and quantify the *probability*. The processing of data should be *objective*. However, unless the frequency data is available for exactly the *risk* under investigation, some level of judgment in the interpretation of data will be inevitable. Transparency and clarity of the analysis allows *stakeholders* to discuss and agree upon the assumptions and, therefore, the results of the frequency data. If numeric data are used, it is imperative that they be credible and verifiable by the public.

There is no "correct" value for *probability*. The information used is the best that the *risk assessment* team can produce. *Probability* estimation involves gathering information (i.e., historical data), analyzing the information, and using the results of the analysis to estimate the *probability*. Analysis of the information should include determining if the information is accurate and relevant to the evaluation.

5.2 ESTIMATING PROBABILITY

The *probability* or frequency of an incident occurring may be based on several means such as historical performance, manufacturer's data, experience, or general statistical data. Data may be available generically, however, if there are specific historical data related to the specific project or activity, these are often the better data to use. *Probability* may be quantifiable, but confidence in *probability* estimates will depend upon the quality of frequency data available. If data are not available, *probability* may be represented qualitatively.

As estimating the *probability* is vital to the *risk* estimation, if previous experience or historical information are inadequate to estimate the *risk*, outside resources may be required to define the project or activity constraints and associated exposure to *risk*, the potential outcomes / *events*, the *probability* of outcomes / *events* occurring, the identification of *stakeholders*, the communication plan, current regulatory requirements, etc. Monitor uncertainties, facts, values, assumptions, boundary conditions, etc. used to guide evaluation as the evaluation progresses to ensure key changes are captured and terms of reference are kept current. Estimates should be on the conservative side, to err on the side of safety.

5.3 ESTIMATING CONSEQUENCES

One important component of assessing the *consequences* of a particular *risk,* is the process of identifying the possible routes of exposure to the *consequences* associated with the occurrence *hazards.* This assessment requires the specification of the safety, societal, economic and legal *consequences*.

As an example, Figure 3 presents a *hazard* – an underground fuel tank which is leaking. The risk analysis identifies the *hazards* and answers questions like why would the tank leak, how much, how often, and what would happen if it does leak. There are numerous routes of exposure: dermal contact with contaminated soil, ingestion of contaminated vegetables, inhalation of vapours in the air, dermal contact and/or ingestion of contaminated surface water, and dermal contact and/or ingestion of contaminated ground water. The *consequences* may be occupational safety and health, environment and public health, legal/financial, and reputation/societal.

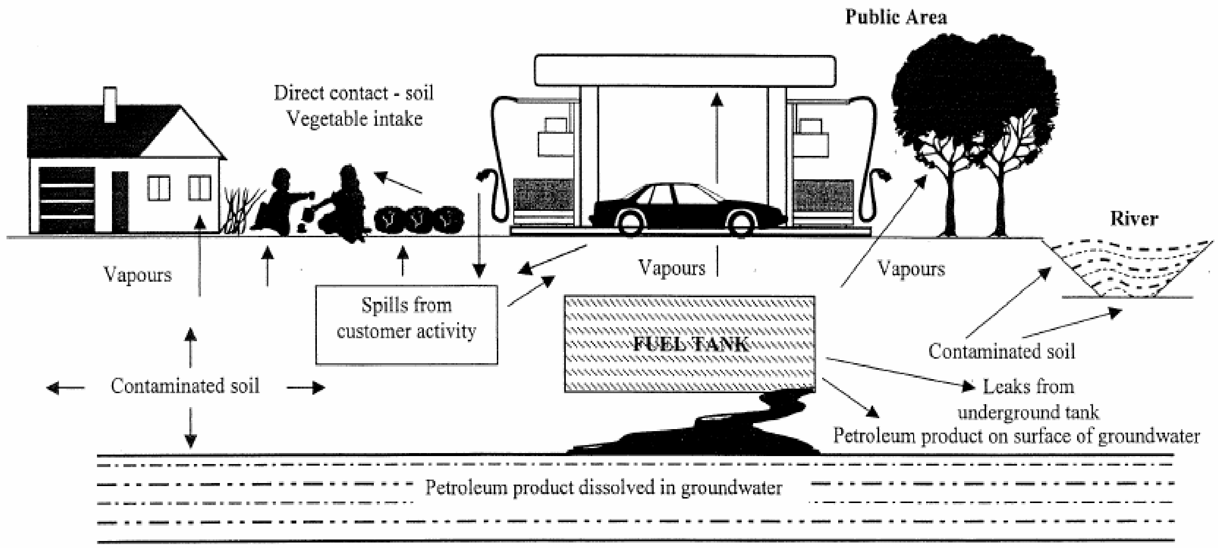

Figure 3 – Leaking fuel tank posing a *hazard*, with numerous routes of exposure, and resulting in various *consequences*[21]

> The location of the project in relation to sensitive environments is key. Consider an underground storage that is leaking fuel. The *consequences* are much more severe if this spill occurs adjacent to a river and fish spawning ground than if it occurs in an industrial area with clay soils.

The potential magnitude or *severity* of the *consequences* would consider maximum loss possible, annual loss, etc. It also depends upon the vulnerability of the *professional practice* or operation, other *stakeholders*, and the surrounding environment. Some ecosystems or companies have the stability to recover from a given loss while others may not. A well-established company with solid financial backing is much less *vulnerable* to financial *consequences* than an individual just starting a business.

5.4 ESTIMATE RISKS BY COMBINING PROBABILITY AND CONSEQUENCES

Risk is estimated by combining the *probability* and *consequences* associated with the *hazards*. *Risk* may be represented as a statement: for a male aged 25-29, the annual risk of dying from cardiovascular diseases is approximately 1 in 21,000.[22] The *risks* associated with the *professional practice* or operation may be represented as a simple, qualitative *risk* matrix (see Figure 4).

21 *Guidelines for* Environmental Risk Assessment and Management, Department of the Environment, Transport and the Regions, Eland House, Bressenden House, London, 2000. Adapted from Institute of Petroleum, Guidelines for the investigation and remediation of contaminated retail sites, Colchester, UK, Portland Press, 1998.

22 S.P. Thomas and S.E. Hrudey, *Risk of Death in Canada – What We Know and How We Know It*, University of Alberta Press, 1997.

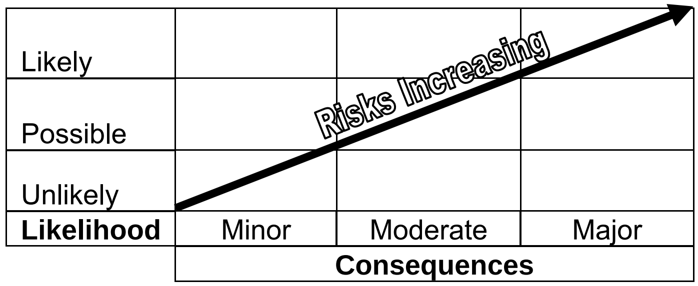

Figure 4 – Simple qualitative *risk* matrix

Risk estimates may also be represented graphically. As an example, Figure 5 illustrates the *frequency* and spatial distribution of *risks*. This figure is a *risk* diagram of a liquefied petroleum gas (LPG) tank at a service station. Known *hazards* include: a relief valve fire on the tank itself, a relief valve fire on the truck that fills it, major leak valve fires and a tank rupture with resulting in a vapour cloud explosion. Each event has a different *likelihood* of occurrence per annum (pa) and a different *consequence* radius, which is estimated as presenting a total *risk* of death of 37 X 10^{-6} per annum (equal to the sum of all constituent risks = 37 = 17 + 10 + 7 + 3).

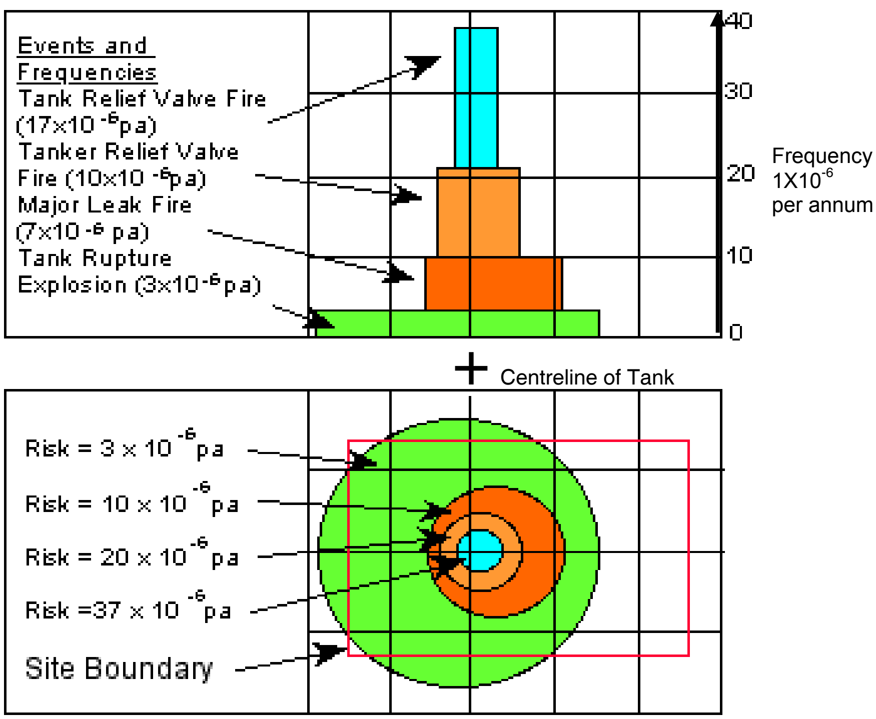

Figure 5 - *Risk* plot for a LPG Tank (plan is a 10m grid)[23]

23 Risk & Reliability Associates, *Risk & Reliability - An Introductory Text, 5th Edition*, available URL: http://www.r2a.com.au/publications/5th_Edition/13_process.html.

5.5 TYPES OF RISKS

The main *risk*s for a *professional practice* may be broadly characterized as occupational safety and health, environment and public health, legal and financial, and reputation/societal – depending on who or what is affected. A primary overview of each *risk* category follows for illustrative purposes. References are provided for a detailed discussion of these *risk* categories.

5.1.1 Occupational Health and Safety Risks

Occupational health and safety *risks* include the health and safety of all workers present at a worksite and environmental impacts inside the company property lines. There may be direct effects to employees and site visitors, their health, and/or their quality of life.

Occupational health and safety *risks* may be identified by gathering the data from various assessment audits, reviews, etc., that are done in the workplace (as described in Section 4.1). There are many types of occupational health and safety *consequences* caused by various industrial *hazards*. The table below provides examples of *hazards* that could have *consequences* on employees or their environment. Some of these *consequences* could extend into the broader environment.

Type of *Hazard*	**Occupational Health and Safety *Consequences***		
	Odor/Irritation Threshold	**Irreversible Effects Threshold**	**Life Threatening Effects Threshold**
Toxic Release (concentration - 1 hour exposure)	ERPG-1*	ERPG-2*	ERPG-3*
Fireball - Immediate Ignition (radiation intensity - 60 second exposure)	1st Degree Burns 2 kw/M^2	2nd Degree Burns 5 kw/M^2	3rd Degree Burns 8 kw/M^2
Flash Fire - Delayed Ignition (flammable gas dispersion)	NOTE There is no lower level *consequence*	1/2 of Low Flammability Limit	1/2 of Lower Flammability Limit
Pool / Jet Fire (radiation intensity - 90 second exposure)	1st Degree Burns 1 kw/M^2	2nd Degree Burns 4 kw/M^2	3rd Degree Burns 6 kw/M^2
Unconfined Vapor Cloud Explosion (overpressure)	Window Breakage 0.3 psig 0.02 bar	Partial Demolition of Houses 1.0 psig 0.07 bar	Threshold of Ear drum rupture Lower limit of serious structural damage 2.3 psig 0.16 bar

* ERPG = Emergency Response Planning Guideline, Emergency Response Planning Guide is a publication from American Industrial Hygienists Association, which has more than 30 technical committees that deal with workplace health and safety issues such as emergency response planning, exposure and *risk assessment* strategies, and workplace environmental exposure levels.

By combining the *consequences* in this table with the associated *probabilities,* the *risk* may be estimated. There are many tools available to help do the *risk* analysis and resulting *risk assessment*. These tools help to quantify the *consequences* of all kinds of *hazards* (e.g. explosions, toxic cloud dispersion models, toxic exposures, lethality, noise, water pollution plumes, etc.) to assist a *professional practice*. Refer to Appendix A for a listing of occupational health and safety *risk assessment* references.

5.5.2 Environment and Public Health Risks

If the *consequences* extend beyond the property line, there may be *risks* to the environment (air, surface water, groundwater, soil) quality and/or quantity and to the public. The project impacts may take some time to appear and the causes may not be readily linked to actions from a specific project.

Environmental and public health *risks* are related because they rely on similar elements and similar approaches to *risk assessment* and *risk management*.[24,25,26] The first major distinction regards whether the focus is on human health effects arising from environmental exposures (public health *risk*s) or on effects on other species in the natural environment (ecological *risk*s). There will often be some inevitable overlap in these approaches. Both will focus on populations, but public health *risk assessment*s will often use hypothetical individuals as a means to make population health *risk*s relevant to potentially affected individuals.

The general approach to public health and environmental *risk*s must reflect the multi-media exposure to *risk*, including exposures via air, water, food or soil contact. Exposure to hazardous agents may arise from multiple *source*s and may involve multiple agents. Compared with industrial and occupational *risk*s the agents, the degree and mode of exposure are likely to be considerably more uncertain and complex. Generally, absolute exposure levels will be lower. Because certainty in adverse outcomes decreases with decreasing exposure, predictions of adverse effects for public health and ecological *risk*s will be much more uncertain than industrial and occupational *risk*s. This trend results from the reality that knowledge about adverse health effects for either humans or other species can only be generated from laboratory toxicology studies or population studies (observational epidemiology studies in the case of human *risk*s), both of which have practical limitations when dealing with low level exposures and/or complex mixtures of agents.[27,28]

The foregoing realities of the evidence upon which environmental and public health *risk*s assessments must be based, mean that many assessments are limited to predicting the levels of exposures to hazardous agents that may occur for various scenarios. The assessment of adverse effects is often limited to comparing predicted exposures with

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24 S. McColl, J. Hicks, L. Craig, and J. Shortreed. *Environmental Health Risk Management - A Primer for Canadians,* Network for Environmental Risk Assessment *and* Management (NERAM) c/o Institute for Risk Research, University of Waterloo, 2000.

25 Environmental Health Risk Assessment - *Guidelines For Assessing Human Health Risks From Environmental Hazards,* Department of Health and Ageing and enHealth Council, June 2002.

26 Presidential / Congressional Commission on Risk Assessment and Risk Management. 1997. Framework for Environmental Health Risk Management, Final Report, Vol. 1 Washington, D.C. Available URL: http://www.riskworld.com/Nreports/nr7me001.htm

27 S.P. Thomas and S.E. Hrudey. 1997. *Risk of Death in Canada – What We Know and How We Know It.* University of Alberta Press. 272 pp.

28 D.J. Paustenbach, Ed. *Human and Ecological Risk Assessment – Theory and Practice*. John Wiley and Sons. New York. 1556 pp, 2002.

various environmental quality criteria[29] (air quality, drinking water, maximum contaminant levels in food or soil) rather than specific predictions of health effects. The guidelines usually have substantial uncertainty factors built in, so that adverse health effects are not normally expected if guideline values are exceeded by a small margin.

> Companies are now being held liable for *risks* that those affected had voluntarily assumed. Examples include smokers' class action suits against tobacco companies for giving them cancer and lawsuits against fast-food companies for causing obesity.

Public expectations for public health or ecological safety are justifiably high. The mismatch between the level of certainty that can be achieved with public health and environmental *risk assessments* and public expectations for precaution in the face of uncertainty provide considerable scope for controversy. These realities underscore the need for early and effective involvement of *stakeholders* in public health and environmental safety issues because the scientific evidence alone will rarely be certain enough to be persuasive unless a common understanding and some level of trust has first been established. A narrow, strictly technical approach to managing public health or environmental *risks* is likely to create conflict that can be avoided by meaningful engagement of *stakeholders*, a transparent *risk management* program, and an effective communication plan.

5.5.3 Legal, Financial, and Other Risks

Professional members and *practices* have significant legal obligations. Failing to diligently perform their tasks to the required standard of care can result in significant legal, economic, and other *risks*. *Professional members* can avoid these *risks* by knowing and complying with the standard of care as defined by contractual agreements, civil and tort law, and legislation and regulations.

Contracts impose obligations upon all involved parties.[30,31] Contracts can be used to raise the standard of care to be met by the *professional practice,* may create liabilities that exceed those which would otherwise exist in law, and set out terms for establishing what and when damages are payable. These obligations are discussed in detail in the APEGGA guideline *Developing Consulting Rate Structures and Contracts*.

No contract needs to exist between parties for tort liability to occur.[32] A tort is "a civil wrong for which a remedy may be obtained, usually in the form of damages".[33] The burden is on the plaintiff to prove that: the defendant owed the plaintiff a duty of care, the defendant breached that duty, that the defendant's conduct caused damage to the plaintiff, and the damages to the plaintiff would be reasonably foreseeable by the defendant. Tort liability can be established against the *professional member* and/or the *professional practice*.

29 CCME 1999 (with updates). Canadian Environmental Quality Guidelines. Canadian Council of Ministers of the Environment. Winnipeg.
http://www.ccme.ca/publications/index.html#174

30 Marston, D.L., Law for Professional Engineers – Canadian and International Perspectives, Third Edition. McGraw-Hill Ryerson, 1996.

31 Excerpt taken from Dr. G. Jergeas' presentation Risk and Loss Management: Roles and Responsibilities of Professionals, given at APEGGA's Professional Development Days in Edmonton and Calgary, November 2004.

32 J.G. Fleming, The Law of Torts, 8th edition. Law Book, Sydney, 1992.

33 Black's Law Dictionary, Second Pocket Edition. Bryan A. Garner, Editor in Chief, West Group, A Thomson Company, St. Paul, Minnesota, 2001.

For a *professional practice*, the two primary types of tort are intentional and negligent tort. Intentional tort is committed by someone acting with general or specific intent such as an abuse of power, abuse of rights, fraudulent misrepresentation, or defamation. Negligent tort is committed by failure to observe the standard of care required by law under the circumstances such as negligence of duty – failure to apply due diligence and a reasonable standard of care; breach of duty to warn; or negligent misrepresentation.

There are various municipal, provincial, and federal laws and regulations that govern the engineering and geoscience professions and set standards for the performance of services. Failure to meet these regulated standards can lead not only to claims for damages but also to fines, penalties and even criminal charges. As *professional practices* face a growing list of regulations, *professional members* need to be diligent in ensuring that they keep abreast of new legislation that may impact their practice. These laws also define potential liabilities, such as: negligence in design or operations, defective manufacturing, failure to provide a safe work place, or failure to warn of dangers associated with the product or activity. *Professional member*s share corporate responsibility for the quality of products and services delivered. The Canadian *Criminal Code* has been amended so that individuals can be charged with the offence jointly with the corporation.

Financial *risks* may result from occupational health and safety, environment and public health, reputation or societal, or legal *risks*. The following summarizes the typical financial *risks* to the *professional member*:

- Damages or losses to tangible assets such as buildings, vehicles, or equipment. The cost to rectifying an error that has been made (i.e., the costs of replacing a slab that is determined to be under-designed).
- Damages or losses to intangible assets - such as losses of trade secrets or goodwill. A *professional member* or *practice* that has lost the faith of their clients has a serious struggle to regain the necessary business levels to survive. Referrals are an important part of the growth of any business and if the referrals are negative the growth will suffer.
- Production losses due to increase in costs, reduction in production volume, reduced pricing, loss of ability to conduct business, or reduced quality or failure to meet deadlines thus incurring penalties or overtime costs.
- Fines and Penalties – these types of losses can be imposed by law or under contract and are generally not insurable.
- Regulatory violations - economic losses from stop-work orders, license suspensions, and other similar *consequence*s.
- Financial liability due to civil suits or criminal negligence - including legal and in-house costs incurred by the *professional practice* in defending against claims, regardless of the merit of the suit. Even if adequate professional liability insurance is place, any litigation involves a great deal of effort and financial cost.

Lastly, there is also the potential for individuals to face ‘other’ *consequences*, such as incarceration if found guilty of an offence under the Canadian *Criminal Code* or a public welfare statute.

5.5.4 Reputation/Societal Risks

Any of the above mentioned *risks* could pose a *risk* to the *professional practice*'s reputation or status. This could have further political or financial *consequences* for the *professional practice*, its employees, or even adjacent property owners.

6 EVALUATING THE RISKS

The next step in the *risk management* process is to evaluate the *risk*s in terms of the *acceptability* or *tolerability* of the *risk*s versus regulatory and other standards, the benefits and costs of the activity, and the needs and concerns of *stakeholders*. The *risk*s may be considered to be either broadly acceptable at the current level, acceptable given compensating benefits but *risk management* measures should be considered, or unacceptable/intolerable under any circumstances.

6.1 REDUCING RISKS TO AS LOW AS REASONABLY PRACTICABLE

The *professional practice*'s *risk management* goal should be to reduce the total *risk* to as low as is reasonably achievable or practicable - known as the ALARA or ALARP principle.[34] This principle along with the *tolerability* versus *acceptability* of *risk* is illustrated in Figure 6. The ALARP principle considers practicality 'Can something be done?' It also considers the costs and benefits of action/inaction 'Is it worth doing something in these circumstances?' Care must be taken in determining who is evaluating the *risks* and determining *acceptability*. What is acceptable to the *decision makers* may not necessarily be acceptable to other *stakeholders*. The practicality and costs/benefits must to be carefully balanced if the *professional practice*'s *risks* are to be handled with an expressed or implied duty of care.[35]

Note that *risk* evaluation is viewed much more critically by courts when assessing civil liability or liability under public welfare statutes. Instances arise where the evaluation of *risk* is a matter of public and/or corporate policy and the *professional member* may not be qualified to make recommendations with respect to the *tolerable level of risk*.

34 U.K. Health and Safety Executive (HSE) available URL: http://www.hse.gov.uk/risk/theory/alarpglance.htm. Discussed further in D. Hartford and G. Baecher. Risk and Uncertainty in Dam Safety, Thomas Telford.

35 Handbook to Risk Management Guidelines Companion to AS/NZS 4360:2004. © 2004 Standards Australia/Standards New Zealand.

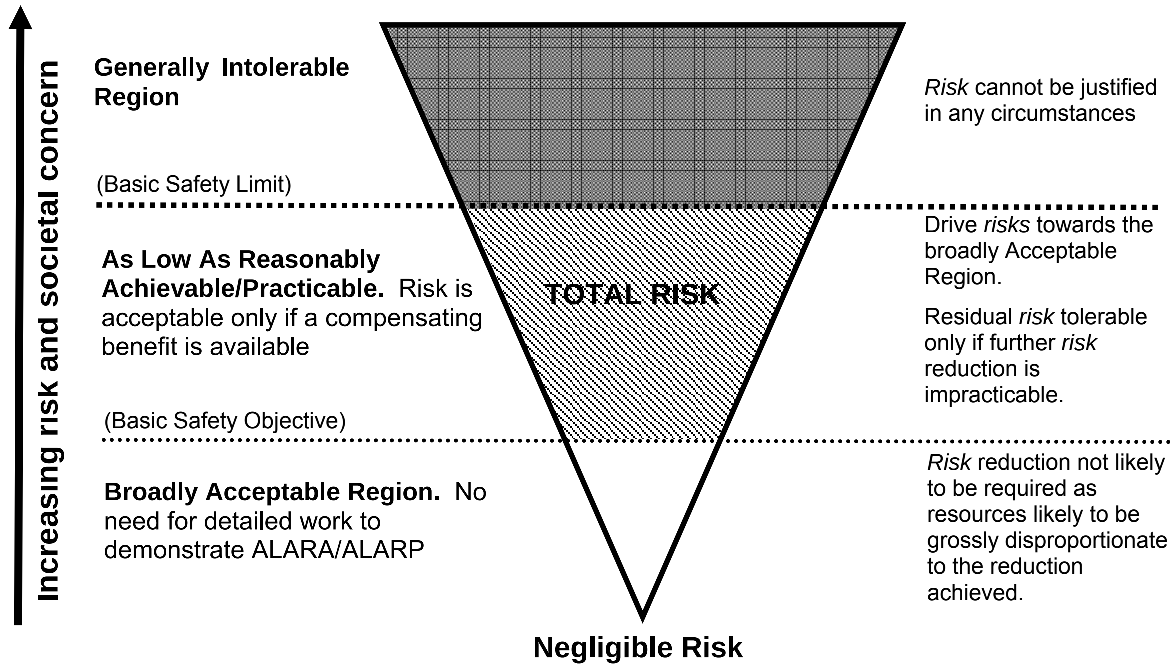

Figure 6 – ALARP principle

6.2 RISK MATRIX

The *professional practice* may develop explicit criteria for considering the *consequences* and *probability* of *risk*s and defining an *acceptable* or *tolerable level of risk*. Effectively, this operationalizes the ALARP principle. Often, this is shown in the form of a *risk* evaluation matrix (see Figure 7), similar to the example given in Figure 4, but includes a description of what are a low level (*acceptable*) *risks*, medium level (*acceptable/tolerable* with certain conditions) *risks* and high level (*intolerable*) *risks*.

Such matrices may be adapted to any *professional practice*'s circumstances, operations, types of *risk,* magnitude of *consequences*, and *vulnerability* to loss. A sole practitioner's *risk* evaluation matrix will differ significantly from that of a large, operating company. Note that this approach does not reflect the time scale (i.e., short, medium, or long-term) associated with the *risk*s, which must be clearly defined.

CONSEQUENCES INCREASING

LIKELIHOOD INCREASING

REPUTATION/ SOCIETAL	LEGAL / FINANCIAL	ENVIRONMENT & PUBLIC HEALTH	HEALTH & SAFETY						
	$100M ≤ Cost	Multiple fatalities	Multiple fatalities	M	M-H	H	H	H	H
Recurring national attention / punitive action by government/ long term impact on market share and share price	Material (corporate) long-term liability $10M ≤ Cost < $100M,	Catastrophic impact Permanent disability / fatality	Permanent disability / fatality	M	M	M-H	H	H	H
National news / public outrage / short term drop in market share and share price	Significant long-term liability, enforcement action $1M ≤ Cost < $10M	Significant adverse impact	Temporary disability/ lost time	L	M	M	M-H	H	H
Provincial news / adverse impact to reputation at provincial level	Permit violation or administrative penalties $100K ≤ Cost < $1M	Minor environmental impact	Medical aid, injury or illness/ restricted work/ nuisance to public	L	L	M	M	M-H	H
Community concern / local media attention / no impact to reputation	Uncontained release below legal limit $10K ≤ Cost < $100K	Small uncontained release with minor impacts	First aid / minor illness, possible cumulative impact onsite	L	L	L	M	M	M-H
Individual concern / local media attention/ no impact to reputation	Cost < $10K	Release onsite - contained immediately	Incident - no treatment	L	L	L	L	M	M
			EVALUATION DESCRIPTOR	Expected never to happen	Not during lifetime of the project	Could happen once in project lifetime	Could happen once in ten years	Could happen as much as once per year	Could happen many times per year
			PROBABILITY	p < 1/10,000 yrs	1/1000 yr ≤ p < 1/10,000 yrs	1/100 yr ≤ p < 1/1000 yrs	1/10 yr ≤ p < 1/100 yrs	1/yr ≤ p < 1/10 yrs	p≥ 1/yr

Figure 7 – Sample *risk evaluation* matrix for a large operating company[36]

36 Revised diagram from various industry sources and Frank E. Bird Jr. & Robert G. Loftus, Practical *Loss Control Leadership*. Revised Edition, 1996.

A *risk* evaluation matrix may be used to clarify to employees what is considered *tolerable*. *Consequence*s may be represented in terms of effects to occupational health and safety, environment and public health, or in economic terms. *Likelihood* may be represented either quantitatively or qualitatively. The low (L) *risk*s are usually *tolerable* without any further management involvement or design additions; employees are aware of the *risks* and follow established procedures. However, it is then essential to develop programs to monitor the situation so that it does not deteriorate over a period of time. Medium (M) or medium-high (M-H) *risk* is where management needs to be involved to ensure the *risk* is kept under control. It is worthwhile noting that management's responsibilities come to the front line as they are assuming the responsibility for tolerating the *risk.* Again, what is acceptable or tolerable to the decision makers may not necessarily be acceptable to other stakeholders. High (H) *risk*s may require that management takes steps to reduce or control the *risk*s or terminate the project or activity entirely.

Diligent *professional practices* have determined what level of *risk* they are willing to accept and have communicated this to all employees. Then the *professional practice* is able to prioritize the *risks* to be managed, often through Pareto-type analysis (i.e., 80% of risks may be reduced with 20% of resources). Further controls, management systems, protective features, etc. can be added to reduce the *risk* to a more *tolerable* or *acceptable* level. Section 7.0 discusses *risk management* principles in more detail.

6.3 BENEFITS VERSUS RISKS

In evaluating *risks*, the opportunities and benefits associated with the project or activity must be compared to the specific vulnerabilities and the particular *risks*. Identification of *risks* and the associated uncertainties is critical to the overall communication and planning, which must be performed before a decision to proceed with a particular project or activity.

Evaluation of the tangible and intangible opportunities and *consequences* should be considered. Benefits from the activity should be considered along with capital and operational costs. "Soft" *risks*, such as negative perceptions, should also be considered because of the significant impact that could result.[37] Negative perceptions need to be managed effectively to ensure perceptions among *stakeholders* do not cause the *risk evaluation* to reach a possibly inaccurate assessment. For example, residents may oppose a landfill being sited in their neighbourhood because they are concerned about noise, additional truck traffic, odour, and reduction in property value without realizing that these impacts could be effectively managed.

Note that the value curve for benefits and costs is asymmetrical – individuals tend to be *risk* averse. Therefore, the benefit-cost analysis is not a simple summation. Costs are weighted more heavily than equivalent benefits. In addition to the net value of the costs and benefits, who bears or receives that net value will affect the acceptability of *risk*.

> Consider the asymmetric value of being on-time at an airport departure gate. The cost of being five minutes early at the gate is much less than the cost of being five minutes late.

37 *Risk* Management *Guideline for Decision Makers*, CAN/CSA-Q850-97 (Reaffirmed 2002), A National Standard for Canada.

The exposure to loss should also be measured against the cost of eliminating or reducing the *risk* of loss. However, members should be clearly warned that business decisions which consciously prioritize profit over safety or environmental concerns can, in fact, significantly increase their potential exposure to civil liability and liability under public welfare statutes.

It is very important to recognize when *risks* may be too high. Company values and objectives all come to play, including the idea of lost profits, personal promotions, and professional defeat. A clear statement on the *intolerability* of *risks* (not do something that is unsafe, pollutes, damages assets; *risk*s business needlessly; or impacts the public's view negatively) will indicate the *professional practice's* values to employees and the public.

> Ford was aware that the placement of its Pinto fuel tank was such that it created significant risk for passengers to be incinerated after a rear-end collision. In its cost-benefit analysis, Ford projected that the Pinto would cause 180 burn deaths, 180 serious burn injuries, and 2100 burned vehicles valued at an annual cost of $49.5M. Ford estimated that the cost of installing safety features would total $137M annually, and decided that it wasn't profitable to fix the Pinto design. Ford was inevitably faced with a civil lawsuit relating to the severe injuries caused by a rear-end collision in a Pinto. The jury returned a $126M civil judgment against Ford, in large part due to its decision to adhere to a cost-benefit analysis which placed a dollar value on human life. After 27 deaths, Ford had suffered a significant loss of public trust and was required to recall and correct all Pintos.

6.4 STAKEHOLDER PERCEPTIONS, PARTICIPATION AND COMMUNICATION

It must be recognized that any public discussion of *risk* is a political exercise - *risk* is not solely defined by individuals and the public as an *objective*, calculable phenomenon.[38] *Stakeholders*' evaluation of the *acceptability* or *tolerability* of *risk*s depends upon the *vulnerability* of their resources, their current status, their perception of *risk*, their cost-benefit evaluation, identifying and comparing feasible risk management strategies and contingency planning (discussed in Section 7.0). The list of *stakeholders* developed in the project or activity scope identification stage may need to be revisited and revised.

Stakeholders' perception of *risk* depends upon various attributes of the *risk* - whether it is controllable, voluntary, immediate, known to science, etc. There are additional contextual variables that determine how the *risk*s are generally perceived by society and by the political process:[39]

> A voluntary, controllable *risk* would be the personal choice to bungee jump or to drink and drive.

- Emotional associations with the *risk* (stigma).
- Trust in regulatory agencies and *risk*-handling institutions.
- Social and cultural beliefs association with the cause of *risk* or *risk management*.

38 C.E. Althaus. "A Disciplinary Perspective on the Epistemological Status of Risk", *Risk Analysis*, Vol. 25, No. 3, 2005.

39 A. Klinkeand O. Renn, "A New Approach to Risk Evaluation and Management: Risk-Based, Precaution-Based, and Discourse-Based Strategies", *Risk Analysis*, Vol. 22, No. 6, 2002.

> One target for safety as a measure of public *risk acceptability* was that used by the Walkerton Inquiry: safety is a level of *risk* so low that a reasonable informed *person* would be justified in not worrying about that *risk*.

The public's evaluation of the *acceptable level of risks* is difficult to determine;[40] making *stakeholder* involvement so necessary in evaluating and managing *risk* issues. *Stakeholders* may not explicitly accept the *risks*, but be willing to tolerate them. The public's determination of the tolerability of *risk*s and their response depends upon four main elements:

- Inequity and injustice associated with the distribution of *risk*s and benefits over time, space, and social status (thus covering the criterion of equity).
- Psychological stress and discomfort associated with the *risk* or the *risk source* (as measured by psychometric scales).
- Potential for social conflict and mobilization (degree of political or public pressure on *risk* regulatory agencies).
- Spill-over effects that are likely to be expected when highly symbolic losses have repercussions on other fields such as financial markets or loss of credibility in management institutions (theory of social amplification of *risk*).

> In December 1994 Shell Oil submitted a plan to sink Brent Spar, a 14,500 ton oil platform in the north Atlantic Sea, to the ocean floor. In weighing disposal options for the platform, Shell used an assessment approach know as BPEO, or Best Practical Environmental Option. This involved evaluation of the following criteria: Engineering Complexity, Risk to Health and Safety of Workforce, Environmental Impact and Resource Use, Cost, and Consultation Process. Essentially, the only stakeholders who were considered were shareholders, the British Government, and consulting companies. When Greenpeace and other environmental advocates learned of Shell's plan, they were furious. Public outrage was so extreme that Shell lost millions of dollars in sales, 200 Shell service stations were threatened in Germany, 50 were damaged, two fire-bombed, and one was fired upon. On June 20th 1995, Shell cancelled plans for Deep Sea Disposal. On June 29th, eleven out of thirteen European governments in the Oslo Commission announced a ban on the dumping of oil installations at sea.

The level of *stakeholder* involvement and communication must also be considered. Is direct involvement in the *risk* evaluation required? Does *stakeholder* participation involve an approval or decision? Communications must be a two way dialogue with realistic expectations. *Professional practices* must listen carefully, allow participants to provide their perspective, and take the time to understand their perspective. The concept of *risk* is not easily understood and often people's first reaction is to "push back" on *risk* issues until they can understand. The skills and tools around successful *risk* communications and *stakeholder* involvement need to be applied throughout this process.[41]

There is no surer way to generate public outrage than to assume that what is acceptable to the *professional practice* will also be acceptable to the public. There is substantial literature on *risk* communication (for more resources, refer to Appendix A). However, the best *risk*

40 D.R. O'Connor. *Report of the Walkerton Inquiry. Part 2. A Strategy for Safe Water*. Toronto, *The Walkerton Inquiry:* 2002. 582 pp.

41 *In the Chamber of Risks - Understanding Risk Controversies* 2001. McGill Queens University Press. 388 pp. ISBN 0-7735-2246-8

communication strategy is to identify *stakeholders* early, include them in the *risk assessment* and *risk evaluation* process, and be honest and transparent throughout the process.

7 RISK MANAGEMENT FOR THE PROFESSIONAL PRACTICE

The *risk management* process is presented in Figure 1. *Professional practice*s that employ this process are able to identify *hazards* and manage the *risks* to occupational health and safety; the environment and public health; legal, financial, and assets; and to the *professional practice's* reputation. This will have a direct bearing on considerations with respect to the need to fund any specific *risks* and the most appropriate vehicle to do so.[42]

7.1 DUE DILIGENCE AND REASONABLE CARE

Professional members are legally, ethically, and morally bound to safeguard the public, their employees, and the environment. How do *professional member*s ensure that they have fulfilled these obligations? The measure is due diligence and reasonableness: "the diligence reasonably expected from, and ordinarily exercised by, a *person* who seeks to satisfy a legal requirement or to discharge an obligation."[43] Reasonable care is "a test of liability for [both civil and criminal] negligence, the degree of care that a prudent and competent *person* engaged in the same line of business or endeavor would exercise under similar circumstances".[44]

There is substantial overlap between the concepts of *risk management* and due diligence. A comprehensive, documented *risk management* plan which operates effectively will provide a due diligence defense in most cases. Thus all topics relevant to *risk* prevention and reduction would also be relevant to the topic of due diligence.

In reviewing a due diligence defense, a judge will consider the following:[45]

1) Foreseeability – Would the incident have been foreseeable to a reasonable member of your industry? Ignorance is not an adequate defense.
2) Preventability – Defendant must demonstrate that everything reasonable was done to prevent the incident, with documented proof of:
   - Identified workplace *hazard*s.
   - Prepared and enforced safe work procedures.
   - Trained workers
   - Monitored workers after training.
   - Implemented progressive disciplinary policies.
3) Controllability – Defendant must demonstrate that he or she had no control over the circumstanced that resulted in the incident.

42 Risk factors associated with characteristics of the owner, of the professional practice, the professional services contract, the contractor and the project are discussed in detail in *Development of Consulting Rate Structures and Contracts,* v1.0. APEGGA, February 2005.

43 Black's Law Dictionary, Second Pocket Edition. Bryan A. Garner, Editor in Chief, West Group, A Thomson Company, St. Paul, Minnesota, 2001.

44 Black's Law Dictionary, Second Pocket Edition. Bryan A. Garner, Editor in Chief, West Group, A Thomson Company, St. Paul, Minnesota, 2001.

45 Dr. G.F. Jergeas, P.Eng, Speaking Notes "Risk and Loss Management – Roles and Responsibilities of Professionals", November 2004.

- Policies and procedures meet or exceed industry standards or accreditations.
- Policies and procedures in place to delegate responsibility.
- Policies and procedures followed in delegating responsibility.

7.2 RISK MANAGEMENT APPROACHES

A professional *practice* can use the *risk management* process in Figure 1 to identify and manage *risks*. This serves to protect the public, employees, the environment and itself while acting with due diligence. How does a *professional practice* develop and implement a *risk management* program? The *Occupational Health and Safety Act* and regulations, other legislation and regulations,[46] and guidelines (refer to Appendix A) outline methods to identify *risk* exposures, prevent accidents, and the means to protect workers and general public. This *risk management* program must be documented – perhaps in the Professional Practice Management Plan (PPMP), Quality, Environmental (ISO14000), Health and Safety, or Special Operational (ISO9000) Plans. For further assurance, have a third party review the *risk management* program.

The generally recognized elements of an effective, overall *risk management* plan for a *professional practice* include the following (note that these elements are not mutually exclusive):[47,48]

1. Management Leadership, Commitment, and Accountability
2. *Risk Assessment* and Management
3. Community Awareness and Emergency Preparedness
4. Management of Change
5. Incident Reporting, Investigation, Analysis, and Actions
6. Program Evaluation and Continuous Improvement
7. Design, Construction, and Start-up
8. Operations and Maintenance
9. Employee Competency and Training
10. Contractor Competency and Integration
11. Operations and Facilities Information and Documentation

Each of these elements is discussed next.

7.2.1 Management Leadership, Commitment, and Accountability

The leadership, commitment, and accountability are the most important components of a *risk management* program. Without leadership the program will fail. Management sets

46 Municipal waste by-laws, Alberta Sale of Goods Act, Alberta Environmental Protection and Enhancement Act, the Alberta Water Act, Canadian Motor Vehicles Safety Act, Hazardous Products Act, Canadian Environmental Protection Act 1999, the Canadian Environmental Assessment Act, Canadian Criminal Code and associated regulations.

47 This listing is consistent with listings used across the US and is supported through the Canadian Society of Chemical Engineering (CSChE), which manages the Major Industrial Accidents Council of Canada (MIACC) with the Canadian Association of Fire Chiefs.

48 L. Wilson and D. McCutcheon. Industrial Safety and Risk Management. Industrial Safety and Loss Management Program, Faculty of Engineering, University of Alberta. University of Alberta Press, Edmonton, 2003.

the corporate goals and objectives, allocates resources, and holds the organization and individuals accountable for performance. *Risk management* must be a priority for the *professional practice* for any efforts to succeed.

7.2.2 Risk Assessment and Management

Sections 3-6 of this guideline outlined the principles for identifying hazards and estimating and evaluating risks. Once *risk*s have been evaluated for a *professional practice*, then these *risks* may be prioritized for management. *Risk management* answers the question: 'What can be done to reduce the *risk*s if we need to?' *Risk management* is a proactive approach to decrease the *probability* and/or *consequences* associated with *hazards* and to control the personnel, material or financial loss or professional liability exposure.

Risk management may be considered as a step-wise function including: the prevention of exposure to loss, the mitigation of loss when loss-producing *events* occur, the transfer of *risk* via insurance policies or contractual agreements, and the retention of any remaining *risk* (refer to Figure 8). It should be emphasized that the ultimate goal of *risk management* should be to eliminate *risk*s, if possible. Once a *risk* is identified, alternatives should first be considered to eliminate the *risk* if possible, failing which, measures should be implemented to control and reduce the *risk*. Thus, the transfer or retention of *risk* is may not be necessary.

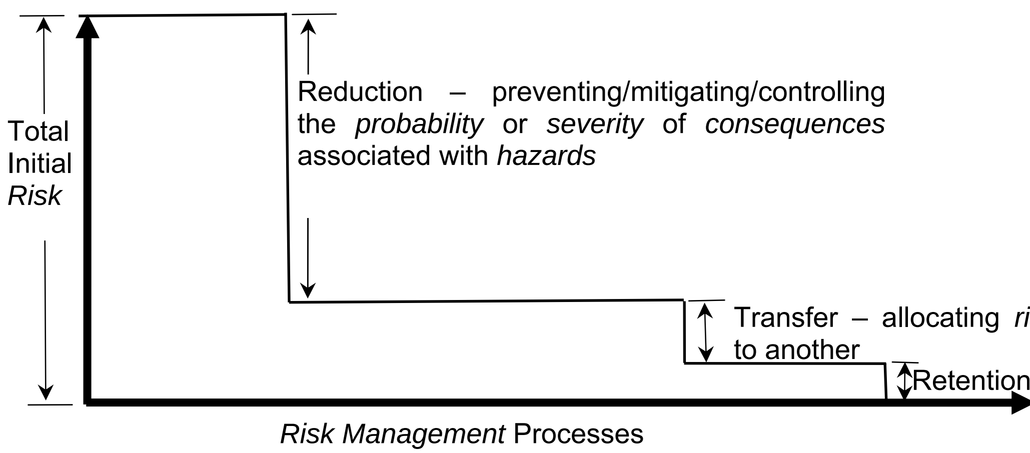

Figure 5 – *Risk management* as a step-wise function, focusing on *risk* reduction first, then *risk* transfer and, lastly, *risk* retention.

What can be done to reduce the *probability* or *severity* of *risks*? *Risk* prevention, mitigation, and control options can be grouped into ten general strategies:[49] Examples of these strategies are given for the leaking fuel tank in Figure 3.

1. Prevent the creation of the *hazard* in the first place (i.e., do not install an underground storage tank).
2. Reduce the amount of *hazard* brought into being (i.e., install a smaller underground storage tank).

49 Haddon, W., "The Basic Strategies for Reducing Damage from Hazards of All Kinds", *Hazard Prevention*, Journal of the System Safety Society, September/October 1980 issue.

3. Prevent the release of the *hazard* that already exists (i.e., install a double wall underground storage tank with a leak detection system).
4. Modify the rate or spatial distribution of release of the *hazard* from its *source* (install a clay liner around the underground storage tank).
5. Separate, in time or in space, the *hazard* from that which is to be protected (i.e., do not install an underground storage tank near residents, ground water, or surface water).
6. Separate the *hazard* and that which is to be protected by the interposition of a material 'barrier' (i.e., pave the ground surface to prevent gas vapours; install an interceptor well to prevent the plume from contaminating the ground or surface water).
7. Modify relevant basic qualities of the *hazard* (i.e., install the fuel tank above ground instead of underground).
8. Make that to be protected more resistant to damage from the *hazard* (i.e., equip gas station workers with breathing apparatus, develop an emergency preparedness plan).
9. Begin to counter damage already done by the *hazard* (i.e., remove underground storage tank).
10. Stabilize, repair, and rehabilitate the object of the damage (i.e., remediate soil, ground water, and surface water contamination).

When *professional practices* estimate and evaluate their *risks*, it is recommended that that they consider these basic principles to prevent or reduce the *risks*. Many of these ten general *risk* reduction strategies are inherent in the following elements of a *risk management* program for any *professional practice,* activity, or project.

7.2.3 Community Awareness and Emergency Preparedness

Understanding the worst case scenario and then developing an emergency plan around managing it is important for the success of the *professional practice* and the well being of its employees and surrounding residents. If the emergency plan is set up to handle the worst case, then it will be able to handle minor incidents.

In addition to handling emergencies, a *professional practice* needs to work with its community and *stakeholders* on an ongoing basis. The public can be a *professional practice*'s greatest supporter if knowledge is shared with them. *Professional practice*s should attempt to understand the needs of the community and *stakeholders* in order to be an effective member of the community.

7.2.4 Management of Change

When any changes are made in a *professional practice's* operations, design, construction change orders, organization, regulatory operations, processes, or policies, the *risk management* process must be used once again to identify new *hazards* and evaluate new *risks*. Changes in processes often create potential problems upstream or downstream. Doing planned reviews ensures that any changes are contemplated by and included in the *professional practices risk management* program. If any new *hazards* are not identified, operational *risk* may unknowingly increase.

7.2.5 Incident Reporting, Investigation, Analysis, and Actions

Documentation and the analysis of incidents can provide a great deal of insight into future consequences of activities or projects. Incidents, including close-calls, should be investigated if the causes are not well known. Without doing this a *professional practice* will not learn from the incident nor proactively reduce the *risk*s. Investigations provide information for future reference, for updating protective features, and improve training materials.

Incidents are usually caused by underlying factors, which may not be readily apparent. Often the fundamental causes are organizational/institutional factors and not human factors. Methodologies are available for doing basic cause investigations.[50]

> In March 2005, there was an explosion at a BP-Amoco refinery in Texas City that killed fifteen people, injured 100 employees and thirty members of the public, with eight in critical condition. The explosion was believed to be the result of an unconfined vapour cloud explosion with a started car as the *source* of ignition. Of interest are the following incidents which occurred at the same plant.
>
> - The day prior to the explosion, a furnace valve caught fire.
> - In March 2004, a similar explosion on the same plant had occurred, requiring evacuation of the entire facility. Afterwards BP was fined $US 63,000 for fourteen safety violations including problems with its Emergency Shutdown System and Employee Training.
> - In 2002, at the same plant, two maintenance employees were killed when scalding hot water (260°C) was released from a pump seal – only a check valve was used as isolation for the pump.

7.2.6 Program Evaluation, Continuous Improvement, and Peer Review

An ever improving *risk management* program is needed to maintain a competitive position and good *stakeholder* relations. Effectively managing *risk*s may also result in improving operations and reducing costs, reducing the *probability* and *consequence*s of incidents, improving personnel morale, and reducing insurance premiums.

Management may also engage peer review – which can be seen as a method of *risk* avoidance for professional design firms. *Risk* issues often originate in the soft side of a *professional practice*; running the firm, managing projects and relating to clients. Insurance companies offering professional liability insurance have long recognized this; and encourage firms to avail themselves of peer review services.[51]

The purpose of a peer review is to give the firm a proactive, voluntary, and confidential means to improve its practice, by identifying the firm's objectives, policies, and procedures (such as might be stated in a Professional Practice Management Plan) and then examining how these policies and procedures are implemented.

7.2.7 Design, Construction, and Start-up

Design, construction, and start-up of a project tend to present particularly greater *risks*. For large projects, a formal *risk management* plan should be developed (including identification and funding of *risk*, development and implementation of quality control procedures, and the effective resolution of disputes). A *risk* manager may be assigned.

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50 Frank E. Bird Jr. & Robert G. Loftus. *Practical Loss Control Leadership.* Revised Edition, 1996.

51 Peer review services are often available through professional societies or associations. For example, the Association of Consulting Engineers of Canada (ACEC) offers a well organized and active peer review program. The accredited reviewers are themselves senior engineering executives with many years of accumulated experience. They have trained for this activity and are obliged to attend refresher sessions at regular intervals.

For smaller projects, *risk management* should be addressed as part of the project management and execution activities.

At the project level, the *risk*s can become very specific with very specific control strategies developed. The *risk*s can be associated with the project owner approvals, financial, political climate, environmental approvals, public or *stakeholder* tolerance, cost control, schedules, communication, site safety, design, specifications, quantity estimates, procurement, construction management and contracts, and commissioning. Following is a brief overview of additional considerations to manage *risk*s:[52]

Preparing Tender and Contract Documents

- Standard policies and procedures should be established for preparing tender and contract documents.
- A system for control of tender documents and handling addenda during tendering should be included. Project management staff should be trained in presiding at tender openings, evaluating tenders and recommending contract awards.
- Standard company contract forms and general conditions of contract should be subject to professional and legal reviews on a regular basis. Personnel should understand the organization's role and responsibilities within the context of these documents.
- The excessive use of wholesale reuse of existing documentation for new projects should be approached with caution. Careful review of any documentation re-used from previous contracts must be conducted in order to ensure the appropriateness to the new project or activity.

Professional Services Agreements[53]

Project owners often engage other *professional members* for design and construction.

- For projects that involve an owner commissioning the services of a consultant, a professional services agreement should be established between involved parties.
- The agreement can reduce or mitigate project *risk* through project management processes, agreement language and terms, and insurance provisions.

> Sound contracts reduce disputes. In 40% of Encon's errors and omissions claims, there have been no contracts signed by the parties.

- Legal advice regarding the wording of the contracts rather than using a generic or simplified agreement may also provide protection to the professional practice.
- Specific contractual clauses may limit liability between the owner, consultant, and other third parties. Further, the *Alberta Limitations Act 1999* sets time limits for breach of contract lawsuits. Refer to *APEGGA's Development of Consulting Rate*

52 More detailed information may be obtained from: Professional Liability Insurance websites such as the Encon Group (www.encon.ca) or XL Capital (www.XLDP.com); the Consulting Engineers of Alberta (www.cea.ca) documents *Procedures & Quality Assurance of Proposals and Projects* and *Quality Based Selection*, and *Risk Management Guideline for Decision Makers*, CAN/CSA-Q850-97 (Reaffirmed 2002), A National Standard for Canada. Also, the Consulting Engineers of Alberta's *Procedures & Quality Assurance of Proposals And Projects* is available online at: http://www.cea.ca/pdf/QAManual.doc.

53 The APEGGA publication entitled *Developing Consulting Rate Structures and Contracts* provides more detailed information regarding Professional Services Agreements.

Structures and Contracts for a more thorough discussion of limitation of contractual liability. Prudent *risk management* requires that *professional members* pay close attention to the terms and conditions of the contracts that they are asked to sign. In some cases, liability assumed under a contract may be uninsurable.

Project Planning, Management, and Execution

For each project, especially for large, multidisciplinary projects, a plan should be developed to confirm the following:

- Clear definition of the objectives, concepts, and assignment project and an understanding of the scope limitations.
- Development of work plan, functional description, site data, code restrictions,
- Budget, cost limitations, schedules, time restrictions.
- Organization and composition of the project team to facilitate communication and coordination of technical disciplines, define lines of communication and define lines of authority to minimize gaps or overlaps.
- Change management system to document and confirm all changes to schedule, cost and project scope.

Risk reduction solutions for the project itself may consider the following:[54]

- substitution in the process,
- change in the design of process systems,
- modification of the control systems,
- organizational change,
- operating and maintenance procedures,
- personal protective equipment,
- improved communications,
- increased of varied training, and
- simulations to improve understanding.

Quality Control Procedures

- Effective project management requires the establishment of ongoing project review, quality standards, and the processes to be used to ensure compliance.
- Critical stages should be identified at which reviews and sign-offs are required and the follow-up to ensure that the reviews are undertaken.

Project Communications and Records

- For larger projects, regular meetings should be held and minutes from these meetings recorded. Procedures should be developed for recording all communications, including identifying when verbal communications will be confirmed in writing.
- A document control and file management system should be in place to ensure that documentation is kept up to date and to facilitate retrieval of project information.

54 Laird Wilson and Doug McCutcheon, *Industrial Safety and Risk Management*, University of Alberta Press, 2003, p. 46.

- Procedures should ensure that only current documents, drawing and specifications are being used or issued. A policy should be in place that sets out file backup and archival requirements.

Cost Estimation and Control

- Procedures for preparing cost estimates and tracking expenditure commitments should be established. The ability to estimate and track costs is essential to effective project management.
- The certainty of any cost estimates and the limitations of their use should also be considered where appropriate.

Construction Management and Review

- Communication procedures should be established for the construction period. Systems should be in place for handling change requests, change orders, progress payment processing, shop drawing reviews and other documentation.
- Project managers should review field reports promptly and follow-up as required. Field personnel should be given clear lines of responsibility, authority and reporting expectations.

Project Close-Out

- Standard policies and procedures should therefore be established for closing out projects, including documentation of original design, change orders, project history and as-builts conditions. These procedures should include archiving requirements, close-out communications, record drawings, sign-off requirements and final project evaluation.

7.2.8 Operations and Maintenance

To control *risk*, the operation and maintenance of facilities must be within established criteria. Real-time operational data provides feedback. A *professional practice* should provide necessary reference resources for decision-making and keep records of activities.

7.2.9 Employee Competency and Training

Careful selection of employees is imperative. It is the responsibility of the *professional practice* to ensure employees are properly trained in order to do their job. That training is of current policy and procedures meaning the content of any training course must be current and kept up to date with changes. The trainers must be qualified to put on course material and have skills in delivery of the content. They need to be skilled in how to deliver training in an effective way such that

> Despite massive media attention about the fatal Walkerton outbreak, only 11 months later North Battleford also had a drinking water outbreak of cryptosporidiosis that affected thousands of residents and travelers. Although the public inquiry into the North Battleford outbreak revealed many institutional, regulatory and technical problems, Justice Laing noted that the City lacked the knowledge to assure safe drinking water and maintained policies that prevented it from acquiring such knowledge. In particular, he noted that the City failed to encourage continuing education for its operators

they can measure how well the training was retained. The water contamination in North Battleford is a prime example of inadequate employee training.[55]

Finally, there is a strong need to provide refresher training on an annual basis to ensure all workers are following the policy and procedures as expected. This is also a time to look at the operation and changes in order to update the training content. It is common knowledge that people will forget the procedures if they do not use them and people will develop short cuts in order to get the work done more easily.

7.2.10 Contractor Competency and Integration

Contractors play an increasingly larger role in companies and may introduce additional *risks* into the operation. Contractors cannot be expected to know the *professional prac*tice's business or policies. Therefore, the *professional practice* must ensure that contractors are trained and audited in safety procedures, included in job briefings, and integrated in operations. Management must recognize where the contractor could have a negative effect on the operation and put in place procedures to protect against possible incidents.

> A maintenance worker experienced difficulty removing bolts on a tank and used a grinder to cut the bolts. Sparks ignited residual gas in the tank and caused an explosion, which resulted in a fatality. Employers must ensure that proper work instructions are in place for contractors. In this case, the operating company and contractor were both fined by Alberta Occupational Health and Safety.

7.2.11 Operations and Facilities Information and Documentation

Selecting what information to document and how to manage it should be part of *professional practice's risk management* program. Documentation of operational details is important from the conceptual stage through the research stage and into design, construction, start-up and operation. Accurate and up to date documentation demonstrates due-diligence and supports informed decision making.

8 TRANSFER, RETENTION, AND MONITORING OF RISK

Risk exists as an integral part of the products of engineering and geoscience and how *professional members* practice their professions. Complete *risk* avoidance is neither possible nor desirable. However, *professional members* are reminded of their ethical obligations as per the *Code of Ethics*: they cannot allow any transfer, retention, or externalization of *risk* that would harm the public, their employees, or the environment.

8.1 TRANSFER OF RISK

There are two primary methods of transferring *risk*: contractually to other parties through terms in an agreement or to an insurer through an insurance policy. *Professional members* are advised to discuss these methods of risk transfer with legal counsel or their insurance providers.

55 R.D. Laing. *Report of the* Commission of Inquiry into matters relating to the safety of the public drinking water in the City of North Battleford, Saskatchewan. March 28, 2002 Department of Justice, Government of Saskatchewan: 372 pp. Available URL; http://www.northbattlefordwaterinquiry.ca

Contract Language
After considering the general terms of the *contract*, specific attention should be given to limiting liability. The degree of care, limitation of liability, and third party indemnity are discussed in the APEGGA document: *'Development of Consulting Rate Structures and Contracts'.*

It is important for a *professional member* to be aware that some aspects of contractual language may not be enforceable, particularly if it is in contravention of regulatory of statutory requirements. Some attempts are made by *professional members* to transfer *risk* or obligations for some types of projects or activities in project documentation or project specifications. Professional members should be aware that to transfer *risk*, more than one method of communicating this transfer may be required.

Insurance
Upon assessing the *risk*, the *professional practice* should ensure that the coverage and terms of the errors and omissions and professional liability insurance are sufficient for the scope of work. In addition to professional practice coverage, project specific insurance may be available and can be arranged by either the owner or the consultant. APEGGA's Guideline for the *Development of Consulting Rate Structures and Contracts* also discusses errors and omissions and general liability insurance. In *professional practice*, it is important to ensure that any sub-consultants or other professionals involved in a particular project or activity have adequate insurance to in the event of negative *consequences*.

A *professional practice* may be able to illustrate that its *risk management* program results in lower than average *risks*. If that is the case, then it may be able to negotiate with insurers for lower premiums or expanded coverage.

8.2 RETENTION AND MONITORING OF RISK

Although a *risk* may be tolerated this does not mean that the *risk* has disappeared or that it has remained static. The *consequences* of that particular *hazard* may occur and it is essential that the *professional practice's risk management* systems are actively monitoring the operation for concerns and take proactive actions to correct potential problems. Also, as a project progresses or a *professional practice*'s business evolves, the *acceptable*/*tolerable* level or type of *risk* will may change. A good *risk management* program must have a mechanism in place for periodic review to continually monitor and manage *risks*.

9 SUMMARY

No document can advise on the level of *risk* a *professional practice* should be willing to assume. This guideline points out some methods to identify and evaluate the *risk* and common methods for managing *risks*. These principles only provide an introduction for a *professional member* to develop a *professional practice's risk management* plan. *Professional members* are advised to source additional references and resources, where appropriate, for their own *professional practices*.

APPENDIX A – ADDITIONAL REFERENCES AND RESOURCES

BOOKS

"Safety and Health for Engineers" second edition by Roger L. Brauer
ISBN –10: 0-471-29189-7 – Publisher John Wiley & Sons Inc.

"Basic Guide to System Safety" second edition by Jeffrey Vincoli
ISBN-10: 0-471-72241-3 – Publisher John Wiley & Sons Inc.

Loss Prevention in the Process Industries Hazard Identification and Control" second edition by Frank P Lees
ISBN 0-7506-1547-8 – Publisher Butterworth-Heinemann

"Risk Communications, Risk Statistics, and Risk Comparisons: A Manual for Plant Managers" by Vincent Covello, Peter Sandman, Paul Slovic – Published by the Chemical Manufacturers Association

Prospects and Problems in Risk Communications" edited by William Leiss – Published by the Institute for Risk Research
ISBN 0-88898-095-7

IEC-61882

WEB SITES

Global Risk Management:
Risk World (a very broad website of risk contacts) www.riskworld.com

Knovel Library (an online library service with many current titles on risk under the "safety, health and hygiene" category. You need to have a subscription to access the documents but many companies might be smart to have it) www.knovel.com

The American Institute for Chemical Engineers "Safety and Health Division" www.shdiv.aiche.org

The Health and Safety Executive of the United Kingdom www.hse.gov.uk

The International Electrotechnical Commission (IEC) (much of what is happening around the world in the areas of electrical standards) www.iec.ch

European Technology Platform – Industrial Safety (many connections to all types of health, safety and risk from a joint European approach) www.industrialsafety-tp.org

Marsh Consulting an insurance industry view of the worlds largest disasters from 1972 – 2001, interesting reading) www.marshriskconsulting.com

ROOT Cause Analysis techniques developed for incident investigations by a company called Apollo Associated Services Corp. www.apollorca.com

ESR Technology, engineering safety and risk topics for many industries and another European connection www.aeat.com

Canadian Risk Management:
Construction Owners Association of Alberta (a very good website for getting useable materials for program development) www.coaa.ab.ca

Alberta Environment www.environment.gov.ab.ca

The Alberta Safety Council www.safetycouncil.ab.ca

The Alberta Construction Safety Association www.acsa-safety.org

Alberta "Workplace Health and Safety" www.gov.ab.ca/hre/whs/index.asp

Alberta Workers' Compensation Board www.wcb.ab.ca

The Encon Group www.encon.ca

XL Capital (formerly DPIC) www.xldp.com

Department of Justice – Canada for "BILL C-45 - AMENDMENTS TO THE CRIMINAL CODE AFFECTING THE CRIMINAL LIABILITY OF ORGANIZATIONS" www.canada.justice.gc.ca

Health Canada "Occupational Health and Safety – *Publications*" www.hrsdc.gc.ca

Association of Workers' Compensation Boards of Canada" www.awcbc.org

Canadian Society for Chemical Engineering Process Safety Division (where the MIACC materials can be located.) www.cheminst.ca/divisions/psm/index.htm

Canadian Centre for Occupational Health and Safety (Canada's version of the US NIOSH, a very good website for current workplace exposure data) www.ccohs.ca

Canadian Centre for Occupational Health and Safety (a specific webpage on Due Diligence in Canada) www.ccohs.ca/oshanswers/legisl/diligence.html

Canadian Association of Fire Chiefs (another location for MIACC information on emergency response) www.cafc.ca

Canadian Standards Association www.csa-intl.org.

Q850/97 "Risk Management Guideline for Decision-Makers"

PLUS 663 "Land use planning for pipelines: A guideline for local authorities, developer, and pipeline operators"

Z1000-06 "Occupational health and safety management"

CAN/CSA Z731 "Emergency Preparedness and Response"

Minerva – Safety Management Education (a program directed at safety education in businesses across Canada, a good place for business case studies)
www.safetymanagementeducation.com

US Risk Management:
The US National Institute for Occupational Safety and Health (NIOSH) a very good resource for hazardous chemicals. www.cdc.gov/niosh/homepage

The US Environmental Protection Agency www.epa.gov

The US Occupational Safety and Health Administration www.osha.gov

The Energy and Utilities Board of Alberta (EUB) www.eub.ca

Risk Communications
Center for Risk Communication www.centerforriskcommunication.org

The human factor topic through the eyes of a psychologist “Stanley Milgram”. Which is interesting in terms of understanding how people think. www.stanleymilgram.com

APPENDIX B - RISK MANAGEMENT CHECKLISTS FOR A PROFESSIONAL PRACTICE

These checklists[56] have been revised as a starting point for *professional practices* to consider the various methods of controlling/reducing their *risks*.

LIMITING RISKS TO WORKERS

- ❑ Provide a safe environment for employees to work in.
- ❑ Make safety everyone's concern.
- ❑ Evaluate the air quality in your building.
- ❑ Control employees' exposure to workplace contaminants and *hazard*s.
- ❑ Incorporate procedures to protect workers from abuse, discrimination, harassment, violence, substance abuse, depression, etc.
- ❑ Pay attention to ergonomics.
- ❑ Evaluate material handling practices.
- ❑ Minimize the *risk* of slips and falls.
- ❑ Use proper machine guards to protect employees.
- ❑ Ensure that emergency egress and evacuation procedures are in place.
- ❑ Ensure WCB coverage is in place.
- ❑ Require employees to report all accidents and illnesses immediately.
- ❑ Focus on getting injured employees back to work quickly and safely.

LIMITING PROPERTY RISKS

- ❑ Identify potential *hazard*s and determine appropriate mitigation strategies.
- ❑ Take inventory of your business assets and store that documentation offsite.
- ❑ Install and maintain appropriate fire detection and suppression equipment.
- ❑ Consider installing a security alarm system.
- ❑ Back up your computer records regularly and store them off site.
- ❑ Install and update anti-virus software on each employee's computer.
- ❑ Make sure your disaster recovery plan is appropriate and comprehensive.
- ❑ Have a contingency plan for power outages.
- ❑ Keep your facilities neat and orderly; inspect and service machinery and equipment annually.
- ❑ Maintain adequate property insurance.
- ❑ Keep up to date with applicable building, safety, and other codes.

LIMITING VEHICLE RISKS

- ❑ Carefully select and supervise employees who will drive your vehicles.
- ❑ Consider testing your drivers for use of controlled substances and alcohol.
- ❑ Implement a comprehensive driver-training program.
- ❑ Limit employees' personal use of company-owned vehicles.
- ❑ Make sure that employed vehicles used for your business are properly insured.
- ❑ Maintain your vehicles regularly.
- ❑ Maintain records for all vehicles.
- ❑ Caution your drivers about the safe use of cell phones.
- ❑ Establish a formal process for reporting and investigating motor vehicle incidents.
- ❑ Ensure your drivers get enough sleep.

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56 Checklists compiled from information provided from The Hartford Business Insurance Centre for Midsize Businesses. Available URL: http://mb.thehartford.com/reduce_risk/

- ❑ Ensure that all drivers are covered by your vehicle's insurance.
- ❑ Caution your drivers about acceptable weather and environmental conditions.

LIMITING PRODUCT LIABILITY

- ❑ Document your company's commitment to product safety.
- ❑ Make sure you can trace every step in the production process.
- ❑ Compile and review complaint files.
- ❑ Ensure any subcomponent suppliers are providing good quality parts.
- ❑ Implement a quality control program for the testing and approving the final product
- ❑ Ensure conformance to any applicable standards for components.
- ❑ Maintain proper documentation throughout every product's life cycle.
- ❑ Develop a formal, written product recall procedure.
- ❑ Have your legal advisor review product literature, warnings, etc.
- ❑ Review contractor and subcontractor agreements periodically.
- ❑ Ensure any operation considerations or limitations are clearly laid out.
- ❑ Ensure you have appropriate insurance for the type of product being produced.

LIMITING PROFESSIONAL LIABILITY

- ❑ Ensure you have a contract for your services that has been reviewed by a lawyer.
- ❑ Ensure you have adequate professional liability insurance.
- ❑ Ensure all subconsultants have adequate professional liability insurance.
- ❑ Stay within your realm of expertise.
- ❑ Clearly outline expectations before work begins.
- ❑ Be aware of any scope drift.
- ❑ Ensure good communication between parties involved in a contract.
- ❑ Keep detailed project and client files.
- ❑ Review how to report a claim to your insurer …before you need to.
- ❑ If you are ever sued, contact your professional liability insurer immediately.
- ❑ If sued and have no or inadequate insurance, contact a lawyer.
- ❑ Do not assume you can transfer all liability with simple clauses in documents.
- ❑ If sued, be prudent with whom you share any information about the incident.

LIMITING LAWSUITS

- ❑ If possible, include 'hold harmless' clauses in your contracts.
- ❑ Ensure you have adequate general liability insurance.
- ❑ Be aware of any co-insurance requirements for your insurance policies.
- ❑ Report any incidents that may result in an insurance claim promptly.
- ❑ Respond to complaints promptly and with care.
- ❑ Carefully maintain your facilities, operations, interior and exterior walkways.
- ❑ Provide written, posted warnings in hazardous areas.
- ❑ Have safety policies to protect visitors.
- ❑ Ensure employees do not admit liability without a formal process.
- ❑ Know what your liability policy does and doesn't cover.