APEGGA

The Association of Professional Engineers, Geologists and Geophysicists of Alberta

Monograph

Voluntary Environmental Standards and the Engineering Profession

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CHAPTERS 1 & 2 (combined)

Environmental Standards:
The Distinction between Mandatory and Discretionary

By: Ronald S. Girvitz, B. Admin., P. Eng., LL.B

Today's professional engineers are faced with a variety of environmental standards addressing topics such as ethics, general standards of conduct and specific practice areas. The difficult often faced by these engineers is to ascertain which of these standards warrant serious attention and which exist merely for their consideration.

The engineer's first and foremost responsibility is to rely upon his or her profession judgement and apply standards which are reasonable and effective. The following chapters of this monograph will discuss many of these standards which the engineer ought to consider for implementation.

Notwithstanding the above, many engineers will look to consequences to determine which standards they would consider implementing. From this perspective, many engineers will discern standards which are mandatory only because of the sanction imposed for their breach. The purpose of this chapter will be to examine the various forms of environmental standards which an engineer might face and to discuss the potential implications for a failure to comply. From this, a decision maker can then weigh the consequences and determine a suitable course of conduct. From a review of the consequences of a failure to comply, a distinction can be drawn between those standards which ought to be considered mandatory and those which are merely discretionary based on the type and severity of sanctions which are attached to each.

1. ENVIRONMENTAL STANDARDS SET BY ENGINEERING ASSOCIATIONS

The first place to examine standards affecting the engineering profession is to look to the standards set by the engineering associations themselves. Because of the importance of the role and engineering association plays in the regulation of the conduct of engineers, the nature of the organization, how standards are enforced and the types of standards engineering associations set which relate to environmental practice shall first be reviewed.

1.1 What Is A Professional Association

Engineering is considered to be one of the "pure" professions owing to its responsibility for public health and safety. For this reason, provincial legislation is responsible for the creation of the profession and governs its existence. A profession is an occupation characterized as on having the following characteristics:[1]

1 Klar et al. (Consultants), *Remedies in Tort*, edited by Linda Rainaldi (1987) Carsell.

- the work performed in the occupation is skilled or specialized with a strong intellectual component. Usually a significant period of technical training is required.

- a professional is expected to be committed to moral principles which go beyond the duty of honesty. This duty may, in fact, transcend the duty to the client, as in the case of the lawyer whose duty of forthrightness to the court may result in disclosure of matters adverse to his client's interest. In general, a professional has, and is seen to have, a duty to the wider community.

- a professional usually belongs to an association which restricts admission and sets codes of conduct and ethical behaviour, and has mechanisms for enforcing them.

Professional organizations were created primarily because of the potential effect on life, health safety or property of the public by professionals, and the need to set standards and controls on the actions of these professionals. These organizations are typically granted the right to self regulate their members. The organization sets the requirements which must be met for a person to gain admission into the organization. Also, the organization sets standards which are intended to ensure that its members adhere to certain practices, which primarily relate to the protection of the public.

Engineering associations are examples of professional organizations created to help ensure the protection of the public. To facilitate this protection, the engineering organization is granted the right of self regulation and exclusivity of practice. Self regulation includes the ability to set admission standards to gain membership and the ability to set and enforce practice standards. Any failure by a member to practice in conformity with these practice standards could subject that member to internal disciplinary proceedings.

Exclusivity of practice refers to the ability of a professional organization to restrict practice only to its members. Any person engaging in an activity that falls within the definition of the "practice of engineering" must be a member of the requisite engineering association. Practicing engineering without such membership is considered an unlawful act.

1.2 How Engineering Associations Enforce Standards

Disciplinary committees determine whether actions of a member have fallen below the acceptable standard. The standard is typically referred to as "unskilled practice" or "professional misconduct." For example, the Association of Professional Engineers, Geologists and Geophysicists of Alberta ("APEGGA") relies on the following standards to determine whether disciplinary actions are required. Specifically, any conduct which:

1. is detrimental to the best interests of the public,

2. contravenes a code of ethics of the profession established under the regulations,
3. harms or tends to harm the standing of the professional generally,
4. displays a lack of knowledge of, or lack of skill, or judgement in the practice of the profession, or
5. displays a lack of knowledge of, or lack of skill, or judgement in the carrying out of any duty or obligation undertaken in the practice of the profession, constitutes unskilled practice or unprofessional conduct[2] and invokes the disciplinary process.

When a disciplinary committee finds that the impugned conduct constitutes unskilled practice or professional misconduct, the committee is typically granted a wide range of remedies for rehabilitating or punishing the member, the most serious being revocation of membership.

1.3 Types of Standards Set by the Engineering Organization

1.3.1 Code of Ethics

Th most visible standard of conduct set by the organization is its Code of Ethics. A code of ethics is the standard by which an engineering organization helps to ensure that the conduct of its members is maintained at an acceptable standard. Its primary purpose is to protect the public[3] but also serves to promote competence and integrity. As discussed, a breach of any one of the codes will constitute unskilled or unprofessional practice.

Various codes of ethics used by Canadian engineering associations reflect environmental standards. Rule 1 of APEGGA's Code of Ethics specifies that:

> "Professional engineers, geologists and geophysicists shall have proper regard in all their work for the safety and welfare of all persons and for the physical environment affected by their work"

The statement is elaborated upon by APEGGA as follows:

> "They shall not complete, sign or seal plans or other documents that, in their professional opinion, would result in projects hazardous to the public or detrimental to human welfare, *would have unnecessary adverse effects on the environment* or do not conform to current engineering, geological or geophysical standards."[4]

A somewhat different wording is found in the British Columbia Code of Ethics:

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2 *Engineering, Geological & Geophysical Professional Act* S.A. 1981 c.E-11.1 as amended December, 1985 at S.43(1).

3 McLachlin, Beverley, Wallace, Wilfred and Grant, Arthur, The Canadian Law of Architecture and Engineering. 2nd Ed. (Toronto: Butterworths, 1994) at 34.

4 Manual of Professional Practice Under the Code of Ethics, First Edition, July, 1990 (Alberta: The Association of Professional Engineers, Geologists and Geophysicists of Alberta, 1990) at 4-3.

> "Hold paramount the safety, health and welfare of the public, and protection of the environment and promote health and safety within the work place."

The Canadian Council of Professional Engineering (the "CCPE") provides similar language to the British Columbia approach in its Code of Ethics and interprets "paramount" as follows:

> "The meaning of "paramount" in this basic tenet is that all other requirements of the Code are subordinate if protection of public safety, the environment or other substantive public interests are involved."[5]

It is incumbent upon any practicing engineer to understand and ensure compliance with the applicable engineering Code of Ethics. Failure to comply can result in disciplinary action and subject the engineer to a wide variety of sanctions, the most serious being a revocation of membership requiring the engineer to refrain from practice.

1.3.2 Practice Standards

In addition to a code of ethics, engineering associations frequently issue practice standards which set specific performance criteria. Similar to the code of ethics, a breach of a practice standard will likely result in internal disciplinary action. The facts of any particular situation will dictate the seriousness of the breach and what remedy might be imposed. It should be noted that the same scope of remedies are available for a breach of a practice standard as for a breach of the code of ethics.

The first environmental practice standard issued in Canada by an engineering association occurred in June 1994 with APEGGA's publication of an environmental practice standard entitled, "Environmental Practice – A Guideline" (hereafter referred to as the "Guideline"). The Guideline was prepared because of the recognition of the relationship between environmental degradation and its effects on the health and safety of the public. For this reason, APEGGA determined that guidance should be provided to its members on sound environmental management approaches. This would help APEGGA members to contribute actively to the protection and well being of the public, while still participating in their capacity of promoting economic development. A summary of the Guideline is presented below. Other engineering associations across Canada including the CCPE have followed suit and published their own versions of environmental practice guidelines.

Depending of the facts of a situation, a breach of a practice standard can easily constitute a "lack of skill or judgement" sufficient to constitute unskilled practice or unprofessional conduct and subject that member to the internal disciplinary process. An engineer should be aware that a breach of a practice standard can be held to be of equal seriousness to a breach of the code of ethics.

[5] Canadian Council of Professional Engineering Guideline "The Environmental Practice of Professional Engineering" at 2.

Summary of the APEGGA Environmental Practice Guideline

Professional engineers, geologists and geophysicists are committed to environmental protection and safeguarding the well-being of the public.

Professional Engineers, Geologists and Geophysicists:

1. Shall develop and maintain a reasonable level of understanding on environmental issues related to their field of expertise.

2. Shall use appropriate expertise of specialists in areas where the member's knowledge alone is not adequate to address environmental issues.

3. Shall apply professional and responsible judgement in their environmental considerations.

4. Shall ensure that environmental planning and management is integrated into all their activities which are likely to have adverse environmental impact.

5. Shall include the costs of environmental protection and/or remediation among the essential factors used for evaluating the life-cycle economic viability of projects for which they are responsible.

6. Shall recognize the value of waste minimization, and endeavour to implement the elimination and/or reduction of waste at the production source.

7. Shall cooperate with public authorities in an open manner, and strive to respond to environmental concerns in a timely fashion.

8. Shall comply with legislation, and when the benefits to society justify the costs, encourage additional environmental protection.

9. Are encouraged to work actively with others to improve environmental understanding and practices.

2. ENVIRONMENTAL STANDARDS SET BY LEGISLATION

2.1 General Standards of Conduct

All environmental legislation, whether provincial or federal in jurisdiction, impose a general standard of conduct with penalties for their breach. For the purposes of this Chapter, a general review of the various types of environmental offenses will be offered, followed by the type and severity of sanctions which are available for their breach. An engineer must be aware of the severity of sanctions available for a breach of legislated conduct in order to ensure these requirements are placed in their proper perspective.

The common law has long recognized a distinction between “criminal” (or *mens rea*) offenses and “regulatory” offenses. Criminal offenses are those crimes which are primarily found in the Criminal Code[6] while regulatory offenses are primarily found in legislation (enacted by either provincial legislatures or federal parliament).[7] Regulatory offenses are further divided into two categories: strict liability offenses and absolute liability offenses.

2.1.1 Criminal Offenses

Criminal offenses or *mens rea* offenses require two elements to substantiate a conviction:

1. proof beyond a reasonable doubt of the prohibited act (the *actus reus*) in question; and
2. proof of the requisite mental element (the *mens rea*).

These crimes are typically signified by either their presence in the Criminal Code or in legislation where explicit requirements of a mental element are included in the offence (“knowingly, intentionally, with intent to…”). The consequences of these offenses are the most serious of all the types of offenses and usually carry a sentence of a high monetary fine (up to $1 million) or imprisonment (up to 2 years) or both.

2.2 Absolute Liability Offenses

Absolute liability offenses are reserved for the least serious offenses. These offenses are utilized for convenience in that the crown does not have a great burden to meet to make out the elements of an offence. The crown need only prove that the prohibited act (*actus reus*) has occurred beyond a reasonable doubt. The mental element (*mens rea*) is irrelevant. Once the act is proven, there are no defenses available to an accused as the reasons and circumstances of why the offence has occurred are of no consequence.

The penalties for these offenses are in the form of a small fine (typically up to $1,000) and there is never a possibility of imprisonment. An example of this offence found in *the Alberta Environmental Protection and Enhancement Act* (the “EPEA”) is disposal of waste on highways, on land owned by a local authority, in water, or on land owned by another person.

2.3 Strict Liability Offenses

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6 Criminal Code, R.S.C., 1985, c. C-46.

7 This distinction was affirmed positively in the case of *R. v. Sault Ste. Marie* [1978] 2 S.C.R. 1299, 3 C.R. (3d) 30, 40 C.C.C. (2d) 353

The middle category, strict liability offenses, comprise the vast majority of environmental offenses. These offenses represent a compromise between the rigorous requirement of proving the mental element (*mens rea*) offenses and the abolition of any available defenses (absolute liability).

The crown is required to prove the prohibited act (*actus reus*) has occurred beyond a reasonable doubt similar to an absolute liability offence. The burden then shifts to the accused who must then establish the due diligence defense on a balance of probabilities in order to be acquitted. In the EPEA, the due diligence defense is stated as:

> "No person shall be convicted of an offence under section … if that person established on a balance of probabilities that he took all reasonable steps to prevent its commission."[8]

Even though the burden is shifted to the accused to prove his innocence, this process can withstand an attack from the Charter of Rights.[9]

The vast majority of environmental offenses are strict liability offenses. The typical penalty for a violation of these offenses is a maximum of $50,000 for an individual and $500,000 for a corporation and there is never a possibility for imprisonment.

2.4 Operating Permits and Regulations

In addition to the general standards of conduct imposed by environmental legislation, specific performance standards are usually imposed. These performance standards are typically in the form of an operating permit which sets specific air and water release targets for companies or individuals who are licensed to engage in activities which are held to adversely affect the environment. In addition to operating permits, most environmental legislation also contain regulations which set specific release standards. It is an offence to breach the terms of an operating permit or the regulations.

3.0 ENVIRONMENTAL STANDARDS SET BY INDUSTRY ASSOCIATIONS

There are three major sources of environmental standards set by industry associations in which an engineer might encounter. The first are standards or environmental principles issued by the specific industry to which the engineer practices. Industry associations such as the Canadian Chemical Producers' Association, the Canadian Association of Petroleum Producers, the European Petroleum Industry Association and many others have complied environmental principles and standards for their constituent members.

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8 *Infra*, note 11 at Section 215

9 R. v. Wholesale Travel Group Inc., (1989), 52 C.C.C. (3d) 9, 73 C.R. (3d) 320, 63 D.L.R. (4th) 325 (C.A.) The shift of the accused to establish the due diligence defence to escape liability does infringe s. 11(d) of the Charter of Rights, the presumption of innocence. However, this is justified as a reasonable limitation on the rights and freedoms of an accused under s.1 of the Charter of Rights.

The second major source of environmental standards which an engineer might encounter are those issued by the Canadian Standards Association (“CSA”). The CSA is a not-for-profit organization whose primary purpose is to develop standards, certification and testing of products and services for Canadian organizations. The CSA has issued a series of guidelines which pertain to topics such as environmental management systems, risk analysis, environmental auditing, pollution prevention and site assessment. Many of these specific guidelines will be discussed in later chapters. Adherence to environmental standards are not mandatory but serve as useful and information guidelines on how companies can address specific environmental issues.

Similar in nature to the CSA, the third major source of environmental standards are those issued by the International Organization for Standardization (“ISO”). ISO provides standards and guidelines that are developed by representatives from some 118 countries. Once these standards are approved they are intended to be adopted as national standards by each country involved in their development. Some of these internationally adopted standards are known as “specification standards”. These standards contain specific requirements that must be met by an organization before they can claim to be in compliance with the standard. Specification standards may be audited by an independent third party so that the organization can prove they are in compliance. This independent audit is usually performed by a registrar. If an organization meets the requirements of the standard the registrar will enter the name of the organization, and the standard it has met, into a register that is open to public inspection. Registrars obtain accreditation from government approved or controlled accreditation agencies such as the Standards Council of Canada.

The set of standards of particular interest are the ISO 14000 series which address such topics as environmental management systems, environmental labeling and life cycle assessment.

4.0 LEGAL IMPLICATIONS OF ENVIRONMENTAL STANDARDS AND PRACTICES

One method to determine the importance of adhering to any one of the environmental standards is to assess the potential consequence for its breach. One approach to considering such consequences is to ascertain how any of these standards might be used in a court of law. There are two circumstances were the provided environmental services might come under such scrutiny. The first is pursuant to an allegation of professional negligence and the second is pursuant to establishing the due diligence defense to a charge of strict liability offense.

With respect to professional negligence, the general standard by which a professional is held accountable is:

> "a duty to exercise the skill, care and diligence which may *reasonably be expected of a person* of ordinary competence, measured by the professional standard of the time."[10]

In addition:

> "The engineer is not obliged to perform to the standards of the most competent member of the profession, unless he so covenants. What is required is *reasonable* skill, care and diligence *as judged by standards of competence in the profession in which he practices*".[11] (emphasis added)

The second circumstance pertains to the due diligence defense which is stated by Section 215 of the EPEA as follows[12]:

> "No person shall be convicted of [a strict liability] offence … if that person establishes on a balance of probabilities that he took *all reasonable steps* to prevent its commission."

The "reasonable standard has emerged as the standard by which the actions of a professional are most often required to met in a court of law in response to both an allegation of professional negligence or establishing the due diligence defense. The question then becomes what constitutes "reasonable" and whether the existence of an environmental standard (whether established by a national standards organization, industry association or an engineering association) would contribute to a determination of the "reasonable" standard.

The leading case on the use of professional standards and practice to determine whether a professional was negligent (and hence, fell below the "reasonable" standard) is the Supreme Court of Canada decision of *Roberge v. Bolduc*[13]. In *Roberge*, an allegation of professional negligence was considered against a notary as a result of advice given to prospective purchasers of real property that the vendor has good and valid title to the property. The evidence showed that the notary, while following common notarial practice, committed an error in the advice given to his clients. At issue was whether the common notarial practice itself was reasonable. The Court concluded:

> "It may very well be that the professional practice reflects prudent and diligent conduct. One would hope that if a certain practice has developed amongst professions in regard to a particular professional act, such practice is in accordance with a prudent course of action. *The fact that a professional has followed the practice of his or her peers may be strong evidence of reasonable and diligent conduct, but it is not determinative.* If the practice is not in accordance with general standards of liability, i.e. that

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10 Supra, note 2 at 101.
11 *Ibid.* at 102.
12 S.A. 1992 c.E-13.3.
13 [1991] 1 S.C.R. 374.

> one must act in a reasonable manner, then the professional who adheres to such a practice can be found liable, depending on the facts of each case"[14] (emphasis added)

Clearly, the Canadian judiciary has given deference to existing professional practices in determining acceptable standard of conduct. By following accepted and recognized professional practices, a professional can make a strong case that he was acting reasonably. This position is not absolute, however. It is fair to challenge the notion that the existing standards and practices of the profession might themselves, be unreasonable.

The issue remains as to what standards or guidelines might amount to a statement of commonly held professional practice so as to influence the standard of conduct expected of a professional in a court of law. It is suggested that the following indications might influence which type of standard may help comprise the "practice of the profession":

1. who comprises the membership of the organization;
2. does the organization purport to represent the entire industry or are major players not included;
3. have the standards been adopted by major players in the industry who are members of the organization that has issued the standard; and
4. does the organization have exclusivity of practice, implying that if members hip is revoked is that party still entitled to conduct its business or remain in the organization?

Some indication of the emergence of what environmental standards might be considered an acceptable practice of the profession is offered in a recent decision of the Provincial Court of Alberta *in R. v. Prospec Chemicals Ltd.*[15] Prospec was convicted of unlawfully contravening a term or condition of an approval under the EPEA. The Court ordered Prospec to deliver a certified copy of certification under the ISO 14001 Environmental Management System Specification. To ensure it compliance, Prospec was ordered to post a letter of credit payable in the amount of $40,000. The recognition by a Court of the ISO 14001 standard adds some weight to an argument that this standard might emerge as an acceptable practice of the profession.

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14 *Ibid*. at 436.

15 Unreported at time of writing of this chapter. Decision is dated January 25, 1996.

CHAPTER 3

Environmental Audits, Assessments and Investigations

By: Nina V. Novak, P. Biol, P. Eng.

3.1 ACTIVITIES INVOLVED IN ENVIRONMENTAL AUDITS, ASSESSMENTS AND INVESTIGATIONS

3.1.1 The Environmental Audit

An environmental audit is usually considered the first step of a phased approach to site environmental assessments. It is a non-intrusive (no sampling) assessment of a property, establishing a basis for cost-effective assessments and investigations at a later time.

As specified in the CSA "Guidelines for Environmental Auditing: Statement of Principles and General Practices" (CSA Z751-94), an environmental audit is:

…"a systematic process of objectively obtaining and evaluating evidence regarding a verifiable assertion about an environmental matter, to ascertain the degree of correspondence between the assertion and established criteria, and then communicating the results to the client. A verifiable assertion is a declaration or statement about a specific subject matter which is supported by documented factual data.."

Audit criteria, which establish the standard to which a site is evaluated, usually consist of applicable laws and relations, and industry or corporate standards, policies, plans, practices or procedures established to protect the environment and ensure effective management of environmental risk.

Numerous other definitions of environmental auditing exist, but their essence is the same: focusing on the determination of compliance with applicable legal, industry or corporate criteria and standards.

Common benefits of various environmental auditing programs are:

- determine and verify compliance with appropriate federal, provincial and local laws and regulations, or corporate policies;
- assist in securing insurance and financing;
- provide assurance to management that systems for managing environmental affairs are operating effectively;

- determine the current cost of compliance with environmental requirements and identify potential cost savings;

- enable comparison between operating facilities and identify shared problems and their solutions;

- assist facility management in identifying and correcting compliance problems;

- assure adequate, up-to-date environmental information for internal management awareness, decision-making and regulatory requirements;

- improve waste management practices;

- evaluate existing employee training programs and provide a comprehensive database which can aid in training personnel;

- assess and increase the effectiveness of emergency response activities;

- reduce costs by improving operation effectiveness and identifying poor operating and maintenance procedures;

- improve the overall environmental performance of operating facilities by reducing and containing environmental problems; and

- avoid corporate liabilities and enforcement proceedings, and minimize fines.

Additional benefits from undertaking environmental audits usually include improved overall environmental awareness, proactive environmental risk management, improved communication between management and operating facilities, and progression toward the development of an effective environmental management system. Another important benefit from a well-planned environmental audit program is that it s a critical aspect of exercising due diligence, a form of legal defense for environmental infractions.

The essential components of an environmental audit are:

- define objectives and scope, identifying criteria for evaluation and level of detail for the study;

- select audit resources, establishing the audit team and communication network;

- review background information, either corporate documentation or that available to the public;

- develop the audit plan, and incorporate an element for establishing audit principles, such as CSA Z751-94, to collect sufficient factual information to support the study findings with respect to the overall objectives;

- collect information through interviews, personal observation and inquiry, document review, report and data analysis, independent confirmation, review of internal controls, tracing or recompiling data, comparison and analysis of other data for similar activities, physical observation, measurement and records;

- evaluate the findings with respect to the agreed criteria; and

- communicate the results through a report providing a clear and consistent understanding of the environmental audit expectations and outcomes.

Establishing the appropriate corrective actions in response to the audit findings is then the responsibility of the client, possibly leading to the need for further environmental assessments or investigations.

Generally, environmental auditing programs initially implement the reactive approach of avoiding problems by undertaking audits that focus on regulatory compliance. As a corporate environmental management program matures, this focus shifts through a diagnostic phase to ultimately a proactive management phase aimed at improved organizational learning and corporate efficiency.

It is important to realize that undertaking an environmental audit does not act as a substitute for the compliance activities mandated by the legislation or standards in place. The audit is merely the tool used to measure corporate performance in meeting prescribed environmental standards.

3.1.2 The Environmental Site Assessment

In a situation where the state of site contamination must be determined, a Phase I Environmental Site Assessment is required to provide preliminary identification of actual and potential site contamination. An Environmental Site Assessment has been defined by CSA (CSA Z768-94), ‘Phase I Environmental Site Assessment’ (ESA)) as:

…”the systematic process, as prescribed by this Standard, by which an Assessor seeks to determine whether a particular property is or may be subject to actual or potential contamination. A Phase I ESA does not involve the investigative procedures of sampling, analysing, and measuring unless enhancements are agreed upon between the Client and Assessor."

Unlike an Environmental Audit, the focus of the Environmental Site Assessment is to identify environmental risks and liabilities. Some of the more common applications of a Phase I Environmental Assessment are presented below:

Financial - as a consequence of the possible legal and financial liabilities associated with control of a contaminated property, property owners, prospective purchasers, lending institutions and insurance companies are requiring ESAs to estimate the likelihood, type and locations of contamination on a property. The information obtained is then used to guide the evaluation of the risk level and possible reclamation costs associated with environmental contamination at the property.

Baseline studies - depending on the level of detail of available environmental information, a Phase I ESA may provide sufficient information to act as an environmental baseline for the site. Future needs may require a determination of site environmental impacts by updating baseline data. Comparison with previous data would highlight the factors that have degraded.

Legal - most contraventions of environmental legislation are considered "strict" forms of liability. In this situation, it is the responsibility of the charged party to demonstrate that all reasonable care had been taken to prevent the commission of the offence. This is referred to as the "due diligence defence." As one component of a comprehensive corporate environmental management system, properly implemented Phase I ESAs may be one step in establishing a due diligence defence.

Remediation - as an initial component of the phased approach to site assessment and remediation, Phase I ESAs provide a basis for determining subsequent needs for site sampling, contaminant analysis and contaminant delineation testing. As such, Phase I ESAs provide many of the initial reviews necessary for property reclamation or decommissioning.

The general components of a Phase I ESA are essentially the same as those presented previously for a Phase I Environmental Audit, except that the applicable standard would be CSA Z768-94 – 'Phase I Environmental Site Assessments'. The focus of the ESA is also different, being to identify any areas of the property that may present an environmental liability. Therefore, a historical component to all information reviews is essential in assisting with the identification of past practices that are no longer undertaken, and that may not have been remediated to current standards. Familiarity with the biophysical characteristics of the site (e.g. soils, groundwater, surface water, topography, vegetation and wildlife) is also necessary to estimate contaminant migration possibilities and assist in identifying potential receptors of the contaminants. Adjacent land uses, both present and historical, should also be reviewed to determine whether there is the possibility of contaminant migration to the property from off-site locations.

3.1.3 Environmental Site Investigations

As a component of the phased approach to overall site assessment and contaminated site remediation, the Phase I Environmental Site Assessment is the initial stage determining the necessity and direction of following stages. The subsequent investigations and activities can be summarized in the stages identified below:

Phase II Environmental Site Investigation: thorough contaminant sampling and analysis and characterization is performed to identify contaminants and delineate the extent of contamination.

Phase III Remedial Investigation: possible remediation options for the contamination delineated at the site are identified, and the most appropriate method is determined.

Phase IV Reclamation: the Phase III recommended method of site reclamation is implemented; this may involve a subsequent monitoring program.

The critical difference between the Phase I ESA and the Phase II investigations is the use of quantitative sampling and analytical techniques in Phase II. Phase II field sampling and analysis programs must be developed on a site-specific basis, using information obtained from the Phase I ESA and other sources, e.g. underground utility locations.

The sampling and analysis program may contain any of the following:

- soil drilling an/or test pit digging;
- geophysical analysis;
- installation of probes for soil vapour surveys and subsurface vapour sampling;
- surface water sampling;
- groundwater sampling;
- indoor air sampling;
- outdoor air sampling;
- sediment sampling;
- vegetation and wildlife sampling;
- analysis for organic and/or inorganic chemicals, metals, soil or water characteristics, r radioactivity; and

- analysis for adverse health effects (individuals or populations).

Following the identification of contaminant types and locations in Phase II Environmental Site Investigations, a subsequent field sampling and analysis program is usually necessary to delineate thoroughly the areas of contamination that exceed regulatory limits. Owing to the large number of samples and analyses required, appropriately selected, inexpensive “indicator” parameters may facilitate this component of site characterization, combined with selective detailed analyses.

Once the contaminated areas requiring remediation have been delineated, a Phase III remedial investigation is usually implemented. Remedial investigations are performed to develop appropriate reclamation protocols for areas having unacceptable levels of contamination. This involves minimal field work, focusing on theoretical science and engineering considerations of the applicability of various reclamation methods to the site and the contaminant(s). Other consideration involve impacts of the reclamation activities, contaminant residues or byproducts; adjacent landowner concern; residue waste handling and disposal; occupational health and safety; space availability; extent of contaminant reduction necessary for compliance; and time limitations for the remediation. After the remedial method is chosen, additional components of the remedial investigation may include treatability studies (bench and pilot scale); detailed design; preparation and tendering of contract documents; regulatory permitting; and public consultation. The actual implementation of the reclamation program is sometimes referred to as the last phase, Phase IV, of site assessment and reclamation. A general requirement after the reclamation activities are completed is to monitor the site to ensure that remedial activities were effective.

3.1.4 Need for Undertaking Environmental Audits or Site Assessments

Environmental liabilities are becoming more expensive as new environmental legislation and guidelines are being implemented. Businesses, whether they are the property owners, prospective purchasers, lending institutions or insurance companies, are in a situation where thy must make themselves aware of site environmental concerns and take appropriate remedial actions if they are to exercise the level of care necessary to show due diligence. A few of the major motivating factors initiating environmental audits or assessments are listed below:

- exercising due diligence by being aware of site conditions and responding appropriately;

- the high cost of non-compliance, either as a result of fines or the cost of remediation;

- negative implications to a corporation’s borrowing potential when deeded to be the party responsible for a contaminated site;

- loss of property value resulting from site contamination, either on or adjacent to the site (in some cases, cleanup costs far exceed the market value of the property even after it is remediated); and

- under certain circumstances, a lender may become the party responsible for the environmental damage. This is known as direct lender liability.

One or a combination of all the above factors invariably initiates most environmental audits and assessments.

3.2 STANDARDS AND SKILLS

3.2.1 Standards

All current standards for environmental audits or assessments are voluntary, since onone of the requirements for qualifications or activities is legislated through statutes or regulations. However, numerous industry organizations have generated or are generating guidelines for undertaking environmental audits or assessments. Some of these organizations are listed below:

Canadian Standards Association: CSA Z751-94 and CSA Z768-94; CSA Z750, Z763, Z760 and Z766;
Canadian Mortgage and Housing Corporation;
Canadian Association of Petroleum Producers;
International Standards Organization (ISO 10011 – and ISO 14000 series);
Treasury Board of Canada
Forest Care;
Canadian Council of Ministers of the Environment (CCME);
International Chamber of Commerce;
Coalition for Environmentally Responsible Economics (CERES) Principles;
Canadian Chemical Producers’ Association;
Keidanren (Japan Federation of Economic Organizations);
Business Council on National Issues;
European Petroleum Industry Association (EUROPIA);
National Round Table on the Environment and the Economy (NRTEE); and
The Association of Professional Engineers, Geologists and Geophysicists of Alberta

3.2.2 Standard Applicability

At present, the only enforceable standards or criteria are those identified through federal, provincial or local legislation. Phase I Environmental Audits are intended to provide a routine check to ensure that facility activities are in compliance with these standards or criteria. As previously mentioned, however, many environmental infractions are legally considered “strict and several” forms of liability, for which the defence is to prove “due diligence”. As such, any individual in a position to control an activity resulting in pollution of the environment must show that all “reasonable care” under the circumstances was taken to prevent the infraction from occurring. Considering this, the established voluntary standards would assist the courts to determine whether all “reasonable care” was undertaken. The voluntary standards are distributed by many organizations as indications of their expectations, and therefore assist in establishing the “industry standard” on which “reasonable care” is assessed. It is in this manner that the voluntary standards become enforceable.

3.2.3 Practitioner’s Qualifications

The recommended requirements for an environmental audit (CSA Z751-94) include independence and objectivity about the property, professional competence and due care. Environmental auditors usually have quite different educational backgrounds. Nonetheless, an auditor should have adequate proficiency, knowledge and experience in the following areas:

- auditing processes, procedures and techniques;
- analysis of environmental management systems;
- applicable regulatory requirements, environmental policies and guidelines;
- environmental protection systems and technologies;
- facility operations, or systems; and
- potential environmental hazards associated with the types of facilities and operations being audited.

The qualifications of Phase I Environmental Assessors are similar to those of Phase I Environmental Auditors. It is also recommended by CSA Z768-94 that assessors have knowledge in the following technical areas:

- water/waste water treatment;
- manufacturing or operation processes;
- waste management;
- air emission control;
- building sciences; and
- geology/hydrogeology.

In addition, it is useful for the auditor to have an appreciation of the interactions of biophysical factors with contaminants, so that contaminant dispersion potential can be estimated.

Individuals undertaking remedial investigations must have a highly technical background in areas such as engineering, geology/hydrogeology, chemistry, biology or soil science. This must be combined with knowledge of available reclamation technologies, their applications and limitations, process design concepts, feasibility assessments, risk management, occupational health and safety, and project design and management.

All the above requirements must be combined with a solid basis of experience with related projects. Some clients also require errors and omissions insurance coverage for consultants undertaking environmental audits, assessments or investigations.

3.2.4 Certification of Practitioners

As a result of the lack of enforceable environmental audit and assessment standards, combined with the vast number and diverse background of individuals providing these services, the question of certification arises. Clients need some guidance as to the credibility of the practitioners offering these services. Currently, the majority of client security comes from hiring individuals possessing professional status, since these individuals are ethically bound to undertake only those activities for which they are qualified. This is usually augmented by requiring contractors to have adequate errors and omissions insurance coverage. Based on their education background and professional status, it is common to have professional engineers performing Phase I environmental audits and assessments.

A number of agencies either have or are considering certification of environmental professionals. A brief list of some of the industry agencies providing either registration or certification is present below:

Canadian Environmental Auditing Association
Canadian Environmental Assessment Agency;
Canadian Council for Human Resources in the Environment Industry;
National Association of Environmental Professionals (Washington);
National Registry of Environmental Professions (Glenview, IL);
Institute of Professional Environmental Practice (Pittsburgh)
American Academy of Environmental Engineers (Annapolis, MD);
California Environmental Protection Agency (EPA);
Nevada Bureau of Chemical Hazards Management;
Environmental Protection Academy (Jacksonville, FL) and
The Wildlife Society.

Educational requirements can vary from none to B.Sc. or M.Sc. degrees. Experience levels range from none to in excess of 15 years (with a technical degree). Testing, from oral exams to 3-hour written exams, may be required. Practice standards have not been developed by many of these groups, while codes of ethics exist with most of them. The right to the title (by copyright) is available with approximately half the groups, but a government approved right to practice exists only with the California EPA and the Nevada Bureau of Chemical Hazards Management.

The extent of protection provided to clients is questionable, however, when the limitation of rights to practice in not enforceable and no disciplinary opportunities exist within the groups providing the certifications.

National certification is being promoted as necessary for business to identify competent practitioners and to improve the level of practice. The need for a national infrastructure to comply with ISO 14000 standards on environmental auditing and assessments is also presented as a basis for a national certification program. Considering that there are currently many professionals – engineers, geologist, lawyers and accountants – working in these areas and controlled by a licensure regime, a critical consideration must be to determine the action need for certification. The possibility also exists for a conflict between the certification activities and the regulation of certain professions. The certification standards may not provide any additional guarantee of qualified individuals and may only serve to confuse or mislead the clients.

CHAPTER 4

Pollution Prevention, Control and Remediation

By: Nina Novak, P.Biol., P.Eng.

Pollution prevention is referred to as “the use of processes, practices, or material and energy that avoid or minimize the creation of pollutants and wastes” (CSA Z754-94). A pollution-prevention program is one component of a corporate environmental protection system. Once generated, contaminants are addressed through pollution control measures, which allow capture, through various technical efforts, of pollutants that have already been created before they are released to the environment (CSA Z754-94). If control measures are not implemented or are ineffective, then remedial actions are necessary. These are “actions taken to lessen or repair the damage and impact of pollutants on the surrounding environment after the pollutants have been released to the environment” (CSA Z754-94). Implementing all these measures ensures that activities are undertaken in a manner conducive to sustainable development. Ensuring future generations a lifestyle comparable or better than ours, without comprising resources or the environment, is becoming a primary goal of many guidelines and political initiatives, in addition to being ethically correct. Consequently, this should become a much stronger focus in corporate environmental management systems.

4.1 POLLUTION PREVENTION

The most effective method for minimizing the effects associated with environmental contamination is to prevent the contaminants from ever forming. A shift in approach is necessary, from the reactive methods that focus on site clean-ups, to the proactive, anticipatory approach that emphasizes prevention. This proactive approach has proven very successful in the health and safety fields. Numerous governmental and industry agencies have prepared guidelines or documents specifying pollution-prevention activities. These agencies include:

Ontario Ministry of Environment and Energy;
UNEP;
Environment Canada:
Industry, Science and Technology Canada;
The Canadian Chemical Producers’ Association;
United States Environmental Protection Agency;
Canadian Council of ministers of the Environment; and
Mining Association of Canada

The critical steps as identified by CSA in developing, implementing and monitoring a pollution-prevention plan are:

- secure senior level commitment;
- establish pollution-prevention guidelines;

- establish a pollution-prevention team;
- develop employee awareness about program initiatives and goals;
- collect data and gather information;
- identify pollution-prevention opportunities;
- determine the feasibility of the opportunities;
- establish targets and rank action items by priority;
- establish a schedule for implementing action items;
- define the financial commitment;
- train employees in the new procedures;
- implement the new procedures;
- monitor the effectiveness of the new procedures for pollution prevention; and
- provide for on-going reviews and improvements.

The magnitude of the improvements increases from maintenance of current processes, to improvements of current processes, and ultimately to effective design of new processes that minimize or eliminate the contaminent concerns. The benefits of implementing a pollution prevention program include any of the following:

- reduce raw materials;
- improve staff safety;
- increase operation efficiency;
- improve environmental performance;
- minimize costs associated with contamination, i.e. fines and reclamation costs;
- improve facility energy efficiency; and
- reduce waste and associated costs.

Pollution prevention is an effective method for managing environmental risk and liability, and for improving facility operation, financial performance and public perception of the site activities.

The ideal time for implementing a pollution-prevention program is when the facility is being designed. Many major facilities currently undergo hazard and operability studies ("hazops") during various phases of the design process. Hazops commonly address operation considerations and employee health and safety. It is a simple task to incorporate environmental consideration in these assessments, thereby ensuring that appropriate mitigative measures are implemented. Ideally, this exercise would also raise questions about waste generating processes and identify alternatives having less potential for waste generation. This approach is comparable to process redesign, without the financial encumbrances associated with having to upgrade process equipment.

In most cases, pollution-prevention programs are initiated on existing facilities. In this case, the most effective starting point of a technical review is to perform an assessment of options for minimizing waste. A comprehensive protocol for minimizing waste has been prepared by the U.S. EPA and is presented in their publications EPA/625/7-88/003

(July 1988) “Waste Minimization Opportunity Assessment Manual”. The major phases of this assessment are planning and organization, assessment, feasibility analysis and implementation. The assessment phase identifies a comprehensive list of options for minimizing waste. A detailed understanding of the plant’s operations and waste generation activities is required to develop this list. The collection of data would focus on identifying the following:

- waste types and quantities generated (a waste inventory);
- sources of these wastes;
- classification of the wastes, e.g. hazard and contaminants;
- raw materials (type and quantity) that contribute to waste generation;
- process efficiency;
- mixing of waste types;
- in-place practices for minimizing waste; and
- process controls used to manage process efficiency.

Once these items are fully characterized, the assessment team identifies possible alternatives for minimizing waste for the various waste streams. This requires expertise in the areas of available waste management alternatives, as well as an understanding of process and site constraints. The most common waste minimization techniques are summarized below:

Recycling: (on-site and off-site)	- use and reuse	- return to original process
		- use waste as a raw material substitute for another process
	- reclamation	- processed for resource recovery
		- processed as a by-product
Source reduction:	- product changes	- product substitution
		- product conservation
		- change in product composition
	- source control	- input material changes (material purification, material substitution, ‘Green Procurement’)
		- technology changes (process changes; equipment, piping or layout changes; additional automation; changes in operation conditions)
		- good operation practices (preventative maintenance, procedural measures; loss prevention; management practices; waste stream segregation; materials handling improvements; production scheduling).

(Source: H. Freeman, “Hazardous Waste Minimization”, 1990)

After specific options have identified for minimizing waste associated with a particular process, they must be evaluated as to their technical, environmental and economic feasibility. Economic considerations should include standard economic components and indicators, e.g. capital costs, rates of return, etc., as well as hidden costs (monitoring, reporting, permitting), future liability costs (remediation, personal injury, property damage), and intangible costs (customer responses, corporate image, employee relation).

A substantial number of waste reduction programs have been introduced since 1981-1982, largely as a result of government guidelines and industry association initiatives. The Canadian Council of Ministers of the Environment has established a number of guideline principles for pollution prevention, encouraging harmonized individual efforts that emphasize voluntary actions undertaken at the earliest development stages which are effective throughout the product life cycle. CSA has developed guidelines (CSA Z760-94 and Plus 1107) on life cycle assessment, where a life cycle assessment is defined as:

> “a concept and a method to evaluate the environmental effects of a product or activity holistically, by analyzing its entire life cycle. This includes identifying and quantifying energy and materials used and wastes released to the environment, assessing their environmental impact, and evaluating opportunities for improvement. The life cycle assessment consists of four complementary components – initiation, inventory, impact and improvement.”

After the scoping process in the initiating phase, the data-gathering inventory then occurs. It is necessary to quantify energy, water, material requirements, air emissions, liquid effluents, solid wastes and other environmental releases. The quantitative and qualitative assessment of the resulting environmental burdens then addresses ecosystem and human health, resource depletion and socio-economic consideration. Numerous models are available for assessing environmental impact. The choice of assessment approach should be determined, keeping the overall management goals in mind, as well as the specific projects or process considerations. Some of the less complex approaches are:

- “less than better”, which is useful for comparing two or more products/processes to identify the one using less of a quantifiable parameter, e.g. resource use, energy consumption. There is no indication, however, of associated environmental impact.

- “yes/no checklist,” in which predetermined consequences are listed, referring to emissions or resources used and a yes/no answer provided.

- “relative magnitude,” which is similar to the “yes/no checklist.” But a range answer is given, enabling impact severity to be determined to some extent.

- “resource consumption ratio,” which provides a comparison of resource and energy use to the natural reserves, available supplies, or the environment’s assimilative capacity.

- “consequences network.” In which an “assessment tree” identifies various cause/effect relationships, their impacts and objectively based weighting factor, enabling a single numerical index value to be determined for each impact component.

- “hazard ranking,” which is used primarily for human health risk assessment. Hazard values are assigned to the various pollutants, which are then ranked according to established toxicological values.

- “hazard matrix,” in which a matrix is developed consisting of the contaminant concerns (e.g. human health, mutagenicity, etc.) on one axis and exposure media on the other axis. Each matrix cell then has a specific hazard score.

- “willingness to pay,” in which product/process environmental impacts with a socio-economic value are subjectively assigned.

Improvements to reduce the impacts over a product’s life cycle are then identified in areas such as product design, optimal raw material use, industrial processing techniques, consumer use guidelines and waste management practices. Possible areas of improvement include:

- extend product life;
- substitute materials;
- improve distribution;
- enhance use/maintainability of product;
- reduce energy consumption;
- improve process efficiencies; and
- improve waste management.

Life cycle assessments are iterative, with initial reviews being based primarily on qualitative information. As more quantitative data are obtained, the process is repeated. Ultimately, a comprehensive understanding of process resource demand and process/product impacts is obtained. The general objectives unique to a life cycle assessment are:

- establish a baseline of overall resource use, energy consumption and environmental loadings;
- identify the points in a product or process life cycle where resource use and environmental emissions can be reduced;

- provide a basis of comparison with other processes or products; and

- assist in developing new products or processes capable of net reductions or resource requirements or emissions.

4.1 POLLUTION CONTROL

Once contaminants have been created by a process, attempts must be made to prevent them from entering the environment. These efforts are technically based and should be thoroughly identified during the design phase of a project. Generally, these methods can include any combination of the following:

- automated controllers and computerized monitoring and regulation of controllers;
- contaminant segregation through methods using adsorption, absorption, or phase separation;
- containment of the contaminant stream;
- storage of the waste stream; and
- treatment of the waste stream to acceptable contaminant levels prior to release.

Automated technology has advance immensely over the last two decades, providing innumerable options for monitoring and controlling process streams. Monitoring of process or stream parameters and contaminants can be effectively connected into the facility interlock controls, so that specified exceedances result in redirection or shutdown of the flow stream, thereby minimizing the possibilities of contaminant release.

Generated contaminants must be contained somehow so as to eliminate their dispersion into environmental media. Examples of these methods include numerous air pollution control processes (e.g. scrubbers, filters, precipitators, impinges, and incinerators); wastewater flocculators, separators, or containment ponds. The contaminant isolation methods generally focus on processes providing contaminant adsorption, absorption, or phase separation.

Once the contaminated waste stream is segregated, the stream may be contained, pending treatment. An example is connecting tank or vessel vents to an incinerator or flare for combustion of organic contaminants. It also addresses interim storage of liquid wastes, such as sumps and drains, which are ultimately directed to longer term storage or treatment areas.

Longer term containment of certain waste streams, primarily liquids or solids, can occur in storage tanks (e.g. contaminated water or spent solvents), lined ponds, or in containers such as bins or drums. An additional method of long-term storage for solids or sludges is burial in approximately designed landfills. In this case, some form of solidification or stabilization may be required prior to landfilliing to immobilize the contaminant for long-term storage.

A final method of contaminant control involves treatment prior to release, resulting in destruction or detoxification of the contaminant. Treatment may consist of any combination of physical, chemical, biological, or thermal processes. These methods are similar to those subsequently discussed under site remediation methods. Pollution control methods, however, are incorporated into the overall facility process operations.

4.2 SITE REMEDIATON

As discussed in a previous chapter, site remediation is one component of the multi-phased approach directed at addressing a site's environmental issues. This includes determining contaminant type, quantity and location; subsequent development of a remedial investigation and feasibility review; and site remediation and follow-up monitoring.

Numerous methods of hazardous waste treatment are available. A brief list is provided below:

Physical Treatment

- sedimentation
- centrifugation
- flocculation
- oil/water separation
- dissolved air floatation
- heavy media separation
- evaporation
- air stripping
- stream stripping
- distillation
- soil flushing/soil washing
- chelation
- liquid/liquid extraction
- superficial extraction
- filtration
- carbon absorption
- reverse osmosis
- ion exchange
- electrodialysis

Chemical Treatment

- neutralization
- chemical precipitation
- chemical hydrolysis
- U.V. photolysis
- chemical oxidation/reduction
- ozonation
- alkaline chlorination
- electrolytic oxidation
- catalytic dehydrochlorination
- alkali metal dechlorination
- alkali metal/polyethylene glycol treatment

Biological Treatment

- aerobic degradation
- bioreclamation

- activated sludge
- rotating biological contractors
- anaerobic degradation

Thermal Destruction

- liquid injection incineration
- rotary kiln incineration
- fluidized bed incineration
- pyrolysis
- wet air oxidation
- industrial boilers/kilns
- infrared incineration
- circulating bed combustors
- supercritical water oxidation
- advanced electric reactor
- molten salt destruction
- molten glass
- plasma torch

Fixation/Stabilization

- lime-based Pozzolan processes
- Portland cement Pozzolan processes
- sorption
- vitrification
- vitrification
- asphalt-based (thermoplastic) microencapsulation
- polymerization

The above technologies have been used to treat hazardous wastes. All methods may extend to site remediation programs, but it is critical that technology sections be based on considerations of government regulation, economics, public relations, process capabilities and constraints, and specific site considerations. Depending on the chosen technology, bench-scale and pilot-scale treatability studies may be necessary to design the field process effectively. Site characterization surveys may be necessary to identify site-specific properties affecting the overall reclamation. Typical site characterization activities could include a geophysical survey, soil-gas survey, site surficial geology testing, site groundwater monitoring, well installation, geohydraulic testing (pump tests and tracer studies and soil analysis tests (total organic carbon, grain size, moisture and clay contents), in addition to the full contaminent characterization that is normally part of a site contaminant delineation study. A number of materials –handling considerations must be included in a complete remediation program. Plans should include proper and safe removal of contaminated materials, safe containment and transportation to the treatment location, preparing it for treatment, and replacing removed materials in an environmentally sound and economic manner. Some additional considerations include surface run-on and run-off, precipitation redirection, vapour release, contaminated dust, treatment emissions, soil heterogencities, buried surprises, and excavation safety.

In addition to the contaminant remediation technologies, some site control technologies may also be implemented to control contaminant dispersion. These could include hydraulic down-gradient positioning of impermeable barriers or filtration/treatment media walls. Contaminant plume control may also be implemented.

Common site remediation methods currently in use include the following:

- soil vapour extraction;
- chemical extraction/soil washing;
- solidification/stabilization;
- chemical (contaminent) destruction, eg. Hydrolysis, dechlorination, and oxidation;
- bioremediation; and
- thermal processes.

These include a combination of in-situ and ex-situ remediation methods. Extensive theoretical chemical destruction, contaminant transport, engineering process design and process modeling are necessary in many site remediation projects. It is also important to consider regulatory permitting, employee occupational health and safety, and public communication issued during reclamation activities.

4.3 COMPLIANCE MONITORING

Compliance monitoring can either be:

- regular and periodic monitoring of emissions for specified contaminants to ensure regulatory and possibly other corporate emission criteria are met;
- monitoring of reclaimed sites to verify that successful reclamation activities were undertaken;
- an internal assessment of operations, maintenance and management systems to verify that corporate requirements and standards are being met; or
- assessments of external groups, e.g. laboratories, or waste management facilities providing support or consultative services to ensure that applicable standards are being met.

Compliance monitoring is an essential component of any corporate environmental management system. It is useful for evaluating internal environmental management systems, external services provided, activities undertaken, or reclamation performed. It is also a use method for exercising due diligence, assuming that an appropriate response is made once the monitoring results are known.

CHAPTER 5

Designing for the Environment

By: Daniel W. Smith

The concept of designing for the environment must become one of the fundamentals of engineering. In the past, the list of fundamental principles for engineering design included:

- protection of public health;
- safety;
- functionality; and
- costs (both capital and operating).

Being aware of the effects that design decisions had on the environment led to the need for assessing impacts on all aspects of the environment. Although engineers were often aware of the impacts that various projects had on the environment, the importance of impact evaluation took time to reach the level of a fundamental design principle.

Today, environmental impact evaluation is a fundamental principle of engineering design. It is essential that the meaning, responsibility and implementation steps of each part of this relatively new engineering design principle be understood.

Environmental Impact

The term “environmental impact” has a wide range of meanings depending on the scope of each project. The concept “environmental” encompasses the entire physical existence, both living and non-living, and requires that changes be observed and evaluated over a reasonable period of time. For many design efforts, boundaries are established for the breadth of the physical region to be considered and the length of time of reasonable significant impact. Boundaries for impact on surface soil are likely to be quite small and restricted to the footprint of the development while some factors such as CO_2 emissions may involve much wider boundaries for consideration.

The concept of “impact” also challenges the design process. All activities, from birth to death to decay; from concept to exploration, design, construction, operations, removal, and ultimately to disposal, have impacts. The boundary conditions to be considered must encompass the significant impacts at each step of the life of a project.

“Evaluation” is the most challenging aspect of this fundamental aspect of design. The evaluation process must include such a broad scope of professional expertise that many well-trained people must be involved. Such evaluation must involve all aspects of the physical existence, both living and non-living, within the region of acceptable impact, but must also include all significant types of impacts.

The professional engineer involved in design activities must acknowledge the responsibility for designing for the environment. By accepting the responsibility, the engineer needs to suggest boundaries for the physical and time ranges, and take the responsibility for seeking professional interaction with appropriate disciplines to ensure the design meets the needs of the environment.

Criteria, Risk Evaluation and Cost-Benefit Analysis

The relationship among criteria, risk evaluation and cost-benefit analysis is so interlocked that these individual items cannot be separated in the design process. Although individual engineers or groups of engineers may be involved in specific activities related to one or more of these factors, the project as a whole must have a manager who can deal with them while giving full consideration of the five fundamental principles for engineering design. These principles are:

- protection of public health;
- safety;
- functionality;
- costs; and
- environmental impact.

The relative importance of these five fundamentals may change from project to project.

Criteria

For each project, a “criteria set” must be developed, and for each component of the “criteria set” a set of boundary conditions must be identified. Listed below are some of the components of a “criteria set” for project development which includes design considerations:

Level 1: Evaluation Envelope criteria:

- physical boundary for evaluation; and
- time period for evaluation

Level 2: Professional criteria:

- professional Code of Ethics; and
- environmental Code of Ethics

Level 3: Conventional design-related criteria:

- client requirements;
- site or physical setting limitation;
- design codes for structural components;
- provincial guidelines and standards for physical construction;

- access limitations;
- environmental regulations, guidelines and standards; and
- total available funding.

Level 4: Influencing factors:

- information availability and retrieval;
- knowledge of materials and analysis techniques; and
- support personnel.

Design is a process of evaluating alternative methods for meeting the boundary conditions established by the “criteria set”. This is done within professional and environmental limitations, and is also a function of the more fundamental responsibilities of knowledge and information acquisition, creation and use.

Risk Evaluation

Risk is the possibility of suffering harm. The source of the harm may be an action, an activity, a condition or a substance. The term “risk assessment” refers to a technical examination of the nature and magnitude of the risk. The expressions “ risk analysis” and risk evaluation” are used to include the assessment methods, as well as the methods for using the information.

The implementation of “risk management” activities necessarily involves assessing and evaluation, along with knowledge about resources, environment, economic, social and political values. The process also includes the use of control options to reduce the risk. The term “management” refers to the process of weighing or evaluating all the criteria for the purpose of making a decision.

Unfortunately, the activity of risk assessment is limited by the boundaries of existing knowledge. Furthermore, the interpretation of knowledge is influenced by individual perceptions. Each person perceives a risk differently, and this will influence the assessment. Perceptions are also influenced by a number of factors (Cohrssen and Covello, 1989) as listed below:

- likelihood of an adverse effect;
- who is affected;
- how widespread the effects;
- the familiarity of the effects;
- the degree of fear of the effects;
- how the individual is affected; and
- the degree of voluntary involvement in decisions related to the exposure.

Risk evaluation can be applied in some fashion to almost all activities.

The definition of risk evaluation involves all the boundary conditions and related factors of design. When a design is constructed, there is always some risk it will cause some aspect of the environment impacted.

Cost-Benefit Analysis

The issues related to evaluation extend to the analysis of project costs and benefits. Traditionally, costs have included all components related to design, construction and commissioning, as well as the cost of capital, and both operating and maintenance costs. AS the need for environmental impact assessment has grown, assessments have also been made part of the costs of impact evaluation and impact mitigation. More recently, a greater recognition of monetary intangibles has further complicated this type of analysis.

Many environmental intangibles are difficult to be expressed in monetary terms alone, if at all. The challenge for the project manager then becomes one of forming a team of experts to evaluate and pass judgment on the importance of intangibles. As a result, this type of evaluation, e.g. total cost accounting, has gained considerable importance, especially for larger projects, and must not be left to the unskilled person.

The Role of Standards

Standards have been developed to identify a minimum reference of performance. By designing to achieve at least the minimum reference performance (or better), the engineer exercises the initial requirements of practicing “due diligence”.

In designing for the environment, the principle roles of standards are similar to those in other areas of engineering. However, the implementation of standards has been limited to public health protection and some aspects of environmental protection. This is largely caused by the changes occurring in the definition of minimum performance as the result of rapid changes in knowledge. As knowledge grows, the standards will be adjusted since these standards normally reflect a state of the practice that is well supported by knowledge and experience.

For many environmental issues, there is a wide range of problem areas that have, or need, a reference for expected performance. In some cases, an intermediate level of performance expectation has been developed using guidelines. Guidelines present a considered consensus of options regarding minimum design criteria. The expectation of guidelines is that a minimum level of performance will be achieved, but it is recognized that high expectations and better methods of design may lead to better systems. In some cases, guidelines reflect limits in the acceptance or vestment of responsibility or liability by those issuing the guidelines.

In some areas of design, such as water treatment or water distribution, the application of design fundamentals concerning public health protection has led to relatively well-defined boundary conditions for performance criteria. The standards and guidelines are well understood, and each revision contains relatively minor adjustments. In other areas, knowledge of parameters and interactions is so limited that definition of the minimum reference performance is being modified routinely. In the latter case, the design engineer must take a more active role in setting the boundary conditions for design. This means the current knowledge beyond the limits of standards must be incorporated into the design decision-making process.

“Due diligence” is a concept developed by the legal profession as one way to define responsibility. In matters of environmental design, the concept is important. This is because “due diligence” is defined as the best practice at the time. With few standards and a few more guidelines available to the designer, this concept is then tied to the knowledge of the profession at the time the design was created.

Furthermore, “due diligence” requires the project manager to be current with respect to knowledge that goes beyond the existing standards and guidelines.

Public Consultation

Several environmental acts and regulations call for public consultation as a project is being developed. It is critical that efforts for nurturing public involvement be included in a project. In some cases, however, there is little, if any need for public involvement, and the potential response from the public and be inconsequential.

With major projects, the public consultation process should begin before the site selection or design has progressed to a point of commitment. This is because it is know that better project development can occur if the public is aware of the intent and scope of the projects. Also, the public must be aware of the trade-offs in terms of impacts on their way of life.

Prevention and Remediation

Real risks mean that there are real potentials for hazards to occur. Risk evaluation is not a one-time activity, but is a continuous process. As risks are identified, options for reducing the risks of concern must be developed. This may involve significant design changes. Designing for remediation is another important component of design work. It requires the definition of risks and then an examination of options for dealing with problems that might occur.

References

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CHAPTER 6

Continual Improvement

By: Joel R. Nodelman, P.Eng.

> "Engineers are a pain to deal with when you are attempting an environmental negotiation. They speak a language that 99% of the human race cannot understand. They have two hemispheres in their brain, just like the rest of us, but they insist on using only one of them, the logical, analytical side. Engineers, for the most part, don't know anything about politics or human nature. They affect an attitude of being above it all, above politics, above people, above everything and everybody." (1)

> "No one doubts that engineers have designed artificial eco-systems that are of immediate benefit to today's human populations, but in the process, huge expanses of nature received no benefit at all. Rather, nature was demolished." (2)

> "Over recent decades individual members of APEGGA have endeavoured to better understand the concerns raised by competent core environmentalists. Meanwhile, they continue to respond to the public's desire for more efficient devices, even though many of these devices, like the automobile, seem to have a negative impact on the environment. Thus, it turns out that protecting the environment, a more obligation to future generations, is often at odds with the demands of today's marketplace." (3)

These quotations all reflect a view of the engineer's environmental responsibility and accountability in professional practice. They are not flattering views of individuals or the engineering profession, yet in many ways, they are correct.

Engineers are agents of change in society. They conceive, design and build. In the process, they change the ecology of the areas in which they build. Historically, this role has been viewed to be beneficial. Over the last two decades, however, society has become far more critical of the environmental impact of engineering activities, and is now demanding a balance between progress and environmental sensitivity. This concept of balance is the essence of the notion of Sustainable Development.

Sustainable Development seems to have as many definitions as there are people who discuss it. However, common themes tend to emerge from discussions about Sustainable Development; themes of continuous improvement, and of activities and behaviour patterns which are not mandated by laws and regulations. Engineers, businesses and governments which adapt to this change will be successful.

Public Expectation and Societal Need

Public perception will define continuous improvement. The direction that society proceeds will be determined through ongoing public debates. The engineering profession has a significant role to play in these debates. To take on this role, engineers must understand what drives the environmental agenda. These matters should be considered an agenda rather than a single issue since professional engineering judgement must cover a broad range of considerations, including biological, technological, scientific, legal, social, moral and ethical factors.

The activities of humankind have managed to:

- threaten biodiversity on this planet;
- possibly change the climate'
- pollute the water, air and soil;
- deplete the ozone layer;
- acidify lakes;
- deplete forests; and
- destroy arable land.

This is a short sampling of a very long list of issues.

Over the years, items on the list come and go, but the list grows no shorter and the level of societal environmental concern does not decrease. This leads to the conclusion that there are drivers behind the environmental agenda which must be considered if the agenda is to be properly addressed.

Professional engineers should understand these drivers to participate properly in the public debate.

One way to view the drivers of the environmental agenda is to consider three fundamental factors. In every item on the environmental agenda, one or more of these factors seem to be present, either as an obvious force or lurking in the background. These factors are:

- Population
- Poverty; and
- Politics

Population

At the root of the environmental agenda is population, and the expansion and development required to sustain the rapidly growing number of humans on this planet. Each hour, the human population grows by approximately 10,000. To sustain this growth, humankind is forced to ever greater rates of consumption of energy and other resources. In many parts of the globe, this has resulted in degradation of air and water, deforestation, depletion of fish stocks, and species extinctions.

In an average Canadian city, the population density is over 2,000 individuals per square mile, and it is much higher in city cores. These sections of land could sustain only a fraction of the population if it weren't for a sophisticated technological infrastructure. This infrastructure includes:

- homes heated with fossil fuels that are extracted from the earth, refined and transported thousand of miles by pipeline and tanker truck;
- power for lighting and appliances that is generated by fossil fuels, hydro, or nuclear power far removed from our comfortable homes;
- **food grown under intensive farming practices and transported thousands of miles in refrigerated vehicles over an extensive network of paved roads, rails, and bridges;**
- warm clothing made from synthetic fibres or natural fibres that is transported over the same transportation networks;
- safe, clean water that comes directly from taps inside our homes, and is produced by a network of water treatment, pumping and transmission facilities; and
- solid wastes collected at the door and treated at facilities far removed from population centres.

Our society is sustained by technology. As the population grows, the technological infrastructure must also grow simply to maintain the existing expected level of health, safety and comfort. Each element of the technological infrastructure that sustains society produces its own waste streams and has its own environmental impact.

Poverty

The majority of the world's population lives in developing nations, and most of them are poor by our standards.

Two fundamental issues are raised by poverty. As the developing world's population grows, more and more of the earth's resources must be applied merely to sustain the population at its existing impoverished level. In addition, the world's poor see the quality of life enjoyed by the developed nations and are now demanding their share of the "good life".

While the developed nations are focusing on biodiversity and climate change, the developing nations are focused on food supply and clean water. A minimum per capita earning potential facilitates an appreciation of environmental issues and impacts.

As a result, proposed solutions to the world's most pressing problems are couched in economic terms.

Politics

Whenever social issues involve the expenditure of money, there will be politics.

Many times, the developed nations have spent billions of dollars on famine relief only to have local authorities prevent the distribution of food to those most in need. Control of the food supply translates into political power.

Even on local levels, politics dominates the environmental agenda. The siting of any new industrial facility can get bound up in political entanglements, resulting in delays in project construction or project cancellations.

It takes money to solve large social problems, and it takes political will to effectively spend the money.

The Environmental Agenda and the Professional Engineer

Professional engineers solve problems by applying rational scientific principles. Each environmental problem faced by the professional engineer can be segmented into four components:

- technical;
- legal
- ethical; and
- **social.**

Environmental problems can only be solved if each component is properly addressed using appropriate tools. Simply stated, it is difficult to solve social problems by using regulations that are meant for solving technological problems.

It is the responsibility of professional engineers to understand the type of environmental problem they are facing and to apply appropriate elements to solving that problem. Where they lack the expertise, they must seek qualified assistance to help solve the problem.

Environmental problems are multi-disciplinary by nature and dominated by facts generally outside of technological control. To deal properly with environmental problems, the professional engineer must become conversant with other professions, and learn to work with social scientists, lawyers, politicians, home-makers, environmentalists and shop keepers.

Technical

Usually, the technical component of most environmental problems is small. This does not mean that technology is unimportant. It will always be an engineer's responsibility to do the engineering correctly, meeting all relevant standards and with an eye to improving practices of the profession. Lives depend on this. However, projects do not generally arrive on the environmental agenda if they are not technically sound. Once the technology has been defined, the bulk of the social debate about the project remains to be completed.

Legal

Environmental laws are extensive and complex. Even so, it is the responsibility of professional engineers to be aware of all legal requirements in their jurisdiction, and when there is doubt, they must know who to ask for help.

Environmental laws and their associated regulations outline how engineering activities can be conducted in a legal manner. Compliance with legislation can be very time consuming and difficult. However, failure to comply can result in serious personal consequences.

Under many pieces of environmental legislation, officers and employees of a company can be held personally liable for non-compliance. This could result in stiff fines for individuals found guilty of offenses under these acts. Additionally, the legislation does not generally allow companies to indemnify employees. If found guilty, the professional engineer could be held personally liable for payment of fines. Beyond this, if the non-compliance was the result of non-professional or poor engineering practice, the provincial professional engineering association can take disciplinary action against the professional engineer.

The profession engineer's responsibilities go well beyond those of average individuals, and the legal and regulatory structures in Canada acknowledge this fact.

Ethics

An activity can be technically sound and meet current legal requirements, but still be wrong. It is the responsibility of professional engineers to evaluate the ethics of their professional activities, and to understand that personal values and affiliations can bias decisions.

Professional engineers are in a unique and special position in society. They are more knowledgeable about the technology they apply than the average person, and they are more aware of the risks and side effects of that technology. It is the professional engineer's responsibility to evaluate and consider the implication of these side effects and take appropriate action.

Social Values

Environmental legislation defines legal requirements and protocols for conducting public consultation. Any engineering activity that has potential environmental impact can proceed only when the affected portion of society is in agreement.

Defining who are the affected parties is a major challenge. Failure to include all affected parties can be disastrous, resulting in ultimate failure of the engineering project. If certain segments of society feel left out of the discussion they can become very aggressive in their opposition.

Even after all reasonable segments of society have been identified, there is no guarantee of success. One of the most difficult challenges the professional engineer faces is that of communicating effectively. In general, professional engineers have difficulty communicating about technical matters with non-engineers. The professional engineer's language is couched in jargon, and replete with qualifiers and exceptions. This is especially true in the profession's area of technical expertise. Unfortunately, the average person responds to this form of communication with cynicism and distrust. When they do not understand what the professional is trying to tell them they believe that the professional is trying to cover up something. This can result in the paradoxical situation where the more knowledgeable and qualified the professional is to speak on an issue, the less likely will that professional be believed.

Communicating well with all audiences is rapidly becoming a professional requirement. It is the professional engineer's responsibility to learn appropriate communication tools to explain adequately their professional work. The professional engineer's work loses all meaning if nobody understands what he has to say about the issue.

Emerging Technology

Professional engineers are in the forefront of new technology development. The profession develops new technical solutions as continuously more demanding problems are faced by society. The rate of technological change has been accelerating to the point where it is now almost impossible to read all the relevant printed material on any given technical issue. Standards development is lagging behind the rate of technological change, and current technological standards may be dated or irrelevant. The role of the professional engineer has become more important than ever.

The professional engineer is faced with difficult professional decisions. This is especially the case in environmental practice where legal standards may not be based on scientific fact, and where the issues can be driven by significant non-technical factors.

In the absence of written standards, or when written standards have become dated, professionals must rely on voluntary standards of the profession, their own professional judgement, and on accepted industry norms. This imposes a significant burden on professionals. It is no longer acceptable professional practice simply to accept written standards.

The only measure of acceptability may be Best Available Practice Technology (BAPT). This means that in many cases the only acceptable technical standard will be the most advanced technology used. It will be the professional's responsibility to be knowledgeable about these technologies, and present valid arguments for or against the use of these technologies in a particular application.

In environmental practice, written standards must be seen as a starting point for feasibility evaluation, rather than as an end point dictating technological choice. It is the professional engineer's responsibility to ensure that a thorough evaluation of emerging technical solutions is conducted.

Maintaining Competence

To maintain a credible level of professional competence, and to protect against liability, the professional must continuously update technical knowledge, be aware of the unwritten standard practices of the discipline and maintain contact with technological advancements at home and abroad. This is a tall order, since three is simply not enough time in the day to review all the information on any discipline. Nonetheless, it is the profession's responsibility to maintain competence and to be able to document continuing advancement in their discipline.

Although a great deal of information is currently available, much of it may not be high quality or relevant to the professional's area of practice. The professional must learn to screen information. There are many ways to do this. It is important for engineers to maintain membership in professional societies dedicated to their area of professional practice. These associations allow their membership the opportunity to network with other practitioners and maintain an understanding of the trends in their areas of professional practice. The organizations may also publish journals or other periodicals which monitor trends.

It is important to note that the professional engineering associations in Canada are not primarily responsible for providing this kind of information. Professional engineering associations are legally responsible for licensing and regulating the profession, whereas technical societies generally provide ongoing opportunities for technical advancement.

In the area of environmental practice, a number of other activities can help the professional maintain a better professional level of understanding. Since the environmental agenda is primarily driven by social issues, it is important to maintain a finger on the pulse of community opinion. Professionals can achieve this by involving themselves in their communities through service clubs, schools, church groups, charitable organizations, political parties and other community organizations. In this manner, the professional has ongoing interaction with people who are not knowledgeable about the professional's area of practice. This can provide great insight into the effectiveness of the profession's ability to communicate to the public, and also provide a non-engineer perspective of environmental issues. In this manner, professional understanding can be improved by pursuing personal interests.

The professional should also monitor the popular media to keep current with public concerns. Television, magazines, radio and local newspapers can provide significant insight into the community's opinions and expectations.

Sustainable Design

In the landmark 1987 report "Our Common Future – World Commission on Environment and Development," sustainable development is defined as:

> "… development that meets the needs of the present without compromising the ability of future generations to meet their own needs."

Since that time, the expression "sustainable development" has become a catch phrase having as many definitions as there are people in the debate. Nonetheless, the concept of sustainability has become ingrained in the public conscience, and society is beginning to demand that sustainability be considered as one criterion in the evaluation of new development opportunities.

The lack of consensus on the meaning of sustainable design creates a significant challenge to the practicing professional engineer. Without an adequate definition, it is seemingly impossible to design in a sustainable manner. Fortunately, even though there is no consensus on a working definition, there is growing consensus on the process of sustainability.

Fundamentally, engineers act as agents of society, designing and building devices and structures to meet the demands of that society. In a sustainable design process, project proponents consult affected parties and ensure that new designs address their concerns rather than a very narrow set of technical criteria. In this way, it is argued, progress today will not impose unacceptable burdens on tomorrow.

Sustainable development is becoming a process rather than a fixed written standard. It will become the kind of voluntary standard discussed throughout this monograph. Successful profession engineers will become adept at understanding these unwritten standards, and applying this knowledge on behalf of their clients and employers to design and implement new and progressive developments.