

**DEVELOPMENT OF AN AUDIT PROTOCOL  
FOR THE INVESTIGATION OF A CONTAMINATED SITE**

**by**

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## **LIST OF ABBREVIATIONS**

ACM	Asbestos Contaminated Material
AHERA	Asbestos Hazard Emergency Response Act
ARAR	Applicable or Relevant and Appropriate Requirements
ASTM	American Society for Testing and Materials
bgl	below ground level
CERCLA	Comprehensive Environment Response, Compensation and liability Act (Superfund)
CI	Confidence Interval
CLARINET	Contaminated Land Rehabilitation Network for Environmental Technologies
CLEA	Contaminated Land Exposure Assessment
COC	Chain of Custody
COE	Cops of Engineers
CO <sub>2</sub>	Carbon Dioxide
CSDS	Chemical Specification Data Sheet
DIV 2000	Dutch Intervention Values (2000)
DO	Dissolved Oxygen
EC	Electrical Conductivity
ECRA	Environmental Cleanup Responsibility Act
EPA	Environmental Protection Agency
EPA ID	Environmental Protection Agency Identification Number
EQA	Environmental Quality Act and Regulation
ESA	Environmental Site Assessment

GC	Gas Chromatography
HRS	Hazard Ranking System
HSE	Health, Safety and Environmental
IPA	Iso-propyl alcohol
ISO	International Organisation for Standardisation
LOR	Level of Reporting
MIC	Methyl isocyanate
na	not analysed
nd	not detected
NESHAP	National Emission Standard for Hazardous Air Pollutants
NGO	Non-governmental Organisation
NPL	National Priorities List
PCB	Polychlorinated biphenyls
PCM	Phase Contrast Microscope
PDC	Penang Development Corporation
PID	Photo-ionisation Detector
PRG	Preliminary Remediation Goals
PRP	Potentially Responsible Party
PVC	Polyvinyl Chloride
QA/QC	Quality Assurance and Quality Control
RCRA	Resources Conservation and Recovery Act
RIVM	Dutch National Institute for Public Health and the Environment
RL	Reduced Level
RM	Ringgit Malaysia
RPD	Relative Percent Difference



SAMM	Skim Akreditsi Makmal Malaysia
SARA	Superfund Amendments and Reauthorisation Act
SVOC	Semi Volatile Organic Compounds
SWL	Standing Water Level
TCLP	Toxicity Characteristic Leaching Procedure
TNB	Tenaga National Berhad
VOC	Volatile Organic Compounds
UK	United Kingdom
US	United States
USCS	United States Classification System
USEPA	United States Environmental Protection Agency
WWTP	Waste Water Treatment Plant

# **PEMBANGUNAN PROTOKOL AUDIT UNTUK PENYIASATAN TAPAK TERCEMAR**

## **ABSTRAK**

Kemunculan polisi-polisi baru di serata dunia secara amnya mempunyai satu tujuan iaitu merangka satu piawai untuk melindungi kualiti tanah dan juga kualiti air bawah tanah. Kesan negatif akibat penyusutan kualiti tanah dan kualiti air bawah tanah secara tidak langsung mendapat perhatian daripada golongan orang awam, para pengusaha industri dan juga peladang supaya satu tindakan yang sewajarnya diambil. Penekanan dalam aspek melindungi penyusutan kualiti tanah dan juga kualiti air bawah tanah agar mematuhi perundangan yang telah ditetapkan adalah perlu bagi kepentingan generasi akan datang. Isu berkenaan penyiasatan tapak yang tercemar diteliti dan tumpuan diberikan dari segi kekurangan dalam perundangan sedia ada bagi kedua-dua perundangan kebangsaan dan juga antarabangsa. Bagi membangunkan protokol audit untuk penyiasatan tapak tercemar penelitian ke atas piawaian dan praktik khusus dalam protokol audit yang digunapakai oleh negara Australia, Kanada, United Kingdom dan juga Jerman dinilai dengan memberi penekanan dalam melihat aspek kelemahan dan kekurangan elemen yang tidak diketengahkan. Protokol audit yang telah dibangunkan kemudiannya dibuat pengesahan keberkesanannya melalui audit persekitaran bagi premis perindustrian dengan menggunakan cara ketelitian berpunca yang melibatkan temuduga, mengkaji sejarah tapak dan pengumpulan serta penganalisaan sampel. Premis tersebut terletak di Zon Perindustrian Prai dan terlibat dalam proses pembuatan dan perekaan barangan elektrik. Audit ketelitian berpunca telah dijalankan untuk memastikan bahawa tapak kajian adalah bebas daripada pencemaran alam sekitar dan

ketidakpatuhan undang-undang kerana ada kemungkinan premis tersebut akan bertukar tangan.

Berdasarkan kajian permulaan iaitu temuduga dengan pekerja daripada tapak bersebelahan dan pihak kerajaan, didapati premis yang dikaji adalah bebas daripada bahan pencemar. Analisis air bawah tanah serta air bawah tanah dengan menggunakan kaedah kajian tanah “borehole” serta kajian yang lebih mendalam dengan menggunakan Inductive Couple Plasma (ICP) spectrometer untuk mengenalpasti tahap logam berat menunjukkan bahawa plumbum dengan nilai 870 ppm yang terdapat di dalam cat yang telah digunakan pada bangunan di suatu lokasi. Barium adalah 1020ppm dan 576ppm di dua lokasi berbeza manakala plumbum didapati adalah 914 dan 880ppm. Kromium dan barium juga dikesan di dalam air bawah tanah di mana tahap kromium adalah 56 dan 63ppm manakala barium adalah 1420 dan 3780ppm. Tahap pencemar yang dikenalpasti telah dibanding dengan Piawai Intervention Belanda (DIV 2000) kerana Malaysia tidak mempunyai piawai bagi pencemaran logam berat di dalam tanah dan air bawah tanah di premis perindustrian.

Penilaian risiko telah dibuat untuk memastikan tahap kerosakan yang boleh berlaku akibat bahan pencemar serta impaknya terhadap penghuni di tapak, tapak bersebelahan dan ekosistem. Berdasarkan protokol audit yang telah digariskan bagi mengkaji tapak yang tercemar, didapati tapak kajian tersebut selamat untuk digunakan.

# **DEVELOPMENT OF AN AUDIT PROTOCOL FOR THE INVESTIGATION OF A CONTAMINATED SITE**

## **ABSTRACT**

New and emerging policies around the globe aim to set standards for the protection of soil and groundwater. Soil and groundwater degradation is seen as the change required from the public, entrepreneurs and cultivators to take a serious view on the harm it is doing. Focus on protecting the soil and groundwater to meet the legislative requirements for the benefit of future generations. Issues on contaminated sites are reviewed and the shortfalls observed with the present regulatory standards for both national and international. To develop an audit protocol for the investigation of a contaminated site a review on specific standards and practices of Australia, Canada, United Kingdom and Germany on their existing audit protocol are assessed and lay emphasis on the gap and lacking elements. The proposed audit protocol was then develops and validated on a selected industrial premise by employing a due diligence approach which includes interview, site historical review, soil and groundwater sampling and analysis. The premise is located in the Prai Industrial Zone and used to be involved in the manufacturing of electronic products and assemblies. The due diligence audit was conducted to ensure that the premise is free from any environmental and regulatory non compliance, since there is a potential property transaction.

Based on the initial investigation comprehending onsite and offsite interviews of workers from neighboring sites and local authorities, findings indicate that the site is free from any contaminant. Soil and groundwater samplings using borehole soil investigation method and further analysis using Inductive Couple Plasma (ICP) spectrometer for determining heavy metals, showed lead in paint at one location at a value of 870 ppm used in the building. Barium and lead was also detected in soil. Barium was 1020 and 576 ppm at two locations and lead was 914 and 880 ppm soil analysis. Chromium and barium was also detected in groundwater. Chromium was 56 and 63 ppm and barium was 1420 and 3780 ppm for groundwater.

The levels of the identified contaminants were compared with the Dutch Intervention (DIV 2000) Standards because Malaysia does not have any heavy metal standards for soil and groundwater contamination on any industrial premise. A risk assessment was made to determine the extent of the potential harm that could arise from the contaminants and the impacts on the occupants on site, the neighbouring sites and the ecosystem. Based on the audit protocol for the investigation of a contaminated site developed in this study indicated that the risk assessment for the site is safe to be used.

# **CHAPTER ONE**

## **INTRODUCTION**

### **1.1 Environmental Audit Protocol**

Conducting an environmental site assessment or audit is a useful activity if we want to embrace fully the concept of sustainable development and a sustainable economy. It provides performance assessment, identifies problems, conserves resources, prevents pollution, reduces liability and improves community relations. It also upholds environmental regulatory system. With consistency in approach and transparency, auditing holds potential for transforming the nature of the relationship between government regulators and regulated community. Environmental auditing is not a substitute for a firm regulatory framework coupled with forceful enforcement and enhanced community awareness.

Conducting an ESA prior to buying a premise is in essence a 'precautionary principle'. It allows the buyer to assess the quality of purchase. The result will outline the quality of the groundwater and soil. It will determine the level of contamination and an assessment of the liability can be established. A risk assessment on the contaminants will determine the premise suitability for human occupation, ecology existence and any potential offsite contamination. By implementing the above, the 'polluter pay principle' may be executed. Innocent buyers are protected and have the option to purchase or determine new terms for the transfer of the premise.

United States and other developed countries have made good strides in improving air and water quality over the last thirty years. Whereas developing countries are following the footsteps of developed countries in establishing regulatory framework, adopting standards, undertake inspections, monitor and analyze report findings and carrying out enforcement actions.

In industrialized countries, there is a shift of responsibility to companies and facilities to demonstrate compliance with environmental laws, standards and procedures. Countries have started developing their own standards to conduct ESAs. The International Organization for Standardization (ISO) started developing an ISO standard and was completed in 2004. The standard was formalized as Soil Quality – Characterization of Soil related to groundwater protection (ISO 14015, 2004) and is getting international acceptance.

In summary, pollution occurs when some part of the environment is made harmful to living organisms. Contamination is the influx of hazardous material to the soil, groundwater or air with the potential of hurting any living organism. For example, insecticide which is used to kill locusts would not be considered a pollutant unless it also kills other organisms that are considered to be beneficial to the environment. Most chemicals are harmful in concentrated form and may be beneficial in low doses. Zinc is an essential element for both plants and animals but is harmful to both in high concentrations.

### **1.1.1 Environmental Site Assessment – Malaysian Practice**

With the Malaysian government's emphasis on industrialization, there are more manufacturing industries being built to earn revenue and reduce unemployment. The industries may practice some cost reduction programs or activities to remain competitive. For example, they may discharge untreated process water to the soil or river at their locality or dispose hazardous waste in an unapproved manner, thus contaminating the site or water stream.

In Malaysia, the Environmental Quality Act (EQA) 1974 and Environmental Regulations are available, but the performance guidelines and regulated standard is not yet available. As such, enforcement lags. In section 33A (1) of the EQA, the Director General may require the owner or occupier of the premise to carry out an environmental audit and submit an audit report. Section 34 (B) of the EQA stipulates the control of scheduled wastes, no person is allowed to place, deposit or dispose waste on land or Malaysian waters except at prescribed premises. Section 37 of the Act allows the Director General to get information, a report or an assessment from the owner or occupier, for the following;

- a) Use of raw materials or environmental hazardous substances at the premise,
- b) Any environmental hazardous substances, pollutants or waste discharged or likely to be discharged,
- c) Any environmental risk that is likely to result from the use of the raw materials, environmentally hazardous substances or process.

Any person failing to provide information required by the Director General is liable to a fine and or imprisonment. The EQA has regulation with regards to the discharge of water from process, sewage discharge, storage and disposal of hazardous waste.



There are no regulations with regards to the control and maintenance for the quality of groundwater and soil. No standard and limits have been determined for the control of groundwater on site. Also, there is no enforcement for offsite contamination. For companies operating in Malaysia, environmental site assessment offers facility managers an immediate means of evaluating the quality of groundwater and soil. Multinational companies are increasingly applying international acceptable standards in conducting environmental site assessments wherever they operate. This can be a prerequisite or performing the due diligence to prevent inheriting any contaminated premise or site. These multinational companies (operating internationally) are adopting codes of their parent companies; this is due to the absence of environmental regulations and standards at their international sites. The US law can request to obtain under some circumstances environment site assessments conducted by the subsidiaries in foreign jurisdiction.

As such, there are no requirements as to when to investigate contaminate sites. Jewell *et al* (1993) has summarized in their study a site is investigated for the following reasons;

- a) Sale of the land,
- b) Rezoning or redevelopment of the land,
- c) Internal review of status of asset,
- d) Whenever there is a proposed change from a less risk sensitive use to a more risk sensitive use, and
- e) Investigation of known or suspected contaminated sites where there is concern among public or the authorities that contamination maybe migrating beyond the site boundaries.

## **1.2 Research Motivation**

This Environment Site Assessment study is carried out on Plot Number PT 3037, Mukim 01, Daerah Seberang Perai Tengah, Pulau Pinang. A one and a half storey detached factory is located on the site. The purchaser's intent is to protect himself from liabilities with regards to any environmental contamination on the site by the seller. By doing so, the purchaser conducts an Environmental Site Assessment (ESA) on the site with permission from the seller.

This practice is not common in Malaysia as the Department of Environment has not made this process a prerequisite in the sale of a property. Neither is there any legal regulatory requirement for such practices in Malaysia. This is a common process in the United States and in some countries in Europe.

The buyer being an established multinational in Penang, is required by the corporate head quarters to conduct the ESA. This activity is to protect the corporation from inheriting a liability in the process of purchasing or leasing a property. Upon completion of the study, the buyer will be in a position to quantitatively make a decision whether to go ahead with the purchase of the property. They would also know about the liabilities they will be inheriting and how to manage the outcome in due course. The intent is also to establish a base line for the soil and groundwater of the site. The study will also be shared with the Department of Environment, Pulau Pinang. This action will establish a transparent relationship between each other as well.

In Malaysia there are no legal regulatory requirements requiring the buyer or seller to conduct an environmental site assessment. So this exercise will help us in learning the

process and also share the knowledge with the local environmental agency. The local agency can use the study as a reference to establish a protocol in the future.

### **1.3 Objectives**

The objectives of this research study are as follows:

- a) To review existing protocols used for the investigation of contaminated sites.
- b) To develop and propose an audit protocol for the investigation of a contaminated site and
- c) To validate the proposed audit protocol to a selected case study.

At the end of this case study, the report will provide a baseline for soil and groundwater of the site investigated and the data can be used for future improvements or litigation matters with the Department of Environment.

### **1.4 Scope of the Study**

The scope of the case study while evaluating the audit protocol and during its application is summarized as follows:

- a) Assessment of the proposed audit protocol.
- b) Identification of potential sources of contamination of the site and any potential historic onsite contamination. Identification of any potential historic off site contamination sources from adjacent locations of the site.
- c) Identification of locations points for boring of wells for the environmental site assessment of the site. Drilling and installation on site wells to conduct the study.

- d) Development of groundwater monitoring wells – gauge and purge monitoring wells prior to collecting samples for evaluation.
- e) Screening the soil samples for volatile organic compounds (VOCs) using a photo ionization detector (PID). Sampling for volatile organic compounds (VOCs) and semi volatile organic compounds (SVOCs) in the soil and groundwater.
- f) Sampling for metals (arsenic, cadmium, chromium, lead, selenium, silver, barium, and mercury) in the soil and groundwater.
- g) Assessment and tabulation of soil and ground water quality levels against Dutch Intervention Value (DIV 2000).
- h) To provide comments on the proposed audit protocol, data, draw conclusions and recommendations.

## **1.5 Benefits of the Research**

Conducting a study or research on any subject matter will enhance knowledge of the researcher. In this case, the researcher is applying all the theoretical skills obtained during the course of study, personal experience on environment, and health/safety practices over the years, using some of the guidelines and established protocols used by existing western countries. The benefits of the research can be summarized as follows;

- a) The research will come with a protocol/manual for the assessment of sites, which can be used to assess sites for investigation and abandoned sites.
- b) The proposed protocol will be validated as a case study of the site.
- c) An assessment of the site will be obtained. The buyer and seller will each know their liability prior to the sale materializing. This study will indicate the extent of any environmental degradation of the site.

- d) This study will indicate the risk implication with regards to health and safety to the occupants of site and neighbours. It will help in establishing the appropriateness and usage of the site of a responsible citizen. This practice of determining the environmental and safety of the site and correcting the site of the pollutants will create an emphasis of a green environment.
- e) The outcome of the research will be shared with the Department of Environment. This will generate knowledge sharing between the multi-national corporation and the local environmental agency.

## **CHAPTER TWO**

### **LITERATURE REVIEW**

#### **2.1 Introduction**

Many western countries regulate the identification and remediation of contaminated sites. Malaysia does not have specific laws governing the requirements with regards to identification and remediation of contaminated sites. However, in recent times the Department of Environment in Malaysia has taken some action against polluters. Among the countries, United States takes a lead in defining requirements, establishing laws and implementing them with regards to polluters. Liability for the clean-up of these sites usually lies on the polluters and if they cannot be found or held liable, the current owner or occupier of the site is held responsible for the clean-up. Thus, to protect innocent owners, the government has introduced and regulated the transfer of contaminated and potentially contaminated sites. Therefore, when acquiring properties an environmental site investigation of the site is conducted to avoid any future environmental liability. Rules governing this process are updated and enhanced periodically for the benefit of purchasers.

#### **2.2 Contaminated Site Issues and Concerns**

Contamination and the nature of contaminants (Jewell *et al*, 1993) is well established on sites such as petrol service stations. This has been established from previous experience and studies. All such sites are contaminated to some extent, the nature of contaminants are mostly hydrocarbons and lead. Smith (1991) also mentioned that hazardous materials,

such as solvents, degreasing agents and lubricants are more commonly present on such sites. So, base line levels are to be calculated carefully as they have both economic and sustainability ramifications. Salminen and Gregorauskiene (2000) illustrated this point clearly, 'To consider for instances, the financial loss of the landowner whose soil is declared contaminated'.

Transactions involving real property or through company acquisitions can convey the liabilities associated with contamination present in the soil or ground water. Bankers who finance the property place their secured capital at risk if collateralized property is contaminated. Certain states such as in New Jersey (United States) require a due diligence audit as per Environmental Clean-up Responsibility Act (ECRA, 1984) to be conducted prior to the transfer of an industrial property. During the process of investigation it has been determined that the liability (with regards to cost) associated with remediation of a contaminated property is very huge and has surprised many land owners, tenants and lending institutions.

Some examples quoted in ECRA (1984) are discussed below:

A purchaser bought a piece of land and finds out later that piece of land was used as a landfill. The purchaser had to pay US\$6 million to clean-up the groundwater in the area. An electronic manufacturing company moves from a site that they had leased for 6 years. The company is acquired 8 years later. Two years later, groundwater contamination is discovered. The site owner successfully sues (10 years later) the acquiring company to pay for the clean-up, claiming that the manufacturer was the 'only tenant likely to have used a sufficient quantity of the chemical known to have caused the contamination'.

A bank lends money to a company. When the business started to have financial difficulties, the bank stepped in and ran part of the company. The bank ultimately foreclosed the company. The property was found to be contaminated. The bank was found to be liable for a major part of the remediation. The cost of remediation was 25 times the amount of the original loan.

Thus, the value of real property can be greatly diminished if the property is found to be contaminated and needs remediation. The need to know the potential liabilities is crucial to both the buyer and seller of the property. The costs of removal of asbestos insulation, or remediation of soil and groundwater contamination resulting from historic uses can greatly exceed the present-time value of the property. Lending institution may lose the property's value as collateral and possibly become liable for the cleanup cost upon foreclosure. For the above reasons it has become prudent that all buyers and commercial lending institutions require an evaluation of the environmental risks before completing the mortgage transactions. Today in the US, site assessments have become a routine part of commercial real estate transaction. Some American and European companies operating in Malaysia have made it mandatory for its subsidiaries to conduct such site assessments prior to any purchase or leasing of real estate.

Ries and Burns (2005) mentioned in their work that environmental litigation always involves scientific issues and expert opinions. The US Supreme Court established a gate keeping requirement under which courts must screen expert opinions for reliability and exclude 'junk sciences' based on the case of 'Daubert versus Merrell Dow Pharmaceuticals' in 1993. The study should include substantive analysis for determining admissibility of scientific evidence. Admissible evidence may be taken from any qualified



witness who is an expert by knowledge, skill, experience, training or education, may testify in the court.

Parties involved for a property transaction for an environmental site assessment are a buyer and a seller. Parties can be an individual, several people and/or a corporation either way. The assessment once performed is beneficial to both the buyer and seller to come to terms during the negotiation process. Each of them will know their individual liabilities (Jewell *et al*, 1993) from the results of the assessment and will assist in the negotiation of setting the price. The assessment process will assure the financial institution the value of the real estate and it also indicates that the property is free from any major environmental liability. When it involves an industrial or commercial property, the tenant and landlord should evaluate liabilities, prior to occupying the property and also on leaving it as this will avoid any future claims. There are no regulatory requirements in Malaysia with regards to conducting an environmental site assessment. As such, the Department of Environment does not require an assessment during the transaction of a property. Whereas, regulatory agencies in the United States have the authority and part of its objective is to protect the environment may bar the transfer of a property to its new owner until an assessment is completed and/or the site remediated.

The focus of assessment is based on historic practices and current operations that may result in the release of hazardous substances into the soil or groundwater. Based on the ECRA reports as mentioned earlier, the largest liabilities derive from historic rather than current practices. The uncertainty of defining the liabilities is the difficulty in detecting the environmental problems. Some typical conditions for contamination are unrecorded

waste disposal operations, use of contaminated fill material and leaks in underground storage tanks.

### **2.3 Site Investigation and Superfund**

The industry standard for conducting assessment of real property is provided by American Society for Testing and Materials (ASTM). The goal of the standard is to identify ‘recognizable environmental conditions’ that could lead to or result in Comprehensive Environmental Response, Compensation and Liability Act (CERCLA, 1980) liability at a site. What this means, is ‘the presence or likely presence of any hazardous substances or petroleum products on a property under conditions that indicate an existing release, a past release, or a material threat of a release of any hazardous substances or petroleum products into structures on the property or into ground, groundwater or surface water of the property’. The standard CERCLA investigation approach for test results such as these would be to classify the site sample as contaminated, and perhaps to evaluate the site data further in a risk assessment. If the site data happen not to exceed an action level or risk based screening level, then additional assessment or remediation would not be necessary. If however, the site data do exceed an action level or risk based screening level, further assessment and possibly remedial action would be required. These activities would take place in spite of the fact that definite evidence of site related contaminated had not been produced.

The US Department of Defense has the task of cleaning up waste that have resulted from industrial, commercial and weapon testing sites usage. According to Salatas *et al* (2004) it is estimated that the department has remediated about 8000 sites in the United States. Out

of all the sites, a majority (67%) contain metal contamination in soils. The decision on remediation was based on the amount of metal that could actually be absorbed by human or ecological receptors. For barium as a metal the human health criteria for an industrial site is 79,000 PPM (USEPA, 2001) and for the ecological receptor criteria for mammalian it is 329 PPM (Efroymson *et al*, 1997).

The ASTM E1527-2005 covers the phase one study of the investigated site and the scope includes the following:

- a) Interviewing of current owner or occupants,
- b) Interviewing with an owner of a neighboring property,
- c) Examination of documents,
- d) Documentation of significant gaps or uncertainties and
- e) Specifying documentation requirements where the subject property cannot be visually inspected.

The ASTM E1528-2006 covers the transaction screen process. It is applied in conjunction with E1527 for commercial properties and has become a customary practice in the US for conducting an environmental site assessment for real estate with respect to the range of contaminants within the scope of CERCLA and petroleum products.

The ASTM E1903-2002 covers the phase two study of the investigated site and the scope includes the following:

- a) Investigation of groundwater contaminants,
- b) Investigation of soil contaminants and
- c) Other contaminants from on site or off site.

The phase three study is done when contaminants are detected on the investigated site. This phase is done when corrective action or remediation is required to contain, remove and dispose the contaminant. Such contaminated material is disposed to approved and licensed waste disposal sites.

Unfortunately, the ASTM standard has a relatively narrow purpose under the US law. Specific reference to and definitions of the ‘hazardous substances or petroleum products’ refers to a specific range of chemicals regulated under CERCLA. It does not cover a wide range of hazardous chemicals that are widely used on industrial sites. The ASTM Standard includes reference to asbestos, radon, lead-based paint and wetlands, but are not included in the standard. The phase one study takes a limited approach based on site audits, document reviews and no invasive investigation is carried out until phase two. An audit or assessment can get accepted based on the minimum requirements of the standard. As such, it is reasonable for the purchaser and seller to outline contractual acceptance of the ESA to include some of the missed out criteria. This will mean the buyer and seller can agree to include additional investigative terms and view the investigation with broader consideration.

Comprehensive Environment Response, Compensation and Liability Act (CERCLA) Superfund was established in 1980 with a fund of US\$1.6 billion. Its primary objective was to implement a massive environmental clean-up program in the US over a five year period. Generators were required to report to the Environmental Protection Agency (EPA) any facility at which hazardous waste are generated, or have been generated, treated, stored, or disposed. The aim was to identify and clean up hazardous waste sites first and

then to litigate to recover the cost. The combination of unrealistic expectation and a deregulation attitude had the impact of slowing down an already difficult program. At the end of the five year period only six sites could be cleaned up.

During this period the Bhopal tragedy (3<sup>rd</sup> December 1984) happened in India. Shrivastava (1987) reported that approximately 45 tons of methyl isocyanate ( $\text{CH}_3\text{NCO}$ ) leaked from a storage tank at the Union Carbide India Ltd., pesticide plant in Bhopal, India. Diamond (1985) called this ‘the worst chemical accident in human history’; nearly 3000 people were dead and about 200,000 injured. The occurrence led for the ‘Community Right-To-Know’ provisions to be included in the SARA. This required industries to plan for emergencies and inform the public of hazardous materials and substances being used. Methyl isocyanate (MIC) is a main chemical used in the manufacture of pesticides and is highly unstable and has to be kept at low temperatures. It is extremely toxic, capable of causing severe broncho-spasm and asthmatic breathing when inhaled. It is also an irritant and can be absorbed through the skin. Sax and Lewis (1989) indicated that exposure to high concentration of this chemical can cause blindness, damage to lungs, emphysema and ultimately death. Union Carbide’s internal investigations suggest that the accident was the direct result of employee sabotage. Kalelkar (1988) presented and reported that the detailed investigation conducted by A.D. Little Inc, suggested that the likely cause of the accident was due to the direct entry of water into the MIC tank. The mixture of water and MIC produced high temperatures and pressures causing the MIC gas to be generated at an extreme high rate.

Due to the outbreak of this incident the US EPA was criticized because it had not listed MIC as a dangerous pollutant. Also, the magnitude of the problem led the US Congress to

include the provision 'Right-To-Know' in SARA. CERCLA was amended in 1986 by the Superfund Amendments and Reauthorization Act (SARA) 1996. SARA created a US\$8.5 billion fund for cleaning up abandoned waste disposal sites and an additional US\$500 million for cleaning up leaking underground petroleum tanks. This program allowed the EPA flexibility to perform removal actions, implement more stringent state standards and establish a preference for permanent remedies that reduce the volume, toxicity and mobility of toxic substances.

Once a site has been identified, EPA uses the Hazard Ranking System (HRS) to estimate the degree of risk each site possesses and its impact to human health and the environment. Factors such as proximity to population, nature of the contamination, potential release and migration pathways are evaluated and then combined to get a HRS score. When the HRS score exceeds the specified threshold value, the site is proposed for placement on the National Priorities List (NPL). After the site gets listed on the NPL, EPA sends notices to the identified Potentially Responsible Party (PRP), giving them opportunity to perform the required studies and perform the clean-up. The PRPs are present, and they are the past owners, operators of the facility at time of operations, generators and transporters. If no agreement is reached, EPA will perform the clean-up work through the US Army Corps of Engineers (COE), outside consultants and contractors working for the COE. Upon the clean-up work being completed, the EPA sues the PRPs to recover the cost spent from the fund.

Based on Superfund Records of United States quoted by Canter and Sabatini (1994), contamination found in public groundwater supplies were mainly volatile organic compounds such as trichloroethylene, tetrachloroethylene, dichloroethylene, vinyl

chloride and benzene. Other contaminants commonly present were heavy metals such as chromium, lead and arsenic. Polynuclear aromatic hydrocarbons were also commonly found. The sources of contamination included municipal landfills, industrial operations, leaking underground tanks, septic tank systems and uncontrolled hazardous waste sites.

### **2.3.1 Other Environmental Site Assessment Standards**

There is increased cooperation among countries, regulatory, industry and research institutions in the enhancement and collaboration in the field of soil contamination and impinging areas (Guerin, 2001).

Laws in Australia vary from each state with regards to environmental auditing. Each state has the power to legislate because the federal government provides policy inputs with respect to environmental issues. There are no requirements to report environmental accidents and the state department controls licenses in pollution discharging. Thus, an industry can obtain a license to operate when they prove that the process will not pollute the soil, groundwater or air. Since 1996, Australian Standards Organization has adopted the ISO 14001 (Environmental Management System) as the National Australian Standard. However there is no legal requirement for any state to implement ISO 14000. In Queensland, under the Environmental Protection Act, 1994, a company which has caused environmental contamination to the soil, groundwater or air may produce a 'program notice' notifying the government that it will draw up an environmental improvement program plan to avoid future violations. This improvement program plan may be used to evade prosecution. In recent years, the Australian federal government is introducing policies on environment control and waste management. It is likely that Australia will

adopt the ISO 14015 standard. This is because the Australian National Standard has already adopted the ISO 14000 series of Environmental Management System and including the ISO 14015 Environmental Site Assessment will be complimentary. This standard requires an assessor in possession of sufficient qualities and experience to conduct the assessment.

In Canada, the ESA was developed by Canadian Standards Association in 1994 and is known as the Z768 Environmental Site Assessment standard. The assessment can be conducted by an environmental professional. Based on the standard the property history has to be included in the study, this will highlight the potential risk that can arise from the site. The standard also calls for all adjoining properties to be assessed for historical practices. The setback of the standard is that it does not address the impacts from surrounding locality. Most of the other requirements are similar to the ASTM standard.

In UK, the Environment Act, 1995 was passed to protect the environment and authority was given to the Department of Environment for its implementation. The regulatory authorities regulate activities which impact the environment through a system of licensing covering a range of activities such as waste management, water abstraction, discharge and industrial processes. The ESAs were developed by the Department of Environmental in 1995. Only local registered environmental professionals can conduct the assessment. The phase one standard is similar to the ASTM standard. The standard emphasized that assessment should include historical activities, practices at the site and include adjoining properties. The standard does not specify the assessment of the locality or does not specify a radius of evaluation from the site.



The Federal Cabinet in Germany has approved a draft law (ENDS, 2006) in place for the individual operators of the sites in preventing and remediating environmental damage. The new law will implement the 2004 EU environmental liability directive, which allows the operator of the site to be sued if owing to their activities they damage land, water, protected habitats and species. This draft legislation is pending the approval of the lower house before it will take effect. More and more governments are taking this move to protect the soil and groundwater.

Redondo-Gomez *et al* (2009) had conducted a study in Spain on metals in soil. They had used the US standards in their investigation and compared the result to US EPA requirements. When a country lacks a regulatory standard on environmental investigation it is common practice to use an international standard. Similarly, Lavado *et al* (2004) conducted study on metals in soil in Argentina and did not compare the result of their investigation to any standard. The data was to determine a base line of the site. Subsequent data will indicate whether natural attenuation is improving the condition of the site or is it deteriorating. Studies conducted in the Leon Valley in Mexico by Robles-Camacho and Armienta (2000) on natural chromium contamination in groundwater had used the US EPA standards in their study. When a country has a regulated standard than it is most appropriate to use and apply the standard and conduct the comparison study.

In summary, typical environmental investigations (Thorbjornsen and Myers, 2007) include the analysis of total metals concentration in groundwater using the appropriate country regulatory standards. Analyses of unfiltered groundwater samples are required for comparison to regulatory standards. The data is used for risk assessments and justify the use of the site. Countries that do not have the country specific regulatory standards, the

choice of the standard will depend on the interest of the vested party. Similar application applies to soil investigation and analysis. Aiyesanmi *et al* (2004) conducted their study in Nigeria on groundwater and had compared their investigation with World Health Organization groundwater standards. This was due to there was no available Nigerian standard.

Malaysia does not have environment site assessment standard for the transaction of properties. Most assessments has been conducted not due to local requirements but based on foreign corporate office request. The Department of Environment, Malaysia has started to register assessors for conducting ESAs. The prerequisite qualification to be registered as an assessor is having an environmental professional qualifications and experience.

Table 2.1 is a summary list of the main headings and sub headings of the common standards used for the investigation of sites. A summary guideline included in the table are from the following standards, namely ASTM E1527 (2005), ASTM E1528 (2006), Environment Agency (2000), Scottish Enterprise (1998a, b) and the ISO 14015 (Environmental Site Assessment).

Table 2.1: Summary of Testing Standards

Main heading	Sub headings
Introduction	Brief intent Purpose of report Objectives
Site	Location and description History Current and proposed use Geology, hydrogeology and hydrology.
Previous site investigation	Quote reference and validation
Site investigation	Methodology and design structure of investigation.
Factual results	Conditions of site ground Groundwater – depth, appearance, visual Plan of the well location. Results of soil test Results of groundwater and surface water
Risk assessment	Comparison to guideline values Hazard assessment Risk assessment and evaluation (human health, plants, animals and regulatory)
Conclusion	Report on site investigation, test results and risk assessment.
Recommendation	Addition information needed Remediation necessary and options Cost estimation when necessary
References	Tables, figures, photographs and appendices.

### 2.3.2 Qualified Site Assessors

In the United States the CERCLA establishes the qualification for site assessors. The standard defines an environmental professional as one who must supervise the project with due diligence, prepare and sign the written report of the results. The environmental

professional conducting the site assessment should possess the following minimum requirements:

- a) Holds a current Professional Engineer's or Geologist's license and have the equivalent of three years of full time relevant experience, or
- b) Licensed or Certified to perform environmental inquiries as defined by the standard and have the equivalent of three years of full time relevant experience, or
- c) Has a Bachelors or higher degree from an accredited institution of higher education in science or engineering and the equivalent of five years of full time relevant experience, or
- d) Having the equivalent of ten years of full time relevant experience.

Similar qualification requirement are the basic need to accomplish an investigation report. The above qualification may be used as a guideline when developing countries start to develop their own standards.

The Contaminated Land Management Act 1997 of the State of New South Wales in Australia requires site auditors to be accredited under the Act to conduct an independent review that relates to investigation, or remediation carried out in respect of the actual or possible contamination of land. The intent of the Act is as listed below:

- a) To define the nature and extent of the contamination of the land.
- b) To determine the nature and extent of the investigation or remediation.
- c) To specify the suitability of the land use.
- d) To specify the investigation or remediation necessary prior to the land is suitable for use.

- e) To determine/assess the suitability and appropriateness of a remediation plan, a long term management plan or a remediation proposal.
- f) Other countries that have introduced regulatory systems to address soil and groundwater contamination include the United Kingdom, Netherlands, Germany, Belgium, France, Spain and Canada.

As such, companies wishing to acquire sites should be aware of what they should do, to conduct investigation and obtain appropriate approvals for their protection. They must use an appropriately qualified environmental professional to perform the investigation.

## **2.4 Soil Pollution**

The care for soil has never been determined until in recent decades. As soil is one of the familiar materials that we take for granted? The challenge has been developing management systems that meet present and future needs of food, fibers and ecosystems services. It is important for the survival of human race as it provides the basic ingredients and support for the growth of arable crops, grassland, trees, which provide food, fiber for clothes, and timber for buildings and fuel. We depend on the earth together with water, air and radiation from the sun to provide the essentials for life. The awareness to maintain soil fertility has been emphasized since early days as the farmers have considered soil as a resource on which their livelihood depended. The development of higher yielding crops and the extensive usage of fertilizers, pesticides and irrigation have led to the over production of food, including animal products.

A soil pollutant can be broadly defined as any chemical or other substance that either is not normally found in the soil or is present in high enough concentrations to be harmful to any living organism (Pierzynski *et al*, 1993). A pathway where contaminants can migrate or a receptor can be affected by the contaminants at a site can be a source of contamination.

The best approach to keeping soil free from contamination is prevention. When this approach fails, removing the contaminants may be necessary and several options are available (LaGrega *et al*, 1994). One of the most commonly used approaches is to excavate the soil and bury it in a hazardous waste landfill. The contaminated soil may be incinerated to burn off organic contaminants and to volatilize metals. The site is then filled with clean soil.

## **2.5 Groundwater and Surface Water pollution**

Groundwater contamination is the result of a combination of industrial development and insufficient measures of environmental protection. The main activities (Naidu *et al*, 2006; Armienta *et al*, 1993) contributing to contamination include industrial, manufacturing, mining, agriculture, commercial, transport and services. These uncontrolled activities and disposal of waste inevitably cause environmental contamination. Contamination at these sites may have appeared to have resulted because of lax regulatory measures prior to the establishment to legislation protecting the environment. Contamination can be generally defined as an undesirable change in the natural quality of the environment that may adversely affect the well being of humans, other living organism and the entire ecosystems either directly or indirectly.