

AUDITING OF CONTAMINATED LAND

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ABSTRACT

This paper has been prepared to assist persons confronted with the problems associated with contaminated or potentially contaminated land. It provides an outline of the major issues involved in the assessment or auditing of contaminated land. The paper lists reasons why an audit may be required, describes the stages of assessment or auditing and outlines some of the issues involved in planning field and laboratory programmes. The paper then addresses specific matters such as sampling frequency, selection of analytes, quality assurance and the determination of acceptable levels of contamination. The paper concludes with a description of the statutory audit process applying in Victoria and provides some information on the selection of professionals who can assist with the assessment or auditing of contaminated land.

1.0 INTRODUCTION

Disposal of waste to land has been a traditional method of waste management for many centuries. This practice continued through the period of rapid industrialisation of the last century to leave a legacy of polluted soil, groundwater and surface water in most industrialised cities. In the last decade we have seen rapid change in the approach to waste management and uncontrolled disposal of waste to land is no longer acceptable in most developed communities. We are now witnessing the formulation of contaminated land legislation and regulation in most Australian states and this is having impact on the way land is purchased, leased and developed. A wide range of professionals now have to deal with the issues of contaminated land including those in local government, state government, industry, land development and consultants.

With the development of contaminated land legislation and regulation there is a need for government and industry to understand the complexity of the issues and to have an appreciation of the technical difficulties involved in assessing and auditing of contaminated land. This is particularly important in view of current Federal and State government policies regarding the redevelopment of inner-urban land for residential purposes. Given that much of this land has been used for industrial purposes and is therefore likely to have some contamination, it is critical that all sections of the community understand the problems of assessing land contamination, the impact of the contamination that is found in the ground and the implications of setting unrealistically low target levels for clean-up of contamination.

The paper has been written from the perspective of a practitioner involved in various forms of auditing and assessment of contaminated land including the performance of statutory audits in Victoria.

2.0 REASONS FOR AUDIT OR ASSESSMENT

Assessment or auditing of land for contamination may be required in any of the following situations:

- When rezoning industrial land to a more sensitive land use, eg residential.
- When there is transfer of land ownership or occupancy. This may be required by any one of the parties involved including the vendor, purchaser, financier, insurer, lessee or lessor to protect their various interests.
- When contamination is suspected by a land owner or an environmental authority.
- As part of a risk management programme of any facility which has the potential to impact on the environment.
- To meet statutory requirements, eg in Victoria for land rezoning or to remove a site from the Contaminated Sites Register.

3.0 STAGES OF LAND ASSESSMENT

It is extremely difficult to complete a land audit or assessment in a single stage of investigation since the investigator needs to have some idea of what he is looking for if he has any chance of finding it! It is for this reason that investigations are generally completed in at least two stages.

Based on a survey of members, the Association of Engineering Firms Practicing in the Geosciences concluded that the best description for initial assessment or auditing of land contamination was *Preliminary Site Assessment*. They considered that this term could be used to describe two levels or stages of investigation which involve the following activities:

- Level 1 - Historical, ownership and regulatory review and site visit. This stage involves collection of "background data" including historical information such as property titles, records maintained by state and local government agencies, operating information including raw materials, products and wastes, published documents reports, anecdotal information from

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existing or former employees of a site and published geological and hydrogeological information.

Level 2 - Level 1 plus geophysical or nominal intrusive exploration and sampling; soil, groundwater or surface water analyses. The objective of this stage of work would be to detect contamination (if present) rather than to define its extent.

In conventional application, a Preliminary Site Assessment (PSA) is conducted to determine the likelihood of a site being affected by substances considered "contaminants" by virtue of applicable authorities' definitions of contaminants, hazardous materials, pollutants, et al. There is no clearly defined scope of work required for a PSA. The level of detail required will depend on a number of factors including:

- the history and use of the site and risk to the environment
- the expected future use of the site
- the physical characteristics of the site including subsurface conditions
- the purpose of the assessment
- the risk to the assessor (ie what qualifications the assessor can include with his report).

Detailed investigation may follow the Level 2 Preliminary Site Assessment. The objectives of the detailed investigation will vary depending on the findings of the PSA and the expected use of the site, but could include one or more of the following:

- to confirm that the site is "clean"
- to provide data for design of remedial treatment
- to validate that the site is "clean" following remedial treatment
- to provide further data for preparation of an Audit Certificate (relevant only to Victoria).

4.0 PLANNING OF FIELD AND LABORATORY INVESTIGATIONS

Careful planning is required for the field and laboratory programmes of a PSA. In the planning, decisions have to be made on:

- the areas to be investigated
- the number of samples to be recovered and analysed
- the location and depth of the samples
- the method of sample recovery, handling and storage
- which samples will be analysed and for which analytes.

Collection of background data on the site and an understanding of the behaviour of the potential contaminants is required to enable development of a rational investigation programme. Primary information required in planning will include:

- Topographical, geological and hydrological characteristics of the site.
- Distribution and type of known fill materials.
- Type and location of industrial activity, including nature of the processes and the storage locations of material (including wastes).
- Locations of known spills, leaks and other releases.
- Depth to groundwater and the permeability of the soil and rock.
- The mobility of potential contaminants.
- Environmental sensitivity of the area (ie potential impact of off-site migration).

The following sections briefly describe some of the factors which should be considered in the development of a sampling and analytical programme for contamination assessment. This is not intended to be a detailed discussion of the procedures used in planning and executing contamination assessments, but merely highlights several aspects that should be considered.

5.0 SAMPLING FREQUENCY

The decision of how many and where to sample is a common problem for all assessors of contaminated land. Given the inevitability of budget constraints it is always necessary to carefully plan an investigation to gain maximum information for reasonable cost. It is obvious that all of the soil or groundwater on a site cannot be sampled and therefore design of a programme must consider the number of samples that are required to be statistically meaningful.

There are no universally recognised techniques for determining sample frequency and it is generally up to the assessor to determine the acceptable number of samples. In doing so the assessor must consider:

- *Previous site use.* Sampling may target specific areas where contamination is suspected (for example adjacent to an underground storage tank) or alternatively, grid sampling may be adopted where either a uniform distribution of contamination is suspected or where little is known about the site.
- *The intended use of the site.* For example if the site is to be used for residential purposes then the sampling frequency should reflect the block size, possibly requiring that each and every block is sampled. Alternatively, if the site is to be used for industrial purposes then a lesser number of samples may be appropriate.
- *The type of investigation.* The sampling frequency and layout for a preliminary investigation will be very different to the frequency and layout for a validation programme after clean-up.
- *The mobility of the contaminants.* The mobility of the contaminants will be dependent on both the physical characteristics of the site (eg permeability and depth to water table) and the characteristics of the contaminants (eg ability to sorb to the soil or solubility in water).

- *The liability or risk to be assumed by the assessor or auditor.* Although this is not a technical consideration it is nevertheless a critical aspect of the design of the assessment or audit programme. In Victoria, where the approved auditor assumes significant liability in the issue of a Certificate of Environmental Audit, he may require more intensive sampling than if his certificate was appropriately qualified or referenced.

6.0 SELECTION OF ANALYTES

It is important to understand that analytical procedures are chemical specific and the laboratory will only analyse for the chemicals which are requested. For organic chemicals, techniques are available for identifying and quantifying a very wide range of chemicals (gas chromatography/mass spectrometry). However, this testing can be very expensive and is generally inappropriate for most programmes. Screening techniques are available to identify classes of compounds but often specific identification and quantification is required.

Fortunately, there is a limited number of chemicals that are considered to be hazardous and can be expected to occur in the environment. In the USA, the EPA has published lists of hazardous chemicals for the various regulatory programmes. These lists include no more than a few hundred of compounds. For example in groundwater assessment there is a list of 133 chemicals which are generally considered in any analytical programme ("Priority Pollutants"). In Australia there is no comparable list of contaminants and some professional judgement is required in design of an analytical programme.

It is critical in the design of any analytical programme to have a sound understanding of the nature of chemicals used on a site through an appropriate background study. By completion of such a study it is often possible to limit the number of analytes to a reasonably sized list.

7.0 QUALITY ASSURANCE FOR FIELD AND LABORATORY PROCEDURES

The adoption of rigorous quality assurance and quality control procedures are a fundamental requirement of any assessment for contaminated land. Quality procedures that should be adopted for field and laboratory work are:

Field

- Field sampling techniques should be designed to minimise the occurrence of cross-contamination of samples either from adjacent samples or from sources external to the site. For example in determining the limits of a contaminated area it is important to ensure there is no cross-contamination from heavily contaminated areas to lightly contaminated areas which may impact on the validity of the results.
- Field sampling techniques should be designed to avoid spread of contamination, either by leaving contaminated

soil or water on the ground surface or by cross-connecting aquifers (a very serious problem).

- Sampling methods and handling should be designed to minimise alteration of the chemical state of the samples. A major problem is the loss of volatiles from soil and water samples leading to under-estimate of volatile concentrations. Consideration must be given to sample preservation and holding times before analysis.
- Careful planning of the sampling programme is required giving consideration to:

- sampling approach, eg random, statistically based or facility based

- data quality objectives; why is the data required ?

Laboratory

- Wherever possible laboratory analyses should be performed using standard methods, preferably recognised by the appropriate authorities. In Australia, analyses should be completed with NATA-endorsement of results.
- Appropriate laboratory quality control procedures should be used. These should include analysis of duplicates, spikes and appropriate use of reference standards. It is often useful to conduct inter-laboratory checks of samples, although it must be appreciated that it is difficult to achieve identical results from two samples of soil. In budgeting for an analytical programme an allowance should be made for quality control testing, generally 10 to 15 % of budget.
- There should be periodic auditing of laboratories, including both systems audits and performance audits.

8.0 ACCEPTABLE LEVELS OF CONTAMINATION

Once sampling and chemical analysis has been completed for a site it is necessary to determine the consequences of the observed concentrations of chemicals with respect to the health of persons using the site and with respect to the impact on the environment. This is one of the most difficult aspects of any site assessment or audit and introduces an area of considerable controversy between industry and the environmentalist. We are often faced with the opposing views regarding what is an acceptable level of contamination to leave on a site. The extreme views are:

- the site operator who says "I've been working here for 40 years and it hasn't hurt me"; versus
- the environmentalist who says "Any level of contamination is unacceptable".

Ideally, it would be best to clean-up to a level which ensured that no contamination remained in soil or groundwater above background levels (contamination can be strictly defined as any concentration of a chemical in the environment which is

above its background level). However, it is indisputable that much of our urban environment is contaminated with chemicals at levels above pre-settlement background levels and the cost to return to background levels would be prohibitively expensive. For practicality, therefore we must consider what levels of contamination are appropriate to ensure there is no unacceptable health risk to persons using a site and that there are no unacceptable environmental risks.

There are two broad approaches that can be used to determine the level of acceptable contamination for a site. These are:

- *Prescribed levels of acceptable contamination.* These are typically prepared by regulatory agencies and generally indicate "trigger" levels for certain actions, eg further investigation of the site or clean-up of the site. In some cases these levels make allowance for differing soil types and final land use. However, in most cases they take no account of soil type and are not site specific. Thus many practitioners do not like this approach to determination of acceptance criteria. However, prescribed acceptance criteria and guidelines are extremely useful for small sites and for decision making at the early stages of investigation.
- *Risk assessment.* This is a process where the risks associated with any particular level of contamination are quantified with respect to health and environmental impact. The process involves:
 - data collection and evaluation
 - exposure assessment
 - toxicity assessment
 - risk characterisation.

A particular contaminant may present a hazard, possibly through a variety of pathways or routes, to one or more receptors or targets, which may vary in importance depending on the intended use of the land. The main groups of receptors or targets which are relevant to the assessment of contaminated land are:

- humans (workers, persons using the site and people off-site)
- plants and animals
- building materials and services.

For humans in particular, there are both direct and indirect pathways affecting mainly those living or working on the site which include:

- i) ingestion of contaminated soil
- ii) inhalation of vapours or contaminated dust
- iii) dermal contact
- iv) uptake of contaminants in food plants;

and indirect pathways, also affecting people outside the site which include:

- v) contamination of water resources (surface and ground water)
- vi) contamination of drinking water in pipes running through the contaminated soil
- vii) ingestion through the food chain

viii) fire or explosion

ix) inhalation of vapours produced in a fire.

Computation of an acceptable concentration of a contaminant should take account of the pathways through which the receptors will be exposed to the contaminants and both carcinogenic and chronic health risks. In process of risk assessment many assumptions must be made and ultimately some professional judgement is required in adopting a particular acceptable level of contamination.

9.0 STATUTORY AUDITS

In the state of Victoria a system of statutory auditing has been developed. The Victorian Environment Protection Act makes provision for the appointment of environmental auditors. At the beginning of 1991, six individuals were appointed as auditors for contaminated land with authority under the Act to issue Certificates of Environmental Audit. Under Ministerial Directive Number 1 of the Environment and Planning Act, Certificates of Environmental Audit are required:

- when land which has been used for industrial purposes is to be rezoned for a sensitive land use such as residential use, agricultural land use and some types of public open space
- prior to a site being removed from the register of contaminated sites.

The current form of the certificate requires the auditor to state "*...that I am of the opinion that the condition of the land at the site is neither detrimental nor potentially detrimental to any beneficial use of the land at the site.*"

In its current form the certificate places extreme responsibility on the auditor and this will have an impact on the feasibility of redeveloping industrial land for residential purposes. It is likely that the auditing system will evolve with time to a less restrictive form.

Consideration is also being given to various forms of statutory auditing in other states of Australia, particularly Queensland which seems to be the most advanced on this course.

10.0 SOURCES OF PROFESSIONAL ADVICE

It is important to understand that the conduct of assessments and audits for contaminated land often involves a multi-disciplinary approach. A range of specialist services are required including geologists, hydrogeologists, geotechnical engineers, geochemists, analytical chemists, biologists and toxicologists. If clean-up is required then further then input from other disciplines are needed including civil engineering, chemical engineering and occupational hygienists.

Very few individuals or even organisations (in Australia) have the experience to provide all of these services. In seeking professional advice the owner of site should seek persons or organisations who have a sound understanding of the problems associated with the assessment of contaminated land and can

draw together the range of professionals necessary to develop a rational assessment of a site and, if necessary, develop practical solutions for the remedial treatment of contaminated land.

11.0 CONCLUSIONS

The identification and management or clean-up of contaminated soil and groundwater is now an important environmental issue in Australia and one that has the potential to impact significantly on industry and the economy in general. To date, the environmental authorities in Australia have been able to adopt a pragmatic approach to land contamination and are prepared to accept relatively high

levels of contamination on industrially or commercially zoned land provided that the contamination does not constitute a hazard to the persons using the land or to the environment. Nevertheless, owners of industrial land and developers of former industrial land will have to be vigilant to avoid liability and/or loss of value of their property. They will have to understand their risks in this area of environmental law and seek advice from professionals with sound experience in the area of assessment and auditing of contaminated land to assist them. In seeking appropriate advice and through careful negotiation with the environmental authorities, in many instances, it will be possible to develop contamination management strategies that minimises both risk to the environment and cost to the site owner or developer.

MONITORING GROUNDWATER AND LEACHATE MOVEMENTS

ENGINEERS:

- ◆ Do you need to monitor moisture flows through soils in the saturated and unsaturated state?
- ◆ Do you need to test the effectiveness of any cut-off measures?
- ◆ Do you need to show that wetting or drying measures have been satisfactorily carried out?
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