Current waste soil disposal practices in NSW

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Abstract
The NSW EPA has through development of guidelines and legislation created a system where it is easier for a consultant working with contaminated soils to dispose of the soils off site rather than reuse, treat or encapsulate the contaminated soil on site. The system has resulted through implementation of incorrect assessment methods such as the toxicity characteristics leaching procedure (TCLP) which in most instances this procedure provides incorrect interpretation of actual leaching characteristics and leads to expensive and unnecessary remedial programs. The TCLP was originally developed by the USEPA as a method for simulating the effects of leachate on wastes disposed in putrescible landfills and its application to assessment of contaminated soils prior to disposal to non putrescible landfills is somewhat misguided. The main rational for the error is the use of a leaching medium with a pH of less than 5.0 in the TCLP, which is not representative of natural groundwaters or the leachate present in most non putrescible landfills. A more suitable method for assessment is the Australian standard leaching procedure (ASLP), however this has currently only been adopted in Western Australia. Another factor contributing to the current incorrect assessment of contaminated soils and their potential leachability is the adoption of dilution attenuation factors (DAF) which are not specific to each individual site which results in the incorrect assessment of the potential leachate production and environmental impacts from a contaminated soil. This paper will outline a more suitable method for assessment of the leachability of a soil and a different approach to management of contaminated soils and wastes, the proposed method involves on site testing of the contaminated materials impact on surrounding profiles coupled with site specific leaching procedures and development of a DAF based on regional or site data.

Key Words
Contaminated soil, encapsulation, remediation, dilution attenuation factor, TCLP, ASLP.

Introduction
The NSW EPA (1994) Draft Environmental Management Guidelines for Solid Waste landfills state that "To help fulfil the objective that relates to disposal the NSW Government waste policy requires the establishment and implementation of *world best* practice guidelines for landfills in NSW. ….purpose of these guidelines is to protect the environment by:

1. Promoting a clear understanding of those environmental impacts which need to be managed when establishing a landfill; and
2. Ensuring adoption of the most appropriate and effective means of managing these impacts."

This document was an early attempt by the NSW EPA to establish a waste management system in NSW, and the statement reproduced above was a promising start to the development process. What has resulted is somewhat disjointed and the current practices undertaken by environmental consultants consists of digging up environmental problems and concentrating them in poorly planned and managed landfills which are invariably destined to fail and leak leachate into the surrounding environment. What allows consultants to do this is the implementation of an outdated set of environmental guidelines or procedures which are not even being used as they were intended.

Following implementation of the toxicity characteristics leaching procedure (TCLP) in the NSW EPA (1988) *Draft Environmental Guideline: landfill disposal of Industrial Waste* and subsequent waste classification documents, an Australian Standard Leaching Procedure (ASLP) was developed and released as AS 4439.3-1997 in 1997. When compared the TCLP is found to allow only a broad assessment of leachability of wastes when exposed to acetic acid simulating aerobic decay of putrescible matter, whereas the ASLP allows site and waste specific assessment of leachabilty and therefore it is considered more suitable to applications in Australia and in meeting the objectives of the NSW EPA as stated above. Having said this, the ASLP cannot be implemented as a stand alone method for waste assessment and a complete restructuring of the current approach including the selection and derivation of guidelines is required.

The current guidelines for waste assessment are the NSW EPA (1999) — *Environmental guidelines; Assessment, classification and management of liquid and non-liquid wastes,* which were released following the release of the ASLP and yet require the use of the TCLP. In addition to this these guidelines select an arbitrary dilution attenuation factor (DAF) of 10x, 100x and 400x for inert, solid and industrial classification respectively as being the applicable DAF for every site in NSW. The DAFs developed by the USEPA in the USEPA (1994) — *Modelling approach for simulating Three Dimensional Migration of Land and Disposal Leachate with Transformation Products and Consideration of Watertable Mounding* and the supplementary revised Appendix E of the USEPA (1996) — *Soil Screening Guideline* (EPA Document Number: EPA540/R-96/018) are however presented in a range of between 1 000 000x and 1x, dependant on site specific conditions including landfill size and location of abstraction well, which was a development of a late 1970s document produced by the USEPA that proposed a 100x factor. Given the detailed fate and transport modelling conducted by the USEPA during the process of development of the DAF ranges and the availability of the DAF data sets to the general public the selection of 100x DAF across the board by the NSW EPA should be reconsidered.

Promoting a clear understanding

Contaminated soil vs waste streams

Many NSW based environmental consultants have been confused by the distinction between a contaminated soil and a waste stream. Maintaining a clear definition between the two is extremely important as the wrong approach can result in a significant increases in remedial costs. The waste assessment guidelines were developed by the NSW EPA under the POEO Act to create a management system for wastes produced by scheduled activities including “Waste Activities”. However, as defined in the POEO Act Schedule 1, the following **activities are not waste activities** for the purposes of this item:

> ***The generating or on site storage of contaminated soil****, recyclable oil or stabilised asbestos waste in bonded matrix, etc.*

Based on this definition, contaminated soil which is to remain on its site of origin is not classified as a waste stream and therefore is not subject to the regulations underwritten by the POEO Act, including the waste assessment guidelines. Furthermore, the POEO Act does not allow for the classification of soil as contaminated, it allows for the classification of “contaminated soil” as a particular waste stream. Therefore classification of “contaminated soil” does not fall under the POEO Act and the waste assessment guidelines are not suitable for the assessment of contaminated soil. This should allow consultants to apply the ASLP when assessing soils which are to be retained on site.

Waste minimisation and identifying a contaminated soil before it becomes waste

The NSW EPA currently allows a simple assessment of contaminated soils and based on either total specific contaminant concentration (SCC) or a combination of SCC and TCLP testing, a waste stream can be classified as inert, solid, industrial or hazardous waste. This makes it a simple procedure for a consultant to transform contaminated soil into a waste stream and for a relatively small price make it some one else’s problem. Little effort is currently made in treating or reusing soils which contain elevated levels of heavy metals. This is partially due to the NSW EPA adopting an approach which makes it hard to gain approval to retain contaminated soils on site and partially due to the NSW EPA making it so easy for consultants to dispose of contaminated soils off site.

The most practical solution to the current waste management problem facing Sydney and other regional centres in NSW and Australia would be to stop creating localised zones of highly concentrated contamination, held within a landfill cell which is destined to leak and instead implement more stringent waste disposal laws which actually promote waste minimisation by onsite treatment, encapsulation or beneficial reuse of soils. Before such a system could successfully be implemented a reassessment of the waste disposal and contaminated soils guidelines needs to be undertaken.

Promoting a clear understanding of the environmental impacts is topical to both on site soil contamination management and ongoing contaminated waste disposal. Based on the EPAs stated approach and the potential for waste types and each landfills geological setting to vary significantly, each individual site and incident needs to be investigated which was the original idea behind DAFs. For example investigations under a revised system would take into account the soil and geological setting and the regional zoning such as residential, industrial and the surrounding potentially vulnerable ecosystems. Both the ASLP and the USEPA developed DAF factors have the capacity to take into account site specific conditions.

In essence a summary environmental impact statement (EIS) needs to be conducted for each proposed landfill and each proposed site at which contaminated soil is to remain on site. This is not to say that an EIS needs to be conducted at every instance of contaminated soil or waste disposal, rather the consultant should consider a number of factors and the disposal/reuse method should be based upon these options. Where an EIS has been conducted for a developed landfill then the conclusions from this EIS should be utilised when deciding the suitability of a waste stream to be deposited, rather than the current system which applies broad guidelines to classification of contaminated soil and waste. Furthermore each individual situation should be assessed. For example a waste soil being produced which when in contact with water is likely to produce a pH of <4.0 should not go to a landfill which current monitoring has shown a low pH leachate exists, rather a landfill which contains a leachate with a pH > 7.0 should be sought to promote neutralisation of the wastes pH. Such information is currently not available to the consultant, nor is this type of assessment of waste streams promoted by the EPA.

Implementation of the DAF
The NSW EPA have in the waste guidleines selected a DAF of 10x for inert and solid wastes and a DAF of 400x for industrial wastes. The reasoning for selection of these numbers is not given, but is stated to be based upon the DAF values derived by the USEPA and is used in the setting of standards for classifying wastes containing heavy metals.

The DAF model refered to as the EPA's *Composite Model for Leachate Migration with Transformation Products (EPACMTP)* was created using Monte Carlo simulations and the relative sensetivity of the model parameters are presented in Table 1. For any specific site the DAF depends on the interaction of various site specific factors. An attempt has been made in the USEPA model to take into account these factors and a list of all variable parameters used is provided in Table 1. The stated sensitivity is the resultant magnitude of variation in results which occurs when each parameter is varied, hence a large variation will occur if the infiltration rate is varied, however only a small variation will occur if the ambient recharge is varied. As can be seen by the results the most important factors are the infiltration rates and the saturated thickness of the aquifer.

Table 1. EPACMTP Sensitivity of model parameters.

Parameter	Relative Sensitivity
Infiltration Rate	11.4
Saturated Thickness	10.4
Groundwater Velocity	8.3
Source Area	3.8
Hydraulic Conductivity	3.5
Vertical Well Position	2.1
Groundwater Gradient	2.1
Longitudinal Dispersivity	1.0
Vertical Dispersivity	1.0
Porosity	0.8
Receptor Well Distance	0.7
Transverse Dispersivity	0.1
Receptor Well Angle	0.1
Ambient Recharge	0.06

The EPACMPT model was developed to simulate the leakage of leachate in the unsaturated zone and a resultant vertical dispersion to the aquifer. As can be seen by the high sensitivity of the model to infiltration rates it would be expected that the use of cell liners as is a requirement of landfills accepting waste streams in NSW would significantly decrease the DAF. The groundwater velocity also holds a significant weight in the model and is a factor which can vary significantly depending on location and geological setting of the aquifer. Both of these parameters are simple measurements which could be provided by the landfills and incorporated into the proposed site specific assessment.

The geological location of a cell in either shale, sandstone or unconsolidated sediments would be expected to hold the greatest influence on the potential migration of a leachate, however as displayed by the model the hydraulic conductivity holds only an average weight. Other factors which should hold significant influence in a groundwater model assessing the potential impact of leachate on a receiving well should be the distance of the receptor well from the landfill (which holds a weight of only 0.7) and the transverse dispersivity (which holds a weight of only 0.1). The EPACMTP designers state that the transverse dispersivity and the distance the receiving groundwater well is away from the cell cancel each other out in the model as in the case where you have no transverse dispersivity and the plume is thin and concentrated there is less chance that the plume will actually intercept the groundwater wells and therefore it also does not matter how close the well is placed. The converse also holds that if the transverse dispersivity is significant and the plume is a large low concentration plume then the well will only ever intercept low concentrations of the leachate.

Should the basis for waste assessment be based on such an obviously inaccurate model and if the model cannot distingush these essential factors should it be incorporated into the state legislation? Groundwater models are notorious for being incorrectly interpreted, which invariably results in either a model being discredited or faulty results being adopted. In this case the EPACMTP has been designed for a specific purpose, which is to simulate the potential effects of leachate on a receptor well, using a numerical three dimensional system. Although the USEPA model does not accurately represent the potential variability in leachate reaching a monitoring or extraction well it still has uses in showing the variable effects of numerous combined parameters on leachate flow and should be considered a valuable tool in estimating the characteristics of different leachates produced in different environments.

USEPA 1996 provides Figures and Tables which show the variation of calculated DAF with changes to source size in six scenarios, these scenarios cover a broad range of potential landfill environments and the results presented vary from 1 000 000x to as low as 1x (it should the noted that the model is not limited to these scenarios and site specific factors can easily be substitued into the model). The high variability of the results demonstrate the importance of completing site specific assessments to ensure relevant results are attained. The implementation of arbitrary values of between 10x and 400x should be considered a misrepresentation of the EPACMTP which is presented in a full program for public download on the USEPA website (http://www.epa.gov/superfund/resources/soil/), reference to and promotion of use of the actual documents would go a great deal further in promoting a clear understanding of the issues of waste management.

Confusion caused by guidelines

In addition to misuse of scientifically developed data described above, legislative bodies are also guilty of confusing issues and applicable environments by applying broad country wide averages or site specific scenarios when developing guidelines. Environment Australia guidelines for waste assessment and classification justify the use of acidic leaching mediums by quoting the following points which jump from region specific acid rain studies to broad Australia wide soil properties:

- Acidic rain (pH 3.6 - 4.9) resulting from the presence of organic acids (such as formic acid) thought to be formed in the atmosphere by the photochemistry of organic compounds (such as isoprene) volatilised from terrestrial vegetation (reported from the largely pristine Alligator Rivers region by Noller *et al.* (1985)), it should be noted that the soil in this area is predominantly alkaline;
- Acidic freshwater (pH 4.0 - 4.5) in the "first flush", the first water to enter a billabong or lake at the start of the wet season (reported from the Magela Creek system by Hart and McKelvie (1986)); or
- Acidic topsoils, because from 1 to 3 million hectares of Australian agricultural land have extremely acidic topsoils (pH less than 4.3), between 11 and 21 million hectares have strongly acidic topsoils (pH 4.3 - 4.8), and 25 to 37 million hectares have moderately acidic topsoils (pH 4.8 - 5.5) (National Land and Water Resources Audit, 2001).

Implementation of guidelines applicable to the Sydney Basin which promote “world best” practices would be expected to be based on more than average figures and should allow the consultant to interpret the system in which they are working in.

TCLP and ASLP differences and significance
The TCLP was originally developed by the USEPA for measurement of the leachability of wastes placed in putrescible landfills and as such the allowable leaching mediums are either pH 2.88 or 4.93 on the pH of the waste. Almost all landfills operating in NSW which have a licence to accept inert, solid or industrial wastes are licensed as non-putrescible landfills a factor which the TCLP does not allow for. The ASLP was developed in Australia with allowances for variable waste receptors including non-putrescible and putrescible cells incorporated into the methods, currently the ASLP has only been adopted in Western Australia. The ASLP is a preferred method for characterisation and management of waste soils as it allows variations to the leaching medium dependant on the proposed disposal method, this includes the use of a reagent water for non putrescible mono cells. Furthermore the ASLP states "The pH and the oxidation-reduction (redox) potential, or Eh, of a leaching fluid may vary with each disposal environment and is known to affect the leaching of metals and possibly some organic species. No provision is made in this procedure, however to control pH and Eh during leaching. As an aid to interpretation of results, it is recommended that the Eh of the extracted sample liquid and the solids leachate be measured and reported." This demonstrates an understanding and acceptance by the ASLP that different landfill environments will affect a waste in different ways due to pH and Eh conditions. Unfortunately no allowance for this type of interpretation is included in the TCLP adopted in the NSW EPA 1999 guidelines.

The ASLP is specifically suitable for assessment of contaminated soils to be either left *insitu*, spread over a site and capped or disposed of in a mono cell as in these instances it allows for the use of a reagent water for the leaching medium.

Where both the TCLP and ASLP fail is application to non-putrescible co-disposal cells, where numerous soil types are disposed of together. Both methods only test the response of the proposed waste stream to a leaching medium. No consideration is made in regards to the actual conditions existing in the landfill cell or the potential future conditions. In the majority of cases the landfill cell will maintain a near neutral pH due to the co-disposal of concrete with the waste, but consider the instance of a truck load of soil (approximately 25 tonnes) which has been tested using either the ASLP or the TCLP and has demonstrated a pH of >5.0 and therefore a leaching medium of 5.0 is added and the results show negligible heavy metal leaching, however, this load of soil is surrounded by 200 tonnes of soil which creates a leachate of pH 3.0 and the heavy metals contained within the waste soil are mobilised. Such an instance is rare and one possible solution would be to implement a new requirement for a leaching procedure to include leaching mediums of 2.9. A more practical solution, however, would be to include a requirement for the landfills to distribute information on the wastes accepted in their landfills (specifically the pH of the wastes) and a requirement for the consultant to consider the most suitable disposal option.

Proposed approach
It is proposed that the consultant is required to research the possible onsite reuse, treatment or encapsulation options prior to consideration of off site disposal. The onsite assessment would include:

- Measurements of the migration of the contaminant under the existing site conditions, including measurement of the concentrations of the chemicals of concern (CoC) in surrounding stratigraphies and in underlying groundwater or perched groundwater tables. This gives an excellent measurement of the leachabilty of the existing CoCs when exposed to onsite conditions.
- Undertaking assessment of the potential reuse options on site such as *insitu* retention, surface sealing with concrete slabs or creation of a mono cell – having assessed which potential options are available the potential leaching fluids should be identified and leaching tests should be carried out using samples of these fluids. The fluid may include rainwater, infiltrating surface water and variable water tables. If evidence exists for a seasonal water table then it is essential that a sample of this fluid be taken and used for the leaching test as there is significant potential for infiltrating surface water which is in contact with the soil for extended periods of time to vary in chemical composition, pH, Eh and other characteristics which could vary the affects of the fluid on the CoCs;
- An assessment of the surrounding soils and geology should be made to determine the ease with which a leachate could migrate
  - Collection of background parameters as listed in Table 1 and running of a site specific EPACMTP model to develop DAF values; and,
- The potential ecological and human targets should be identified.

Based on the results of this assessment the potential risk to the environment and/or human health should be rated and considered. Following assessment of the risks an informed opinion on the suitability of the proposed reuse options could be made. If the consultant feels the contaminated soil is not suitable to remain on site and onsite treatment is also not considered to be an option. A waste stream will have to be created and in this instance the consultant should be required by the EPA to show reason as to why the material is not suitable to be retained on site. Such a system would be in direct contradiction to the existing system in which the EPA requires scientific data as to why a soil would be suitable to be retained on site.

In the case that the soil is deemed unsuitable to be retained on site and a waste stream is to be created it is proposed that the selection of a suitable landfill site be undertaken by the consultant and the selection process is to be based on:

- The chemical suitability of the landfill rather than selection of the closest landfill due to monetary constraints;
- The chemical suitability will be based on comparison of the current pH and Eh of material already existing in the landfill and assessment of the potential for the waste to react with other wastes within the landfill;
- Completion of a leaching procedure using leachates already existing in the landfill or using suitable reagents;
- Comparison of the CoCs to the identified ecosystem surrounding the landfill (which should have been identified in the landfill's EIS) and the potential effects of the CoCs on the identified ecosystems;
- Assessment of the potential future uses of the land immediately surrounding the landfill and the potential for beneficial use of groundwater from an aquifer underlying the landfill; and,
- It would be expected that each landfill would run and maintain their own EPACMTP or at least have a suitable set of parameters available for use by the consultant which could be utilised for assessment of the suitability of the landfill to accept the proposed waste.

Based on assessment of the above factors a suitable landfill could be chosen by the consultant, but only after all possible reuse, treatment or onsite encapsulation options had been exhausted.

Conclusions

The NSW EPA and several other state environmental agencies (eg. Vic, Qld and SA) currently claim to have an approach of waste minimisation when dealing with contaminated soils, unfortunately the guideline system developed has resulted in a system in which the EPA require consultants to justify why contaminated soils should be allowed to remain on site rather than why they should be allowed to be disposed of off site. Not only is this the case but the NSW EPA have developed waste disposal guidelines which are based on incorrect or broad interpretations of outdated systems, such errors include:

- Continued implementation of the TCLP which was developed for assessment of soils to be disposed of in putrescible landfills, rather than adoption of the ASLP which were developed in Australia and allow for the selection of a leaching procedure based on the type of waste receptor such as non-putrescible and putrescible landfills;
- The assessment of leachability of a waste based only on its reaction to a leachate and not the chemical influences of surrounding wastes of different composition and from different sources;
- The implementation of 3 DAFs 10x, 100x and 400x which are chosen arbitrarily from a complex groundwater model developed by the USEPA which has potential ranges of between 1 000 000x and 1x dependant on the specific site conditions;
- The adoption of a guideline system which is based on broad studies rather than allowance for derivation of site or regionally specific guidelines based on regionally collected data.

It is proposed that a different approach be adopted which puts emphasis on the consultant to assess the potential options for retention of a contaminated soil on site before waste disposal is considered as an option. The assessment process would incorporate a site specific leaching test utilising reagents which are considered likely to be present on the site, development of a site specific DAF and based on this completion of an assessment into the suitability of the specified option.

It is only when it is found that there are no viable onsite options available to the consultant that approval for waste disposal would be granted. It is also proposed that the current NSW EPA system in use for the assessment of wastes be reassessed to incorporate a more site specific assessment process, including consideration of the effects of all waste streams present within the landfill, development of a landfill specific DAF utilising the EPACMTP.

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