# A life cycle impact assessment indicator for ash management in coal-based power generation

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## Synopsis

The coal-based power generation industry faces increased pressure from all sectors to improve its environmental performance. This is due to increased awareness of and concerns regarding greenhouse- and acid-gas emissions, toxic metal releases (to both air and water) and water availability. A methodology to assess this industry's environmental performance is needed. Such a methodology should assess all environmental impacts accurately, recognizing their spatial and temporal dependence, and taking into account the social acceptability of technologies employed.

Here, we develop a methodology to determine the environmental impact associated with solid wastes generated by this industry, and apply this to the specific case of ash management. More specifically, the case study compares the environmental footprint of an ash deposit for a number of operational water management scenarios. The methodology considers leachate generation processes from ash impoundments to obtain a time-dependent concentration profile of mobile constituents at the interface between the ash impoundment and the surrounding environment. This leachate prediction modelling is subsequently linked to plume dispersion modelling tools to determine the fate and transport of leached components, predominantly salts, into groundwater. Together, these provide a measure of the extent to which a land mass is affected by leachate migration from the deposit. To determine the exact boundary between regions of acceptable and unacceptable risk to the environment, we use Ecological Risk Assessment concepts. In this way it is possible to obtain a time dependent affected land footprint which could be used as an indicator of the environmental impact of solid waste management practices. This information can be included in a set of environmental criteria which form the basis of an overall environmental impact assessment, using tools such as Life Cycle Assessment (LCA). The value of LCA is that its structure is consistent with accepted models of environmental decision making, where different approaches to valuation in impact assessment assist in prioritizing impacts on the basis of their perceived significance. The proposed 'affected land footprint' metric represents a significant improvement over current LCA impact indicators for solid waste management practices.


Keywords: Environmental Impact Assessment, Environmental Risk Assessment; Life Cycle Assessment; coal ash; leachability; salinity

## Coal-based power generation

The coal-based power generation industry in South Africa produces in the order of 22 Mt of ash each year, most of which is consigned to land disposal (Eskom, 1999). These coarse and fly ashes along with other wastes generated during coal mining and subsequent processing, including spoils, rejects, tailings and discards, contain leachable constituents which may constitute an environmental risk if they remain mobile and bioavailable. There are also significant liquid waste volumes produced which are used to slurry the wastes, and as a dust suppression medium, resulting in an elevated potential for leachate generation. Leachates generated from these deposits are characterized by high dissolved salt contents, elevated trace metal concentrations and extreme pH. In general, these wastes are poorly characterized and the mechanisms for leachate generation are poorly understood.

Environmental issues are now a key determinant in decisions which affect both the design of new power generation technologies and the operation of the existing utility plant. An increased understanding of the processes involved in leachate generation and mobility would facilitate better environmental control. At present, the industry lacks an approach to incorporating solid waste management issues, even if quantified, into an environmental impact assessment, beyond the trivial notion of landfill volume occupied. Without this consideration of impacts from solid waste, the industry has limited avenues through which to improve its performance. Typical approaches to waste minimization would be of little benefit when considering the large volumes of waste generated and, clearly, the focus needs to be on impact minimization. As an overall goal, we


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desire new assessment tools to include waste deposits as additional unit operations in the process, with well-defined input streams, measurable process variables, and thus predictable outputs. In this way the effect on environmental performance due to upstream operational or technological changes can be assessed, leading not only to better waste- and water-management strategies but also a reduced overall impact (if suitable mitigation measures are identified).

The work presented here is a subset of a larger research project which explores Multi-Criteria Decision Making tools in the coal-based power generation industry (Basson and Petrie, 2000). In this paper, we also limit our discussion to issues pertaining to leaching from ash deposits, although work is in hand to characterize biogeochemical mechanisms for leachate generation in coal stockpiles, which have been identified as the major contributor to leachate generation on site (Hansen, 1999).

## Assessing the environmental impact through Life Cycle Assessment

Evaluation of the performance of waste management practices requires that the spatial- and time-dependent nature of environmental impacts be quantified. To accomplish this requires prediction through modelling, not only of leachate generation processes, but also of the spread of the resulting pollution plume. Together, these constitute the necessary ‘first steps’ to accurate assessment of environmental impact. It is our premise that this information can be used as introductory input to a modified Life Cycle Assessment exercise, wherein the significance of environmental impacts from leachate generation are highlighted.

Life Cycle Assessment (LCA) is a tool used to support environmental decision making. It addresses impacts across the entire life cycle of a product, or the provision of a service, from resource extraction to disposal. This extended boundary ensures that the impacts associated with both process inputs and process outputs are included in the analysis. LCA attempts to quantify the environmental consequences of the function that the product is designed to perform and thus provides the environmental argument to be used in conjunction with economic, social and political arguments in an objective decision making process. Details of LCA methodology are covered elsewhere (Jensen *et al.*, 1997; ISO, 1997; Guinee *et al.*, 1998; ISO, 1998; ISO 2000a and 2000b). It is sufficient here to report that LCA is gaining increasing acceptability amongst environmental decision makers, as it is consistent with the tenets of sustainability, to which the minerals and utility sectors are purportedly committed. This is not to suggest that LCA is without its faults, as the next section explores.

### *Life Cycle Assessment and solid waste*

In its present guise, LCA is recognized to be deficient with respect to the treatment of impacts associated with the management of solid wastes (Finnveden *et al.*, 1995; Nielsen and Hauschild, 1998; Finnveden and Nielsen, 1999). Solid waste impacts are often dealt with by simply listing the amounts or volumes of solid waste generated. No recognition is given to the secondary impacts associated with the generation of leachates and migration of pollutants into the environment. It is probably because these impacts are difficult to quantify that they are often ignored or dealt with simplistically, thereby leading to a distorted or skewed assessment. Attempts are being made, however, to include an estimation of the impact of solid waste on the environment. The most common approach appears to be the incorporation of multi-media fate models that may range in complexity from simple dilution equations to complex spatially segmented and temporally variable flow and transport models (Mackay, 1991; Guinee *et al.*, 1996; SETAC, 1994). These models are used to understand the fate of chemicals that are in, or may migrate from, waste sites. Although, the extent to which these methods address chemical transformations within a deposit—both thermodynamically and kinetically—is limited. This information can then be used either to obtain a qualitative understanding of the fate of chemicals or to obtain quantitative predictions of environmental concentrations. These environmental concentrations can then be compared directly with levels believed to cause effects, thereby giving an indication of environmental risk.

The use of these multi-media fate models in LCA to incorporate fate and exposure considerations has highlighted some other deficiencies of the LCA methodology. Many impacts, such as those associated with solid waste disposal, are both spatially and temporally dependent. In the inventory analysis stage of LCA, emissions are entered as a total mass, without a specified rate of release term. As such, these amounts are considered as being released instantaneously into the environment, as pulses. Whilst this is often reasonable in terms of gaseous emissions, it is less acceptable for solid wastes, where there is often a substantial time lag between production of the waste and the environmental impacts to which the waste gives rise. Therefore, input into any kind of model to describe the distribution of leachates to the environment would require that their input be characterized in terms of flux or mass per time.

Furthermore, the LCA approach is limited, as it does not support a localized view of environmental impacts, preferring to aggregate emissions and translate them into contributions to potential impacts on a global scale. This is because, in essence, LCA is not concerned with impact prediction but rather with environmental valuation of alternatives using generic knowledge on fate, exposure and toxicity (Guinee *et al.*, 1996). However, in reality, both fate and exposure assessments and toxicity assessments will require a degree of site-specific information.

## The affected land footprint

Although LCA is deficient in its treatment of impacts from solid waste disposal, it is nonetheless a useful and well-established tool for environmental decision making and there is potential to expand it to address these deficiencies. We have therefore accepted it as a starting point for our inclusion of solid waste impacts into an environmental impact assessment exercise. Leachate generation processes and subsequent plume dispersion would result in a potentially contaminated land mass which, when correlated with toxicological information, would give an overall ‘end point’ indication of environmental impact. In the absence of reliable human- and eco-toxicology data, the impacted land mass still serves as a useful 'mid point' impact indicator, and certainly an improvement over current LCA practice. We have chosen to term this land mass an 'affected land area' or 'affected land footprint' which would be seen to vary both spatially and temporally, as well as being a function of the contaminants of concern. To be able to quantify this affected land footprint, the following are then required:

- Tools to predict leachate generation and pollution plume migration
- A methodology that will allow the boundary of the affected land footprint to be drawn
- An approach that will incorporate these quantified impacts into a modified LCA.

The multi-media models discussed above used Ecological Risk Assessment to compare predicted environmental concentrations with levels believed to cause effects, thereby giving an indication of risk (SETAC, 1994; Heijungs, 1999). It is proposed that Ecological Risk Assessment be used in our investigation to draw the boundary between unacceptable risk to the environment and acceptable risk. The differentiation between acceptable and unacceptable risk would be based on the environmental value which is to be protected. Translation of this environmental value into acceptable concentration limits of particular contaminants is accomplished by both a consideration of dose-response and other ecotoxicological data or the use of criteria such as water quality guidelines (EPA, 1996; Beinat, 1997). In this way it would be possible to obtain an affected land footprint which could be used as an indicator of the impact of solid waste in a LCA exercise.

Using this approach would also allow a site-specific element to be introduced, whilst still retaining compatibility with the structure of LCA. The degree of site-specificity would be determined by the data input into the various modelling structures. The more generic the data, the less site-specific the assessment. Taking snapshots of the footprint at pertinent times, such as at closure of the power generation facility or post closure, can address the temporal limitation of LCA.

### *Tools to predict leachate generation and pollution plume migration*

To obtain the affected land footprint requires an understanding of the physico-chemical processes taking place within the ash deposit and the ability to predict the composition of the leachate that will be produced, as well as the path of the resulting plume. A model for predicting the leachate generation from ash disposal should exhibit the following features:

- Hydrodynamic behaviour, reflecting variations in degree of saturation corresponding to wet disposal and dry landfill disposal
- Chemistry modelling should be complex enough to consider dissolution and precipitation reactions, sorption and desorption as well as kinetically controlled chemical reactions such as redox reactions and leaching.
- Incorporation of multiple species behaviour via solution thermodynamic models to account for high salinity

Particulars of the model developed for this work, incorporating the above features, are detailed elsewhere (Hansen *et al.*, 2000). At this stage our modelling is limited to salts, as including trace elements as components would increase the model complexity significantly. However, it has been seen that salinity and metals mobility are related. In particular, with increased salinity, metals mobility increases due to inorganic salts competing with metals for adsorption sites (Bourg, 1995). It follows then, that trace metals will follow a salinity pollution plume. However, it must be noted that there will be a likely reduction in source terms for metal fluxes due to decreased solubility.

Once the leachate concentration has been calculated, the fate of the contaminants in the environment may be assessed. The extent to which a chemical species is dispersed in the environment is dictated by processes which both encourage and retard transport. Besides these, process factors, which relate to the subsoil and the characteristics of the contaminant itself, also need to be considered (Carlson and Adriano, 1993; Sakata, 1987). The three main processes that govern the extent to which chemical species migrate in groundwater are advection, dispersion and retardation (Freeze and Cherry, 1979). The degree to which these mechanisms influence contaminant transport depends on a number of factors, including geohydrological and geochemical properties, pH and conductivity, leachate composition and characteristics of the waste material and waste deposit.

The data requirements and model sophistication required for such an exercise are extensive (Anderson and Woessner, 1992). Historically, the extent to which a full-scale waste deposit scenario with its multiplicity of interacting components (infiltration of rainwater, potential groundwater inflows, chemical reactions, interaction between leachate and aquifer materials) can be modelled accurately has been limited. It is only relatively recently that the necessary fundamental scientific knowledge and computing power have evolved sufficiently for the development of comprehensive modelling frameworks which combine hydrological transport with chemical reaction (Mangold and Tsang, 1991). Now there is an array of readily available software packages which model groundwater flow patterns and solute transport (Zheng and Bennett, 1995). The most popular numerical flow modelling software and solute modelling software in use is MODFLOW and MT3D respectively (McDonald and Harbaugh, 1988; Zheng, 1992).

Despite such groundwater modelling sophistication, problems remain in quantifying chemical reactions occurring in the subsurface. Ideally, all chemical and biochemical reactions expected to occur should be included in the mathematical formulation of the model. However, chemical reactions typically used in these transport models are limited to adsorption (described simplistically by a retardation factor), and hydrolysis and decay (described by a first-order rate constant). Consequently, most modelling applications have been limited to a single chemical species. Although, work has been done to couple chemical transport models with aqueous geochemical codes (Zheng and Bennett, 1995; Hostetler and Erikson, 1993).

At this stage, the question needs to be asked: How much value will be gained from a detailed groundwater flow and contaminant transport model incorporating the complete site-specific physical, hydrogeological and geochemical frameworks, and is the effort warranted? The answer to this question is related to the type of decision which is to be made, based on the affected land footprint. In general, Life Cycle Assessment is used to make comparative assessments. If the comparisons are around changes in process variables or technology choice, there is little to be gained (besides accuracy) in a detailed fate and transport model. It must be noted that this argument does not apply to leachate generation modelling as changes in process variables or technology choice directly affect waste characteristics and the resulting effect on environmental performance is the focus of the investigation. However, if the comparisons are to be made, for example, around site placement of a waste deposit, then detailed groundwater flow and contaminant transport modelling are essential. It is therefore possible to default to generic data inputs without compromising the outcome of the analysis when the decision relates to process performance. The inputs into the modified Life Cycle Assessment would then be semi-site specific as opposed to site-specific.

### *Definition of acceptable risk criteria*

Once the exposure to the environment has been assessed, it is necessary to define the boundary between acceptable risk and unacceptable risk and define the boundary of the affected land footprint. As mentioned previously, Environmental Risk Assessment has been chosen to perform this task as, by definition, ERA can be used to determine whether the release of a substance will have an adverse effect on the environment. There are three main steps to risk assessment: (1) exposure characterization; (2) effects characterization; and (3) risk characterization as depicted in Figure 1.

'Exposure characterization' examines the magnitude, duration and pathways of environmental exposure to the chemicals of concern. This assessment involves, firstly, identifying significant sources of chemical releases to the environment and characterizing the nature and magnitude of these releases. 'Exposure pathways' from the source to the receptor are then analysed by examining the fate and transport of chemicals to predict the chemical concentrations in the environment. Determining the behaviour of chemicals in the environment is typically evaluated using mathematical models based either on empirical data from field or laboratory studies or on theoretical considerations (Simmonds *et al.*, 1992). The final stage of exposure characterization involves estimating the dose of each chemical of concern for each exposure pathway based on the predicted concentrations in the environment. This step usually draws on assumptions regarding the dose received by the ecological species or population of concern.

The 'effects characterization' component of Ecological Risk Assessment involves the collection and evaluation of data on the toxicity of the chemicals released to the environment. This information is obtained from toxicological investigations or experimental studies to determine the dose-response relationship of each chemical of concern on a particular species or population (Simmonds *et al.*, 1992; Hertwich, 1999).

In the risk characterization phase, all the information from the above steps is integrated to obtain a risk estimate. These phases constitute the risk assessment. The decision making process by which this information is used to control or regulate risks is called risk management.

We have already completed a number of steps in the exposure characterization stage. Emissions have been calculated by modelling leachate generation from ash deposits while the environmental concentrations have been calculated by modelling pollution plume migration. As our assessment endpoint is the area of affected land, we are not concerned with determining the dose received by the ecological species or population of concern.

The US EPA (1996) has identified the need to define the endpoints in any risk assessment exercise, these being explicit expressions of the actual environmental value to be protected and the affected environment. The assessment endpoints selected should reflect the management concerns which will drive the decision making process. These are typically explicit expressions of values that are to be protected, for example, maintenance of biodiversity in a particular ecosystem, and as such are inherently difficult to measure (Solomon, 1996). In cases like these, it may be beneficial to use surrogate assessment endpoints, which are more readily measurable. However, it is important that these surrogate endpoints be biologically and deterministically linked to the assessment endpoints (Solomon, 1996). The use of standards, such as water quality criteria, is particularly attractive as surrogate assessment endpoints. These are typically expressed in terms of concentrations (or concentration ranges) of particular chemicals and have been developed to ensure protection of the environment. As a result, this provides an opportunity to link back to impact assessment criteria in tools such as LCA.

Using Ecological Risk Assessment, together with modelling tools to determine leachate generation and mobility we are now in a position to explore the potential impacts of leachate generation from a waste deposit.

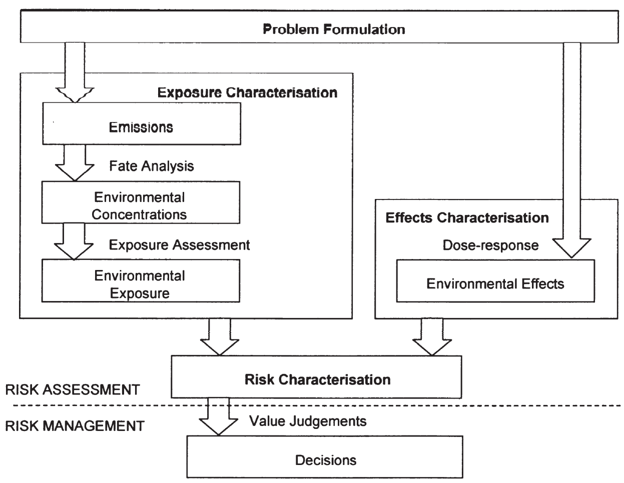


**Figure 1—Stages of Ecological Risk Assessment (based on EPA, 1996; Beinat, 1997)**

## Operational case study

We pose a real situation relating to ash management in a South African power station to demonstrate the above methodology. A power station's tied colliery is struggling to contain and dispose of its excess effluent. The problem statement that can be formulated from known information is effectively: 'Where in the power station's water circuit should this water be placed in order to maximize environmental benefit?'. This problem statement, however, can be broadened if we consider that the mine has significant volumes of excess water available and that the power station is not limited to accepting a certain quantity of water. The problem statement might then be: 'What volume of water should the power station be taking, and where in the water circuit should this water be integrated, for there to be a net environmental benefit to the combined mine/power station system?'. Taking this approach is of more value, in that, as water regulations become more stringent, co-operation between the power station and its tied colliery to minimize water use and discharge is likely to become more beneficial.

For this case study, it is assumed that the power station will use the mine water in the cooling water circuit and only operational changes will be made to accommodate the poorer quality feed water. It is clear that trade-offs will have to be made between reduced raw water consumption and mine water emissions on one hand, and increased chemical and energy use in water treatment along with increased potential leachate formation from the ash dump on the other. These trade-offs will become evident in a comparative Life Cycle Assessment exercise where the different options are evaluated. It is evident, therefore, that the LCA must include impacts relating not only to resource use, gaseous emissions and water emissions but also an indication of the impacts arising from leachate generation and pollution plume dispersion.

### *Modelling approach*

The power station has a dry ash deposit and operates under a zero liquid effluent discharge (ZLED) policy. The ash 'sink' capacity is a major constraint on the water plant. Effluent is used to condition (moisten) the ash before it is conveyed to the ash dump and is sprayed on the dump to suppress dust formation. The carrying capacity of the ash and the volume of ash produced are therefore significant variables as they dictate the volume of effluent that can be disposed of without violating the ZLED policy. The options for mine water uptake by the power station affect a number of streams in the power station water circuit as shown in Figure 2.

There are a number of options for mine water uptake, each of which has implications in terms of the volume and concentration of effluent sent to the ash deposit. Some options require changes to water treatment technologies. These are described here simply as TT1 and TT2. Option A, where mine water is added to the cooling water circuit, results in an increase in the volume of effluent requiring disposal as well as the amount of salts requiring entrainment in the ash. Option B, which also inputs the mine water into the water circuit, but with additional treatment using TT1, results in a lower volume of water but with a similar mass of salts as before. Another alternative for mine water input into the water circuit, Option C, employs TT2 which leads to increases in both the salt loading and effluent volume to the ash dam. Bypassing the power station water circuits altogether and using the mine water directly for ash conditioning and dust suppression, Option D, increases the effluent volume but the effluent concentrations are less due to dilution effects. The volume of effluent and effluent concentrations both influence leachate generation potential. It is therefore essential to be able to quantify this potential for leachate generation to assess not only whether an immediate release by the mine is favourable to a more diffuse release over time by the power station but also which option produces the least potential for leachate generation. The various options considered here are summarized in Table I.

The impact of these options on effluent volume and concentration sent to the ash deposit was estimated through an operational model of the power station, with the interaction between solids and water circuits clearly identified. These values, along with ash compositions and other parameters, allowed for the calculation of leachate concentration at the base of the dry ash deposit. In this case study we considered an affected land footprint based on salinity, whilst recognizing that salinity and metals' mobility are linked. Salinity is usually measured as electrical conductivity in μS/cm. However, this is not easily modelled and data linking electrical conductivity values to toxic effects are unlikely to be available. A more meaningful and convenient measure of salinity is the solution ionic strength, defined as:

$$1 = 0.5\sum_i M_i z_i^2 \qquad [1]$$

Where 1 is the ionic strength of the solution, $M_i$ is the molality of species $i$ and $z_i$ is the charge on species $i$. The summation is over all ions in solution. For the ash system, the leachate ionic strength was calculated at two extremes. The actual leachate composition is assumed to lie between the extreme situation where the effluent and ash are in contact long enough to attain equilibrium and the situation where the effluent and the ash do not interact (for example, in the presence of channelling and fluid bypass). The

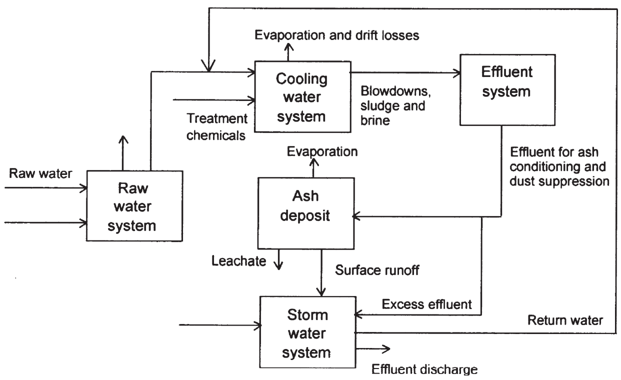


**Figure 2—Simplified representation of power station water circuit showing streams affected by mine water uptake**

*Table I*

**Options considered**

| Option | Process description |
|---|---|
| Option A | Mine water to cooling water circuit |
| Option B | Mine water to cooling water circuit with TT1 |
| Option C | Mine water to cooling water circuit with TT2 |
| Option D | Mine water straight to ashing |
| Option E | No mine water taken (base case) |

equilibrium ionic strength was calculated using the solution speciation program, MINTEQA2 (Allison, *et al*., 1991), whilst the other extreme ionic strength, referred to as a 'straight through' value was determined through mass balance considerations. Table II shows the salinity extremes and corresponding leachate generation rates.

These ionic strength values were used as a constant source term in a simplified groundwater flow and contaminant transport model to obtain the extent of the pollution plume. Clearly this is a simplification, and, in reality, the dynamic behaviour within the deposit needs to be considered. This is the subject of further work currently being undertaken. Generic data inputs were used to define the geohydrology of the subsurface environment. It was also assumed that all species were attenuated to the same extent. A simplified model was adequate in this case as the decision of where to input mine water in the power station circuit can be assessed via a comparative assessment. A salinity footprint was then calculated at two time periods: at site closure and after 100 years (Figure 3). The boundary of the pollution plume was estimated at two values. Firstly a 'legislative limit' in terms of ionic strength was defined, based on the drinking water quality guideline for Total Dissolved Solids of 1000 mg/l and using average values for molar mass and charge of the leachate components (NHMRC and ARMCANZ, 1996). Secondly, the absolute extent of the plume where the ionic strength was negligible was estimated.

The sensitivity of the modelling approach to changes in a number of pertinent variables, including leachate flowrate, effluent flowrate and retardation factor in the groundwater flow and mass transport model, has been investigated (Hansen *et al*., 2000). Interestingly, it was found that the impacted land area is a much stronger function of leachate generation rate than of total salinity.

### Discussion of results

It is difficult to assess which option will be of greatest environmental benefit to both the mine and the power station combined, as the affected land footprint of the ash deposit is the only impact category considered here. A rigorous, comparative Life Cycle Assessment exercise will show the trade-offs between both reduced raw water consumption and

*Table II*

**Leachate salinity extremes at the base of the ash deposit and corresponding leachate generation rates**

| | Option A | Option B | Option C | Option D | Option E |
|---|---|---|---|---|---|
| Salinity (equilibrium) | 3.021 | 3.839 | 2.770 | 1.188 | 6.718 |
| Salinity (straight through) | 0.048 | 0.049 | 0.048 | 0.046 | 0.052 |
| Leachate generation rate (Ml/mth) | 39 | 28 | 44 | 121 | 12 |

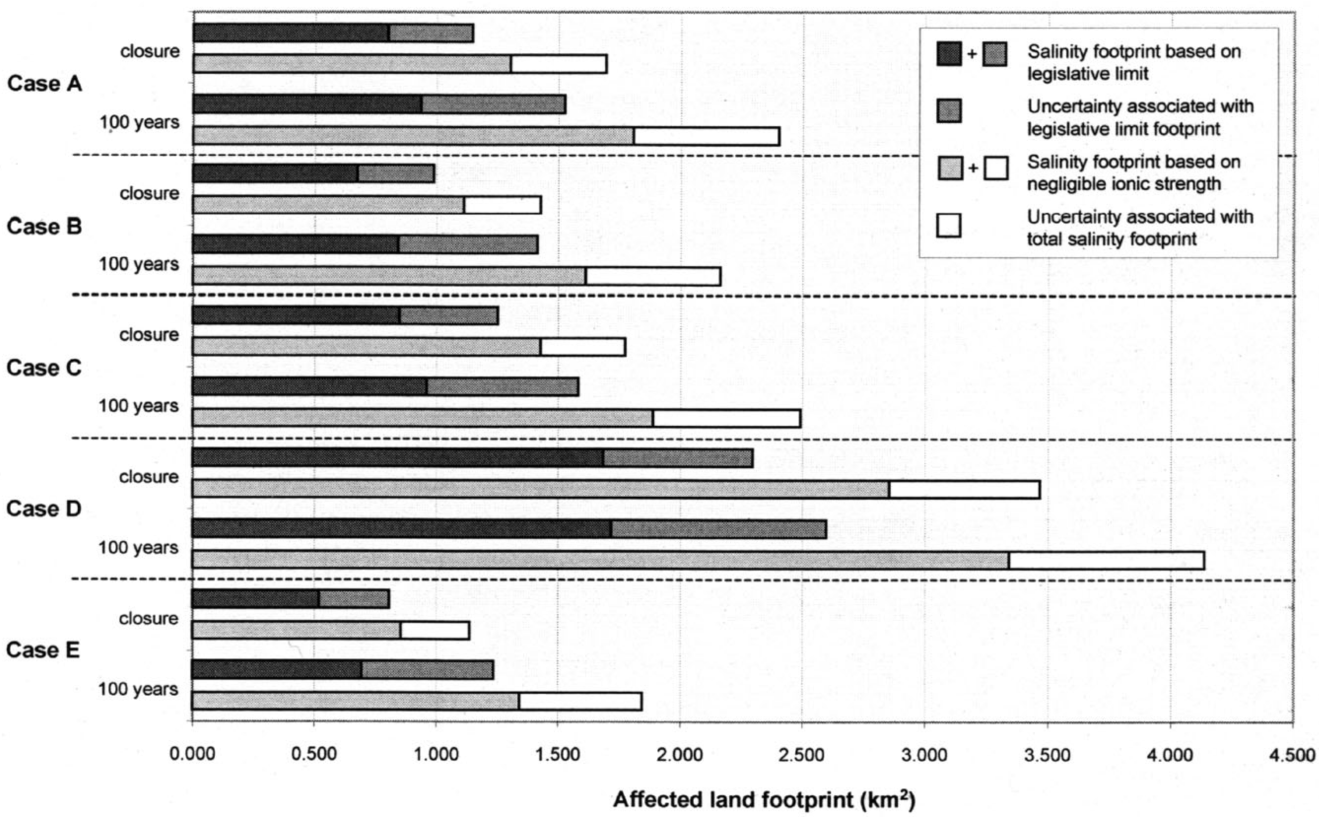


**Figure 3—Results showing the affected land footprint at closure and after 100 years calculated using both salinity extremes**

mine water emissions and increased chemical and energy use in water treatment and increased potential for leachate generation from the ash deposit. It must also be noted that there are many other options relating to the volume of mine water introduced to the power station water circuit that were not considered here and each would have a differing effect on the key areas listed above. However, the above exercise does demonstrate the relative ease with which an indication of ash management impacts can be assessed.

## Conclusions

The methodology to determine the environmental impact associated with solid wastes outlined in this paper involves detailed leachate generation modelling, followed by pollution plume modelling through existing groundwater flow and mass transport modelling software. The boundary of affected land may be drawn using ecological risk assessment methods or, in the absence of detailed human- and eco-toxicological data, by comparing the environmental concentrations to an acceptable or legislative limit. Further details of the methodology are described elsewhere (Hansen, 1999; Hansen *et al.*, 2000).

It has been shown that an LCA of primary industries is of limited benefit without a consideration of impacts arising from solid waste management. The footprint of affected land metric provides a first-order indicator of the impact of solid-waste repositories and extends the current ability of LCA to address site-specific, time dependent impacts associated with leachate generation and mobility. As a concept this approach is a significant improvement over current LCA approaches.

This approach to a risk-based assessment of leachate generation from waste deposits has many applications. Apart from the obvious benefit to decision making pertaining to the management of solid wastes from various industries as it allows prediction and visualization of impacts, this approach also enables the effect of upstream technology choice to be investigated and assessed. This assists in the identification of environmental impacts and allows the assessment of cleaner technologies through linking of waste management practices back to the unit technologies that generated the waste.

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# Tzaneen woman graduates in electronics*

**Khutsong**—In March 2002, the first twenty electronics graduates received their diplomas at the specially equipped Mineworkers Development Agency Training Centre in Khutsong, near Carletonville. One of the top two graduates was Betty Sibiso, a young Tzaneen woman with no previous training or experience in electronics who obtained a near perfect score in the exam. For her exceptional efforts, Betty received a fully equipped, high quality toolbox that will assist her in applying her new trade.

'I am extremely proud and happy today', said Miss Sibiso after the ceremony 'I will be able to pursue my own business or gain employment with a company specializing in the type of electrical equipment I can now install and repair'.

This electronics training is part of 'The Care Project', an innovative training and counseling project developed by South Deep Mine to assist ex-miners and their families to gain employment or to start their own small enterprises. The Care Project is solidly backed by the Placer Dome Group (owner of 50% of the South Deep Mine), as part of its world-wide Sustainable Development Programme.

As part of this project, 60 ex-mine workers or their nominees will receive electronics training to prepare them for new careers. Two courses are being offered: a television repair course, which includes training on repairing other appliances as well, and a solar panel installation course. These courses were designed after market research had been undertaken to determine the needs of rural communities, the course content and the relevance of the courses to rural entrepreneurs. The research indicated that there is a need for repair services for televisions and other electrical appliances, and for businesses that install solar panels—a cost-effective and reliable alternative energy source for many non-electrified rural communities.

Along with this specialized training in electronics, students receive training in business skills, including business plan preparation. They are provided with marketing support and equipment as well as with on-going counseling to assist them in starting their own businesses. The project will maintain its support for a number of months following business start-up. For those students seeking salaried employment, placement assistance will be provided.

NEKSA (National Electronics Kollege of Southern Africa, based in Roodepoort) has been charged with providing the training at the Khutsong Centre. NEKSA has more than 20 years experience in practical electronics tuition, training students with a diversity of skill levels and backgrounds. The course and selection process were developed by the Care Project in consultation with the Mineworkers Development Agency (MDA) and The Employment Bureau of Africa (TEBA Ltd). The first course of 20 students commenced in October last year, and terminated in March 2002. The current course commenced in March and is being delivered in Portuguese to the 20 course delegates, who are all ex-mineworkers from Mozambique. A further course, also with 20 students, will commence in approximately four-and a half month's time. Since the Care Project aims to provide services to ex-mineworkers from five countries in southern Africa, the students are drawn proportionately from all mineworker residential areas.

Placer Dome's Sustainable Development Programme also incorporates other initiatives in South Africa. The Care Project, together with The Employment Bureau of Africa (TEBA Ltd), is also funding an HIV/AIDS home-care support programme for ex-employees and their families. In addition, South Deep (Placer Dome's major investment in South Africa) provides non-traditional opportunities for women at the mine site. The company recently hired 48 women to work underground as shaft helpers, artisan assistants, survey assistants and sampling helpers. ◆

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