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for

AUSTRALIAN NATURAL BURIAL GROUND PIONEERS

Guideline 2: Environmental Considerations for Establishment of Natural Burial Grounds

A Literature Review

Australian Natural Burial Project

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ANBP
Willara Cottage
Range View Road
Armidale NSW 2350

australiannaturalburialproject@gmail.com

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ENVIRONMENTAL CONSIDERATIONS FOR ESTABLISHMENT OF NATURAL BURIAL GROUNDS

INTRODUCTION, PURPOSE AND USE OF THIS GUIDELINE

Introduction

Each Guideline in this series builds upon the information presented in the previous Guideline/s. In this way, a comprehensive understanding of the subject matter is developed gradually, and without repetition. If you have not read the Guideline/s that preceed this one, it is recommended you do so.

The ethos of natural burial demands environmental awareness at every level, starting with understanding the different types of natural burial grounds (see Guideline No 1 in this series), and including an appreciation of both the environmental benefits and risks associated the process.

Purpose of this Guideline

This Guideline is written to afford Natural Burial Pioneers a sound tecnical understanding of the nature of environmental risk posed by the burial of human remains, and how that risk differs between traditional cemetery burial and natural burial practices.

Literature Review

The Literature Review that follows is a examination, and analysis, of formal research dealing with the potential environmental harm associated with the concentrated burial of human remains. Reading this Literature Review will provide a practical understanding of the relevant environmental issues, and the scientific principles that underpin a systematic site assessment process (the subject matter of Guideline 3 in this series).

It should be noted that virtually all available research is focussed on historical, ‘cemetery’ sites (many in poorly selected locations) where traditional, high density burials were (or are) conducted, often with the use of embalming. Some of the cemeteries investigated represent the worst case scenario in terms of siting and potential for environmental harm. Practically speaking, however, these studies provide a wealth of valid, useful information about exactly ‘what not to do’ when it comes to selecting a burial ground site.

LITERATURE REVIEW: ENVIRONMENTAL CONSIDERATIONS IN THE SELECTION OF BURIAL GROUND SITES:

Introduction

Historically, the placement of cemeteries and burial grounds has mainly been influenced by proximity to human settlements, as well as religious and cultural traditions (Spongberg & Becks, 1999). It was not until the mid 1900s that concerns about the environmental impact of burial grounds emerged.

Recent research has aimed at determining the reality, extent and nature of the environmental risks posed by the concentrated burial of human remains at formal burial sites (Dent, 2002; Silva, Costa, & Malagutti Filho, 2012; WHO, 1998; Zychowski, 2012). This literature is cemetery focused, as opposed to natural burial ground focused, and reveals that some long-established cemeteries are indeed poorly sited from a geoscientific standpoint.

Literature on the nature and management of natural burial is not extensive, does not address the lesser environmental effects of the practice and tends to be humanities-based rather than scientific. For example, the qualitative research report on UK 'Sustainable Deathstyles' by geographers Yarwood, Sidaway, Kelly, and Stillwell (2015), or the planning-focussed paper on Green Burials in Australia by Marshall and Rounds (2010).

In a sense, the cemetery studies could be regarded as 'worst case scenario' investigation for Natural Burial. Most studies define impacts from high density and often very large scale interments not aligned with natural burial principles, so the margin for error is generous for natural burial.

There is also an increasingly extensive informal and experiential literature, not reviewed here, emergent over the last few decades. These are narrative rather than scientific, reflect the modern origin of the notion of natural burial and 'natural death', and the struggles of advocates to popularise these concepts. Handbooks written by these proponents tend to focus mostly on funeral services, customs around body preparation and ceremonial practices.

The research literature reviewed here supports the argument that environmental, and especially hydrogeological impacts should be assessed above all other considerations with regard to the siting of any cemetery or burial ground. Terrain, soil type and structure and appropriate landscape design are also critical elements.

This Review distils the key findings from a broad array of available scientific writings to answering three important, practical questions:

- Is there a risk?
- What is the nature of the risk? and
- How can any risk be lessened and managed?

In discussing these questions, a range of related topics is addressed, including the composition of the human body, the biological decomposition process, and the longivity and behaviour of decomposition products in the ground.

Is there a risk? Potentially, Yes…

Spongberg and Becks (1999, p. 313) state that “anything buried underground has the possibility of causing contamination”. The central concern at issue is the dispersal in the ground, near the actual burial, of the products of decomposition of the human remains, and in the longer term, the timber, metal and plastics buried with the remains (WHO, 1998). The early stages of the decomposition process are primarily bacterial in nature, and the liquids and soft tissues of the body are the first parts to break down (Dent, Forbes, & Stuart, 2004; Zychowski, 2011). This leads in due course to the production of a potentially mobile, viscous liquid mass referred to variously as a ‘decomposition plume’ or ‘leachate’. ‘Leachate’ suggests the notion of a leaching or migration of breakdown products through the soil, and also flags the existence of a primary risk associated with burial (Dent & Knight, 1998; Spongberg & Becks, 2000; WHO, 1998).

The environmental risk presented by the leachate takes two forms. The first form concerns the direct effect of the leachate upon the soil in the vicinity of the burial. The second, and more critical form, concerns the possibility of the leachate (or products of decomposition) moving through the soil and entering water bodies, aquifers and ground water supplies (WHO, 1998). Accordingly, it is the location of the burial site, in terms of its geological and hydrogeological characteristics, that constitutes the single most critical factor with regard to potential risk (Oliveira et al., 2013; Pacheco, Mendes, Martins, Hassuda, & Kimmelmann, 1991; Silva et al., 2012; WHO, 1998; Zychowski, 2012).

A primary concern is risk to human health via contamination of potable water supplies (Dent, 2002). The magnitude of risk depends on whether any constituents of the leachate are likely to be harmful, and the possibility for direct or indirect human exposure to these products or disease-bearing entities.

Lesser risks in need of consideration for natural burial would include any impact to ecosystem health, and particularly to indigenous plant species, as a core aim for natural burial is for ecological system enhancement.

The exact composition of leachate varies from case to case, and across time, and is dependent on factors such as the stage of decomposition, variance in body types, depth of burial, the nature of funeral related materials buried with the remains, temperature, soil acidity and moisture levels (Silva et al., 2012; Zychowski, 2011).

Nevertheless, the leachate will generally contain a varying mixture of bacteria, viruses and organic and inorganic elements (Dent, 2002; WHO, 1998). The nature of these constituents and the physical properties of leachate are now discussed.

What is the nature of the risk?

Organic and inorganic elements

On average, the human body contains between 55 to 67% water, 14 to 24% protein, 12 to 24% fat, and 5% minerals (Dent et al., 2004; Spongberg & Becks, 2000).

The World Health Organisation informs us that

> "the body of a 70 kg human adult male contains approximately: 16 000 g carbon, 1800 g nitrogen, 1100 g calcium, 500 g phosphorous, 140 g sulphur, 140 g potassium, 100 g sodium, 95 g chlorine, 19 g magnesium, 4.2 g iron, and water 70–74% by weight"

and that many of the products of decomposition of the human body are identical to those found as nutrients in the natural environment.

It is considered that the environmental risk attached to the naturally occurring elements of decomposition are associated more with increased concentrations of these products at the burial site, as opposed to "any specific toxicity they possess" (WHO, 1998, p. 8).

Toxicity of leachate to people and vegetation

Elevated levels of elements such as lead, zinc, copper, iron and arsenic have been detected in cemetery soils by some researchers. Rather than arising from the decomposition of a body, these are the result of various funeral practices such as the use of toxic adhesives and preservatives in coffin manufacture and recent or historical use of toxic embalming fluids (Spongberg & Becks, 1999; Zychowski, 2011).

Human or land animal contact with buried heavy metals (possibly arising from historic use of asenic based embalming fluids) is unlikely in an undisturbed area, and concentrations have rarely been identified at biotoxic levels. It is mainly in concentrated interment situations, and in relation to water movement, that real concern lies. Yet, interestingly, significant contamination outside cemetery boundaries has not been detected (Kim & Kim, 2012; Spongberg & Becks, 1999; WHO, 1998).

These understandings form the basis for many natural burial principles and startegies intended to achieve non-toxic burial.

Natural burial eliminates concerns of contamination from embalming fluids and metals. However, where a natural burial ground is linked to revegetation and/or conservation works attention needs to be paid to the potential impact of burials on existing vegetation in conservation sites and new plantings in greenfields sites. To a large extent these concerns can be mitigated by avoiding too high a burial density, too close a burial to an existing vegetation (established trees), and by having a working knowledge of nutrient sensitive plants.

Bacteria and viruses

Bacteria and viruses detected in leachate originate primarily from within the body itself, particularly the intestines, and their ability to survive for any period of time is dependent upon environmental factors such as temperature, oxygen supply (or absence), nutrient availability and moisture (Dent, 2002; Dent et al., 2004; Silva et al., 2012). In a study of three cemeteries in South America, Pacheco et al. (1991) found measurable levels of various bacteria in some of the ground water samples collected within those cemeteries. They concluded that the contamination was made more likely by the combination of sandy soils and high water tables at the sites.

One of the cemeteries investigated was in a coastal location, where tidal action varied the level of the water table beneath the cemetery through a range between 0.6 and 2.2 metres. Most bacteria are absorbed by the soil, but this ability is limited by the presence and velocity of ground water (WHO, 1998). Therefore, in the circumstance described by Pacheco et al. (1991), where human remains were buried within the active range of the water table, the presence of bacteria was not surprising.

By contrast, Dent and Knight (1995) studied a large coastal cemetery in Australia, sited over a potentially vulnerable aquifer, reported negligible bacterial concentrations and adjudged the ground water suitable for irrigation.

Interestingly, despite the existence of inappropriately sited cemeteries, such as those described above, the World Health Organisation confirms there are no recorded incidents of epidemic or widespread disease outbreak linked to contamination of groundwater by cemetery leachate (WHO, 1998). Nonetheless, the research suggests the practical possibility of bacterial contamination of ground water, emphasising the necessity for informed consideration in the siting of burial grounds.

Persistence of leachate

Bearing in mind the strong influence of environmental variation, estimates for skeleton-level decomposition range from less than 1 year in ‘ideal’ conditions, through to 12 years (Young, Blackmore, Leavens, & Reynolds, 2002). A calculated estimate of 10 years was made, based upon observations of human remains buried in the Netherlands at the depth of 2.5 metres (Kim & Kim, 2012, citing Bouwer, 1978). Burial at this depth, coupled with a cooler climate, is arguably sub-optimal for decomposition. Given the complex interactions, and sheer number of environmental, and funeral related variables, decisively determining an average decomposition period is not feasible; however, for practical purposes “a minimum working time frame is at least 50 years” is recommended (Dent, 2002, p. 331).

In circumstances where the process of decomposition is not impaired by extreme environmental conditions or practices such as embalming or the use of plastic coffin liners, the production of leachate could persist for several years. It would be expected to be highest immediately following burial, and to decrease (and eventually cease) over time (Dent, 2002; Kim & Kim, 2012; Spongberg & Becks, 2000; Young et al., 2002).

The concentration of leachate would be expected to be greatest immediately around the interment, and decrease gradually with extension beyond the grave. The ultimate degree of extension would be dependent on prevailing environmental factors (Dent & Knight, 1998; WHO, 1998; Zychowski, 2011).

When considering leachate load at cemetery sites, UK regulators apply a formula based on an estimate that 50% of the potential leachate production occurs within the first year, with the remainder decreasing by a further 50% each year thereafter. Theoretically, this would result in a residue of only 0.1% of the original leachate load assuming a 10 year decomposition period (Environment Agency, 2002). This formula is not explicitedly supported by the scientific literature, and should be considered as more of an estimate for practical purposes. Provided its limitations are understood, it could provide a rational, commonsense approach to considering cumulative leachate loads.

Percolation of leachate from the burial site

The movement of leachate is influenced by environmental factors, particularly soil type, and the presence and height of permanent or ephemeral (short lived) water flows (Dent & Knight, 1998; Silva et al., 2012; WHO, 1998).

Spongberg and Becks (2000) investigated soil contamination in a poorly sited, historical cemetery in Ohio containing more than 14,000 burials dating back to the mid 1800s. They found elevated levels of certain compounds which they determined to be the product of organic decomposition.

The site was adjacent to a river, divided by an intermittent stream that flooded frequently, and had a water table that fluctuated between 0.3 and 0.9 m from the surface during wet seasons. Despite these conditions, the compounds detected in samples within the cemetery were not found in samples taken beyond the cemetery boundary. The researchers suggested the fine textured soils at the site may have been responsible for keeping the decomposition products within the cemetery grounds.

It follows that it is the location of the burial site, in terms of its geological and hydrogeological characteristics, that constitutes the single most critical factor with regard to potential risk (Dent, 2002; Oliveira et al., 2013; Pacheco et al., 1991; Silva et al., 2012; WHO, 1998; Zychowski, 2012).

How can the risk be lessened and managed?

Any environmental risk associated with the burial of human remains is directly proportional to the potential for leachate to enter underground water sources, or to extend excessively beyond grave sites (Dent et al., 2004; Kim & Kim, 2012; Oliveira et al., 2013; Silva et al., 2012; WHO, 1998).

Certain site management practices can mitigate leachate load. These include managing the density of burials at the site, both in terms of the actual number of interments and the time frame and spatial proximity within which they occur (Dent, 2002; Kim & Kim, 2012; WHO, 1998).

Dent (1999, p. 7) concludes that “the risks posed by correctly sited and operated cemeteries are small in most soil types”, a view reflected by the The World Health Organisation’s (WHO, 1998, p. 9) statement that:

> “ … pollution potential from cemeteries is present, but in a well managed cemetery with suitable soil conditions and drainage arrangements, the risk is probably slight.”

Key factors affecting the mitigation and management of risk are therefore site selection (from a hydrogeological standpoint), soil suitability (particularly in relation to soil type and available depth), density and timing of burials, funeral industry practices, and the presence of natural vegetation. A geoscientific evaluation of any potential site should be made in advance of development planning.

The importance of suitable hydrogeological conditions has already been discussed. Regarding aspects of soil composition, there is agreement that acidic soils of low permability, composed of fine to small grained, clayey-sand or sandy-clay particles are most effective for retention of decomposition products in the vicinity of the burial (Dent, 2002; Dent & Knight, 1998; Spongberg & Becks, 2000; WHO, 1998; Zychowski, 2011). As well as the type of soil, research highlights the importance of what is referred to as the ‘unsaturated zone’; the presence of unsaturated soil and materials immediately around the grave, and extending beneath the bottom of the grave (Oliveira et al., 2013; Silva et al., 2012; WHO, 1998). The presence of an adequate unsaturated zone is considered to be the “most important line of defence against the transport of degradation products into aquifers. It acts as both a filter and an adsorbent." (WHO, 1998, p. 7).

Logically, the greater the extent, and depth, of the unsaturated zone, particularly beneath the grave, the better. Early researchers suggested that a depth of between 0.5 to 0.7 metres was adequate to prevent harm provided the general hydrogeological aspects of the site are appropriate (Oliveira et al., 2013; Silva et al., 2012). Schraps (cited in Spongberg & Becks, 2000, p. 90) asserts that burial sites with water table depth greater that 2.5 metres, suitable soil type and an unsaturated zone of at least 0.7 metres should be "void of groundwater contamination". Derived from more extensive, and more recent, research, Dent (2002) proposes a more conservative extension of the unsaturated zone to at least 1 metre beneath the bottom of the grave excavation.

The presence of native vegetation (as opposed to turf grass), and the presence of deep rooted trees in and surrounding, burial sites, limits the potential extension of leachate, and therefore the potential for harm (Dent & Knight, 1998; Oliveira et al., 2013; WHO, 1998). Phytoremediation practices should be employed at all burial sites, with the use of locally adapted native species considered prefereable.

Understanding the life cycle of leachate, and its ability to extend outwards from the grave, makes the issue of density of burial relevant, as is the spatio-temporal sequencing of burials within any particular site. The greater the number of bodies buried within a defined space, the greater the total leachate load upon that local environment; however, timing is a critical factor. If 100 bodies were buried at the same time, within a defined space, all would contribute to the total leachate load concurrently (Zychowski, 2011). Therefore, the total load would be experienced within the local environment over a relatively short time frame. On the other hand, if one body were buried each year, for 100 years, in the same space, the local environment would encounter the same load but it would be spread out over a long time frame. Taken together, considered application of density and timing in the management of burial grounds could significantly mitigate potential environmental harm (Oliveira et al., 2013).

Funeral practices that encourage the burial of non-biodegradable coffins, metals and plastics, as well as the use of embalming fluids, preservatives, lacquers and adhesives increase the risk of environmental harm (Spongberg & Becks, 1999; Zychowski, 2011). Improved products and the environmentally conscious operation of burial sites would lower the risk.

Summary

Over the last fifty years, a better understanding of complex systems, has encouraged a more wholistic way of thinking about environmental and ecological issues. The term 'wholistic' is used here to refer to '*the organic or functional relationship between parts and the whole*'.

Wholistic, systems thinking is particuarly applicable in considering the appropriate siting of natural burial grounds. In this framework, a natural burial ground can be readily conceived of as one small part of the entire living planet: a place where the biological material of *once* living organisms is gradually absorbed back into the *still* living organism of the planet. Certainly, this conception is well-matched with the sentiment of 'returning the body to the earth' so often voiced at funeral services.

Considered in this living context, all the separate issues discussed here, in relation to the ecologically-conscious siting and operation of burial grounds, come together naturally to guide action.

A well-informed, ethically motivated group would not contemplate using a swampy, shallow soiled site for the return of human remains to the Earth. Instead, it would select a site where the local environment favoured the processes of natural decomposition, and where the possibility of ecological harm was slight.

In practical management, it would take care not to overload the capacity of the local environment by thoughtfully scaling, distributing, and timing interments. Likewise, it would not knowingly (and unnecessarily) bury metal, plastics or toxins, nor allow potential weed species to be introduced. At the same time, it would seek to meet all reasonable cultural and social needs of living visitors and their treasured recumbents.

Decomposition of human remains in the earth generates leachate and decomposition products that if permitted to enter aquifers, or extend greatly beyond the grave site, have the potential to cause ecological harm. But understanding the nature and behaviour of the products of decomposition allows for the effective management of possible risk through environmentally responsible siting, design, plantings and operation of burial grounds.

ABOUT THE AUTHORS

Vanda Rounsefell PhD, MB, BS, FACNEM, CTA, ITAA
Vanda has a PhD in Human Geography and Environmental Studies from the University of Adelaide, on the application of complex systems theory to sustainable human habitat design and development, and inter alia, has a background in wholistic and environmental medicine and eco-community development.

Kevin Hartley BPsySc
Kevin has a 20-year broad spectrum experience in all areas of the traditional and sustainable funeral industries, holds a bachelor degree in psychological science from the University of New England. He has won awards for innovations in the funeral industry, and study tours in Malaysia (2014) and Europe (2015) under the Vice Chancellor's Scholar Award program from the University of New England.

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