Successful Revegetation of Closed Landfills

Graham Ussher[1] and Chris Hillman[2]

ABSTRACT

Recreating or enhancing aesthetic and ecological values are important outcomes for civil works on closed landfills. Managers must also consider the long-term risks to cap integrity and potential effects on public safety. Remediation designs should also include comparisons of potential risk under proposed end uses. This paper looks at recent work undertaken to identify the key issues to be considered when tree planting is proposed, to ensure that aesthetic and ecological enhancement is appropriately integrated into rehabilitation designs. Several case studies from around the Auckland area are used to illustrate the opportunities, technical challenges and proposed solutions for closed landfill remediations on public land. In particular, comparison is made to provisions of the Closed Landfill Management Guidelines to demonstrate how these guidelines can be put into practice.

INTRODUCTION

Landfills are commonly places of biodiversity. Indeed, in a town setting, the difficult ground conditions for building often make closed landfills havens of biodiversity. Incongruous though it may seem, landfills can, and do, become disproportionately important in a town setting, both to people and ecology. Therefore, revegetation schemes need to account for this.

In general terms, the older the landfill, the more opportunity there is likely to be to provide planting that will be both of community and/or ecological value. In highly urbanised areas where closed landfills are not used as a recreational resource, the resulting wasteland can attract conservation interest in restoring indigenous shrubland or forest cover (hereafter replanting). Replanting over part or all of such landfills may have occurred many years ago and the subsequent forest cover may represent a significant community focus and resource and be a place of considerable biodiversity value on a local and regional scale. Therefore several landfills in the Auckland region alone that support diverse regenerating forest with resident listed threatened species which could meet the definition of significant ecological areas for statutory protection

[1] Tonkin & Taylor Ltd, Auckland (GUssher@tonkin.co.nz)
[2] Tonkin & Taylor Ltd, Auckland (CHillman@tonkin.co.nz)
[3] Photo above – Aerial view of Newmarket Park Closed Landfill.

under the current Auckland Region Policy Statement. The drive in recent years by urban councils to stimulate the involvement of residents in conservation work in local areas (e.g. replanting, stream care, weed control) means that public enthusiasm for replanting areas of open spaces, especially those not used for recreation, is greater than ever before.

OPPORTUNITIES FOR REVEGETATION

The decomposition of the wastes creates landfill gas. This can affect the ability of plants, particularly deep-rooted trees, to establish successfully. In addition, the decomposition and ongoing consolidation of the waste mass also causes long-term settlement that can destabilise the planting substrate. Much of this decomposition occurs within a generation of closure (approximately 30 years), making older closed landfills a better prospect for long-term survival of revegetation schemes. Also, the difficulties in building on closed landfills, often results in these areas becoming open spaces that over time have accumulated considerable community and ecological value, which adds value to revegetation schemes. On recently closed landfills, the high decomposition rates and production of landfill gas may make revegetation with grass the only reasonable option, although even this should be considered against opportunities where local communities may favour alternative restoration options.

Meola Creek, Seddon Fields Closed Landfill

Older, unrestored landfills often present problems such as slope instability and caps that are too thin (or even non-existent). Engineering works are required to remedy these problems, and complete vegetation removal is often a necessary precursor to these works. Such stripping can provide the opportunity for value-added revegetation, however, care needs to be taken. Existing ecological value, which may be of heritage value, may need to be protected or preserved. As a minimum, broad consultation with potentially interested parties is likely to be required as part of the process for undertaking the necessary works and designing an appropriate form of mitigation or replacement.

The MfE Closed Landfill Guidelines[4] provide general advice on what to plant, including a focus on native (indigenous) species and support for sourcing plant stock locally (ecosourcing). The Guidelines also consider that closed landfills are in effect, clean slates for plant colonisation,

4 Ministry for the Environment (2001) A Guide for the Management of Closing and Closed Landfills in New Zealand

following the natural succession pathways from simple plant communities to complex, long-lived forests as advocated in restoration ecology manuals. Perhaps not so well recognised by the Guidelines is that closed landfills in urban settings can help contribute towards local biodiversity conservation efforts now (instead of many years in the future under natural plant succession pathways) and that the capping and soils typically used in rehabilitation are often capable of supporting a diverse mix of native plant species now, with their attendant birds, insects and lizards, rather than having to wait generations to realise such values.

Thus, the value of closed landfills is two-fold with respect to the replanting and the conservation of local biodiversity. Firstly, they may already be supporting native vegetation that has naturally established or been planted by people and may be supporting considerable conservation values which Council and communities may wish to see returned in the shortest period of time. Secondly, recently closed landfills may represent a valuable future conservation asset where most nearby native vegetation has been cleared (e.g. urbanised or intensively farmed areas) and where establishing native vegetation may contribute significantly towards the goal of local biodiversity enhancement.

CONTRASTING NEEDS OF ENGINEERS AND VEGETATION

As with any disturbance works on closed landfills, revegetation or planting closed landfills create human health and environmental risks if not appropriately designed. These risks occur both in the short term and the long-term. Short term risk management measures during construction of the rehabilitation areas are usually addressed with adequate personal protective equipment (PPE) and good hygiene. Long term risks are usually addressed through the creation of an engineered cap; however the requirements of an engineered cap are often contrary to the requirements for healthy tree planting. These conflicting requirements are summarised on Table 1 below.

Table 1: The contrasting needs of the engineer and vegetation

Requirements for plant health	Requirements for an effective cap
• Air	• Removal of air by heavy compaction plant.
• Stable, friable substrate that will allow roots to grow both vertically and laterally	• Compact soil, usually to a degree that would prevent penetration by roots.
• Nutrients (right mix) • Fungal hyphae	• Inert engineered fill that is likely to be free from nutrients and fungal hyphae.

These conflicting requirements are relatively simple to solve on flat sites, where the engineered cap can be overlain by a self-contained growing medium. However, many old closed landfills do not offer this simplicity. To illustrate some of the complexities, three case studies are discussed below.

CASE STUDIES

The following studies are all older closed landfills in a town setting and this reinforces our earlier comment regarding the importance often given to revegetation of such areas.

Case Study 1: Retention of trees – Victoria Park

This case study provides an example of the ways and extent to which in situ tree protection can be achieved when the values of the trees are such that removal, relocation or replacement is untenable.

In 2006 Auckland City Council – Environmental and Utility Management remediated the Victoria Park playground close to the Auckland CBD. The trees within the remediation area were mature heritage Plane trees of considerable community value that required protection and preservation.

Victoria Park was reclaimed from the Waitemata Harbour in the late nineteenth century. Incorporated within the reclamation fill were wastes generated from the nearby Beaumont Street Gasworks and also possibly waste from a nearby incinerator. High benzo(a)pyrene and lead concentrations were detected in the surface soils at the park, which were above human health criteria. No landfill gases or significant vapours were being generated by the wastes.

To isolate the contamination from the public, a 450mm thick soil barrier was installed across the playground to isolate the site users from the contamination and also to mitigate the risks of release of the contamination into the environment.

Around the protected trees, the barriers had to be designed so that they provided protection to human health and the environment as well as enabling the trees to remain healthy.


Air spading complete, Victoria Park

Ground levels could not be raised directly against the existing tree boles as this may cause rot and have limited air intake. In addition, excavation below 100mm to 200mm depth was likely to damage roots. Care also had to be taken not to overly compress the soil beneath the dripline as this would reduce the air-permeability of the ground and could asphyxiate the tree.

To enable a soil barrier to be constructed, 100 to 200mm of soil was removed from the surface Excavation ceased when roots were encountered.

Air spades were used to excavate soils from above the main root bole, leading to less risk of damage to the root system and a higher probability of the tree remaining healthy. Although the air spading performed well in protecting the roots of the trees, the work took a number of weeks to complete and required that personnel hand operate equipment in full PPE (due to the high densities of contaminated dust generated within the tent). A similar exercise had been undertaken during the remediation of several childcare centres by Auckland City Council[5] using a mechanical excavator rather than air spades. The excavator had the advantage of making the excavation of the surface soils a relatively quick operation involving personnel operating machinery from a cab with significantly less PPE, although the risk of harming the tree roots with the excavator was greater than with the air spades.

To enable air and water to permeate into the ground, 100mm to 200mm no fines concrete was placed over approximately the first 1m around the tree bole. Beyond this beneath the drip line, 200mm of scoria was placed, followed by a geotextile barrier, then 150mm of topsoil.

The capping outside the tree drip line generally only extended to 450mm depth and so the ability of the tree to extend its root system in the future was not significantly compromised.

Case Study 2: Revegetation on a slope - Newmarket Park

This case study provides an excellent example of the challenges inherent in attempting to meet community and ecological aspirations for a project that is driven primarily by the need to ensure public safety. Rehabilitation of the slope in this example created challenges for meeting local community aspirations for tree salvage and visual screening, and presented ecological challenges for establishing fast-growing native forest to replace pre-works ecological values.

Slope stabilisation works on behalf of Auckland City Council are currently being undertaken at Newmarket Park in Parnell, Auckland. The park is a closed landfill surrounded by residential housing. In one area a steep slope, up to 25m high is unstable. The steepness of the slope combined with the nature of the landfill materials makes this slope prone to slips, of which many have occurred over the past 50 years. Slope instability threatens critical local drainage and sewer infrastructure and could also expose waste materials.

Historical records suggest that filling and other earthworks were carried out primarily during the 1930s and 1940s at the Park. The Park was later modified and improved after 1962 to form a soccer pitch, athletics track and stadium. Following a major failure in 1979, which severely damaged the stadium, the stadium and associated structures were removed and the Park landscaped for general recreational use. Since that date, the slope forming the southern boundary of the Park has been subject to ongoing instability. Investigations showed the surface soils of the slope to be elevated in a range of inorganic contaminants and polycyclic aromatic hydrocarbons. Significant landfill gas generation has ceased (probably in the 1970s or 80s).

Vegetation on the slope comprised a mixture of naturally regenerating native forest (approximately 60-80 years old) and native forest planted by Council and the local community some 25 years previously. The botanical values of the site were low due to the poor diversity of naturally regenerating native vegetation, unknown provenance of planted species and high susceptibility to weed invasion. However, the abundance of birds, particularly native species, indicated that the site may provide important habitat and food resources for birdlife in the

5 Herrmann, M, et al (2006) The urgent assessment, remediation and management of six contaminated childcare centres, Auckland, New Zealand, Waste Management Institute NZ Inc (WasteMINZ)

surrounding city area. At a landscape scale, Park forest formed part of a near-continuous vegetation band providing habitat from the coast (nearby Ayr Street reserve) to the upper Newmarket gully. In addition, the site has significant value to the residents surrounding the park in terms of a recreational resource and also a visual screen, given that native forest was up to 10 m tall and effectively screened residents around the periphery of the Park from each other.

The slope stabilisation works comprise flattening the slope and the first operation was to strip the established vegetation across the slope (undertaken during February and August 2010). Mitigation proposed for the site included the establishment of diverse mature native forest including salvage and reuse of 50 mature tree ferns from the site, planting of 3m tall visual screening buffers for some residents and planting designs to cater for birdlife, protected wildlife (lizards) and health and safety of public using walking tracks. Additional mitigation, not discussed as part of this case study, included weed control, lizard relocation, enrichment understorey planting and pest animal control in a nearby reserve to assist with offsetting the temporary loss of resources for wildlife until the native forest plantings at the Park could provide habitat and resources.

Planting of tree ferns, Newmarket Park

The engineering requirements of the rehabilitated slope meant that most of the usual assumptions for a tree planting programme had to be reconsidered. The soil barrier cap (600 mm) was required to be compacted beyond the normal level expected for native tree planting and the slope of the finished face (1V: 2.5H) and proximity to an estuary of listed conservation significance meant that topsoil and mulch could not practicably be used as a deep planting medium. In addition, the number of trees being planted (10,000 approximately) made self-contained root pits sized to accommodate the plant's mature root ball requirements impractical.

The solutions adopted (and which are being used now during the landscaping phase of the project) are:

1. Establish a thick sward of pasture grasses to deter weed invasion, nitrify the soil (via clover) and protect planted seedlings from wind-twist and browse by pukeko and rabbits;

2. Over-excavate planting holes to twice their normal size and line with good quality soils to support plant root growth for several years until the upper part of the compacted cap relaxes and allows root penetration;

3. Plant a mixture of fast-growing shrubs and slower-growing sun-tolerant canopy trees, as well as later plantings of shade-loving canopy trees to provide a diverse botanical assemblage and diverse food resources for wildlife;

4. Re-use felled logs to create refuges to encourage ground-dwelling lizards and insects to naturally recolonise the site quickly; and

5. Where trees are salvaged from the site (50 mature tree ferns) or where large-grade trees are planted for visual screens (e.g. several dozen 3 m tall natives), plant only specimens with shallow root plates to minimise the chances of roots penetrating the compacted clay barrier. Given that most native trees have root plates that are seldom deeper than 400 mm, the planting plans for the site were able to use a wide diversity of plant types, grades and forms to meet ecological, community and engineering needs.

Of interest for this case study was also the issue of cap penetration by associated activities. Relocation of the mature tree ferns and planned planting of large-grade trees require that plants are adequately staked to ensure stability. Typical means are by driving long stakes into the ground and securing the plants to them. In the case of Newmarket Park, such stakes would have penetrated the cap into the underlying wastes. Instead of stakes, trees were stabilised by running support wires to shallow-driven pegs within the capping layer.

Despite the solutions incorporated into the planting programme for this site, there remain challenges; such as the degree to which tree stability will be influenced over time by the soil cap surrounding the planting holes, the degree to which supplemental irrigation is needed and the survival rates of late-stage forest tree species planted on the slope. Evidence from planting programmes elsewhere in compacted pasture environments suggests that all planted trees at Newmarket Park's rehabilitated slope should survive and prosper, however time will tell.

Case Study 3: Revegetation on a gassing closed landfill – Seddon Fields

In 2009 Auckland City Council commissioned riparian revegetation along a kilometre of Motions Creek, which borders Seddon Fields in the Auckland suburb of Western Springs. This work is to be done through Auckland City's Small Local Improvements Project (SLIPs).

Seddon Fields is a reclaimed domestic and industrial waste landfill that was operated by ACC between 1930 and the mid 1970s. Following cessation of the operations the landfill was clay capped and planted in grass and used as sports fields and a dog exercise area. Much of the cap has been rehabilitated (an additional depth of capping laid over the original cap). However the original cap remained in the riparian area (only 300mm thick in some areas and locally absent).

Landfill gas is being generated by the closed landfill, including through the riparian area planned for planting. The cap within the riparian area is gas-permeable and thought to provide important passive venting of landfill gas. Riparian works were therefore designed to retain the ability of this gas to vent. There is a paucity of literature regarding the effects of landfill gases on the survival of native plants in New Zealand. Studies overseas indicate that deep rooted trees are most vulnerable to the effects of landfill gas and develop shallow root plates in its presence. Other tree species are neutral to the effects or respond with positive root growth where landfill gas is present. For Seddon Fields, the planting design included all of the native plant species already growing well in the riparian/ landfill gas venting area as well as shallow-rooted species and a well-developed growing medium to circumvent such problems.

The playing fields are an important community recreational asset and so the planting programme included construction of pathways that would encourage the public into the riparian area, where the cap above the landfill waste was relatively thin.

Existing vegetation in the planting area is generally of variable quality and so presented no significant issues with removal to enable planting to proceed. However, a nationally endangered indigenous moss (*Fissidens berteroi*) is present in Motions Creek through part of the subject site. This moss is currently known from only a handful of locations in New Zealand. The moss was surveyed as part of the planning for the revegetation and this work revealed significant new information on the habitat requirements of this nationally endangered aquatic moss.

In selecting the plants to be used, native species representative of historical vegetation coastal communities for the local environment and ecological area were selected with the support of Ngati Whatua. The planting programme also preferentially used species indicated to have tolerance to landfill gas emissions. For example, Coprosma repens, C. robusta, Cordyline australis, Phormium tenax and Pittosporum crassifolium have a good survival rate at the Brady Road (Seaside Park) closed landfill. They also have very good survival and growth rates in non-landfill planting conditions.

General view, Seddon Fields Closed Landfill

To maintain a barrier between wastes and the public, where the cap is thin, 300mm of materials are planned to be deposited. In addition, the whole planted area will be topped with 200mm of mulch to provide a friable, organic-rich growing medium for the native plants. These measures have also been employed to reduce the chance of roots penetrating through the capping materials and into the underlying waste. To maintain the gas-permeability, organic growth medium (e.g. topsoil and mulch) will be used (up to 300mm thick) where landfill cap thickness needs to be increased to provide a barrier or where a suitable growing medium for the planting needs to be provided.

Where public access is proposed, footpaths have been designed to form a barrier between people and the underlying landfill materials (eg a compacted metal track). In some areas, excavation into the cap will be required to construct the paths and these areas will be undercut by 300mm and infilled with engineered capping materials to form a physical barrier. Fences will be provided to restrict public access away from paths where planting is not dense enough to discourage people from walking off the tracks and into areas of thin capping.

The proposed revegetation along part of the Creek is designed to provide a suitable habitat to restore the presence of *F. Berteroi* and is provided in such a way that this habitat will be maintained throughout the planting and establishment periods.

CONCLUSIONS

It is possible to create high ecological and amenity value areas on closed landfills, however, revegetation schemes can be complex. Schemes need to work with and enhance existing biodiversity and public amenity, as well as ensure cap integrity. Heritage/rare species can be present, requiring special care. Balancing these issues often requires novel approaches not addressed in the MfE Closed Landfill Guidelines. However the more complex the site, usually the greater the value of the final scheme.

To ensure a scheme is successful, careful design is required to ensure that the landfill wastes remain isolated from the public and that stormwater ingress paths are not created, whilst still providing soil that will allow roots to grow freely, along with sufficient air and nutrients. New plants need to be selected that can survive the levels of landfill gas present at the site.

Specific considerations for revegetation schemes are:

1. Consider establishing diverse plant types, including later successional stages, especially if it is important to achieve larger conservation gains over a short period of time than can be delivered by shrubland and early seral stage plantings;

2. Most native plants are shallow-rooted, meaning that cap integrity can be sustained whilst allowing for large-grade plantings and relocation of some native trees (such as tree ferns); and

3. For steep sites, constraints on the use of topsoil coatings and mulch does not necessarily mean that native plants cannot be included in landscaping plans.