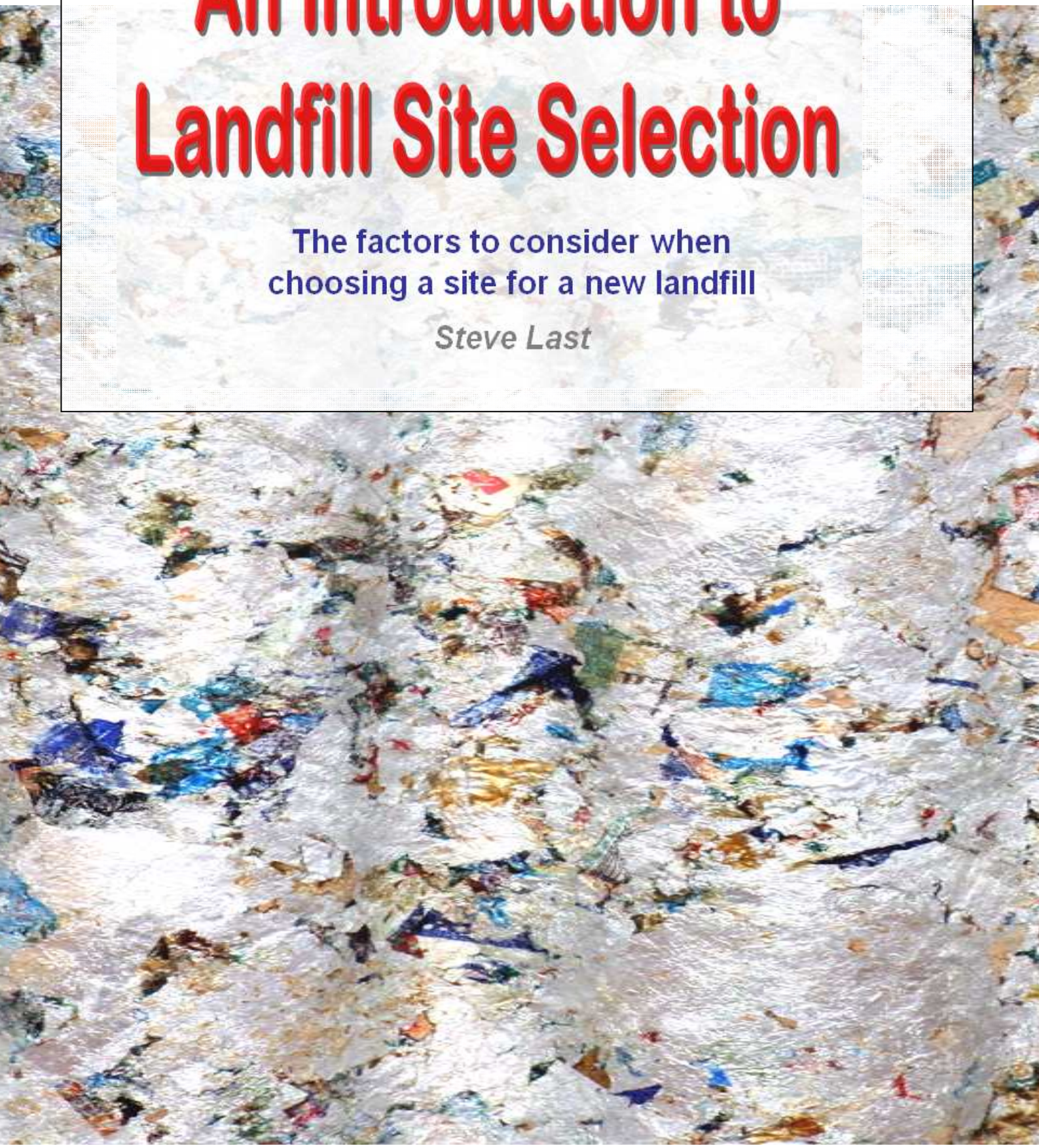
An Introduction to Landfill Site Selection

The factors to consider when choosing a site for a new landfill

Steve Last



An Introduction to Landfill Site Selection

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Preface

I wrote this document in December 2008 for professionals and students seeking information about landfills and landfill design, and I very much hope you will find it a useful introduction to this subject.

I am a UK Chartered Civil Engineer (MICE) and a member of the Chartered Institution of Waste Management (MCIWM) and Chartered Environmentalist (CEnv). I have over twenty years of waste management experience in landfill design, installation, and Construction Quality Assurance, and leachate treatment plant design and installation experience.

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Cover illustration: Recycled Tetra Pack® cartons after being processed and turned into roofing sheets.

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AN INTRODUCTION TO LANDFILL SITE SELECTION

Selecting a landfill site is a difficult achievement when the chances are that wherever in the world that you want to put one, there will be objections and even possible a local campaign set up to stop the development of the site.

It is true that most landfills are not good neighbors, but equally we all generate the waste so ultimately we have to take on some responsibility for the need to dispose of it.

So, assuming that we are tasked with selecting a landfill site where would we start?

The principle concerns in any landfill site selection environmental protection and public health considerations should be. So, all our initial efforts will go towards the selection of an appropriate site that will minimize potential environmental impacts and provide a sound basis for effective management.

So, to break that down further; what are the factors which need to be addressed during site selection?

A good list of factors to consider to start-out will include first and foremost the potential for the creation of public health hazards or nuisance. These might be addressed under the following headings:

1. potential for the pollution of water bodies, including the effects of any historical use of the site (adits, mines, existing hazardous wastes (for brownfield sites etc)
2. suitability of local topography and soil erosion risk, stability under additional loads from waste
3. suitability of soils for earthworks construction materials and use as media for containment of leachates
4. adjacent land uses and the accessibility of the site to users.

In the sections that follow we will consider these aspects in more detail.

HYDROLOGY AND HYDROGEOLOGY

The first of the above items can be discovered by using site investigation information, geological maps, and reading up on the history of the site, and then considering the site hydrology and hydrogeology.

Pollution of surface and ground water resources by leachates is a principle concern in relation to landfill location. Leachates are highly concentrated with contaminants.

Leachate is generated by water passing through waste materials in landfills and becoming exposed to and dissolving a wide range of contaminants.

Contaminants may be removed or reduced in concentration as they pass through soil surrounding the landfill, by processes involving filtration, dilution, absorption and microbial decomposition. The extent to which these factors and the rate of flow of groundwater through the underlying rocks in many types of geology will be able to withstand self cleanse and dilute the contaminates without harm, varies greatly from one area to another.

A knowledge of the hydrology (flux and nature of flow, flow direction etc) will be needed enable discovery of those facts.

In many cases the presence of watercourses, things like adits creating drainage lines and underground aquifers, will limit the utility of sites, and this should be further considered within a study of the site hydrogeology.

Although site design and management can reduce the potential for water pollution, some sites are not suitable due to the potential for inundation by floodwaters and/or the proximity to water bodies, and these must be eliminated at an early stage.

The following locations may need to be eliminated at an early stage as are generally not suitable for siting a landfill:

- Groundwater recharge areas
- Water supply catchments where little or no treatment takes place before human use
- Coastal and estuarine areas subject to storm surge
- Sites very close to water courses
- Sites subject to flooding
- Wetlands and estuaries below high water Level
- Sites close to airport runways due to concerns about aircraft safety from increased bird strikes.

TOPOGRAPHY AND SOILS

Landform in the vicinity of disposal sites will influence drainage, potential ground water problems, soil erosion risk, access, site visibility and protection from prevailing winds.

A suitable site will preferably have a sufficient contour cross-fall to provide drainage of surface runoff and adequate level areas to enable excavation of trenches and associated earthworks and the construction of service facilities.

Mountainous sites with slopes exceeding 1 in 5 are generally not suitable because of soil erosion risk, and long-term stability concerns (especially of the capping materials in shallow slip failure mode) after construction.

Soil structure should be suitable for the excavation of landfill cells or trenches and the construction of drainage works and, should also be of sufficiently low permeability to slow the passage of leachates from the site, if natural leachate attenuation in the unsaturated zone is the environmental protection measure used.

Sites in clay-rich environments are preferable, as their low permeability will allow more time for natural attenuation of leachates to occur, if dilute and disperse is the disposal mechanism chosen for leachate management. Sites with clay suitable for a clay cap will be

preferred but will require a method of treating disposing of the leachate eventually extracted.

In establishing the suitability of a site, a Site Investigation will be necessary. As part of this test pits are dug to determine the ease of excavation of the in-situ material and the suitability of the soil types.

ADJACENT LAND USE

Consideration should be given to existing and possible future developments adjacent to the site.

Sites with potential for higher value alternative uses such as nature conservation, agriculture and residential development should not be used.

Restored landfills are not suitable for many options, and after uses will be limited by the need to preserve site features, not disrupt the capping, and avoid risks from settlement and landfill gas migration and the inherent risks if it did migrate. Migration implies risks such as explosion, and carbon dioxide asphyxiation.

Consideration should therefore be given to long term planning projections to ensure that the establishment of the site will not jeopardize any environmentally sensitive areas or have an unacceptable negative impact on existing or future land uses.

The impact of landfill operations on neighboring residential, commercial or public developments should be minimized, by including a buffer zone around the landfill. Adequate buffer distances should also be provided between landfill sites and airfields to minimize the risk of bird strike.

Buffer distances should be measured from the closest proposed tipping face to any development. Where a sensitive development already exists within the buffer zone, the tipping schedule should be planned so that the landfill face moves progressively away from the sensitive land use.

CLIMATE

Rain and wind are major climatic factors influencing site selection. For high rainfall areas, effective storm water diversion is essential if leachates production is to be avoided. Litter and dust will be more difficult to control where the site is not protected from prevailing winds.

FLORA AND FAUNA

Some areas may contain protected or important natural flora and fauna, which causes the site to assume a special significance that may render it unsuitable for landfill.

Wetlands are also important for nature conservation, especially bird life and selection of a site near a wetland may also increase the risk of spreading disease through scavenging birds visiting the landfill and then travelling into gardens and other populated areas.

Control of vermin such as insect, bird and animal pests is an important factor in maintaining both public health and the natural ecology of an area. Poorly designed and managed landfill sites would provide an ideal situation for rapid breeding of insects and vermin. These increases in vermin populations, including cats and rodents, can cause major disruption to local native flora and fauna.

SITE CAPACITY CONSIDERATIONS

Capacity The available void space must be calculated by comparison of the landform with a proposed restoration profile.

The calculation of capacity should be based upon:

- Density of the wastes
- Amount of intermediate and daily cover
- Amount of settlement that the waste will undergo following tipping
- Thickness of capping

- Construction of lining and drainage layers.

Generally only sites which would have a large enough capacity to allow for at least 10 years of operation should be selected. This will allow establishment costs to be written off over a reasonable period and thus justify the necessary capital expenditure on access roads, fencing, drainage, landscaping and machinery.

The following calculation provides an example of how site capacity can be estimated based on an average per capita waste generation rate and an estimated waste compaction rate.

If we assume that the average waste generation rate = 800 kg/person/year when industrial and commercial waste is allowed for, and intermediate and daily cover volume percentage are added, for the average population (use your actual local rates from nation or local waste composition studies, and weighbridge data).

If a waste compaction rate at landfill of 1 tonne/ cubic metre is achieved, then the average volume of landfill space per head of population can be derived mathematically by simple calculation.

VEHICLE ACCESS

Access to the site should be as direct as possible to ensure that people are not tempted to dump their rubbish before getting to the landfill, and to minimize waste spillage from vehicles. Roads leading to the site should be in good condition and wide enough to handle the anticipated traffic load.

A minimum buffer distance of 100 meters should ideally be maintained to ensure that landfill operations are adequately screened from the nearest main road. Avoid scenic and tourist routes and access roads should be as far as possible available in all weathers.

OTHER SUBSIDIARY ISSUES

The following aspects should also be considered about the selected landfill site location:

- Suitability for locations of transfer stations in town, if the chosen site is remote from the waste source to the extent of being too far to run the waste transport (bin lorries) all the way from the collection rounds and back
- Finance and availability if necessary to purchase land at the existing land value
- Cost of meeting government regulatory requirements at the selected site
- Type of construction required for containment or dilute and disperse and availability of necessary materials at reasonable cost
- Type of landfill:
    i. Quarry - filling existing minerals extraction industry holes in the ground, typically left behind by mining
    ii. Valley - filling in naturally occurring valleys or canyons
    iii. Land Raise - placing the waste above the ground on a hill or mound
- Stability
- Seismic activity risk such as from nearby earthquake faults
- Water table (high water table may give development problems and needs to be assessed)
- Location of nearby rivers, streams, and flood plains
- Protection of soil and water through:
    i. Installation of liner and collection systems
    ii. Storm water control
    iii. Leachate management
    iv. Landfill gas management.
- Nuisances and hazards management.

COST FACTORS

To finalize site selection when enough of the unknowns have been removed or best guess assumptions made, will be to assess costs for the site, or multiple site options considered, based upon the following main headings:

- Feasibility study scoping and design options
- Site investigations (it is possible that at some small sites the SI costs involved may render those sites uneconomical)
- Site purchase costs, and infrastructure and any transfer station costs
- Site development costs
- Site operational costs
- Site after care and after use.

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This ebook was inspired by, and is partly based upon, a paper in the conference proceedings of; The Sardinia Symposium 2007, and the Wikipedia landfill page.

LANDFILL SITE SELECTION

If you need a professional consultant to assist you in your selection of a landfill, this is a service we provide regularly through our associated consultants. Just Contact us by email at info [at] wastersblog.com (Please replace [at] with @) and explain your requirements and a free quotation for this service will be provided.)