

Phytocap Technology

The development and application of phytocap technology

Our knowledge of the comparative performance of phytocaps and conventional caps comes primarily from the findings of major quantitative research programs in the United States of America (USA) and Australia. There has been more than a decade of quantitative research and commercial application in the USA and an additional 6 years of research and field trials in Australia. Both the US and Australian research used field-scale research facilities at actual landfills to measure and compare the performance of phytocaps and conventional designs.

The US

In the US the main research effort was the Environmental Protection Agency's 1998-2010 'Alternative Covers Assessment Program' (US ACAP) (see <http://www.dri.edu/acap-research> for details, including research publications). This produced an extensive database and peer reviewed research on the comparative hydrological performance of phytocaps and several conventional cap technologies in a wide range of climates and soil/plant communities.

Following the US ACAP, phytocaps are now being approved and implemented in North America. It is still an innovative technology but, because of its demonstrated performance and economics, it is gaining acceptance and popularity with landfill operators and regulators across a wide variety of climate and vegetation types in North America. In some States of the USA, (e.g. California) phytocaps are almost the 'conventional' technology.

Australia

The Waste Management Association of Australia's 2006-2011 'Australian Alternative Covers Assessment Program' (A-ACAP) has been the principal Australian vehicle for quantitative research on phytocap performance, complemented by Hanson's field trial at its Wollert (Vic) landfill.

A-ACAP's objectives were to:

- evaluate the US ACAP's hydrological findings in an Australian context;
- investigate soil-plant interactions;
- investigate phytocap oxidation of fugitive methane emissions;
- prepare a 'Guidance Manual' for landfill stakeholders on the assessment, design, construction and maintenance of phytocaps; and
- contribute to global research on basic phytocap mechanisms.

A-ACAP established test facilities in each of Australia's mainland States and, in 2011, it has entered its 6th and final year. The program's last output – the 'Phytocap Guidance Manual' – will be released at the National Landfill Conference in September 2011.

The mainland State regulatory agencies have advised and participated in A-ACAP and are familiar with its results. Three of these – EPA Victoria, NSW DECCW and Qld DERM – are also financial sponsors. Recently some Australian State regulators have begun considering applications for landfill phytocap approvals. In Victoria the EPA has recently approved a full scale 2.5 Ha field demonstration trial. It is expected

that the publication of the Phytocap Guidance Manual in September 2011 will further facilitate regulator acceptance of the technology.

Phytocaps compared to conventional caps

In summary, data from the US ACAP and A-ACAP and subsequent commercial experience have demonstrated that:

- conventional clay caps rarely meet design hydraulic performance criteria throughout the design life of the facility;
- in most situations phytocaps provide equivalent or superior hydraulic performance to clay covers and also are more effective in oxidising fugitive gas emissions; and
- phytocaps are generally significantly cheaper to build and maintain than the conventional options.

Conventional Caps

Conventional technologies, such as compacted clay, geosynthetic clay liners (GCL) and geomembrane covers, are *assumed* to produce a specified performance. However the evidence from ACAP and A-ACAP shows that actual performance frequently falls short for reasons such as the following:

- the integrity of a clay cap deteriorates over time because preferential flow paths form along desiccation and subsidence cracks, creating reduced performance and additional leachate control costs. Preferential flow paths cannot be repaired effectively;
- GCL caps may suffer degraded performance and increased hydraulic conductivity due to wet/dry cycles and ion exchange; and
- geomembrane caps are easily damaged during construction and by post-construction settlement, resulting in reduced performance.

In addition, conventional technologies are relatively expensive compared to phytocaps in most situations. This is because their materials are generally more expensive, while building the caps requires more intensive and costly engineering. Geomembrane caps are particularly expensive. Repair of subsequent failures, such as preferential flow paths, cracks or tears caused by subsidence and punctured geomembranes, is also expensive and difficult to achieve.

Phytocaps

- More than a decade of monitoring at US ACAP and A-ACAP sites has demonstrated that phytocaps are resilient and can meet performance requirements under a wide range of climatic, geographic, geological and hydrological conditions. They have produced equivalent or superior hydraulic performance to compacted clay caps in most situations. Moreover their performance improves over time as vegetation matures;
- Phytocaps control fugitive anaerobic gas emissions effectively, and at no additional cost, through oxidation of the gases by the action of enhanced populations of methanotrophic organisms in the root zones. Depending on government climate change policy settings, this may translate into an economic benefit for landfill owners;
- Phytocaps work with, rather than against nature and so are not as subject to post-construction failure. Because they are self sustaining they require low maintenance. Where maintenance is required, they can be repaired effectively

and relatively easily and cheaply. They therefore retain their performance characteristics more effectively;

- Because they are applied in thick and lightly compacted lifts and take advantage of borrow soils available at or near the site, construction costs for phytocaps are typically less than for conventional caps. Planting costs are relatively minor.
- Phytocaps provide an aesthetically pleasing and more biodiverse cover and end use.

A new design philosophy

While phytocaps provide significant benefits relative to conventional caps, they do require a more intensive design process and a shift in design philosophy.

Conventional technologies are assumed to produce a specified performance. This assumption allows a generic approach based on the specification of methods and materials and regulation-based engineering; actual demonstration that quantitative performance criteria can be met is not required.

Phytocovers, in contrast, are built to meet specified performance criteria and must meet those criteria with the available local soils and plants and in the given climate at the site. Key tasks are to determine the depth of soil that is necessary to achieve a satisfactory performance and to select plants that will survive and perform well in the given soil and climate.

This shift in philosophy requires a defined process for design and construction and expertise in its application. PhytoLink's design process draws on experience in both the USA and Australia and can be summarized as:

1. Define the performance criteria;
2. Select and validate the design concept;
3. Characterize the site – soil, plants and climate;
4. Prepare a preliminary design:
 - describe an initial soil profile
 - select plants
 - undertake a cost analysis;
5. Model the preliminary design:
 - to understand important design parameters and environmental stresses
 - to support the construction process;
6. Prepare a final design and identify construction issues.