clay fill, as liners or caps, to provide landfill leachate containment.

Site investigations for proposed waste disposal sites and more particularly, for existing contaminated sites have their own characteristic problems. For contaminated sites, historical site records can give all important clues to likely contaminants and therefore which analytical tests to perform - you need to know what you are looking for to arrive at the correct test for finding it !! Again a prior knowledge of the site can be all important in knowing where to drill to locate any buried contamination.

These and other aspects of site investigation of contaminated land are addressed in "Auditing of Contaminated Land", a very useful paper by David Parker. Reasons for auditing are given together with key steps and pitfalls in the processes of field investigation, testing and assessing contaminated sites. Answers to 'What are acceptable levels of contamination for a particular site ??' are discussed and mention is made of Victoria's statutory audits. One wonders how long it will be before other states follow suit!!

Leachates from waste deposits contain chemicals which may adversely affect the sealing properties of clay liners or foundations. This type of chemical interaction was examined in the comprehensive investigations carried out for a landfill disposal site for aluminium smelter waste - the subject of an interesting paper by Sullivan and Knight. Fortunately in this particular case, batch tests identified good absorbtive capacity in the clay.

Gaining an understanding of the likely migration of contaminant plumes was achieved by Hensley and Savidou in experimental work using geotechnical centrifuge modelling. Results of the physical modelling according to their paper, compared favourably with numerical modelling and demonstrate yet again the versatility of the centrifuge in engineering investigations.

Mine tailings - the water borne fine waste product from mining activity deposited traditionally in characteristic and frequently unattractive waste dumps - has its own brand of environmental engineering problems:

> Traditional tailings disposal involving thickening and pumping the slurried tailings to dams/lagoons, presents problems for rehabilitation. The deposited tailings have initial high water content, correspondingly weak shear strength and occupy large areas of land which are susceptible to erosion.

A promising alternative disposal technique which overcomes many of these problems, involves mixing the tailings with 'coarse reject'. The combination of materials has improved engineering properties and behaviour, is easier to rehabilitate and has better future land use capabilities. The technique has been trialled successfully in the NSW coal mining industry and forms the subject of a paper by Williams.

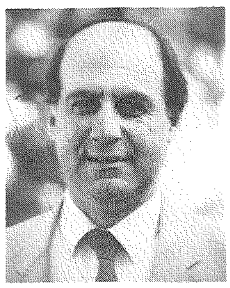
One of the key imponderables in the management of tailings disposal is the question of how quickly the waste material will consolidate and therefore improve in its properties. Fahey and Toh in their paper have developed a technique for examining and predicting consolidation behaviour of slurried tailings under various filling rates and boundary drainage conditions. For this they used a combination of numerical modelling based on large strain consolidation theory with input consolidation parameters obtained from geotechnical centrifuge modelling.

By its very nature, waste management frequently requires a multidisciplinary approach. This presents geotechnical engineers with a unique challenge in which they have to work with and have an understanding of many other disciplines. The latter can be achieved not only by training but by encouraging interdisciplinary debate in technical journals and in speciality conferences. One such conference is the forthcoming Conference on Geotechnical Management of Waste and Contamination due to be held in Sydney in March 1993.

The Editorial Panel strongly recommend anyone with an interest in waste management to take up the challenge and contribute to what we are sure will be a very successful conference.

Colin Bradbury, Trevor Osborne, Charles Waterton.

PETER BROWNE-COOPER —GUEST EDITOR



Peter Browne-Cooper is very well known in the environmental and waste management industries in Western Australia and indeed throughout Australia. In addition, he has come into public prominence here in the West through his previous position as Director of the Pollution Control division of the Environmental Protection Authority.

He graduated from the University of WA in 1964 with a B.Sc, majoring in physics and mathematics. He was with the 1965 Australian National Antarctic Research Expedition, specialising in geomagnetics and seismology. After a year with the Bureau of Mineral Research doing airborne geomagnetic surveys, he worked with the firm Geotechnics during the WA nickel boom.

Peter joined the Department of Environmental Protection (forerunner of the Department of Conservation and Environment) in March 1972 and, except for a secondment to the Australian Overseas Projects Corporation during which he worked in Jedda, Saudi Arabia, he has been with the EPA (and its antecedents) ever since.

He is currently A/Assistant Chief Executive Officer of the Environmental Protection Authority.

ECOLOGICALLY SUSTAINABLE DEVELOPMENT

IDEALISTIC MYTH OR A PRACTICAL APPROACH TO OUR FUTURE

Almost everyone - even the odd Geotechnical Engineer - has been exposed at some time recently to the term "ecologically sustainable development" (ESD): its the current environmental buzzword. A few of us may even have thought about what the term means. I suspect that very few indeed recognise the extent to which the concept can, and must, be applied to every aspect of human endeavour.

So what is ESD and why is it so important?

It is perhaps relatively easy to grasp the ESD concept in the context of forest or fishery management: one can see, at least theoretically, how the volume of timber removed can be limited to the growth volume each year, or the number of fish caught can be limited to the natural population growth. But is this true ecological sustainability - the action of removing trees or fish must change the ecological balance.

The practical implementation of ESD requires an understanding of two more "jargon" terms - *beneficial use and assimilative capacity.*

The *beneficial us* of a portion of the environment is the use assigned to it by society. The use of one piece of bush may be for protection of flora, another may be set aside for future residential development and another used for logging and regrowth; one estuary may be reserved as a shipping harbour, another for swimming, another for oyster culture; or there may be desire for a mixture of all these activities.

The ecology that we aim to sustain in those different areas of bush or those different estuaries may vary considerably:

- For the residential development we need to ensure that removal of vegetation will not produce flooding; perhaps that drainage will not adversely affect the beneficial use of the adjoining National Park; that air quality standards can be maintained; that groundwater uses are protected - very little of the pre-existing ecological diversity is necessary to sustain this beneficial use.

- For the flora protection reserve we need to ensure against introduced weeds and grazing animals; fire management may be necessary; flower picking may need to be controlled; a diverse range of insects and animals may need to be maintained for pollination; water quality and quantity in a wetland and depth to groundwater may be critical - a substantial amount, but perhaps not all, of the pre-existing ecological diversity may be necessary to sustain this beneficial use.

- For the logging area, removal of "weed" trees may be desirable to encourage commercial species; fire protection may be required; insect and animal pests may need control - if the only beneficial use to be sustained is timber production, some but not a lot, of the pre-existing ecological diversity may be necessary. If, on the other hand, multiple beneficial uses of timber production and wildlife conservation are desired, a far greater range of ecological diversity will be necessary.

The *assimilative capacity* of a portion of the environment is its ability to maintain a quality acceptable for the beneficial use or uses assigned to it or traditionally made of it, despite being subjected to some level of continuing interference.

Assimilative capacity is expressed as the quantity of a substance or intensity of an activity, alone or in combination with other substances or activities, which that portion of the environment can accept without jeopardising the beneficial use or uses assigned to it or traditionally made of it.

Looking again at the examples we have above:

- The residential area has a very large capacity to assimilate human trespass; being a low lying area with no wind it may have a very low capacity to assimilate smoke from domestic fires; the capacity to assimilate lawn fertiliser may be high if groundwater will only be used for garden irrigation but if there is a groundwater connection to wetlands in the adjacent National Park this beneficial use will dictate a lower assimilative capacity in order to avoid wetland damage.

- The flora reserve may be able to assimilate some human trespass, perhaps along designated tracks; smoke may not be problem but the plants may be highly susceptible to hydrogen fluoride for which the assimilative capacity will be virtually zero; a slightly elevated level of nutrients in the groundwater may be an asset but too much will kill the plants.

- The logging area may tolerate a quite high level of human trespass in the area of mature trees but seedling areas may have a very low assimilative capacity; smoke and some other air contaminants may only need to be controlled to levels appropriate to protect forest workers and casual visitors; quite high levels of nutrients in the groundwater might be able to be tolerated.

So different beneficial uses require different environmental management for their maintenance and may imply very different assimilative capacities. it follows that pollution or degradation of the environment only occurs when its assimilative capacity for the specified beneficial use is exceeded; conversely if the stresses placed on the environment are kept within its assimilative capacity they can continue indefinitely - ie we have ecological sustainability.

These concepts can be applied to virtually everything we propose to do - opening up land for housing or agriculture, building a factory, establishing a mine, disposing of wastes, creating a National Park, fishing for rock lobsters etc. We can test the sustainability of our proposal by following these steps:

1. Determine the present and likely future beneficial uses of, and surrounding, the site of the proposal;

2. Determine that environmental characteristics, which are likely to be impacted by some aspect of the proposal, are necessary to maintain those beneficial uses;

3. Determine for each of those aspects, the assimilative capacity in relation to the most sensitive beneficial use;

4. Measure the pre-existing load of each of those aspects;

5. Add the proposed load to the pre-existing load and compare the total to the assimilative capacity.

All this may look like an environmental consultant's dream come true - the trick is to make sure investigations are only done to the level of detail necessary to demonstrate that our proposal meets the requirements. If we want to dispose of large quantities of saline water to our tailings dam near the town water supply, we may need to do very detailed hydrogeological and engineering studies. If we are a long way from town in an area of known hypersaline groundwater very little investigation may be necessary.

If our proposal can be implemented and managed so that all the stresses placed on the environment are within its assimilative capacity our proposal will be *ecologically sustainable* and therefore:

- Our factory would be able to operate indefinitely without unacceptable environmental effect;

- We should be able to walk away from our mine and its tailings dam or the foundations of our offshore oil platform, confident that no unacceptable environmental hazard will arise in the future; and

- Our housing development will remain a pleasant place to live without adversely affecting the adjacent National Park which, in turn, should be able to continue to support its wildlife conservation and tourism functions indefinitely.

This is what ecologically sustainable development is all about - a sensible and essential approach to human activity.

Peter Browne-Cooper