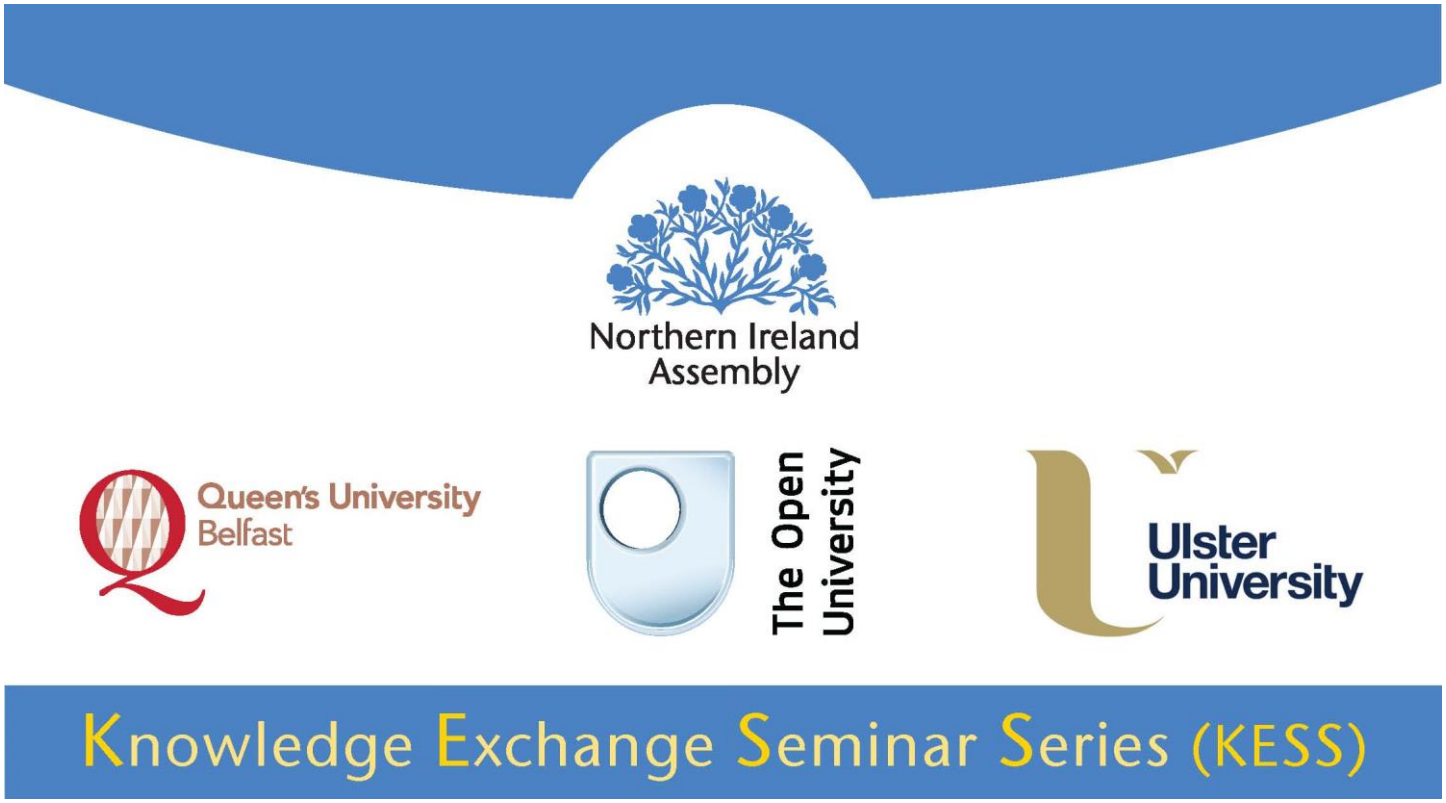

Summary

Buried illegal waste and uncontrolled legal waste dumps are a major problem in Northern Ireland, as well as in Scotland, Ireland, Italy, Canada. The mention of the words 'Moubouy Road' will be enough to demonstrate to anyone in N.Ireland the politically-charged nature of this problem. Yet the environmental (loss of habitat, pollution of groundwater) and economic (landfill tax, loss of recycling profit) costs are equally significant as the political background as to why waste is buried in the first place. Both applied crime fighting as well as pure science are being brought together to better understand how to locate and characterise buried illegal waste. When a case is brought to the courts, a number of facts must be presented such as the volume of waste, it's makeup (toxic, domestic, demolition) and whether it has polluted areas outside of the owner's land. Geophysics and remote sensing assist in answering these court questions, and have been used successfully in cases brought by the Scottish Environmental Protection Agency and Northern Ireland Environmental Agency (NIEA), which are outlined in this presentation. Pure science has recently involved the application of the Tellus and TellusBorder data to assessing whether buried waste, and the pollution plumes it can generate, can be located from the air. The results of this work are outlined in this presentation as a model of how focussed

and cost-effective means maybe deployed to locate and assess waste, and thus assist in protecting our natural environment, especially surface and ground water.

Introduction

There's cash in trash, there is brass in muck. In Germany, 1950's landfills are currently being mined for the metal they contain: in Canada, waste sand from tar sands extraction is being processed for lithium and platinum; Bryson House make more money from their 'Cash for Cans' operation than any other. So if there is money to be made in recycling: why bury rubbish? Because it is easy to do and the perpetrators still make money from 'recycling'. How? Lets look at an example. A local authority wishes to extend their recycling operations, so they tender for this and a number of bids come in. One of them is lower than the rest. The council visit all premises, including the cheapest one (which looks *bona fide* and is clean and efficient), who win the contract. Waste begins to arrive at said plant, but is not processed for the costs agreed, but is placed in sealed steel containers on trucks and shipped elsewhere or across jurisdictional border(s). Here, an owner of a disused quarry, some other excavation, or low-lying field is persuaded to be absent when the waste-laden trucks arrive, who dump the material and soil is placed on top. The waste appears to have been recycled, but has simply been buried.

A number of questions arise. 1. What is in the buried waste? 2. Where will leachate (flowing groundwater plus waste) move? 3. What is the volume of the waste? 4. Does the burial or its leachate extend beyond the owner's land? 5. Finally, most critically for this presentation – how can we find the waste (after all, it is buried, so out of sight, out of mind, right?). Let us start from the end and examine how to find the waste.

Finding buried objects/materials/waste

The search for buried items is one part of a sub-discipline of the Earth Sciences (geology, geography, archaeology) that is termed Forensic Geology, or Geoforensics. The other two parts to this sub-discipline, we will meet in the presentation are: the science of the crime scene and the science of the trace evidence sample. When environmental law enforcement agencies began using the Geoforensic use of Search, in the early 2000's, this was based on intelligence, followed by ground walk-over searches, then geophysics to define targets, and finally digging to establish the nature of the buried material. To some extent, this process still occurs, with some refinements. With advances in satellite and aerial imagery through the late 2000's, so it was established that like a buried human body, or stash of drugs/weapons/money, leachate could be generated in the groundwater that would provide a far larger 'footprint' than the target itself. This concept has proven invaluable in forensic searches, and effectively mimics what the scent dogs (missing persons, drugs) have been doing for years, in reacting to a plume of water or vapour. Thus intelligence can be crosschecked against remotely-sensed imagery, strengthening the case for on-the-ground searches to establish whether the intelligence and remote sensing were correct. Now lets get back to Earth.

What is in the ground at the target?

Intelligence, cross-checked with remote sensing, or *visa versa*, suggests something anomalous about an area. The next stage also follows classic law enforcement guidelines. A full desktop study of solid geology, drift geology, soils, hydrology, hydrogeology, past land use (using all Ordnance Survey and historical data), recent land use (using aerial and satellite imagery) and local interviews is carried out. This desktop study provides baseline data and can avoid unpleasant surprises. Next, as in classic law enforcement, a walk-over and/or surface line search is conducted: this can often prove critical as expressions of worked soil/imported soil/macerated waste/smell of degrading waste, can prove indicative of buried material. Geophysics (deployed later) may also provide some indications as to the nature of any buried material.

Where will any leachate move?

Having established there are indications of buried waste in an area, its likely effect on the surrounding area must be established. There maybe scent movements or release of inflammable methane and thus pollution of the air, but a far greater concern is damage to groundwater, and thus eventually borehole drinking water and surface rivers and lakes. The desktop study (above) will provide some of the critical information in establishing potential leachate flow. Topography, soils and drift geology (as in the desktop study, above) will control the movement of shallow groundwater, that may interact with solid geology and thus deep groundwater. These models may be tested with geophysics and boreholes, from which water samples can be obtained for analysis. This stage is critical, as damage to groundwater, and especially that beyond the landowner's property, carried a higher court sentence than if restricted to the owner's own land.

What is the volume of the waste?

This was the original reason that environmental law enforcement officers from NIEA, SEPA and EPA/DoJ began to use geophysicists from Queen's, London, Stirling and Keele universities. The problem was this: buried waste had been identified, test pits dug and cases brought by the CPS/PPS. But in court, whilst the magnitude of the crime in terms of illegal burial and perhaps groundwater damage had been established, the volume of waste was under contention. Like the effects on groundwater, this determines the severity of the sentence. The prosecution argued that extrapolating their 4-5 test pits over the area determined by intelligence/remote sensing/walkover surveys resulted in XXX metres^2 or equivalent tons of waste. The defence counter-argued that these test pits were not representative, and maybe hit pockets of deeper waste, or were statistically not significant, and thus the accused was only guilty of a minor crime of effectively fly tipping and some burial of waste. The well-informed

environmental law officers (above) realised that geophysics could provide a more complete picture of the volume (and makeup, see above) of the buried waste. Subsequently, the author has conducted over 30 geophysical surveys of illegal waste burial sites, with the majority resulting in agreement (between defence and prosecution), admission of guilt, or court proceedings. Geophysics and remote sensing can also assist in our fourth question (above): does the waste and/or its leachate extend beyond the owner's land.

Conclusion

Since two staff from Environmental Crime in the NIEA walked into my laboratory some 15 years ago, we have seen huge advances in the detection, measurement and prosecution of environmental crime. Yet some elements remain unchanged, that hard work in background data, surveying and digging still occur. Major problems still exist in terms of detecting sites and criminal activity (to be outlined in the presentation), and in the associated political problems of jurisdiction and prosecution. Scientific advances have been great in terms of remote imagery and detection of waste material in groundwater far beyond the area of the dump, using the Conceptual Geological Model that will be outlined in the presentation. Much has been done and a lot more has yet to be uncovered, but as geologists and archaeologists know, and what terrifies criminals, is that the Earth always gives up her secrets.