Geoenvironmental engineering (also known as environmental geotechnology or environmental geotechnics) is an emerging science. It was born out of the need to handle the steadily increasing environmental problems caused by various sorts of pollution, first of all in the wake of rapid industrialisation. The main types of geoenvironmental problems include contaminated site remediation, waste containment and waste minimisation. Contaminated site remediation is targeted to already contaminated soils and groundwater, using in situ barriers and in situ or ex situ treatment methods. Waste containment refers to safe disposal of newly generated wastes in engineered impoundments and landfills. Waste minimisation can be accomplished by recycling and using waste materials in various civil engineering applications and beneficial use of closed waste disposal sites. To provide an all-encompassing scope, the book is divided into four parts. Part I deals with basic principles, which include: environmental regulations; a brief chemistry overview; soil composition and properties; geochemistry; groundwater; and contaminant fate and transport. These subjects are essential to an understanding of geoenvironmental problems. Part II includes remediation technologies: assessment and remediation of contaminated sites with an overview of sources of subsurface contamination; methods to characterise contaminated sites; methods to quantify the risk posed by the site contamination; and various remedial methods – in situ barriers, soil and groundwater remediation technologies. Part III is devoted to waste characterisation and waste containment systems, describing sources and types of wastes and their properties, followed by the siting, permitting and design of landfills. Design of surface impoundments is also discussed. Emerging waste management technologies are described in Part IV, including waste material recycling, end use of closed landfills, bioreactor landfills, and subaqueous sediment containment.

After briefly discussing the main relevant environmental laws and regulations, Part I Basic principles deals with toxic chemicals, inorganic, organic and nuclear chemistry; composition of soils, soil properties, geochemistry; groundwater flow, and contaminant transport and fate. The knowledge summed up in these chapters gives a brief and useful recapitulation of relevant basic subjects that readers will usually be familiar with from previous studies. Their compilation within this volume, however, helps us to understand the most important processes relevant to contaminant transport and binding to soil particles which are useful in devising technologies for their removal, isolation, solidification, etc. The information in this section is at the right depth for its purpose. Knowledge of groundwater flow in both confined and unconfined aquifers is of special importance, since most contaminants are transported through or in groundwater and its movement predetermines contaminant transport. The main transport processes (including chemical and biological transport) are advection, diffusion, dispersion, sorption and desorption, precipitation and dissolution, redox reactions, acid–base reaction, complexation, ion exchange, volatilisation, and biodegradation. Contaminant transport and fate modelling are also dealt with: both analytical and numerical methods are discussed.

Part II Remediation technologies is the most important part of the book. Subsurface contamination is generated by inadequate disposal techniques in the past, due to lack of knowledge and suitable technology, but, in many cases, due simply to negligence. The contamination problems vary from simple inconveniences such as taste, odour, colour, hardness or foaming, to serious health hazards caused by pathogenic organisms, flammable or explosive substances or toxic chemicals and their by-products. Contamination sources may originate on the ground surface (infiltration of contaminated surface water, land disposal of solid and liquid wastes,
accidental spills, fertilisers and pesticides, disposal of sewage sludges, salt storage and road spreading, animal feedlots, particulate matter from airborne sources), in the vadose zone (waste disposal in excavations, landfills, surface impoundments, leakage from underground storage tanks and pipelines, septic tanks), and in the saturated zone (waste disposal in wet excavations, deep well injection, mines, agricultural drainage wells, abandoned and improperly constructed wells). Remediation comprises site characterisation, risk assessment and the remedial action itself. The number of the contaminated sites was estimated by US EPA in 1997 at well over 200,000, with an expected overall remedial cost of almost $200bn. The US EPA has developed a risk assessment procedure to address risk associated with major contaminated sites which consists of data collection and evaluation, exposure assessment, toxicity assessment and risk characterisation. In situ containment methods may rely on passive systems (vertical and bottom barriers and surface caps or covers) and active systems (groundwater pumping and subsurface drains) and they are mainly used as interim remedial actions; however, they can be used as final solutions if other clean-up technologies are prohibitively expensive. The main soil remediation technologies include soil vapour extraction, soil washing, stabilisation and solidification, thermal desorption, electrokinetic remediation, vitrification, bioremediation, phytoremediation, and soil fracturing. It is generally true that the higher the energy level (temperature) of the technology applied, the higher the costs incurred. Therefore, energy-intensive methods should only be used when there is a high level of risk to the environment. Low-energy-level technologies (biological methods) are justified when sufficient time is available for the procedure to produce substantial results. Soil fracturing is not a remediation method by itself, but it enhances the efficiency of other in situ technologies by creating a low-permeability zone. Another principal group of remediation technologies targets contaminated groundwater, and includes pump and treat, in situ flushing, permeable reactive barriers, in situ air-sparging, monitored natural attenuation, and bioremediation. For each of these remediation methods, the following are presented: description, applicability, advantages and disadvantages, fundamental processes, design methodology, predictive modelling, modified and complementary technology and case studies. A major beneficial feature of the technology descriptions is that, where available, design principles and operational parameters are discussed and case studies illustrate the theory. The basics discussed in Part I of the book are applied from time to time in the detailed technology descriptions. Monitored natural attenuation (MNA) is, strictly speaking, not a remediation technology, but rather the umbrella term for nature’s healing forces, involving physical, chemical and biological processes that act without human intervention to reduce the mass, toxicity, mobility, volume or concentration of contaminants. MNA is applicable when natural attenuation processes are observed or strongly expected to be occurring; there is no high risk to human health; and alternative remedial technologies are not cost-effective or pose significant added risk.

Part III Landfills and surface impoundments is another main section of the book. There is a minor but justified thematic overlap between Part III and ‘In situ waste containment’ in Part II, as certain barriers used for waste containment form the essential elements of landfills and surface impoundments. Part III begins with the description of sources and characteristics of wastes, and, suitably, gives a few definitions of waste in the technical and economic senses and from a regulatory perspective. Principal sources of wastes are: dredging and irrigation; mining and quarrying; farming and ranching; residential, commercial and institutional activities; industrial and nuclear power; and nuclear weapons. Wastes can be classified as solid, hazardous, radioactive, and infectious (medical). Since even small amounts of hazardous, radioactive and infectious waste may adversely affect human health or the environment, these wastes often require special handling procedures and disposal facilities. Wastes generally have to be characterised from the chemical and physical points of view – the latter usually relying on parameters borrowed from soil mechanics. Increasing amounts of waste cause various environmental concerns, partly due to their sheer quantity, improper handling, toxic chemical content and effects on health and ecosystems. The main waste management strategies are pollution prevention, waste minimisation, recycling, incineration and waste disposal (landfilling). The most common landfill types are area fill, above- and below-ground fill, valley fill and trench fill. Slope stability is an
important issue in all of them. Waste containment systems must be constructed with a composite liner and leachate collection system. The composite liner must consist of a flexible membrane liner (geomembrane), usually high-density polyethylene, and a compacted soil-material layer. The final cover (capping) must have an erosion layer consisting of a vegetative layer and an earthen infiltration layer. Hazardous solid waste landfills must have two or more liners and a leak detection/collection/removal system. The compacted soil–material layer may either be constructed from naturally occurring cohesive soils (clay) or a bentonite–soil blend (admixed) material with a hydraulic conductivity of less than or equal to $1 \times 10^{-9}$ m/s. Geomembrane liners are made of either thermoplastic polymers, thermoset polymers or a combination of these. Further materials of importance used in liner systems are geotextiles, geosynthetic clay liners, geonets, and geocomposite drains and geogrids. Due to decomposition processes in municipal solid waste, gases are generated. The major constituent of landfill gas is methane, which is a combustible gas. With the help of a suitable gas collection system, the gas can be vented, flared or fed into a recovery system, where it is either used to fuel gas turbines; burnt in an internal combustion engine; used as a boiler fuel; or upgraded to pipeline quality. Monitoring of groundwater at a landfill is required to evaluate the performance of the landfill, as well as to discover leaks and begin remediation if groundwater is affected by the landfill. The monitoring well design must be based on site-specific hydrogeological data, and an appropriate monitoring and corrective action programme should be applied. Surface impoundments are natural topographic depressions, man-made excavations or dyked areas formed primarily of earthen materials. They are designed to hold an accumulation of liquid wastes or wastes containing free liquids (e.g. holding, settling or aeration pits, ponds and lagoons). They can be provided with a top liner consisting of a geomembrane, and must be equipped with a composite double bottom liner with a leak detection and collection layer. Surface impoundments may be designed for treatment, storage or evaporation. Water balance due to precipitation and evaporation is a main concern in their design and operation.

Part IV Emerging technologies is the most forward-looking part of the book, which will certainly generate great interest among readers. The section on recycling looks into the beneficial use of a large number of waste materials, such as fly ash, blast furnace slag, foundry sand, paper mill sludge, municipal sludge, incinerator ash (sewage sludge ash), glass, plastics, scrap tyres, demolition debris, and recycled concrete and wood wastes. Common to all these materials is that large amounts of them are generated world-wide, their disposal requires considerable effort, and they take up large landfill capacity. By their reuse, materials can be obtained for various useful purposes, and the increasing availability of recycled materials reduces demand for primary raw materials. In addition, the threat to the environment is considerably decreased. This is an essential feature of sustainable resource management and environmental protection. It is important to survey the sources of waste materials and estimate the amounts generated, looking into their potential reuses, chemical and engineering properties, environmental concerns and economic considerations connected with their application. Although landfill engineering is a fairly new discipline, industry has generated a number of completed landfills over the past 20 years. They are mainly located near urban areas where land is in short supply, so they are often the subject of investigations concerning their end use. The end use of a closed landfill usually includes landscaping, planting trees, grass, bushes, etc. Recreational, commercial and industrial uses are also common. Afterclosure use may limit landfills’ capacity, while landfill gas, leachate and settlement often impair structures and buildings erected on landfills; therefore, end use should be included in the original design considerations. Extracting the energy content from landfill gas by internal combustion engines or generators is another method of waste utilisation. The shortage of land near urban areas often forces planners and builders to re-open landfills and extend their capacity by ‘piggybacking’. Another emerging technology is established by bioreactor landfills which, in contrast to conventional landfills, enhance microbiological degradation processes by the control of moisture, temperature, pH, nutrients and waste properties. Anaerobic and aerobic bioreactor landfill types have been developed, and a hybrid type combining both anaerobic and aerobic microorganisms is being investigated. In addition to liner and leachate collection systems, liquid injection and gas extraction
are essential in bioreactor operations. In order to maintain proper operation, reduced-permeability daily covers have to be applied. A special problem of bioreactor landfill operation is slope stability, as the enhanced degradation results in considerable removal of material. In situ capping of subaqueous sediments is a challenging issue in environmental engineering, as a great variety of contaminants have been released to bodies of water. Once the contaminants bind to the sediments, bottom-feeding organisms consume them, and they enter the food chain. In addition to conventional removal technologies (mainly mechanical and hydraulic dredging), in situ isolation holds great potential. Physical and chemical isolation and stabilisation are the main methods of in situ capping; and design, modelling, construction and monitoring ensure that the cap contains the contamination.

The book’s chapters are appropriately balanced, and many represent the themes of major international conferences. Each chapter is accompanied by a number of questions and problems which help the reader recapitulate the information provided. An exhaustive list of references guides readers wanting further detail. The authors possess the special ability of presenting scientific and engineering information while maintaining an easy-to-read style. Almost all topics dealt with include one or more examples of practical application (this feature may be one the authors’ secrets which make their book so reader friendly). The book contains a number of basic equations for design purposes, which could be used for developing worked examples in a potential follow-up volume. Case studies and examples are taken from and refer to applications in the USA. This book provides an extensive compilation of up-to-date knowledge on geoenvironmental technologies and makes a major contribution to putting this essential discipline on a solid footing. It will not be surprising if it rapidly becomes a best seller.