PROJECTS SUITABLE FOR GEOSCIENCE HONOURS AND MSc STUDENTS

The Environmental Geology Group has a large number of projects available for students entering Geosciences (Hons) and in MSc (research). Some of the available projects are briefly described below, but many others are available, so please come and talk to myself, or my postgraduate students for other projects that do not appear below. If you have an environmental (marine or geoscience) project in which you are specifically interested and is not listed, come and see us and we can suggest ways in which it could be set up within the group.

Currently, the main thrust of research being undertaken by the Environmental Geology Group in the School of Geosciences is on the impact of urbanization and industrialization on Sydney catchment and its effect on estuarine condition. Another emphasis is to construct a water/sedimentation model for the estuary and develop a detailed understanding of estuarine response to catchment processes leading to building of a source-fate model for metals.

Contact Person: Gavin Birch, Environmental Geology Group, School of Geosciences. Ph. 9351 2921, Fax. 9351 2442, Email. gavin.birch@sydney.edu.au

- Contaminant History of Sydney Estuary and Catchment using a combination of Human Geographical and Geological approaches
- A Water/Sedimentation Model for Sydney estuary
- Modelling of sources, loads and fate of metals in a well-characterised, highly-urbanised catchment
- Contaminant concentrations in urban and market vegetables
- Heavy metals in roof and domestic dust
- Partitioning of heavy metals in contaminated estuarine sediments
- Nutrients as indicators of estuarine health
- Evaluating the change in quality of marine sediments two decades after moving Sydney’s sewage discharge offshore (dependent on funding)
- Total catchment management – Cooks River and upper Middle Harbour catchment
An investigation of the effects of historic changes in catchment condition on the health of Sydney Estuary

Supervisors: Gavin Birch, Philip McManus and Andrew Wilson

Objectives:

The overall aim of this project is to determine how temporal changes in catchment status controls estuarine condition.

This project will investigate Sydney Estuary as a considerable amount of data is available for this catchment-estuary system and substantial temporal change has been demonstrated for both environments. The project will record the development of the nation’s first and largest city and its effect in the iconic Sydney Harbour and will include the following:

- Create a spatial time series of catchment status and estuarine condition from 1788 to 2010 using GIS-based historic landuse maps and dated sedimentary cores.
- Model historic environmental impact on Sydney Harbour
- Use hindsight information on impact to model future environmental trends
- Identify key pressure indicators driving changes in estuarine response for use in development of future strategies in urban Management and Planning.

This project fits neatly within the School of Geosciences ambit as it combines Human Geography and Geoscience parts of the School. The work would suit students from both disciplines and comes with strong supervision in estuarine science (Gavin), urban geography (Philip) and spatial (GIS) science (Andrew). The shorelines of Port Jackson have been extensively reclaimed and previous work done by this Group has shown that this process has had a considerable impact on quality of the adjacent estuarine environment. We need to extend this work to determine the effects of urbanization and industrialization of the catchment on the condition of the estuary. The project involves mapping the development of urbanisation and industry in the catchment of Sydney Harbour using historic records/maps and GIS. Sediment adjacent to industrial sites will be cored for evidence of impact. Removal of industry from the catchment, so prominent in the last 10 years, will also be documented. This ‘rise and fall’ of industry in Sydney will be related to temporal impact as detected in dated sedimentary cores from the estuary. Different vintages of chemical data for harbour sediments will be entered into the GIS database and related to changes in the development of the catchment.

Recent (2011) data indicate that the status of Sydney estuary is improving. This project sets out to determine why and how estuarine condition deteriorated and is now recovering and use this valuable information to suggest how we should proceed in future urban planning, not only for Sydney, but other heavily impacted estuaries.
This project has the enormous potential for popularisation through publication (book) and TV

A water and sedimentation model for Sydney estuary

Supervisors: Gavin Birch and Guillaume Duclaux (CSIRO)

Objectives:
- Determining the amount of stormwater available within the Sydney estuary catchment for water harvesting
- Determining erosion rates and mass of contaminants exported to Sydney estuary
- Determining sedimentation rates in Sydney estuary
- Construct a sedimentation model for Sydney estuary based on the new ‘Tellus’ CSIRO-supported 3D-parallel code

Background: Water resources have, belatedly, come to be realised as Australia’s most precious (and wasted) resource. This is not restricted to a rural/agricultural problem. Combined reservoirs serving Sydney were (September 2007) at a historical minimum, i.e. at 34% capacity. Sedimentation in Port Jackson is of vital importance to the management of the estuary. High sedimentation rates affect seagrass growth, smother fringe populations and prevent vessels from using large valuable marine facilities. Sediment, especially the finer fraction, is the major carrier of contaminants and in some parts of Port Jackson sediment contains concentrations of some chemicals that are adversely effecting benthic populations.

Yet to date no water budget is available for Port Jackson catchment and little is known about sedimentation rates in the estuary. Currently, an unknown quantity of re-useable stormwater is being discharges into Port Jackson and there are no plans for harvesting such resources. There is a desperate need to improve the quality of some surficial sediment in Port Jackson so that benthic populations can be re-established and yet there is no consideration on how this can be achieved. A very expensive (> $1m) program has been ongoing in Sydney for a considerable period to prevent sediment leaving construction sites without the success of the venture being evaluated.

The Project: The project aims to produce a runoff and sedimentation model for Port Jackson using data already acquired by the Environmental Geology Group. The environmental status of canals and creeks currently discharging to the Sydney estuary will be assessed and categorised to assist in management of these valuable resources. Theoretical water runoff and soil erosion/transportation models will use digital evaluation models, landuse, impervious surface data and rainfall information. Data outputs will be
introduced into ‘Tellus’ a new CSIRO-supported 3D-parallel code based on particle-in-cell technique capable of simulating geomorphic evolution. Tellus solves the shallow water equation to simulate various types of flow on an unstructured grid. External forces such as sea-level fluctuation, vertical displacement, rainfall and river inflows can be imposed. A sediment transport criterion allows siliciclastic material to be eroded, transported and deposited. The code is capable of modelling compaction based on sediment loading. Model outputs will be compared to flow rates, sedimentation rates and temporal changes in bathymetry in the estuary.

The second part of the project will include a detailed critique of water use in the catchment and how stormwater can be harvested to provide a valuable in situ resource for domestic use and recreational areas in some of the most densely urbanised areas of the city. This will link elegantly with a current PhD project which is aiming to optimise the efficiency of a filtration device to remediate stormwater discharging into the estuary. Storage of stormwater is an issue and there is a need to think ‘outside the square’. Can the (porous) Hawkesbury Sandstone underlying the city be used for storage, or can the Sydney storage tunnel be utilised for short term benefits? On-the-ground work will be undertaken to determine actual mass of sediment leaving a number of better known catchments and these data will be related to modelled information and sedimentation rates as determined from the receiving basin. Then theoretical sedimentation model may have to be calibrated for the Sydney estuary and catchment. We have already determined metal concentrations of soil in the entire Sydney estuary catchment and now we need to know how or if this material is being exported to the estuary. If soil is being delivered to the harbour in large amounts, is there a need to remove contaminated sediment from the estuary? If so, how should this be undertaken? Dredging is an option, but why is it not being considered?

This project will be integrated with other work being undertaken within the School, i.e. modelling catchment contaminant loading, stormwater runoff studies, stormwater remediation and building a science-based strategy for the long-term management of the harbour.

**Modelling of sources, loads and fate of metals in a well-characterised, highly-urbanised catchment**

**Supervisor: Gavin Birch**

**Objectives:**
- Determine and quantify primary sources of metal contamination in a well characterised catchment (Iron Cove)
- Establish source and magnitude of vehicular contributions of metals to runoff
- Investigate generation of ‘new’ metals by residential landuse
Urban stormwater is commonly contaminated with high concentrations of contaminants, including metals. These toxicants are a threat to the health of our aquatic ecosystems and recent work has shown that 60% of streams in the USA and 30% in New Zealand contain concentrations in excess of guidelines.

A considerable amount of data exists for a catchment-estuary ecosystem in Sydney estuary (Iron Cove), which provides, for the first time, the opportunity of establishing a verified, well-documented, integrated source-fate model for metals in a highly-urbanised catchment. The large amount of data collected in this coupled system has lead to a general assumption of the primary sources of these chemicals however, there have been few attempts to either confirm these sources or determine the relative contributions from each source. The main reason for this is that such investigations require accurate estimates of the chemical loads contributed by each of the individual sources and of the total loads draining from the catchments containing the sources. These load estimates may be obtained with sufficient accuracy only from intensive monitoring and modelling of stormwater quality and quantity for each individual source, as well as for the catchment containing the sources. Monitoring and modelling programmes on this scale are very expensive. At Sydney University we have now reached a situation where separate studies together provide most of the data required to enable metal sources in urban catchments to be identified and quantified.

Existing treatment technologies such as wetlands and swales may fail to effectively remove soluble pollutants, which are generally considered the most toxic component. In addition, there is typically limited available open space in the densely populated urban areas where heavy metal and hydrocarbon pollution is prevalent, precluding the use of wetlands and/or swales for treatment of stormwater.

The present study therefore focuses on identifying and quantifying urban metal sources and developing a deep understanding of catchment processes sources and establishing best management practise for this catchment-estuary system

Contaminant concentrations in urban and market vegetables

Supervisor: Gavin Birch
Objectives:

- Determine concentration of metals in vegetables grown in urban settings
- Compare metal concentrations of urban and market vegetables
- Relate tissue concentrations to health guidelines
- Model human uptake potential

An increasing number of vegetable gardens are being constructed in urban settings, especially in areas such as Sydney. Metal atmospheric deposition models developed by USEEG show that a significant mass of contaminants is settling in extensive parts of metropolitan Sydney. No information currently exists in relation to the concentration of metals in urban vegetable soils or in the tissue of plants being grown in these soils. It is therefore important to determine the processes governing the uptake of metals by plants being increasingly grown in these settings.

Large capital cities, such as Sydney, are rapidly expanding into areas traditionally used for market gardening. With urban expansion comes increased road infrastructure and industrialisation which in turn elevates the production and deposition of heavy metals. Soils in these areas are expected to have increasing concentrations of heavy metals. Currently, there is no information as to the changing nature of these soils, nor are there any data on possible increasing metal concentrations in vegetables that have been grown in these areas.

Heavy metals in roof and domestic dust

Supervisor: Gavin Birch

Objectives

- Estimate contribution by atmospheric processes
- Relate roof dust to existing metal model of atmospheric contributions
- Estimate of contaminant loading over time
- Biomonitor atmospheric conditions within domestic homes
- Provide important information for determining methods for source control and remediation.

A pilot study undertaken by an Honours student in 2004 has shown that roof dust is highly contaminated by a wide range of heavy metals. Roof dust provides an estimate of the
contribution by atmospheric processes of heavy metal emissions from a variety of sources, e.g. vehicles, industry, incineration, etc. Information from roof dust will be related to metal modelling of atmospheric contributions undertaken in 2004, as well as to data now being generated on soil chemistry in the Port Jackson catchment. Roof dust also provides an estimate of contaminant loading over time, which will be very useful as input parameters for catchment modelling now being carried out within the Group.

Domestic dust is a useful biomonitor of atmospheric conditions within domestic homes, as well as other premises e.g. working environment. It is therefore a method of assessing the potential threat facing humans within their homes and places of work. The origin of these contaminants will provide important information for determining methods for source control and remediation.

Partitioning of heavy metals in contaminated estuarine sediments

Supervisor: Gavin Birch

Objectives

- Determine major phases with which the contaminants are associated
- Establish processes controlling metal bioavailability
- Characterize the chemical composition of pore water
- Investigate improved sediment quality assessment techniques

A deeper understanding of the effects of contaminants can be gleaned by determining the major phases with which the contaminants are associated. There are many selective and sequential extraction methodologies which can provide such information, but after some experimentation in conjunction with other groups, one technique is being used by this Group. This information can be augmented by undertaking further extraction procedures with different mixtures and concentrations of acids and chelating agents. The dominance of sediment sulphides in controlling metal bioavailability is well recognised for some sediments. Sulphides can complex with metal ions to form water-insoluble precipitates and it is the extent to which this sulphide component is soluble in cold acid that is important in controlling toxicity of some heavy metals. This so called ‘AVS’ technique needs to be tested against other methods. Another common approach is to characterize the chemical composition of pore water. The assumption here is that it is the nature of the interstitial fluids that is important in the uptake by infauna. Again there are several methods by which the chemistry of the pore waters can be determined, including removal of the sediment and centrifugation, in situ diffusion, or filtration techniques, etc. and some of these will be attempted. Several other techniques for assessing sediment quality currently in use should be tested, including SEM, EDAX techniques, equilibrium partitioning, etc.
Ultimately, the optimum approach is to express contaminant concentrations as a function of the capacity of the sediment to bind them. This involves the size, mineralogy and chemistry of the sediment, as well as the physio-chemical characteristics of the ambient sediment. This is a complex area of environmental science, but it is one of the most important problems which need to be dealt with urgently, and it is one for which there may not be a unique solution. The results of this study will hopefully lead to an improved sediment quality assessment technique.

Any mutually agreed environmental (marine and geoscience) topic