John Gash celebrates a research programme looking at how water moves into lowland rivers and what happens once it gets there.

From rainfall

The dry winter of 2005-06, followed by drought orders over much of the south-east of England this summer, have highlighted the vulnerability of water resources in the lowland catchments on which much of England depends for its water supply. Our water resources are under pressure. Each of us is, on average, steadily using more water, and – particularly in southern England – the population is increasing, creating a further new demand.

Lowland England has relatively little rain, and probably 70 per cent of it is lost to evaporation by the crops and woods which cover the landscape. The remaining 30 per cent has to replenish reservoirs and aquifers, and sustain the ecological balance of rivers and wetlands. How will the growing demand for water be met without damaging the environment?

NERC's Lowland Catchment Research programme, LOCAR, was designed to address this question, by providing the underpinning science to support the regulation and management of water in permeable lowland catchments. The programme concluded that the health of England's lowland rivers depends on good land management over the entire area that drains into the river: its catchment.

The European Water Framework Directive means that we must create and maintain rivers as healthy ecological habitats. But river quality is the result of water and the material it carries, moving through a complex, dynamic web of interacting physical pathways and chemical reactions, eventually leading to an ecological habitat which is itself influenced by the plants and animals that live there. LOCAR has helped to untangle these complex interactions.

LOCAR installed an impressive network of instruments in three contrasting permeable catchments on chalk or sandstone: the Frome and Piddle in Dorset, the Pang and Lambourn in Berkshire, and the Tern in Shropshire. An integrated research team from two NERC research centres and 12 universities then investigated the hydrology and aquatic ecology of these catchments.

We followed the water from when it falls as rain to when it is flowing in the river. Individual studies ranged from measuring the variability of the evaporation which defines how much water is left to top up the groundwater, to understanding the role of stream side-channels as refuges for fish. All emphasised the importance of considering the process under study as a part of the larger catchment system.

The work involved the largest programme of drilling boreholes for research ever undertaken in Britain. Along with new geological mapping, this revealed in impressive detail that chalk groundwater moves along different routes at different speeds. In some areas chemicals move from the land into streams in hours or days, yet in other parts of the same catchment they take many years (40 or more in some places). At greater depths, water movement is influenced by large-scale geological structures and does not always follow the direction of surface valleys.

As the use of agricultural chemicals has increased over the last

Above: The River Pang after the dry winter of 2005-06.

Left: Using a ground penetrating radar to measure the structure under the river bed.

Want to know more?

This article is based on the booklet *Go with the flow* (see back cover for details). For more on the LOCAR programme, see www.nerc.ac.uk

to river

50 years, fertilisers and pesticides have built up in the chalk, creating a time bomb of pollution waiting to find its way into the rivers. These findings have been incorporated into a new computer model which predicts when this pollution will reach the rivers. The model will help catchment managers to draw up a timetable for remedial action.

Eroded soil can damage aquatic life by silting up river channels – salmon don't breed well when their gravel spawning beds are clogged up. Silt can also carry pesticides and nutrients into the water from fields. Catchment managers need to know where the eroded sediment comes from, so that it can be controlled. Innovative 'fingerprinting' methods used in LOCAR revealed the source of the fine sediment moving through the study catchments and led to the conclusion that bank erosion is only a minor source of sediments. It is the shift from pasture to arable agriculture that is mostly to blame for the increased sediment, with much of it coming from ploughed fields (see *Planet Earth,* Winter 2005, pp20-21). This important new information can be used by environmentally sensitive farming initiatives to reduce silt in rivers.

LOCAR researchers found that the active upper layer of the stream bed, where biological and chemical changes are regulating stream chemistry, is an important pressure point. River plants play a critical role here – they are the engineers of a healthy river. Plants influence the speed of the current, where sediments are deposited and eroded, where nutrients are recycled and where the animals of the river live. Faster currents between dense patches of water weeds can clean silt from river-bed gravels. Where plants slow the current down, plant debris, organic and mineral particles are deposited. As a result, new bed and bank forms develop, new plants germinate and grow, and hotspots for processing organic matter are created. Sensitive management of vegetation in the river and on its banks is therefore critical for a complex and healthy habitat in lowland rivers.

Most conventional biological assessments of the LOCAR rivers, based on the diversity and type of the animals and plants that live in them, would conclude that the rivers are ecologically healthy. But LOCAR scientists identified significant changes taking place in stream beds which suggest that these rivers may not be as healthy as previously thought. Salmon and trout eggs survive poorly, the rivers contain too many nutrients and their clogged-up beds emit significant quantities of gases such as methane and nitrous oxide – not features of high-quality river ecosystems. This analysis of river function seems to be telling a different story to the conventional assessments, and suggests that we might need a new ecosystem-based approach to ecological assessment.

The Environment Agency regulates how catchments in England and Wales are managed. The Agency's Bob Harris has been following LOCAR research to ensure that they make full use of the results as soon as they appear. Bob said, 'Our objective is sustainable water use and healthy aquatic ecosystems. LOCAR is changing the way we perceive lowland catchments – the processes controlling water and pollutant movement are far more dynamic than we had thought. LOCAR is providing us with a new appreciation of how permeable, lowland catchments function and with invaluable scientific underpinning to help us develop the regulatory framework we need.'

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