The quality is clear

Dr Richard McLaughlin introduces his novel cost-effective solutions for improving water quality, which have the potential to protect a diverse range of aquatic environments

Can you introduce your research on water quality protection, and the wider context of this work?

The focus of my research programme has been to develop and test simple, inexpensive approaches to reduce the impact of land development on water quality. The emphasis has been on techniques that can be implemented during the 'bulldozer phase' of construction, when large areas of land are stripped of vegetation for significant periods of time while a new building, development or road is built.

What first sparked your interest in this area of research?

I have always loved being in and on the water – swimming, snorkelling, fishing and water sports – and these activities are much more enjoyable in clear, clean water. Unfortunately, many of our streams and rivers turn into 'chocolate milk' during storm events due to erosion and sediment washing into them from nearby exposed land. Since this is largely preventable, I wanted to seek out ways to either improve existing pollution prevention methods or develop new systems that are more effective.

In what ways do turbidity and elevated levels of sediment impact the environment?

The major water quality problems in the US and many other areas of the world are caused by nutrients, bacteria, sediment and turbidity. Sediment causes many issues such as habitat loss, reduced flow capacity of streams and in-filling of lakes and reservoirs. Aquatic organisms that inhabit high quality waters tend to be intolerant of sediment. Turbidity is also toxic to aquatic organisms because it causes a reduction in the ability to locate food and reduces sunlight penetration, which is detrimental to aquatic plants.

How did you discover the beneficial effects of using porous baffles in sediment basins?

When we started using polyacrylamide to cause suspended sediment to clump together in our experiments, the manufacturer suggested we put coir 'filter fences' in our sediment basins to trap the aggregates. When we ran our first test, we observed that the normal turbulence caused by water entering the pool was largely removed as the flow passed through the fences, which we now call porous baffles.

Using baffles is a well-known engineering technique to push the flow in a basin from side to side, but I am not aware of anyone trying porous baffles as a method of encouraging particulate settling. Fortunately, a colleague had equipment to measure three-dimensional flows, so we set up experiments to quantify the effects of porous baffles. Sure enough, they greatly reduced turbulence and flow velocity in the basin, resulting in much better capture of sediment.

To what extent do construction sites readily accept the use of controlled sediment basins for improving the quality of water runoff?

All US states must regulate runoff from construction sites to prevent loss of sediment. Most states have a minimum requirement that runoff be held in a pond to drop out the heavy sediment before being released. Ditches are normally used to bring water from various parts of the site to the pond, and these usually contain check dams to control velocity. Our system simply improves that combination with check dams made of natural fibre and containing polyacrylamide, porous baffles in the pond and a surface outlet. There is little additional cost but significant improvement in the quality of stormwater discharges.

Can you elaborate on some of the biggest challenges you have faced in this investigation?

Erosion and sediment control is required on construction sites, but it is an expense with no benefit to developers aside from avoiding fines. Our challenge has been to improve the quality of discharged stormwater without significant additional expense. In some areas, the developer has to bring in huge pumps and filters at great cost. We simply use gravity and minor modifications to achieve significant water quality improvements.

Where will you be focusing your attention in the future?

We are working on methods to reduce runoff from vegetated areas once construction is complete. This involves ways to till and possibly amend the soil, as well as evaluating the impact of different types of vegetation. To date, we've found that even heavy soils can have relatively high infiltration rates for as long as we've monitored them; almost three years after treatment. We are now investigating the possibility of capturing road runoff in these high infiltration soil areas. We are also working on a number of variations on that, but I'll keep those to myself until we publish the results!

Dr McLaughlin demonstrates numerous methods for cleaning up muddy construction site runoff at a workshop at the Sediment and Erosion Control Research and Education Facility.

Cleaning up construction runoff

Environmental impact is an increasing concern in the construction industry. Research at **North Carolina State University** is helping to reduce the damage caused by water discharge from building sites

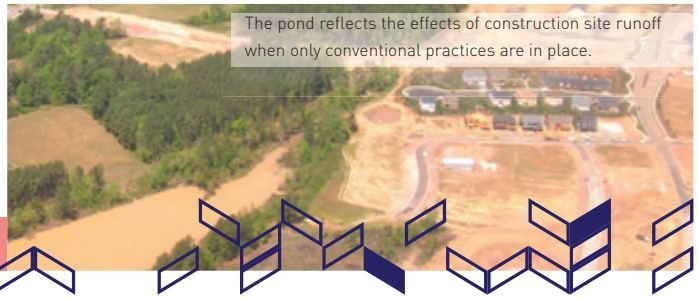
THE PHRASE 'WATER quality' is one most people tend to associate with drinking water. The quality of the water being used for other purposes is less of an immediate concern – and yet it is often equally important and can have significant impacts on whole ecosystems. Two of the most widespread pollutants, sediment and turbidity, are very detrimental to habitat and water quality.

Firstly, sediment – material carried by a water flow which ends up settling – can cause in-filling of streams, ponds and lakes, thereby robbing many life forms of their habitat. It also reduces the storage capacity of drinking water reservoirs, and causes flooding by filling in water courses. Secondly, turbidity – small particles that don't settle out easily – can cause further habitat damage by restricting the sunlight that can penetrate the water and reach aquatic plants, and by preventing water-dwelling animals from finding food. "In the context of streams, sediment is usually the larger soil particles, such as sand, which can settle very quickly," clarifies Dr Richard McLaughlin. "The turbidity that comes from erosion is composed of the smaller soil particles, such as clay, which settle so slowly that they remain in the water column for a long time."

IMPLEMENTING POROUS BAFFLES

McLaughlin is a professor in the Soil Science Department at North Carolina State University (NCSU), USA, where there has been a longstanding research focus on reducing sediment and turbidity in storm water flows, such as those on construction sites. The aim is to make these less environmentally damaging. The challenge not only involves developing techniques to reduce sediment and turbidity, but also ensuring that novel strategies are cost-effective and will thus be widely implemented.

McLaughlin's research includes two unique foci. The first involves the use of porous baffles – a device that restrains the flow of the water in certain directions – to improve the efficiency of sedimentation basins. When the NCSU team first introduced the baffles to improve water filtration, they were surprised to discover that their implementation also significantly reduced water turbulence. This allowed for a



The pond reflects the effects of construction site runoff when only conventional practices are in place.

REDUCING IMPACTS ON WATER QUALITY

OBJECTIVES

- To develop and test simple, inexpensive approaches to reduce the impact of land development on water quality
- To reduce the movement of sediment from developed and developing areas
- To improve vegetation establishment and soil properties in lawns, buffers and landscaped areas in order to reduce runoff volume and improve water quality

KEY COLLABORATORS

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FUNDING

North Carolina Department of Transportation

North Carolina Water Resources Research Institute

National Science Foundation

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NC STATE UNIVERSITY

Workshop attendees have a hands-on experience in installing porous baffles.

much greater capture of sedimentation in the basins.

The second unique area of research involves using a number of techniques to passively dose polyacrylamide (PAM) into construction site runoff flows. The role of this chemical is to induce more particles that are suspended in the water to settle in the basins. "There are many types of PAM, but we normally use those that have a negative charge and linear structure 10,000–100,000 carbons in length," elaborates McLaughlin. "These long molecules bind to the suspended particles, pulling them together into 'flocs' that settle much faster than the particles by themselves." This technique allows the turbidity of the water to be reduced by up to 100-fold.

> The prevention of so much sediment material from being released into the surrounding environment can only be positive for flora and fauna of these aqueous habitats

Both of these approaches to improve water quality are cheap to implement, require almost no change to the ways in which most construction companies operate, and have little to no negative environmental impact. Although the presence of PAM in the water has caused some concerns, evidence supports the fact that these are unfounded. "Some people worry that there are traces of free acrylamide in all PAM products; however, we use food-grade PAM which has extremely low acrylamide concentrations, which are quickly degraded by microorganisms in the environment," explains McLaughlin. The result is a safe process that is relatively inexpensive for construction companies to implement.

ACHIEVING IMPACT

The work carried out at NCSU has already led to many tangible achievements and the adoption of McLaughlin's techniques by construction companies nationwide. The increased efficiency of surface outlets from sedimentation basins can be attributed to this work. "Previously, the outlet was a pile of rocks placed in the dam and, often, more than half of the sediment that came into the basin went out through this outlet. Now we are capturing well over 90 per cent of sediment," McLaughlin enthuses. The prevention of large quantities of sediment material from being released into the surrounding environment can only be positive for flora and fauna of these aqueous habitats.

The success of these improvements has led to some of the team's techniques being adopted into law. "The requirement by the US Environmental Protection Agency (EPA) that all sediment basins must have a surface outlet is a significant improvement, one which may have been influenced by our constant promotion of this concept," states McLaughlin. Furthermore, in North Carolina, and some other states, the team's porous baffle technology is now required in construction site sedimentation basins. The EPA even proposed a 'national standard' for turbidity, partially supported by McLaughlin's research, although this was unfortunately rejected through lawsuits by the construction industry.

While there will always be more that humankind can do to reduce its environmental impact, it is certain that researchers in the Soil Science Department at NCSU will continue their sterling work towards facilitating this important endeavour. Their research to date has led to a low cost and innovative technique that allows construction companies to effectively and efficiently reduce the impact of their work on the surrounding environment.