

# Environmental Audit Committee

Oral evidence: [Nitrate](#), HC 656

Wednesday, 28 February 2018

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Members present: Mary Creagh (Chair); Colin Clark; Geraint Davies; Glyn Davies; Mr Philip Dunne; Robert Goodwill; Kerry McCarthy; Anna McMorrin; Dr Matthew Offord]

Questions 1 - 88

## Witnesses

I: Professor Robert Ward, Director of Science, British Geological Survey; Professor Helen Jarvie, Principal Scientist Hydrochemistry, Centre for Ecology and Hydrology; Professor Penny Johnes, Professor of Biogeochemistry, University of Bristol.

II: David Johnson, Director of the Rivers Trust, representing Wildlife and Countryside Link; Will Andrews Tipper, Head of Natural Environment, Green Alliance.

Written evidence from witnesses:

- [British Geological Survey](#)
- [Centre for Ecology and Hydrology](#)
- [Professor Penny Johnes](#)
- [Wildlife and Countryside Link](#)
- [Green Alliance](#)

## Examination of witnesses

Witnesses: Professor Robert Ward, Professor Helen Jarvie and Professor Penny Johnes.

Q1 **Chair:** For the purposes of Hansard, can I ask you to introduce yourselves from left to right, please?

**Professor Helen Jarvie:** Hello, I am Professor Helen Jarvie. I am a principal scientist in hydrochemistry, river water quality and professor at the Centre for Ecology and Hydrology.

**Professor Penny Johnes:** Hello, I am Penny Johnes. I am a professor of biogeochemistry—that is like the biogeochemistry of the environment—at the University of Bristol.

**Professor Robert Ward:** Hello, I am Rob Ward. I am Director of Groundwater Science at the British Geological Survey. By profession I am a hydrogeologist, studying groundwater quality and water resources.

Q2 **Chair:** We are absolutely thrilled that you can all be with us today and that you have battled bravely through the snow and we wish you all the best on the journey home as well.

I want to start by saying none of us are experts in this area. I was not even sure what biogeochemistry was. I thought that was a typo when I saw your job title, Professor Johnes, so we may need to pause, rewind and just ask you to go slowly because you are our first session and we are just getting to grips with this.

Can I begin with a question to you, Professor Ward? You published an article very recently about the scale of nitrate pollution in rocks. The press took it up and said it was “a nitrate time bomb”. What is the scale of nitrate pollution?

**Professor Robert Ward:** Our area of focus is on groundwater, nitrate in the subsurface. I am sure Penny will tell you a little bit more about nitrogen and the different forms of nitrogen in the environment. In groundwater, however, the key parameter is nitrate because that is principally the form in which the nitrogen is found in groundwater.

The principal source of nitrate in groundwater is coming from agriculture. At least 70% is derived from agriculture, there are other sources. Our particular interest is looking at how much of the nitrate that leaches from the soil into the groundwater is entering the groundwater. Much of that groundwater is used for public supply, supporting river flows through springs and also feeding sensitive ecosystems.

The scale of the problem is that obviously large amounts of nitrates have been applied as fertiliser since the 1950s, increasing fertiliser over that time, with intensification of agriculture, until a peak in the 1980s, when



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controls were put in place and nitrate loading or nitrate application on the land surface was reduced. That nitrate has been moving slowly through the subsurface, through the soils, through the rocks overlying our acquirers. Because of the downward slow movement, the nitrate is still stored in the unsaturated zone and we have a peak of nitrate moving through, which is, in many areas—particularly the areas of the chalk, which is one of our principal aquifers—still to reach the groundwater so concentrations of nitrate are continuing to rise in some areas, particularly in the chalk aquifers, which reflects the legacy use of nitrate.

**Q3 Chair:** For those of us who did not get O-level geography, can you talk about oolitic, permo-triassic and chalk and tell us where those places are?

**Professor Robert Ward:** You have described there different types of rock. We obviously have a very complex geology in the UK. Some of the rocks beneath our feet are able to store more water than others, and not only store the water but they are able to transmit the water to allow us to abstract it for drinking water. Many of our water companies abstract water for drinking water proposes. They also support river flows as well in some areas. You may be familiar with chalk streams, which derives most of its water from the chalk.

The words you use there are geological descriptions. The chalk is perhaps one that most people are familiar with in the southeast of England. We see the White Cliffs of Dover; that is chalk. It is one of our principal aquifers and that extends across southern England, through East Anglia up into East Yorkshire, a very widespread rock. We also have the permo-triassic sandstone, which is more of a red sandstone rock, which extends through the Midlands into northwest England. The oolitic limestone is another white limestone rock, similar to chalk, older in age, which extends from the south through the Midlands to the northeast as well.

**Q4 Chair:** Is that like Malham Cove in Yorkshire?

**Professor Robert Ward:** Malham Cover is carboniferous limestone, so it is an older limestone, but is less extensive than the other rock types that we have just talked about.

**Q5 Chair:** We do not have any maps. If you do have a map, I think it would be lovely if we could see it.

**Professor Robert Ward:** We can certainly provide a map, yes.

**Q6 Chair:** A picture says a thousand words. You talked about chalk. You say that they hold the water and we get the water from them. Does it go through it like a sieve?

**Professor Robert Ward:** If we think about rainfall on the land surface, some of that runs off into streams but a lot will infiltrate through the soil where the rocks are permeable. That is rocks such as the chalk, the oolitic limestone and the sandstone. They are permeable so they will allow the water to infiltrate and move through those rocks downwards.



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They will move down to a point where the rocks are fully saturated with water, which is what we call the saturated zone, and the level at which is the water table.

The groundwater, or the water in the subsurface, which we call the groundwater, once it reaches the zone of saturation will move laterally along an energy gradient, effectively a down gradient, very similar to the way a river flows downhill. The groundwater also moves but very, very slowly. That water will re-emerge at the surface at low-lying locations, which will form springs, which you are familiar with, which is the discharge of groundwater, or water companies will take advantage of permeable rocks by drilling wells and then pumping the water out to use it for public water supply, farmers for irrigation and so on.

Q7 **Chair:** What is underneath the saturated zone? Is that an impermeable rock or is it still going down below?

**Professor Robert Ward:** The depth of our aquifers, which are the water-bearing rocks, is very variable. Generally, if we go down further, underneath the aquifer will be a more impermeable layer, which effectively holds the water and becomes the base of the aquifer. Rocks obviously continue down and we can get multiple layers of aquifers.

Q8 **Chair:** That is very helpful, thank you. What is the likelihood that these nitrates are going to be released into the environment and over what time period? Obviously they are all seeping through at different times. What is the rate of seepage, if you can measure that or say that, with these different types of rock?

**Professor Robert Ward:** Over the last 30 or 40 years the Geological Survey have been looking at the movement of nitrate in the subsurface. Certainly during the 1980s and 1990s we drilled a number of boreholes where we extracted the rock core, the core from the drill, and we looked at the movement of nitrate. We looked at concentrations of nitrate in the profile and we also looked at other traces in the waters what we call the unsaturated zone. That is the zone above the water table. On the basis of those traces and the movement of nitrate, we estimate that the downward velocity of movement of water and nitrate in this case is on average about 1 metre per year. It varies between rock types. With some of the more fractured rocks you have a faster flowrate. In the more dense or tighter rocks you have a slower flowrate. For the chalk, for example, the average is about 1 metre per year.

Q9 **Chair:** What about permo-triassic and oolitic? I just want to keep saying oolitic, to be honest with you.

**Professor Robert Ward:** They vary between—I think the sandstone is around about 0.8 and the oolitic limestone 1.4. I might have got those the wrong way around, so I will need to confirm those.

Q10 **Chair:** That is very helpful. What are the main risks associated with this? I am happy for our other professors to come in if you want to talk about



the risks of the nitrates getting in.

**Professor Robert Ward:** From groundwater, because of the slow movement of groundwater and the downward movement to the groundwater, the saturated zone, obviously what has happened in the past over the last decades where we have applied lots of fertiliser, and in a way that perhaps was less controlled, or certainly less controlled than it is now, the excess nitrate has moved down into the groundwater. As you referred to earlier, this time bomb, because we have had this slow-moving nitrate moving through the system and a very large amount of nitrate stored, eventually that will come back to the surface in many locations, through springs, through water supplies, so the problem will continue for, in some locations, many decades, following the groundwater pathway.

I think from the evidence that you have received from the water companies, the four companies that I have seen who are abstracting groundwater for public water supply, have reported increasing trends in nitrate concentration still, despite the controls that are being applied on the land surface. That is reflecting the lag time within the groundwater system.

**Chair:** Professor Johnes, Professor Jarvie?

**Professor Penny Johnes:** Did you want to know about what the problems are in terms of the ecological—

**Chair:** Exactly. Just at a general GCSE level.

**Professor Penny Johnes:** I will preface any remarks I make by saying that it is not just about nitrate. If you imagine a pizza, it is part of the pizza, it is not the whole pizza. The whole pizza, if you like, is your nitrogen. All of those forms play a role in terms of driving how ecosystems work, because ecosystems and every biological organism needs nitrogen to exist. It also needs carbon and it needs phosphorous and a number of other minor elements are also needed as well. Nitrate is playing a part in driving ecosystem responses, it is not the only driver of those.

One of the big problems we have had with policy development so far is that we tend to go for the silver-bullet approach. We think, "If we just control this thing, everything will be hunky dory", and it just does not work like that. These biota have been around for billennia, they have evolved over time, they need these nutrient forms. They have evolved just about every mechanism you could possibly think of to acquire them. Nitrate is one of them and it is a really important one. In chalk landscapes, the sort of thing that Rob has been talking about, it is the dominant form that is present. There are other parts of the UK where it is present, but it might be only 50% of what is driving the ecosystem and the ecosystem response in terms of nitrogen alone. The rest of that is in other chemical forms that the biota can also access and that are driving



the consistent degradation. I want the Committee to understand that it is about nitrogen and not just nitrates.

Q11 **Chair:** How does that nitrogen come through, if it is not as nitrate?

**Professor Penny Johnes:** There is a range of different forms. We have nitrite, which is a very minor, in terms of quantity, form but is quite toxic to some organisms. Some of the macroinvertebrates, for example, find this very toxic. Nitrite is like nitrate but it has one less oxygen and it can cause a toxic effect. Some of the legislation to which we are subscribed through the European Union, requires us to control for nitrite, but it is less than 1% of the total amount that is there. It is a small amount but it can be quite damaging if it ekes up at times. You will find that wherever you have organic effluents being discharged from sewage works, from animal agriculture, for example, and a slow-flowing water body. You tend to have very little oxygen and the nitrate that is in there can lose an oxygen quite quickly and become nitrite. I am talking in the order of seconds to minutes, a rapid transformation.

Then there is the ammonia, which is un-ionised. That is  $\text{NH}_3$ . There is another form called ammonium, which has given away an electron so it has a positive charge. I am getting into a bit of chemistry here. The ammonia is very toxic to fish in particular and so we have a range of legislation in relation to controlling ammonium in our waters in relation to salmonid and freshwater fish: salmon, trout, sea trout and so on. There is specific legislation and thresholds available for those. There are also comparable pieces of legislation for things like sea urchins in the marine environment. It is not just a freshwater problem. Those are what we call the inorganic forms and the transformations between them are really rapid.

The other half of the story is the organic nutrient fraction. There we have tens to hundreds of thousands of compounds that make up something called dissolved organic nitrogen, dissolved and particulate organic nitrogen. Particulate is anything that is in a particle, and dissolved is anything that is below a certain arbitrary threshold—Helen will confirm this—based on which filter paper you use and how small the holes are that are in it, sieving it out, if you like.

This material is highly biodegradable and it is very, very reactive. When you have a lot of organic waste—from sewage works or from livestock production, slurry pits that are leaking, animals that are allowed to access a watercourse and so on and so forth—then you have a large amount of this material. That provides the organisms in the stream, not only with their nitrogen needs but their phosphorus needs. It also gives them their carbon needs and a whole range of other things that go in there. It acts like an energy pack for the system and it drives the system to go into overproduction, so that is also part of the story. That is just the nitrogen and then there are all the same arguments you could advance for the other nutrient things that are equally important.



**Q12 Mr Philip Dunne:** Could you give us a similar overview for phosphorus as you have done for nitrogen?

**Professor Penny Johnes:** In terms of the phosphorus, we have the main form, which is phosphate, or orthophosphate it is sometimes called, and sometimes we call it soluble reactive phosphorus, or soluble reactive phosphorus as well. That is because there is a range of different sciences that have worked on this and each has developed its own terms.

Effectively, the phosphate group includes orthophosphate, which is  $\text{PO}_4^{3-}$ —it has three negative charges, three electrons. There is also a group of phosphorus pentoxides. A number of these are found in things like laundry detergents. There is legislation and there are drivers to reduce the amount of phosphorus use in detergent production, for example, because every time you use your washing machine, you use a phosphorus-based detergent, your dishwasher, you are discharging these phosphate compounds into the natural environment and they are highly bioavailable.

They are also extremely rare in the natural environment. They are only found in rock. Unlike nitrogen—which is natural in the atmosphere, it is the most dominant form, the gaseous form, in the atmosphere in total. There is far more nitrogen than there is oxygen or carbon dioxide in the atmosphere—the phosphorus is in rock, so to get it out you have to be able to break it down.

There are lots of clever things that things like micromycete fungi do. They exude something called oxalic acid that helps to break it down. In a natural environment phosphorus would be really scarce, although obviously we have rocks that have more of this mineral form now, then they are going to have more phosphorus in them naturally than ones that do not, but it is a very, very low level.

In addition to that you then have the dissolved organic phosphorus in the same as dissolved organic nitrogen. Again, tens of thousands of compounds at least are present in every measurement we make of this big fraction. It is very, very difficult to do.

The other big one is particulate phosphorus. Phosphate behaves in a very different way to nitrate. Rob has alluded to the fact that nitrate moves easily. The best way to describe that is to that chemically it is not very sticky. It tends to repel against solid particles and stays in solution, so when you have a rainfall event you might imagine fresh rainfall comes in and pushes nitrate-rich water out. It is like a piston flow effect.

But phosphorus is not. It is quite chemically active. It sticks to other things in the soil so it tends to be bound in the sediment more. To move that phosphorus, you either have to mobilise it off the soil particles or you have to move the soil particles. Wherever you get sediment erosion, wherever the soils are eroding—in arable croplands in particular, where you have poaching of riverbanks, where the livestock are allowed to come



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in and churn up the riverbanks—in all of those areas you would be moving that particulate phosphorus into the watercourse. When it gets there it readily desorbs once it gets deposited in sediments.

**Professor Helen Jarvie:** You asked about the scale of the issue. Taking it back one step, of course nitrogen is vital for us in terms of growing our crops. Healthy ecosystems require a certain amount of nitrogen and phosphorus, but the problem comes when it is in excess. In terms of the scale of the issue, it depends whether you are looking in terms of the drinking-water standards—that is at 50 milligrams of nitrate per litre, equivalent to 11.3 milligrams of nitrogen per litre—or whether you are interested in the effects on the biota. There, of course, the main issue is something called eutrophication, where you have excess nitrogen and phosphorus, which promote growth of nuisance, sometimes harmful, algae and higher plants. That can promote the proliferation of nutrient-tolerant species and reduce biodiversity, but also the build-up of large amounts of biomass in our watercourses. When that is broken down by microbes, it takes out the dissolved oxygen from the water. That is what causes problems for fish. There are other problems associated with the issues of obstruction of water if there is a high algal content. It has wider societal implications for fishing and angling and nature conservation, tourism and the recreational value of our waters.

In terms of thinking about the drinking-water standard, if we look at DEFRA in its 2017 article on reporting on the state of implementation of the Nitrates Directive, at present about 6% of England's rivers and lakes have mean annual concentrations above the 50 milligrams of nitrate-per-litre standard. Of course, the levels that are required to avoid ecological damage are much, much lower than that 50 milligrams, 11.3 milligrams of nitrogen per litre. Really what you need to do is to get below about 1 to 2 milligrams per litre, so there is a big gap in terms of the threshold concentrations of concern.

If we take the percentage of England's rivers and lakes that are above the ecological threshold, this would be about 72% of England's rivers and lakes. At CEH we have very recently published a report that looks a little bit more at the regional distribution of some of these issues in relation to eutrophication. What we found was that it is really very much in our lowland permeable catchments, the ones with the aquifer inputs, that we have the highest nitrate concentrations. When we go to these lowland permeable catchments—lowland high alkalinity topography into the Water Framework Directive—what we find is 78% of our headwater streams and 98% of our rivers are above the limiting levels of nitrate for promoting eutrophication, obviously in the presence of phosphorus as well. You have to have both and you cannot keep them independent. Whereas if you go to the upland low-alkalinity topography catchment systems, only about 15% of headwater streams, 61% of our rivers in those kinds of environments, if you go to the west and north, are impaired in terms of nitrate.

**Chair:** It is a pretty big problem.



**Professor Helen Jarvie:** There is a big issue in a lot of excess nitrate in a lot of our lowland river systems, but really what we are interested in is the limiting nutrient. What we find is we are grossly in excess in terms of nitrate but the limiting nutrient very much in our lowland rivers is phosphorus. This is why it is really important that we are considering—we cannot consider nitrogen independent from phosphorus in terms of these eutrophication impacts.

**Chair:** Thank you all very much indeed for that. I feel like I am about to get a level 6 at GCSE.

**Professor Penny Johnes:** Might I just add—

**Chair:** We are going to move on to the next question. There will be a chance to come back but I am keen to make progress.

**Glyn Davies:** I think we may well be returning to one or two points. I do not think I picked up every single detail.

**Chair:** That is why we have Hansard, so we can all take it away and read it and understand it for homework.

Q13 **Glyn Davies:** I want to go back to the issue of nitrogen and ask you whether it is an issue and whether it is a problem at all. We have had evidence submitted to us from the Agricultural Industries Confederation and the Ulster Farmers Union saying that the evidence is that it is not really an issue. They have tested the current measures in place and the trends are sufficient so they are not going to make the nitrate pollution worse. Are these findings that you can accept or do you disagree with them.

**Professor Penny Johnes:** No, I completely disagree. I think this is possibly because we are talking about apples and pears here. They may well be referring specifically to nitrate and to achieving the threshold set under EU Nitrates Directive, which are set to produce a nitrate concentration that is safe, for drinking-water purposes, for human consumption in relation to very specific risks, in relation to stomach cancer, in relation to blue-baby syndrome, which is methaemoglobinemia, which have been set by the World Health Organisation and brought into European policy.

Those are not the same standards as we are talking about in relation to the ecosystems. The ecosystem standards are substantially lower under the European Nitrogen Assessment, which is an activity involving 400 scientists, policymakers, representatives from the Fertiliser Manufacturers Association and so on. It was not just a science-driven thing. That was published in 2011. In that we gathered together the evidence that we could find for Europe that we felt was sound and relatively complete, and we derived from that that the target concentration for an ecosystem not to be damaged by nitrogen in freshwaters was 2 milligrams per litre of nitrogen. When you get down to 2 milligrams per litre of nitrogen, the nitrate is around about 0.5 to 0.75 milligrams of that 2 milligrams. It is a very small proportion of the total. Most of the nitrogen in undamaged



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ecosystems is in the organic form, which they are not measuring and they not responding to.

Their response is probably in relation to nitrate and in relation to drinking-water standards. What we are trying to tell you is in terms of ecosystems those standards are meaningless. They are far too high and they do not reflect the levels that the ecosystem needs in order for the ecosystem to be undamaged. It is two separate things.

**Q14 Glyn Davies:** Do either of the other panellists want to add to that?

**Professor Helen Jarvie:** Yes. I think the other issue is in terms of trends. Certainly if you look at the average concentration of nitrate in England's rivers, these have been going down year by year. Clearly there is a high degree of variability in all of that, because if you go down to some of the chalk streams in Dorset, they are continuing to rise because of the legacy of nitrate coming in from the chalk, so there is a variability across the country. It has stabilised in a number of places like the Thames, for example, because you have declining fertiliser input but a breakthrough of groundwater inputs.

In general, I think some of the evidence is in relation to this broad downward trend, which is a good thing to see, but of course the supposition that things will just continue to improve is based on an assumption of stable baselines. I think that is very difficult to accept, given that clearly there are going to be increasing population pressures and increasing pressure from effluents.

Obviously there is a lot of uncertainty at the moment in regard to the structure and intensity of UK farming post-Brexit and how our changing international trading relationships may alter the way that UK farming works, but perhaps most importantly, also climate change. There has been a lot of work done to look at potential scenarios for changing distributions and rainfall pattern, temperatures, drought effects and how this might affect the nitrate concentration in our rivers.

There has been work undertaken using the INCA model. Paul Whitehead and his colleagues have shown that there is a trend towards increasing flushing of nitrate from the soils, particularly after drought events. So we are not dealing with stable baselines and I think that is something very important in terms of looking to the future, that we have to be aware and cognisant of some of these changes, which many put increasing pressure on the nitrate in our water bodies.

**Q15 Glyn Davies:** Professor Ward, the lag effect you have talked about a bit. It looks to be improving but it seems as if it could be decades until the consequences of that are seen. Can you give us a bit of idea of this lag effect and the timescales? I accept this is going to be repetition from what you said before. I will have to read Hansard a couple of times to get a grip on everything you said, but I think that is a bit of an interest. It is interesting to me because I know a lot of farmers who complain bitterly.



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They think it is getting a lot better so why do we need to consider this to be a problem? The lag effect I think is quite interesting to point out as a defence for why we need to be a bit more serious about this.

**Professor Robert Ward:** I think the lag effect complicates things. Because the pathway through the subsurface, through the unsaturated zone, the unsaturated rocks to the groundwater below is so slow, therefore the groundwater and subsequently the surface water, the springs, the wetlands that then receive that groundwater, will take a long time before they see a response to the actions that take place on the land surface.

As I said, the peak of nitrate fertiliser application was in the mid-1980s. There has been a decline since then. What we have seen is that for a while concentrations in the unsaturated zone, the amount of nitrate stored in the unsaturated zone, continue to increase because the nitrate was moving through slowly and there was a lag. It has started to decline now. Our modelling and our estimates show that the amount of nitrate in the unsaturated zone is starting to decline; there is less going in than there was previously. There is a reduction in what is going in, so the unsaturated zone is—that movement is still going through to the groundwater below. We have this historical legacy of fertiliser use and nitrates still moving through and it is decoupled a little bit from what is happening on the land surface.

Q16 **Glyn Davies:** Thirty years later?

**Professor Robert Ward:** Because, as I said, the downward velocity is approximately 1 metre a year, we can have what we call the unsaturated zone of rock. If we take the chalk, there can be up to 100 metres of unsaturated zone of rock before that nitrate that is applied at the land surface reaches the water table. It could be 100 years but I think that is quite extreme. In the chalk, we are looking at several decades in some locations before that peak of nitrate reaches the water table. What we say is that groundwater concentrations in some locations will get worse before they get better.

There is not a lot we can do about that in terms of what has happened in the past. It is about making sure that we are controlling things on the land surface now so that that problem will eventually work its way through the system. In the meantime, of course, our public water supplies, our groundwater-fed wetlands and rivers are seeing the consequences of what has happened in the past.

Q17 **Glyn Davies:** So we will be taking action today that will have its full impact in 30 years' time?

**Professor Robert Ward:** It is variable but in some cases, yes.

**Glyn Davies:** I think I have covered all the points I wanted to cover.

Q18 **Chair:** Could you say something very quickly about stomach cancer and



what the links are there?

**Professor Penny Johnes:** I am not an expert. You are going to have to find an epidemiologist or someone along those lines to explain it fully for you, but the driver is nitrite not nitrate. Nitrite, as I mentioned before, is happy to drop an oxygen when it gets into a low oxygen environment like the inside of your stomach. You ingest nitrate and you have a reduction to nitrite in your stomach.

Drinking water is not the only source of nitrite. It is also in smoked meats, for example, things like lamb sausage. Those all have quite a lot of nitrite in them. Nitrite is sprayed on meat to keep it looking red in supermarkets. There are lots of things that you ingest nitrite in. Most smoked products have it. It is the nitrite that then gets into the bloodstream. In the stomach it can be part of the trigger for stomach cancer. The evidence is out there but I am not going to try to talk about it because I do not know enough about it.

**Chair:** Excellent. That is another thing to worry about.

**Professor Penny Johnes:** In blue-baby syndrome what happens is the nitrite gets into the blood and it locks on—there are very few instances, I have to say, in Europe, but it locks on to the haemoglobin molecule and that then stops the haemoglobin from carrying oxygen. That is when you get the blue-baby syndrome.

**Chair:** Goodness me. We are having a full triple-science moment.

Q19 **Anna McMorris:** I want to ask about the European Directives and how they tackle nitrogen and the impacts that you have been talking about. We have seen that there was a report prepared for the European Commission as long ago as 2012, which said that the many Directives looking at agriculture, water, energy, environment, were formulated without sufficient consideration of how they all work together in any comprehensive manner, or some unintended consequences. What do you think about this? Is the full nitrogen cycle tackled with the various Directives? If not, what is needed?

**Professor Penny Johnes:** I will try to be succinct on this one and I can hand over to Helen afterwards. We have a number of different Directives and each one is trying to bite off a chunk of the problem. We have the Nitrates Directive, the most well-known one. It is a misnomer. It is not nitrates, it is nitrate. Science nomenclature is important. I am sorry if I sound pedantic, but in the same way you would not send a report out from this Committee that had typographical errors in, so it is important to get the science right.

The Nitrates Directive is aimed at controlling the nitrogen in drinking-water supply. It has no ambition to tackle nitrogen and its role, or nitrate and its role, in ecosystems. We have the European Water Framework Directive where we have no nitrogen standards in the UK for our surface freshwaters, and a limited range, which Rob can tell you more about, for



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groundwater-fed wetlands in relation to nitrate. The legislation there is driven by phosphate.

In fact, the evidence that is out there suggests that most of the water bodies that we are looking at are driven by what we call multiple stressors. Just as humans are influenced by multiple stressors, so are organisms as well. The nitrogen is one of those, phosphorus is another. We have a better answer for phosphorus, we do not have fresh answers for nitrogen. That is a mistake and we are out of line with thinking in continental Europe, if that might be an appropriate term to use to describe other nations.

Other nations have been developing them. The Dutch have a limit of 1.5 milligrams per litre of nitrogen going into their shallow lakes. Other countries have a limit of 4 milligrams per litre of nitrogen. Limits have been proposed in the UK of 2 milligrams per litre of nitrate in the winter months, so there is a whole range of different standards.

Each one of these pieces of legislation directed to the nutrients is trying to tackle a different part of the problem but they are not necessarily speaking to each other. What that leads to is a situation where you can have a driver to meet, let's say, the International Convention on Long-range Transboundary Air Pollution. I am part of the team that advises on that. That is aiming at reducing ammonia emissions to the atmosphere, because when they get deposited they have devastating impacts on terrestrial ecosystems and widespread loss of biodiversity, a lot of damage, particularly in upland areas. The very areas that we think are so important for nature conservation are often the areas receiving this really large burden.

Some of those measures involve turning the manures they are applying to the land into slurries, mixing them with water, making them all runny and then injecting them into the soil. I was at a meeting where a group of my colleagues were very excited about this and thought, "That is great. We are really going to reduce the amount of ammonia we have". I was going, "Excuse me, but speaking for the freshwater environment, that has just mobilised that nitrogen into the soil in a really liquid form and it is going to move down into the water". You get what we call pollutant swapping. Where you have policy that is developed in this piecemeal way, the individual parts of the problem, you often end up with situations where you can end up with pollutant swapping. That is the negative side.

The argument I would say, that we need to move towards a system where we have cross-compliance and holistic policy that controls for the whole system, is that you can then look for the win-wins. If we do for this for carbon, we can also manage this problem of nitrogen at the same time and by the way we are also going to reduce the fertiliser costs for the farmer. There could be an economic benefit, a carbon benefit and a nitrogen benefit. We call those the win-win situations.



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When you do not pull the policy together in a cohesive way and you do not try think in the round, you miss those opportunities to look for the win-wins, as well as leading to this shunting the problem into somebody else's domain, which is what the practice has been so far.

**Professor Helen Jarvie:** I totally agree with Penny on this. I think there is an opportunity for a more coherent and holistic approach, an overarching nutrient strategy. I would not stick just at the nitrogen cycle, I would say that the nitrogen and phosphorus cycles are interlinked. They are coupled, so the interventions that are done in good faith and good practice to address one can again have unintended consequences for others.

I think there is in general a great benefit to looking at ways that we can improve the societal efficiency of nutrient use at all stages along the agri-food chain, not just on the farmer's field in terms of costs saved in terms of phosphorus lost, but the losses that occur right from farm to fork through to consumption and waste management in terms of effluent.

At various stages in that continuum there are real opportunities where there are concentrated waste streams. One of the opportunities is in terms of recycling and recovery of nutrients so that we are not so dependent on use of constant input of inorganic fertilisers into our farming systems and then losses going through the systems in terms of livestock management, in terms of sewage effluent waste. There are various points where those concentrated waste streams could be mobilised and recycled. I think this has all sorts of opportunities in terms of financial benefits, prosperity, improving food and water security in terms of the circular economy. I think in terms of both nitrogen and phosphorus this really needs to come to the fore to improve the efficiency of our nutrient use.

Q20 **Anna McMorris:** Can I ask Professor Johnes, after what you explained, did you contribute to DEFRA's Clean Air Strategy that is due to be published later this year?

**Professor Penny Johnes:** No, I did not.

Q21 **Anna McMorris:** Moving on, you seem to be saying that we do need additional measures to reduce nitrate pollution. What should those be?

**Professor Penny Johnes:** One of the programmes I do work on for DEFRA is something called the Demonstration Test Catchments programme. This involves quite a large team of scientists at four major water catchments in the UK. There is the Eden, which is in Cumbria, there is the Wensum in Norfolk, each one selected to represent particular farming types. We are responsible for the Hampshire Avon, which is a chalk catchment, and also for the Tamar, which is down in Devon, in the rolling Devon hills and that type of grassland-based animal livestock production system. We have been looking at a whole range of different things that we might do.



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Some of them are relatively easy wins. If you imagine that we want to stop sediment leaving a field, or sediment and manure because it has livestock on it, one of the simplest things you can do in a field is simply move the gate to the bottom to the top of the field, because the water pours down the field. Water goes downhill. If you move the gate you do not have that ready access on to a road, where once it gets on to a road it routes down the road really quickly and straight into a watercourse, really quite simple measures like that.

Some of the stuff involves looking at separating what we call clean and dirty water on farmyards. Typically on a livestock farm you will have a lot of livestock wastes in the farmyard. Some of them will be in slurry fields, some will be in manure heaps, some will just be puddled around the dairy unit. All of those are managed by the farmer. If you can stop the rainwater dripping off the roof into the yard, and mobilising those fields and flushing the stream, you have a quick route to the—new gutters. Something as simple as new gutters can allow you to separate the rainwater from the rest of the material in the yard.

Some of it is really simple but the bigger challenge is where we starting saying we want to go beyond the little measures, because ecosystems in terms of how they respond to nutrient enrichment do not respond to small changes. They are quite elastic in their response. They can tolerate quite wide ranges of chemistry or physical stress in the environment. To tip them into a better state you need to be able to push things quite a long way. To do that you are starting to talk about reducing fertiliser use on the farm, you are talking about asking farmers, for example, to treat manures and slurries as a resource with nitrophosphates and carbon in them and not maybe as a waste product to dress on the surface of the land because you do not have any more storage capacity because it is expensive to build a slurry again.

You want the farmer to start developing a farm-scale nitrogen and phosphorus budget. A carbon budget would be great as well. We could do all three together. We can then start to look to drive up nutrient-use efficiency so that what we bring in at the farm gate in terms of nutrients is balanced by what we take out in our crops or we store within the sewer system. We reduce then the net loss. It is nutrients efficiency and I think we are looking for strategies to drive us towards developing those kinds of policies at the farm scale.

**Q22 Anna McMorris:** Thank you. Can I go back to what you were saying about Water Framework Directive and water quality, Professor Jarvie? The Water Framework Directive sets several targets for different water bodies, such as surface water, groundwater, bathing water. There are different targets, such as ecological and chemical targets, some of which you have talked about. Are we measuring the right things to improve water quality and nitrate pollution and, if we are not, how do we make changes there?



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**Professor Helen Jarvie:** Are we measuring the right things? Penny has mentioned that nitrate is one form of nitrogen. It is an important contributor to eutrophication. But, as I said before, it cannot be regarded in isolation without phosphorus. There are phosphorus standards as part of the Water Framework Directive supporting classification of good ecological status. There are not criteria for nitrate.

If we move to some of our waters that have protected status—for example the Natura 2000 sites, special areas of conservation under the Habitats Directive, special protection areas under the Birds Directive—as I understand, those can have their own locally designated nutrient standards that are appropriate to those waters of high conservation status. There is provision under that type of legislation for standards that are related to nitrate that are conversant with the requirements of those sorts of ecosystems. It is certainly true that there are not any standards for freshwaters. There are for coastal and estuarine waters, and a high proportion of the estuarine waters, I think it is 95%, are currently failing those. That is dissolved inorganic nitrogen, so that is nitrate, nitrite and ammonium.

Q23 **Kerry McCarthy:** There is probably some overlap with the questions that we have just asked, but I want to ask about monitoring. You have been talking about measuring and they are obviously very closely related, but can I ask, do you think there are any gaps in the monitoring of nitrate pollution at the moment? Professor Johnes and Professor Ward.

**Professor Robert Ward:** When we are looking at the groundwater system, most of the monitoring of groundwater is from the saturated zone, so we are looking at what has got to the groundwater. The measurement of the nitrate leaching from the soil below the crops is generally modelled data. It is quite expensive to measure the subsurface, which is why we use models. One of the key things is about maintaining a good dataset of water quality in the subsurface, and because of the long term of the lag time that I have described, we need to make sure that we can understand how things are changing over quite long time periods. In order to do that, we need good long-term datasets.

Obviously the discharge of groundwater to the surface is through public water discharge. They have a responsibility to measure their raw water quality. Again, that is very important, that they maintain and continue to do that, because that is one of the receptors effectively of nitrate, it is the exposure ultimately to humans and then there is the environment as well.

We were talking about standards and Penny said the Nitrates Directive introduced a 50 milligram per litre standard. That was the first standard that applied during the first cycle of the Water Framework Directive river basin planning, but since then, recognising groundwater discharges to groundwater-fed wetlands, and there are a number of those that are



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impacted due to nutrient concentrations in groundwater, they are being damaged because of that, then lower standards are being set in groundwater specifically to protect those wetlands.

We have multiple standards now or threshold values that apply for groundwater. One of the areas where we are not monitoring is at those wetlands. Again, we have used modelling, we are using other evidence to show evidence of damage that we believe to be caused by nutrient impact, but we do not have very good data to substantiate that, because there can be multiple reasons for a wetland being damaged.

**Q24 Kerry McCarthy:** This modelling is predicting on the basis of what you know, so predicting how things would change, whereas monitoring is going in and checking for yourself where things have changed?

**Professor Helen Jarvie:** Yes. You need a combination really. The modelling can bring evidence together to give you an overview or form an opinion about the condition of something. You can also use it to predict how things may change in the future when you change some of the variables, but what you really need is real data, real measurements, real monitoring data to help develop the models in the first place, but then to calibrate the models to make sure they are performing correctly and then validate them in the future. It is a combination of modelling and monitoring that is required.

**Q25 Kerry McCarthy:** We have been given the figures. I think Friends of the Earth Northern Ireland have said that the number of surface water monitoring sites in Northern Ireland has decreased from 622 in 2008 to 2011 to 156 in 2015, so 622 down to 156. That sounds like a pretty huge drop to me. Is that a cause for concern?

**Professor Penny Johnes:** Yes, there is a big debate around monitoring. I will give an answer in two parts, first of all to clarify what the limitations are for monitoring and then perhaps give some context to that statistic, if it is true, because I have not seen it myself.

In terms of the monitoring whether it is fit for purpose, it is not fit for purpose and we have been saying for decades that it is not fit for purpose. We have continued with our monitoring programme at quite a range of sites and there is a review coming up of English sites as well, so that will be coming forward.

**Q26 Kerry McCarthy:** Sorry, who is conducting that review of the English sites?

**Professor Penny Johnes:** The Environment Agency, I believe. We will hear more about that when that review comes to fruition. We carried on measuring the same things in the same way at the same sites and there are core groups of things that we measure. We measure nitrate and we measure ammonia and we measure phosphate, but we do not measure the other forms of the nutrients that are generating these impacts as well alongside, in tandem with these forms that we are monitoring for.



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Some of the information you have been given about fertilisers driving nitrate pollution, that is probably true, but if you are in a livestock farming area, the other nitrogen component is this organic and this particulate fraction. That is not driven by fertilisers so much as by manures. Livestock numbers have been increasing substantially and produced in a more intensive way, with all sorts of knock-on consequences for animal welfare, for example. We are not measuring those things that drive the system in those parts of the country that have livestock farming.

**Q27 Kerry McCarthy:** For clarification on that, as I know there have been concerns when there were planning applications for mega dairy farms a while ago, there was concern about the local environmental impact, about slurry entering the water streams. Are you saying that that is not sufficiently monitored at the moment and perhaps with the growth of intensive farming it is potentially an issue that is not being picked up?

**Professor Penny Johnes:** There are two things there. One is what the monitoring is at the site and the Environment Agency will be responsible for doing that, but it is also the chemistry that you are monitoring, because the dominant form of nutrients coming out from those types of waste is not nitrate. The dominant form is these other forms and we do not routinely monitor for it, but when we go out and do research, which is what we do, where we measure everything, we find that there is a very large amount of it. When we present that material to organisms in test tubes in the laboratory under controlled conditions, we then can see that there is a direct response, so we know that biota are using it.

That drives a whole range of problems, not just nutrient measurement; it also drives the microbes, because the microbes like nothing more than a good portion of organic matter, because it is what they feed on. When they do that, they consume the oxygen that is in the water body and that leads to this sag in oxygen status, which then can impact on fish. Helen has already mentioned this in the context of eutrophication. It is the same thing.

**Q28 Kerry McCarthy:** As politicians, it would be is that a risk? What is the harm that is potentially caused by not monitoring across the board?

**Professor Penny Johnes:** The harm that is caused is you get a very warped view about where the problem sits. At the moment, if you focus on nitrate, you think the problem is largely in the east of England, but in fact it is right across England and all the lowland areas. Wherever we farm intensively, the problem exists, it just exists in a slightly different chemical form. One of the problems with the monitoring is we are not measuring the right things. The evidence is quite clear, so there is no good reason not to do the right thing.

The other reason where we have a problem with the monitoring is it is very infrequent. I say that as a scientist. If you talk to our colleagues in other countries, they think of the UK as a data-rich country. We have



done monitoring for longer, for more things in more places, so when you want to run a model at a global scale, they come to the UK and they use our datasets and you can generate some really useful outcomes. But we are only monitoring at roughly a monthly frequency. Many of these fluxes that we have been talking about, the groundwater is slow, but when we have a storm event and we have soil erosion and the water is pouring on to the road, that happens over a matter of hours. If you are not out on the day that event happens, you can miss a really large chunk of material that is moving through your system.

If you look at what we call the uncertainties associated with sampling at that frequency, they are huge. You could be estimating your concentration at 75% below what it is or 500% higher than what the mean concentration is. They are not small errors. There is an argument, a scientific argument, that says maybe we should revisit what we do as a nation in terms of what we measure, where we measure it and how frequently we measure it and measure at fewer sites, given that we have budgetary constraints, but measure for the right things at a higher frequency. There is a tension there between those. Obviously what we would like to see as scientists is measuring more things, everything more frequently, but there are huge budgetary constraints. I do not know the rationale for the information you have given us from Friends of the Earth Northern Ireland, but that might well be a budget-driven strategy or it might be, "We only have X amount of money, so instead of doing lots of things infrequently, we are going to do it at fewer sites and do it in more detail".

**Q29 Kerry McCarthy:** Would there be a problem with the directives in terms of what we are required to do under that if we were to change our approach or do we have the flexibility?

**Professor Penny Johnes:** Is that not going to rather depend on what happens after Brexit and whether still subscribe to those directives?

**Kerry McCarthy:** Let's concentrate on what we can do at the moment, because everything else is up in the air.

**Professor Penny Johnes:** Yes, but some of that monitoring is targeted to directives and some is just because we have always done it. We need to be quite brave and say that the science community is telling us that we have a problem with what we are measuring, we have a problem with not having a complete evidence base, which is driving us to develop policy that leads to investments in say the water industry, which do not deliver what they are supposed to deliver in terms of ecological improvements. If we have a problem with the fullness of the evidence, we should be brave enough to say let's have a look at it again, let's have a strategic review and let's say, "What do we need to measure? How frequently, to be relatively certain, and where do we need to do it?" I think there is a need for that to happen.

**Q30 Kerry McCarthy:** I have two more quick questions. Hafren Water has



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called for assessment of nitrate pollution in watercourses rather than at catchment areas. Is that something that you agree with?

Then I also see from the notes that there is no general national lake monitoring programme. Sometimes lakes are covered because the rivers that flow in and out of them are covered, but generally speaking, there is no standard method or system for monitoring reservoirs and lakes.

**Professor Penny Johnes:** I am going to answer part of it and I think Helen, perhaps you would like to deal with the Hafren one. The issue in relation to lake monitoring is a traditional problem in the way in which we have approached the Water Framework Directive in the UK. I was the scientist who was working with someone called Professor Brian Moss—he died recently; he was at the University of Liverpool—who developed a lake classification monitoring scheme for what was then the NRA, the National River Authority, and is now the Environment Agency. Then the Water Framework Directive came in and kind of superseded it. Lake monitoring tended to focus very much on phosphorus. River monitoring, up to the point at which it went into the Water Framework Directive, focused on nitrates.

Q31 **Kerry McCarthy:** Is that a logical split?

**Professor Penny Johnes:** No, there is absolutely no good reason for it. It is just the way in which the monitoring was done. When we went into the Water Framework Directive, we had to quickly cobble something together. It is absolutely the case that we should be monitoring lakes. The problem is it is very difficult to do. If we look out of the window, you have the Thames, wherever it is—it is over there, we cannot look out of the window—and if I gave you a bottle this big and I told you to go and collect a representative sample of the Thames, I think you would realise just how difficult it would be to decide where to collect it. Do you have to take a boat out into the middle; how deep; at what stage of the tide or what stage of the day? You would get a different answer in that sample depending on where you collected it.

Lakes are three-dimensional spaces. They are incredibly difficult to sample. They have vertical variation as you move from the air/water interface to the sediment/water interface. Your chemistry changes, you get less light, your plant communities change. There are all sort of things that change beneath the lakes. That varies laterally across the lake and longitudinally along in the other direction. It is quite difficult to monitor lakes effectively. I will come on to the outflow of a lake.

Q32 **Kerry McCarthy:** Sorry, in terms of that, or any type of monitoring, is there not a scientific assessment of where the highest concentration of pollutants is likely to be in terms of if you are looking at what the risk levels are? Excuse my ignorance, I have no idea.

**Professor Penny Johnes:** No, you are absolutely right.

**Kerry McCarthy:** I just wondered, are they more likely to be down at



the bottom or at the sides or somewhere?

**Professor Penny Johnes:** No, you are absolutely right. It rather depends on the pollutant, so if you were looking at phosphorus, a lot of that phosphorus will come in in the winter months and then it will drop down to the bed sediments of the lake. If you wanted your highest concentration of phosphorus, the chances are you would find it a couple of centimetres above the sediment. But if you are looking at something that is coming in, supposing your lake is driven by the atmosphere, by a deposition of nitrogen from a local poultry farm, for example, then your highest concentrations are likely to be in the upper levels of the water. If your pollution problem is because you have a sewage discharge coming from a town near the lake, it is going to be around the pipe. It is going to vary, so it is very variable.

There are strategies that you can use. There is no reason not to do it, but you need to think about lakes in a slightly different way than rivers, which effectively channel all the water to a point at which can collect your sample, unless the river gets too wide.

**Professor Robert Ward:** Can I just say something about groundwater as well? Again, that adds complexity because you need to monitor groundwater or water that is contained with a rock matrix, so you have to access that by drilling boreholes. Just picking up on your point, high risk and high concentration do not necessarily mean the same thing. Your risk may be potentially greatest at a public water supply, but you do not want to just monitor there if a problem, a pollutant, is migrating or moving towards that through the subsurface. You want to be monitoring in a location that allows you to take action before it reaches the receptor, be that a public water supply well or a wetland or an ecosystem. It is about designing the monitoring accordingly to move the objectives you set.

Perhaps I should say that before I was the Geological Survey, I was at the Environment Agency and I worked on supporting the Environment Agency implementation of the Water Framework Directive, particularly the groundwater aspects and also helping us influencing the European guidance around implementation. For groundwater monitoring, the European guidance for groundwater monitoring, which is embedded within the technical guidance and the Water Framework Directive itself, is strongly influenced by the UK. It is a risk-based approach and we have done pretty well in the UK at implementing it, but I would say we are only just meeting the requirements for groundwater and any further reduction in the amount of monitoring we do for groundwater will probably bring us below the threshold that the Water Framework Directive or the European Commission would require.

Q33 **Kerry McCarthy:** Were you going to come in on the watercourse catchment issue?

**Professor Helen Jarvie:** Yes. I am not quite familiar with how this came about, but I think maybe it is in relation to the importance of within water



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body processes and particularly within river processes, which we have not really touched upon yet, but rivers provide a vital connectivity between the land surface and receiving water bodies like lakes and estuaries, but an awful lot of processing of nitrogen goes on within the river. Rivers can be incredibly efficient at retaining nitrogen in terms of assimilation, uptake into growing plants, which we have talked about in relation to eutrophication, but also microbial processes of denitrification. That is a permanent loss of the nitrate, which is converted into nitrogen gas, which is lost to the atmosphere.

You can see big changes in the flux of nitrate going along watercourses, so things like the water retention time, meandering and that sort of thing and hydromorphology of a watercourse can play a really big impact in terms of how efficient that watercourse is in terms of cleaning up some of the nitrate before it ends up in a receiving lake or estuary. I wonder whether that is a sort of driver for that particular question.

**Chair:** Thank you. We are going to move along now. Colin.

Q34 **Colin Clark:** We have received evidence from some organisations who also highlight the importance of phosphates. The Ulster Farming Union, who we heard from before, for example, states that, "Nitrates in waterways are not a significant problem in Northern Ireland; however, more action is needed on phosphates". Would you agree with this across the UK?

**Professor Helen Jarvie:** I will go first. We have mentioned before the eutrophication, the ecological problems driven by nutrients, relates to the availability of carbon, nitrogen and phosphorus and the availability of those in relation to the demands of the growing plants and algae. We talk about limiting concentrations and as a rule of thumb, phosphorus is generally the limiting nutrient in our river systems. Not everywhere, it tends to be more in lowlands. There can be nitrogen limitation in the uplands. The limiting nutrient is the one that is most likely to limit the growth of nuisance algae if the concentrations are sufficiently depleted. You get your biggest bang for your buck by going for one of them. It will be the limiting nutrient, because it will get you below that limiting level.

In a lot of freshwater systems, phosphorus can be the limiting nutrient, but not always. Certainly CEH's work on lakes has shown that even in upland and lowland lakes, nitrogen is as much of a limiting nutrient as phosphorus and when you move to some of the cleaner headwater systems, nitrogen can be a limiting nutrient. It depends from place to place. Certainly in many areas phosphorus is the first target, but certainly, in our opinion, you need to be considering nitrogen and phosphorus together and looking at ways to reduce both.

**Professor Penny Johnes:** Just to clarify where that may come from, the focus on phosphorus as a limiting nutrient is often based on calculation of what is known as the Redfield ratio. Redfield did some research in 1954 and collected some marine phytoplankton off the Chesapeake Bay coast



and took them into the laboratory and worked out what was the optimal amount of carbon to nitrogen to phosphorus to make them grow. That ratio for a single species of marine phytoplankton has now become applied across all sorts of domains, environments it was never suitable for, for groups of biota that do not acquire nutrients in that way and therefore is often wrong.

For example, if you would like to imagine a freshwater ecosystem, you have your phytoplankton growing usually at the top of the water column, because that is where the light is, and they have to take their nutrients from the water column. If you collect your water sample and you measure how much nutrient is in the water sample, that will be a fairly good indication of what the phytoplankton can get hold of and you could calculate the ratio of that. But if you are looking at the plants, because they are also part of the ecosystem, they are growing with their roots in the sediment and they do not care about what is going on in the water column because they cannot acquire their nutrients that way; they take them through the roots. If you are the microbes, you are living on the surface of their sediment, you do not care what the phosphate concentration is a metre above you, because what you are using is what you are growing on. That is why you are growing there.

When you look at whole ecosystems and you look at whole ecosystem nutrient acquisition strategies, you tend to find that any one part of the ecosystem at any one point of time may be limited by any one of the nutrients or by light or by the rate of flow through the system or if you have a lot of sediment running through the system, it can act like sandpaper, so it can sand the fish, which will usually swim away, but it will sand away at the plants and the plants become very fragmented. Lots of different things drive the ecosystem; this multiple stressor is the really important thing.

I would not agree with the statement from Northern Ireland. I would suggest that you look at all of it, otherwise you will continue spending money on going after that single bullet and it will not deliver that outcome that you are looking for.

**Q35 Colin Clark:** The Ulster Farming Union, thinking back to my farming roots, they are concerned about phosphate because it locks up other nutrients in the soil. Is that maybe where their thinking is coming from?

**Professor Penny Johnes:** It might be, because one of the major sources of phosphate that arrives in the water bodies comes from sewage works. There are two major sources. If you have arable land, you have exposed soils in the winter, you will have soil erosion and you have this particulate phosphorus coming in and that drives part of the problem, but a lot of it comes down the effluent pipeline from the sewage works and then of course there is the Urban Waste Water Treatment Directive through the EU, which requires us to reduce the amount the phosphorus coming out of sewage in treated effluent to a specific standard. It is quite



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easy, in relative terms, to do that, to address a point source coming down a pipe that you can identify.

It is much more difficult to deal with phosphorus coming from the wider environment, because when you collect your sample of water in the water body and you say, "Where did my phosphorus come from?" it is very difficult to unpick that. It could come from any one or all of the farms in the landscape. By going after phosphorus, it tends to be going after the water treatment process. There is no reason why we should not do that, because it is part of the problem, but it does not excuse dealing with phosphorus coming from farming and dealing with nitrogen coming from all of those sources, those diffuse sources, in the landscape as well.

- Q36 **Colin Clark:** With more houses in the countryside and more septic tanks, a lot of them not operating properly, you were speaking about detergents earlier. There is quite a lot of blue water coming from septic tanks, which was never really supposed to happen, was it?

**Professor Penny Johnes:** Septic tanks are the traditional way. They would have been cesspits originally, a hole in the ground. As I bought a house in a chalk environment, the guy who was selling it to me said to me, "It is fantastic, it just disappears" and I thought, "No, no, no, it really doesn't just disappear. It goes somewhere and what it does is it goes into the rock and it goes into the stream, but it does not go". They are the traditional approach, but the problem you have is that where you have a large sewage treatment works with more than 10,000 people or population equivalent attached to it and it comes under the terms of the Urban Waste Water Treatment Directive, you can implement industrial technology to strip that phosphorus. It usually involves pouring the phosphorus-rich effluent through a tower full of iron-rich sand and it binds on to the iron and it strips it out. It is very efficient.

You cannot do that with lots of dispersed septic tanks and that is why they are a problem. They are often a problem because they are usually prevalent in environments that have relatively low population density and are farms, so they are contributing to this problem that we have in these environments.

- Q37 **Colin Clark:** Just to add on to that, would measures that tackle nitrogen pollution also tackle phosphate pollution to some extent?

**Professor Penny Johnes:** Sometimes. The problem you have is sometimes they will and you will get both of them. This is this win-win situation. If we said we want to reduce fertiliser application rates by 20%, that would hit both. If we implement a measure that says we are going to increase the efficiency with which the crop takes nutrients up, then we can hit both at the same time. One of the classic ones was the shift from whether you had winter wheat or spring wheat, because you had this there in the winter or not. One of them favoured nitrate removal or reduction of nitrate loss and the other one favoured phosphorus and



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drove the other one out. That was where the two would not be synchronised and you would not get the win-win.

Q38 **Colin Clark:** The take-up of nutrients by plants is amazingly inefficient.

**Professor Penny Johnes:** Yes, it is massively inefficient, but it can be improved. There are all sorts of really interesting ways in which you can do that. There is novel technology, where instead of just broadcasting fertiliser across a field, we have now robotic systems that go through the field and they use sensors to measure the nutrient need of the crop and then apply the fertiliser only in those areas. That is much more efficient way of doing things. There are technological solutions that we could bring to bear.

**Chair:** Three farmers in the room, so the questions are coming thick and fast.

Q39 **Mr Robert Goodwill:** Obviously many farmers are using slurry or farm manure or indeed some organic farmers are using no inorganic fertiliser at all. Is it more difficult to spoon-feed the crops if you are using those inorganic sources of nitrogen or is it that the soil has a better body to it and holds the nutrients better?

**Professor Penny Johnes:** No, because there are ways in which you can inject these into the soil, but you have to do it in a targeted way. You could certainly develop technologies to do that. I think it would be less easy than dealing with an inorganic fertiliser, but the advantage of using some of the manures and slurries of course is that then meet your crop needs in terms of other nutrients that they also need in order to grow healthier. They have carbon, they have nitrogen, they have phosphorus and they have a suite of these micro-nutrients in them. The disadvantage can be that they can also have pharmaceutical by-products. You have veterinary pharmaceuticals in many of these livestock wastes.

If you are looking at sewage sludge, you have a whole range of other toxins that could be in there that are going into the food production system. It requires thinking about, but I am sure that there are solutions. I think the most important thing is that you do not double-dose. In many farming systems where we work, our biggest problems is we have fertiliser applications calculated for the crop and an extra 10% on top just to make sure, so we already have an excess, and then the manures and slurries are applied in addition to that. We are then well in excess of the crop nutrient need and that is where there is a problem. That is just about nutrient budgeting at the farm scale.

Q40 **Mr Robert Goodwill:** Usually it is the fields nearest the farm buildings that get that special treatment.

**Professor Penny Johnes:** Yes.

Q41 **Mr Philip Dunne:** I am very conscious that you have engrossed us so much that we have rather overrun the allocated time, so I will be quite



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quick. We have touched on international comparators a little in some of the answers you have given, but not many. I would just like to focus on that for a moment. Am I right in thinking that NVZ regime, which was introduced across Europe, relates to river catchments primarily and it is looking to improve water quality through the river systems?

**Professor Robert Ward:** Also groundwater as well, so those areas of the country where groundwater is vulnerable to nitrate leaching and nitrate pollution are also designated NVZ. We have surface water and groundwater NVS and in some cases obviously they are coincident.

Q42 **Mr Philip Dunne:** All of the four nations of the UK have been criticised by the EU for not meeting standards, but as have a number of other countries. Would you like to give us a perspective on how we are doing relative to other countries in the EU?

**Professor Helen Jarvie:** The European Environment Agency has published data on just the average river nitrate concentrations right across Europe. The UK certainly sits right at the top end of those. I think one of the things that is really quite staggering is the levels of reduction that some countries have achieved. Within the UK over the last 20 years, our average nitrates/nitrogen concentration has maybe gone down about a milligram per litre from maybe about 5 milligrams of nitrogen per litre to around about 4. That is where we were sitting in 2012, when they last published the data. But if you look at some of the other European countries, Denmark is one that really stands out, the reductions have been absolutely staggering. They have gone from around about 7.5 milligrams per litre of nitrogen down to about 3.5, so there is more than a halving of nitrate concentrations.

Q43 **Mr Philip Dunne:** Is that in river water?

**Professor Helen Jarvie:** In river waters, yes. As I understand it, there have been some fairly strict measures that have gone in, particularly in Denmark and some of the Low Countries, where there is a very high intensity of livestock farming, so an awful lot of these organic manures and wastes and slurries are produced per unit area. As I understood it, one of the restrictions has been to reduce applications to below the crop optimum, which has obviously forced other ways of dealing with some of these slurries, which clearly has important implications in terms of recycling and recovery of products, but clearly has some costs in terms of production of arable crops if you are fertilising below the crop optimum. There are some interesting trade-offs, but certainly in terms of river water quality, there have been some very dramatic reductions.

Q44 **Mr Philip Dunne:** Have there been any comparisons done in other things? In the groundwater area, for example?

**Professor Robert Ward:** As I understand it, we have seen improvement in Denmark in the surface water, but for groundwater it is not the same. Denmark has a very similar problem to the UK in that the lag time has resulted in a failure to achieve environmental objectives under the



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Nitrates Directive, under the Water Framework Directive. It has initiated research to demonstrate that the lag time exists and is the reason for failing to achieve these objectives, but it has applied it a slightly different way to the UK in terms of how it has gone about the research. BGS has published research work that shows the “nitrate time bomb”, as we call it, that peak moving through, in a way, but it has done an equivalent study. We have the same issues there with respect to groundwater.

- Q45 **Mr Philip Dunne:** Denmark has given us an interesting illustration of how well it has done in reducing it, but, as one of the most intensive countries in Europe for agriculture usage, it started in a much worse place than we did. Is that right, or not?

**Professor Penny Johnes:** No, that is not true.

- Q46 **Mr Philip Dunne:** You have us the 7.5 in the ground, compared to our 5.

**Professor Penny Johnes:** Yes, but in terms of the total nitrogen that would not be true. It has a very sandy soil system, it has a lot of arable production as well, and then it has these intensive pig-rearing units and so on. No. If you look at the total nitrogen statistics across Europe, the UK is right up there at the top.

- Q47 **Mr Philip Dunne:** Are we able to get some statistics comparing the total? I think ours relate to river water only. It would be quite useful if there are some.

**Chair:** We have just had some of that evidence in from the European Environment Agency today, and we would circulate that. There are some very useful graphics on that.

**Professor Penny Johnes:** I would also recommend the European Nitrogen Assessment. It is available freely to download online. That was produced by the big community of nitrogen scientists across Europe, and the stakeholders in the industry were involved, and there are a lot of data available in that that have been collated together for the first time across Europe. If you are looking for Europe-wide trends, that is a really interesting one to go for.

- Q48 **Mr Philip Dunne:** The last question is about what other countries are doing to help reduce nitrate pollution, measures that are successful, which are not doing, which we could be doing. Germany, for example: the entire country is designated as an NVZ, as we do, I believe, in Northern Ireland but not in the other three nations. It has also compensated farmers for implementing groundwater protection measures, which I think we do to a small degree through EA grants. Do you have any things that stand out to you that other countries are doing that we ought to?

**Professor Penny Johnes:** I would like to offer comment in relation to the NVZ designation. It has never made any sense that we have cherry-picked bits of the UK. Nitrate leaches in all environments, every single one—even in Snowdon, nitrate will leach—so there is no reason to



suggest that there are only certain areas that are vulnerable to nitrate movement. The German approach was quite pragmatic. I think they felt they could not cherry-pick and, therefore, they would just do the whole thing.

If you think about the evidence that Robert has informed you of in relation to reductions in nitrate moving into those areas, particularly in those NVZ areas in relation to measures, it shows what could be achieved if that had been rolled out or is rolled out across the rest of the UK. That would be the first thing.

In terms of the specific measures, the system that I am familiar with in Denmark is the one where they have fertiliser accounting. It is moving towards this idea of a nutrient balance per farm. Can you achieve the balance between what you bring in and what you take off in crops and food and feed and export to other systems, and you leave your system in balance so that there is very little left to leach away or to volatilise to the environment or to contribute to ecosystem damage? That type of system is the one I would like to see us thinking about developing, something like that, for the UK.

**Q49 Mr Philip Dunne:** You can do that more readily where you have very traditional mixed farm enterprises. If you have a farm that is very specialised on one thing, it may be more difficult.

**Professor Penny Johnes:** There are a number of big programmes going on. Defra has been funding something called the Sustainable Intensification Platform, the idea being: how can we increase food production? Some other scientists, like me, think we should not. They are trying to see: can we do that, and what kinds of mechanisms do we need to put in place in order to deal with precisely what you have said? Can you develop trading partnerships? You have a poultry farm that has no land. That would be typical somewhere like Norfolk. Then you have those vast grain barons, with these huge estates, which are producing nearly only grain, and they have relatively low carbon in their soils, and they are losing carbon at a very high rate. That is another problem that we need to deal with as well.

Can you develop a trading relationship between those farms, a collaboration in which those manures are dressed to the land in an appropriate way as part of the farm scale budget? There is a lot of interesting information now coming out of that, and it is called SIP, the Sustainable Intensification Platform, and it is one of Defra's flagship programmes.

**Chair:** Fantastic. Thank you all very much for explaining it quite slowly, sometimes twice, and we wish you a very safe onward journey back to your homes. Thank you very much.

Examination of witnesses

Witnesses: David Johnson and Will Andrews Tipper.

Q50 **Chair:** Can I welcome our second panel, and can you introduce yourselves from my left to right, please?

**Will Andrews Tipper:** I am Will Andrews Tipper. I am Head of Natural Environment at Green Alliance. We are an environmental think-tank.

**David Johnson:** Hello. I am David Johnson. I am a hydrogeologist and a chartered civil engineer. I am Director of the Rivers Trust, and I am representing Wildlife and Countryside Link.

**Chair:** Thank you both very much for being with us today and for the evidence that you have submitted.

Q51 **Kerry McCarthy:** Is current policy currently tackling all sources of nitrate pollution, or are we focusing a bit too much on nitrate pollution from agriculture?

**David Johnson:** We agree that there is a gap in terms of the urban nitrate, but the sources of urban nitrate are quite complicated, so it is very difficult for me to see—I have thought about this question before I came, obviously—how we would control those. The only way we can see that you can control those is through a partnership type approach, where you work with the local catchment, the water company, the local authority and so forth in order to identify the multitude of different sources and gradually manage them down. We have examples of where that has happened in urban areas. Yes, I agree that most of it is targeted at the agricultural end, but the urban end is more complicated.

**Will Andrews Tipper:** I would agree. Yes, almost all measures focus on agriculture, but, nevertheless, agriculture remains the biggest source, certainly with regards to water impacts, so it is appropriate to focus there.

Q52 **Kerry McCarthy:** On that point, then, do you think the 25-Year Environment Plan and the New Farming Rules for Water, which come into effect 2 April, cover this issue adequately? Could it be improved, basically?

**David Johnson:** I think it could be improved. There is a twin-track approach to dealing with the issue. The first of that is regulation, and the second part of it is partnership. The regulation is the 25-Year Environment Plan, the Nitrates Directive, and so on. That is capable of reducing nitrate concentrations but it will not achieve the ecological standards that your panel was talking about earlier on, nor will it achieve drinking-water standards in some places. It is a good practice level that we should aim for but it will not give us those high levels of quality that we need for drinking-water and the ecology.



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The issue we see with that regulatory approach at the moment is enforcement. We see that there is not enough enforcement of that condition, and that is really important because that enforcement supports the second part of the approach, which is partnership. The partnership approach can really thrive where there is a good baseline of enforcement, and the partnership approach is what gives you the step-change in nitrate reductions that the water companies want in order to supply the drinking-water and that the ecologists want in order to supply the protected sites.

In terms of the partnership approach, Defra started the partnership approach in 2013 and supported it, called the catchment-based approach, and it is that type of approach that brings together multiple organisations—water companies, local authorities, farmers and so forth—to identify the “win-wins” that Professor Johnes was talking about in particular catchments. That is the two-track approach that we see.

**Q53 Kerry McCarthy:** When you have that partnership approach, is there then a problem as to working out who is taking the lead, who is in the driver’s seat, who has ultimate responsibility? I know when there were the floods a few years ago it was one of the problems there in that there was some really good partnership work at a catchment level to try to stop flooding happening, but when things went wrong it was a little bit more difficult to know whom to hold to account.

**David Johnson:** That is absolutely right. There are 106 catchment partnerships across the country, and the ones that are flying at the moment are the ones that have developed a common understanding of the issues within their catchments. They are the ones that are driven by data and evidence, and where those different parties have come together and gone, “Okay, that is a coherent picture of where the issues are in our catchment”. Those are the ones who, as soon as they get to that point, it is much easier for them to go, “We have a common understanding. These are the things we can do about it. How are we going to move forward?” You can see that happening in some catchments where they are really driven by the evidence.

**Q54 Kerry McCarthy:** Where are the best examples?

**David Johnson:** A good example of regulation working well with a catchment-based approach is in the Lugg catchment, where the Environment Agency targeted regulation, and that then enabled the farmers who were not engaged beforehand, who wanted to work then with the local Rivers Trust, to improve the water quality. It is both things working together.

There are lots of other examples where it is water companies working with the catchment partnership. In some existing projects I am doing, they want to identify where they can reduce nitrate, but other members within the partnership are interested in reducing flood risk. Then you are looking for those two benefits, or three or four benefits, as you go.



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- Q55 Kerry McCarthy:** Can I ask about whether you feel that the agricultural industry is doing enough? In the 25-Year Plan, they talk about the fall since 1980 of ammonia emissions by 10%, so that is since 1980, but I think figures show that there was a rise of more than 3% over the years 2015 to 2016, which rather suggests that the trend has quite sharply reversed. They say that is mainly due to slurry and the use of fertiliser on farms. Is that something we ought to be worried about and do we need to step up a gear in terms of tackling it?

**David Johnson:** There are two levels that the agricultural industry can go to. If you go to best practice, then that still will not deliver some of the improvements that we need, but at that point we believe that the polluter-pays principle stops. If you want improved water quality over that, that is where the farming industry needs to be supported to make those changes. That is one of the reasons why we are bumping up against a ceiling, because there is only a certain amount you can do up to best practice. It still will not get us to the right point. We have to provide additional support to the farming industry where we want them to take, for example, sub-optimal fertiliser applications and so forth. If I were a farmer, I would not want to damage my business for no recompense.

- Q56 Kerry McCarthy:** Is that something that was the general thrust of yesterday's command paper, on using public money for public good? Do you think that potentially we could be supporting farmers who are trying to move in that direction?

**Will Andrews Tipper:** It has the potential to. I just echo a number of points of David's, particularly about the fact that even complying with good practice, best practice that meets legal standards, will not be sufficient to address the ecological need that was outlined by earlier panellists, and the importance of partnership working in helping farmers to go beyond what they are required to by law.

That was really the thrust of the evidence that we submitted. We think there should be scope for water companies and farmers to work together more than they are, but also to work together in different ways. There is a limiting factor in timescales, if nothing else, of the projects that it is possible to support. Water company investments are counted over decades in terms of their return periods, but that is not as easily applicable to catchment management methods, and it is very hard for catchment management, which works with much more natural processes in the way that David was talking about, to deliver reductions in nutrient application. That has to be justified over a five-year cycle, but if you can find ways to take a longer-term view and find ways to displace what can be millions of pounds' worth of water company investment into nitrate removal, then you could have a lot more money available to support farmers in maintaining thriving agricultural businesses, which are not just being managed for ecosystem services, but which go further than we might otherwise do in reducing emissions of nitrates to water.

- Q57 Anna McMorris:** Several organisations submitted comments around the



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lack of resources of the Environment Agency and lack of enforcement of cross-compliance rules by the Rural Payments Agency. Would you agree with this?

**David Johnson:** Yes. We think it is really important. I cannot comment on whether they have enough resources, but the resource is not being put into enforcement. I can certainly say that. Enforcement is so important, because if you are trying to work with one farmer, but the next-door neighbour is not coming up to good agricultural practice, you end up with a non-level playing field. It is very difficult then for the partnership approach to really flourish. That enforcement is a really important part of the picture.

Q58 **Anna McMorris:** Do you think that is the case in the devolved nations as well, with Natural Resources Wales and Environment Agency Scotland, or are we just talking about England?

**David Johnson:** My understanding in Scotland is that they had—I cannot remember what the rules were called—a three-strikes-and-out process for regulating the farmers. They went in once and gave them a warning. What happened was they ran out of resources before they could get to the third strikes. That is what I understand in Scotland. It is potentially very resource-intensive to do that sort of regulation, so you have to target it where there is the highest pressure and the known issues.

There is the example I gave you earlier: they knew there was an issue in a particular catchment, they targeted the enforcement there, but you have the separation between the regulator and the partner. The regulator can come in and say, “We see there is a problem. Will you work in partnership with these other organisations?” That is what drove the change.

Q59 **Anna McMorris:** Without having the appropriate teeth and enforcement mechanism behind it?

**David Johnson:** The teeth are there from the regulator. It is a vital part of that picture. You have to have the teeth.

Q60 **Anna McMorris:** Yes, but you are saying the EA does not have the resources then, rather than does not have the teeth?

**David Johnson:** Yes, it has the teeth, definitely, but it does not have the resources. Sorry.

**Will Andrews Tipper:** Just to add to that, I think that could become arguably even more of a challenge as we go through the process of regulatory simplification as outlined in the farming command paper, simply because if there is a reduction in inspections—let us say at a time when regulation is changing—it will become harder to pick up on problems, which there will inevitably be as a new system is introduced. There is scope for that to become even more of a problem than it is now.

Q61 **Anna McMorris:** What would you both say is needed for an effective



compliance regime to be set up?

**David Johnson:** There needs to be a very clear policy from the agency on what it is going to do. If it sets out a clear policy with the consequences so that it is going to regulate in a particular way and then it goes ahead and does it, that is what you need. You have to accept that it will not be able to do it everywhere, so it will target and move its resources around. That would then send a very clear message, “We have teeth and we are going to use them, up to good practice, but we will also support this second part of the approach to help you. We do not want to go to enforcement unless we absolutely have to”. I think it is possible.

**Will Andrews Tipper:** That is right. One of the challenges I think will occur in the system is it is very much compliance-driven. There are no upsides really available to farmers who wish to go further unless they take quite a long-term view of what good environmental stewardship might mean for the long-term productivity of their soils, for example. Finding ways in which there can be a financial upside from low-input farming, for example, which could help go beyond a regime that is a purely compliance-driven, is going to be necessary if we are to not only meet legal targets but go some way towards addressing the ecological need.

**David Johnson:** I have thought of something as well. Some of the farmers that I have been working with over in the east of the country, one of the things that they said was that removing the threat—I cannot think of a better word—of regulation reduces their paperwork enormously and is a real bonus to them. That is a place where we could go quite easily to say that for farmers who are working in partnership with the local water companies, with the local catchment partnership, there is no point in regulating them because we already know they are trying to take on their responsibilities. That is an instant win for them in terms of reducing that regulatory burden and the concern of having an agency person coming down the drive.

Q62 **Anna McMorris:** Carrot, rather than the stick?

**David Johnson:** Yes. We want both, but carrot will get a lot further a lot quicker.

**Will Andrews Tipper:** Carrot is lacking, I think. I would agree the stick is, too.

Q63 **Anna McMorris:** What role does the Environment Agency—or, in Scotland and Wales, their varying agencies, NRW, Environment Agency Scotland—need to play for water companies?

**David Johnson:** For the water company, typically, if we are talking about nitrate, it is a groundwater issue more, which is the study I was doing over in East Anglia. The Environment Agency can only get to a certain point. I interviewed various Environment Agency people when we were looking at this area, and I keep on saying the same thing, I am



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sorry: all they can do is the advice, but it only takes them so far. The only thing they can really do in terms of the water company is support that second tier of the approach.

I experienced it quite a lot with water companies getting frustrated with the NVZs because they did not deliver the water quality that they needed. Even if they were regulated to within an inch of their lives, they would never provide the water quality that the water companies deliver. All the agency can do is support the partners with the evidence and so forth that they need to work with water companies. That is the best thing, I think.

**Will Andrews Tipper:** Yes. Exactly as you say, in a very pragmatic way, better information sharing between the Environment Agency and water companies could be extremely beneficial. I have heard anecdotal frustration from water companies that they do not know everything the Environment Agency knows, and they might behave differently if they had access to all of that data. That could be a relatively simple, straightforward but quite effective way of supporting water companies.

**David Johnson:** That has got a lot better over the last couple of years. The agency has gone to open data. It has really led the way, and it is really sharing data. I have been very involved with it, and it is fantastic what it is doing now in terms of sharing data. Data and evidence are really important in terms of driving change.

Some of the skills within the agency, the science skills, the analysis skills, that is the next step in providing those to the catchment partnerships so they can really interpret the data and see what they can and cannot do. That could be useful as well. The Environment Agency is part of the catchment partnership. It is an integral part of it, so those skills exist there already.

Q64 **Anna McMorris:** Do the water companies listen to what the Environment Agency is saying?

**David Johnson:** Yes, absolutely. The water companies have business plans that are about trying to minimise their treatment costs. If they think there is a way of reducing the pollution so that they have lower treatment costs, they will listen to that. The frustration they have had with the agency is the fact that the agency can only take them so far, and that is where it has come to at the moment. If, as you say, the data are provided and so forth, they will listen to the agency in terms of the next steps.

There is lots of evidence there that can be used to improve water quality. It has been collected over the last 30 years, and water companies are using that. There are a number of them around the country starting to do so.



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**Will Andrews Tipper:** Also there is scope for the Environment Agency and water companies to share information on probably a broader set of environmental indicators, rather than, for example, water flows or the presence of particular substances in water. Some of the work that water companies are doing on natural capital accounting and natural capital approaches would absolutely need the support of all the regulators in order for that to be able to be translated into investment in business plans, and I think there is scope for that relationship between water companies and the Environment Agency and ultimately Ofwat to be a bit more effective in terms of what they are looking at.

Q65 **Chair:** Before we move on, can I just ask you about Natural England, which in 2012 developed diffuse water pollution plans to improve 39 sites, and the Environment Agency has failed to publish any of these plans? Do you know why that might be?

**David Johnson:** No, I do not.

Q66 **Mr Robert Goodwill:** On the subject of carrots and sticks, we already have a number of sticks out there. If farmers do not meet cross-compliance requirements to get their farm payments, they can be penalised; or indeed, if they wish to engage in some enhanced environmental schemes, they get additional rewards coming their way. Mr Tipper, you suggested a natural infrastructure scheme whereby the private sector will pay farmers for the delivery of a service and for avoiding cost. How will that be different from the current catchment management approach that the water companies have?

**Will Andrews Tipper:** Different in several ways. One of the most important differences would be if it were contractable on the basis of outcomes, so that there is a greater share of risk between the buyers, the water company, and the sellers, farmers. That would be quite a significant difference. Agreements would need to be over a longer period of time, which is the point I made at the start of this discussion.

For catchment management schemes to be interesting financially for water companies, they need to believe that it could save them a lot of money from avoiding the need to build nitrate removal plants, which are extraordinarily expensive. For that, they need to have a very high degree of confidence that the reductions in nitrates they think they are buying will be delivered. How you do that will be very different in different parts of the country, but schemes such as EnTrade's have shown that it is possible, albeit for surface water, not groundwater currently.

Outcomes-based contracts, some better degree of risk sharing between farmers and water companies, and longer-term agreements I think would be probably the three principal differences.

Q67 **Mr Robert Goodwill:** Would it be practical to apply the polluter-pays principle in this case? If agriculture in an area is deemed to be responsible for high levels of nitrate, could that in some way be



implemented, or would that be too difficult to attach the blame to any particular farmer in a catchment area?

**Will Andrews Tipper:** In regards to our scheme, we have conceived the concept as a means of going beyond compliance. We would not envisage paying farmers to comply with the law. The challenge is how farmers can be rewarded for doing more than the bare minimum. That is really the space that we are trying to play in. There is a discussion as to whether the existing standards could do with tightening or extending or being enforced differently, but we have not taken a view of that in that publication.

Q68 **Mr Robert Goodwill:** Would that be a blanket approach across the country, across the NVZs, or just in specific areas where there was a problem that needed to be addressed?

**Will Andrews Tipper:** I think it would have to be very locally specific in terms of the ability of a natural infrastructure scheme as we proposed it to be feasible because, for all sorts of reasons, you would need to know very much as you have said, that by reducing, for example, fertiliser application in a location, you would be reducing nitrate concentrations in a surface water body, in an aquifer. Your ability to predict that will vary, depending on local geology and local hydrology. We think it is absolutely possible but it would not be universally true.

**David Johnson:** We absolutely agree polluter-pays works up to good following practice, and then beyond that, that is why you pay for the difference. It would be far too expensive to do that everywhere, so you do it where it really matters, and you decide that for source protection zones, for groundwater or for a drinking-water source or for a particularly sensitive ecological site. That way, we spend our money wisely, targeted at where it can make the most difference, that extra spend for public good. That is how we—

Q69 **Mr Robert Goodwill:** It might just be an idea to give the farmer a grant to build a better slurry store so that he can store for longer and apply at more optimum times.

**David Johnson:** I believe that slurry storage is a part of national infrastructure to make sure that we use nutrients as well as possible. I believe that farmers should be supported to build them because it absolutely allows them to make the best use of the N and P within their manures. Yes.

Q70 **Mr Robert Goodwill:** To go back to Mr Tipper, can I ask how this will fit with the natural capital approach, which is something I have not quite got my head around, personally?

**Will Andrews Tipper:** Yes. It is quite different, the reason being natural capital approaches are based around valuing ecosystem services. There are many different ways and methodologies for calculating that. We absolutely, fundamentally support development of those approaches, but



it is very difficult to turn theoretical natural capital values into money that would compensate a farmer, or potentially not compensate a farmer, for not producing food on that bit of the land.

Our approach has been a bit more pragmatic to look at where the impacts of land management on water are currently creating costs for organisations. Water companies, with regard to water quality, but all sorts of infrastructure sectors with regard to flood risk, whether it is Network Rail, whether it is Highways England, whether it is local authorities, whether it is private manufacturing facilities. Our concept is all about looking at how much money is already being spent managing water quality problems and flood risk, and seeing if there is potential to divert some of that existing spending to support more environmentally sensitive land management. It is not about theoretical values. It is simply about diverting existing spending for a different purpose.

**Q71 Mr Robert Goodwill:** Just turning back to Mr Johnson—and this may relate to the slurry storage we were just talking about—what is your opinion on the natural infrastructure scheme? Is this something you would support?

**David Johnson:** Yes, broadly. We do support it. Elements of it are already being used, aren't they, in terms with the water companies paying for catchment management? What we are talking about here now is widening it so that we align more sources of money, get a greater bucket of money to spend on the environment. That is the really exciting part of it in terms of making that step-change.

One thing that has happened over the last year or so that I think is a really interesting development is to see large corporates and the way that they are starting to incorporate water stewardship into their pricing models, into their supply chains. Again, that is a way of adding money into this pot to manage the environment for specific outcomes in specific places. That seems to me really exciting.

In order for that to really take off and flourish, there needs to be this honest broker who is bringing all those parties together and trading off the benefits so that we get the maximum benefit for floods, for water quality and so forth. That is what we need for this to really flourish and fulfil its potential, which is part of this school of approach.

**Q72 Mr Robert Goodwill:** During Lord Turner's evidence session, he just dropped into conversation the prospect of a nitrogen tax or a nitrate charge, a bit like a carbon pricing scheme. If you want to reduce the amount of a particular commodity that is used, you could tax it. Do you feel that would be a tool that could be used? I am a farmer myself, and it fills me with great consternation, but would that tool work, even if it were unpopular and got called a food tax or whatever?

**David Johnson:** I am sure it would work in terms of reducing overall nitrate application. I did a project a few years ago where we looked at



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farm gate nutrient balances and we looked at how they fell over the last number of decades, and they started to fall for phosphorus and they fell in the grassland sector when the profitability of that sector was particularly low. The fertiliser cost became a very significant part of the profit, and that drove down the application.

I am quite uncomfortable with a fertiliser tax in the sense that it is quite a blunt tool. I would much rather be paying where we can see real benefits, but not penalising growing more crops, which we need to do as well, where the impact is less. I am slightly uncomfortable with a fertiliser tax.

**Will Andrews Tipper:** It is a very blunt tool. It would need to be introduced alongside some fairly effective measures to support farmers in moving to lower-input farming models.

Q73 **Mr Robert Goodwill:** It might have implications on food quality as well, because things like milling wheat, for example, require high levels of nitrate. With some of the intensive horticulture, if you cut the levels of nitrate, the supermarkets would start rejecting the lettuces.

**David Johnson:** That is a perfect example of where this partnership approach can really work. There are food processors that are already talking to farmers about that breadmaking wheat protein level and whether it can be reduced and, therefore, reduce the nitrate required. The farmers are putting on additional nitrate to hit that protein level, and it is quite hit-and-miss. The science is not good on whether you get it or not.

Q74 **Mr Robert Goodwill:** You need the rain to wash it in the ground for a start.

**David Johnson:** Absolutely. When we were in ADAS, we did a study that said that you cannot predict whether that additional fertiliser is going to give you that premium price for your wheat. From the farmer's point of view—this is what happened when I was interviewing various farmers with these sorts of ideas—they were saying, "Why would I take the risk of potentially losing that premium by reducing my fertiliser? I am going to keep it at that level". What they were saying to me was they wanted to gradually build up the confidence to take the sort of system that Will is talking about, whereby they work out what really costs their business money. They accept that some of the additional fertiliser that they add on may not give them the premium price, but they want to gradually work their way towards that, rather than sign up to a 25-year covenant that then does not give them the flexibility.

One of the things that I talked about with them was that a first stage would be to accept that you are in, for example, a supply zone for a borehole, and therefore these are the sorts of high-risk activities. What they were really interested in was having independent agricultural advice



to help them start to move to take these risks and see whether they were worth taking for their business.

One of the things that they also said to me was that they were really concerned about crop failure. It was one of their biggest concerns. There is not very much in it for them. The beneficiary of them taking that small risk with their nitrate is the water company, so somehow or another you need to put those two together so that the beneficiary is also the farmer. In the ideal situation, which I talked about with them, you would, as a farmer, be glad that your land was in a groundwater protection zone because that gave you an income stream that you could rely on in the long term. That makes sense to me, then, because you are farming, which is exactly what you are aiming for, clean water and agricultural produce. That makes sense long-term. It needs energy to make that market work and get it going. It is starting.

**Q75 Mr Philip Dunne:** I would like to ask you a question about anaerobic digestion. There has been a big increase in recent years in the development of anaerobic digestion plants around intensive agricultural units, in particular pig units as well and around dairy units. The sewerage companies have been increasingly investing in anaerobic digestion as a means of dealing with their waste. Do you think that this is a good thing or do you think it has gone too far? What is your perception of that as a means of dealing with the by-products of anaerobic digestion?

**David Johnson:** Overwhelmingly, it is positive. Anaerobic digestion allows us to turn waste into a higher-value product and potentially recover energy as well in combined heat and power. Overwhelmingly positive. However, there are things to watch out for. Where that drives land use change—for example, maize, feed—then you have lost some of your benefits and in fact you have gained some dis-benefits in terms of maize, which is high sediment loss and so forth. I cannot see any disadvantages for the water companies, and I see major positives for farming, so long as it is being used to treat waste and not driving land use change.

**Mr Philip Dunne:** I think in France they introduced a requirement for cover crops after maize in order to help deal with erosion and other soil damage. Is that something you would like to see come across—

**Q76 Chair:** I do not want us to get distracted by maize, because this is primarily an effluent question. We have to stick to the poo. We also recommended loose ploughing after maize in our soil report. Can you address the effluent question? The issue is not about land use. It is more about lots of facilities and then how the effluent is handled, stored and disposed of, and whether those by-products are hazardous. It is fine if you do not know the answer.

**David Johnson:** They are generally better-value products, higher-quality products that can be used more efficiently. As far as we are concerned, from that point of view they are positive.



**Chair:** Fine. Thanks.

- Q77 **Colin Clark:** Can I just ask a supplementary question on that last point, just what the Chairman was saying? Where we are producing anaerobic digesters, where there was not necessarily the same production before, so people are using grass and maize, you are going to end up with an extra amount of effluent. Does that have a detrimental effect? Say the farm was traditionally farmed before as a cattle farm, which most of them would have been livestock farms. They have evidence from Northern Ireland that they are now going to make silage using an anaerobic digester, which is going to create effluent. Which was better, the farm producing cattle or the farm producing anaerobic digestion? They are going to take five, six, 10 crops a year of silage, compared to cattle walking about the field.

**David Johnson:** That is why I am saying, so long as it is being used to treat the waste that is there—if we are growing something to put in it, then I think it is not positive.

- Q78 **Colin Clark:** You did say a universal benefit.

**David Johnson:** For waste. I should have clarified: for waste products, yes.

- Q79 **Chair:** We need to bring that question forward because it seems to be a Northern Ireland issue, not so much a main—you think it is not?

**Colin Clark:** It is an issue here as well.

**Mr Philip Dunne:** It is an issue across the country. There is a backlog. We must move on to the next question.

**Chair:** No, no, no. If you do want to probe further, I do not mind. It is fine.

**Mr Philip Dunne:** No, no.

- Q80 **Colin Clark:** What are the consequences of nitrate pollution for biodiversity?

**David Johnson:** We have heard from the real experts this morning more than I am going to tell you. The only thing I wanted to add from what you have heard this morning is that the levels of nitrate pollution that would be required to give us that pristine ecology I believe do not allow us to have a modern farming industry. We have to be realistic about this. We can do it in small areas and for locally important places. That is why I am talking about targeting. If we have a target where we really value those ecosystems—

- Q81 **Mr Robert Goodwill:** Like freshwater mussels, or something like that, where we really want to—

**David Johnson:** Yes, or priority sites or whatever. Returning all our fresh waters to a level where they can support that pristine ecology: I have not seen the evidence that we could do that without losing modern



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agriculture. We just have to be realistic about that. We need to target it where we can get the greatest benefit.

Q82 **Colin Clark:** Do you want to add anything?

**Will Andrews Tipper:** I do not think so.

Q83 **Colin Clark:** On the same theme, then, there was a judicial review of Defra's implementation of the Water Framework Directive in 2015, where Defra agreed to consider introducing mandatory water protection zones. Is this something you would support? Why? What are the consequences of this? You, Mr Johnson, have to some extent said you would not be able to have modern farming.

**Will Andrews Tipper:** Again, if it were part of a proper system for managing land use and the impacts on natural resources, water and others, then fine. If it resulted in another set of requirements that may not be effectively policed for farmers, then I am not confident that it would lead to significant environmental improvements.

Q84 **Colin Clark:** You said before, Mr Johnson, that if there were a financial benefit—what I am trying to get at is that this may be something to get pristine water or something thereabout. There has to be some sort of benefit. There has to be some sort of compensation for the farmer, the land use.

**David Johnson:** Yes, because the farmer is supplying an additional service. The easiest example for me to visualise is the water company one, and you can have a water protection zone to supply the borehole. That makes perfect sense. We think that a water protection zone is a good thing to have in our toolkit, but I would not want to force farmers to do that. It would be in partnership so that they got the compensation for the change in their business.

Q85 **Chair:** A final question, and it is a Republic of Ireland question, which is very topical today. The Republic of Ireland has been granted a derogation under the Nitrates Directive until 2021. What do you think the consequences of this are for nitrate pollution in Northern Ireland? Are you aware of any? Obviously there will be cross-border river flows, and we have Carlingford Lough, which I believe is an oyster bed fishery as well, so that is very important locally.

**Will Andrews Tipper:** I have no relevant knowledge.

**David Johnson:** Derogation, I know, is to do with the closed period for spreading.

Q86 **Chair:** Yes. They can apply nitrogen. Yes, exactly.

**David Johnson:** They are given the flexibility to apply it outside a closed period. There is concern. The reason for the closed periods is that that is when the crops are not taking up the nitrate, so it will be wastefully used. Then there should be a concern that it is going to be inefficiently used



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and that we will lose more, and there certainly is that concern in Northern Ireland. They have identified that agriculture and the environment are two of the six areas where they want to have the closest co-operation across the border after Brexit.

**Chair:** “Regulatory alignment” I believe is the buzzword. Full regulatory alignment is what was promised before Christmas, although—

**Kerry McCarthy:** We are not expecting them to comment on that.

**Mr Robert Goodwill:** That could be in basket 3, though, couldn’t it?

Q87 **Chair:** Who knows? It is some sort of basket. Obviously there is a concern, is there not? You have farms. My mother was born on a farm six miles from the Irish border, and there are farms that span the border. How is that going to work?

**David Johnson:** At the moment, they have set up cross-border catchment groups because catchments work on natural, not political boundaries. They have already dealt with that, and that is one of the reasons why they want to keep this cross-border co-operation. They are using this catchment-based approach, which makes perfect sense, so they need to have that level playing field across the border.

As I understand it, there are two issues that they are very concerned about at the moment. One is that there is this strategy for growth in Northern Ireland but there is not an independent environment agency in Northern Ireland. There is a real concern that they are going to increase the issues without the ability to manage them. There is some good in terms of those cross-border, catchment-scale initiatives, which is the right way to go, but there are some concerns as well.

Q88 **Chair:** Are you concerned about the laws being transposed and the concern about what the post-Brexit environment will bring?

**David Johnson:** I am not really able to comment. All I can say is that they want to have that consistency across the border. That is all I can say.

**Chair:** Wonderful. Thank you both very much indeed for a fascinating session. This is the end of our very first hearing on nitrates. I think we all feel a lot wiser thanks to your combined wisdom, so thank you very much indeed.