Hampshire Avon Catchment

Catchment Invertebrate Fingerprinting Study

Wessex Chalk Stream & Rivers Trust

CATCHMENT INVERTEBRATE FINGERPRINTING STUDY

What is Invertebrate Fingerprinting?

The evaluation of invertebrate communities living in a river or stream is one of the best methods available for assessing the impacts of environmental stress on the health of an aquatic ecosystem. Invertebrates that spend all, or part, of their lifecycle living in a river are constantly exposed to changes in the structural composition of the river bed, in the volume of water in the river and in the chemical composition of the water flowing over them.

To assess the health of aquatic invertebrate communities, samples are collected using a standardised method and the organisms found are identified to the taxonomic level of family or species. The approximate abundance of each group found in the sample is also recorded and this combined data is used to calculate so–called biotic indices, which are used to draw conclusions about the condition of the river and to make comparisons between sites on the same or different rivers.

Catchment Invertebrate Fingerprinting (CIF) Study:

The CIF study is examining the responses of aquatic invertebrate communities to four environmental stresses**; sedimentation**, **phosphate pollution**, **organic pollution** and **low-flow** impacts.

The first phase of the study examined historic invertebrate sampling data, supplied by the Environment Agency. The community structure at each sampling site was analysed, essentially to **family level***, for four biometric indices: PSI (fine sediment), TRPI (total reactive phosphorous index), Saprobic (organic pollution) and LIFE (low-flow impacts).

For each of the indices, an invertebrate group is allocated a score according to its sensitivity to the particular environmental stressor. When a river becomes polluted the most sensitive and highest scoring groups are the first to be lost and the average score falls. Where the average score of the groups found is high, it indicates that the most sensitive groups are present in the river and that, by inference, the pollution levels are low.

The second phase of the study used the same set of biometric indices to provide a more detailed examination, at the **species level**, of a smaller number samples which were taken by the WCSRT and the Environment Agency, at targeted sites, during autumn 2014 and spring 2015.

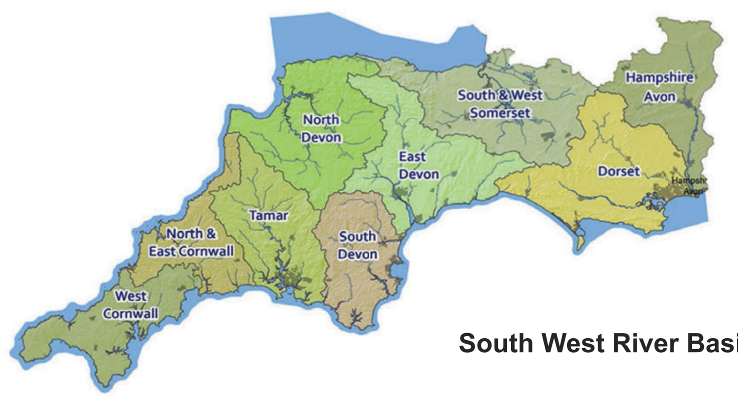
This booklet looks at each of the four environmental stress signatures individually and maps the results of the first phase analysis and the more detailed species level analysis. Together the results help provide an overall picture of river water quality across the Hampshire Avon catchment.

**The latter part of the EA data period, will have contained some species data which means our analysis will have provided some mixed family/species biometric predictions (as RICT does).*

CATCHMENT BACKGROUND

HAMPSHIRE AVON CATCHMENT: Principal catchment features

The Hampshire Avon River catchment is located in the south of England and flows through the counties of Hampshire, Wiltshire and Dorset. The river is 60 km in length and covers a total catchment area of approximately 1,750 km2. It begins in Wiltshire as two separate rivers: the western Avon rises to the east of Devizes, draining the Vale of Pewsey, and the eastern Avon rises just east of Pewsey. These merge at Upavon, flowing south across the Salisbury Plain, through the New Forest at Fordingbridge and Ringwood and meeting the river Stour at Christchurch where it flows into Christchurch Harbour reaching the English Channel at Mudeford, Dorset. The Avon river catchment includes the Sem, Nadder, Wylye, Bourne and Ebble tributaries, which all converge within a short distance around Salisbury. The River Avon and most tributaries are designated as a Special Area of Conservation (SAC) and a high proportion are also Sites of Special Scientific Interest (SSSIs).

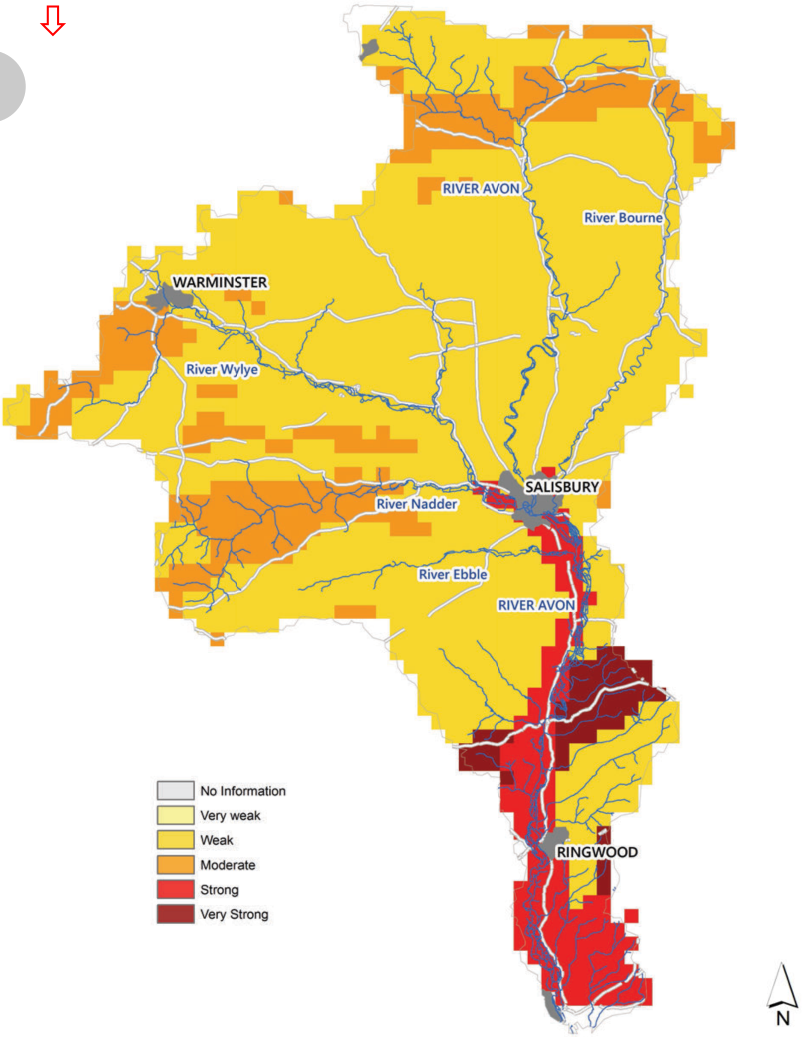


South West River Basin District

Soil typology

Soil is the medium in which plants grow and is a vital habitat that supports a huge diversity of animal species and micro-organisms. Fertile soil is critical for the production of food, timber and fibre, and it is therefore essential for our survival and economic prosperity. Soils also influence the character of our local landscapes and play a key role in the regulation of environmental services such as nutrient cycling, water quality, water flow regulation and carbon storage. The map below identifies soils which are vulnerable to erosion if high risk land management activities are practiced. The darker the colour the higher the risk of soil erosion for any given land management.

3



4

Underlying Geology

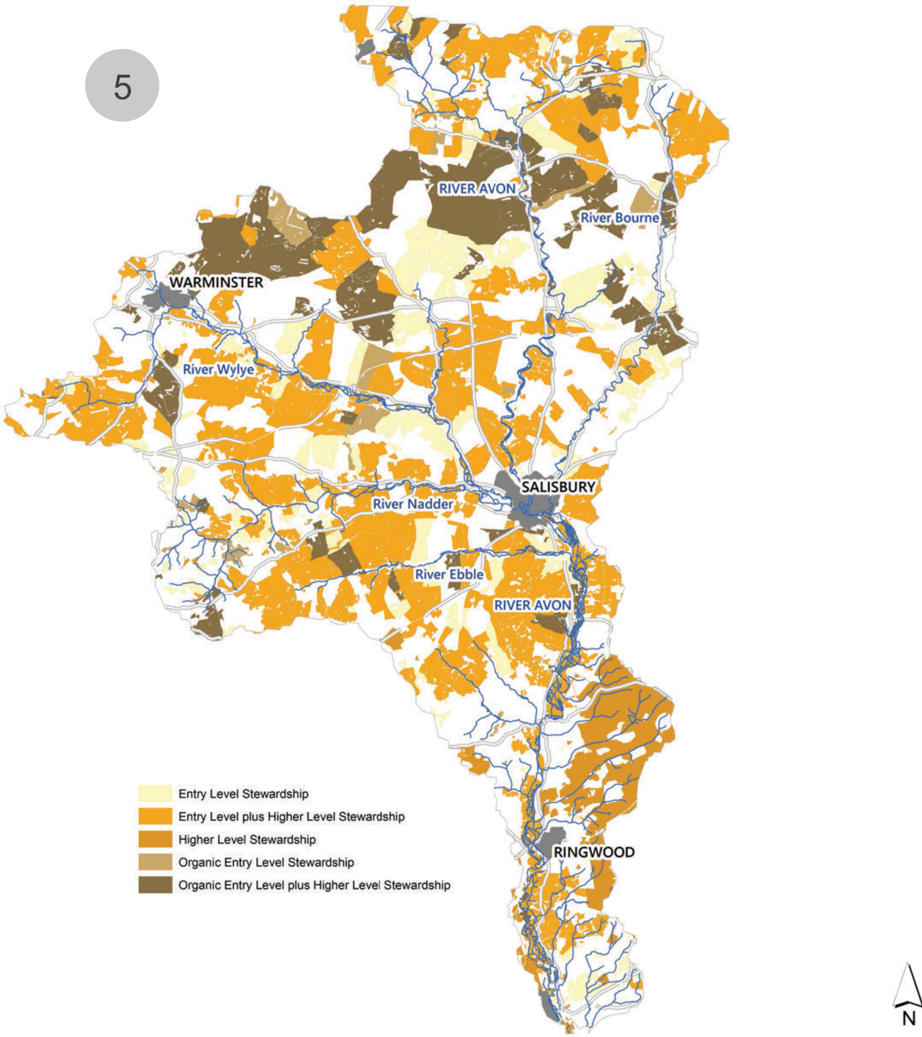
Geological maps are of potential use to a wide range of people with both interests in planning and development, oil and gas (including shale gas) reserves, water and mineral resources (especially groundwater), waste disposal sites, utilities, transport, geo-hazards and property insurance; as well as academic interests such as the Earth's geological history, its fossils, and its landscape development.

Environmental Stewardship Agreements

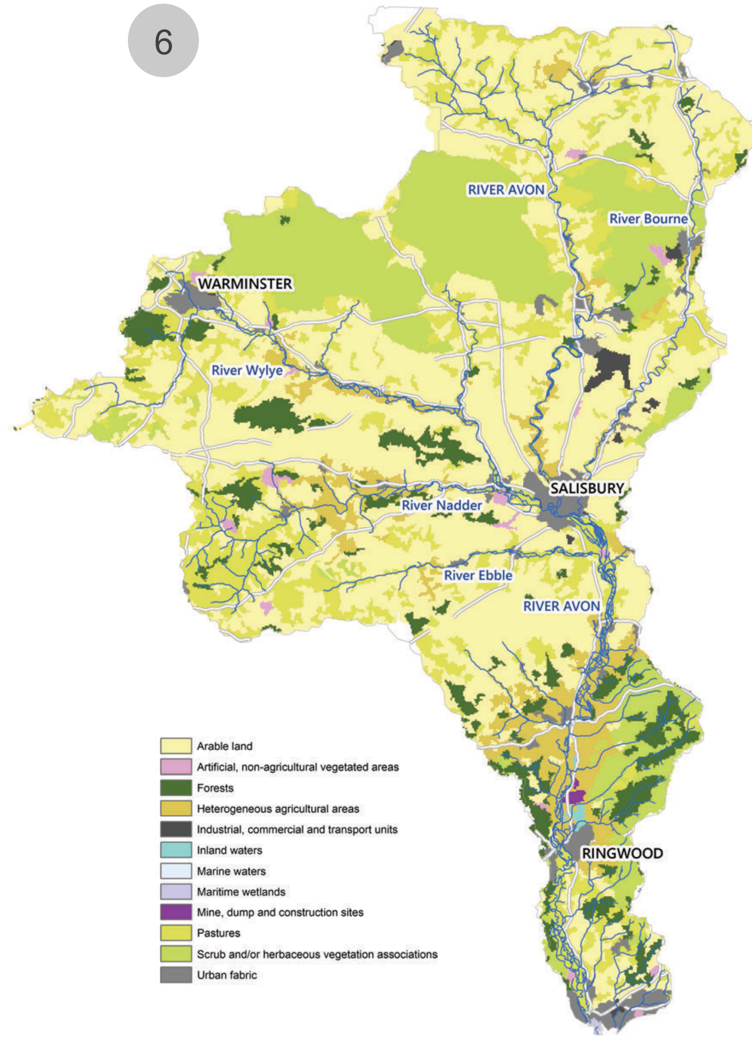
Under DEFRA's previous Environmental Stewardship, which has now been replaced with Countryside Stewardship, there were three tiers of agri-environment schemes available to farmers and landowners; Entry Level Stewardship, Organic Entry Level Stewardship and Higher Level Stewardship.

The data represented below shows the take-up of Environmental Stewardship for the Hampshire Avon catchment. The map illustrates the wide coverage of agreements, particularly apparent is Salisbury Plain which is managed under organic stewardship agreements and covers a significant area across the upper Avon and Wylye sub catchments.

5



6



Land Use Practices

The The Hampshire Avon is characterised by open chalk downland with steep scarp slopes, sheltered valleys, chalk hills, ridges and limestone plateaux. The land use in the catchment is predominantly rural (98%) comprising of arable, improved pasture grasslands and woodland with the exception of the River Bourne tributary which is strongly influenced by urban areas, fisheries management, historic milling and water meadow agricultural systems.

ENVIRONMENTAL STRESSOR 1:

SEDIMENT

Sediment

'Sediment' is the mineral and organic material that is eroded, from all across a catchment (**source**), transported via rills, gullies, drains etc (**pathway**) and eventually deposited into the river network (**receptor**). Naturally occurring sediment is an important part of a healthy river system and is an essential component of many aquatic ecosystems. However, problems arise when human activity increases the amount of sediment entering the watercourse, impacting on the river's natural processes.

What is the problem?

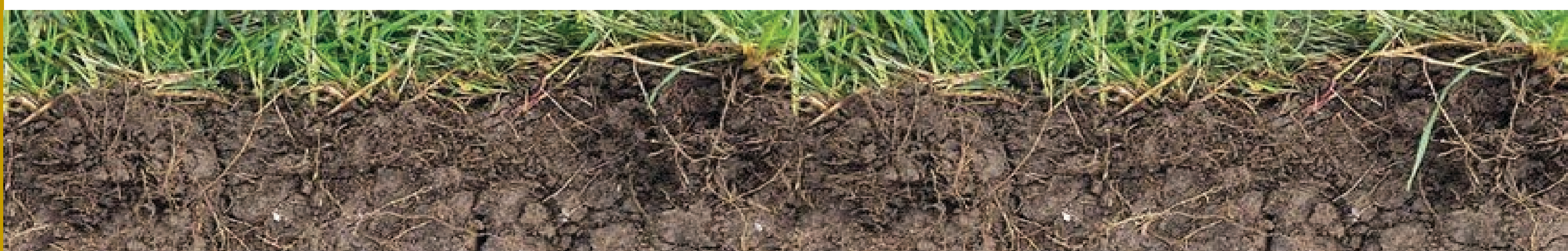
Increased levels of sediment can have a number of impacts on our river catchments. In particular, sediment is known to damage **Aquatic Ecosystems** by blocking light to aquatic plants, clogging the gills of fish and smothering benthic habitats, suffocating the organisms and eggs that reside in the substrate. Similarly, sediment is often a contributor to increased nutrients and chemical contaminants that can cause **Water Pollution** and impact on the provision of clean **Drinking Water**, increasing the associated costs of water treatment and price to the consumer. Sediment is also known to impact on **Flood Risk,** reducing the rivers carrying capacity of water and slowing down and in some extreme cases blocking conveyance through the river catchment. Finally, chalk river catchments are renowned for the amenity value they provide for recreational angling and the associated economic benefits that this delivers. **Fisheries,** Salmon stocks in particular, are vulnerable to the impacts of sediment on water quality and spawning habitats.

What are the solutions?

There are a range of well established measures for reducing sediment loads entering rivers and streams. These measures are primarily aimed at mitigating the availability of sediment sources, decreasing the likelihood of material being mobilised and disconnecting pathways via which particulate matter (mainly soil) is carried to watercourses. In the Hampshire Avon catchment there are mechanisms to deliver these mitigation measures, including initiatives that assist landowners with improving land use and soil management to deliver benefits to farm businesses as well as the environment. Further information and advice for landowners is available from:

A clear solution for farmers
CATCHMENT SENSITIVE FARMING

Contact: Duncan Jones
CSFO, Hampshire Avon
Email:
duncan.jones@naturalengland.org.uk

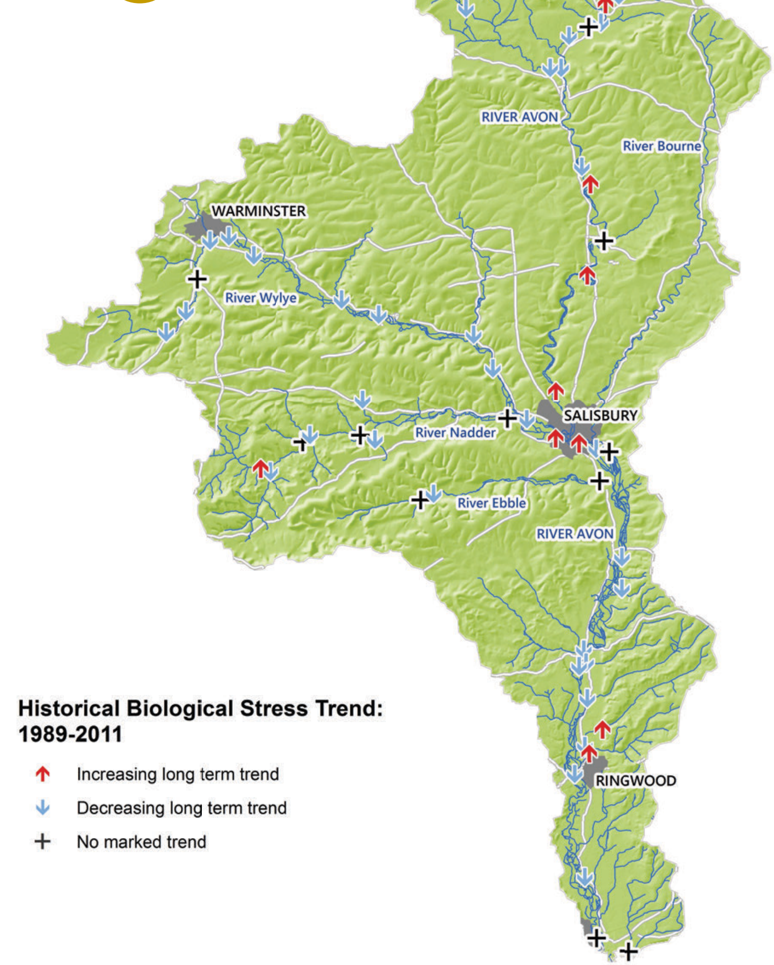


Sediment – Family Level Results (up to 2014)

In map 2, many reaches of the Rive Avon show increasing biological signatures for sediment stress (red arrows) and some reaches of the river and feeder tributaries also show decreasing stress fingerprints (blue arrows) for sedimentation over time. Some of these increasing signatures for sedimentation will have been associated with population expansion plus the associated human pressures on the rivers in the form of e.g. agriculture, abstraction, discharges and both man-made and natural bank erosion. In map 1, there remained up to 2014 a mix of slightly impacted to impacted biological signatures of sedimentation in the River Avon and feeder tributaries. In the Avon catchment sediment stress impacts are more marked in the lower reaches of the River Avon below Salisbury as both anthropogenic input and natural gradient encourages deposition of greater sediment load in the river bed.

1

2



Index: Proportion of Sediment-sensitive Invertebrates (PSI)

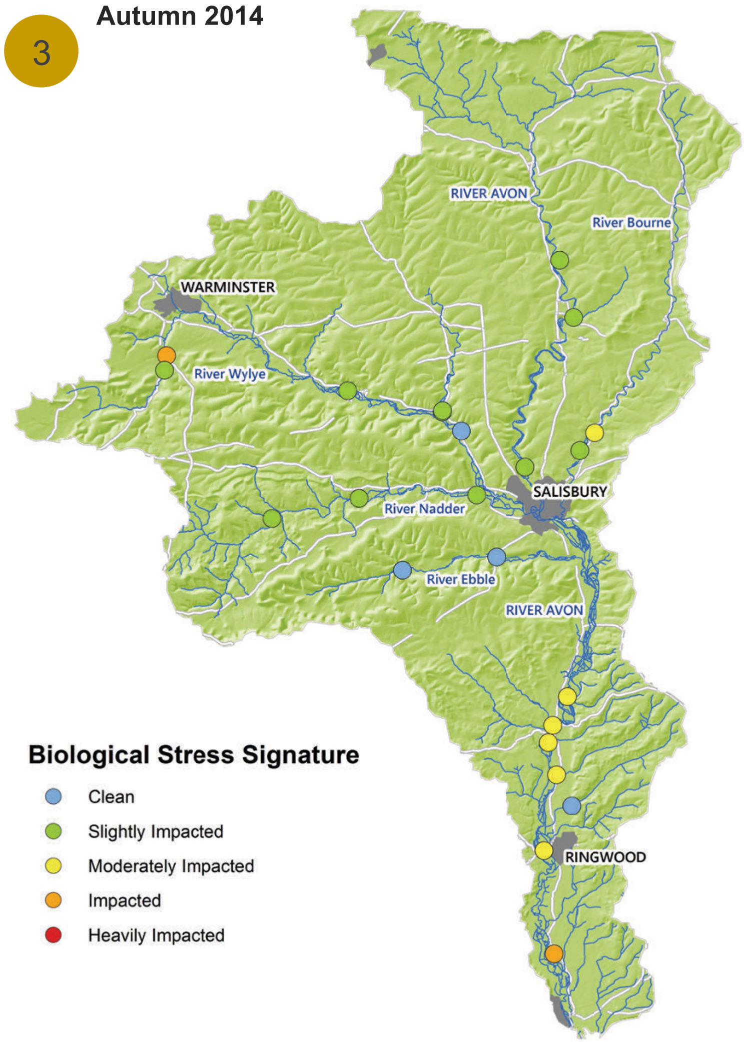
Extence et. al. (2010) proposed the use of a sediment-sensitive macro-invertebrate metric, PSI (Proportion of Sediment-sensitive Invertebrates) which can act as a proxy to describe temporal and spatial suspended sediment ecological impacts on a river catchment scale.

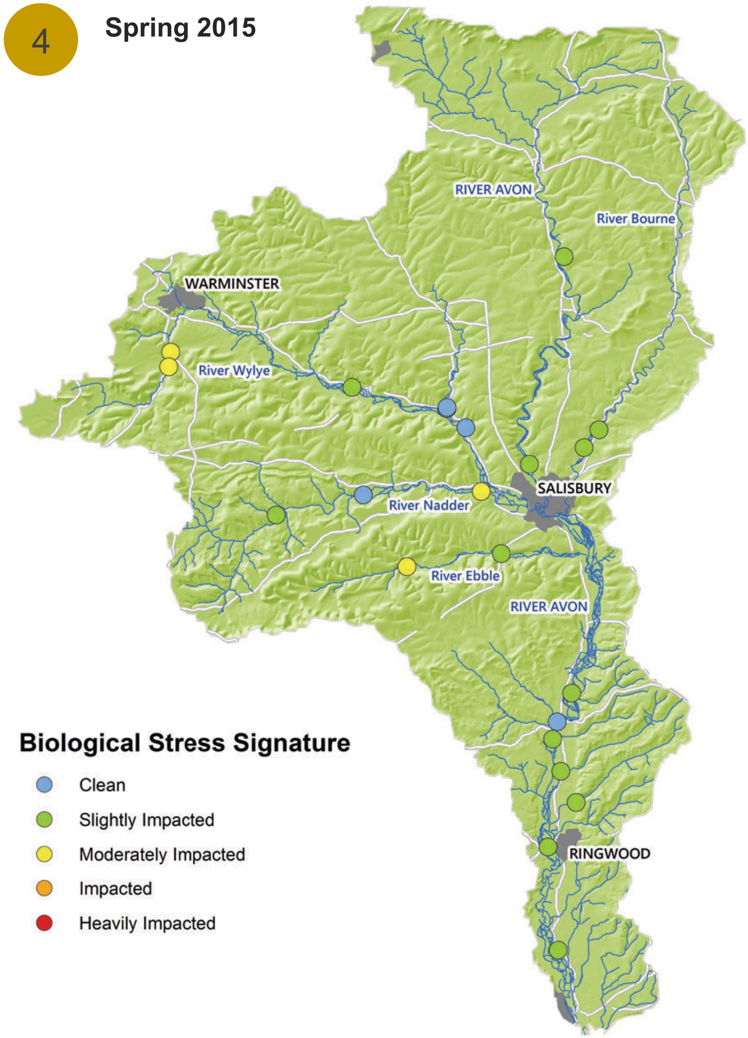
The PSI score describes the percentage of sediment-sensitive taxa present in a kick/sweep net sample and the metric is calculated using scores for the differing invertebrate groups.

PSI scores range from 0 (entirely silted river bed) to 100 (entirely silt-free river bed).

Sediment – Species Level Results (2014/15)

WCSRT's targeted investigational surveys for the biological signatures of sediment stress shown in map 3 and 4 indicated a number of essentially sediment un-impacted or only slightly impacted reaches and a number of localised potential sources of sedimentation in these rivers with moderately to impacted sediment conditions. The overall picture of apparently improving sediment stress post-2014 may relate to invertebrate recovery following the extremely high rainfall across the UK in 2014, with winter flooding and associated river bed flushing of sediment deposit. These results and additional species level fingerprinting across local rivers have shown that moderately to impacted sediment signatures do not associate with good riverfly species richness and abundance at the base of these fishery food chains.





N

Amongst the riverflies particularly sensitive to sediment are some of the iconic species found in these chalk streams e.g. Southern Iron Blue (*Baetis niger*)

Nymph
© Dr. Cyril Bennett

Adult
© Dr. Cyril Bennett

Dry fly pattern

ENVIRONMENTAL STRESSOR 2:

PHOSPHATE

Phosphate

Phosphate is a naturally occurring compound derived from phosphorus, a mineral which is essential to human, animal and plant life. It is a fundamental component of a healthy water environment, supporting aquatic plants which produce oxygen and create habitats needed by other aquatic organisms, such as invertebrates and fish. However, phosphate is also commercially processed and used in many cleaning, industrial and agricultural production processes. Excess phosphate acts as a pollutant and although it can't be seen in the water, it makes its presence plain by triggering algal blooms.

There are many potential sources of phosphate in river catchments; including diffuse sources such as fertiliser applied to agricultural land, sewage discharges, domestic waste water and agricultural point sources such as cress farms and slurry stores.

What is the problem?

Human activity within our river catchments can cause an increase in the accumulation of commercially produced phosphate in the freshwater environment. This leads to unbalanced and uncontrolled growth of aquatic plants and algae in a process known as 'eutrophication'. Algae are dying and decomposing over short timescales all the time, both under natural and eutrophic conditions. However, where particularly high biomasses of plants and algae are rapidly decomposed by oxygen-consuming bacteria a 'sag' in dissolved oxygen can occur, limiting survival of sensitive invertebrates and fish while compromising the ecological health of the watercourse. The problem can also have detrimental effects on the supply of water for drinking water, recreational use of rivers and the production of food such as fish.

What are the solutions?

Tighter regulation has led to activity from water companies, cress farmers and the farming industry to address some of the major sources of phosphate. However, large numbers of small sources from domestic waste water and septic tanks are still a significant problem.

Householders can help reduce their impact on the water environment by using low phosphate or phosphate free products and ensuring septic tanks are properly maintained.

Diffuse agricultural sources of phosphate are still a significant issue but there are a number of well established soil, land and fertiliser management solutions available to help improve farm business efficiencies and reduce the impact of farming activities on the environment.

Catchment Based Approach
Partnerships for Action

For further information, contact:
Hampshire Avon Catchment Partnership
Contact: Paul Jose

www.hampshireavoncatchmentpartnership.org.uk

Phosphate – Family Level Results (up to 2014)

In map 2, some locations across the Avon catchment show historical trends of increasing biological stress from phosphorus (red arrows), whilst other locations show a stress decrease (blue arrows) over time for eutrophication over time. Some of these increasing signatures for eutrophication will have been associated with population expansion plus the associated human pressures on the rivers in the form of e.g. agriculture, abstraction and discharges. In map 1, there remained up to 2014 a mix of slightly impacted to impacted biological signatures of phosphate stress in the Avon catchment rivers. Potentially associated with and linked to the sediment stress fingerprints, greater eutrophication signatures are evident downstream and may be attributable to phosphate inputs accumulating in the rivers lower reaches.

Index: Total Reactive Phosphorous Index (TRPI)

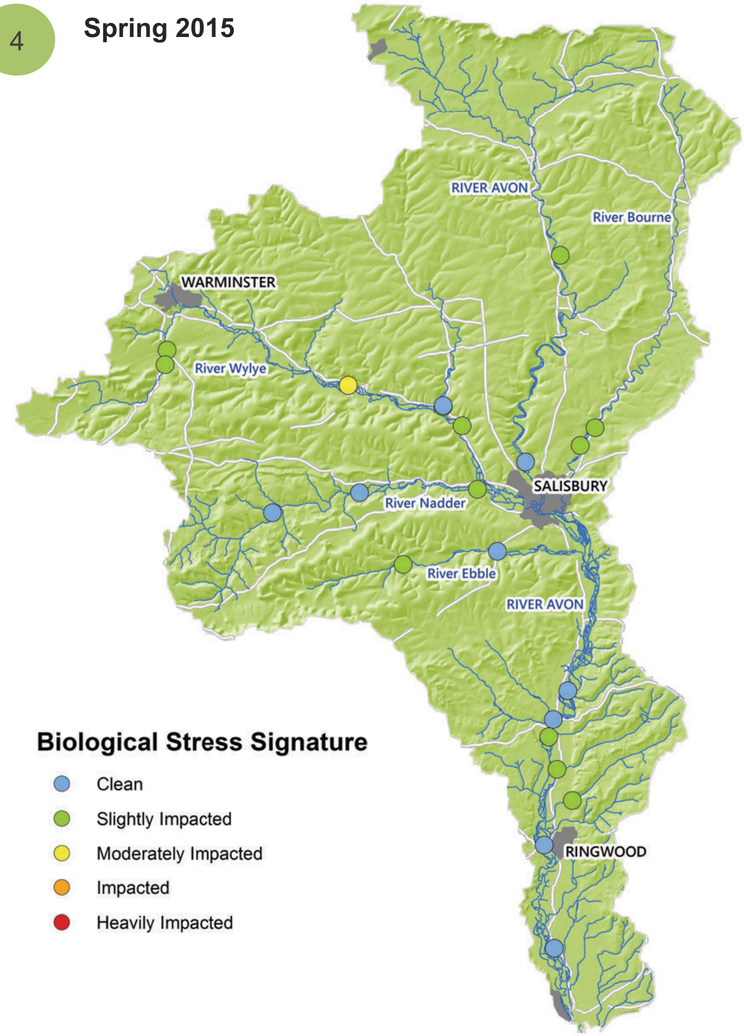
Eutrophication, the enrichment of waters by nutrients resulting in an array of biological changes, is widespread in the lakes and rivers of industrialised countries. Typical symptoms include algal blooms and sometimes enhanced growth of higher aquatic plants. A new phosphorus index has been developed by Dr Nick Everall and co-workers where the Total Reactive Phosphorous Index or TRPI, uses sensitive invertebrate groupings present in a sample to calculate scores across five groups of invertebrate taxa (A to E, where A taxa are very TRP sensitive through to E taxa which are relatively insensitive).

Phosphate – Species Level Results (2014/15)

WCSRT's targeted investigational surveys for the biological signatures of sediment stress shown in maps 3 and 4 indicated a number of essentially phosphate un-impacted or only slightly impacted reaches and a small number of localised potential sources of eutrophication in these rivers with moderately impacted phosphate conditions. In particular, the high eutrophication signatures in the lower reaches of the River Avon in the Autumn of 2014 warrant further investigation. An overall picture of apparently improving phosphate stress post-2014 may have been associated with the extremely high rainfall inputs of 2014 associated across the UK with marked winter flooding and river flushing. Species level fingerprinting of UK-wide rivers has shown that moderately to impacted phosphate signatures do not associate with good riverfly species richness and abundance at the base of these fishery food chains.

3 Autumn 2014

4 Spring 2015



N

Amongst the riverflies particularly sensitive to phosphate are some of the iconic species found in these chalk streams e.g. Blue Winged Olive (*Serratella ignita*)

Nymph

© Dr. Cyril Bennett

Adult

© Dr. Cyril Bennett

Dry fly pattern

ENVIRONMENTAL STRESSOR 3:

Organic Pollution

Organic pollution is caused by human activities which introduce highly degradable material into the watercourse. Typically, the most common sources of organic pollution are sewage works, sewage misconnections, farm waste and organic fertilisers such as farmyard manure.

What is the problem?

Organic pollutants are principally a problem because they increase the activity of aerobic bacteria which decompose organic waste and, in doing so, use up more oxygen from the water as they respire. This increase in Biochemical Oxygen Demand (BOD) puts pressure on other aquatic organisms such as invertebrates and fish which also depend on oxygen for respiration. Organic pollution can also lead to a number of other problems such as physically smothering the stream bed, exacerbating eutrophication where plant communities benefit from residual nutrients left behind after organic material has been decomposed and finally, increased levels of ammonia, which is toxic and harmful to aquatic life.

What are the solutions?

Over the past twenty years there has been a steady reduction in organic pollution, largely due to investment from water companies and improved farming practices from the agricultural sector.

Investment from water companies to improve treatment at sewage treatment works is on-going and includes efforts to address sewage misconnections in urban areas.

Farmers are required to meet regulations on storing silage and slurry (SSAFO Regulations) as well as standards linked to the Basic Payment Scheme, with additional compliance measures for farmers in Nitrate Vulnerable Zones (NVZs).

Advice and support to help farmers meet the various standards and regulations is available through Catchment Sensitive Farming. Capital grants are also available through Countryside Stewardship and can contribute towards works including; watercourse fencing, yard infrastructure, cattle tracks and many other items.

Further information is available from:

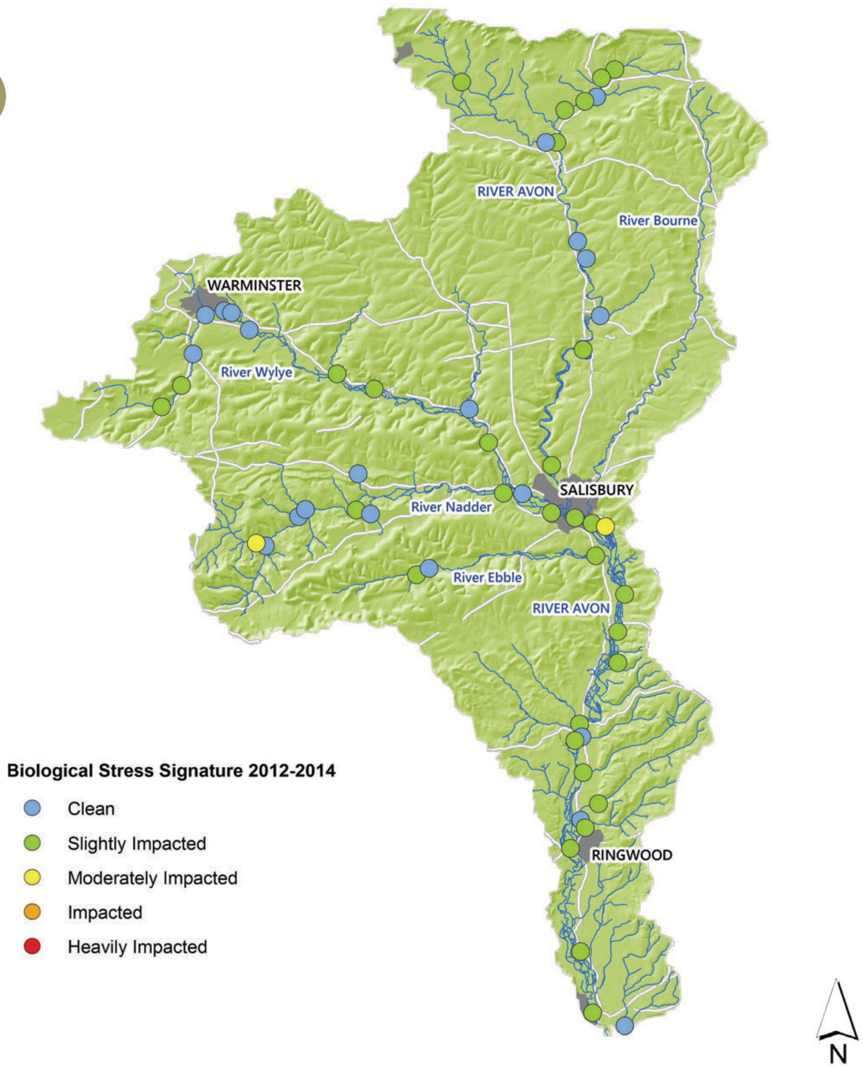
A clear solution for farmers
CATCHMENT SENSITIVE FARMING

Contact: Duncan Jones
CSFO, Hampshire Avon
Email: duncan.jones@naturalengland.org.uk

Organic Pollution – Family Level Results (up to 2014)

In map 2, most of the reaches of the River Avon and feeder rivers show longer-term un-changed or decreasing biological signatures for organic pollution, as reflected by the Saprobic Index, suggesting successful control and abatement of the sources of organic inputs to these watercourses over time. In map 1, there remains today a mix of mainly clean or slightly impacted biological signatures of organic enrichment in the rivers of the Avon catchment. With the exception of the odd ephemeral hot-spot then longer-term organic enrichment and pollution appeared largely under control in the rivers of the Avon catchment.

1



2

Index: Saprobic Index

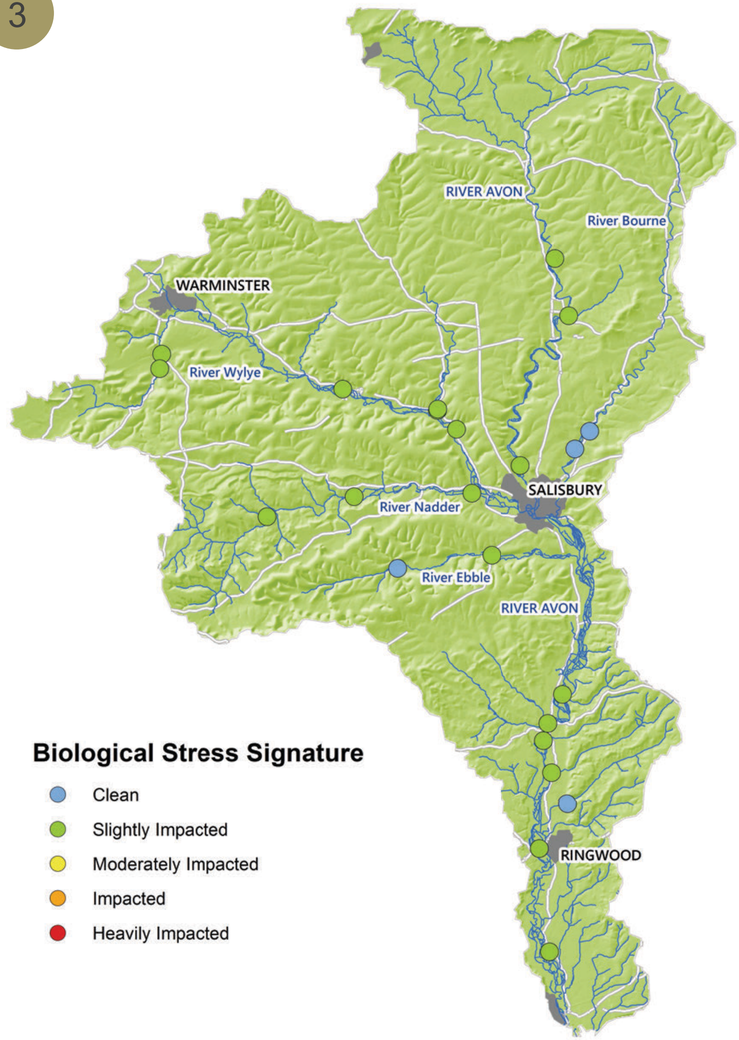
Saprobic indexing at the species and family level allows for a more revealing insight into the nature and quantum of organic pollution in watercourses than other methods, as it accounts for species differences in tolerance to organic pollutants (e.g. elevated ammonia and lowering dissolved oxygen regimes).

Organic Pollution – Species Level Results (2014/15)

In map 3 and 4, all of the WCSRT surveyed reaches of the River Avon and feeder rivers showed clean or slightly impacted biological signatures for organic pollution. However, a (green circle) slightly impacted biological signature for organic enrichment is not clean or un-impacted and represents a mild organic load with BOD typically in the range of 2-6 mg/l. While not by itself a threat to aquatic life these mild organic loads in additive combination with other stresses like sediment and phosphate can quicken the 'tipping point' for combined environmental impacts versus a background of clean or un-impacted (blue circle) conditions. It is therefore important to continue to maintain the drive towards controlling and abating organic enrichment and pollution in these watercourses.

3

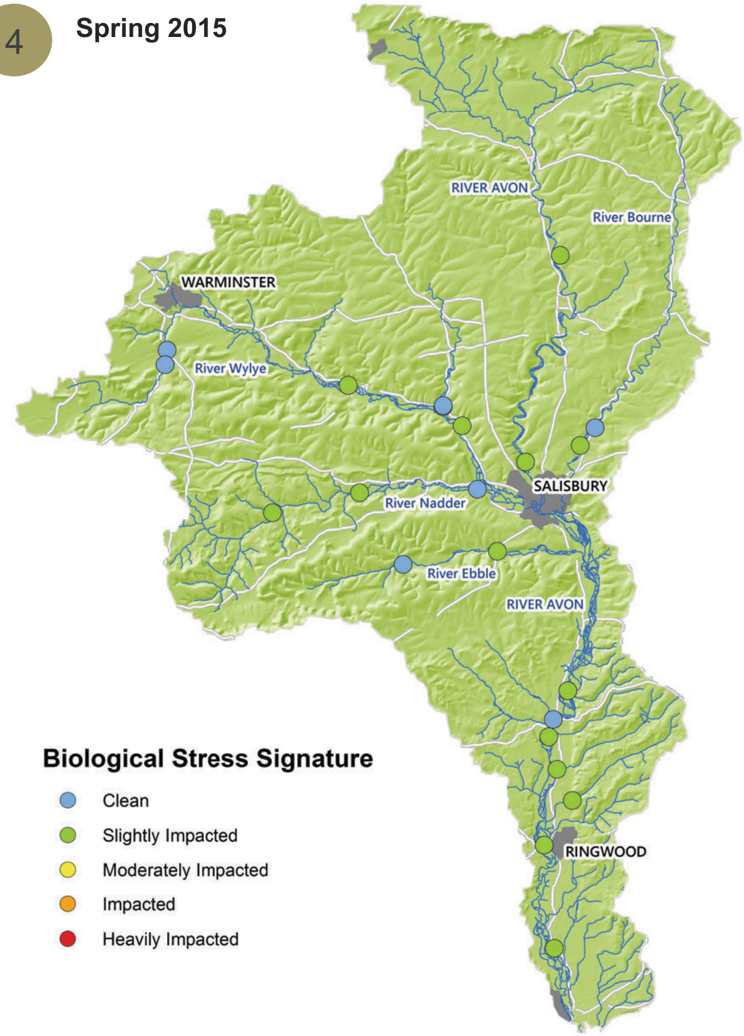
Autumn 2014



N

4

Spring 2015



Amongst the riverflies particularly sensitive to organic pollution are some of the iconic species found in these chalk streams e.g. Yellow Sally (*Isoperla grammatica*)

Nymph

© Dr. Cyril Bennett

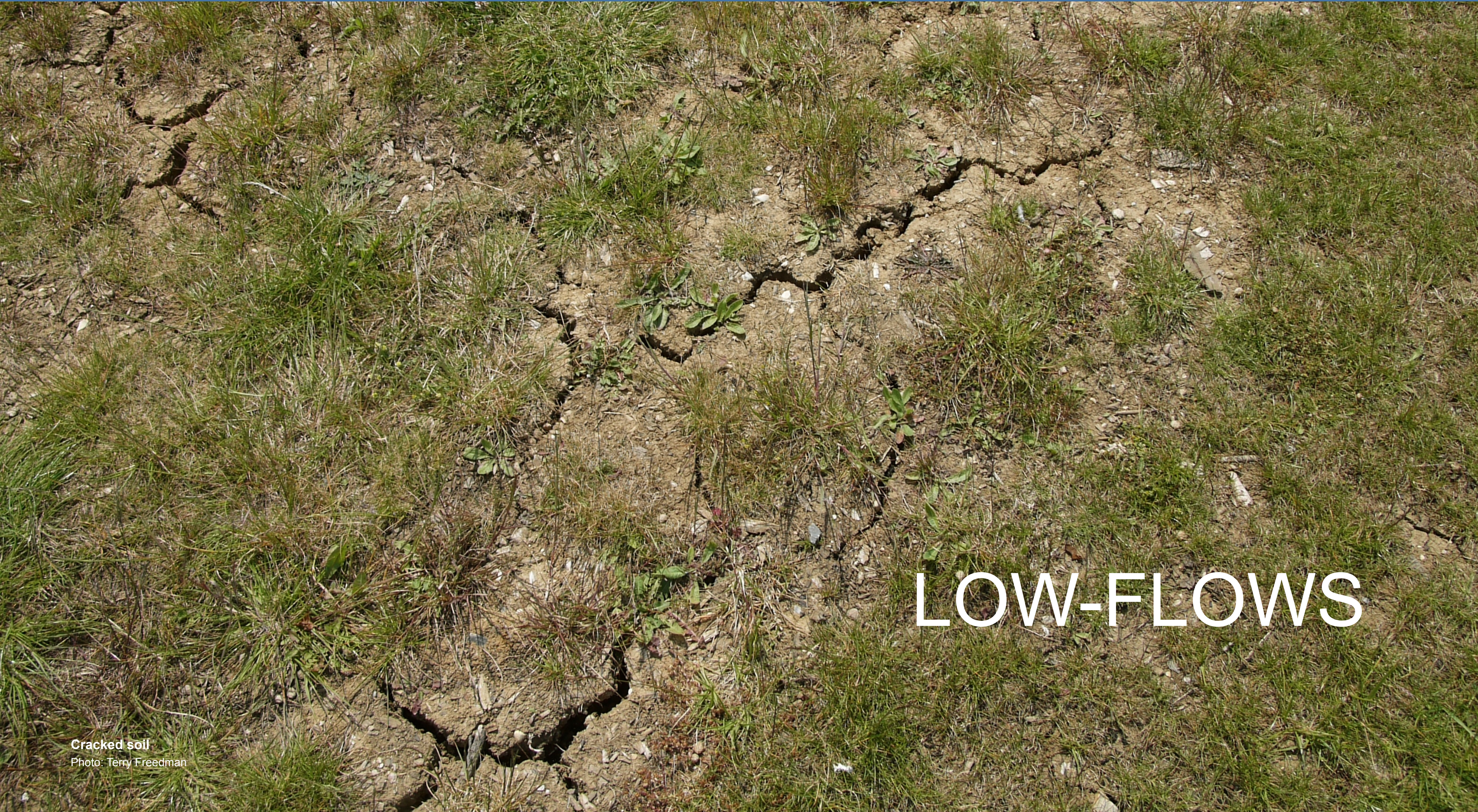
Adult

© Dr. Cyril Bennett

Dry fly pattern

ENVIRONMENTAL STRESSOR 4:

LOW-FLOWS



Cracked soil
Photo: Terry Freedman

Low-Flows

Chalk streams can derive as much as 80% of their annual stream discharge from groundwater, stored in chalk aquifers. Overland flow is therefore only a relatively small component of natural stream flow, meaning that chalk streams benefit from a relatively stable hydrological regime. However, human activity through historic management practices and increasing abstraction have caused changes to the natural flow regime which do not always support a healthy ecology.

What is the problem?

Abstraction is the removal of water, permanently or temporarily, from a water body. It can alter the natural flow regime either directly on surface water flows or indirectly by groundwater pumping, depleting groundwater levels. Other human activity which regulates flow e.g. by physically modifying rivers with impounding structures such as weirs and sluices can similarly alter natural velocity patterns. The changes brought about by these human activities can have a number of subsequent effects on the in-river ecology, including; increasing sedimentation rates, loss of habitats, loss of in-channel geo-morphological diversity and hindering the passage of migratory fish.

What are the solutions?

Abstraction of water is controlled through a licensing system operated by the Environment Agency. Recent changes to this system have seen a drive towards more sustainable abstraction and a regime that meets the environmental obligations set by the Water Framework Directive. Similarly, water companies have responsibility for planning how they can meet future customer demand, whilst maintaining an affordable price and not damaging the environment. Finally, as consumers we are all responsible for saving and using water more efficiently and can seek information and advice from local water companies on improving water use efficiencies in homes and businesses.

Wessex Water a YTL company

sembcorp bournemouth water

In addition to reducing demand and making the abstraction of water more sustainable, there are also a number of opportunities for using natural processes to mitigate the impacts of human activity:

River Restoration:

Improving river habitats and restoring natural process, e.g. removing impoundments, can help reduce the physical effects of low flows and support the recovery to a more naturally functioning ecosystem.

Wetland Restoration:

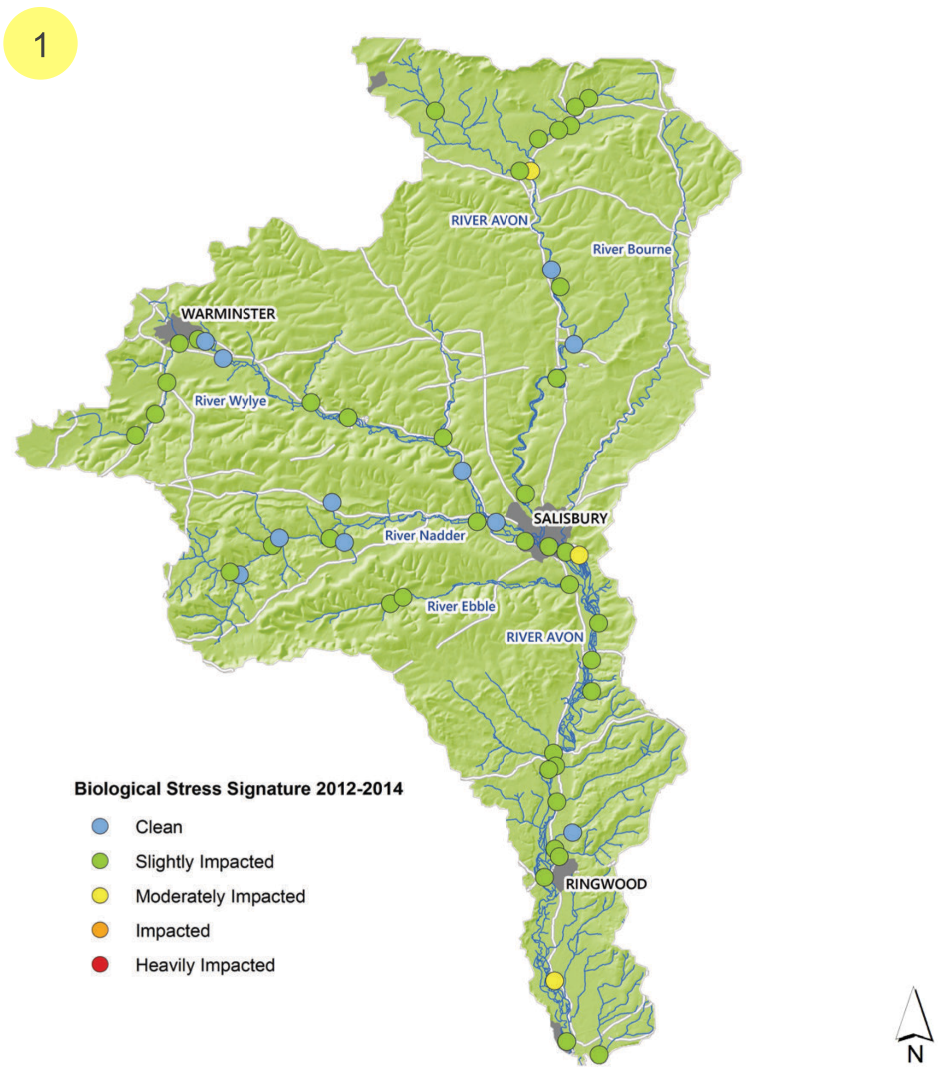
Wetland restoration can increase the attenuation of water, which can benefit groundwater recharge, support summer base flows to rivers and improve water quality and sediment retention at some locations.

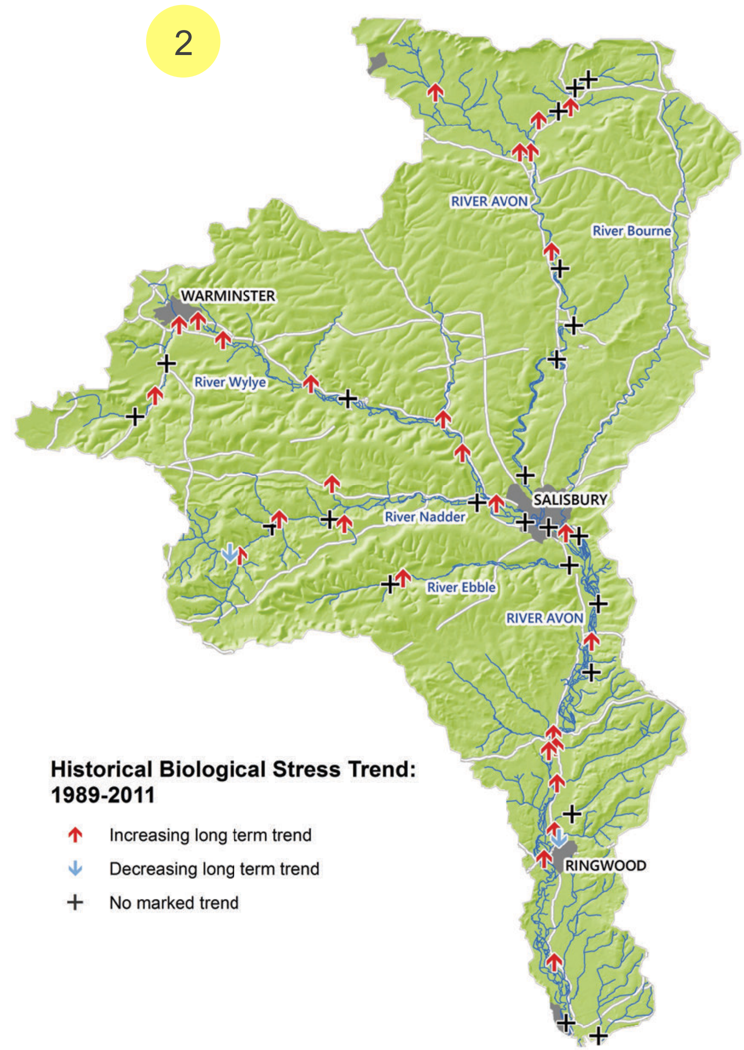
Catchment Management:

Changes in land management practices can alter the way water moves through or is retained in the catchment. Similarly, soil management practices can have a significant influence on the volume and rate at which water infiltrates through the catchment.

Flow – Family Level Results (up to 2014)

In map 2, most of the reaches of the River Avon and feeder rivers show increasing biological stress signatures (red arrows) or no change (black crosses) responses to the prevailing conditions over time. In map 1, there remained in 2014 largely good biological signatures of flow velocity throughout much of the River Avon and feeder tributaries.





Index: Flow velocity conditions from Lotic Flow Evaluation (LIFE)

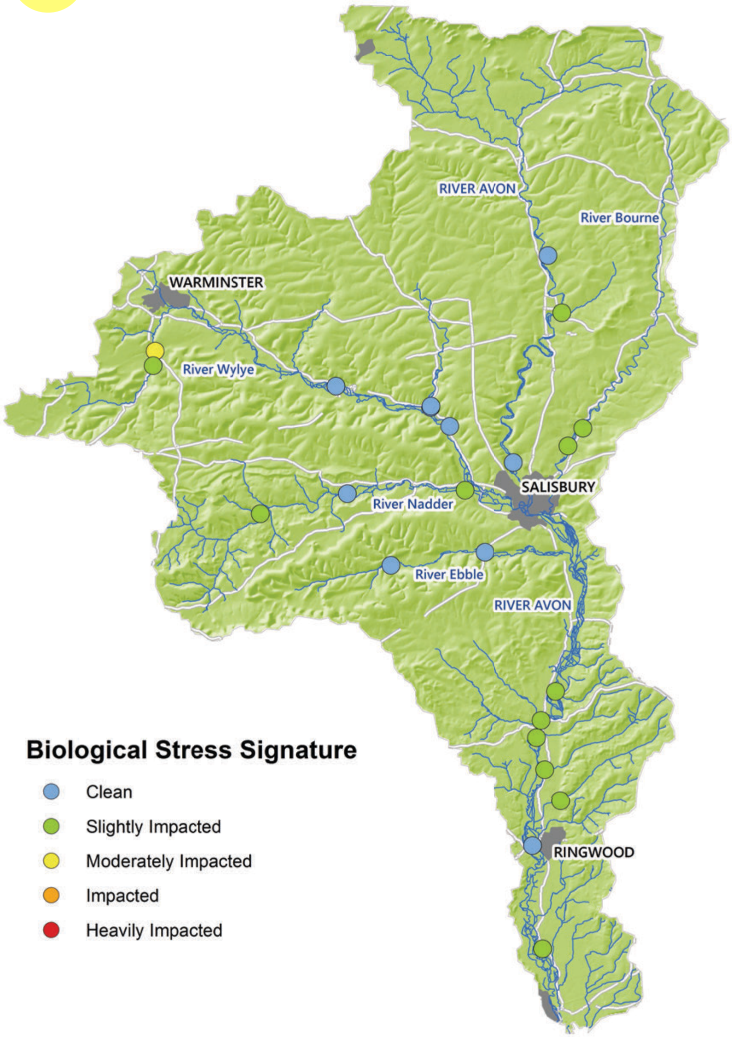
Many freshwater invertebrates have precise requirements for particular current velocities or flow ranges, and certain taxa are ideal indicators of prevailing flow conditions.

The LIFE technique is based on data derived from standardised 3 minute kick-sweep net sampling of macro-invertebrates in order to assess the impact of variable flows on benthic populations (Extence et. al.,1999). The higher the LIFE score in comparable flow-habitat sections of watercourse the higher the prevailing flow conditions and vice versa.

Flow – Species Level Results (2014/15)

In map 3 and 4, most of the reaches of the River Avon and feeder rivers showed good biological signatures for flow. However, the high rainfall patterns of 2014 had done much to augment groundwater, maintaining and ephemerally increasing flow regimes in these river catchments. It is probable that such augmented flows were manifested in the recent biological signatures of flow captured in the 2014-2015 species level stress fingerprinting.

3 Autumn 2014



4 Spring 2015

N

Amongst the riverflies particularly sensitive to low flows are some of the iconic species found in these chalk streams e.g. Yellow May Dun (*Heptagenia sulpherea*)

Nymph

Adult

Dry fly pattern

Wessex Chalk Stream & Rivers Trust

CATCHMENT INVERTEBRATE FINGERPRINTING STUDY

Summary of Results:

The results from the study's biological signatures, which are associated with reduced riverfly species richness and abundance, indicate that sediment and phosphate were impinging upon the ecological condition of some reaches of the River Avon and associated feeder rivers. However, with the exception of eutrophication in the lower reaches of the River Avon up to 2014, the main river exhibited fewer and less marked biological signatures of flow, organic, phosphate and sediment stress than the nearby Rivers Test and Itchen.

Where the key environmental stresses of sediment, phosphate, flow and organic enrichment have shown biological signatures at or above moderately impacted then they associate with impacted ecological condition in those river reaches. These stresses, however, seldom act in isolation and the combined and additive impacts of raised signatures for sediment, phosphate, flow and organic enrichment are found to be greater than the individual stresses. These are also not 'anecdotal' impacts since the bands of biological signatures for these stresses relate directly to chemical bands of e.g. ammonia and BOD for organic enrichment and phosphate levels for phosphates.

Tackling the problem – a partnership approach:

The clean or slightly impacted reaches of our rivers can hold the answers to improving less good stretches and we can generate the best results by working under a catchment management umbrella.

In-stream habitat management to enhance habitat quality, targeted agricultural investment, regulatory discharge and abstraction control, planning permissions and litigation may all be required.

There is no time for complacency, since the findings from this study and those of other workers show direct links between raised biological signatures of, for example, sediment and phosphate stress, with loss of riverflies, both in rivers and in matching controlled laboratory studies.

Anglers have long recognised the plight of riverflies in some UK rivers and we are now seeing scientific data to support these concerns. The move towards species-level invertebrate fingerprinting of river samples is key to this understanding.

We must all work together to address, in particular, the excessive levels of sediment and phosphate that are impacting the richness and abundance of flylife in these rivers.

Experience shows that substantial improvements can be achieved, sometimes at surprisingly little cost, to increase water quality, habitat for flylife, fish and other species and the overall recreational values of chalk streams via collaborative, well-targeted project work.

There is much that we can do with a collective mind-set and we owe it to future generations to do so. As with other rivers throughout the UK, the invertebrate stress fingerprints being detected in some reaches of our rivers are reversible: aquatic invertebrate communities have responded well to the control of excess sediment, artificial low-flows, organic and phosphate enrichment and pesticide pollution.

The WCSRT would like to thank the following organisations for their generous support:

Environment Agency
Esmée Fairbairn Foundation
ASRA Avon & Stour Rivers Association
AquaScience
Wiltshire Fishery Association
Strutt & Parker

Wessex Chalk Stream & Rivers Trust

Environment Agency

Esmée Fairbairn Foundation

ASRA
Avon & Stour Rivers Association

AquaScience

Wiltshire Fishery Association

Strutt & Parker