METOC

WAPUG

ACCOUNTING FOR DIFFUSE POLLUTION:

BENEFIT OR BURDEN?

Metoc plc
Exchange House
Liphook
Hants GU30 7DW
United Kingdom

Tel: +44 (0) 1428 727800
Fax: +44 (0) 1428 727122

E-mail: info@metoc.co.uk
Web Site: www.metoc.co.uk

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ABSTRACT

During a Price Review (PR) the environmental regulator will identify an environmental "Outcome" in support of legislation or policy. This might be compliance with the Fresh Water Fish Directive, Shellfish Waters Directive etc. Operators will then formulate engineering "Outputs" which are believed to support a particular Outcome.

Whilst the regulator owns the Outcome risk, it is not in the operator's interest to invest in Outputs that do not deliver real improvements. There are a number of considerations that need to be made in order to avoid ineffective investment:

- Typically, the Outputs are formulated at the beginning of the PR process – at a time when there may be little information to establish a clear link between asset performance and Outcome Risk.
- Whilst wastewater loads from discharges may be well understood, diffuse loads are often poorly defined. Therefore, determining how much of the Outcome Risk is associated with wastewater discharges becomes problematic.
- Where a number of assets impact an area it is often unclear which investment most effectively supports the environmental Outcome

This paper draws on a number of case studies to illustrate how the above factors can be accounted for and how Outputs can be reviewed and developed as more information becomes available. In particular, we look at the importance of identifying the contribution from both industry assets and diffuse sources.

CONTENTS

1 INTRODUCTION

The goal of improving and maintaining a good standard of chemical and biological water quality in the UK has been driven by a raft of water-related legislation over the last 20 years or so.

The introduction of an environmental regulator coupled with periodic investment periods, where wastewater infrastructure is upgraded has produced significant improvements in water quality over this period.

This periodic investment is associated with the Asset Management Programme (AMP) which is based on 5-year period of spending and investment, sanctioned by the economic regulator, OFWAT. In Scotland, a similar process is now followed, although the industry still remains in public ownership.

The Price Review (PR) which precedes an AMP period provides an opportunity for the environmental regulator to identify an 'environmental outcome' for given areas, in support of legislation or policy. This might be compliance with set standards of the Fresh Water Fish Directive or Bathing Waters Directive.

Operators (water companies) will formulate engineering "Outputs" which are believed to support a particular environmental outcome. For example, the engineering output for a combined sewer overflow (CSO) could be 3 spills per bathing season to meet the environmental outcome of mandatory compliance under the Bathing Water directive. Often, these outputs are delivered on the basis of agreed assumptions or conservative margins of error, which have made allowance for the lack of detailed knowledge of the fate of potentially polluting substances in the environment.

Whilst the regulator owns the Outcome risk, it is not in the operator's interest to invest in Outputs that do not deliver real improvements. There are a number of considerations that need to be made in order to avoid ineffective investment:

- Typically, the Outputs are formulated at the beginning of the PR process – at a time when there may be little information to establish a clear link between asset performance and Outcome Risk.
- Whilst wastewater loads from discharges may be well understood, diffuse loads are often poorly defined. Therefore, determining how much of the Outcome Risk is associated with wastewater discharges becomes problematic.
- Where a number of assets impact an area it is often unclear which investment most effectively supports the environmental Outcome

One of the principal areas of uncertainty lies in the understanding and integration of 'diffuse' sources when assessing the impact and design of investment obligations under the AMP system.

Diffuse sources are becoming of increasing importance as the large scale of investment in water company assets has led to the increasing importance of non-industry sources for compliance.

This paper sets out the importance of understanding diffuse sources, the impact this understanding can have on investment decisions, and ultimately the impact on delivery of the environmental Outcome that the investment is intended to secure.

2 WASTEWATER INVESTMENT

2.1 WHY IS THERE INVESTMENT?

Investment in capital projects in the water industry is, in general a response to an environmental driver. Dealing with wastewater, the driver is designed to ultimately protect the environment and public health.

Investment therefore improves public health, maintains and protects the greater [ecological] environmental, and also preserves the status of the watercourse, which is the fundamental asset of the water industry.

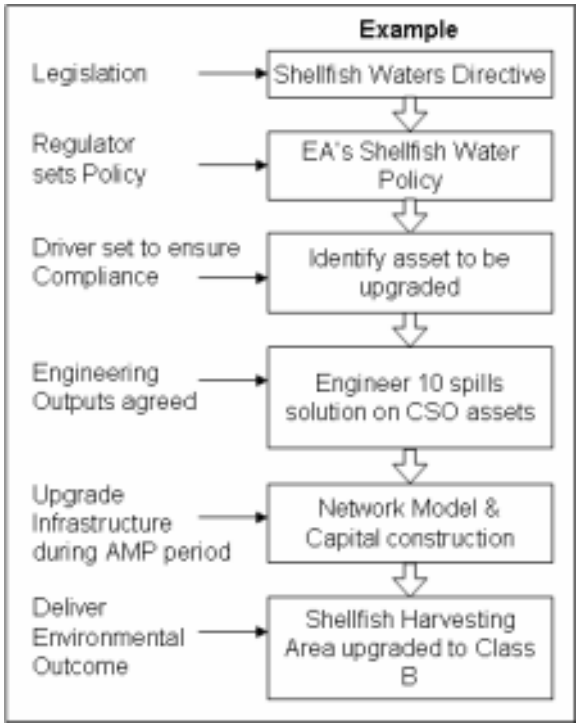
2.2 INVESTMENT PROCESS

Environmental drivers are established at the start of regular investment periods, known as the Asset Management Plan (AMP) system, which are based on a five year AMP cycle.

The Driver and the associated investment is owned by the operator who manages and operates the assets to be 'improved'. Engineering outputs that are believed to support a particular outcome are agreed, and asset upgrades are made within the 5-year AMP period.

The ideal process of investment via this route is presented in Figure 1, using the example of the Shellfish Waters Directive and the AMP investment system to deliver the Environmental outcome of raising the quality of shellfish flesh for human consumption.

Figure 2.1 – Wastewater Investment Process – An example



If the critical factor in any environmental quality problem does not arise from the water industry, then no amount of investment from the water industry will solve that problem.

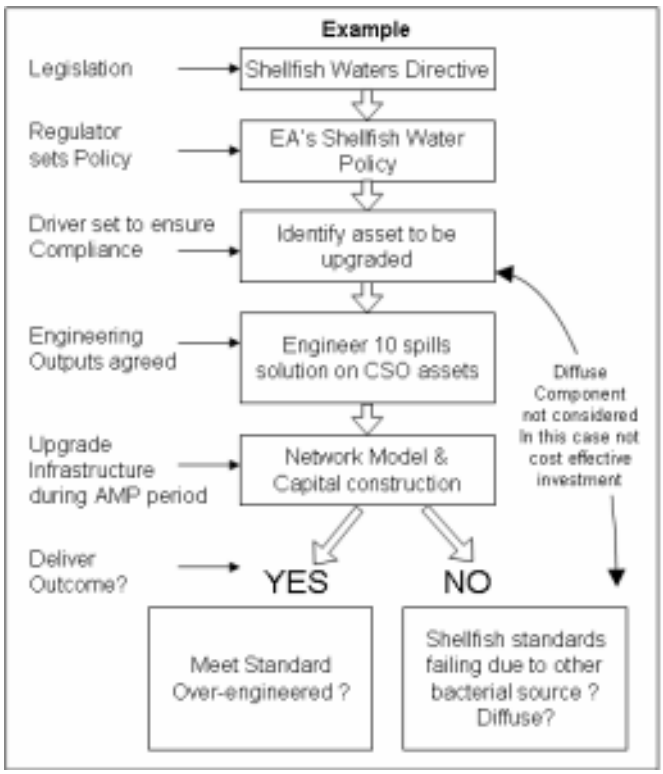
2.3 COST EFFECTIVE INVESTMENT

Whether the Driver is the most efficient way of delivering the Outcome is a major part of the consideration of this paper.

As well as seeking to protect the environment it is important that costly investment is delivering to maximise benefit, i.e. the capital solution is delivering the required Outcome or contribution to the Outcome in the most efficient way possible. As misdirected investment in wastewater assets is in itself an environmental cost.

By the same token, if the Driver does not have any material affect on the Outcome, or the Outcome would be better served by investment elsewhere, then it is clear that investment should not take place. Figure 2 illustrates how failure to deliver an environmental outcome, through non-compliance to the set standards highlights a lack of effective investment via the 'driver' process. In this example, diffuse sources of bacteria contribute to non-compliance of the shellfish waters standard.

Figure 2.2 – Cost effective Investment



Therefore, in particular situations, original AMP drivers, based on conservative assumptions can lead to over-engineered solutions, which are at risk of failing to deliver the proposed environmental outcome. Examples are provided in the case of the Three Rivers Assessment in Section 5.2. Even where the environmental outcome is delivered, the

investment may have proved more expensive (in terms of financial and environmental cost) than was necessary to achieve the Outcome.

Even when we use more robust approaches, such as the use of data analysis, data collection or predictive approaches, the impact of sources outside of the immediate control or influence of the assets themselves have often not been accounted for, or not well resolved.

3 UNDERSTANDING DIFFUSE SOURCES

3.1 WHY ARE DIFFUSE SOURCES IMPORTANT TO WASTEWATER?

Understanding the potential impact of other ('diffuse') sources helps to place the impact of identified assets in context. If investigation shows that 80% of a given impact arises through diffuse pollution, then it is less likely that investment for a given asset will provide any material environmental gain. In fact, if the Outcome is not delivered, the investment is almost certainly a net environmental loss, as concrete, energy, transport costs will have been incurred at the wrong target.

Understanding the sources and impacts of diffuse water pollution, and targeting solutions will allow for a reduction in the financial burden to the water sector in delivering compliance.

The Water Framework Directive explicitly draws attention to the issue of diffuse water pollution (DWP). With the WFD, a number of policy drivers are being developed by the regulators and DEFRA, to assist the implementation of the directive at the river-catchment scale.

Wastewater undertakes will be required to take a pro-active role in the river basin policies currently being developed.

In line with WFD, imminent environmental legislation such as the Bathing Water Directive (2005) imposes more stringent standards on water quality at sensitive areas. Tighter controls may, in the short to medium term, lead to reduced compliance until mitigation measures come on-line. As diffuse sources are now recognised as having a significant impact on bathing water compliance, pro-active asset management and liaison with other sectors is required. It will be important to understand the relative impacts if satisfactory compliance is not met, to ensure that 'knee jerk' investment reactions, aimed at inappropriate targets, are avoided.

3.2 WHAT ARE THE SOURCES?

Four main categories of potential sources of water pollution can be identified:

- Point sources from sewerage undertakers (WwTW & intermittent discharges)
- Industrial point source discharges
- Diffuse water pollution from agriculture (DWPA)
- Diffuse water pollution from non-agricultural sources

Point source impacts from wastewater assets are well known and understood, from continued study and assessment. Similarly Industrial point source discharges are controlled by a consent-to-discharge, placing limits on flow and maximum allowable concentrations (MACs) specific to the type of discharge.

Diffuse sources of pollution are harder to quantify and understand. Diffuse sources can be divided between agricultural and non-agricultural; the latter including sources from industrial & construction sites, transport (roads & rail) runoff, urban areas, forestry areas and contaminated land.

3.3 DIFFUSE WATER POLLUTION FROM AGRICULTURE

Although non-agricultural diffuse sources are of particular importance in more urban catchments, the largest component of water pollution from diffuse sources comes from agriculture. Land used for agriculture occupies over 70% of the total area of England and Wales. Coupled with significant 'intensification' of farming practices on this land, it is not surprising that diffuse water pollution from agriculture (DWPA) is now considered a priority issue.

In recent years a considerable body of research has been developed to appreciate the sources, transportation mechanisms and impacts of DWPA. This has been undertaken by government, regulators, academia and the private sector. A full review of the sources, transport pathways and impacts is beyond the scope of this paper, however, some key sources of DWPA can be summarised in Table 1.

Table 3.1 – Sources Diffuse Water Pollution from Agriculture

Diffuse Pollutant Type	Contaminants	Sources	Env' Impact
Fertilisers	Nutrients (Nitrate & Phosphate)	Inorganic Fertilisers Slurry & Manure	Eutrophication
Pesticides	420+ active ingredients	herbicides, insecticides, fungicides	Toxicity to aquatic species
Faecal Pathogens	*E.coli,* F.coliforms, F. streps	Slurry/manure runoff, excreation direct to land, manure storage	Non-compliance with Bathing Water/Shellfish water standards

Understanding how diffuse sources enter the environment is problematic. Contaminants are not discharged as discrete events, but affect sensitive receivers via number of pathways, such as run-off directly to rivers, via baseflow from aquifers or through open irrigation drains into watercourses. The timing of diffuse inputs is equally variable, with some faecal pathogens from livestock waste entering watercourses fairly constantly throughout the year. In contrast, fertiliser application and herbicide application and subsequent loss to the environment is dictated by the particular crop type, for example excess nutrients in soils after the autumn cultivation, can lead to winter leaching over the winter months.

4 HOW DO WE ACCOUNT FOR DIFFUSE SOURCES?

4.1.1 Data – Understanding the sources

The identification quantification of diffuse sources will rely on a combination of approaches.

Field data for a wide range of environmental conditions (wet, dry, summer, winter, crop type, livestock density, topography, etc) would obviously be the perfect solution for understanding pathways and transport fate. However, we would suggest that it is unlikely that the amount of data required to fully populate a database could be collected in a cost effective and timely manner.

Field data therefore needs to be used in conjunction with predictive or interpolative methods to fill the gaps in the data series.

When taking into consideration the responsibilities of different bodies for managing this type of pollution, it is perhaps not appropriate to expect water companies to populate detailed data libraries for diffuse pollution. A partnership, or information exchange, between parties would seem to be the most effective solution, where collected data can be utilised for predictive approaches to understand baseline and future asset management strategies or investment planning.

We feel it is important that water companies address diffuse sources and their impacts, in as robust a manner as possible, as this improves the ability to make informed decisions regarding asset management and asset investment. This will lead to better environmental performance and better cost efficiency.

It is probably fair to say that historically diffuse sources have not been addressed by the water industry.

The water industry has a good familiarity with the application of predictive systems, as demonstrated by the widespread use of sewer network models, river models and coastal models in investment planning to date.

4.1.2 Knowledge Gaps

The existing 8,000 sampling locations maintained by the Environment Agency across England and Wales for all receiving waters, provides good baseline data for river quality and river flow. Chemical water quality parameters routinely measured include nitrate, phosphate, biochemical oxygen demand (BOD), dissolved oxygen and ammonia. The density of chemical sampling locations within England and Wales is greater than other EU member states.

However, there are gaps in the existing monitoring programmes that will need to be addressed to provide suitable baseline data for assessing changes to diffuse background concentrations over time. River quality is very well monitored in England as Wales by the EA. However,

catchment-wide monitoring will have to be undertaken, from 'source to coast', accounting for lakes, estuaries and aquifers.

The surveillance of a wider variety of pollutants is a requirement of the WFD, which will include pesticides, faecal indicator organisms (FIO) and suspended soil particles. However, cost implications of increasing monitoring coverage will have to be weighted against real gains where there is evidence of gaps.

4.1.3 Predicting the Impact of Diffuse Sources

There a number of approaches to modelling predicted impacts, which include:

- Data driven (empirical) approaches
- Simple river modelling approach, assuming various parameters (including upstream boundaries, run-off and base flow characteristics)
- Fully calibrated dynamic model approach (incorporating river, run-off, groundwater and coastal elements)

As we have stated, having sufficient data for a data driven approach is unlikely, extremely expensive and impractical. Neither does it allow forecasting for the future or testing of mitigation measures.

Simple river modelling has many applications, providing that the data driving the assumptions are robust. However, even with this simple approach, it is important to be able to identify, separate and characterise each discharge or source of pollution. This is because to design mitigation, or to identify critical sources, individual impacts must be understood.

The most flexible and potentially valuable approach is the use of a modelling tool (or suite of tools) which can provide the discrete assessment of individual sources, over a wide variety of environmental conditions (including fluvial, lacustrine and coastal situations). The additional benefits of a dynamic approach is the flexibility it engenders. There is the ability to control the amount of field data required, in that a defined and limited dataset will provide the means to calibrate and validate the full model. A dynamic model provides a fully flexible approach for baseline (present day) and future conditions and provides the best means of testing mitigation measures or other asset interventions.

The immediate reaction to a dynamic approach are most often concerns regarding cost and timescales. It is important to realise that modelling studies do not now have to take months or years to complete, and the de-coupling of compliance or impact assessment from the actual model runs provides a means of delivering thousands of environmental and asset scenarios in a perfectly reasonable project timescale.

The added value to this type of approach can be extremely significant. This can be measured in terms of environmental benefit (improved compliance, targeted engineering and the identification of sources

outside of the industry's control) and improved cost-benefit. The value management process is improved significantly because more information is available to make better informed decisions.

A series of case studies follows, each of which identifies studies or projects where diffuse, or non-industry sources have been the critical factor to environmental performance, and appropriate investigation has led to the most appropriate solution.

5 CASE STUDIES

5.1 SENSITIVE AREAS (EUTROPHIC) IN ANGLIAN RIVERS

An area may be designated a sensitive area (Eutrophic) under the Urban Wastewater Treatment Directive (UWWTD) regulations. The Environment Agency is the responsible body for defining rivers reaches as sensitive areas (Eutrophic), in summary:

- An area may be nominated as a Sensitive Area if it is eutrophic, or likely to become so if no action is taken,
- If an area is eutrophic then nutrient removal (phosphorous, nitrogen or both) should be provided at qualifying discharges unless it can be shown that this will have no effect on the level of eutrophication

Work was undertaken by Metoc to review the designation of river reaches as sensitive under the UWWTD regulations. The review aimed to answer the questions of

1) is the proposed sensitive area under threat from eutrophication based on sampling results?

2) Is the investment (upgraded P removal or P-stripping) proposed at local WwTW appropriate to meet the standards?

A number of rivers in the Anglian region were considered and assessment was undertaken to investigate the impact from phosphorous discharged by the identified WwTWs on the identified downstream sensitive rivers.

It was found that measured background sources of phosphates contributed significantly to the predicted compliance failure under the UWWTD regulations imposed on the designated rivers. In addition, it was estimated that if total P removal at the critical WwTW was installed, the <100 µg/l PO_4 threshold would still not be achieved at the designated river; i.e. there would be no significant difference in trophic state of the watercourse.

5.2 THREE RIVERS ESTUARY, WALES

The objective of this study was to assess compliance of wastewater assets against the Shellfish Waters standard as set out in the EA's Shellfish Waters policy. The assets included intermittent CSOs and WwTW within the Three Rivers estuary, south west Wales. A water quality model was developed for the area and used for the assessment, with approved regulator sign-off and independent audit of the water quality modelling methodology.

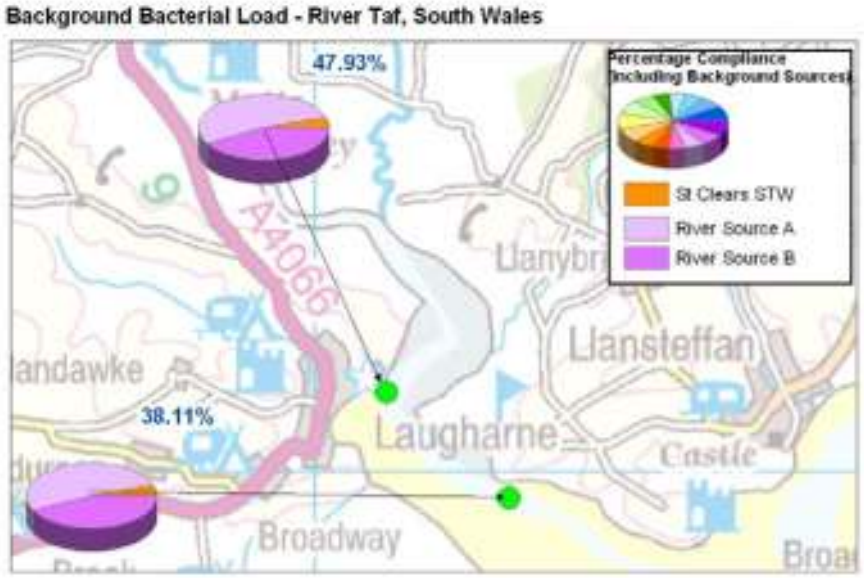
To accurately represent sources of bacterial pollution, the main rivers, Taff, Tywi and Gwendraeth, were sampled for faecal coliform (FC) concentrations. When multiplied with simultaneously measured river

flow, calculated river 'background' load of bacteria was input to the water quality model.

Using STORM-IMPACT, output from the Three Rivers water quality model and network model output was combined to predict the percentage compliance against any known standard. In this case, compliance to the shellfish waters standard of <1500 FC / 100 ml for 97% of the time, was assessed.

Scenarios were assessed with and without river background loads. Where estimated background loads were included they dominate over the wastewater operator assets and lead to non-compliance of the shellfish waters standard throughout the estuary. In the Taf Estuary compliance of <1500 FC/ 100 ml was predicted to be as low as ~40% of the time. The percentage contribution to compliance for the river Taf area of the Three Rivers estuary is presented in Figure 5.1.

Figure 5.1 – River Background Sources entering the Taf Estuary



No major wastewater assets were known upstream of the tidal limits of the rivers, at were not explicitly assessed, therefore significant estimated river loads could only be attributed to an upstream as yet un-identified source of diffuse load.

Further investigation of upstream river sources of bacteria is due to commence within the coming months deploying a more comprehensive upstream sampling programme.

A cost-benefit analysis of the AMP3 drivers on the operator assets for this shellfish water was undertaken. No amount of local investment in asset upgrades would have ensured compliance, due to the inland sources.

The original drivers required significant capital investment which would have had **no benefit in terms of delivering the Regulator's required environmental outcome**.

5.3 RIVER TEST, HAMPSHIRE – NITRATE SCREENING ASSESSMENT

A collaborative academic research project was undertaken in 2005 between Metoc and the University of Surrey which developed an approach to assess the vulnerability of river catchments to nitrate pollution. The pilot area selected was the upper River Test river catchment, Hampshire between the river source, near Overton and the downstream village of Stockbridge.

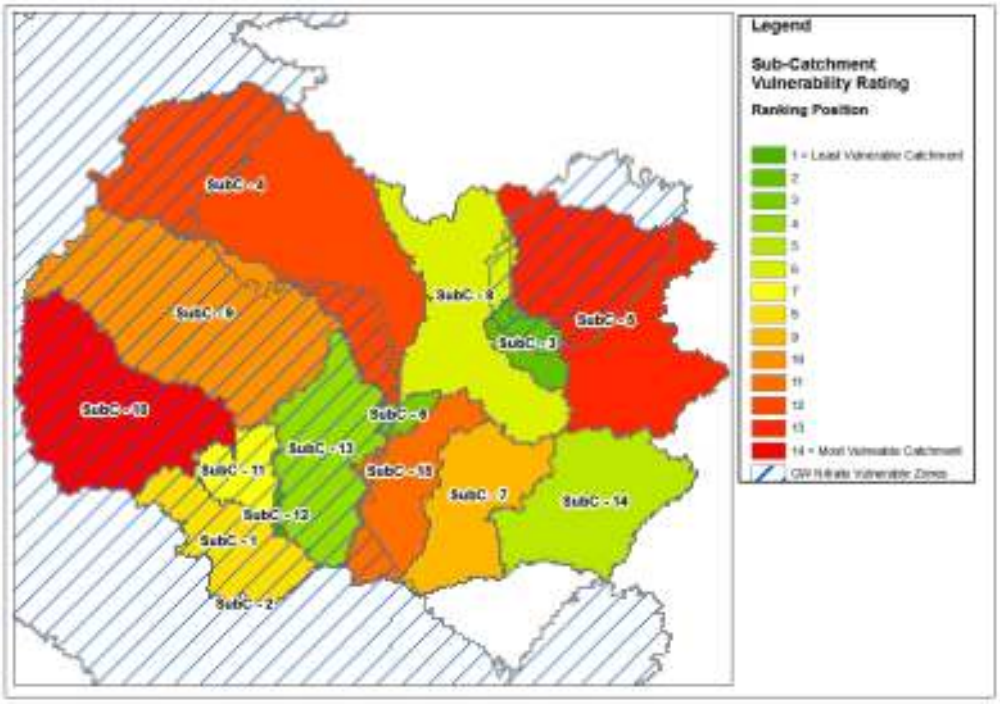
The objective was to identify areas of the river catchment most vulnerable to nitrate pollution. Vulnerablitiy considered both known point sources such as WWTW and industrial discharges, and importantly diffuse sources based on transport factors associated with land-use, such as hydrogeological parameters and surface runoff.

The approach taken combined various critical datasets within a GIS (Geographic Information System) engine, ultimately calculating a vulnerability score based on 'weighted' datasets.

Predicted vulnerable scores for river 'sub-catchments' showed good agreement with measured EA water quality results for nitrates.

This approach allowed for the prioritisation of 'sub-catchments' in terms of vulnerability to nitrates, effectively acting as a rapid 'screening tool'. Once priority sub-catchments are identified as vulnerable to diffuse pollutants, focused investigation into land-use practices can be made. Figure 5.2, presents output of the screening tool, where river 'sub-catchments' are prioritised in terms of vulnerability to nitrates.

Figure 5.2 – Prioritised Approach to River Catchment Vulnerability



This approach is useful as it can be rapidly deployed, allowing targeted investigation of identified 'priority' areas within a river basin; accounting for known point sources and diffuse sources based on farming practices.

6 WATER FRAMEWORK DIRECTIVE - RIVER CATCHMENT INVESTIGATION

The concept of river-basin wide investigation forms the basis of the Water Framework Directive delivery strategy. To deliver the environmental outcomes of 'good' ecological status, all sources of impacts for a variety of contaminants will have to be assessed.

Wastewater operators will play a key role in targeting investment at assets that are identified to cause or significantly contribute to non-compliance. However, the importance of the diffuse source component in contributing to non-compliance will only continue to increase over time.

Although the Environmental Regulator is charged with the delivery of the objectives of the Water Framework Directive, water companies should be in a position to understand the implications of the Directive on their future asset management and asset planning. Just as importantly, they should be able to understand the implications of their asset management on the objectives of the Water Framework Directive.

There is a risk that the water industry will face significant investment expectations, especially considering the relatively short delivery timescales for the WFD, and the fact that these timescales are out of phase with the current AMP process in England and Wales.

It will be to the benefit of all stakeholders – water companies, Regulators and customers – to fully understand the drivers behind compliance with the WFD, and to plan compliance investment effectively.

This means that if diffuse sources are the problem, they are mitigated against – and that point sources are not seen as a convenient (if expensive) means of delivering improvements.

Better knowledge management is the effective means of delivering environmental improvements. Misdirected investment is not neutral. It has a significant environmental cost, and may not even deliver the compliance standard it is supposed to achieve.

7 SUMMARY AND CONCLUSIONS

Embracing the assessment of diffuse pollution leads to greater confidence, both for the operator and regulator, as the solution develops. This is because a complete picture of the environmental impact is built up and understood by both parties. In contrast, when diffuse pollution has not been included the high degree of uncertainty associated with an incomplete picture often leads to protracted consenting processes (i.e. project delays), additional cost and increases the risk of misdirected investment.

In addition:

- Past investment in sewerage upgrades has not always produced the desired effect of the AMP driver, to meet the environmental outcome. This has in some cases caused ineffective investment.
- The contribution of diffuse pollution has become more significant in recent years given the improvement in quality of point source wastewater assets.
- Diffuse water pollution is recognised as a critical issue for the implementation of WFD. The characterisation of water bodies, under WFD, highlights diffuse sources as a major threat to attaining 'good' status.
- Approaches require the integration of existing data sets and robust predictive tools which can account for a multitude of environmental scenarios and can be used to identify the most appropriate mitigation (i.e. engineering solutions).
- Previous work to assess the impact of diffuse sources have demonstrated the efficacy of this approach, and the improvements in environmental and financial performance can be significant.