Improvement Programme for England's Natura 2000 Sites (IPENS) – Planning for the Future IPENS071

Water Quality Catchment Assessment: Detailed SAGIS spreadsheets - technical note

Covers multiple Natura 2000 sites within England

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Foreword

The **Improvement Programme for England's Natura 2000 sites (IPENS)**, supported by European Union LIFE+ funding, is a new strategic approach to managing England's Natura 2000 sites. It is enabling Natural England, the Environment Agency, and other key partners to plan what, how, where and when they will target their efforts on Natura 2000 sites and areas surrounding them.

As part of the IPENS programme, we are identifying gaps in our knowledge and, where possible, addressing these through a range of evidence projects. The project findings are being used to help develop our Theme Plans and Site Improvement Plans. This report is one of the evidence project studies we commissioned.

Water pollution, in particular excessive phosphorus (P) load, is contributing to the failure of a number of England's Natura 2000 sites to meet conservation objectives, and presents a risk to the long term integrity of the network.

This pollution comes from a variety of catchment sources including sewage treatment work discharges, industry, agriculture, small domestic discharges and other diffuse sources such as runoff from roads and urban areas.

Future population growth in certain catchments will result in increased volumes of sewage discharge to certain Natura 2000 rivers. In many instances this can be accommodated within existing permit limits for discharge flow and would not normally trigger a permit review. Understanding the risks presented by this permit 'headroom' is important to informing our future strategy for the restoration of Natura 2000 site condition and protection of long term integrity. For example it can identify where additional improvements in discharge quality are required to mitigate for increased discharge volumes.

The water quality model SAGIS (Source Apportionment Geographical Information System) has recently been used to help understand the relative importance of different sources of P to Natura 2000 catchments. This has been based on monitoring data for discharges from permitted sources.

This project developed a simple spreadsheet tool based on outputs from SAGIS that enables permitted discharges to be adjusted from actual measured quality and flow to fully permitted conditions. This was run for a number of Natura 2000 catchments allowing us to identify where utilisation of permit headroom through growth may present a significant risk to water quality. This technical note describes the methodology used to generate outputs from SAGIS and develop the spreadsheet tool for selected sites.

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Water Quality Catchment Assessment

Detailed SAGIS spreadsheets

1. Background

1.1. Introduction

This technical note describes the methodology that was used to generate outputs from SAGIS (Source Apportionment Geographical Information System) for the following the following sites:

1. River Mease
2. Rivers Wye
3. River Lugg
4. River Itchen
5. Rivers Test
6. River Ehen (Lower Ehen)
7. River Dee
8. River Derwent (Yorkshire)
9. Upstream of the Waveney Broads and Marshes
10. Upstream of the Yare Broads and Marshes
11. River Axe
12. River Camel

These outputs were provided by Atkins to Westcountry Rivers Ltd to feed into consultation with CABA delivery organisations and Natural England.

2. Methodology

2.1. Overview

A deliverable of a recent UKWIR funded project (WW02B207) was a national calibrated outputs from SAGIS for orthophosphate and nitrate. The project involved a series of pre-calibration steps including improvements to: representation of headwater defaults, improved application of regionally defined default values for effluent quality in the absence of observed data and the application of non parametric files to better define the relationship between catchment inputs of chemicals and river flow. An automated calibration methodology was then developed and applied, following discussion with the Environment Agency, based on optimising model fit in relation to observed data by adjusting diffuse inputs.

To allow manipulation of these outputs for both calibration and the testing of scenarios without the need to re-run SAGIS, a **Scenario Testing** spreadsheet was developed. The spreadsheet is based on the following concepts:

1) SAGIS produces outputs at all river locations for the sector contribution to river concentrations
2) For each location it models the contribution of each individual point source to the point sources sector concentration (i.e. wastewater treatment works, industrial discharges, mines, intermittent discharges)
3) For each location it models the contribution of each upstream waterbody to the relevant diffuse source sector
4) The relationship between the scale of the input and the consequent downstream concentration is linear; for example if an input from a point or diffuse source is halved the associated downstream concentration will also be halved.
5) At any point in the river, concentrations can be broken down into their individual sources and recalculated once these individual sources have been modified.
6) This provides a means to quickly recalculate within river concentrations once inputs have been modified either for calibration or running scenarios (e.g. impacts of growth)

2.2. Scenario Testing spreadsheets

Spreadsheets were set up for each of the twelve sites. The key steps in operation of the spreadsheets are described below:

1) On the **Control** Sheet the SIMCAT dat file name and location is defined (cell **B1**) along with the SIMCAT reach numbers (cells **B7** and **B8**) that define the area of interest. A map of the SIMCAT reach structure is provided on Sheet **Connectivity.**

2) Clicking on the **Read In Files** arrow runs a macro that reads in the SIMCAT output files and populates to following Sheets:

- **DataIn:** This contains the SAGIS output for river flow, concentrations and sector apportionment for all of the output locations
- **UpstreamSewageWorks:** For each output location, the upstream point sources are listed along with their contribution to point source loads and river concentrations
- **UpstreamArable:** For each output location, the upstream waterbodies are listed along with their contribution to arable concentrations
- **UpstreamLivestock:** For each output location, the upstream waterbodies are listed along with their contribution to livestock concentrations
- **UpstreamUrban:** For each output location, the upstream waterbodies are listed along with their contribution to urban concentrations
- **UpstreamBackground:** For each output location, the upstream waterbodies are listed along with their contribution to background concentrations
- **UpstreamAtmospheric:** For each output location, the upstream waterbodies are listed along with their contribution to atmosperic concentrations
- **UpstreamOSWWTWs:** For each output location, the upstream waterbodies are listed along with their contribution to on site wastewater treatment works concentrations

This step is used to build the spreadsheet and does not need to be carried out by the user

3) The **Measures** Sheet lists all of the point (Cell **A26** downward) and diffuse (Cell **F26** downward) sources in the selected model area. For point sources, it also lists the feature type (3=wastewater treatment works, 5 = industrial discharge and 12 = CSO or storm tank) and identifies sources that are too small to be tracked by SIMCAT and, therefore, cannot be modified by the spreadsheet (generally these are small CSOs). Beside each source, a factor can be applied to modify the individual input upward or downward

4) The **Measures** Sheet also shows chainage plots of overall river concentration and source apportionment for the start and end reaches specified in Cells B1 and E1, respectively. Chainage plots covering different stretches of rivers are generated by changing the start and end reach numbers and clicking on the **Run** button.

5) Measures are applied by changing the factors for each individual source and clicking on the **Run** button.

6) On the Sheet **Derived Concentrations,** the recalculated concentrations after applying the factors are presented in the Green part of the Sheet compared to the original values (Orange part of the Sheet). These are filtered to show only the output for the selected chain of reaches but all results can be shown by changing the filter in Column **AL** to **Select All** (this needs to be changed back to 1 for the chainage plots on the **Measures** Sheet to be shown).

7) Sheet **Connectivity** contains information on the connectivity between reaches along with a map of the reach structure (this can be used to select the start and end reaches of interest to create the chainage plots).

8) Sheet **Permit** contains information on the permitted flow for sewage works (estimated mean value derived from the dry weather flow) compared to the actual flow in SAGIS. It also contains information on the permitted concentration for phosphorus. This information is derived from national databases provided to the SAGIS project team by the Environment Agency and is provided to help the user to set up scenarios (it is not used in the spreadsheet calculations).

2.3. Other outputs

The following additional outputs from SAGIS were also provided:

- A shapefile of simulated river concentrations and source apportionment before modification (i.e. before running scenarios). It does, however, take into account refinements to the model as described below in Section 2.4 of this note.
- A shapefile with data to create pie charts of apportionment of the inputs to the rivers and simulated concentrations for each waterbody outlet.

2.4. Modifications to SAGIS

Following an initial review of the outputs for the twelve rivers, it was necessary to make some corrections to the SAGIS data/structure before generating the outputs. These changes form part of the ongoing maintenance and refinement of the SAGIS models, funded by the Environment Agency and UKWIR. Consequently, in some cases (i.e. for five of the sites), the outputs are different from those previously provided to Natural England. These changes are listed in Table 1 below:

Table 1 Modifications to SAGIS models before generating the outputs

Model area	Change made
River Mease	No changes made
River Wye	Diffuse inputs (arable and livestock) calibrated to improve model fit.
River Lugg	No changes made
River Itchen	No changes made
River Test	Input load from Morestead sewage works corrected (original data was incorrect)
River Ehen	Diffuse inputs (arable and livestock) calibrated to improve model fit. The auto-calibration failed to achieve improvements to the Lakes SAGIS model so previous outputs from UKWIR project - WW02B207 - were issued pre-calibration
River Dee	No changes made
River Derwent	No changes made
River Axe	No changes made
River Camel	No changes made
Waveney Broads and Marshes	River travel times decreased to reflect slow flowing nature of this river

Model area	Change made
Yare Broads and Marches	Waterbody GB105034055880 split upstream of Norwich to separate the influence of the city on the upstream river. Reach structure downstream of Norwich modified to allow outputs upstream of the Yare Broads and Marshes (previously this part of the model was classified as non freshwater and therefore not included in the SIMCAT models). In reality, although tidal this section of river is fresh. Input loads from Whitlingham sewage works modified to reflect phosphorus removal (previously River travel times decreased to reflect slow flowing nature of this river

Table 2 List of SAGIS output spreadsheets

Scenario spreadsheets based on detailed SAGIS outputs adjusted for permitted flow estimates
ScenarioTesterAxe ScenarioTesterCamel ScenarioTesterDee2 ScenarioTesterDerwent ScenarioTesterEhen ScenarioTesterItchen ScenarioTesterLugg ScenarioTesterMease ScenarioTesterTest ScenarioTesterWaveney ScenarioTesterWye ScenarioTesterYare

Shape files illustrating the outputs for all the core catchments, which are the focus of the current catchment investigations (i.e. excluding the Axe and Camel), are also provided.