Annex 4 – RIVERS – Invertebrates - WHPT

THE WHALLEY HAWKES PAISLEY TRIGG (WHPT) METHOD FOR ASSESSING RIVER INVERTEBRATE COMMUNITIES

Contents

A1 Description of method

This technical annex for the Whalley Hawkes Paisley Trigg (WHPT) metric is based on the Method Statement of the predecessor approach, referred to as the River Invertebrate Classification Tool (RICT). The acronym "RICT" actually refers to a software tool which can predict and apply classification to a wide variety of invertebrate assessment metrics, including BMWP-NTAXA and BMWP-ASPT, (which were used for the first RBMP), and which has now been updated to incorporate similar metrics for WHPT.

Where italics are used in this annex, it indicates that the Method Statement has changed to accommodate the WHPT method, or where it may still be changed in the future as the method is made operational. RICT is an advanced and complex software package which will require the concerted effort of regulators and software engineers to update it over the lifetime of a dedicated project. Therefore at some points, only indications can be made as to the likely changes that will appear in the final Method Statement for WHPT.

1. Introduction

This method statement describes a monitoring system for monitoring, assessing and classifying rivers in accordance with the requirements of Article 8; Section 1.3 of Annex II; and Annex V of the Water Framework Directive (2000/60/EC). The method is known as the *Whalley Hawkes Paisley Trigg Method (WHPT).*

Geographic application of the method

The method can be applied to rivers in England, Northern Ireland, Scotland and Wales.

Quality element assessed by the method

The method enables an assessment of the condition of the quality element, "benthic invertebrates", listed in Table 1.2.1 of Annex V to the Water Framework Directive

Pressures to which the method is known to be sensitive

The method has been designed to detect the impact on the quality element of organic enrichment. It is also known to be sensitive to toxic pollution. It may also detect the impact on the quality element of other pressures or combinations of pressures.

Parameters used to assess the quality element

The *WHPT* method assesses the condition of the quality element using the parameters:

Number of taxa (*WHPT*-NTAXA); and

Average Score Per Taxon (*WHPT*-ASPT).

The parameters are indicative of the impact of organic enrichment on the quality element. They are calculated using information on benthic macro-invertebrate species and groups of species

2. Sampling and analysis

This section is under review. It will be updated in the revised version of the Method Statement for WHPT.

To apply the method, benthic macro-invertebrates should be collected from shallow flowing waters by disturbing the substratum with the feet ("kick" sampling) upstream of a hand net (nominal mesh size: 1 mm) held vertically on the riverbed

All habitats in the chosen sampling site in the river should be sampled within a 3-minute period. In addition, a manual search, lasting one minute, should be performed and any invertebrates found attached to submerged plant stems, stones, logs or other solid surfaces should be removed and placed in the net.

Rivers that are too deep to be sampled by the kick sampling method described above should be sampled by:

(i) sweeping a long-handled pond net (nominal mesh size: 1 mm) through any aquatic vegetation within reach of the banks of the river; and
(ii) kick sampling in any shallow areas;

or

(iii) sampling using a naturalist's dredge or an air-lift sampler.

The sampling methods used should be compliant with:

(a) BS EN 27828:1994, ISO 7828-1985 Water quality. Methods for biological testing. Methods of biological sampling: guidance on handnet sampling of aquatic benthic macro-invertebrates; or
(b) BS EN ISO 9391:1995, BS 6068-5.15:1995 Water quality. Sampling in deep water for macro-invertebrates. Guidance on the use of colonization, qualitative and quantitative samplers.

Samples should be analysed to identify the presence of the invertebrate taxa listed in Column 1 of Table 1.

3. Procedure for deriving the ecological quality ratio for the parameters

3.1 Calculation of the observed value of each parameter

(i) Number of taxa (NTAXA)

The observed value of the parameter, NTAXA, should be the sum of the number of different taxa listed in Column 1 of Table 2 and present in *each* of the samples obtained from the sampling site in the same calendar year.

Due to sample sorting and identification errors, the calculated observed value for NTAXA may be underestimated. In order to account for this, the observed values should be converted to bias-corrected observed values. This should be done using the following procedure.

An NTAXA bias value should be determined representing an estimate of the average under-estimation of the observed number of taxa listed in Column 1 of Table 2 in a sample. Separate bias values should be determined for each season (i.e. Spring, Summer and Autumn). The values should be based on proper analysis (e.g. an external audit of samples taken and analysed) and determined by the quality systems and procedures in place where the samples were analysed.

The observed value of the parameter should then be calculated using the applicable equation in Column 2 of Table 1.

Table 1 will no longer be relevant since samples will no longer be combined over seasons in this manner. The BMWP method combines seasons by 'pooling' the presence of the organisms found in spring and autumn etc. This is no longer a feasible approach when *the abundance of the organisms is taken into account, therefore WHPT will calculate EQR for each season and take an annual average of these.*

Since the WHPT method demands that the annual average is calculated at the EQR level, it is probable that the following calculations (Table 1) will no longer be necessary.

Table 1: Calculation of bias-corrected observed values for the parameter, NTAXA

Column 1	Column 2
Data used to calculate observed value	Bias-corrected observed value for NTAXA
Sampling data collected during single season	Observed value + NTAXA bias value for the season
Combined sampling data from two seasons	Observed value + [0.51 x (sum of NTAXA bias values for the two seasons)]
Combined sampling data from three seasons	Observed value + [0.37 x (sum of NTAXA bias values for the three seasons)]

(ii) Average Score Per Taxon (ASPT)

To calculate the observed value of the parameter, ASPT, the number of individuals in each of the taxa listed in Column 1 of Table 2 should be counted, and the pressure sensitivity score for relevant Abundance Code (AB code) column should be read off.

The Abundance Codes are applies as follows:

AB1 = 1 to 10 individuals present in the sample

AB2 = 11 to 100 individuals present in the sample

AB3 = 101 to 1000 individuals present in the sample

AB4 = >1000 individuals present in the sample

The observed value of the parameter should then be calculated using the following equation:

Observed value of ASPT = $PS_s \div NTAXA$

where:

"PS_s" is the sum of the pressure sensitivity scores assigned to each taxon present in *a single sample from a single season.*

The observed value should then be converted to bias-corrected values as follows:

The value of ASPT for taxa missed because of sample sorting and identification errors should be estimated using the equation:

Estimated ASPT of missed taxa = 4.29 + 0.077 x observed value of NTAXA

where the observed value of NTAXA is the value prior to bias correction.

The values in this equation may change if the mean estimated pressure sensitivity score for the missing taxa used in the WHPT index are markedly different to those for the BMWP index.

The bias-corrected value of ASPT is then given by the following equation:

Bias-corrected observed value of ASPT =	[(Observed value of NTAXA x observed value of ASPT) + (NTAXA bias value x estimated ASPT of missed taxa)] ÷ bias-corrected observed value of NTAXA

where the NTAXA bias value depends on the sampling data used to calculate the observed value of the parameter as follows:

Since the WHPT method demands that the annual average is calculated at the EQR level, it is probable that the following calculations will no longer be necessary.

Observed value calculated using sampling data collected during single season	NTAXA bias value = NTAXA bias value for the season
Observed value calculated using combined sampling data from two seasons	NTAXA bias value = 0.51 x (sum of NTAXA bias values for the two seasons)
Observed value calculated using combined sampling data from three seasons	NTAXA bias value = 0.37 x (sum of NTAXA bias values for the three seasons)

3.2 Calculation of the reference values for each parameter

Reference conditions were derived using best available sites with modeling.

The value for the parameters in the reference conditions applicable to the river should be calculated using the procedure set out in Annex I *(of this Method Statement, see below)*.

3.3 Calculation of the ecological quality ratio (EQR) for each parameter

(i) Number of taxa (NTAXA)

The ecological quality ratio (EQR) for the parameter, NTAXA, should be calculated using the equation:

EQR_{N_TAXA} = ((*spring observed value of NTAXA ÷ spring reference value for NTAXA) + (autumn observed value of NTAXA ÷ autumn reference value for NTAXA)) x 0.9396*

(ii) Average Score Per Taxon (ASPT)

The ecological quality ratio (EQR) for the parameter, ASPT, should be calculated using the equation:

EQR_{ASPT} = ((*spring observed value of ASPT ÷ spring reference value for ASPT) + (autumn observed value of ASPT ÷ autumn reference value for ASPT)) x 0.9921*

3.4 Application of the method for the purposes of classification

When using the method for the purposes of classifying the ecological status or potential of a water body, the annual mean value of the ecological quality ratio for each parameter should be used.

Table 2 The WHPT Pressure Sensitivity Scores (PS_s) for each Abundance Category

Taxon	**AB1**	**AB2**	**AB3**	**AB4**
TRICLADA (Flatworms)				
Dendrocoelidae	3.0	2.6	2.6	2.6
Dugesiidae	2.8	3.1	3.1	3.1
Planariidae	4.7	5.4	5.4	5.4
MOLLUSCA (Snails, Limpets and Mussels)				
Neritidae	6.4	6.5	6.9	6.9
Viviparidae	5.2	6.7	6.7	6.7
Unionidae	5.2	6.8	6.8	6.8
Sphaeriidae_Pea_mussels	4.4	3.5	3.4	2.3
Lymnaeidae	3.6	2.5	1.2	1.2
Planorbidae	3.2	3.0	2.4	2.4
Valvatidae	3.3	3.1	2.7	2.7
Physidae	2.7	2.0	0.4	0.4
Acroloxidae	3.6	3.8	3.8	3.8

Taxon	AB1	AB2	AB3	AB4
Ancylidae	5.8	5.5	5.5	5.5
Bithyniidae	3.6	3.8	3.3	3.3
Dreissenidae	3.7	3.7	3.7	3.7
Hydrobiidae	4.1	4.2	4.6	3.7
OLIGOCHAETA (worms)				
Oligochaeta	3.6	2.3	1.4	-0.6
HIRUDINIA (Leeches)				
Piscicolidae	5.2	4.9	4.9	4.9
Glossiphoniidae	3.4	2.5	0.8	0.8
Erpobdellidae	3.6	2.0	-0.8	-0.8
Hirudinidae	-0.8	-0.8	-0.8	-0.8
CRUSTACEA (Crayfish, Shrimps and Slaters)				
Astacidae	7.9	7.9	7.9	7.9
Corophiidae	5.7	5.8	5.8	5.8
Asellidae	4.0	2.3	0.8	-1.6
Crangonyctidae	3.8	4.0	3.6	3.6
Gammaridae	4.2	4.5	4.6	3.9
Niphargidae	6.3	6.3	6.3	6.3
EPHEMEROPTERA (Mayflies)				
Siphlonuridae (incl Ameletidae)	11.3	12.2	12.2	12.2
Heptageniidae	8.5	10.3	11.1	11.1
Ephemeridae	8.3	8.8	9.4	9.4

Taxon	AB1	AB2	AB3	AB4
Leptophlebiidae	8.8	9.1	9.2	9.2
Ephemerellidae	7.9	8.5	9.0	9.0
Potamanthidae	9.8	10.4	10.4	10.4
Caenidae	6.5	6.5	6.5	6.5
Baetidae	3.6	5.9	7.2	7.5
PLECOPTERA (Stoneflies)				
Perlidae	12.6	13.0	13.0	13.0
Chloroperlidae	11.4	12.2	12.2	12.2
Taeniopterygidae	11.0	11.9	12.1	12.1
Perlodidae	10.5	11.5	11.5	11.5
Capniidae	9.7	9.4	9.4	9.4
Leuctridae	9.3	10.6	10.6	10.6
Nemouridae	8.7	10.7	10.7	10.7
ODONATA (Damselflies)				
Calopterygidae	5.9	6.2	6.2	6.2
Platycnemididae	6.0	6.0	6.0	6.0
Coenagriidae	3.4	3.8	3.8	3.8
ODONATA (Dragonflies)				
Cordulegasteridae	9.8	9.8	9.8	9.8
Aeshnidae	4.7	4.7	4.7	4.7
Libellulidae	4.1	4.1	4.1	4.1
HEMIPTERA (Bugs)				

Taxon	AB1	AB2	AB3	AB4
Aphelocheiridae	8.6	8.5	8.0	8.0
Hydrometridae	4.3	4.3	4.3	4.3
Gerridae	5.2	5.5	5.5	5.5
Mesoveliidae	4.7	4.7	4.7	4.7
Nepidae	2.9	2.9	2.9	2.9
Naucoridae	3.7	3.7	3.7	3.7
Pleidae	3.3	3.3	3.3	3.3
Notonectidae	3.4	3.9	3.9	3.9
Corixidae	3.7	3.9	3.7	3.7
Veliidae	4.5	3.9	3.9	3.9
COLEOPTERA (Beetles)				
Gyrinidae	8.1	9.0	9.0	9.0
Scirtidae	6.9	6.8	6.8	6.8
Dryopidae	6.0	6.0	6.0	6.0
Elmidae	5.3	7.4	8.3	8.3
Haliplidae	3.6	3.4	3.4	3.4
Hygrobiidae	3.8	3.8	3.8	3.8
Dytiscidae	4.5	4.8	4.8	4.8
Hydraenidae	8.5	10.5	10.5	10.5
Hydrophilidae	5.8	8.8	8.8	8.8
Noteridae	3.2	3.2	3.2	3.2
MEGALOPTERA				

Taxon	AB1	AB2	AB3	AB4
Sialidae	4.2	4.4	4.4	4.4
NEUROPTERA, PLANIPENNIA				
Sisyridae	5.7	5.7	5.7	5.7
TRICHOPTERA (Caddis-flies - caseless)				
Philopotamidae	11.2	11.1	11.1	11.1
Polycentropodidae	8.2	8.1	8.1	8.1
Hydropsychidae	5.8	7.2	7.4	7.4
Glossosomatidae	7.8	7.6	7.2	7.2
Psychomyiidae	5.8	5.7	5.7	5.7
Rhyacophilidae	8.1	9.2	8.3	8.3
TRICHOPTERA (Caddis-flies - cased)				
Odontoceridae	11.1	10.3	10.3	10.3
Lepidostomatidae	9.9	10.3	10.2	10.2
Goeridae	8.8	8.8	9.4	9.4
Brachycentridae	9.6	9.5	8.9	8.9
Sericostomatidae	8.9	9.4	9.5	9.5
Beraeidae	8.8	7.3	7.3	7.3
Molannidae	6.5	7.6	7.6	7.6
Leptoceridae	6.7	6.9	7.1	7.1
Phryganeidae	5.5	5.5	5.5	5.5
Limnephilidae (incl Apatanidae)	5.9	6.9	6.9	6.9
Hydroptilidae	6.1	6.5	6.8	6.8

Taxon	AB1	AB2	AB3	AB4
DIPTERA (True flies)				
Simuliidae	5.5	6.1	5.8	3.9
Tipulidae (incl Cylindrotomidae, Limoniidae & Pedicidae)	5.4	6.9	6.9	7.1
Chironomidae	1.2	1.3	-0.9	-0.9
Athericidae	9.3	9.5	9.5	9.5
Ceratopogonidae	5.4	5.5	5.5	5.5
Chaoboridae	3.0	3.0	3.0	3.0
Culicidae	2.0	1.9	1.9	1.9
Dixidae	7.0	7.0	7.0	7.0
Dolichopodidae	4.9	4.9	4.9	4.9
Empididae	7.0	7.6	7.6	7.6
Ephydridae	4.4	4.4	4.4	4.4
Muscidae	4.0	2.6	2.6	2.6
Psychodidae	4.5	3.0	3.0	3.0
Ptychopteridae	6.4	6.4	6.4	6.4
Rhagionidae	9.6	9.6	9.6	9.6
Sciomyzidae	3.4	3.4	3.4	3.4
Stratiomyidae	3.6	3.6	3.6	3.6
Syrphidae	1.9	1.9	1.9	1.9
Tabanidae	7.1	7.3	7.3	7.3

(Sub-) Annex 1: Procedure for calculating the reference value for each parameter

This Annex provides all the information necessary to be able to calculate the reference values for the two parameters NTAXA and ASPT. Note that NTAXA and ASPT are also commonly known as indices and that is how they are referred to in this Annex.

Acknowledgement

It should be noted that the methodology described in this Annex (and in the main body of the Method Statement) is based on RIVPACS methodologies. RIVPACS stands for River Invertebrate Prediction and Classification System and has been developed over a number of years by the Freshwater Biology Association and the Centre for Ecology and Hydrology with support from the UK environmental agencies.

Contents

1.1 Measure the required Environmental Variables (EVs)

In order to be able to predict values for NTAXA and ASPT for a site, values for the 12 Environmental Variables (EVs) detailed below are required. It is not the purpose of this document to specify in detail how these EVs are to be measured. However, summary information has been included in Appendix A *(of the original method statement, which may be subject to change)*, which should enable those with suitable knowledge to be able to measure the EVs correctly.

No.	Name	Unit	Comments
1	National Grid Reference		2 letters followed by up to 6 digit Easting and up to 6 digit Northing. Used to derive Latitude, Longitude, Mean Air Temperature and Air Temperature Range
2	Altitude	M	
3	Slope	$m\ km^{-1}$	
4	Discharge Category	numeric (1 to 9)	If not known then a value for water velocity can be used to estimate a value for Discharge Category – see Appendix B *(of the original method statement, which may be subject to change)*
5	Distance from Source	Km	
6	Stream Width	M	
7	Stream Depth	Cm	
8	Alkalinity	$mg\ l^{-1}$ $CaCo_3$	If not known then values for water hardness, calcium concentration or conductivity can be used to estimate a value for Alkalinity – see Appendix C *(of the original method statement, which may be subject to change)*
9	% cover of boulders & cobbles		
10	% cover of pebbles & gravel		
11	% cover sand		
12	% cover of silt & clay		

1.2 Convert the measured EVs to Predictive Environmental Variables (PEVs)

The prediction process (see 1.3) uses Multiple Discriminant Analysis (MDA), which requires values for 13 Predictive Environmental Variables (PEVs). These are listed below along with details of how the values are determined from the measured EVs.

Env_v	Description	Form used in MDA
Env_1	Latitude	Derived from National Grid Reference – see Appendix D *(of the original method statement, which may be subject to change)*
Env_2	Longitude	Derived from National Grid Reference – see Appendix D *(of the original method statement, which may be subject to change)*
Env_3	Altitude	Log_{10}(Altitude)
Env_4	Distance from source	Log_{10}(Distance from source)
Env_5	Stream width	Log_{10}(Stream width)
Env_6	Stream depth	Log_{10}(Stream depth)
Env_7	Mean substratum	Derived from the '% cover' EVs – see Appendix E *(of the original method statement, which may be subject to change)*
Env_8	Discharge Category	Value of Discharge Category
Env_9	Alkalinity	Value of Alkalinity
Env_{10}	Alkalinity (log)	Log_{10}(Alkalinity)
Env_{11}	Slope at site	Log_{10}(Slope at site)
Env_{12}	Mean air temperature	Derived from National Grid Reference – see Appendix D *(of the original method statement, which may be subject to change)*
Env_{13}	Air temperature range	Derived from National Grid Reference – see Appendix D *(of the original method statement, which may be subject to change)*

Notes:

a) The final two PEVs are not required for sites in Northern Ireland.

b) If the values of certain EVs that are used in the predictions in their logarithmic form are zero or < 0.1 then they need to be reset as follows:

IF ALT = 0 THEN ALT = 1

IF DIST <0.1 THEN DIST = 0.1

IF WIDTH < 0.1 THEN WIDTH = 0.1

IF DEPTH < 1 THEN DEPTH = 1

IF DCH = 0 THEN DCH = 0.1

IF ALK < 0.1 THEN ALK = 0.1

1.3 Validate the EVs/PEVs

Although values may be measured for EVs they may not be suitable for use in the prediction process (e.g. due to errors in the measurement process).

Therefore, there are checks that require to be carried out on both EVs and calculated PEVs in order to highlight any issues there might be with the measured data.

Valid Minimum/Maximum Values for EVs/PEVs

There are minimum/maximum values for EVs/PEVs whereby, if any of the EVs/PEVs are outwith their range, then this should result in the prediction process being stopped and the classification process being abandoned. These values are the same for both GB and NI and are included in Appendix F *(of the original method statement, which may be subject to change)*.

'Warning' Minimum/Maximum Values for EVs/PEVs

There are minimum/maximum values for EVs/PEVs whereby, if any of the EVs/PEVs are outwith their range, then this should result in the prediction process continuing but with the resultant classification being treated with caution. These values can be different for GB and NI and are also included in Appendix F *(of the original method statement, which may be subject to change)*.

Note that there is also a calculation of a Suitability Code in order to highlight a situation where there is a very low probability of the site being in any of the end groups based on the data provided. This calculation requires access to the probabilities of end group membership data and can, therefore, only be carried out once the probabilities are determined (see 1.4.3). It is specified in detail in section 1.6.

1.4 Calculate the Predicted Values for NTAXA and ASPT

1.4.1 Overview

The prediction process involves working out the probability of a site belonging to each End Group in the relevant End Group Set (e.g. NI) and then using these probabilities in conjunction with index means for each end group to calculate predicted index values.

The probability of a site belonging to an End Group is determined by the similarity of its Environmental Variables (EVs) to those of the relevant End Group.

Due to the multivariate nature of the EV data, Multiple Discriminant Analysis (MDA) is used to turn the EV data into a format, which can be used to discriminate between the end groups using the Mahalanobis Distance statistical technique.

MDA depends on multiple Discriminant Functions (DF). A Discriminant Function has the general format:-

$Z = c_1{*}Env_1 + c_2{*}Env_2 + c_3{*}Env_3 \ldots\ldots. + c_nEnv_n$

where Z is the Discriminant Score (DS) for that particular discriminant function, $c_1 \ldots c_n$ are the coefficients of that discriminant function and $Env_1 \ldots Env_n$ are the values of the predictive environmental variables.

A DF is a linear combination of the variables and the coefficients, which maximises the separation in data space of the end groups. Specifically, it finds aspects of the EV variation, which maximise the ratio of the variation between end group means to the variation between sites within end groups.

1.4.2 Reference/Parameter Data Required

In order to carry out the prediction process, a number of datasets are required as outlined below. There are separate datasets for GB and NI.

a) Discriminant Functions (DFs) and their coefficients

There are 13 DFs to be used for GB and 10 DFs to be used for NI. As outlined in section 1.2, there are 13 PEVs for GB and 11 PEVs for NI.

Appendix G *(of the original method statement, which may be subject to change)* contains the relevant coefficients.

b) DF Means per End Group

There are 43 End groups for GB and each of these has a mean DF score for each of the 13 DFs.

There are 11 End groups for NI and each of these has a mean DF score for each of the 10 DFs.

Appendix H *(of the original method statement, which may be subject to change)* contains the relevant DF Means.

c) Index Means per End Group

There are 43 End groups for GB and 11 End Groups for NI with each of these having a mean index value for NTAXA and ASPT. In addition, there are separate mean index values per 'Season Code' where Season Code can be 1 to 7 (1 = Spring, 2 = Summer, 3 = Autumn, 4 = Spring+Summer, 5 = Spring+Autumn, 6 = Summer+Autumn, 7 = Spring+Summer+Autumn). The recommended way of classifying for 2007 is to use combined Spring+Autumn samples and so only values for Season Code 5 are usually required. However, all values are included in Appendix I *(of the original method statement, which may be subject to change)* for completeness.

d) Number of Reference Sites in each End Group

Appendix I *(of the original method statement, which may be subject to change)* also contains the number of reference sites in each of the 43 End Groups for GB and 11 End Groups for NI.

1.4.3 Detailed Algorithms for Calculating Probabilities of End Group Membership

Definitions :

v = id of current predictive environmental variable

vN = number of predictive environmental variables

g = id of current end group

gN = number of end groups in current end group set (set: 1 = GB, 2 =NI)

$NRef_g$ = number of reference sites in end group g

d = id of current discriminant function axis

dN = number of discriminant function axes in current end group set

$DFCoef_{v,d}$ = discriminant function coefficient for predictor variable v on discriminant function d

Env_v = value of predictive environmental variable v for the current test site

$DFScore_d$ = discriminant function score on axis d for the current test site

$DFMean_{g,d}$ = mean discriminant function score of end group g on axis d

$MahDist_g$ = Mahalanobis distance of test site from end group g

$Prob_g$ = Probability test site belongs to end group g

$x_1 + ... + x_n$ = sum of the list of *n* variables x_1, $x_{2,}$, x_3 ... up to x_n

$b_1 * x_1 + ... b_n * x_n$ = sum of the list of *n* items $(b_1 * x_1)$, $(b_2 * x_2)$, up to $(b_{1n} * x_{1n})$

where $(b_1 * x_1)$ denotes b_1 multiplied by x_1

Algorithms:

$DFScore_d$ = $DFCoef_{1,d} * Env_1 + ... + DFCoef_{vN,d} * Env_{vN}$; for d = 1,...,dN

$MahDist_g$ = $(DFScore_1 - DFMean_{g,1})^2 + ... + (DFScore_{dN} - DFMean_{g,dN})^2$;

for g = 1,...,gN

$PDist_g$ = $NRef_g * EXP(-MahDist_g / 2)$; where EXP is the natural exponential function

$PDistTot$ = $PDist_1 + ... + PDist_{gN}$

$Prob_g$ = $PDist_g / PDistTot$

1.4.4 Detailed Algorithm for Calculating Predicted Index Values

Definitions :

g = id of current end group

gN = number of end groups in current end group set (set: 1 = GB, 2 =NI)

$Prob_g$ = Probability test site belongs to end group g

i = id of current biological index

s = id of selected season(s) combination (referred to as 'season *s*');

(1 = spring, 2 = summer, 3 = autumn, 4 = spring+summer,

5 = spring+autumn, 6 = summer+autumn, 7 = all three seasons)

$IDXMean_{i,s,g}$ = Mean value of index *i* for season *s* for reference sites in end group *g*

$ExpIDX_i$= Expected value of index *i* for selected season *s* for current test site

Algorithm :

$ExpIDX_i$ = $Prob_1$ * $IDXmean_{i,s,1,}$ + ... + $Prob_{gN}$ * $IDXmean_{i,s,gN}$

Note that Season Code should typically be 5 for WFD classification purposes.

1.5 Convert the Predicted Values to Reference Values

1.5.1 Overview

The predicted index values are calculated using index values for reference sites that are considered to be representative of the best quality available for the range of river types found in the UK. However, WFD requires that classifications are based on Reference State and, since not all reference sites are at Reference State, an adjustment has to be carried out to the predicted index values in order to reflect the expected values at Reference State. *To this end, any predictions that are based on data from sites that are known to be of reduced quality are adjusted upwards to be in line with the predictions made from data known to be of high quality.*

1.5.2 Reference/Parameter Data Required

The adjustment calculations require access to the following datasets:

a) Proportion of Reference Sites in each End Group by Assessment Score

All reference sites have been allocated an assessment score of 1 to 5, where 1 is of the highest quality. The algorithm needs to know the proportion of reference sites in each end group by assessment score and this data is included in Appendix J *(of the original method statement, which may be subject to change)*.

b) Adjustment Factors per Index/Assessment Score

The adjustment factors to be used vary per index and assessment score. The values to be used are defined within 1.5.3 below.

1.5.3 Detailed Algorithm for Converting Predicted Values to Reference Values

E_{face} = Predicted Index Value

P_i = Probability that test site belongs to end group *i* (as calculated in 1.4.3)

Q_{ij} = Proportion of reference sites in end group *i* with assessment score *j*

A_j = Multiplicative factor to be used for relevant index/assessment score as defined in following table:

		Assessment score				
		1	2	3	4	5
A_j	TAXA	1.0	1.0	1.0	0.967	0.926
	ASPT	1.0	1.0	1.0	0.977	0.945

Algorithm

The expected reference value (E_{adj}) for a test site is estimated by:

$$E_{adj} = E_{face} F_{adj}$$

where $F_{adj} = 1 / \sum_{j=1}^{5} (A_j R_j)$ and $R_j = \sum_{i=1}^{g} (P_i Q_{ij})$

Note that, if more than one reference value is calculated for a parameter (e.g. due to data being used for more than one year) then the annual mean of the reference value should be used for the EQR calculation.

1.6 Calculate the Suitability Code

The rules for determining the environmental suitability (codes 1-5) of a test site for prediction based on its multiple discriminant analysis (MDA) distance from each end group are outlined below.

Definitions :

$MahDist_g$ = Mahalanobis distance of test site from end group g (see 1.4.3)

$MahDist_{min}$ = minimum of ($MahDist_1$,...,$MahDist_{gN}$)

SuitCode = suitability code for the test site

SuitText = Upper limit of probability that test site belongs to any end group

Data Table 1 : Chi-square values (CQ_1, CQ_2, CQ_3, CQ_4) used in determining the suitability code for a test site

End group set	CQ_1	CQ_2	CQ_3	CQ_4
1 = GB	21.02606	24.05393	26.21696	32.90923
2 = NI	18.30700	21.16080	23.20930	29.58830

Algorithm :

Use the following order of rules to determine SuitCode and SuitProb:

Range of values for $MahDist_{min}$	SuitCode	SuitText
$MahDist_{min} < CQ_1$	1	'>5%'
$CQ_1 \leq MahDist_{min} < CQ_2$	2	'< 5%'
$CQ_2 \leq MahDist_{min} < CQ_3$	3	'<2%'
$CQ_3 \leq MahDist_{min} < CQ_4$	4	'<1%'
$MahDist_{min} \geq CQ_4$	5	'<0.1%'

If any site has a Suitability Code greater than 1, then the predictions and classifications arising should be carefully reviewed to consider if they are appropriate.

A2 Summary of changes between 1st and 2nd RBMP

Abundance Scores and Seasonal Sample Combination

The over-riding change is the change from 'Presence Only' taxa scores used in the BMWP metric, to the Abundance Category taxa scores used in the WHPT metric. The Abundance Categories are based on orders of increasing number of individuals in any given taxa within the sample, and although the assigned scores still depend on the relative sensitivity of the taxa, the Abundance Category scores now reflect the increase or decrease in water quality that is inferred from the increasing abundance of the taxon in question. The Abundance Categories and their scores for each taxa can be found in Table 2, and further details of the development of the WHPT scoring system can be found in the Scottish and Northern Ireland Forum For Environmental Research (SNIFFER) report WFD72a (2007).

Both the BMWP and the WHPT metrics require that samples be taken in both the Spring and the Autumn and that these samples are combined by some means to reflect the annual status of the waterbody being assessed. This is because certain taxa are more likely to be found in either the Spring or the Autumn. For the BMWP, the Spring and Autumn taxa lists were combined into a single list of all the taxa present in the year before the data was input to RICT and the annual EQR calculated. However, when taxa abundance is taken into account, it is necessary to find a way to express the differences in abundance that can be recorded for any one taxa in Spring and in Autumn. Averaging the abundances at the taxa level is not satisfactory since a taxon that is very abundant in one season may appear only half so abundant in the annual average if it is not present at all in the other. Fortunately, RICT is capable of calculating separate WHPT EQR for each of these seasons, and these EQR are simply averaged to produce an annual EQR equivalent to that calculated for BMWP.

Updating the Reference Dataset

The RIVCPACS software that underlies RICT uses a set of reference data that encompasses all the variations in river types in Great Britain and Northern Ireland. By necessity, some of these data are from sites that are not entirely free from disturbance as there are no longer stretches of rivers of certain types that can be considered to be in reference state, and data from the least perturbed of those remaining must be used to predict the fauna that should occur in reference conditions. For this reason, the predicted scores are adjusted upwards in these cases to be more closely aligned with the scores that might be expected were the reference river data truly in reference conditions. The process for how this adjustment is determined has been updated with regard to research that has been completed since Phase 1 of inter-calibration, and further details can be found in the SNIFFER report WFD72b (2006).

Additionally, the RIVPACS software and reference dataset was comprehensively updated to include abundance data in order that WHPT predictions could be generated, to bring the taxonomy up to date and to review and amend the river categorisations. This resulted in the package now referred to as RIVPACS IV, incorporating 43 ‘end-groups’ instead of 35, as currently used by RICT. Further details of the development of and upgrade to RIVPACS IV can be found in the SNIFFER report WFD72c (2008).

The new boundary EQR values for WPHT are shown in the Table 3:

Table 3. Boundary EQR values for WHPT

	WHPT-ASPT	WHPT-NTAXA
High/Good	0.969	0.80
Good/Moderate	0.860	0.68
Moderate/Poor	0.723	0.56
Poor/Bad	0.585	0.47

A3 Consequences of changes

England

Table 4. Comparison of classifications of ecological status determined by original (BMWP) and revised (WHPT) versions of the invertebrate tool.

		Revised					
		High	Good	Moderate	Poor	Bad	Grand Total
Current	High	307	59	1			367
	Good	122	241	58	1		422
	Moderate	5	41	145	37	3	231
	Poor			25	40	24	89
	Bad				3	14	17
	Grand Total	434	341	229	81	41	1126

Table 5. Percentage of water bodies in each class, determined using original (BMWP) and revised (WHPT) versions of the invertebrate tool.

Class	Current Method	Revised Method
High	32.6%	38.5%
Good	37.5%	30.3%
Moderate	20.5%	20.3%
Poor	7.9%	7.2%
Bad	1.5%	3.6%

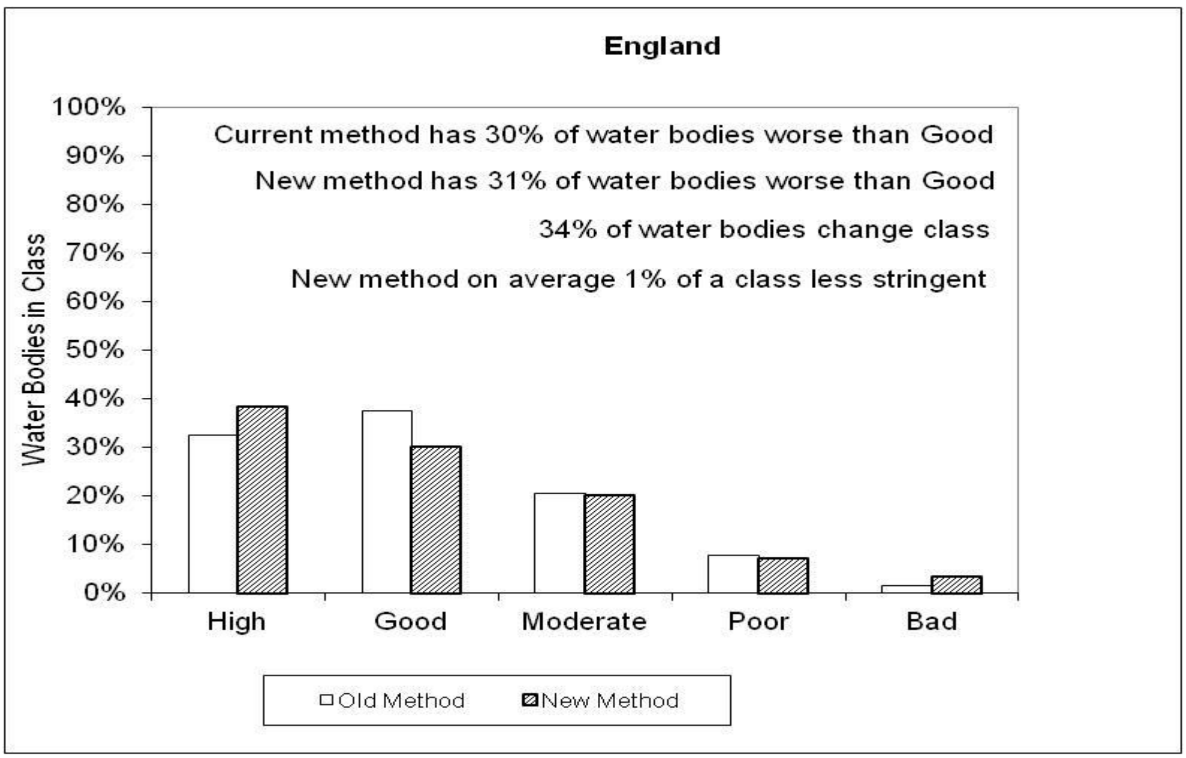

Figure 1. Percentage of water bodies in each class, determined using original (BMWP) and revised (WHPT) versions of the invertebrate tool.

Table 6. Number and percentage of water bodies that change class when using the revised version of the invertebrate tool, WHPT.

	Number	Percentage
Current 4 class worse	0	0.0%
Current 3 class worse	0	0.0%
Current 2 class worse	5	0.4%
Current 1 class worse	191	17.0%
Same class	747	66.3%
Revised 1 class worse	178	15.8%
Revised 2 class worse	5	0.4%
Revised 3 class worse	0	0.0%
Revised 4 class worse	0	0.0%

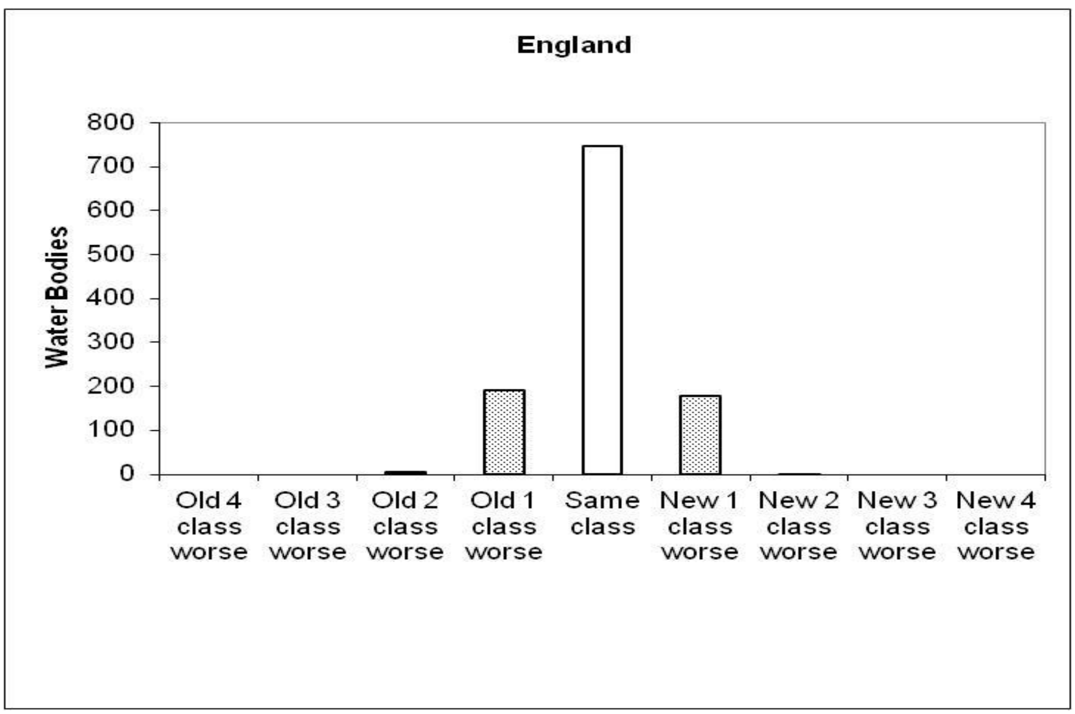

Figure 2. Number of water bodies that change class when using the revised version of the invertebrate tool, WHPT.

Wales

Table 7. Comparison of classifications of ecological status determined by original (BMWP) and revised (WHPT) versions of the invertebrate tool.

		Revised					
		High	Good	Moderate	Poor	Bad	Grand Total
Current	High	53	23	1			77
	Good	34	72	25	1		132
	Moderate		6	11	2		19
	Poor					1	1
	Bad					1	1
	Grand Total	87	101	37	3	2	230

Table 8. Percentage of water bodies in each class, determined using original (BMWP) and revised (WHPT) versions of the invertebrate tool).

Class	Current Method	Revised Method
High	33.5%	37.8%
Good	57.4%	43.9%
Moderate	8.3%	16.1%
Poor	0.4%	1.3%
Bad	0.4%	0.9%

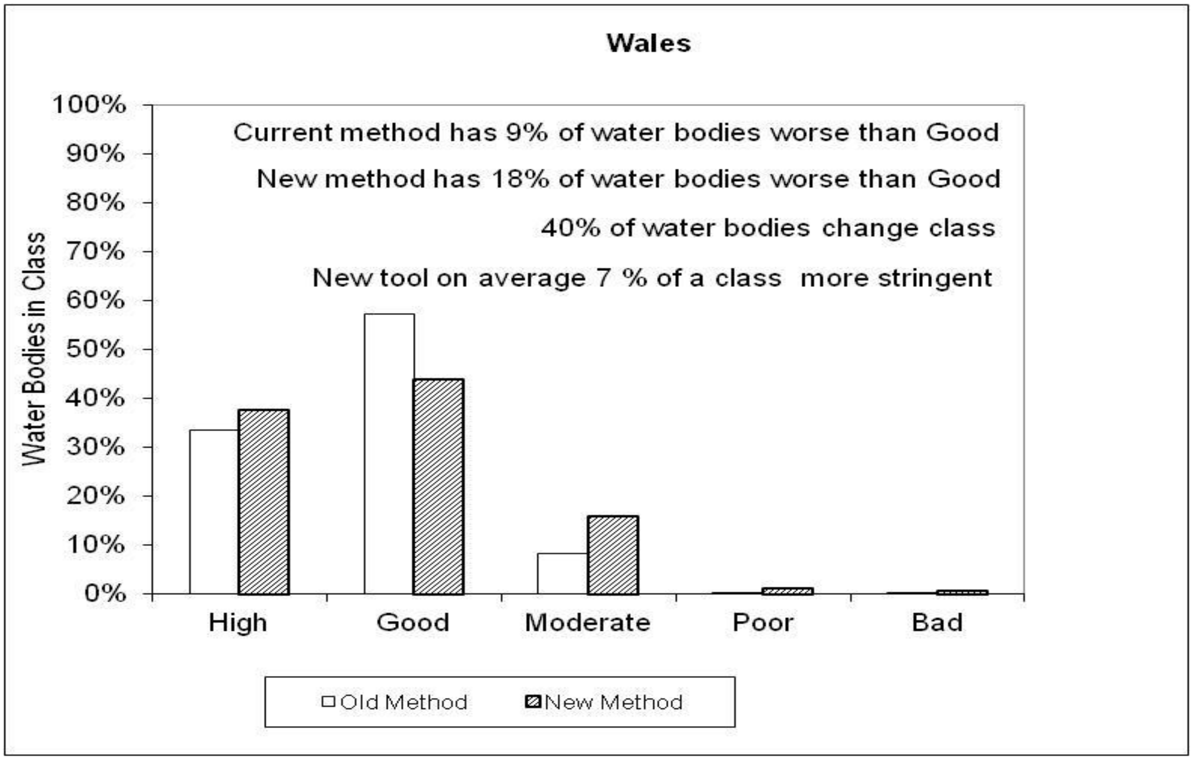

Figure 3. Percentage of water bodies in each class, determined using original (BMWP) and revised (WHPT) versions of the invertebrate tool.

Table 9. Number and percentage of water bodies that change class when using the revised version of the invertebrate tool, WHPT.

	Number	Percentage
Current 4 class worse	0	0.0%
Current 3 class worse	0	0.0%
Current 2 class worse	0	0.0%
Current 1 class worse	40	17.4%
Same class	137	59.6%
Revised 1 class worse	51	22.2%
Revised 2 class worse	2	0.9%
Revised 3 class worse	0	0.0%
Revised 4 class worse	0	0.0%

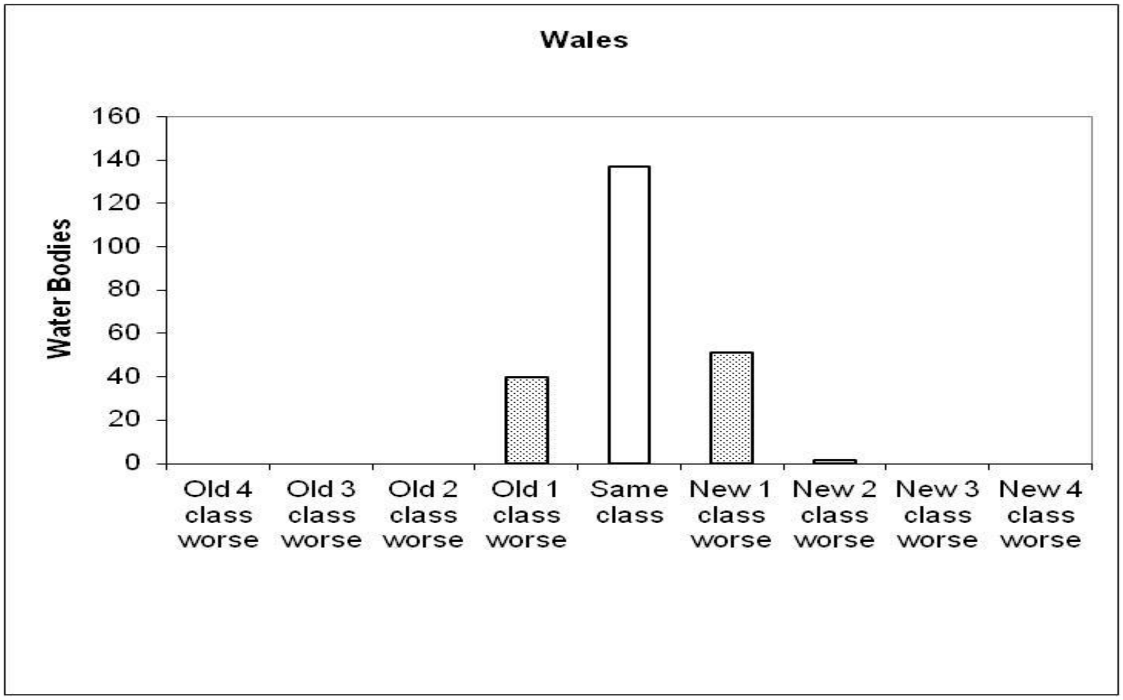

Figure 4. Number of water bodies that change class when using the revised version of the invertebrate tool, WHPT.

Scotland

Table 10. Comparison of classifications of ecological status determined by original (BMWP) and revised (WHPT) versions of the invertebrate tool.

		Revised					
		High	Good	Moderate	Poor	Bad	Grand Total
Current	High	200	106	1			307
	Good	20	161	36	1		218
	Moderate		2	49	8		59
	Poor	1		10	18	3	32
	Bad					4	4
	Grand Total	221	269	96	27	7	620

Table 11. Percentage of water bodies in each class, determined using original (BMWP) and revised (WHPT) versions of the invertebrate tool.

Class	Current Method	Revised Method
High	49.5%	35.6%
Good	35.2%	43.4%
Moderate	9.5%	15.5%
Poor	5.2%	4.4%
Bad	0.6%	1.1%

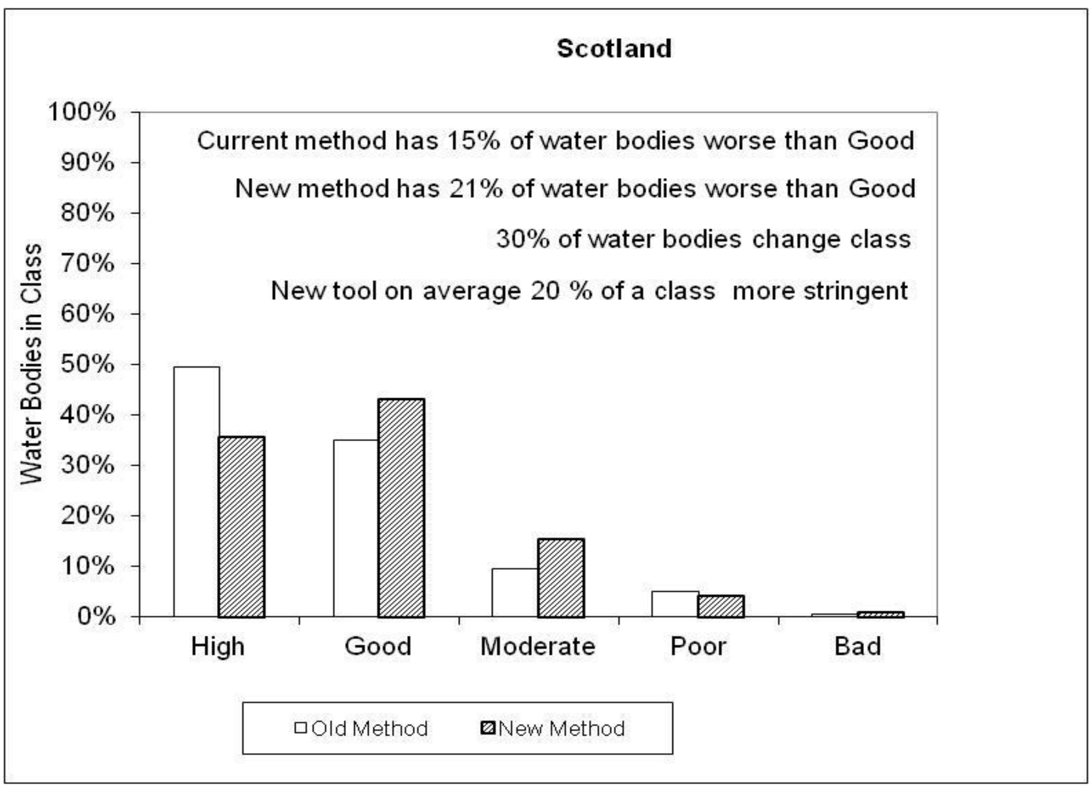

Figure 5. Percentage of water bodies in each class, determined using original (BMWP) and revised (WHPT) versions of the invertebrate tool.

Table 12. Number and percentage of water bodies that change class when using the revised version of the invertebrate tool, WHPT.

	Number	Percentage
Current 4 class worse	0	0.0%
Current 3 class worse	1	0.2%
Current 2 class worse	0	0.0%
Current 1 class worse	32	5.2%
Same class	432	69.7%
Revised 1 class worse	153	24.7%
Revised 2 class worse	2	0.3%
Revised 3 class worse	0	0.0%
Revised 4 class worse	0	0.0%

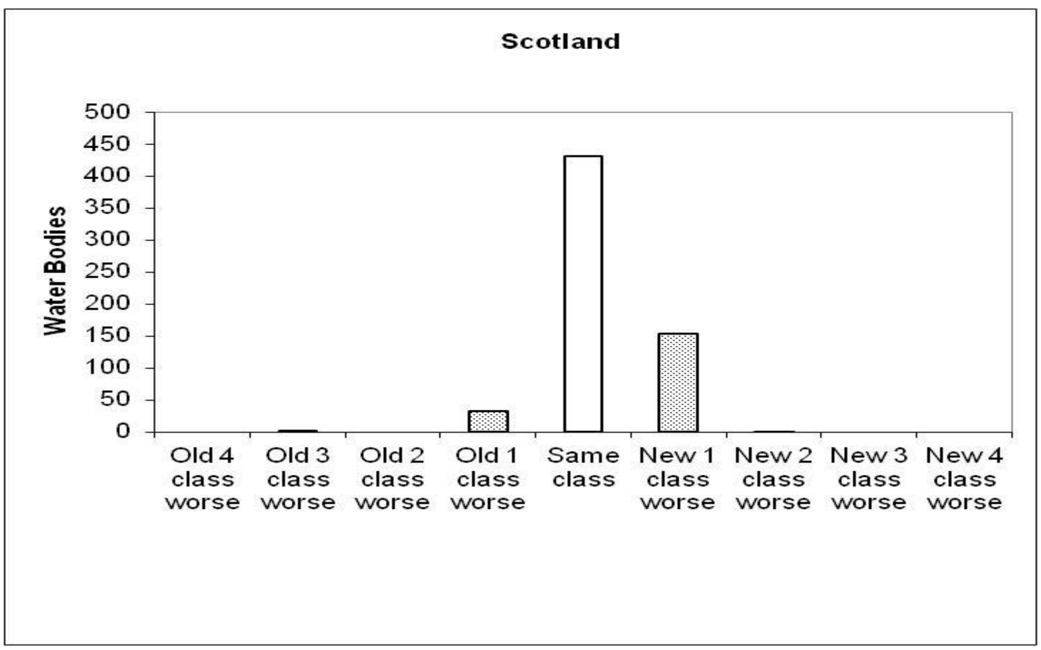

Figure 6. Number of water bodies that change class when using the revised version of the invertebrate tool, WHPT.

Northern Ireland

Table 13. Comparison of classifications of ecological status determined by original (BMWP) and revised (WHPT) versions of the invertebrate tool.

		Revised					
		High	Good	Moderate	Poor	Bad	Grand Total
Current	High	19	2				21
	Good	38	59	1			98
	Moderate		19	25	2		46
	Poor			10	7	1	18
	Bad				1	4	5
	Grand Total	57	80	36	10	5	188

Table 14. Percentage of water bodies in each class, determined using original (BMWP) and revised (WHPT) versions of the invertebrate tool.

Class	Current Method	Revised Method
High	11.2%	30.3%
Good	52.1%	42.6%
Moderate	24.5%	19.1%
Poor	9.6%	5.3%
Bad	2.7%	2.7%

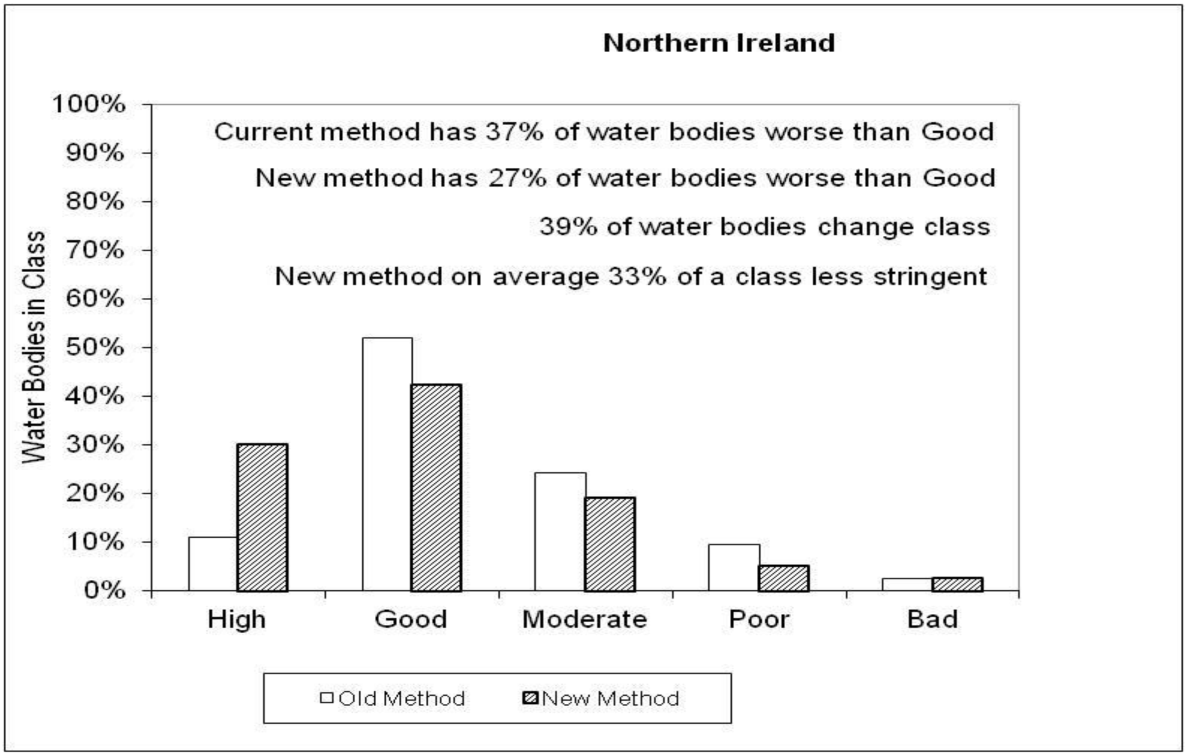

Figure 7. Percentage of water bodies in each class, determined using original (BMWP) and revised (WHPT) versions of the invertebrate tool.

Table 15. Number and percentage of water bodies that change class when using the revised version of the invertebrate tool, WHPT.

	Number	Percentage
Current 4 class worse	0	0.0%
Current 3 class worse	0	0.0%
Current 2 class worse	0	0.0%
Current 1 class worse	68	36.2%
Same class	114	60.6%
Revised 1 class worse	6	3.2%
Revised 2 class worse	0	0.0%
Revised 3 class worse	0	0.0%
Revised 4 class worse	0	0.0%

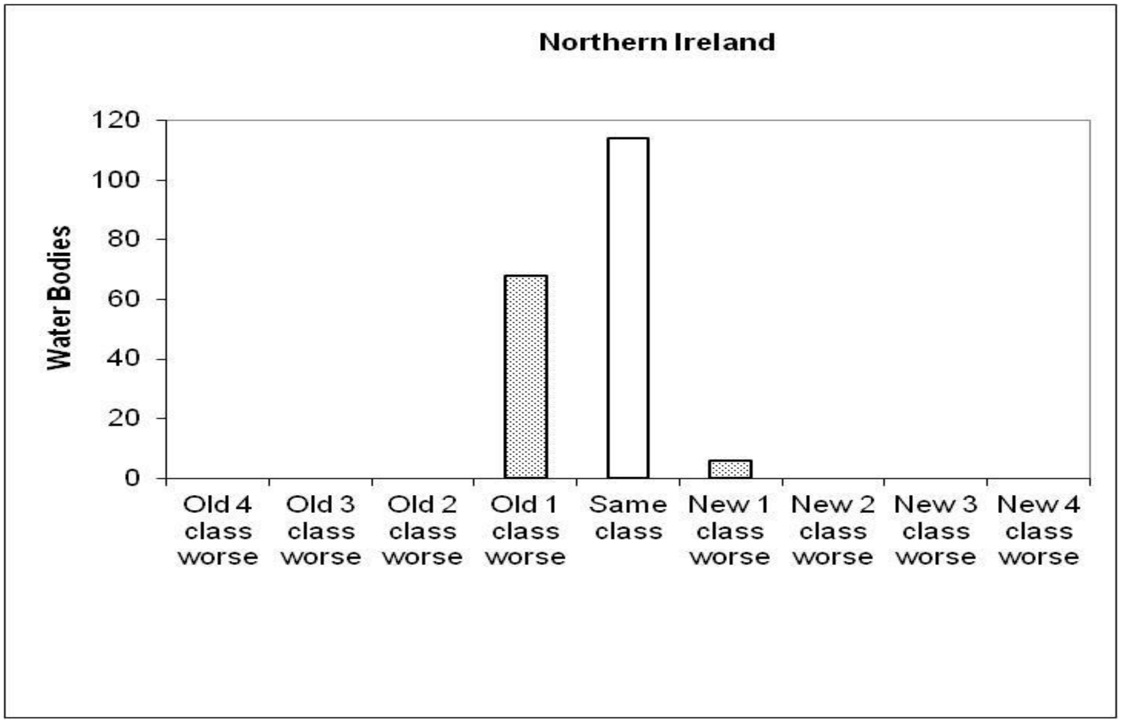

Figure 8. Number of water bodies that change class when using the revised version of the invertebrate tool, WHPT.

A4 Key documents

River invertebrates method statement	detailed description of method used for 1st RBMP (sampling and analytical method unchanged, changes to calculations for 2nd RBMP)

SNIFFER (2007) *Revision and Testing of BMWP Scores*. WFD72a

SNIFFER (2006) *Development of the Scientific Rationale and Formulae for altering RIVPACS Predicted Indices for WFD Reference Condition.* WFD72b

SNIFFER (2008) *River Invertebrate Classification Tool*. WFD72c

Wright, J. , Sutcliffe, D. and Furse, M. (eds) 2000. *Assessing the biological quality of fresh waters. RIVPACS and other techniques*. Freshwater Biological Association, Ambleside Cumbria UK.