Quality Assurance Report: surveying condition of headwater streams and ponds

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Introduction

The freshwater module of Countryside Survey 2007 (CS2007) aimed to provide high-quality information on changes in the physical and biological condition of small streams and ponds across Great Britain. Changes in the distribution of components of biological diversity in these habitats were also measured.

In order to be confident in the data gathered and derived results, it was necessary to first, ensure that the CS field surveyors were sufficiently experienced, skilled and adequately trained to do the job. Therefore:

- All freshwater field surveyors recruited were required to have a solid knowledge of aquatic plant taxonomy and received detailed training on all aspects of the CS freshwater tasks.
- All freshwater field surveyors undertaking River Habitat Surveys (RHS) were Environment Agency accredited.
- An experienced freshwater biologist visited teams in the field to ensure that they were adhering to the methods and to assist them with any issues.

Second, it was necessary to ensure that any laboratory analytical procedures were carried out to the highest standards. Therefore:

- Water chemistry analysis was carried by a CEH laboratory which is ISO 17025 accredited by UK Accreditation Service (UKAS).
- All macroinvertebrate samples are being processed using the strict laboratory protocols of the CEH River Communities Group (the Group that audits all regulatory biomonitoring carried out by the UK environment agencies), and by staff with taxonomic accreditation from the Natural History Museum.

Thirdly, it was also important to quantify the uncertainty associated with the collection of data in the field. Therefore:

- An experienced CEH freshwater biologist repeated the freshwater tasks at a random-stratified sub-sample of squares to assess error/variation in the data collected and the derived condition measures.

This technical report focuses on this final aspect of the CS freshwater quality assurance (QA) process.

While the biological sampling of freshwater habitats has been part of CS since 1990, there were no properly coordinated QA surveys undertaken in either 1990 or 1998. Therefore the CS2007 QA report acts as a baseline against which future Surveys can be judged.

Field Survey Methods

At a random-stratified sub-sample of 31 squares that had been successfully surveyed by CS2007 field surveyors, an experienced CEH freshwater biologist repeated the freshwater tasks carried out by the main CS survey teams. Squares were chosen to incorporate all environmental zones and CS field survey teams as much as possible.

In all 31 squares a stream was re-sampled, while 18 of the 31 squares contained a pond, which was re-surveyed. This represents an 8% re-survey effort for the stream tasks and a 7% re-survey effort for the pond tasks.

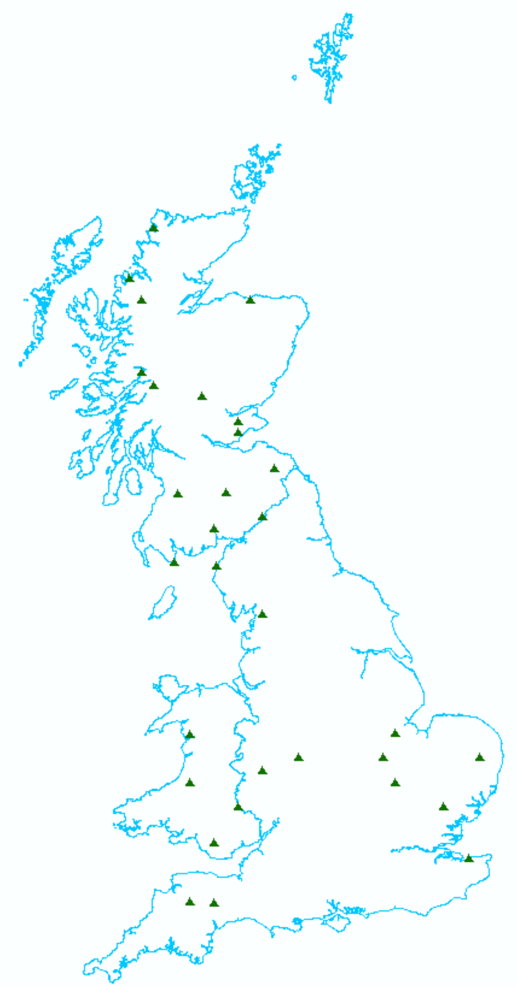


Fig. 1 Location of the freshwater quality assurance squares

Headwater Streams

Aquatic Plants

At 30 of the 31 QA stream sites (one stream site was dry when QA surveyed) an experienced CEH freshwater biologist repeated the aquatic plant survey at the same location as that surveyed for CS2000. The 100m survey stretch was centred on the invert sampling location. The QA exercise incorporated the ability of the CS2007 team to accurately re-locate the survey stretch. Both the CS team and the QA surveyor used a combination of photographs, grid references and map annotations to re-locate the CS2000 aquatic plant survey stretch. Both the CS team and the QA surveyor used IRIS on a Tablet PC to record the plant and associated environmental data.

Countryside Survey Technical Report No. 5/07 provides more details of the aquatic plant survey method and IRIS, the digital data entry system.

River Habitat Survey

At each of the 31 stream sites a River Habitat Survey was carried out at the same location as that surveyed for CS2000. The RHS QA exercise incorporated the ability of the CS2007 team to accurately re-locate the 500m CS2000 RHS stretch. Both the CS team and the QA surveyor used the same set of photographs, grid references and map annotations to re-locate the 500m CS2000 RHS stretch.

Both the CS team and the QA surveyor used RAPID on a Tablet PC to record the RHS data. The RHS method involves various physical features of the stream channel and banks e.g. bank material, channel substrate, riparian vegetation structure, being recorded at 10 equally-spaced transects. Additionally an overall assessment or other features e.g. number of riffles, pools & weirs, bank profile, riparian land-use is made for the full 500 m survey reach. CS Technical Report No. 5/07 provides more details of the RHS method and RAPID, the digital data entry system.

Aquatic Macroinvertebrates

At 30 of the 31 QA stream sites (one stream site was dry when QA surveyed) an experienced CEH freshwater biologist took an aquatic macroinvertebrate community sample at the same location as that sampled for CS2000. The QA exercise incorporated the ability of the CS2007 team to accurately re-locate the sample site. Both the CS team and the QA surveyor used a combination of photographs, grid references and map annotations to re-locate the CS2000 sample site. Both the CS team and the QA surveyor used standard macroinvertebrate sampling protocols when collecting the sample and recording associated environmental data (see CS Technical Report No. 5/07 for more details). These sampled are currently being processed by the CEH River Communities Group and the results of the macroinvertebrate QA analysis will be reported as part of the main Freshwaters Report, due out in late 2009.

Hydrochemistry

At 30 of the 31 QA stream sites (one stream site was dry when QA surveyed) a water sample was taken for laboratory analysis of phosphate, nitrogen and alkalinity concentrations. The pH and conductivity of the stream water were measured on-site using a calibrated field meter.

Ponds

Aquatic Plants

At 18 of the 31 QA squares an experienced CEH freshwater biologist re-surveyed the same randomly-selected pond that was surveyed by the CS team. Both the CS team and the QA surveyor used standard pond surveying protocols when recording the aquatic plant community and associated environmental data (see CS Technical Report No. 5/07 for more details).

Hydrochemistry

At 15 of the 18 re-surveyed ponds a water sample was taken for laboratory analysis of phosphate, nitrogen and alkalinity concentrations. The pH and conductivity of the pond water were measured on-site using a calibrated field meter.

Data Analysis & Results

Headwater Streams

Aquatic Plants

Initially, the plant data were validated; a process which included taxonomic standardisation and removal of terrestrial species from the database. Following validation, there were 29 QA sites surveyed with aquatic plants and 1 site QA-surveyed with no aquatic flora.

We can consider the aquatic plant surveys to be analogous to the terrestrial vegetation plots in that the cover of all species within the survey area is recorded. The quality of the work is judged by comparing concordance between the main CS surveyor and the QA surveyor in the species recorded.

Initially the number of plant taxa found at each of the 29 squares, by the main and QA surveys was compared. We found that there was a significant bias (P<0.001) evident in the data, with the main survey tending to find 1.9 (± 0.87 95%CL) fewer taxa than the QA.

A more informative measure of the quality of the data is to compare the CS2007 and CS2007QA species lists for each of the 29 sites and to calculate the % agreement (% of all taxa recorded at a site, that were recorded by both the main and QA surveyors). Mean % agreement was only 31%, with there being 100% agreement only at those few sites where only a single species was found in both surveys. Reasons for these discrepancies include: misidentifications and inadequate searching, differences in the exact location of the 100m survey reach, seasonal differences in the plant community between the survey dates (Fig. 2), vegetation cutting between the two surveys and difficulties in defining the lateral limits of the survey area.

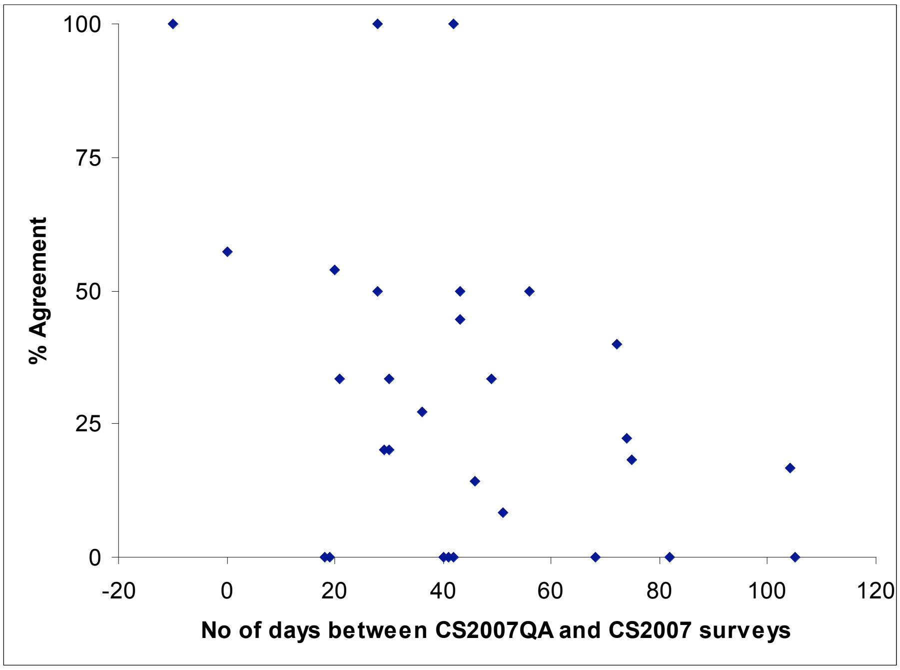


Fig. 2 Relationship between time difference (days) between main CS2207 survey and QA survey and % agreement of plant survey results

Over 80% of the errors involved species that were rare at the site i.e. with a recorded cover less than 1%. This highlights the importance of undertaking a thorough search of the full 100m site. There was no pronounced bias towards marginal species being more likely to be missed than those more restricted to in-stream habitats. Over 60% of the errors were those where species were considered to have been overlooked by the main CS surveyor. Only 15% of the errors were likely to have involved species incorrectly identified and forming an obvious couplet with another species identified by the QA surveyor.

Among the most commonly missed taxa were the liverwort *Pelia* sp.,the moss *Rhynchostegium riparioides*, the marginal grass *Agrostis stolonifera* and algae such as *Cladophera* and *Vaucheria*.

These differences between the main and QA surveys had an effect on the derived MTR scores. On average the QA surveys tended to score 5.6 (± 10.6 95%CL) more than the main survey. While this was not a statistically significant bias, there was a considerable range of differences between the two surveys.

Ultimately, the QA analysis has highlighted the difficulty inherent in repeating an aquatic plant survey. Even at a stream site where the QA and main surveys were on the same day and both teams met each other at the site, there were substantial differences in the species lists (only 57% agreement).

As there were no QA data for CS2000 we can only assume that the CS2000 surveyors were of equal standard to those in CS2007. Hence we have to assume that the level of bias in taxon richness was similar in both years and would not affect any change estimates. Therefore analysis of the main CS2007 data can proceed without the need for any corrections or adjustments, while being mindful of the data quality issues. These QA data act as a baseline for the next CS and will inform efforts to improve field protocols and highlights plant groups where greater expertise is required.

River Habitat Survey

The RHS QA analysis focussed on the degree of variation in the 2007 RHS data between the CS and QA surveyors. Initially a simple objective test of concordance between the main CS and QA surveys was undertaken where the numbers of a range of distinct features within the 500m survey stretch i.e. bridges and culverts, were recorded.

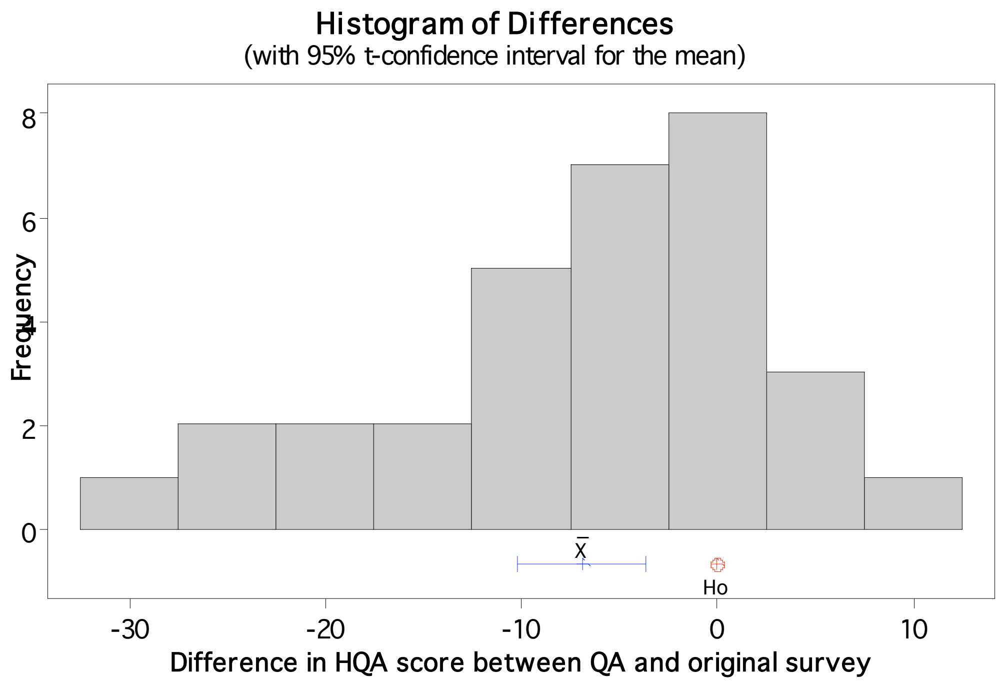
At 70% of the sites there was no difference between the main and QA surveys in the count of bridges or culverts. Five of the 31 sites had discrepancies ±1 in the bridge estimates. Six of the 31 sites had discrepancies ±1 in the culvert estimates and one with a difference of two. The reasons for the discrepancies are probably related to slight differences in the location 500m stretch, such that some bridges or culverts may have been included for the main survey while excluded from the QA survey.

Habitat Quality Assessment (HQA) values were generated from the CS2007 and QA data for the 31 stream sites. The HQA score increases as the diversity and abundance of natural river channel and bank features increases within the 500m stretch. The HQA tends to vary from 10-80, with no one hydromorphological feature dominating the scores. Since the RHS data will ultimately be reported as HQA index values it is most appropriate that a QA assessment is made through the combined impact of all the surveyor decisions, relocation and counting errors on this measure.

Table 1. RHS HQA index scores calculated for the main CS and QA surveys.

CS square	QA	CS	%diff	CS square	QA	CS	%diff
73	64	66	3	702	36	38	5
75	23	25	8	703	31	26	-19
195	21	20	-5	753	13	20	35
203	46	43	-7	773	17	35	51
294	48	63	24	800	20	25	20
311	29	19	-53	804	27	50	46
347	35	32	-9	847	22	34	35
364	40	45	11	898	17	18	6
383	59	77	23	912	29	27	-7
413	25	27	7	941	35	63	44
420	16	26	39	955	42	51	18
428	28	35	20	970	44	58	24
460	30	39	23	1090	39	43	9
477	22	25	12	1099	16	18	11
657	44	53	17	1118	30	36	17
				1163	36	61	41

Fig 3. Difference in RHS HQA score between the QA and main CS surveys.



For the 31 squares re-surveyed in CS2007 as part of the QA exercise we calculated the average difference in HQA between the main survey and the QA survey (CS2007-CS2007QA). We found that there was a significant bias (*P*<0.001) evident in the HQA results, with the main survey tending to score 6.9 (± 3.3 95% CL) units greater than the QA survey (Table 1, Fig 3). Indeed none of the 31 squares received the same overall HQA score from the CS and QA surveys. Much of the HQA variation could be traced to differences between the main and QA surveyors in how they classified the structural complexity of the bank-face and bank-top vegetation. This was a particular issue in moorland landscapes where CS surveyors tended to interpret open moorland vegetation with *Molinia* grass and heather clumps as 'Simple' while the QA survey recorded it as 'Uniform'. These features score differently in the HQA scoring system. While the RHS manual does provide guidance on vegetation types, there is a degree of ambiguity that obviously does lead to differing judgements. As a result of this difference, the QA sites in upland environmental zones were those with greatest disparity in overall HQA between the two surveys.

As there are no QA data available for CS2000, the most precautionary and defensible approach is to assume that both CS2000 and CS2007 are equally biased. Therefore analysis of the main CS2007 RHS data can proceed without the need for any corrections or adjustments, while being mindful of the data quality issues.

Hydrochemistry

The concentrations of most hydrochemical parameters can vary considerably over even short time-scales; making comparison of two separate water samples from the same site difficult to judge. However we would not expect the ranking of the 31 sites based on values of a given parameter to differ substantially. Therefore simple rank correlation between the main and QA values across the 31sites for each of the five measured parameters gives an indication of the repeatability of the hydrochemistry survey.

There were highly significant correlations between the ranked values in the QA and main survey for the five measured parameters; soluble reactive phosphorus ($r = 0.89$, $P < 0.001$), total oxidised nitrogen ($r = 0.79$, $P < 0.001$), alkalinity ($r = 0.97$, $P < 0.001$), pH ($r = 0.74$, $P < 0.01$) and conductivity ($r = 0.97$, $P < 0.001$). This indicates that both the field and laboratory procedures were consistently applied and that we can have confidence in the measured results.

Ponds

Wetland Plants

For 16 of the 31 QA squares there was a pond surveyed in both the main and QA surveys. The number of wetland plant taxa found at each of the 16 ponds, by the main and QA surveys was compared. We found that there was no significant bias (*P*>0.214) evident in the data, with the main survey tending to find 0.6 (± 1.03 95%CL) more taxa than the QA.

Mean percentage agreement was 59%, with 100% agreement at five of the ponds. Reasons for the discrepancies include: misidentifications and inadequate searching, differences in defining the outer boundary of the pond (maximum winter water level) and seasonal differences in the plant community between the survey dates.

There were a total of 36 taxa missed by either the CS or QA surveyor; though 29 of the 36 taxa were only missed on one occasion. These 29 taxa were from a range of plant groups: eight taxa were grass/sedge/rush species, eight were small-leaved submerged aquatics, which are easy to miss. The remaining 13 taxa included representatives from most the other plant types. In total, seven taxa were missed at more than one site. All seven were grass, sedge or rush-like species. More specifically: cotton-grasses, deergrass, rushes, sedges, creeping bent. Of these, soft rush (*Juncus effusus)* and creeping bent (*Agrostis stolonifera)* were the most commonly missed species. The fact that the most frequently missed plants were grass or rush-like taxa is notable and can be used to inform future CS training.

CS2007 was the first Countryside Survey to collect plant survey data from ponds across Britain. The QA data will act as a baseline for any future plant surveys of the CS ponds.

Hydrochemistry

There were significant correlations between the ranked values in the QA and main survey for four of the five measured parameters; soluble reactive phosphorus ($r = 0.60$, $P < 0.05$), alkalinity ($r = 0.95$, $P < 0.001$), pH ($r = 0.84$, $P < 0.001$) and conductivity ($r = 0.98$, $P < 0.001$). However, the total oxidised nitrogen values did vary between the QA and main survey ($r = 0.47$, $P = 0.12$). In particular, there were two ponds that differed considerably in the measured TON levels between the main and QA survey. For both these ponds there was a 2 month gap between both visits. The results again reinforce the need to keep the QA and main surveys as close together in time. However overall the field and laboratory procedures were consistently applied and we can have confidence in the measured results.

Discussion

There is inherent uncertainty associated with any environmental measurement (Clarke & Hering 2006[3]). The quality assurance survey described here provides a first indication of the variability associated with the freshwater data within Countryside Survey. This information can be used to inform our ability to confidently detect change, to better target training of surveyors, and also to refine protocols, including freshwater QA protocols.

The variation/error associated with a given record, measurement or index score can be attributed to a variety of sources. For example, when undertaking a stream aquatic plant survey the error associated with the species richness value is derived from a combination of spatial errors (accurately locating the survey stretch, defining the stream lateral margins), temporal errors (natural changes to the plant community between repeat surveys, changes due to prior disturbance events), and inter-surveyor competence (ability to thoroughly search survey stretch and correctly identify any plants found) and finally residual un-attributed error.

The purpose of the CS QA survey was to quantify the extent of the error associated with inter-surveyor competence. However it is impossible to isolate this source of error from the spatial and temporal sources of error. In CS2007 we sought to reduce the contribution or chance of temporal error by carrying out the QA and main survey as close in time to each other as possible; though this was not always achieved (Fig. 2). The extent of spatial error inevitably overlaped with inter-surveyor competence as the ability to accurately locate the CS2000 survey stretch was dependent on the surveyor. CS and QA surveyors may also have differed in their judgement as to the location of the lateral limits of the survey stretch.

The CS2007 QA survey found that there was variation between the main and QA results for the stream plant survey and river habitat survey. However, it is difficult to sub-divide the total variation into the different compartments, in particular we did not manage to minimise the influence of temporal error. Many of the QA surveys were carried out many weeks after the original survey. This undermined our ability to draw strong conclusions from the QA results, especially in relation to the plant surveys.

Given the subjective nature of some of the data recorded as part of a RHS e.g. classifying bank vegetation structure, it is not surprising that there is a degree of variability between the CS and QA results. However, you would expect near identical information when it came to counts of bridges and culverts within the 500m survey reach. This was achieved for 22 of the 31 QA sites (70%). That there were differences illustrates the difficulty in accurately measuring out a 500m survey stretch along a potentially sinuous water course.

Ultimately the CS2007 freshwater QA survey acts as a baseline against which the standard of future CS freshwater surveys can be compared. It has also provided us with invaluable information on the elements of the field protocols that are most vulnerable to mis-interpretation or that are most difficult to accurately repeat. We can focus more on these features when planning training for the next survey.

In particular this includes:

- Improved identification skills for aquatic bryophytes and algae

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[3] Clarke, R.T & D. Hering (2006) Errors and uncertainty in bioassessment methods- major results and conclusions from the STAR projectand their application using STARBUGS. *Hydrobiologia* **566**: 433=439.

- Increased awareness of bryophytes, algae and inconspicuous grass-like species during plant survey.
- Greater emphasis on importance of returning exactly to previous survey stretch
- Reinforcement of RHS training with particular attention to elements known to be more prone to error or subjective judgement.

This first CS freshwater QA survey has also highlighted the need to ensure the QA work at a site is carried out within two weeks of the main survey team completing their work at that same location.

The Freshwater Technical Report, due out in late 2009 will contain details of the macroinvertebrate QA analysis and results.