# The UK Benchmark Network – Designation, Evolution and Application

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## Abstract

The UK has one of the densest gauging station networks in the world – a necessary response to its diversity in terms of climate, geology, land use and patterns of water utilisation. This diversity and, particularly, the compelling impact of artificial influences on natural flow regimes across most of the country, implies a considerable challenge in identifying, interpreting and indexing changes in river flow regimes. Quantifying and interpreting trends in river flows – in particular separating climate-driven changes from those resulting from other driving mechanisms – is a necessary pre-requisite to the development of improved river and water management strategies. It is also a primary strategic objective of many national and international river flow monitoring programmes.

This paper charts the development of the UK Benchmark Network through its initial promotion phase – involving key institutional partners in both the hydrometric data acquisition and user communities – through to its exploitation across a wide a range of policy, scientific and engineering design applications. Particular consideration is given to the criteria used to appraise and select candidate catchments and gauging stations. Spatial characterisations (particularly physiographic, geological and land use) are used to determine the representativeness of individual candidate catchments and hydrometric performance (in the extreme flow ranges especially), together with record length, is of primary importance in relation to gauging station selection. Indexing the degree to which artificial influences disturb the natural flow regime is also a necessary pre-requisite for selection across much of the UK. Descriptions are given of a number of network and data review mechanisms developed to maximize the utility of the Benchmark Network and the burgeoning range of applications which have capitalized on it – embracing both national and international monitoring programmes.

The review finishes with an overview of the strategic benefits deriving from the operation of the Benchmark Network and examines some of the enduring issues which require further work – including the continuing focus on operationally driven gauging activities; meeting the more stringent data demands of the Benchmark Network, and the need for further integration of catchment monitoring activities – embracing a wider range of hydrometeorogical variables.

*Note: This paper is complemented by a companion paper which examines the exploitation of the UK Benchmark Network in a series of national and international studies of hydrological trends (Hannaford, J. 2010 Exploitation and analysis of the Benchmark Network: insights into hydrological variability in the UK and Europe)*

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## Introduction

River flow data are the foundation of water management. Data are required for resource assessments, regulatory purposes, river management and, in a digested form, to direct policy development and help draft legislation. As with much environmental monitoring, the need for river flow data becomes particularly compelling during periods of actual, or anticipated, hydrological change. In the UK, a cluster of droughts in the last 20 years, together with a series of exceptional flood events in the first decade of the 21st century (Marsh, 1996, Centre for Ecology & Hydrology, 2001-2010) have demonstrated a continuing vulnerability to extreme weather conditions. The hydrological volatility during the recent past, together with a growing public and political awareness that climate change impacts could be substantial, provided the impetus for an ongoing strategic review of the UK gauging station network aimed at identifying those catchments which offer most potential in identifying flow regime changes and hydrological trends, particularly in relation to extreme flows.

This paper outlines the evolution of the UK Benchmark Network and reviews the stakeholder dialogue, network appraisal and data stewardship issues which influenced its designation and operation.

## Hydrological background

Located adjacent to the European mainland and on the eastern edge of the Atlantic Ocean, the UK is exposed to a wide range of climatic influences: sub-polar airmasses from the northern quadrant, continental airmasses from the east and sub-tropical airmasses from the south and south-west. The UK geographical position contributes to an inherently capricious climate which manifests itself in substantial hydrological variability across a range of timeframes – from sub-daily to multi-decadel.

Most of the UK's rainfall, in the west particularly, derives from moisture-laden Atlantic low pressure systems although convective storms can produce a significant fraction of the rainfall through the summer half-year. Annual average precipitation totals range from around 5000mm in parts of the western Highlands of Scotland to an order of magnitude less in some low-lying parts of eastern England. On average, the rainfall is well distributed throught the year but with a tendency towards an atumn and early winter maximum.

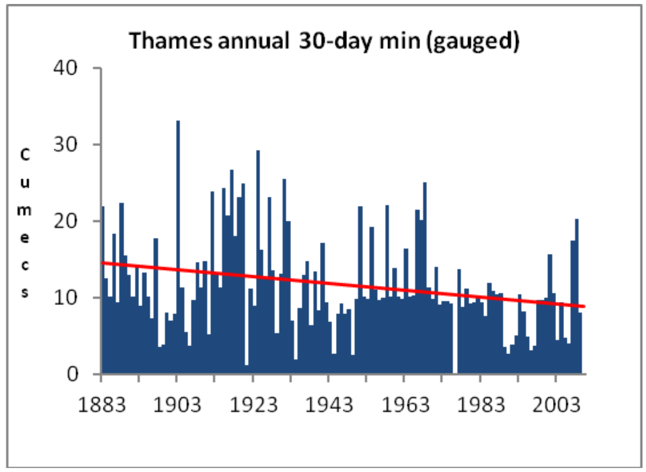
At a national scale around half of the rainfall is lost to evaporation but the proportion generally increases along a NW/SE transect. In parts of south-east England evaporation losses can account for >75% of the rainfall. As a consequence, the NW/SE gradient in annual runoff is notably steep with large parts of the English Lowlands recording average runoff totals of less than 150mm.

## The UK Gauging Station Network

In a global context UK rivers are mere streams but the river network is dense: some 200,000 km of watercourses in 1500 discrete river systems draining to the sea through over 100 estuaries (NERC, 1990). Correspondingly, the gauging station network is also very dense – reflecting also the diversity of the UK in terms of its climate, geology, land use and patterns of water utilisation. In total there are around 1400 primary gauging stations representing a capital investment of more than £300 million. A distinguishing characteristic of the UK network is the variety of gauging stations deployed but purpose-built structures (including a wide variety of weirs and flumes) constitute around 70% of the network in England & Wales; an exceptional proportion in a global context.

Flow measurement in the UK rarely presents the difficulties of access, large velocity ranges, inadequate hydraulic conditions and paucity of hydrometric equipment and trained personnel that are common throughout the developing world. Nonetheless, the relatively modest flow and limited depth of UK rivers, combined with the technical and logistical difficulties of defining the stage-discharge relation in the highest and lowest flow ranges, implies that the accuracy bands which characterise the medium flow ranges can seldom be approached in extreme flows. In addition, man's impact on flow regimes has been increasingly pervasive – only a small proportion of the flow regimes for gauged rivers in the UK can be considered natural (see page ?) – this is especially true in the English Lowlands where, generally, runoff rates are lowest and public water supply demands and irrigation needs are at their greatest.

The multiplicity of artificial influences on natural flow patterns is perhaps best illustrated by the River Thames which drains the largest catchment in the UK and has the longest continuous flow record; routine flow measurement began at Teddington Weir in 1883. Figure 1 shows gauged 30-day minimum flows for the Teddington gauging station[1]; these show a compelling overall decline over the 128-year series. However, if naturalised flows (which adjust for the major abstractions, upstream of Teddington, to meet London's water demand) are examined, the trend is reversed, showing a modest (non-significant) increase over time. Abstraction rates have increased by an order of magnitude over the last 100 years and can, exceed 50 $m^3s^{-1}$ – by comparison the median annual maximum flow is 315 $m^3s^{-1}$. Failure to allow for the upstream abstractions would, in itself, introduce a modest but significant decline in the time series of annual maximum flows.



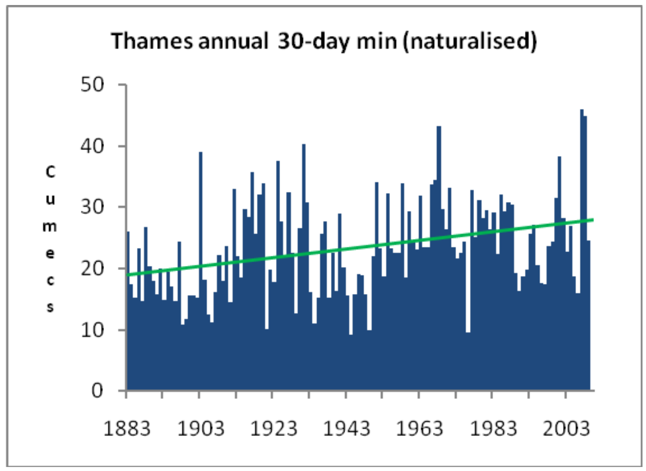




*Figure 1 Annual 30-minimum flows for the Thames at Teddington*

## Measuring Authorities

Responsibility for river flow measurement in the UK resides primarily with the Environment Agency (EA) in England and Wales, the Scottish Environment Protection Agency (SEPA) and, in Northern Ireland, the Rivers Agency (RA); the principle measuring authorities are responsible for around 95% of the country's primary gauging stations. Some small and often temporary gauging networks are maintained by other organisations and research bodies; the Centre for Ecology & Hydrology (CEH) has operated a number of research catchments throughout the

[1] Note: a minimum flow over Teddington Weir was maintained for part of the record.

UK including a long-running programme in the hills of central Wales. A wider range of public bodies and commercial organisations collected flow data in the past. Nonetheless, there are relatively few records extending back to before 1960 and only around a dozen with continuous records of more than 70 years.

For the great majority of contemporary gauging stations, river levels are recorded at 15-minute intervals and converted to flows in local or regional offices. Daily flow data are routinely forwarded to the National River Flow Archive (NRFA) maintained by CEH. The NRFA provides a national data validation capability and a comprehensive data retrieval service; it also provides an essential historical context within which contemporary hydrological variability can be examined.

**Network evolution**

Prior to the 1950s, the UK gauging station network was sparse and very unevenly distributed. The formation of the Water Resources Board in 1963 heralded a period of rapid network growth encouraged by substantial grant aid for capital expenditure. By 1975, there were around 1000 stations in the national network which continued to increase, reaching 1550 in 1990 before declining modestly.

In ideal circumstances, the number and disposition of gauging stations should be kept under continuous review to match changing information needs and maximise synergistic benefits (e.g. by harmonising monitoring effort across a range of environmental monitoring programmes). In practice however network growth in the UK, from the late-1970s, primarily reflected the operational needs of the measuring authorities. Several regionally focussed network reviews led to the decommissioning of a number of small catchments with sensibly natural flow regimes (Lees, 1987). In strategic terms these are often the most valuable for understanding hydrological processes, the development of regionalisation procedures, and the detection of trends.

In the 30 years following the demise of the WRB in 1974 there were no comprehensive UK gauging station network review to ascertain whether the network was optimal with regard to national strategic requirements. However, a number of appraisals of gauging station performance were undertaken as part of major research programmes aimed at developing improved engineering design procedures or water management tools (NERC, 1975, Gustard et al, 1992, Institute of Hydrology, 1999). Often in response to continuing pressures to contain monitoring costs, the increasing use of hydrological models was seen as a particular justification for a number of attempts to rationalise the existing hydrometric networks. Prior to 2005, almost all such reviews were been regionally-based, normally reflecting operational and regulatory imperatives rather than national needs. As in other countries, there was concern that in the UK piecemeal reviews were impacting on the overall utility of the network and its ability to address strategic issues.

A positive development has been the increasing availability of relevant metadata, for example indices of hydrometric performance (Environment Agency 2008), quantification of the net impact of abstractions and discharges, or improved digital catchment characterizations (Laize et al 2008). These have provided a firm foundation for more rigorous reviews of the national network. They have also underlined the disproportionate contribution of a minority of catchments to the overall strategic utility of the UK network (Marsh, 2002).

## Towards an improved strategic capability

The modest size of UK rivers and the pervasive impact of artificial influences make them particularly susceptible to regime changes. Less than 15% of gauged flow records may be considered to be unaffected by abstractions and discharges[2] – and filtering out any climatic change signal from both the general climatic variability and the impact of more immediate anthropogenic causes is a considerable scientific challenge.

The consequential need to enhance the UK's ability to identify, quantify and interpret hydrological trends was a primary stimulus for a strategic review, initiated in 1999, of the NRFA's activities[3]. The review's aim was to redefine the NRFA's objectives in anticipation of the information needs of the 21st century (Anon., 1999). A meeting of the principal stakeholders – including representatives of government departments, measuring authorities and major archive users – was followed by a wider consultation exercise to identify the primary future information needs and their implications both for the gauging station network and the stewardship of hydrometric data. A revised set of objectives was formulated to guide the future development of the NRFA (see Tabe1). Several of the objectives specifically reflect the scientific, political and public interest in climate change and the potential adaptation costs associated with changes in the frequency and magnitude of damaging flood and drought events.

Meeting the new objectives required that any strategic inadequacies in the existing network be identified and addressed. Conceptually, this could imply substantial network modification. In practice however, considerable network inertia is an unavoidable reality and the challenge is to capitalise most effectively on the existing network (with recommendations for extensions where appropriate). A particular objective was to formally identify those catchments with the greatest strategic utility thereby securing a degree of protection against their decommissioning in future network rationalisation exercises.

[2] Conventionally, a 'natural' regime implies that the net impact of artificial influences is <10% of the $Q_{95}$ flow.

[3] The review also embraced the National Groundwater Level Archived maintained by the British Geological Survey.

Table 1 National River Flow Archive Objectives

- Assess national and regional resources and monitor variability
- Establish regional (and flow regime) baseline hydrological conditions
- Identify and interpret national and regional trends in river flow patterns
- Service the data requirements of a range of publications and official reports
- Meet national and international obligations for data dissemination and exchange
- Provide the continuous daily flow data required to complement the national water quality archive
- Constitute a national database to meet Strategic research requirements
- Increase public awareness and understanding ofwater-related issues

As part of the NRFA Review, four national network categories were defined: *Benchmark, Artificial Impacts, Regionalisation, and Integrated Monitoring* (see Table 2). The categories are not mutually exclusive – many well gauged catchments will qualify for selection in several categories – but they do provide an important guide to the types of applications to which individual gauging station records are most suited. All gauging stations included in the four categories are considered to have strategic value and are subject to enhanced levels of data validation and hydrometric performance appraisals; they are also supported by a more extensive range of metadata (see page 7) than the remainder of the UK network.

Table 2 National network categories

| Category | Main objectives |
|---|---|
| Benchmark | Identify and interpret hydrological trends – principally climate-driven |
| Artificial Impacts | Monitor heavily impacted catchments to establish the degree of disturbance (and monitor remedial measures) |
| Regionalisation | Underpin the development of regionalisation techniques and modelling procedures |
| Integrated Monitoring | Provide a focus for the improved understanding of hydrological processes, from the sub-catchment to the basin scale |

## Identifying Benchmark Catchments

The principal criteria for the designation of candidate stations for the Benchmark Network were: consistency of the gauging station's hydrometric performance (in the extreme ranges especially), the degree of artificial disturbance to the flow regime, the homogeneity of the time series, and record length (Bradford and Marsh, 2003). At the initial stage a measure of the contribution of groundwater to river flow – the Base Flow Index (Gustard et al, 1992) was used to help select a representative mix of catchment types. A more sophisticated spatial analysis technique was later used to refine the initial catchment selection (Laize et al 2008). The technique exploits digital characterizations of relief, land use and rainfall to determine how representative individual catchments are of the UK (or particular regions thereof).

In order to achieve a full national coverage some compromises were necessary especially in the English Lowlands where, for instance, a limited net impact of abstractions/returns on average runoff was tolerated. In addition a few of the initial Benchmark nominations were on an aspirational basis; confirmation of their status being contingent upon, for example, more detailed assessment of the impact of artificial influences or an upgrading of the hydrometric performance of the associated gauging station.

A provisional national network of around 110 Benchmark Catchments was identified (see Figure 2). Ongoing review mechanisms (see below) have eliminated a number of the original nominations (e.g. due to clear lack of homogeneity in the river flow time series or intractable hydrometric problems) and there remains a dearth of Benchmark Catchments in the Scottish Highlands where the density of gauging stations is low, record lengths are generally short and the flow regimes of many, otherwise suitable, rivers are substantially altered to facilitate hydro-power generation.

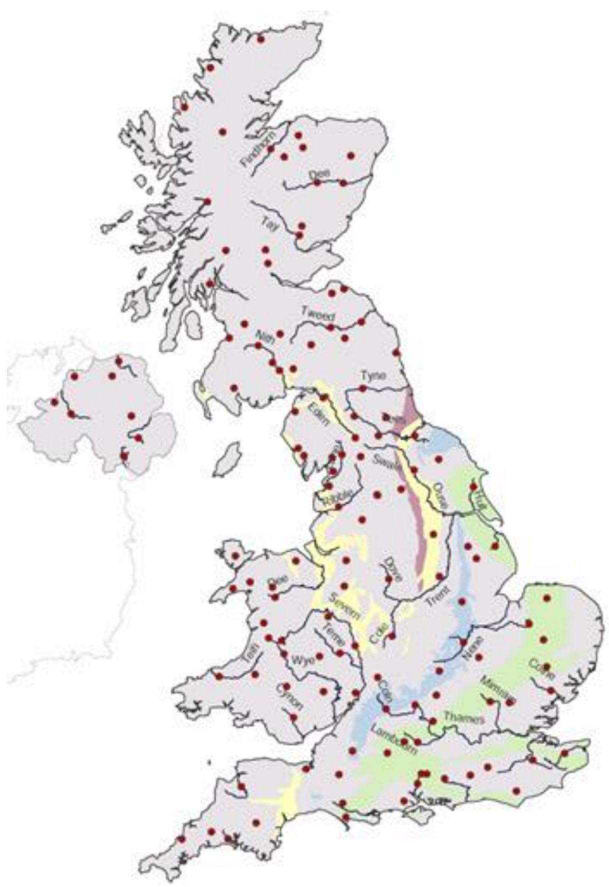



*Figure 2 The UK Benchmark Network*

## Capitalising on the Benchmark Network

The ultimate purpose of the Benchmark Network is to aid policy development and water management (in the face of continuing change) but the quality of the information deriving from it depends on effective linkages between all of the components in the data acquisition chain (Marsh, 2002); the dialogue between network designers and end-users of the information generated being especially important – see Figure 3. Correspondingly, for any Benchmark Network initiative to succeed it is essential that the selected stations are kept under periodic review and mechanisms are established to secure the quality, completeness and homogeneity of the associated hydrological time series. In this regard, it is helpful that the promoting organization has both a recognized national role in the stewardship and exploitation of the data and, ideally, experience in designing operating and exploiting hydrometric networks.

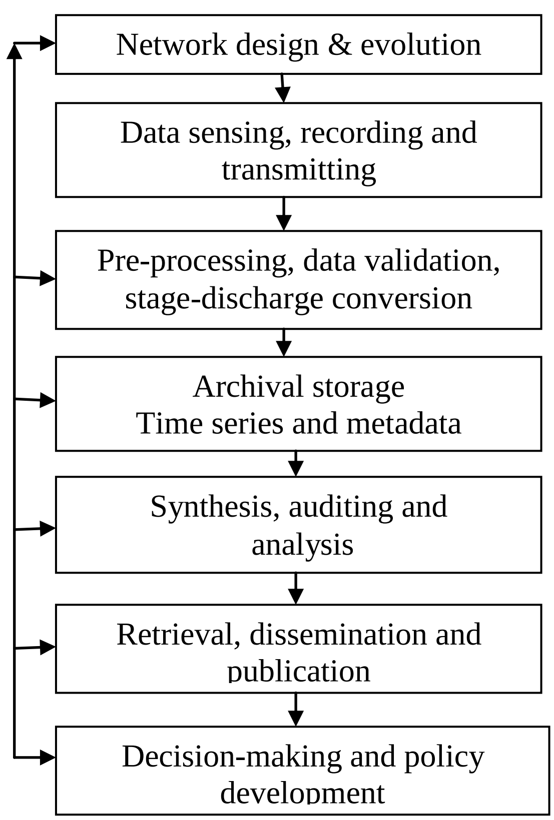



*Figure 3 Hydrometric data processing flowchart*

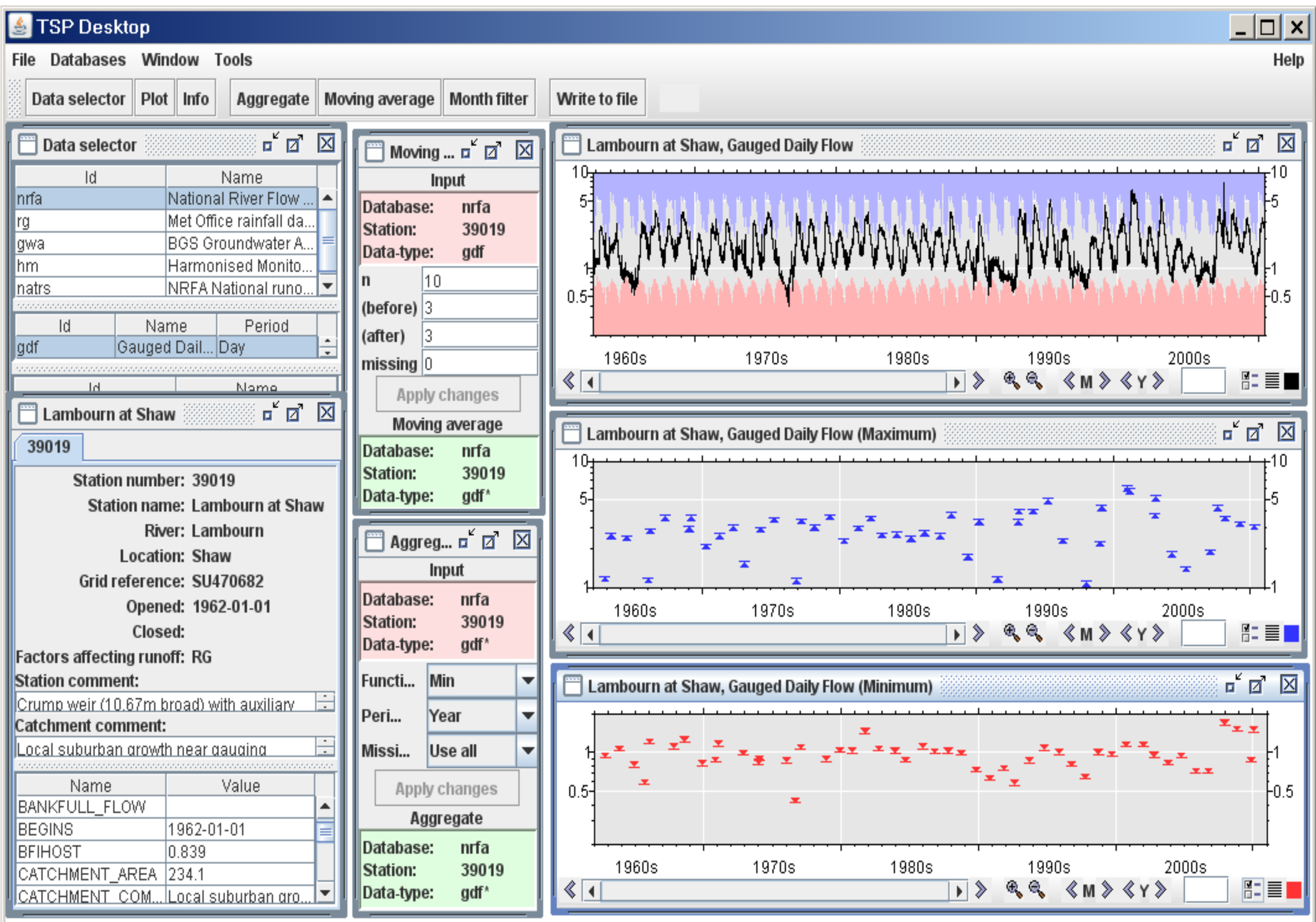
In the UK, the SAGA Steering Group group – established in 1982 – has oversight of the NRFA and National Hydrological Monitoring Programme but, in relation to data acquisition and management, the utility of the Benchmark Network is promoted and enhanced through a suite of Service Level Agreements (SLAs) developed in close collaboration with the Measuring Authorities (Dixon and Hannaford, 2010). Regional Hydrometric Audits, scheduled every three or four years, provide an over-arching framework within which to review the suitability and performance (particularly in the extreme flow ranges) of the nominated Benchmark Catchments. These audits are complemented by a suite of SLAs devoted to ensuring a professional stewardship of the associated hydrometric data. Objective scoring mechanisms assess the completeness and timeliness of data submissions to the archive and the proportion of data queries raised by national validation checks (Hannaford, 2004). This allows the information delivery of individual gauging stations or particular network groupings to be monitored and indexed.

The adoption of a reporting structure based on key performance indicators encourages improvements in underperforming components of the network and focuses attention on data quality improvements. Associated SLA initiatives ensure that a full audit trail exists for all data amendments and that the infilling of record gaps, using a range of mechanisms, is actively pursued (Harvey, et al, 2010).

The utility of hydrometric data is greatly enhanced by consistently applied quality assurance procedures (Environment Agency, 2007) and access to sufficient reference, spatial and descriptive information for the user to judge its suitability for given applications and to guide the interpretation of analyses based on the raw flow data. Therefore, considerable effort is devoted to updating and extending the metadata associated with benchmark gauging stations and the catchments they command.

To maximise the exploitation of the Benchmark Network it is essential that the associated data (both time series and metadata) can be readily accessed and manipulated. To this end CEH has developed a flexible suite of data selection, manipulation and visualisation procedures (incorporating basic data analysis options) which together constitute a powerful toolkit for users to explore the temporal and spatial characteristics of hydrometeorological time series (see Figure 4).

*Figure 4 Shows the selection, manipulation and display of hydrological time series (and selected metadata) for a Benchmark Gauging Station. The plots show daily mean flows (with daily extremes indicated by the shaded envelopes) plus annual 10-day maximum and minimum gauged flows.*




## Network evolution and appraisal

By their nature all hydrometric networks are subject to modification, driven by changes in stakeholder priorities, monitoring technologies and other factors including funding constraints, Health and Safety issues, and ecological concerns (e.g. where gauging weirs constitute a barrier to fish movement).

Reviews of the hydrometric performance of individual gauging stations in the Benchmark Network (including improved indexing the degree of artificial disturbance to the natural flow regime) has resulted in a small proportion of the initial Benchmark nominations being rejected.

Whilst the strategic value of the Benchmark Network is widely acknowledged, individual stations can also be vulnerable to decommissioning, particularly where only limited operational needs for flow data can be identified. Consequently, an important component of the overall SLA structure is the provision for CEH/MA consultation in circumstances where a Benchmark Station may be under threat of closure. Often such stations may be of considerable strategic value particularly where there is minimal disturbance to the flow regime, the flow record is lengthy and the catchment is a representative one.

An instructive example relates to the gauging station shown on Plate 1. It is a relatively remote trapezoidal flume in east Wales with significant maintenance problems in the low flow range (due to gravel accumulation downstream). There are also no over-riding operational water resources, flood management or ecological justifications for the gauging station. Correspondingly, the station was identified as a possible candidate for decommissioning. However, the exceptional capacity of the flume (it has never been overtopped), the length of the flow record (60 years) and the absence of significant artificial influences on the flow regime testify to the catchments strategic value.

These factors were stressed during the required consultation exercise when supporting evidence relating to the utility of the catchment for regionalisation purposes was also assembled (see Appendix I). After careful consideration of the evidence the MA agreed to retain the station was duly retained as an operational component in the UK Benchmark Network.

Plate 1 Trapezoidal flume on the River Dulas at Rhos-y-pentref

**Operational experience with the Benchmark Network**

Ultimately, the value of any gauging station network is judged by its breadth of application and its impact on water management and policy development. The UK Benchmark Network has been operational for over a decade and has proved very successful – being widely exploited in a range of national and international monitoring programmes and major research projects (Hannaford, 2010). The network has been exploited in Defra's Climate Change Indicators programme, to explore trends in the runoff, flood magnitude and low flows, and to inform the UK's input to the IPCC 4$^{th}$ Assessment.

However, a number of network and data stewardship issues have been identified which merit continuing attention. They are outlined briefly below, and will be addressed in the future development of the UK Benchmark Network programme.

i. There is a ongoing need for gauging station reviews to balance operational and strategic objectives in order to maximize the overall economic benefits of hydrometric monitoring.

ii. A number of additional Benchmark catchments are required in parts of the English Lowlands (where artificial flow disturbance is generally high) and in the wettest parts of the country (where flow measurement is often challenging).

iii. The recent availability of more comprehensive assessments of the net impact of upstream abstractions and discharges on flow regime provides an opportunity to review the suitability of individual catchments in the Benchmark Network.

iv. A significant proportion of gauging stations in the Benchwork Network do not have comparable levels of performance in both the very high and very low flow ranges. Consequently, consideration is being given to the designation of separate, but complementary, high and low flow components of the network.

v. The quality and completeness of relevant metadata material needs to be regularly reviewed to ensure its contemporary validity.

vi. Reflecting the generality of UK gauging stations, the average record length of those in the Benchmark network is less than 40 years. A parallel initiative (see Table 1) is in place to increase the historical data holdings (not necessarily from primary gauging stations) associated with the NRFA in order to provide a more extensive historical framework within which to explore multi-decadal hydrological variability.

vii. There should be a continuing focus on hydrological extremes in data validation programmes and archiving systems should endeavor to accommodate (audited) estimates rather than leaving record gaps. An annual review of flow extremes could provide the mechanism.

viii. Increased attention needs to be directed to the integrated monitoring of hydrometeorological variables (e.g. rainfall, groundwater and water quality) in selected Benchmark Catchments in order help identify the hydrological processes which are driving regime/quality changes.

## Concluding remarks

Identifying climate-driven trends in river flows in the UK is hampered by a lack of long, quality time series data for rivers with relatively undisturbed regimes. This is a global problem compounded by the difficulties of galvanising support for essential long-term monitoring programmes (Rodda, 1998). Experience in the UK demonstrates that with clear strategic objectives, and the support of both sponsoring organizations and Measuring Authorities Benchmark Networks can constitute an exceptionally valuable strategic capability to effectively identify, quantify and interpret hydrological change; the speed and magnitude of which is expected to a be a primary driver of water management and flood alleviation strategies through the 21st century.

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## Appendix I The Dulas as Rhos-y-pentref – A case study

In assessing the strategic utility of individual Benchmark (or any other) Catchments an important factor is the degree to which it is representative of other catchments throughout the UK. Generally, the most representative catchments have the greatest potential for exploitation in regionalization techniques (e.g. to estimate extreme flows at ungauged sites). The increased availability of spatial datasets has allowed the characteristics of individual catchments to be explored much more rigorously than hitherto. This has encouraged the development of mechanisms to index representativeness. Such mechanisms, when combined with indices of the hydrometric capability of gauging stations, have an important role in the design and evolution of hydrometric networks.

### *Catchment characteristics and representativeness*

The river Dulas drains a catchment which is a geomorphological mix of relatively steep slopes and extensive tracts of the central Wales plateau (over 75% of the catchment is between 250 and 400 metres). The catchment is developed almost entirely on Llandovery slates, giving it a baseflow index (BFI) typical of much of Wales and upland areas across most of the UK. For catchments monitored by the Environment Agency (EA) within Wales that have data on the NRFA, there are 12 small catchments (30-85 $km^2$) which combine average annual rainfall in the 1000-1750 mm range with BFIs in the 0.30-0.35 range. Five have been decommissioned and of the seven still operational, two have substantially influenced regimes and one now operates primarily as a flood warning station. The Dulas has the longest flow record of the remaining four.

A particularly notable feature of the Dulas catchment is the high proportion of grassland. For Wales, it has the highest proportion of grassland of any EA gauged catchment and, considering land use and relief together, it is the 4th most representative gauged catchment above 200 metres; the flow regimes of rivers draining each of the higher ranked catchments are all artificially influenced to some degree.

### *Monitoring and modelling*

The rapidly growing requirement to assess flow information for ungauged sites underlines the need to index the contribution individual gauging stations make to the overall information delivery from regional or national hydrometric networks. This could, for example, be in relation to the improved understanding of hydrological processes and the detection of any trends in flows patterns. More generally, it concerns their role in the development and application of regionalisation techniques and decision support systems that increasingly underpin water management in the UK. Modelling and monitoring are interdependent with the predictive skill of the former largely determined by the number, disposition and performance of the gauging stations in the hydrometric network.

The notable strategic utility of the Rhos-y-pentref gauging station can be well demonstrated in relation to flood risk assessments and the development and application of engineering design procedures. Using a methodology developed at CEH (Laize et al, 2008) the frequency with which individual catchments may be expected to be incorporated in pooling groups for flood estimation (Institute of Hydrology, 1999) provides a useful index of their utility. Because of its particular combination of size, wetness, and soil type the Dulas catchment ranks among the top 25 gauged catchments in the UK (see Table 1) – and the top three or four in Wales – to service target catchments in the 25-100$km^2$ range (of which there are over 10,000 across the UK). In relation to its actual use in flood analysis it will rank somewhat higher: Its record length and high flow performance imply that during the review phase of pooling-group selection, the Rhos-y-pentreth flood time series would be retained whilst other stations, selected on the basis of their catchment characteristics alone, would be discarded. This point is reinforced by the number of gauging stations in Table 1 (around half) which are not currently considered suitable for use in flood pooling groups.

Elevation (150-600m) | Rainfall (1000-1500mm) | Geology (primarily basement Series: Llandovery) | Land use (primarily Grassland)

Figure 1 Spatial characteristics of the River Dulas catchment

*Table 1 Catchment Utility Scores for catchments of 25-100 km$^2$*

| *NRFA* | *River* | *Station Name* | *Catchment Area* | *First Yr* | *Utility Score* | *Measuring* |
|---|---|---|---|---|---|---|
| 83007 | Lugton Wtr | Eglington | 54.6 | 1977 | 15657 | SEPA |
| 84008 | Rotten Calder | Redlees | 51.2 | 1966 | 13407 | SEPA |
| 72007 | Brock | Upstream of A6 | 32.0 | 1978 | 13249 | EA |
| 27084 | Eastburn Beck | Crosshills | 43.3 | 1988 | 12281 | EA |
| 58008 | Dulais | Cilfrew | 43.0 | 1971 | 12155 | EA |
| 74002 | Irt | Galesyke | 44.2 | 1967 | 11996 | EA |
| 71013 | Darwen | Ewood | 39.5 | 1976 | 11800 | EA |
| 84026 | Allander Wtr | Milngavie | 32.8 | 1974 | 11677 | SEPA |
| 46007 | West Dart | Dunnabridge | 47.9 | 1972 | 11600 | EA |
| 21026 | Tima Wtr | Deephope | 31.0 | 1973 | 11535 | SEPA |
| 84016 | Luggie Wtr | Condorrat | 33.9 | 1966 | 11431 | SEPA |
| 63003 | Wyre | Llanrhystyd | 40.6 | 1970 | 11272 | EA |
| 17003 | Bonny Wtr | Bonnybridge | 50.5 | 1971 | 11160 | SEPA |
| 38026 | Pincey Brk | Sheering Hall | 54.6 | 1974 | 10872 | EA |
| 81005 | Piltanton Burn | Barsolus | 34.2 | 1985 | 10611 | EA |
| 23017 | Team | Team Valley | 61.9 | 1991 | 10597 | EA |
| 28041 | Hamps | Waterhouses | 35.1 | 1968 | 10561 | EA |
| 19002 | Almond | Almond Weir | 43.8 | 1962 | 10537 | SEPA |
| 63004 | Ystwyth | Cwm Ystwyth | 32.1 | 1984 | 10440 | EA |
| **54025** | **Dulas** | **Rhos-y-pentref** | **52.7** | **1969** | **10339** | **EA** |
| 69008 | Dean | Stanneylands | 51.8 | 1976 | 10324 | EA |
| 19020 | Almond | Whitburn | 30.3 | 1986 | 10123 | SEPA |
| 84020 | Glazert Wtr | Milton of Campsie | 51..9 | 1968 | 10041 | SEPA |
| 27044 | Blackfoss Bck | Sandhills Bridge | 47.0 | 1974 | 9973 | EA |
| 23011 | Keilder Burn | Keilder | 58.8 | 1970 | 9932 | EA |

Notes: Utility Scores are derived by adapting the procedures used to define FEH pooling groups (Institute of Hydrology, 1999). The 20 nearest gauging stations (in Area, Rain and BFIHost space) to all potential target catchments across Great Britain are identified. Scores are allocated according to their proximity (1.0 for closest; 0.05 for the 20$^{th}$ closest); finally the scores across all target catchments (in this case those with catchment areas between 25-100 km$^2$) are summed to give the overall Utility Score for each gauging station.
Stations which are no longer operational or where the catchment includes significant urban development have been excluded from the Table. A full listing of the Utility Scores would feature 840 catchments.

## References

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