River Glen:
River Channel Assessment - Executive Summary

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Prof. G Petts
I Maddock
M Bickerton

Freshwater Environments Group

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RIVER CHANNEL ASSESSMENT

WITH PARTICULAR REFERENCE TO PROBLEMS OF LOW FLOWS

INCLUDING THE EXAMPLE OF THE RIVER GLEN

EXECUTIVE SUMMARY

Undertaken for the National Rivers Authority, Anglian Region

By

FRESHWATER ENVIRONMENTS GROUP,
INTERNATIONAL CENTRE OF LANDSCAPE ECOLOGY,
LOUGHBOROUGH UNIVERSITY,
LEICESTERSHIRE, LE11 3TU

Supervised by Professor G.E.Petts

Researchers: Mr I. Maddock, Miss M. Bickerton,

Research Assistants: Miss V. Adams and Mr D. Milan.

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FOREWORD

The Water Resources Act (1991) defines the NRA's responsibilities for maintaining and improving the natural water environment. These responsibilities include:

- Maintenance and improvement of water quality;
- Provision of flood defence, including the protection of property and people;
- Management of water resources;
- Maintenance and improvement of fisheries;
- Conservation of the natural water environment and promotion of water-based recreation and navigation.

In order to provide value for money in meeting these responsibilities, the NRA is developing methods of assessing priorities for river improvements. This can only be achieved by studying the river environment as a whole and presenting the recommendations for these improvements in the form of catchment management plans. There are many aspects to this planning process which need investigation in order to identify the natural resources, identify the current and potential uses, quantify the potential improvements and describe what can be achieved with the available resources.

The results of the River Glen catchment study provide a basic methodology for a structured approach to describing the river system in relation to the natural resources. A sector-scale approach underpins the development of realistic recommendations for managing this complex river system which are made in the Report.

The study provides methodologies which will benefit the development of other catchment management plans.

Dr Alastair J. D. Ferguson
Anglian NRA
Project Leader

1. INTRODUCTION

1.1 Background

The drought of 1976 created an awareness within the water industry and among the general public of the potential consequences of abstractions from groundwater and surface waters for the fauna and flora or rivers and streams. The current drought has heightened concern for river degradation caused by extreme low flows. However, the level of degradation in many rivers reflects the history of agricultural intensification, industrialization and urban growth over the past 250 years. Streamflow changes, for example, have been caused by a range of human activities including land drainage, land-use change, urban growth, and flood control as well as by water abstractions from surface and underground resources.

One river for which concern has been growing since the mid-1970's is the River Glen, Lincolnshire. The river drains low-lying hills formed of permeable Lincolnshire Limestone and summer river levels are maintained by spring flows from the limestone aquifer. Reports suggest that by 1976, abstractions had already lowered groundwater levels and springflows below their natural state. Further they suggest that the declining flows in the River Glen had had deleterious effects on the biology and fisheries of the river.

1.2 The Project

The River Glen, in common with other catchments, requires management plans to meet river quality objectives and environmental targets. In particular, methods are required to assess biological quality in relation to flow and to distinguish between the effects on biota of the many different factors involved.

This project, commissioned by the National Rivers Authority, Anglian Region (formerly Anglian Water Authority), has two primary aims:

i) to develop an approach for assessing the main management-influenced and natural factors affecting the flora and fauna of rivers;

ii) to apply the approach to the River Glen and to make recommendations as to how the river could be managed to enhance its conservation value and fish stocks, especially in relation to sport fishing.

The Report is in two parts. The Main Report describes the approach developed during the Project, illustrates the application of the various methods by reference to the River Glen and concludes by using the results to present recommendations for managing the river. The Main Report also includes a post-project appraisal of flow augmentation achieved by the Gwash-Glen transfer.

The second part comprises six Annexes and provides a detailed examination of the River Glen catchment. The Annexes are: A) The Database; B) Analysis of NRA Invertebrate Records; C) Hydrological Assessment; D) Channel Substrate Analysis; and E) Physical Habitat Assessment.

2. THE APPROACH

2.1 Structure

The Main Report presents a framework for directing scientific information towards restoration objectives, recognising the multifunctional nature of catchment management, involving: water resources, water quality, flood control and land drainage, fisheries, recreation, conservation and navigation. Appropriate space and time scales are defined which are both practicable for management and scientifically defensible.

The appropriate scale is shown to be the sector, usually having a length of between 1 and 50 km. Each sector comprises a typical range of ecological patches - individual habitat types (e.g. gravel bar, pool, cutoff channel) of different ages (or successional stage). The location of specific patches within a sector may change over a timescale of 10-100 years, but the composition of patches within each sector will remain relatively stable, about an average condition, as long as the general regime of inputs from upstream is unchanged. Important relationships exist between patches, especially between the aquatic ecosystem of the river and the semi-aquatic/terrestrial systems of the river margin.

At this spatial scale three important principles are emphasized:

i) Each sector must be viewed in the context of its *catchment* as its hydrology, sediment supplies and water-quality are dominated by inputs from upstream.

2) Within each sector, quasi-equilibrium relationships may be defined between environmental processes, channel morphology and biota.

3) Lateral exchanges between the channel and the river margins play an important role in sustaining the functioning of river sectors.

2.2 Application

The Main Report develops the above approach in six stages, each one being illustrated by reference to the River Glen:

- Preliminary Assessment

i) Database Assessment & Historical Appraisal. The collation, synthesis and critical evaluation of all available information, including historic records, is an important first step in any study of river systems concerned with environmental degradation, not least because of the many factors that may be involved over long periods of time.

ii) Definition and Classification of Sectors. The criteria used to define sectors are those variables that influence the important hydrological, geomorphological and ecological processes. A preliminary classification based on maps and other secondary sources, is based on scale, location in stream network, slope, landuse and geology. This is then refined by reference to field data on habitat type and condition, hydrological status, and quality of target habitats (such spawning grounds).

- Analysis of Biological Records

iii) Analysis of NRA Fisheries Records. Simple descriptive measures are used to define fish zones and to examine trends in species diversity and biomass in relation to the physically-defined sectors.

iv) Analysis of NRA Invertebrate Records. A sequence of analyses has been designed to elucidate the maximum information from a set of invertebrate records for a hypothetical river system. By using methods of classification and ordination it is possible to identify faunal groupings at different spatial scales. Site- and sector-specific differences other than water quality are are shown to be significant in determining the fauna.

- Development of Flow-Habitat-Biota Relationships. The morphology of a stream channel is a key component for river management influencing the productivity and biological quality of the instream habitat. In particular the hydraulic conditions - the diversity of velocities, depths, and shear stresses - determine the suitability of a channel for different biota. Two approaches are used.

v) Identification of Key Environmental Variables influencing Biological Quality within Channel Sectors. Spatial relationships are developed between biota or biotic indices and environmental variables for rivers within the same general biogeographic region. These models are used to identify the relative sensitivity of biota to the different environmental variables.

vi) Assessment of Biological Responses to Habitat Variables within Channel Sectors. A simulation model (PHABSIM) has been used to relate changes in discharge and variations of channel structure to physical habitat availability for Dace, Trout and Chub.

3. THE RIVER GLEN

3.1 A Historical Appraisal

There is a long history of water abstraction from the Lincolnshire Limestone, and records of water levels in boreholes suggest a progressive decline of maximum and minimum reset levels since about 1940. Over the same period there has been an eastward movement of the western limit of artesian overflow. However, perception of the potential quality of the river may be exaggerated because the baseline for information happens to be the 1960's - a high-flow decade. John Grundy of Spalding (1719-1783) describes the Grimsthorpe Brook in the 1740's as an ephemeral stream, drying-up during summer. Today potholes can be seen in the bed of the West Glen at Burton Coggles (Plate A). It is likely that much of the upper Glens were ephemeral even under pristine conditions.

Water-quality problems have declined in recent years but sewage effluent remains responsible for poor quality in some reaches. Low rainfall and low flows could reduce the dilution of effluent, exacerbating any water-quality problems. Land-use change between 1932 and 1963 included an expansion of the arable area which may have resulted not only in increased storm runoff but also increased nutrient loads in the river.

The morphology of the channel has been drastically altered throughout its length, by ditching and straightening. Earliest works occurred during the 18th and 19th centuries. Probably the first channelisation works on the Glen, the East Glen at Edenham, was planned by Grundy in 1756 - his 'improvement' of the stretch between two (road) bridges involved "a new cut to straighten the channel". Dredging and channel incision following straightening may well have increased water losses through the bed of the river at times when the channel is perched above the groundwater table.

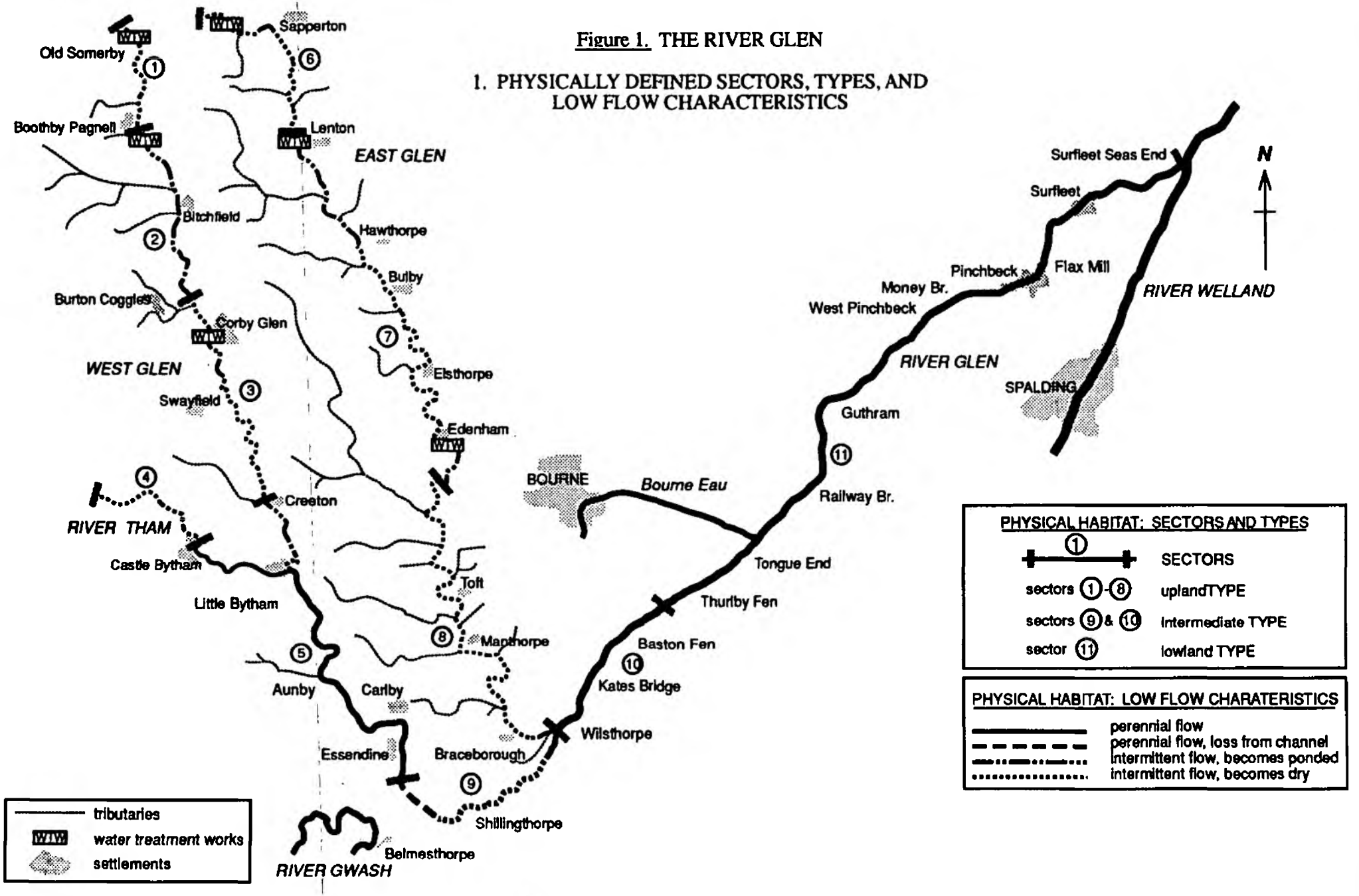
Figure 1. THE RIVER GLEN
1. PHYSICALLY DEFINED SECTORS, TYPES, AND LOW FLOW CHARACTERISTICS
Old Somerby
Sapperton
Boothby Pagnell
Lenton
EAST GLEN
Bitchfield
Hawthorpe
Bulby
Burton Coggles
Corby Glen
WEST GLEN
Swayfield
Elsthorpe
Edenham
RIVER THAM
Creeton
Castle Bytham
Little Bytham
Toft
Manthorpe
Aunby
Carlby
Essendine
Braceborough
Shillingthorpe
Belmesthorpe
RIVER GWASH
BOURNE
Bourne Eau
Tongue End
Thurlby Fen
Baston Fen
Kates Bridge
Wilsthorpe
Guthram
Railway Br.
Money Br.
West Pinchbeck
Pinchbeck
Flax Mill
Surfleet
Surfleet Seas End
RIVER GLEN
RIVER WELLAND
SPALDING
N
tributaries
water treatment works
settlements
PHYSICAL HABITAT: SECTORS AND TYPES
SECTORS
sectors 1-8 upland TYPE
sectors 9 & 10 Intermediate TYPE
sector 11 lowland TYPE
PHYSICAL HABITAT: LOW FLOW CHARATERISTICS
perennial flow
perennial flow, loss from channel
intermittent flow, becomes ponded
intermittent flow, becomes dry

3.2 Restoration of the River Glen

The results of the physical habitat assessment, analyses of NRA fisheries data and invertebrate records demonstrate that the Glen may be classified into three **river types** (upland, intermediate and lowland) and 11 **sectors** (Figure 1). *The study demonstrates that the course of the main River Glen effectively begins at Creeton and Castle Bytham springs.*

i) The **upland type** sectors comprise sectors 1,2,3,4,6,7,8 and sector 5. Typically they have low BMWP scores and low and intermittent discharges (Plate B). However, within sector 5, flows are maintained by springs; invertebrate scores are good; the characteristic fish species are Dace and Trout; and substrate sediments are relatively clean, providing suitable Trout spawning habitat.

ii) The **lowland type** sites are sustained by perennial flow with low velocities and deep run habitat (Plate C). The invertebrate fauna indicate that the water-quality is good.

iii) **Intermediate type** sites have large proportions of riffle habitat although the impact of the weirs at Kates Bridge, Fletland Mill (Plate D) and Greatford is to create ponded reaches. The fishery is characterised by Dace and Chub) and this river type has highest invertebrate diversity.

3.2.1 Headwater sectors

The upper sectors (1-4 and 6-8) of the East and West Glens are considered to be naturally ephemeral but most reaches have been channelised to some degree. The main function of these sectors today is to convey storm runoff which transports considerable amounts of fine sediment and associated pollutants.

Restoration of a natural channel form, especially the natural sinuosity and associated bed forms would enhance habitat diversity. However, *the priority within these sectors, including any tributaries, is to establish buffer zones along the channels*. This will have two major benefits: i) creating important habitat for wildlife and ii) trapping fine sediments from surface runoff thereby protecting the river downstream from siltation and pollution during storm events.

3.2.2 Middle sectors

Sectors 5, 9 and 10 have a high potential ecological value and are classified as a F1 fishery. Important opportunities are shown to exist for restoration. *Priority actions are i) to maintain water quality (see 3.2.2) and ii) to maintain flows.*

The Gwash-Glen transfer is demonstrated to have realised considerable ecological benefits in sector 9 by maintaining summer flows, but during November through to mid August flows have been lower than the levels required, especially for fish. Recommendations are made for flows in the River Glen at Shillingthorpe. In summary:-

i) Optimisation of habitat for fish.

- Flows should be maintained above 0.3 m^3s^{-1} throughout the year, a situation which occurs naturally once in every 5-7 years.

ii) Protection of river ecology.

- To protect the general ecological character of the river, indexed by good BMWP and LQI scores, the annual minimum flow should not fall below 0.04 m^3s^{-1} but a higher minimum flow (0.1 m^3s^{-1}) is needed to protect fish habitat.

iii) Recommended monthly minimum flows to improve habitat for fish.

- Flows of at least 0.3 m^3s^{-1} should be maintained during November, April and May, and ideally throughout the winter.
- Minimum flows in June, July, August should follow the natural recession (respectively 0.2 m^3s^{-1} , 0.15 m^3s^{-1}, 0.10 m^3s^{-1}).
- Flows in September and October should be maintained at 0.10 m^3s^{-1}.
- A flushing flow of at least 1.0 m^3s^{-1} is required in early autumn.

Restoration also requires instream habitat improvements, not least to maximize the benefits of the water transfer scheme. Instream habitat quality could be improved by:

- increasing the unit discharge under low flow conditions by reducing low-flow channel width;
- enhancing morphological diversity, at least by introducing pools;
- improving instream cover; and
- planting riparian trees on the south bank, providing shade to control instream macrophyte growth.

The existence of weirs along the river severely constrains options for management. Nevertheless, particular benefits will arise by enhancing sector 9 which has been channelised such that the river today is straight and incised. Ideally, the natural meandering channel pattern should be restored. In any case, diversification of channel morphology within this sector should be considered a priority. The primary need is shown to be for the creation of pools.

3.2.3 Lowland sector

Throughout Sector 11 the channel is artificial but the slow-flowing river sustains an important coarse fishery and contains a diversity of plants and invertebrates. However, the landscape quality and ecological quality of different reaches within this Sector vary markedly. It is recommended that enhancement measures should be introduced, comprising:

- diversifying instream and marginal habitat, especially creating pools, marginal shallows, embayments and 'wetland' patches; and
- planting riparian trees, especially on the south bank, to provide instream cover and shade to control the development of aquatic macrophytes.

3.3 Application and Development of the Approach

The Main Report offers a practicable approach to the assessment of degraded river systems. It is recommended that Sector Classification should be the basis not only for river restoration but also for determining Catchment Management Plans.

A major problem encountered during the study was the difficulty of achieving an integrated analysis of the hydrological and biological data held by the NRA because of a lack of coordination in routine data collection. Thus, it is also recommended that consideration is given to an improved system of environmental monitoring based on representative or target sites within designated sectors.

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Plate A. (top) Pothole in the bed of the West Glen at Burton Coggles at NGR SK988260.

Plate B. (bottom) The dry Burton Coggles gauging station on the West Glen .

Plate C. (top) The lowland Glen at Tongue End.
Plate D. (bottom) The ponded Glen upstream of Fletland Mill.