2nd CROCUS seminar

Restored Rivers as Contested Nature: engineered components of urban lifestyles

Wednesday 3rd May

9.30 am	**Welcome and coffee**
10.20 am	**Geraldene Wharton:** ***CROCUS: aims and objectives***
10.30 am	**Mariana Nikolova and Tsvetan Kotsev:** ***Restoration of mining affected systems in the Lower Danube Basin: Perspectives, Problems and Potential***
11.00 am	**Sabine Apitz:** ***Catchment scale risk assessments for sediment management***
11.30 am	**Ruben Sakrabani:** ***Chemistry of urban sediments***
12.00 pm	**Hazel Faulkner:** ***The complexity of sediment-associated contaminant transfer in a small North London stream: implications for amenity planning in engineered settings***
12.30 pm	**Discussion**
12.45 pm	**Lunch**

1.30 pm	**Pete Worrall: *Rivers of Concrete: Twin Rivers Project, Heathrow T5***
2.00 pm	**Sylvia Tunstall: *Social Science and River Restoration***
2.30 pm	**Discussion groups**
3.30 pm	**Tea and Coffee**
3.45 pm	**Discussion**
4.30 pm	**Jenny Mant: Restoration of the River Brent**
5.00 pm	**Close**

Thursday 4th May

10.30 am	**Jenny Mant: *Site visit to the River Brent***
2.00 pm	**Close**

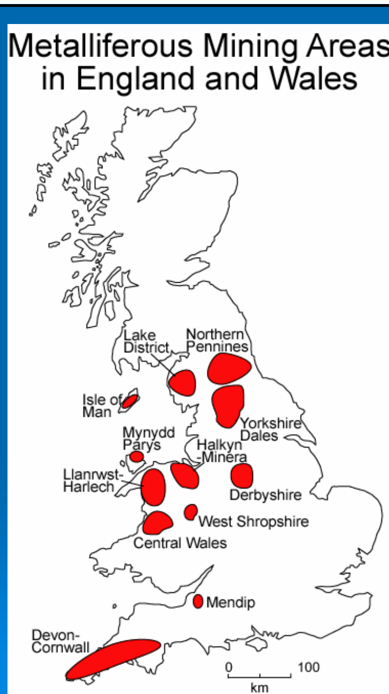
Management of metal mining-contaminated river systems in the UK and the Lower Danube Basin

Paul A. Brewer[1], Mark G. Macklin[1], Mariyana Nikolova[2], Tsvetan Kotsev[2], Graham Bird[1], Mihail Mollov[3] & Catherine Swain[1]

[1] Institute of Geography and Earth Sciences, University of Wales, Aberystwyth, Ceredigion, SY23 3DB, UK.
[2] Institute of Geography, Bulgarian Academy of Sciences, "Acad. G. Bonchev" street, bl.3 1113 Sofia, Bulgaria
[3] Executive Environmental Agency – Ministry of Environment and Waters, "Tsar Boris III" boulevard, № 136, 1618 Sofia, Bulgaria

Outline of Presentation

- History & environmental legacy of metal mining in the UK
- Dispersal & storage of mine waste in river systems
- Changing climate & WFD: remediation versus management
- Approaches to managing historically metal contaminated rivers
- The next steps
- The Lower Danube Basin



Mining History

Dating
back over 4000
years to the
Bronze Age

Mining Output:
8.5 m tonnes lead
1.3 m tonnes zinc
0.13 m tonnes copper

Peak mining mid-late
19th century

After Dunham *et al*., 1978,
and Lewin and Macklin, 1987

The Environmental Legacy of Metal Mining

- No environmental protection legislation during 18th and 19th centuries
- Inefficient processing during this period: 60-70% metal recovery
- Fine-grained (< 2 mm) solid and liquid waste discharged directly into river systems

Dispersal and Storage of Mining Waste in River Systems

- Majority of metal contaminant dispersal (90%) occurred in sediment-associated form
- Metal-rich sediment transported, generally as suspended load, 10s to 100s of km from source
- Deposited and stored in channel and floodplain environments through vertical and lateral accretion processes

Dispersal and Storage of Mining Waste in River Systems

- Long residence times (100s – 1000s years)
- Remobilised from channel and floodplain storage through physical and chemical processes
- Mining-related contamination started as a point source but has evolved to a large-scale diffuse source

UK river catchments contaminated by historical metal mining

- 12,000 km^2 of rivers in northern England alone are contaminated

Catchment	Ore field
South Tyne	Northern Pennines
Wear	Northern Pennines
Tees	Northern Pennines
Swale, Wharfe, Nidd, Ure	Yorkshire Dales
Glenridding Beck	Lake District
Ecclesbourne, Hamps, Manifold, Derwent	Southern Pennines (Derbyshire)
Rea Brook	West Shropshire
Afon Goch	Mynydd Parys
Twymyn	Central Wales
Rheidol	Central Wales
Ystwyth	Central Wales
upper Severn	Central Wales
Yeo	Mendip
Axe	Mendip
Camel	Devon-Cornwall
Erme	Devon-Cornwall
Fal	Devon-Cornwall
Fowey	Devon-Cornwall
Gannel	Devon-Cornwall
Tamar	Devon-Cornwall

Mean contaminant metal concentrations in floodplain sediments (mg/kg)

River systems affected by historical metal mining

River	Pb	Zn	Number
Swale, northern England	1360	970	314
Tyne, northern England	2830	5500	93
Ystwyth, Wales	1800	530	24

River systems affected by tailings dam failures

River	Pb	Zn	Number
Guadiamar, SW Spain	1000	1200	29
Someş, NW Romania	200	850	18

The sediment-water contamination link

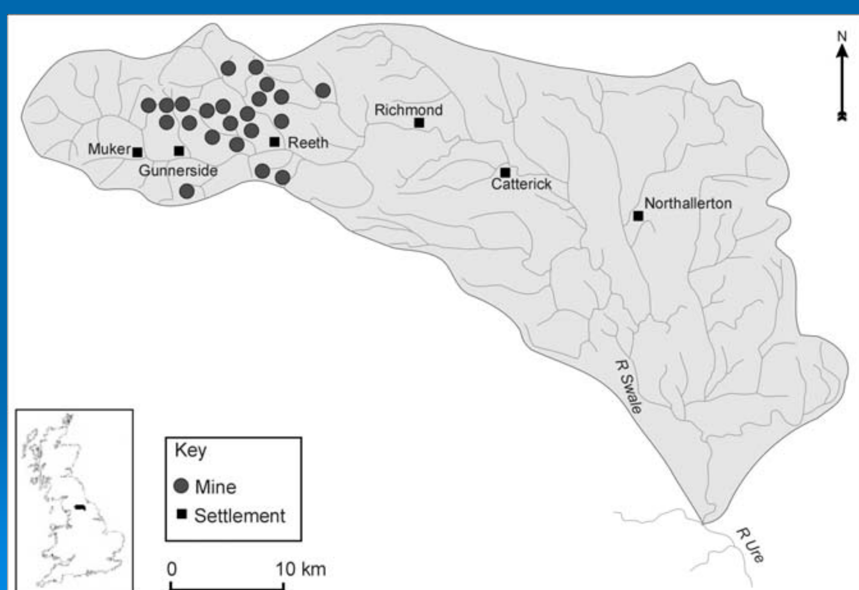
- Water in mining-affected river systems is contaminated with heavy metals (Pb, Cu, Cd, Zn) and arsenic through:
  - Direct discharge of adit or spoil heap waters
  - Acid mine drainage
  - *In situ* weathering of contaminated alluvium through changes in pH and redox potential
  - High-flow events that result in desorption of metals from sediments

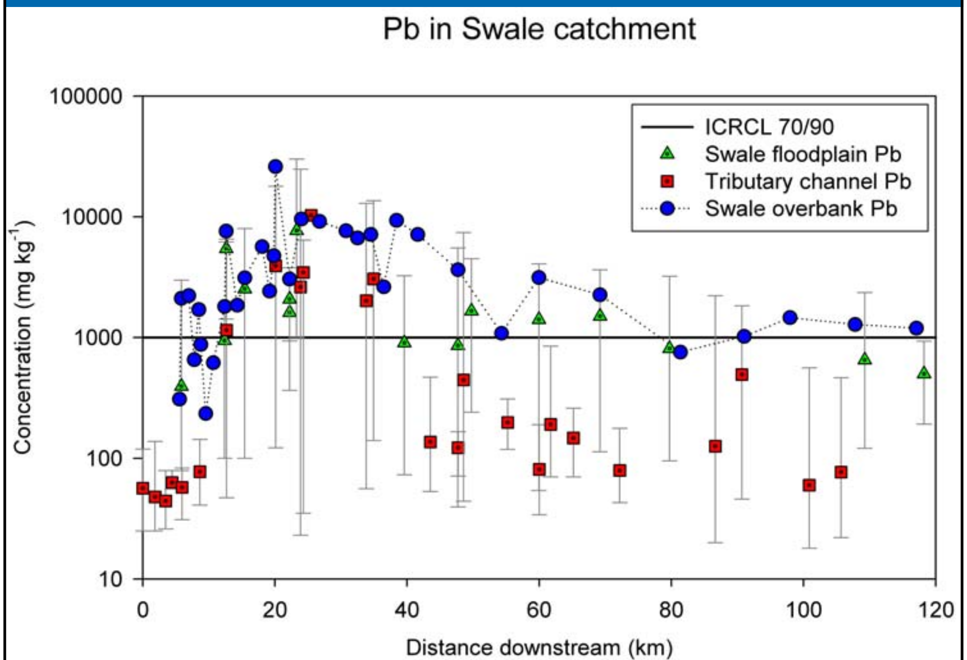
If this problem has been around for more than 100 years, why has it now become a major issue?

- **Recent increase in flooding (e.g., Millennium Floods)**
- Greater seasonality of water tables in floodplains (wetting and drying)
- Need to comply with Water Framework Directive

Autumn 2000 floods – a 'wake-up call' for catchments affected by past metal mining

Swale catchment, northern England





Implications of climate change for catchments affected by past metal mining

- Most of the severely affected river systems are in the north and west of Britain where the greatest increase in flooding is expected to occur in the next 10-50 years
- Floodplain sediments contaminated by mine waste represent a major diffuse source and (because of increased flooding) they are likely to become the predominant supplier of sediment-associated metals in many catchments

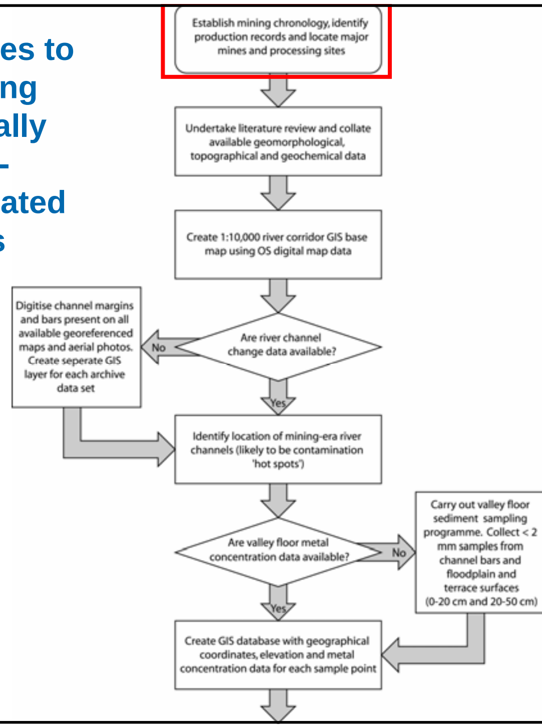
If this problem has been around for more than 100 years, why has it now become a major issue?

- Recent increase in flooding (e.g., Millennium Floods)
- **Greater seasonality of water tables in floodplains (wetting and drying)**
- **Need to comply with Water Framework Directive**

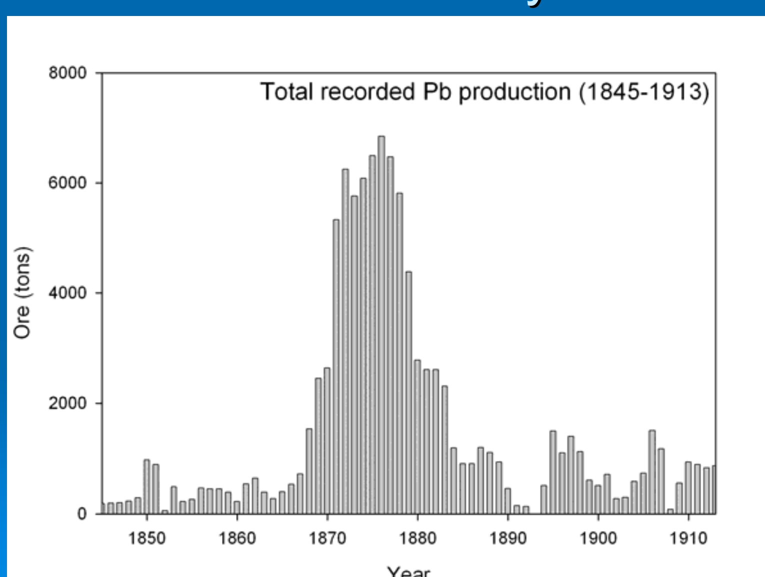
Remediation versus Management

- River are dynamic, and contaminated sediment is frequently added to channels and floodplain surfaces after flooding
- Physical and chemical remobilisation of contaminated sediment are long-term and ongoing processes
- Large scale nature of historical metal mining contamination makes remediation generally unfeasible (e.g., 29.1 km^2 of valley floor of River Swale contaminated with Pb, Zn, Cd; Brewer *et al*., 2005)

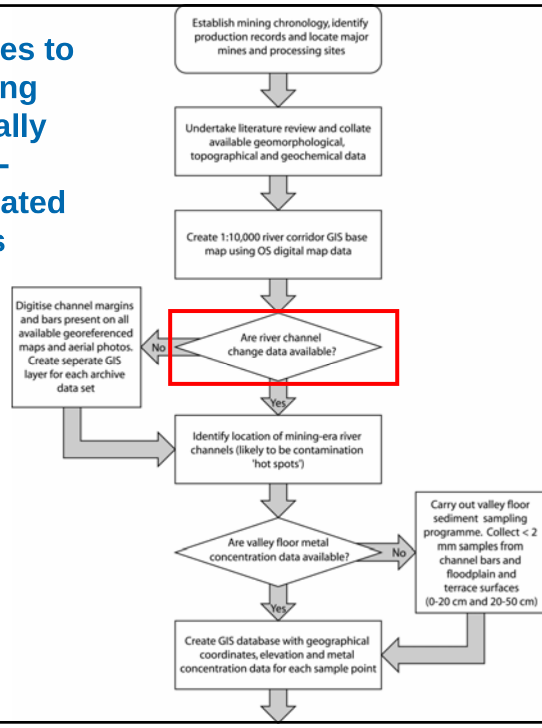
Approaches to managing historically metal-contaminated rivers

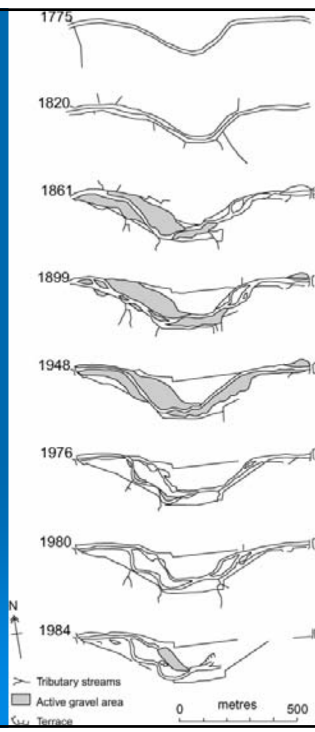


Lead Production in the upper Severn Valley



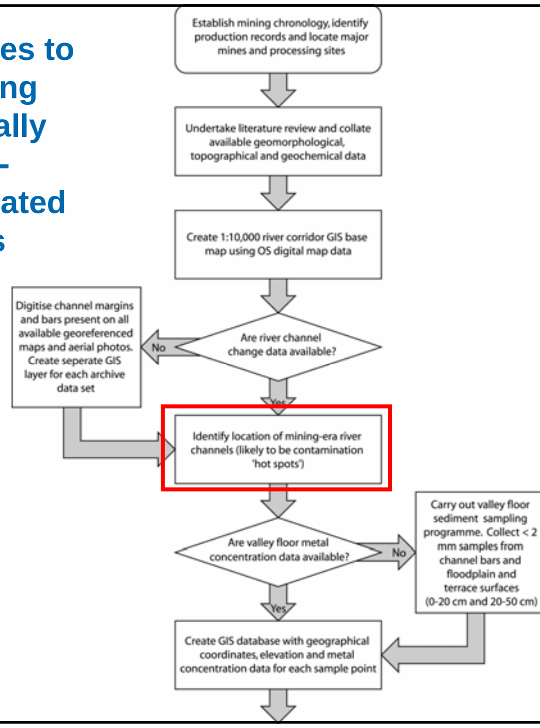
Approaches to managing historically metal-contaminated rivers



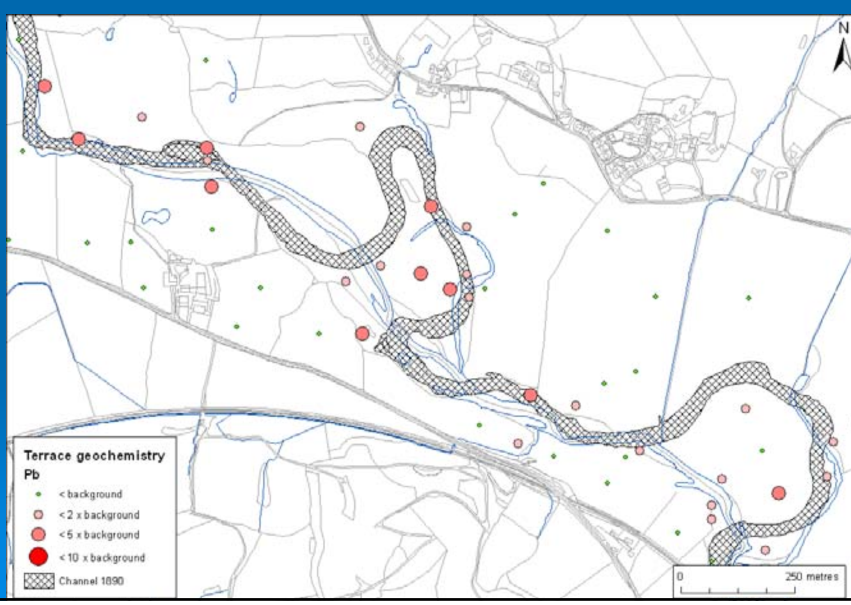


River Nent, South Tyne Basin

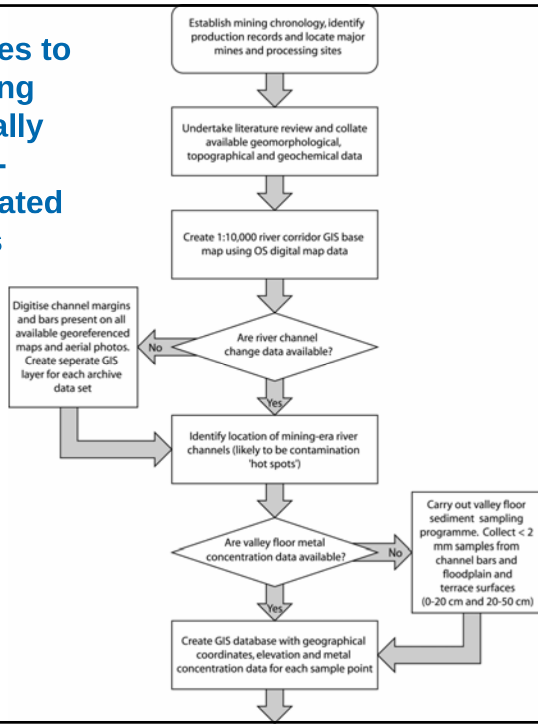
Approaches to managing historically metal-contaminated rivers

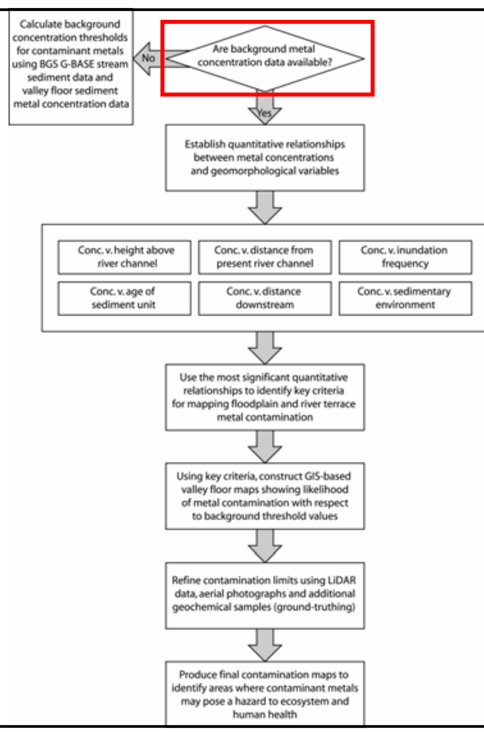


Historical channel patterns



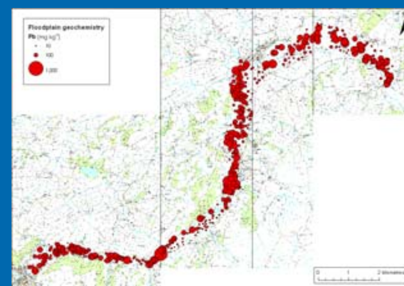
Approaches to managing historically metal-contaminated rivers

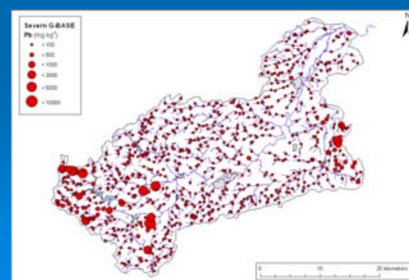




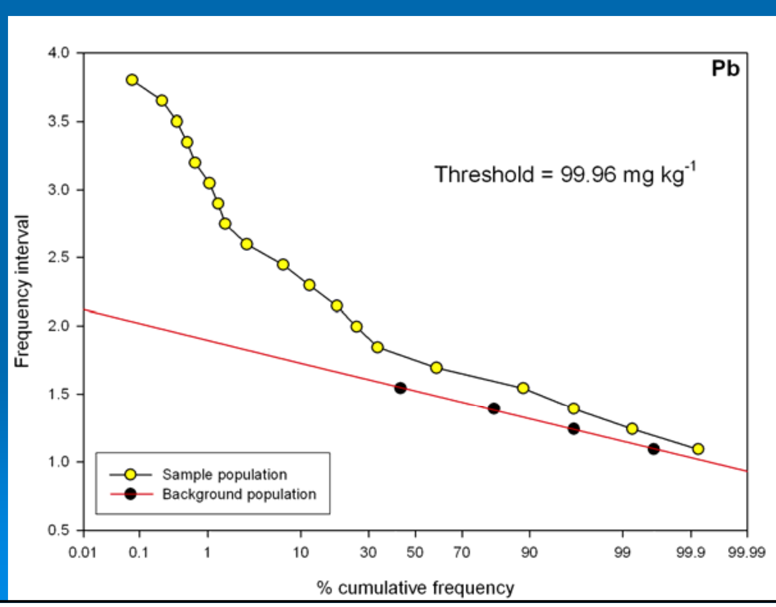
Background Threshold Determinations

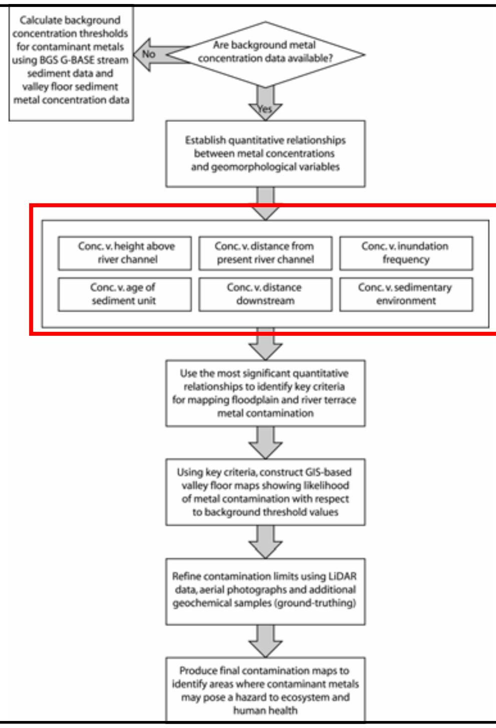
- Derived using cumulative frequency curves
- Include all available data
  - Floodplain samples
  - BGS G-BASE stream sediment data

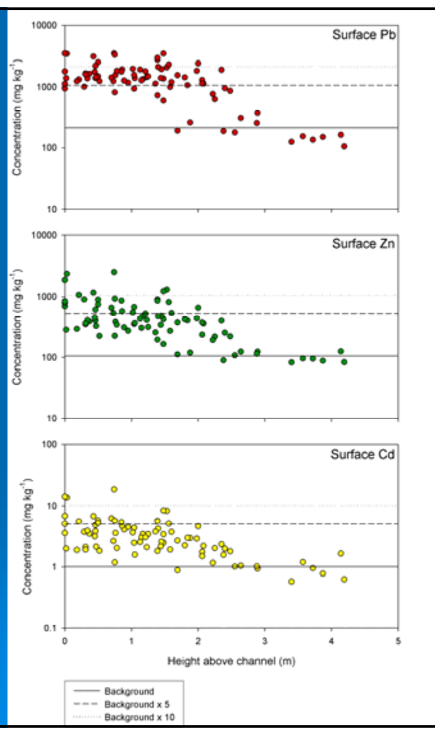




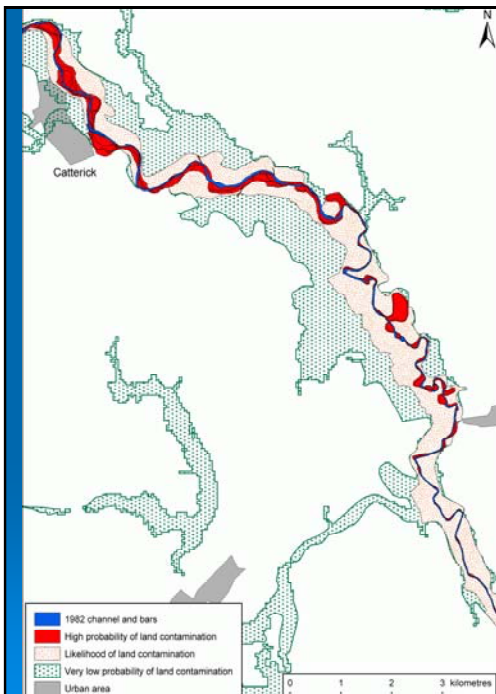
Background Pb threshold



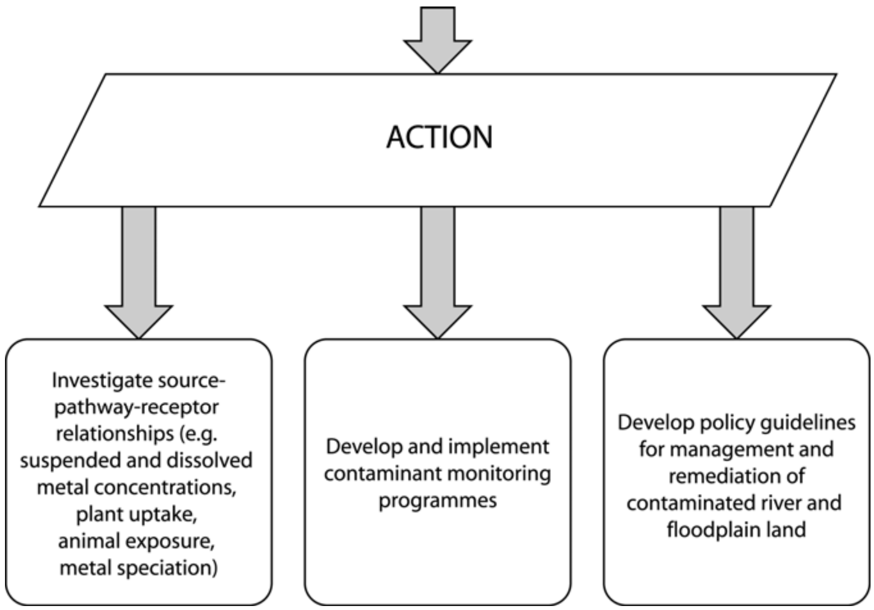




Height above low-flow channel, River Swale



River Swale Metal Contaminant Hazard Map



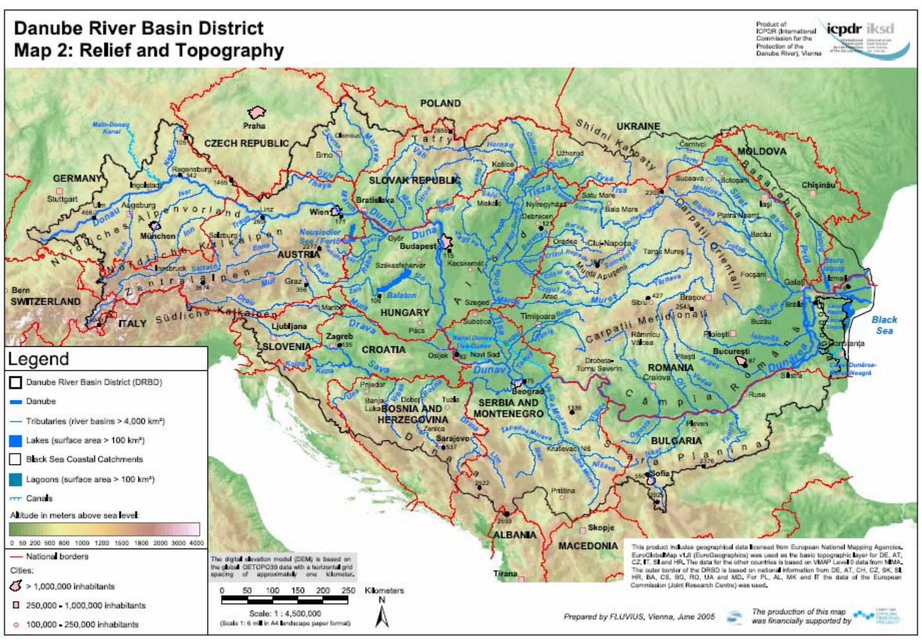
The Next Steps

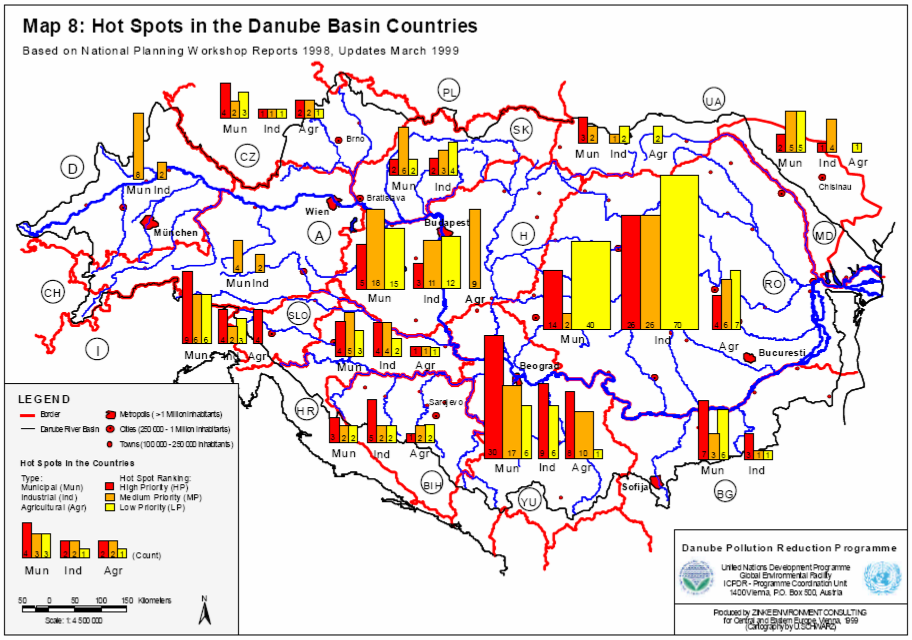
- Test and upscale our management approach in larger river systems currently affected by metal mining (e.g. Lower Danube Basin)

The Danube Basin

- The Danube River Basin is Europe's second largest river basin: total area 801,463 km², 2,870 km long
- It is the world's most international river basin: it includes the territories of 18 countries
- The ecosystems of the Danube River Basin are highly valuable in environmental, economic, historical and social terms, but they are subject to increasing pressure and serious pollution from agriculture, industry, urban areas and mining
- High potential for trans-border transfer of contaminants, this issue was highlighted following the Romanian tailings dam failures in 2000

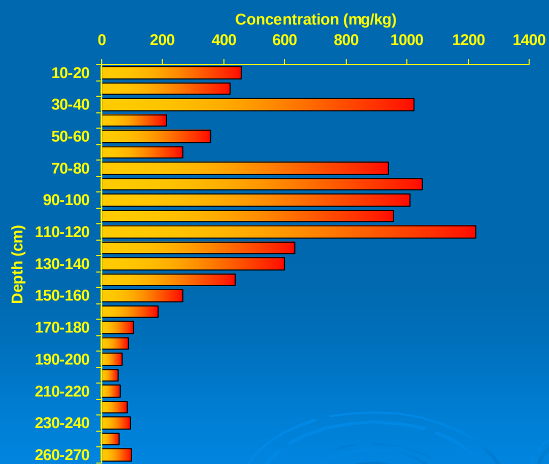
(ICPDR, 2006)





Contamination sources - AMD

Contamination sources - floodplains



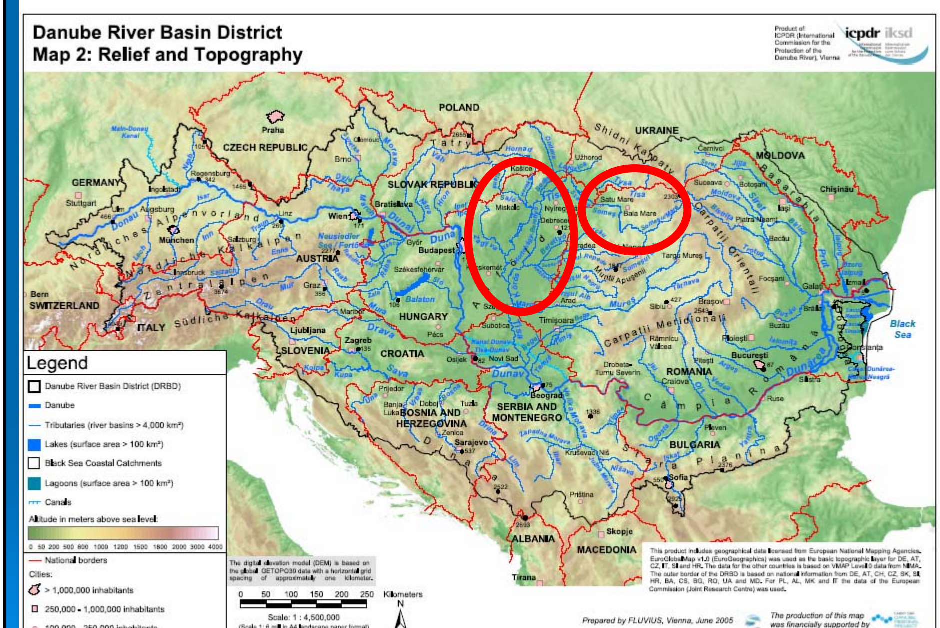
Contamination sources – tailings dam failures

The 64 m high Mialu tailings dam in the Certej River catchment

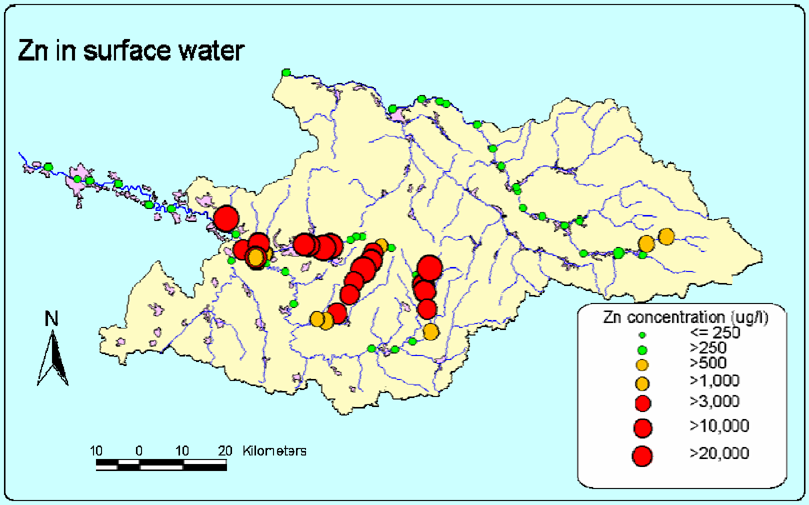
The Novaț River valley downstream of the failed Novaț-Roşu tailings dam March 2000.

The Danube Basin

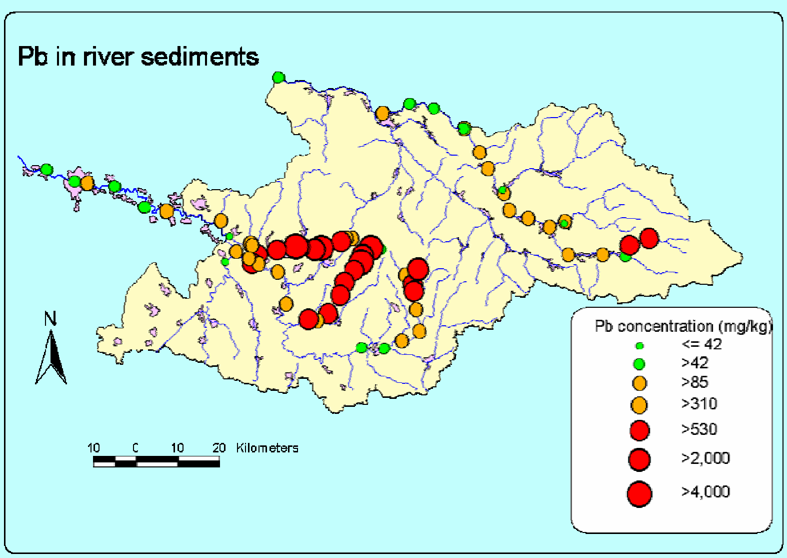
- But what is the extent and magnitude of heavy metal contamination in the lower Danube Basin?
- To address this questions, an extensive 5 year survey of metal and As contamination in surface water, groundwater, river channel and floodplain sediment undertaken
- Over 2,000 water and sediment samples, collected from over 750 sites in the Tisa and North Bulgaria sub-basins



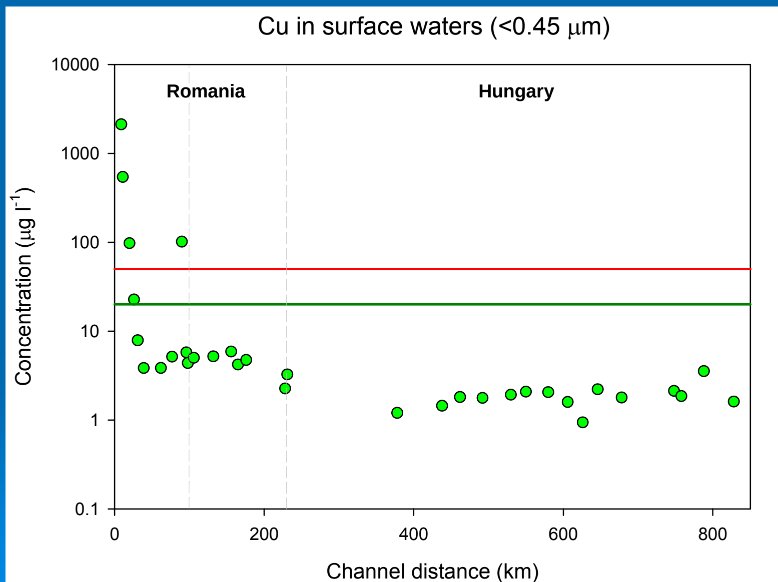
Maramures County – NW Romania

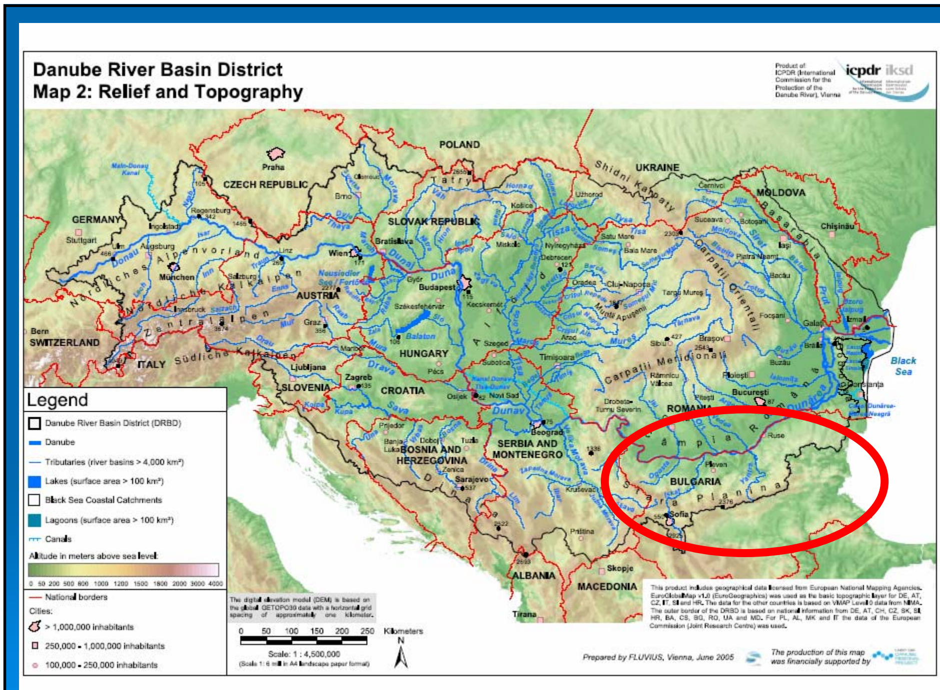


Maramures County – NW Romania

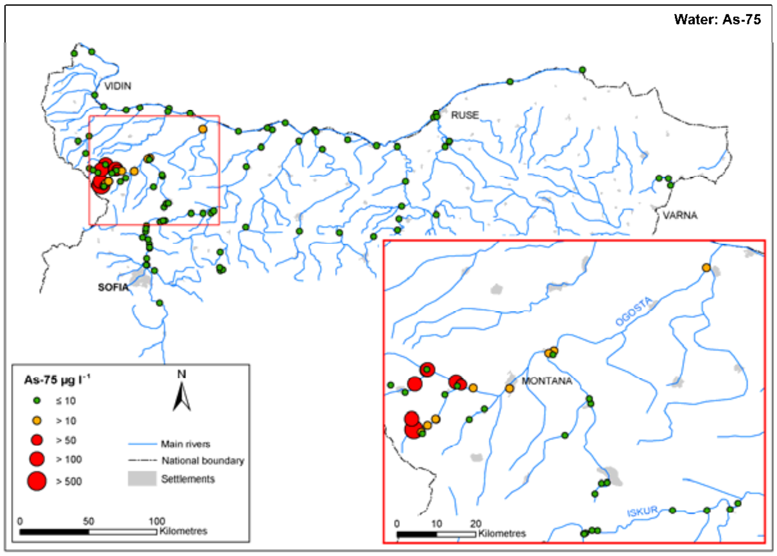


Tisa Basin – Romania & Hungary

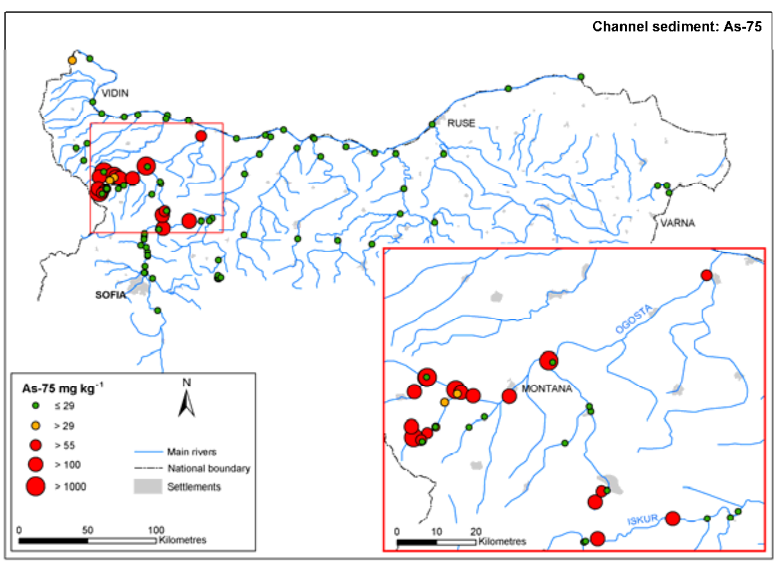




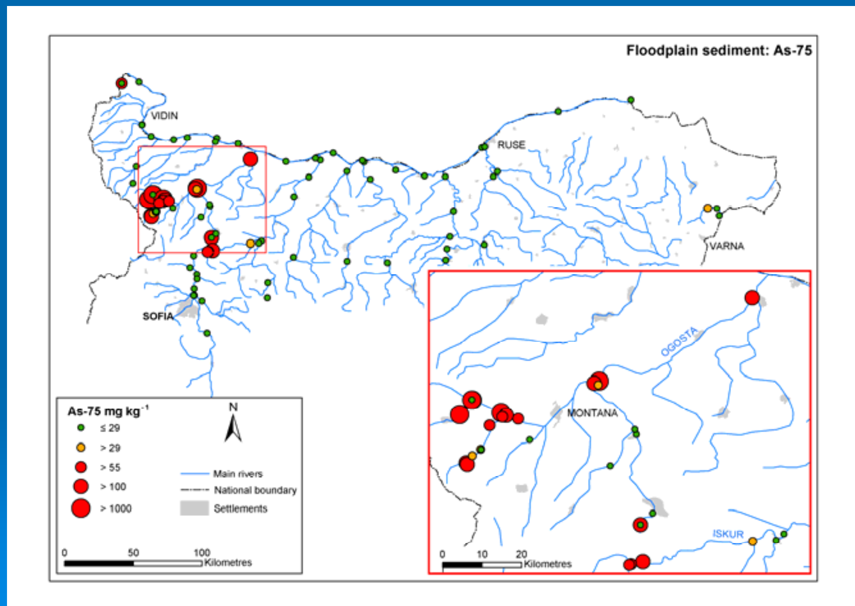
North Bulgaria - As in surface water



North Bulgaria - As in river channel sediment



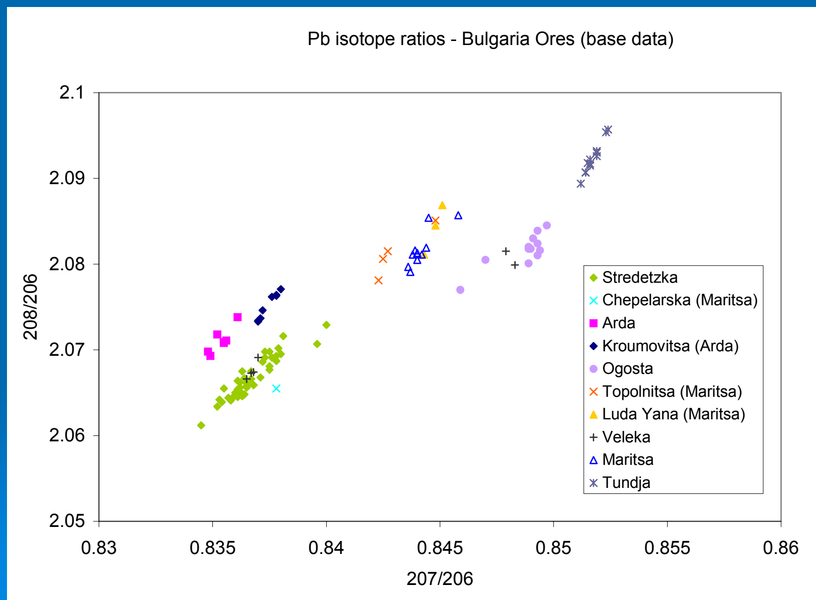
North Bulgaria - As in floodplain sediment



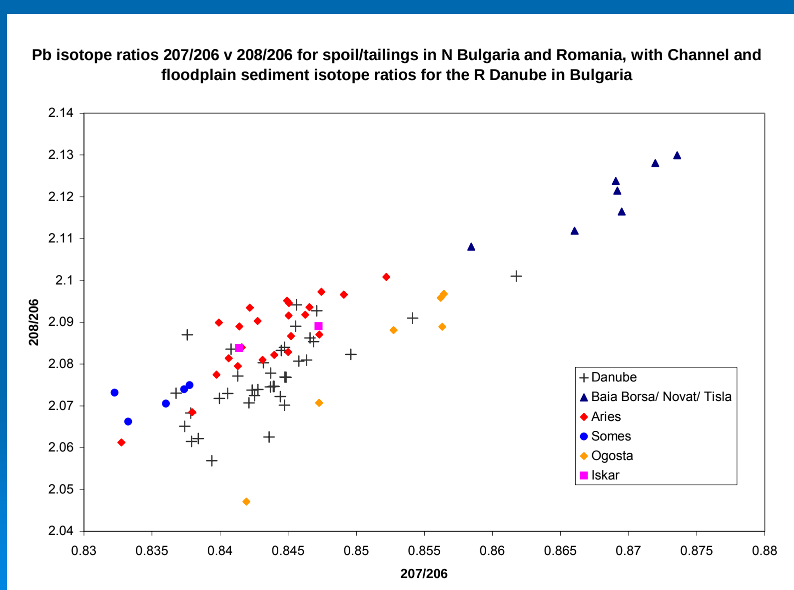
The Lower Danube Basin

- Water and sediment quality in the lower Danube Basin is highly variable; in general, highest metal & As levels found in tributary catchments where water and sediments can be grossly polluted
- Little evidence of extensive downstream or trans-border dispersal, this is because of dilution by ‘clean’ sediment
- But, for effective management and ultimate remediation of metal mining affected rivers systems, we need to know the sources of contamination ………

Pb isotopic fingerprinting

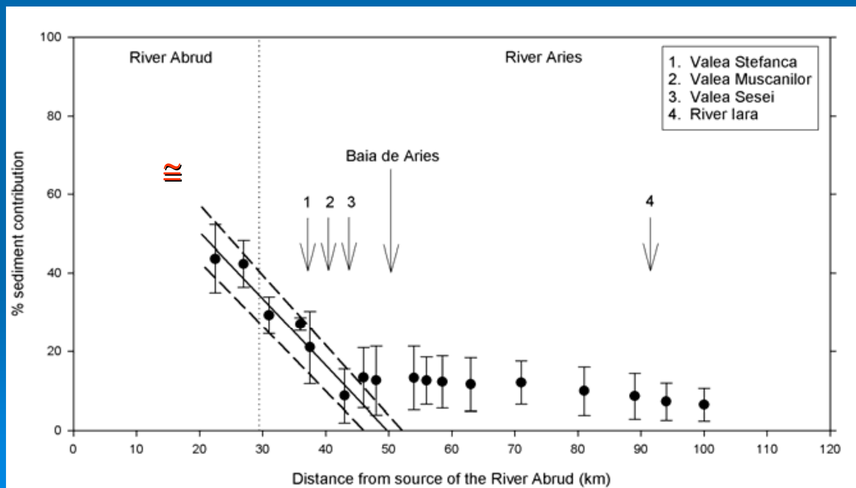


Pb isotopic fingerprinting



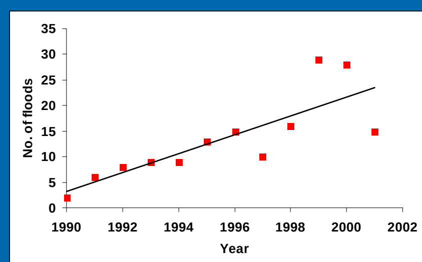
Sediment mixing models

e.g. River Aries, Romania



Implications and conclusions

- Evidence of a recent increase in flood frequency in the Danube River Basin



- It is highly likely that increased flooding will remobilise contaminated floodplain material which will then become a major secondary source of contaminant metals in the Ogosta and Iskăr Rivers, in particular

Implications and conclusions

- From a management perspective it is therefore essential to protect floodplain environments from contamination by sediment associated pollutants

- We need to learn the lessons from the environmental impacts of historical metal mining in the UK in order to effectively manage and protect river system affected by present and future mining activity

INSTITUTE OF WATER AND ENVIRONMENT

SEA Environmental Decisions, Ltd.

Cranfield UNIVERSITY Silsoe

Catchment based sediment risk assessment and management

Sabine Apitz[1,2] and Sue White[2]

1. SEA Environmental Decisions, Ltd. Little Hadham, UK
2. Institute of Water and Environment
Cranfield University, UK

SedNet European Sediment Research Network

Definitions

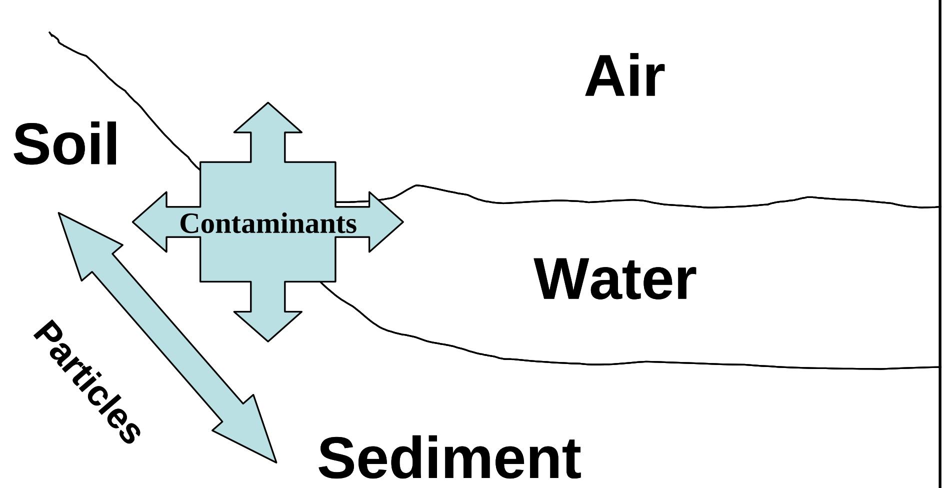
- Sediment assessment: process to ***characterise sediment for a given purpose*** (e.g., evaluations for dredged disposal, land spreading, risks to environmental health, habitat construction, etc.)
- Sediment management: process of ***making decisions and taking actions*** on sediments, taking into consideration a wide range of factors

Sediment assessment and management can be divided into two basic categories

- Management to achieve socioeconomic goals (e.g., construction, navigational dredging, flood defense - managing sediment **quantity**, but sometimes with quality issues)
- Management to achieve ecological goals (managing sediment **quality**, but sometimes with quantity issues)

These two types of management are generally done by different organisations, at different sites, with little interaction.

However, contaminants and mass transfer between all environmental media. We cannot manage one medium without taking this into account, nor can we manage connected sites in isolation. To reduce risk, we must assess and manage it holistically and at the ***basin (catchment/watershed) scale***.



Within the EU SedNet study we moved on to look at how we would assess and manage sediments at a river basin level

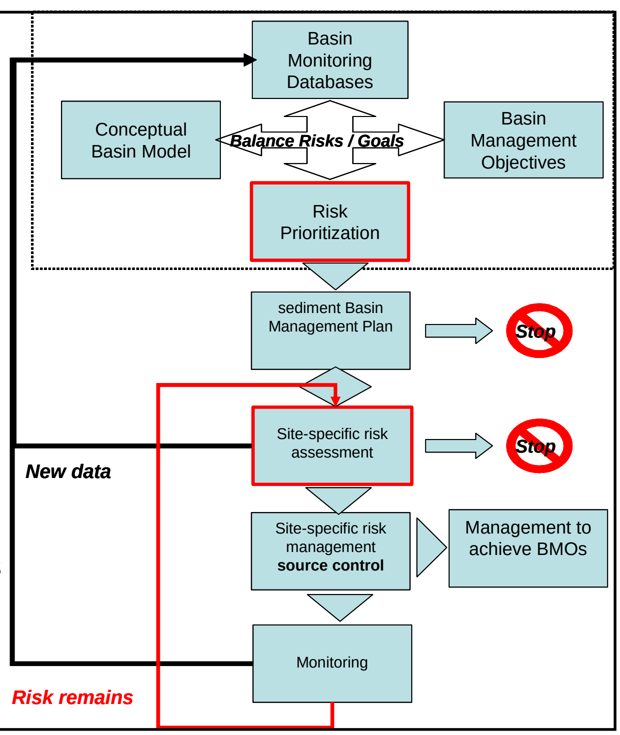
SedNet: The European Sediment Research Network

- EC funded research network
  - EVK1-CT-2001-20002
- Producing recommendations for sediment management in Europe
- Will provide input into a possible daughter directive to WFD on sediment
- Final reports, recommendations and books are in preparation

SedNet
European Sediment Research Network

http://www.sednet.org

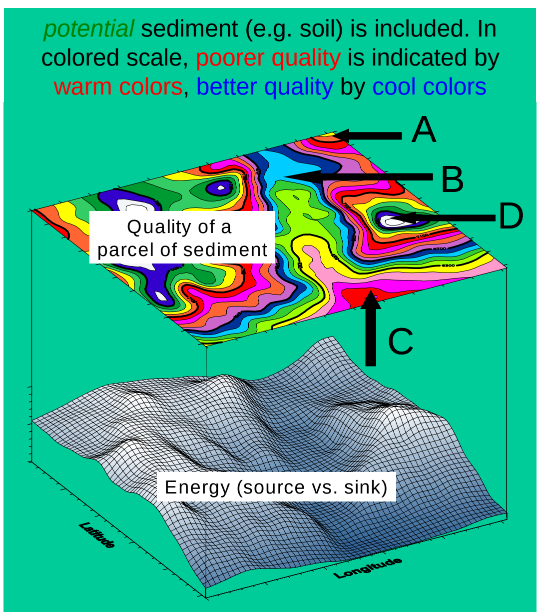
- A basin-scale risk management framework should be comprised of two principal levels of decision making
- basin-scale evaluation (**risk prioritisation** of sites for further evaluation and/or management) and
- an assessment of specific sites for risks and management options (**site-specific risk ranking and management**).



Basin-scale management

- Sediment risk management should be closely linked with the management of soil, water, and industrial and agricultural policy
  - Conceptual models are required to identify, quantify and communicate the links between these processes and media
- An understanding of the particle, water and contaminant flows and interactions within a river basin can be termed a Conceptual Basin Model (CBM)
  - A CBM describes how materials (and risk) move and interact between sites and media
  - Use of a CBM leads to increased knowledge about the river basin system and serves as an important communication tool between scientists, decision makers and stakeholders

- It is the relationship between hydro-dynamically connected sediments, in terms of *quality*, *quantity* and *energy*, that defines their relative risk, and their priority in a risk management strategy
- conceptual diagram (a projection of *sediment energy* - *source vs sink* - and *quality*) using data from a CBM allowing to inform Risk Prioritisation
  - Priority order:
    - A > C > B > D
  - Not all sediments are contaminated!
  - Not all sources must be controlled



Example from the Rhine
Test of site prioritisation at the Basin Scale

Relevant parameters for prioritisation at catchment scale

- Location → Distance to the mouth?
- Potential energy → Slope? altitude?
- Quantity → Volumes?
- Quality → Chemicals vs SQGs, toxicity tests
- Mobility → Sand/silt %? Shear stress?
- Expected benefits?

How can they be measured?

How do they play together?

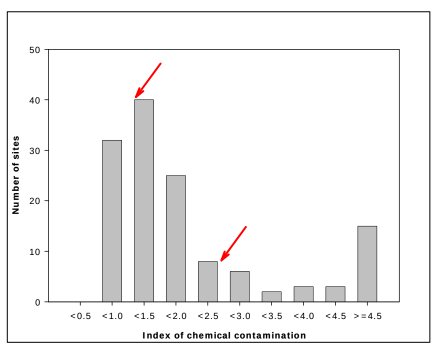
Can we develop systematic methods to carry out prioritisation?

Testing the an approach to prioritisation in the Rhine catchment

- ≈ 1000 km from “Bodensee” to the sea, many tributaries with large catchments
- Several conflicting uses, important management stakes
  - Industries
  - Drinking water supply
  - Ecological restoration (and fisheries)
  - Sediment management
- Existing data from monitoring, local and regional studies …

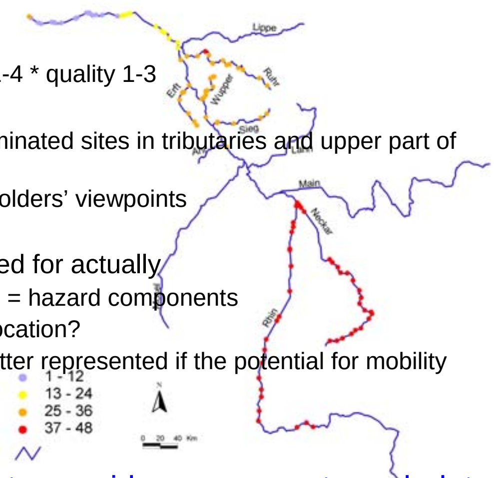
Results: data availability, classes

- GIS – GTOPO30 (USGS)
  - Location
  - Altitude
  - Limited accuracy
- Quantity (budget) = no data; SPM fluxes?
- Quantity (mobility) = no data
- Quality
  - Chemistry; CTT values as SQGs
  - Class boundaries at 50 and 75% of the distribution



Results of the score ordination approach

- Score span 1 – 48:
  - location 1-4 * energy 1-4 * quality 1-3
- 135 sites classified
  - High priority on contaminated sites in tributaries and upper part of the Rhine
  - Need to collect stakeholders' viewpoints
  - Incomplete sets?
- "Exposure" not accounted for actually
  - Energy, contamination = hazard components
  - Too much weight on location?
  - Exposure would be better represented if the potential for mobility was accounted for

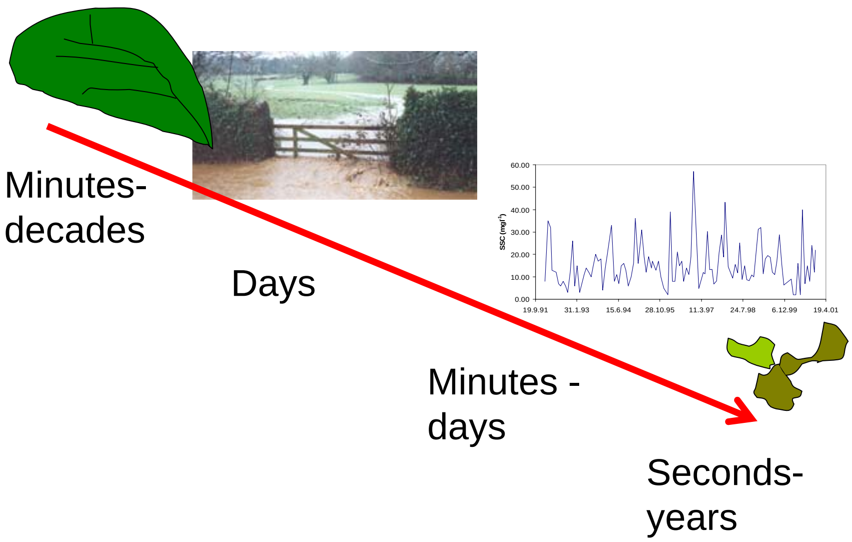


This first test has allowed us to consider new ways to rank data; but the right data are not always available

New dimensions

- The SedNet approach suggest we need to deal with the spatial dimension of sediment better
- Considering sediment management within the dynamic river basin system in which it exists is essential
- But there is another dimension we need to consider
  - Time

Most relevant sediment processes are variable on various time and space scales



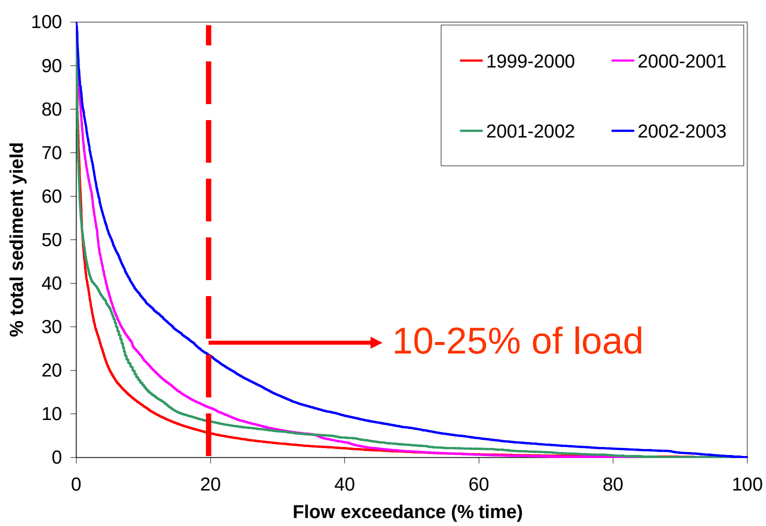
The time dimension

- Sediment supply to rivers is a sporadic process. It is related to:
  - Climate, topography, soil types, land use & management, flow dynamics
  - Supply can vary from minute to minute, at an hourly, daily, seasonal, annual, decadal or longer level
- Sediment movement in rivers is also sporadic. It is related to:
  - The sporadic nature of the supply
  - Flow velocity
  - Particle size
  - Obstructions to the flow

Activation of sediment sources

Sediment exceedance - most sediment moves in major flow events

Data for the R. Tees – based on 15-min flow and turbidity measurements

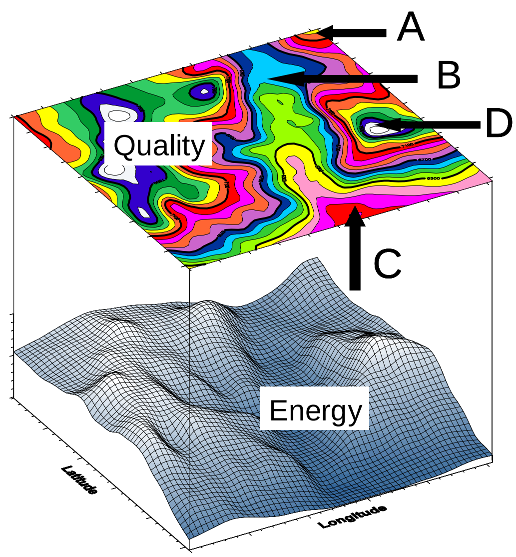


Prioritisation at basin scale

We need to consider probability of activation/supply

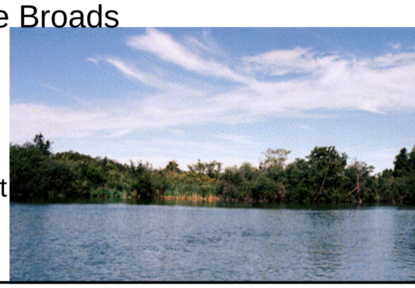
We need to consider sediment transport dynamics in river

We need a clear understanding of the time variation in these processes



The Norfolk Broads - a sediment management case study

- Eastern England: low rainfall, high temperatures, flat land
- A series of man-made shallow lakes linked by rivers
  - Tidal
- Heavily drained landscape
- High ecological importance at European level
- Administered by the Broads Authority who have statutory duties to:
  - Maintain navigation
  - Protect environment
  - Encourage tourism



The problem

- Dredging required to maintain navigation
  - Expensive annual dredging programme
  - Contaminants in sediment (phosphate, TBT, others) mean risks in dredging; increasing disposal costs
  - It is becoming increasingly difficult to dredge enough to maintain navigation
- Conflicts of interest
- There is a need for a long-range sediment management strategy (SMS) to identify and manage inputs and to project (but reduce) removal needs over time

Like most catchments, many issues are complicating management

- Lakes are degrading in ecological terms
  - A limited number conserve important plant species
- Eutrophication
  - Phosphate from catchment and from sediments
  - Sediment resuspension - boats, wind induced wave activity
- Rising sea level
- Bank erosion
  - Flood management programme, moving banks back
  - Boat activity, etc.

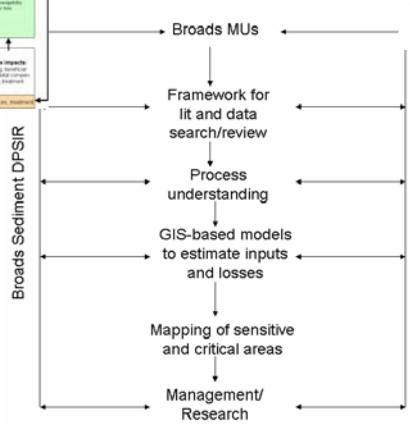
A sustainable solution?

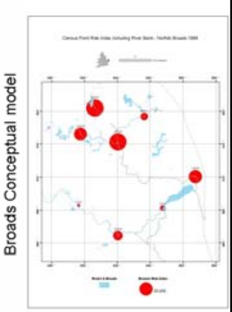
- Identify sediment sources in order to investigate source control to reduce dredging
  - Seen as vital before attempting restoration of individual lakes
- Identify knowledge gaps
- Identify management options
  - Identify where source control could be applied

Our task was to examine existing literature and data to frame this issue

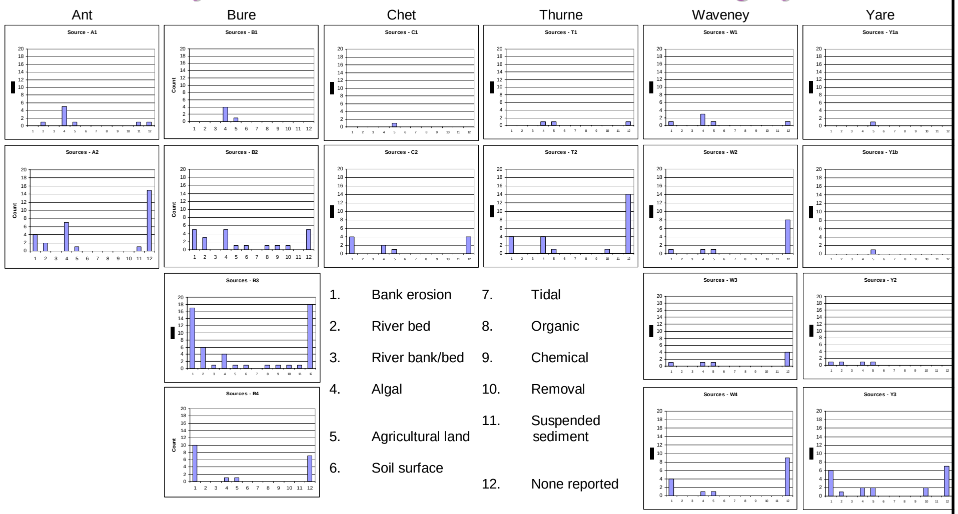
---

If serendipitous data are to be used to address a complex question, a conceptual framework is needed to bring it all together





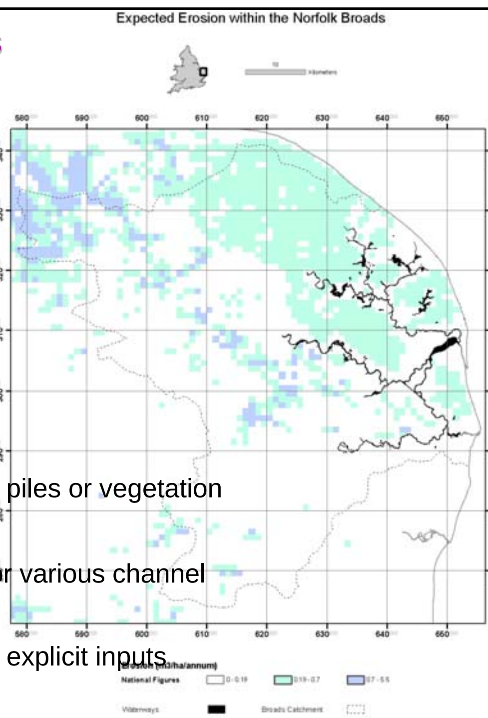
Results of review: sediment sources
Availability of data on various sources was highly variable



1. Bank erosion
2. River bed
3. River bank/bed
4. Algal
5. Agricultural land
6. Soil surface
7. Tidal
8. Organic
9. Chemical
10. Removal
11. Suspended sediment
12. None reported

Y axis: number of references addressing given sediment source type for a given SMU
X axis: Sediment source type (from list)

Quantifying sources

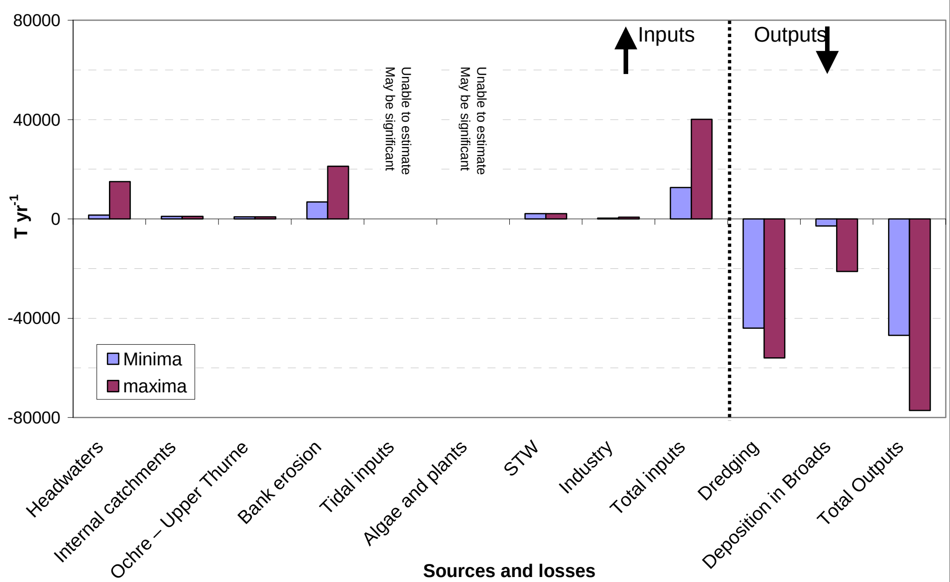


- Bank erosion
  - Due to boats
    - Boat movements
    - Boat speed limits
    - Identified potential risk areas
  - Due to river flows
    - Water level range
  - Due to tides
    - Tidal range
  - Some banks are protected with piles or vegetation
    - System was mapped
  - Data on bank erosion rates – for various channel forms
  - Combined to calculate spatially explicit inputs

Quantifying outputs

- Dredging
  - Some data available but not spatially explicit or comprehensive
- Floods
  - Limited data suggest this could be significant
- Tides
  - ??
- Accumulation in lakes
  - Limited data on sedimentation rates from coring studies

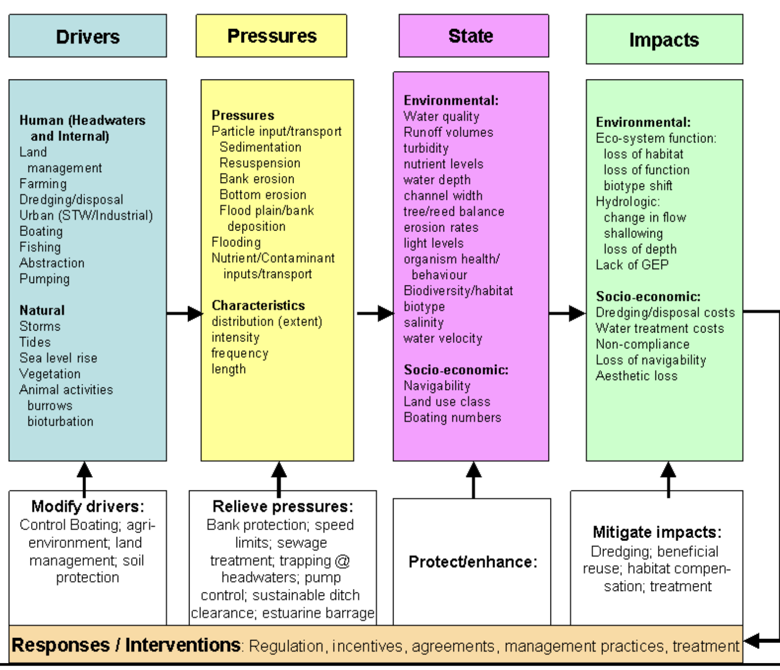
A very tentative sediment budget bounds the estimates, but some sources could not be quantified



Information at Management Unit level

- For each management unit we have identified the principal sediment suppliers
- Whilst catchment erosion is important for the headwater catchments, sewage treatment works and industry also play an important role
- As we move downstream bank erosion becomes more important

DPSIR framework for sediment management



What do we do with this information?

- Identify key processes and sources in time and space
  - Identify where these lie outside the BA area of responsibility
  - Different actions required
- Identify significant unknowns
  - Suggest methods for infilling data/knowledge gaps
- Translate into prioritised management actions
  - Influence, negotiate, encourage, discuss, control, investigate, act
- Summarise in a DPSIR approach
- Putting all processes in perspective, on a catchment scale, and linking them with management objectives, allows for a prioritisation of actions

Sediment management

- Sediment is a factor which cuts across many management (and catchment) functions
  - Navigation, fisheries, flooding, water resources etc
- As such we often "manage" sediments to achieve other management objectives – dredging, soil conservation, flushing….
- With the advent of a range of EU legislation (WFD, Habitats, Marine, Soil Directives) we are being forced to think about river basin systems in a more integrated way
- In order to do this we also need to consider sediments at river basin scale, across sites, media and management objectives

Thank you

drsea@cvrl.org

sue.white@cranfield.ac.uk

Thanks also to:

Marc Babut, Pieter J. den Besten, Susanne Heise, Henner Hollert, Andrea Kelly, Amy Oen, and Trudi Wakelin

The Broads Authority

EC FP-6

The University Of Sheffield.

AALBORG UNIVERSITY

Cranfield UNIVERSITY Silsoe

Chemistry of urban sediments : its importance in river restoration

Ruben Sakrabani

National Soil Resources Institute

down to earth science

r.sakrabani@cranfield.ac.uk

Cranfield UNIVERSITY Silsoe

Outline of presentation

- Introduction
- Components of the sewer system
- In sewer transformation processes
- Origin of solids and effects
- Types of solids
- CSOs and discharge to water courses
- Biochemical composition of solids
- Conclusions – impacts to the river ecosystem

Introduction

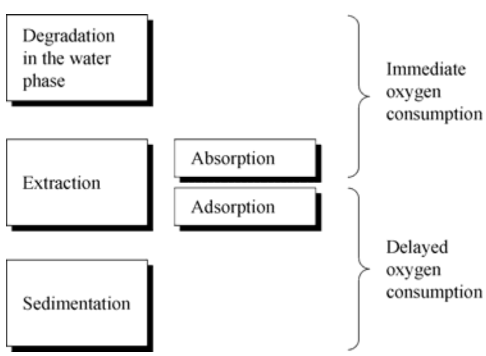
Cranfield UNIVERSITY Silsoe

- sewer is more than just not a conduit to transport wastewater
- complex processes influence quality of wastewater
- components of a sewer : sediment, biofilms, wastewater, sewer atmosphere & sewer wall
- more research focus on physical aspects of the sewer
- not sufficient knowledge on science of wastewater processes in sewer during wet weather compared to dry weather
- more than 1/3 of all sewers in the UK suffer from sediment deposition problems

Introduction

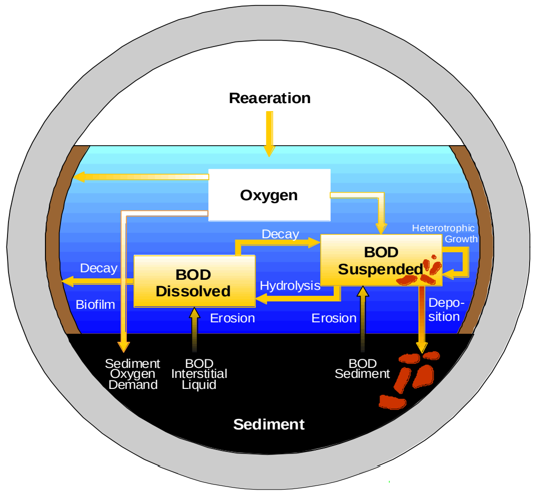
Cranfield UNIVERSITY Silsoe

- UPM – managing storm water in the UK



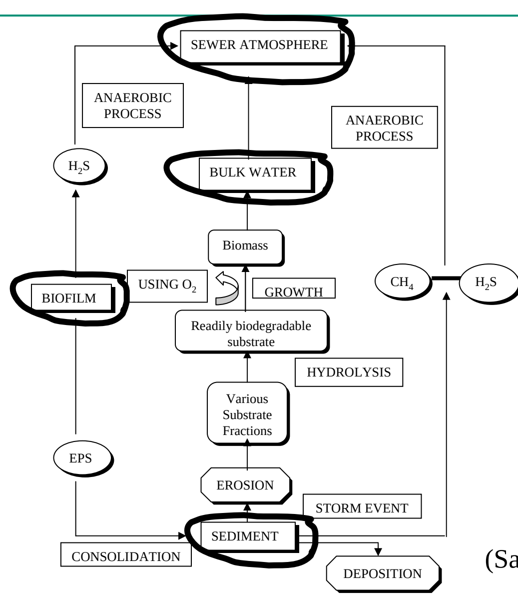
The assessment of the potential impacts of flows spilled from CSOs into receiving watercourses (Ashley *et al.*, 1999)

Physical and chemical processes in a sewer



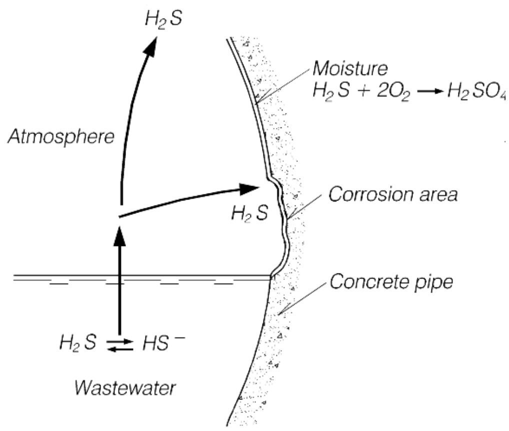
(Arthur S., 1997)

Processes In The Sewer System



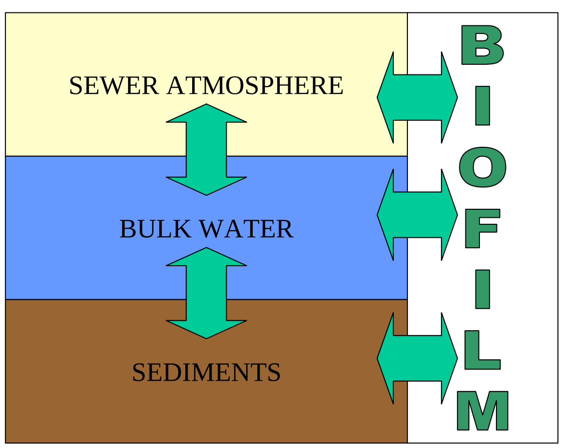
(Sakrabani, 2004)

Principle for release of hydrogen sulphide and corrosion

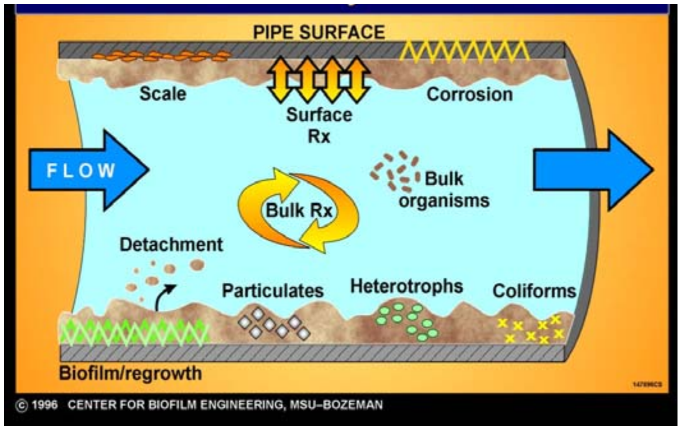


(Hvitved-Jacobsen, 2002)

Interactions between components of the sewer system

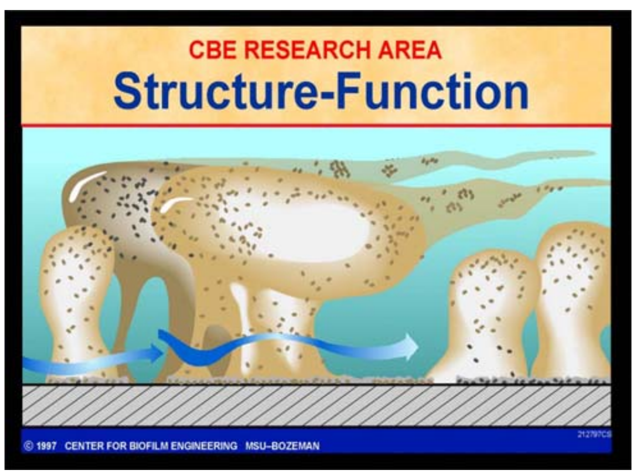


Sewer as a reactor



(Montana State University, 1999)

Internal structure of biofilms



(Montana State University, 1999)

Sediment deposition – Dundee

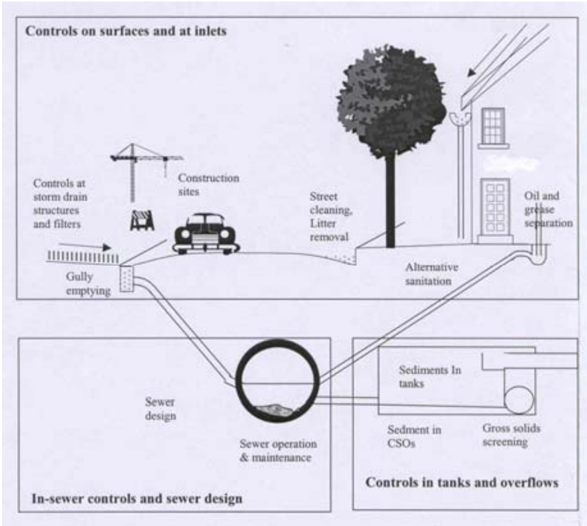
(Photograph: Richard Ashley)

Build-up of solids on the walls in a Dutch concrete pipe [these are encrustations and not in the standard classes]

(Photograph: Robin Veldkamp, Delft)

Solids transport and accumulation on urban surfaces

Cranfield UNIVERSITY Silsoe



(adapted from Butler &Clark, 1995)

Effects caused by solids

Cranfield UNIVERSITY Silsoe

- Reduction in hydraulic capacity, increase in surcharging, flooding.
- Blockage
- Premature operation of CSOs
- Enhanced pollutant washout from CSOs
- Gases, odours, explosions
- Sewer corrosion
- Screen blockages and damage
- Shock loads to treatment plants
- Rodents (rats)
- Health risks to sewer workers
- Fat and grease deposits – can reduce capacity or get washed out in 'lumps'

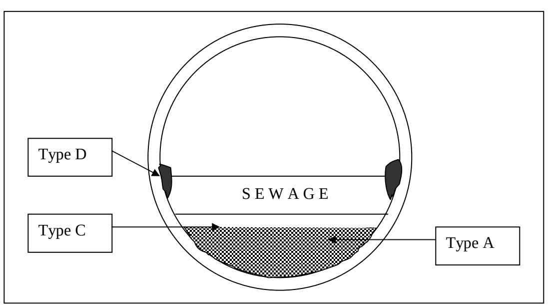
Gross solids collected on a screen at the outlet from a combined sewer overflow

(Photograph: Adrian Saul)

Typical sediment deposits in a combined sewer pipe

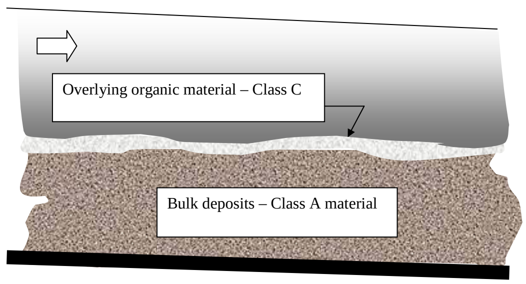
Cranfield UNIVERSITY Silsoe

- Type A : coarse, loose, granular, predominantly mineral, material found in the inverts of pipes
- Type B : as A but concreted by addition of fat, bitumen, cement, etc. into a solid mass
- Type C : mobile, fine grained deposits found in slack flow zones, either in isolation or above Type A material
- Type D : organic pipe wall slimes and zoogloeal biofilms around the mean flow level
- Type E : fine-grained mineral and organic deposits found CSO storage tanks



(Crabtree 1989)

Class C sediment – polluting potential



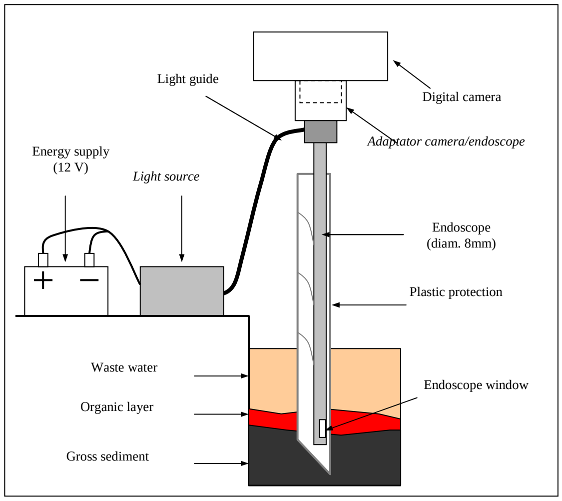
Class C sediments – near bed solids (UK), dense undercurrent (Belgium), fluid sediment (Germany), water sediment interface (France)

(Ashley *et al*. (2004),

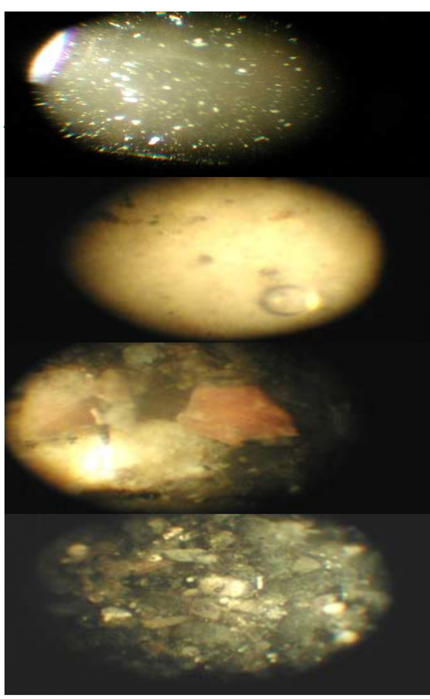
Near bed solids (NBS) sampling box

(Sakrabani, 2004)

Endoscope



C. Oms, M.C. Gromaire-Mertz, M., G. Chebbo (CEREVE, Paris) (2001)



Waste water

Organic cream

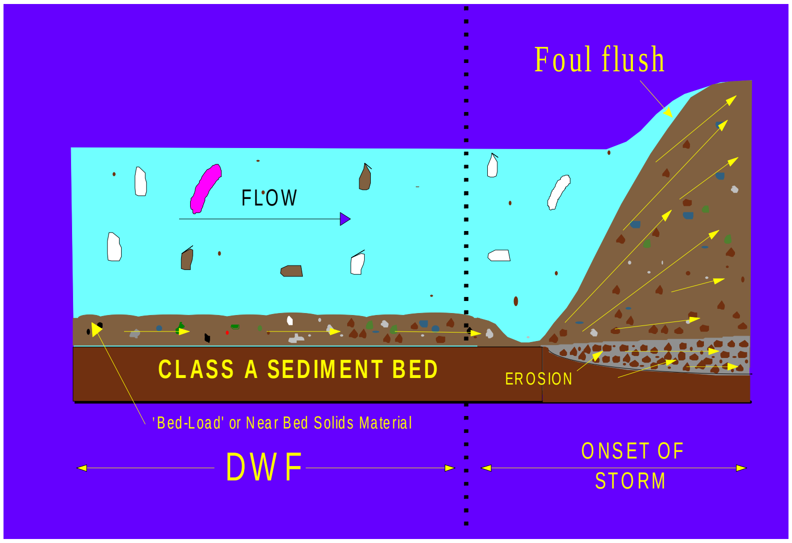
Organic layer

Gross sediment

C. Oms *et al.* (CEREVE, Paris) (2001)

Sediment erosion during dry and wet weather

Cranfield UNIVERSITY Silsoe



(Scott Arthur)

Hydrant Flush Test - Dundee

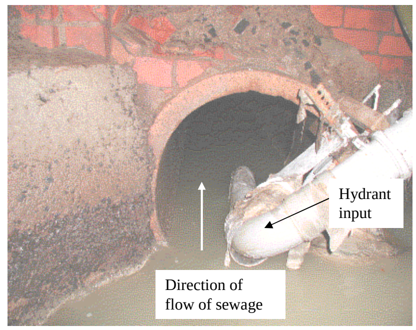
Cranfield UNIVERSITY Silsoe

(Sakrabani, 2004)

Cranfield UNIVERSITY Silsoe

Hydrant Flush Test - Dundee

Sampling tubes during the flush event



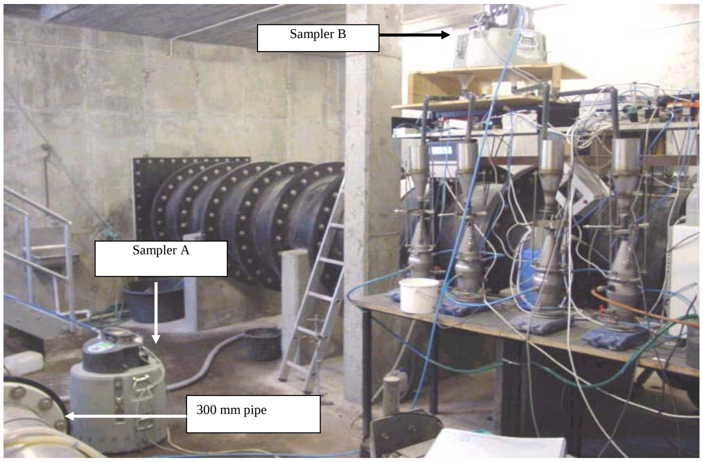
Hydrant flush set up during the flush event

(Sakrabani, 2004)

Cranfield UNIVERSITY Silsoe

Location of Frejlev, Aalborg, Denmark

Frejlev Monitoring Station

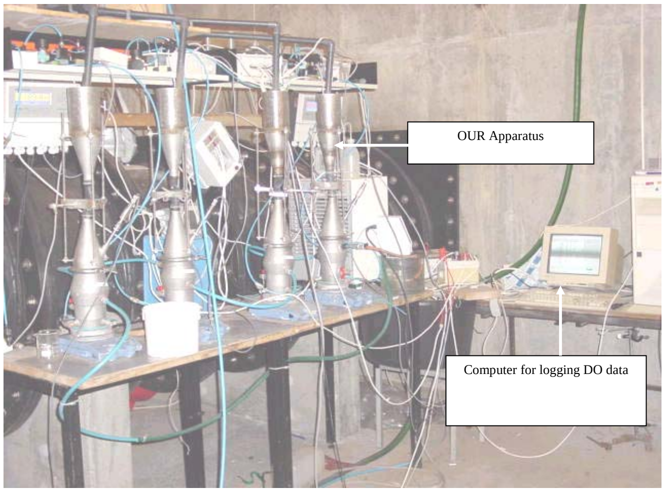


(Sakrabani, 2004)

Frejlev Monitoring Station

(Sakrabani, 2004)

Frejlev Monitoring Station



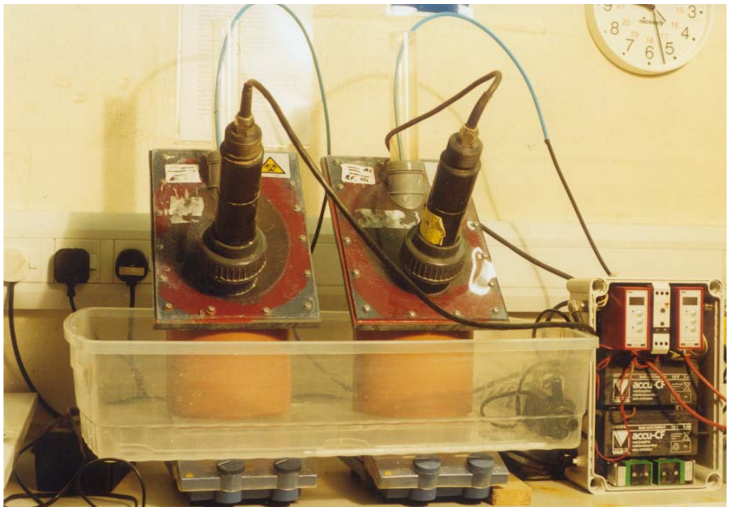
(Sakrabani, 2004)

Frejlev Monitoring Station

(Sakrabani, 2004)

Oxygen Utilisation Rate (OUR) Apparatus

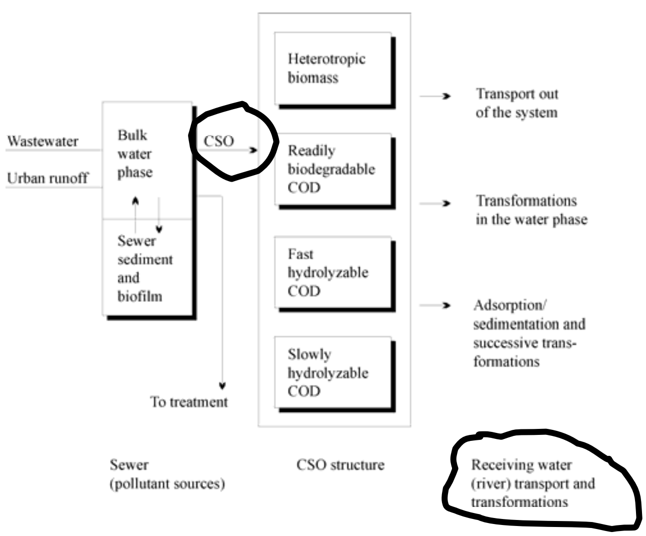
Cranfield UNIVERSITY Silsoe



(Sakrabani, 2004)

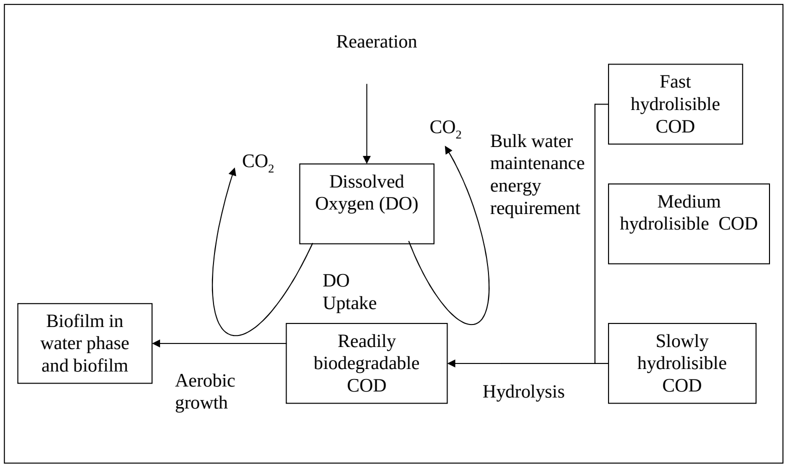
In-sewer processes and links with water courses

Cranfield UNIVERSITY Silsoe



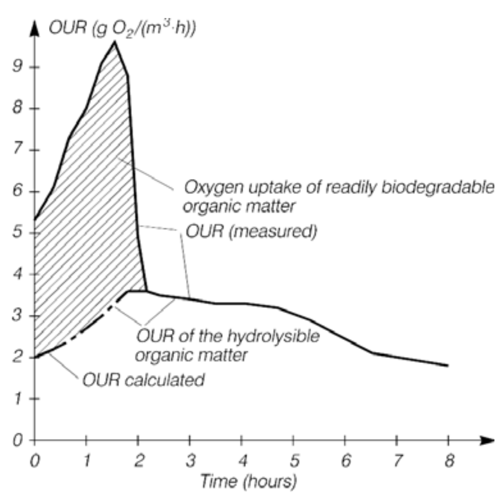
(Vollertsen, Hvitved-Jacobsen, 1998)

Concept for aerobic heterotrophic transformations of wastewater organic matter under sewer conditions



(Vollersten & Hvitved-Jacobsen, 1998)

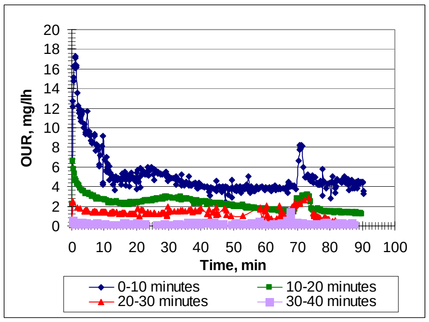
Information obtained from an OUR graph

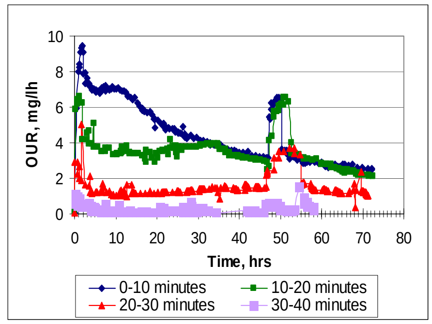


(Vollersten & Hvitved-Jacobsen, 1998)

OUR profile during storm events at Frejlev, Denmark (2001)

Cranfield UNIVERSITY Silsoe

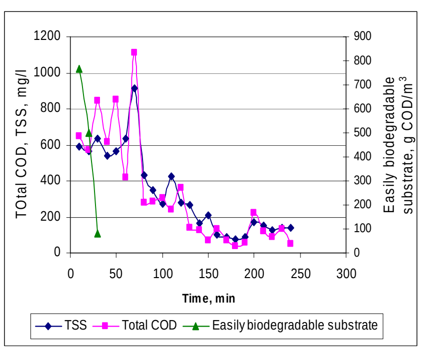


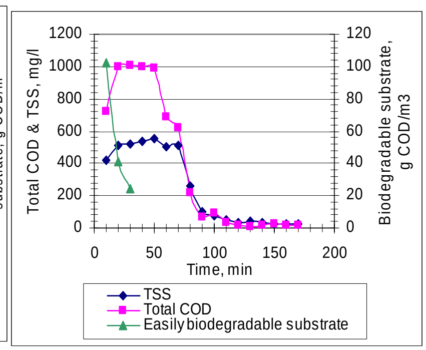


(Sakrabani, 2004)

Variation of easily biodegradable substrate with TSS and Total COD during storm events at Frejlev, Denmark

Cranfield UNIVERSITY Silsoe

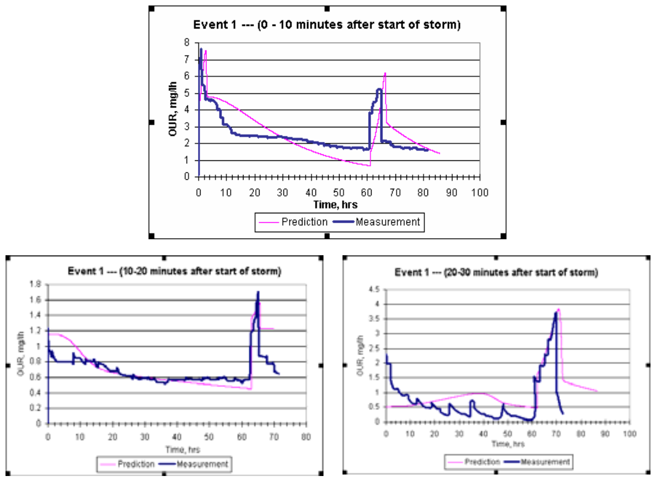




(Sakrabani, 2004)

Predictions and measurements of the OUR trend for 3 different durations of storm event at Frejlev, Denmark

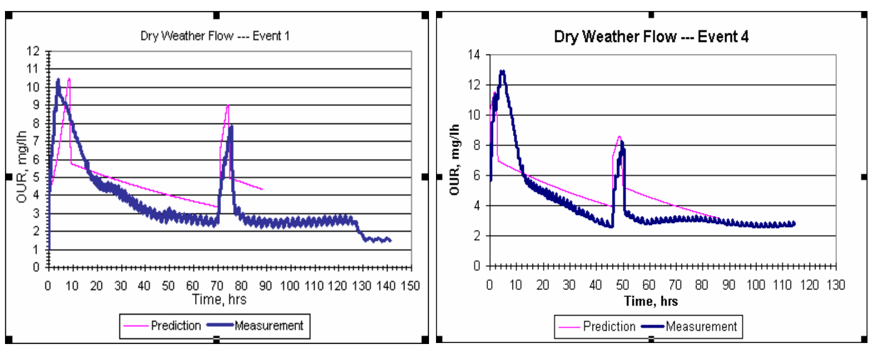
Cranfield UNIVERSITY Silsoe



Sakrabani, Ashley, Vollertsen (2005). *Wat. Sci. Tech.* 51 (2) 89-97

Predictions and measurements of OUR carried out during dry weather conditions in Frejlev

Cranfield UNIVERSITY Silsoe

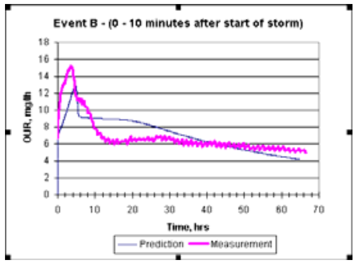


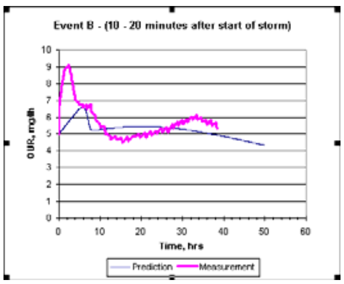
(Sakrabani, 2004)

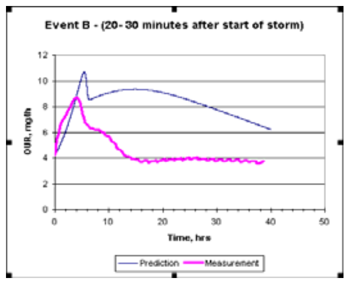
Validation of the OUR prediction methodology in Frejlev

Cranfield UNIVERSITY Silsoe

(Sakrabani, 2004)

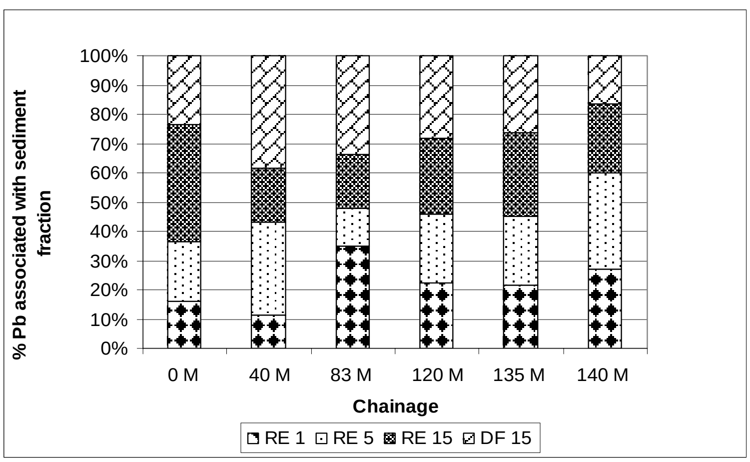






Pb (mg/kg) distribution in various sediment fractions from the Dundee Murraygate sewer

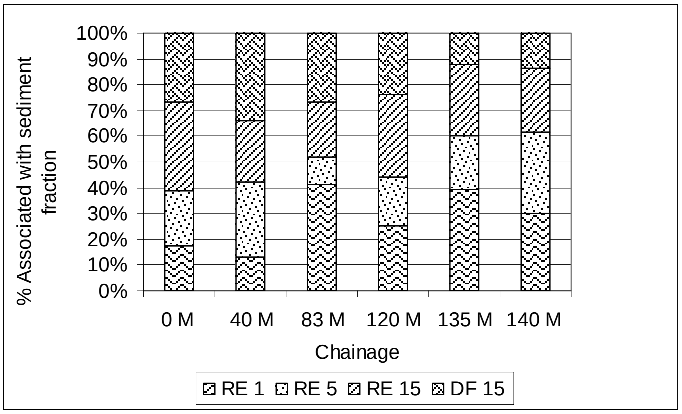
Cranfield UNIVERSITY Silsoe



McIlhatton, Sakrabani (2002). *Wat. Sci. Tech.* 45 (3) 61-69

Cu (mg/kg) distribution in various sediment fractions from the Dundee Murraygate sewer

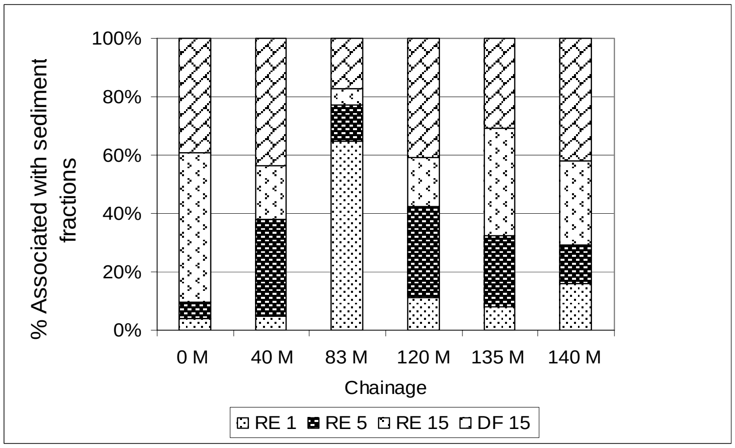
Cranfield UNIVERSITY Silsoe



McIlhatton, Sakrabani (2002). *Wat. Sci. Tech.* 45 (3) 61-69

Cd (mg/kg) distribution in various sediment fractions from the Dundee Murraygate sewer

Cranfield UNIVERSITY Silsoe



McIlhatton, Sakrabani (2002). *Wat. Sci. Tech.* 45 (3) 61-69

Cranfield UNIVERSITY Silsoe

Conclusions – Chemical pollution potential to rivers

- Chemistry and biology of sediments discharging from CSOs
- Considerations during river restoration work
- NBS – stock of [metals], but low in volume compared to bulk sediment
- potential release from bulk sediments – effects downstream via CSO

Parameter	Readily erodible	Dissolved fraction
Solids	✓	
NH_3		✓
COD	✓	✓
Pb	✓	
Cd		✓ (associated with sulphide)
Cu	✓	✓

Cranfield UNIVERSITY Silsoe

Conclusions – Oxygen depletion potential to rivers

- During wet weather, solids and COD released at the start of the event is most biodegradable and detrimental to water courses
- Long residing bacteria originating from in-sewer deposits respond to availability of excess substrates during wet weather

	Biomass	Microbial growth rate	Reasons
Bulk water	↑	↓	Biomass not well acclimatised
Bulk sediment	↓	↑	Biomass well acclimatised and utilise substrates at a higher rate
NBS	↓	↓	Micro-organisms in NBS are less acclimatised in comparison to the bulk sediment
Biofilm	Various	Various	Very dynamic system

Ruben in action !!!

Ruben in action !!!

Acknowledgements

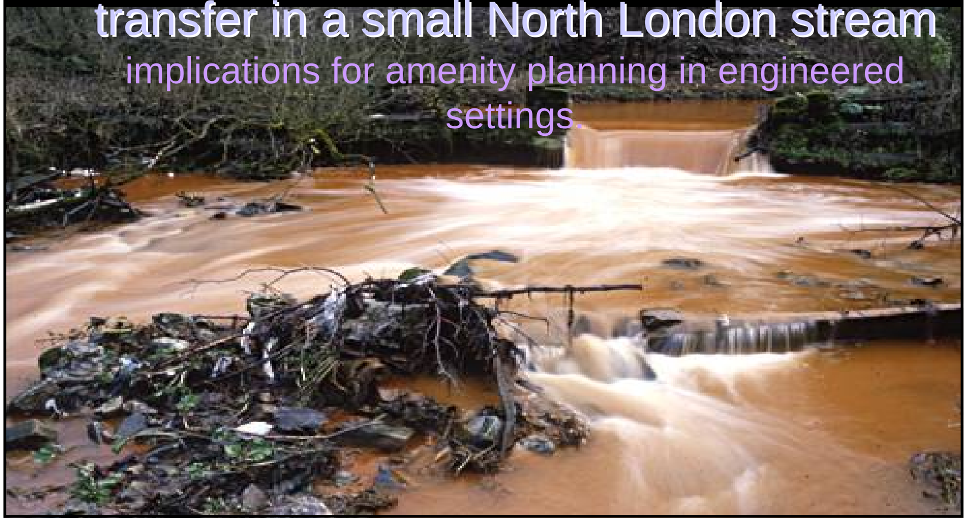
- Prof R.M. Ashley
- Dr. Jes Vollertsen
- Prof Thorkild Hvitved-Jacobsen
- technical staff of Delft Hydraulics

fhrc

Hazel Faulkner

The complexity of sediment-associated contaminant transfer in a small North London stream

implications for amenity planning in engineered settings.

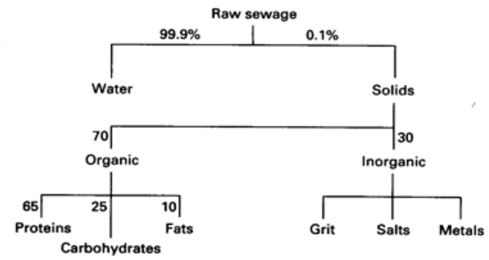


Heavy metals

Sewage

Both bound to sediments

Not routinely monitored in water quality assessments



Composition of sewage

...mostly organic.

Important indicators of sewage in water

Typical Sewage Analyses

	Source		
	Crude	Settled	Final effluent
BOD	300	175	20
COD	700	400	90
TOC	200	90	30
SS	400	200	30
Amm.N	40	40	5
NO_3N	<1	<1	20

The composition of sewage

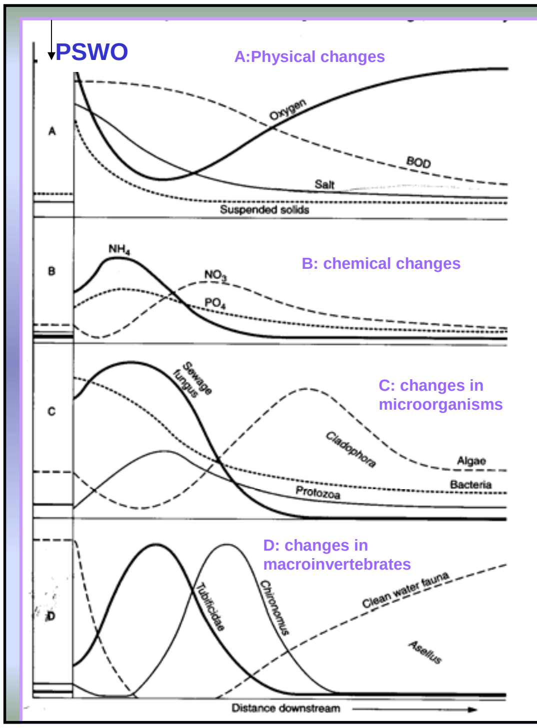
- The eutrophic effects of organic material create an oxygen demand **(Biological Oxygen demand, BOD)** in mg/litre.
- So does the chemical content **(COD)** in mg/litre.
- It gives off **ammonia** and contains **nitrates and nitrites.**
- It increases the **suspended solids in the river (SS).**
- It may also contain viruses and pathogens – and ***Eschericia Coli-*** a gut bacteria.

URBAN WATER & SEDIMENT QUALITY

Water supply to urban areas is a major part of UK river management. In the urban area, as well as dealing with ***storm water***, the ***foulwater*** (including sewage and dirty water from washing machines and baths) has to be dealt with.

Sewerage systems are installed to do these two jobs. These are of two kinds:

- Separate sewerage schemes (better, newer)
- Combined sewerage schemes . These are in places joined, designed to overtop from storm to foul during storms….now frequently operate the other way… Those that do are called Polluted surface water outfalls **(PSWOs)**



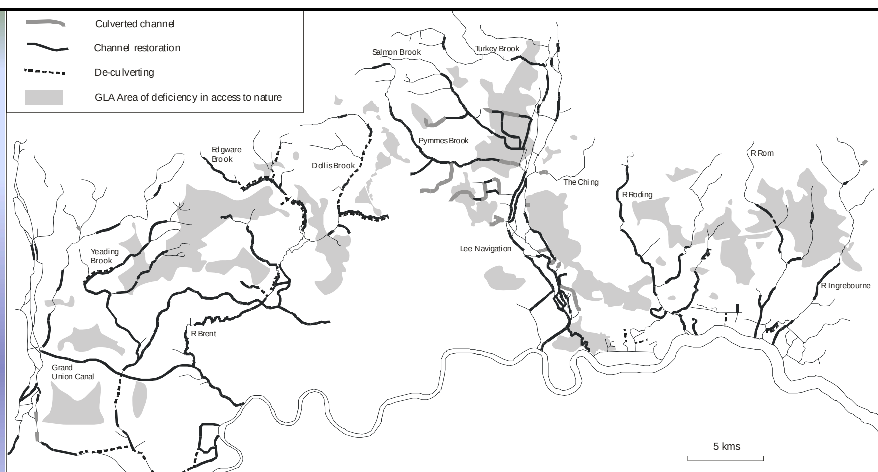
Local effect of sewage contamination on a stream

Hyne’s (1960) diagram explains schematically the changes that occur in water quality and the population of organisms in a river below a PSWO

Along with the colloidally-locked heavy metal content, excessive organic loads are a potentially ‘missed’ source of contamination

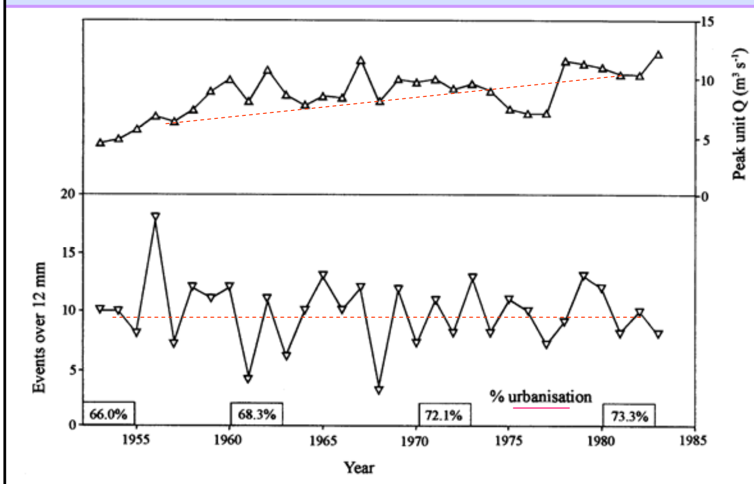
A case study in Urban Water & sediment contamination:

PYMME'S BROOK, North LONDON



- Rising in Hadley wood, Pymme's brook forms part of London's heavily managed river system
- The basin is 4km^2 in area before it joins with Salmon's Brook.
- Has no point sources or sewage works on it, i.e. it is diffusely polluted, having an ancient poorly connected combined sewerage system, which backs up producing **PSWOs** during storm events

Progressive urbanisation of the catchment has had inevitable effects



trend in unit hydrograph with progressive urbanisation

..despite no trend in rainfall event size

Research Questions:

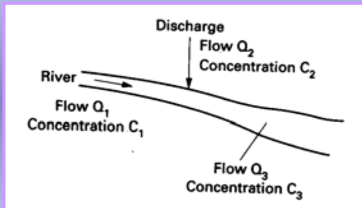
- What effect does the pattern of downstream entry of contamination have on downstream water quality parameters, sediment quality, and macroinvertebrate community structure?
- is the effect worse during high or low flows?
- What are the implications of this spatial and temporal variability for :

(a) river audit schedules;

(b) public access to natural sites on the stream?

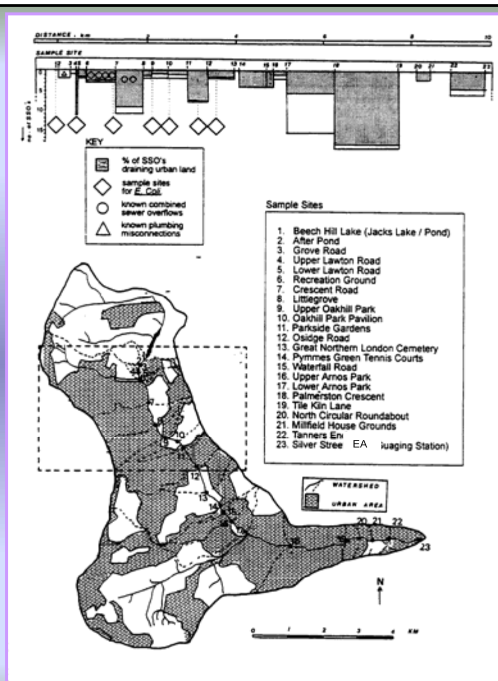
Downstream patterns in polluted storm water overflows (PSWOs)

At each entry point, mixing occurs.



The mass balance concept in river pollution.

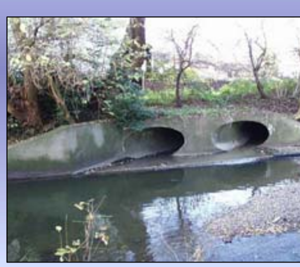
i.e. $Q_1C_1 + Q_2C_2 = Q_3C_3$



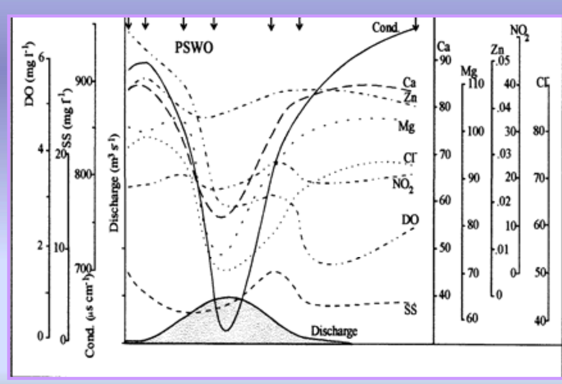
The Pymme's brook catchment area, showing extent of urban SSO provision and sample sites 1 to 23.

The Cat Hill PSWO

- Cat Hill **PSWO** (polluted surface water outfall) was studied before construction of the East Barnet Low Level intersecting foulwater Sewerage scheme
- Aimed to see how well the entering contaminants are dispersed by the river during an 'event'.

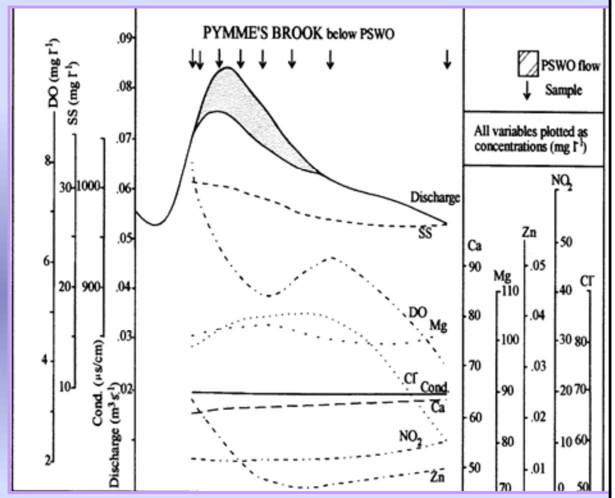


Cat Hill PSWO before construction of the East Barnet Low Level intersecting foulwater Sewerage scheme



….the Cat Hill hydrograph & contamination variability

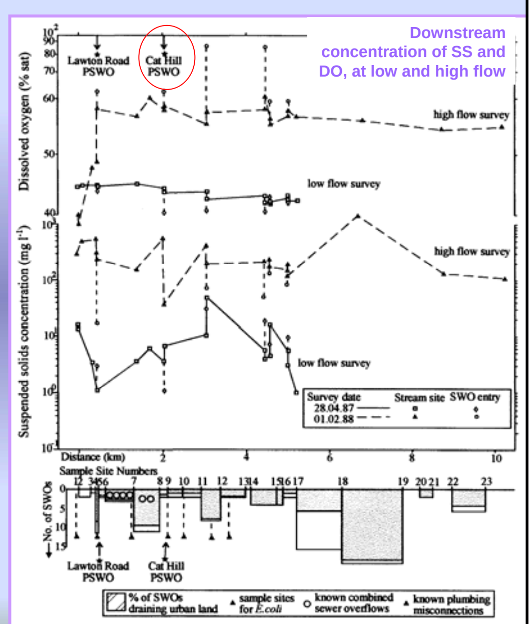
Cat Hill PSWO before construction of the East Barnet Low Level intersecting foulwater Sewerage scheme



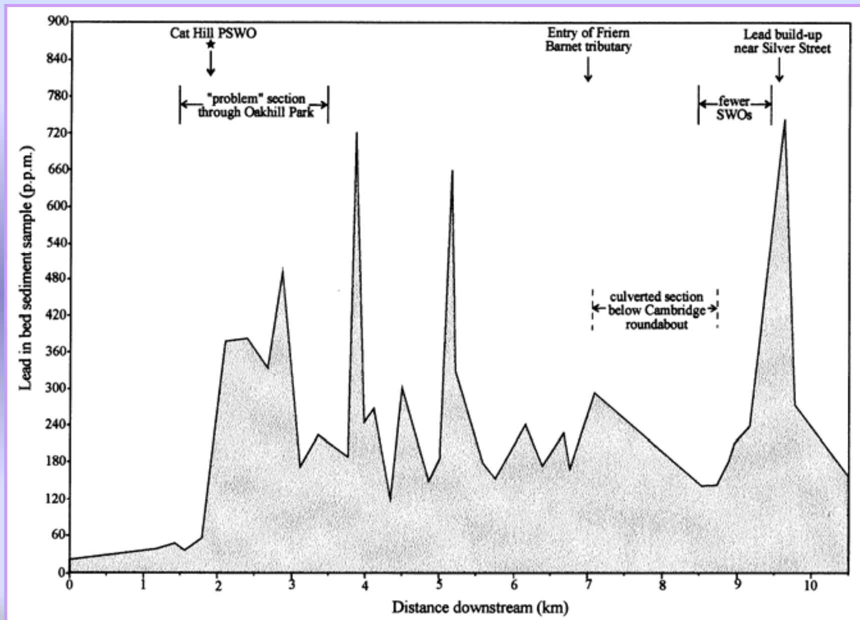
- The brook at high flow copes well with the entry of chemical pollutants. However, deoxygenation is an obvious local effect

Downstream (spatial) quality: (a) inputs from PSWOs

- We sampled downstream, at both low and high flow, looking for trends..

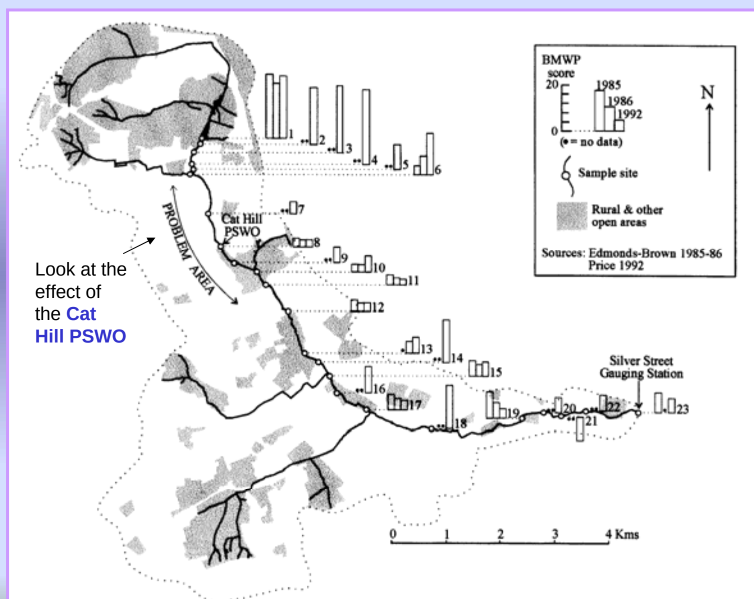


Downstream (spatial) quality (b) heavy metals in bed sediments



Downstream bed sediment Lead concentrations

Downstream (spatial) deterioration in macroinvertebrate community matched the heavy metal and deoxgenation patterns…

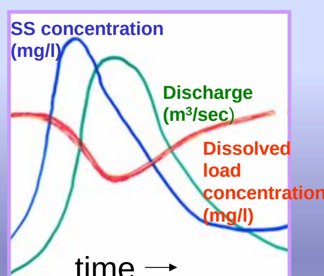


➢The bed sediments were found to be contaminated with heavy metals, sewage-related contaminants (***E. Coli*** levels high), and are deoxygenated at low flow.

➢The mapped quality deterioration downstream is unique, reflecting the pattern of lateral inputs and their relative concentration in relation to the channel they are joining, and this is very spatially and temporally variable.

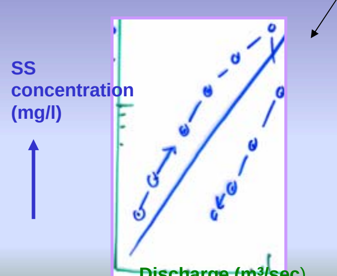
➢Thus, quality deterioration can be closely linked to what is entering as lateral inputs, and in a sense could have been anticipated from the map and pattern of inputs….

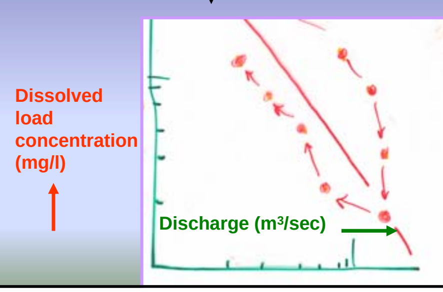
Temporal variation in water quality determinants : the 'first flush' effect



Idealised version of variability in SS and dissolved contaminants during a storm

SS and dissolved contaminants -this time plotted against changes in Q during the storm





Plotting determinand concentrations during the“ first flush”

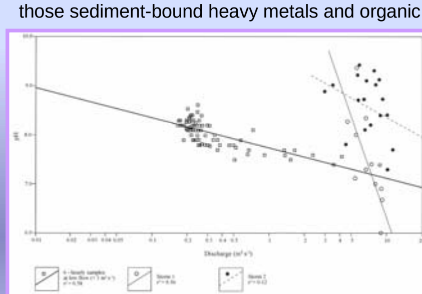
data 1986-2000

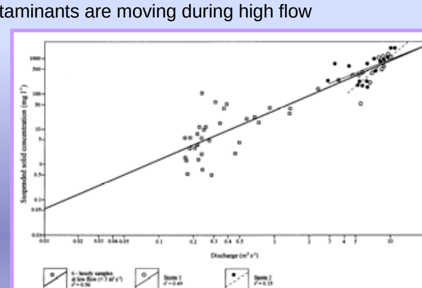
Discharges measured continuously by the EA

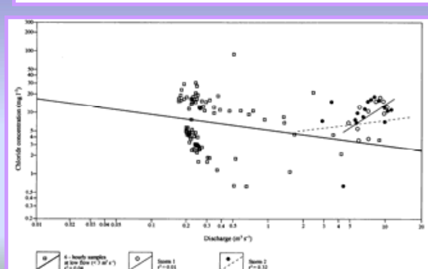
Rock and Taylor sampler at Silver Street gauging station – taking water quality samples at known discharges

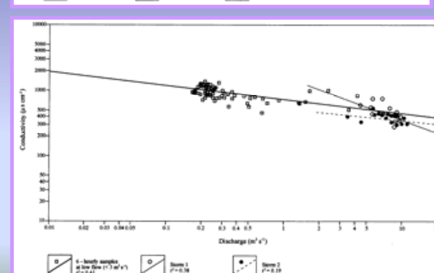
Sediment rating curves at Silver Street gauging station

those sediment-bound heavy metals and organic contaminants are moving during high flow

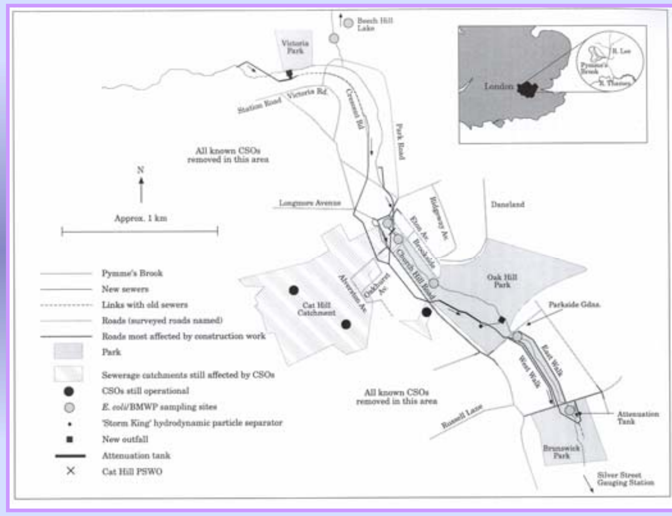








The TWUL Low level intersecting foul-water sewerage scheme: Post-project assessment



Upper section of the Pymme's Brook study catchment section showing the section addressed by the 1995 scheme ; the planform of the pipe network, and the streets included in the residents' survey as well as those affecetd by engineeringdisruption are also shown

Trends in:

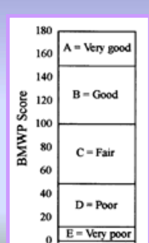
(a)

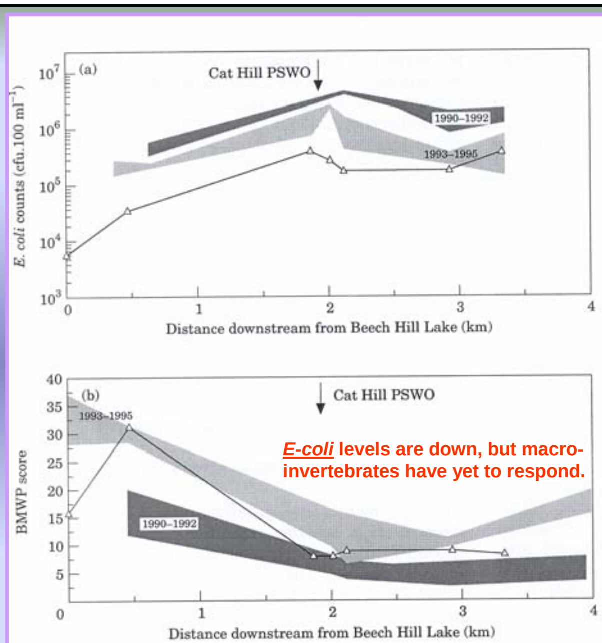
Escherichia coli

in cfu.ml^{-1}

(b) BMWP score

In the 'problem section' between 1990 and 1992; 1993 and 1995, and post-project data (since 1996)





a) *Eschenichia coli* and (b) BMWP trends in the upper reaches of Pymme's Brook 1990–1992 ■; spread of annual data; 1993–1995 ▨; post-project data (1996) (–△–

➢Spatial and temporal variability of sediment-bound contaminants is considerable

➢The low flow, chemically-based monitoring system which has been adopted by the Environment Agency has identified some long-term changes in water quality, which may be a result of the construction of the East Barnet sewerage scheme;

➢ fails to pick up a reduction in the input of organic matter to the watercourse

Spatial and temporal complexity: audit

➢The method of assessing river-water quality using chemical determinants sampled at low flow is flawed with respect to urban catchments, because it fails to assess conditions during storms, when contamination is likely to be at its worst.

➢Macroinvertebrate community structure is a sensitive indicator of change, but reacts relatively slowly.

Spatial and temporal complexity : public access and amenity

- Pymme's Brook is contaminated through the sections where there is a considerable degree of public access

- Pre- deculverting assay of sediment delivery might allow those sites that are less contaminated to be the sites of access, and to restrict the degree of 'opening-up' top those sections that are chronically contaminated

- requires planning that incorporates these temporally-sensitive pre-management methodologies to inform management

References:

- Edmonds-Brown, V. and Faulkner, H., 1994. Causes and effects of serious foulwater contamination, Pymmes Brook, North London. **International Journal of Environmental Studies** 47, 235-255.

- Faulkner, H. Green, A. and Edmonds-Brown V., 2000. Limitations of Quality designation in Diffusely-polluted urban streams- the case of Pymme's Brook, north London. **Environmental Pollution** 109, 91-107.

- Green, A., and Faulkner, H., 2000. An assessment of the suitability of the Environment Agency's water quality classification system for use in urban catchments. **J. of the Ch. Instit. of Water and Environmental Management** , 14(2), 131-139.

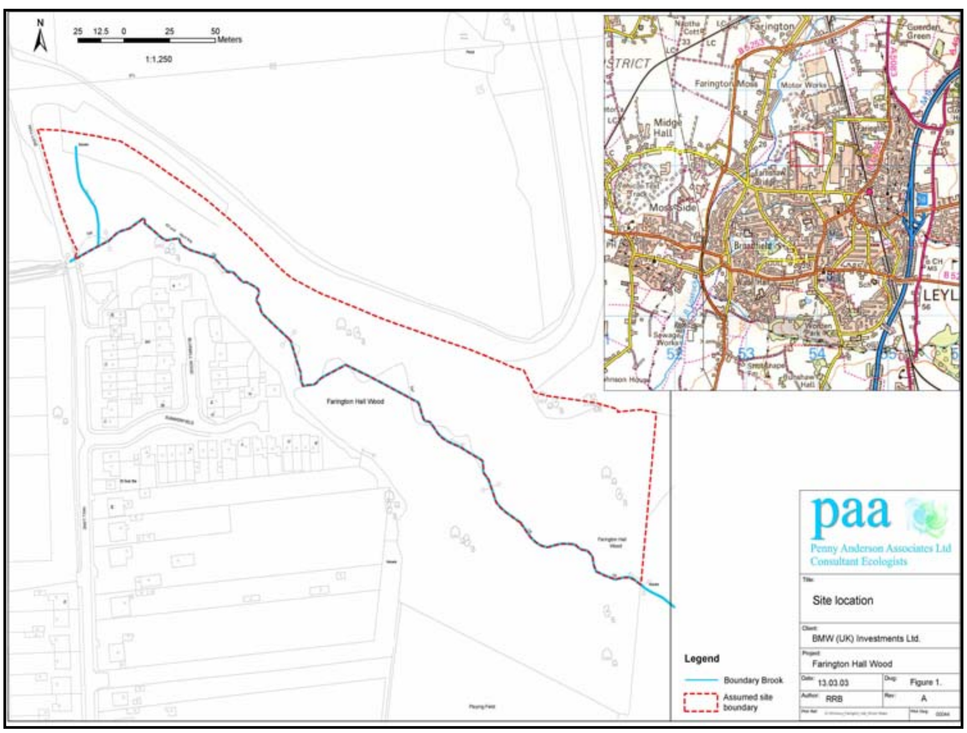
- Faulkner,H., Pellaumail, K., Green, A., and Weaver, T., 2001. Residents' perceptions of improvements in water quality following engineering remediation work on Pymme's Brook, north London. **Int. Journal of Environmental Management** 62(3): 239-254.

LINKING REMEDIATION WITH RESTORATION

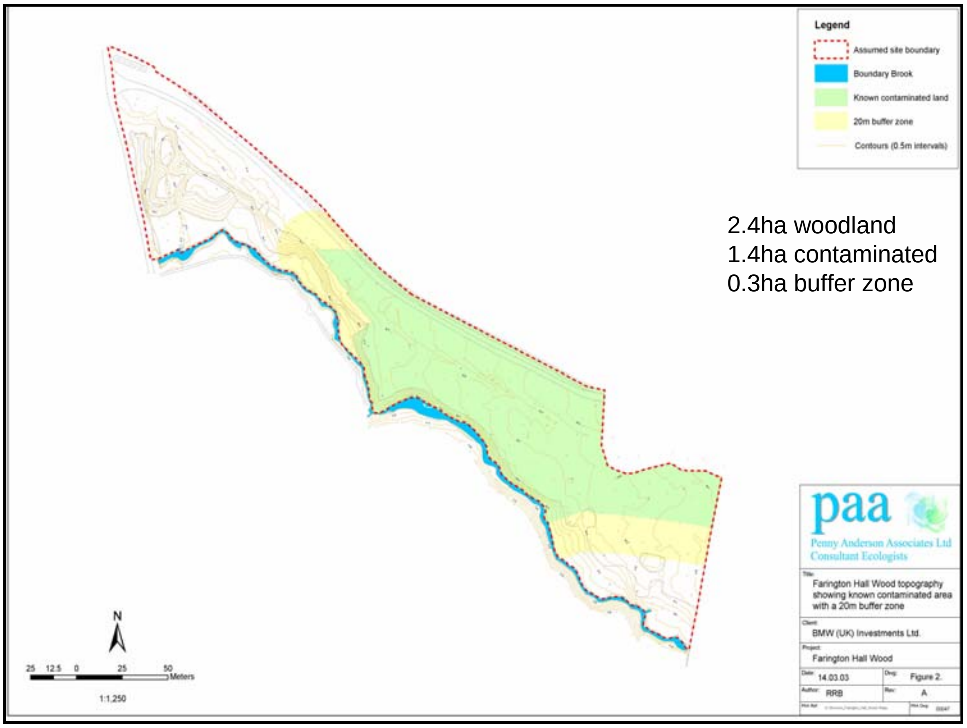
Peter Worrall, Technical Director
Penny Anderson Associates Limited

CROCUS Seminar – Restored Rivers as Contested Nature
(May 2006)

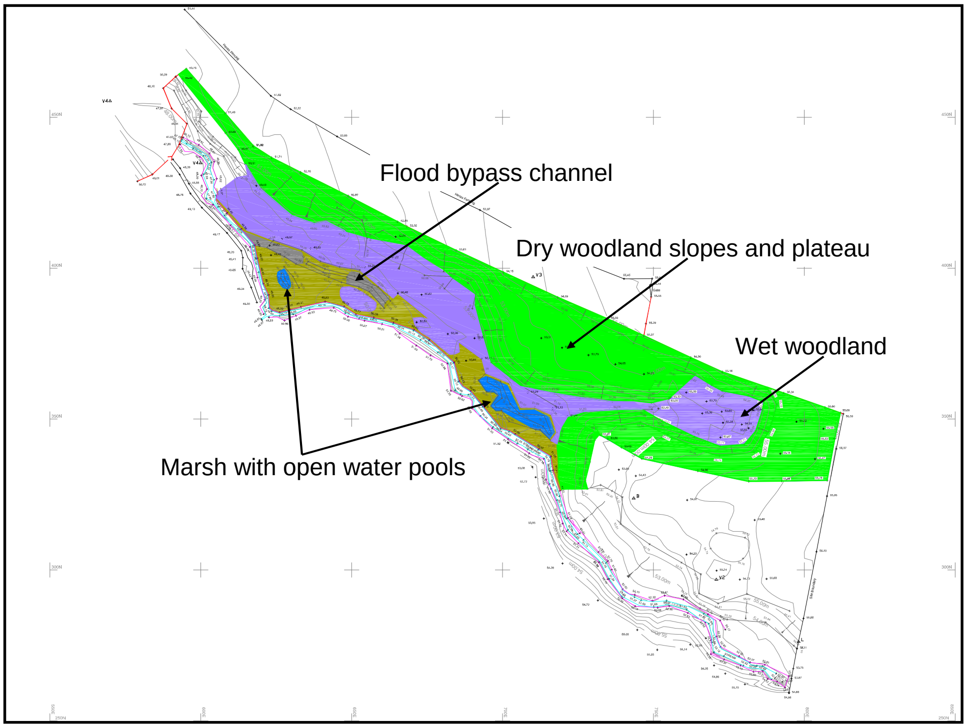
Leyland,
Lancashire



N
25 12.5 0 25 50 Meters
1:1,250
Farington Hall Wood
Legend
Boundary Brook
Assumed site boundary
paa
Penny Anderson Associates Ltd
Consultant Ecologists
Site location
BMW (UK) Investments Ltd.
Farington Hall Wood
13.03.03
Figure 1.
RRB
A


Legend
Assumed site boundary
Boundary Brook
Known contaminated land
20m buffer zone
Contours (0.5m intervals)
2.4ha woodland
1.4ha contaminated
0.3ha buffer zone
paa
Penny Anderson Associates Ltd
Consultant Ecologists
Title:
Farington Hall Wood topography showing known contaminated area with a 20m buffer zone
Client:
BMW (UK) Investments Ltd.
Project:
Farington Hall Wood
Date: 14.03.03
Dwg: Figure 2.
Author: RRB
Rev: A
N
25 12.5 0 25 50 Meters
1:1,250


Arsenic 260mg/kg
Cadmium 230mg/kg
Lead 38,000mg/kg
Mercury 21mg/kg
Copper 6,000mg/kg
Zinc 29,000mg/kg


Flood bypass channel
Dry woodland slopes and plateau
Wet woodland
Marsh with open water pools

River Restoration and Social Science

Sylvia Tunstall
Middlesex University
Flood Hazard Research Centre

2nd Crocus Seminar, Cranfield University, 3-4 May 2006

Middlesex University empirical social research and river restoration

- Research programme with NRA on public perception of rivers and flood defence (1988-1993)

  Study of restoration proposals for River Ravensbourne, London (with Sue Tapsell)

- ESRC/RRP funded project on public responses to river restoration: Skerne, Cole, Medway (with Sally Eden and Sue Tapsell) (1995-1998)

- **River Brent Improvement/Restoration Project: qualitative study of the early stages of this project (1999-2000)**

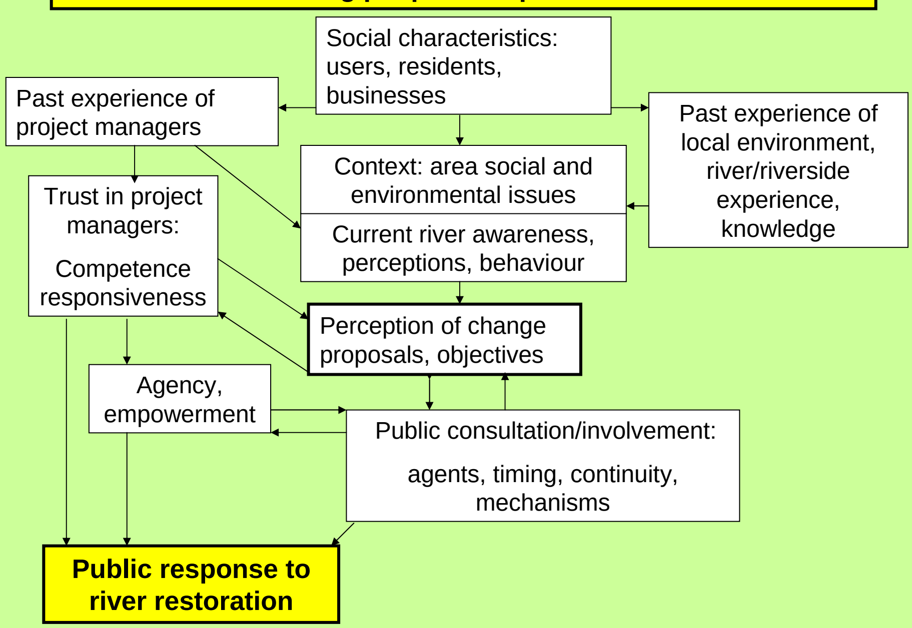
  Participant observation of Phase 1 consultation: public meetings, site visits, 'Planning for Real' exercise

  Recruited and conducted 4 resident focus groups.

Why social science and river restoration?

- Implicit/explicit social objectives, impacts/issues - benefits/disbenefits of projects
  - Who defines the social objectives? Funders/Project managers,
  - Potential beneficiaries/those affected through engagement?
  - Are the objectives measurable/aspirational?
- Stakeholder/public involvement
- Social monitoring
- Behaviour and restored rivers

Social factors affecting people's responses to river restoration

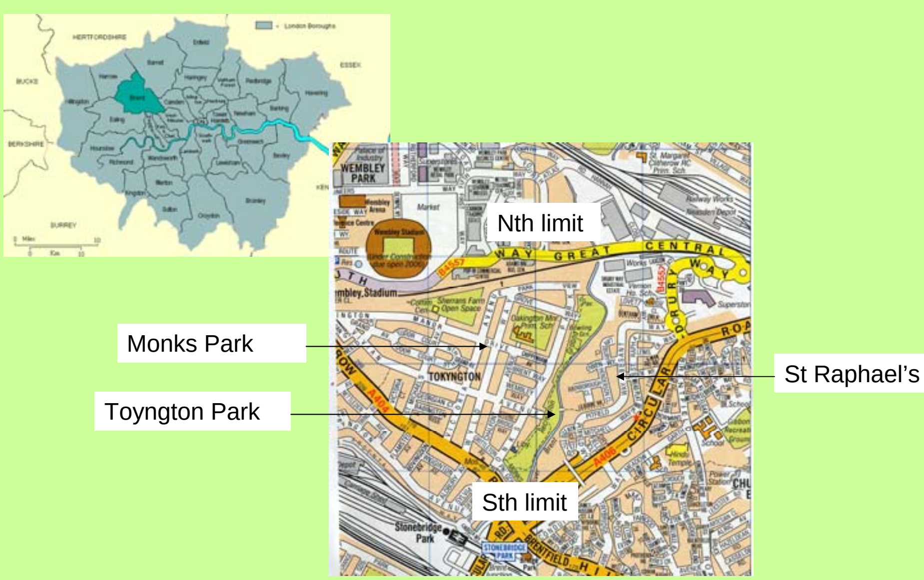


River Brent Restoration objectives

- Project origins: Environment Agency and LB Brent
- Process of bidding for funding may initiates defining objectives
  E.g. LB Brent's application to London's Waterway Partnership SRB December 1998
  - For community consultation and technical feasibility study
- Need to fit in with SRB funding requirements

- Ambitious, aspirational objectives. Were they potentially measurable? e.g:
  Context: New National Wembley Stadium as a catalyst for wider regeneration of which Brent scheme a part
  - Improve safety and security
  - Improve water quality
  - More use of park for leisure and recreation and for healthy journeys on foot or by bike
  - Create educational opportunities

London Borough of Brent and River Brent Restoration site



Social context of Brent River restoration

1.8km restoration scheme in Tokyngton Park, river straightened, channelised, and fenced in 1939 flood protection works

Rivers as divides:

Brent:
Originally -
Boroughs' boundary
Now -
Wards

Two distinct and different housing areas
Wembley Industrial Estate to the North

Social characteristics of housing areas

On east bank: **St Raphael's Estate**

Between Nth Circular and River,
1,000 1970s houses and flats,
Deprived ward, high unemployment
41% black ethnic groups (1991 Census), Major refurbishment project for estate '98/99

On the west bank: Monks Park Housing area,

Tokyngton Recreation Ground,
1930s terraced, semi-detached,
Mostly owner-occupied,
39% Asian inc. Indian (1991 Census)

Social Context: Distrust between the two communities

Concern of Monks Park residents: Bridge used for access/exit by muggers, burglars etc.

Looking west to Monks Park area

Bridge over River

CCTV camera

Proposal for a second bridge to the Nth to create a circular route remained contentious

Perceptions of the local environment and park as: degraded, concerns about personal safety, poor lighting,crime/vandalism,litter, dog fouling, burnt cars, drinkers, lack of play/ recreational facilities

'We had the cricket, the pavillion, we had tea, we had the rose garden, we had the bowling green, the river was better kept' (Monks Park)
'I won't let my children play there now because it's a mess' (St Raphael's)

Key concerns about river: pollution, channel form, river as habitat

Pollution and river water quality

'To have your children saying, "it smells, mummy" when you're walking past it, it does need to be cleaned' (St Raphaels)

'Flies, there's no water in it, things are thrown in it' (St Raphaels)

Channel form

'It doesn't look like a *proper river*, I mean, proper rivers…there's no concrete' (St Raphaels)

'It's a river, we've got to get away from people thinking it's a canal. I thought it was a canal when I first moved here (Monks Park)

'If it was a *proper* river you wouldn't have a fence there at all' (Monks Park)

Wildlife

'Once it's cleaned up, the wildlife will come back (St Raphaels).

Flood risk and safety issues

Flood risk

'We used to be flooded here….it overflowed into the park and into residents gardens and into their front rooms. It was a shock when that happened to me (Monks Park)

'It's always in your mind when you have torrential rain' (Monks Park)

Safety of decanalised, unfenced river

'I think it's a bit dangerous,. I mean how could children play around this bit… Someone could fall in' (St Raphaels)

'If its anything like this where the water is low anyway… I mean who is going to drown' (Monks Park)

Issues of trust and agency

Maintenance issues

'Who is going to maintain it?'

'Look what happened to that pond'. (Monks Park)

Responsiveness and agency

'They don't really listen. I think they take in the views and make their own…what they want' (Monks Park)

'To be honest, Brent do not care. There's been a car dumped outside where I live since November. I've phone 3 times …and it's still not done' (St Raphaels)

'They should have closed that bridge, if that bridge is open , I don't want to hear nothing about it' (Monks Park)

Public consultation and involvement Phase 1 1999-2000

Undertaken by voluntary environmental group and facilitator

Early involvement

Varied techniques

- Leaflet and questionnaire to 2,300 residents and 60 businesses with 227 community responses, 11% response March 1999:
- 4 initial public meetings, June/July 1999: poorly attended; RRP video shown
- Briefings to local groups, Councillors in Library
- Displays in community and business locations

- 'Planning for Real' exercise
- Visit to the Skerne restoration scheme
- Establishing a Community Steering Group

‘Planning for Real’ July 1999

0ver 100 participants including children

Issues/improvements shown with cards on model built by local school kids

Public response to Brent River Restoration Phase 1

- Support for decanalising river in Brent post questionnaire

    Strongly in favour 54%

    In favour 24%

- Focus group participants’ support and hopes for the river

    ‘It’s just a forgotten river at the moment. So we need to make it to be remembered, so that we know its there, that we can appreciate it’ (Monks Park)

    ‘Tranquility, alright, maybe it’s a dream but I mean this is what all this is about’ (Monks Park)

Monitoring and post restoration behaviour and use

- Monitoring:
  Do projects meet their social objectives?
  Pre and post restoration systematic measures and observation
  Full publication on results

- Evaluation of post restoration behaviour
  Concern about possible health risks from polluted water/ toxic sediments in restored rivers

  Need to know about post restoration behaviour –
  - Do people esp. children go in restored rivers?
  - Do they behave in a way to activate sediments?

Restored section of the River Brent looking south

Wednesday 3rd May: Discussion Groups

The attendees were allocated to one of three discussion groups to consider the main issues arising from the presentations and the challenges facing river restoration in urban environments where channel and floodplain sediments may be contaminated.

These are the summary points from the three groups.

Group 1:

- A framework for urban river restoration needs to be built into the planning system.
- Adaptive management is necessary which monitors and maintains the restored site and achieves a balance between environmental requirements and goals and societal issues / needs.
- Contaminants need to be considered from a catchment perspective (source to sink).
- Sediment quality guidelines and risk assessments are urgently needed.
- There is a need to establish the baseline ecology for urban areas.

Group 2:

- How should the success or failure of urban river restoration be evaluated in an interdisciplinary context?
- Urban river systems are dynamic and adaptive management is thus required to address this dynamism and moving targets.
- Climate change will result in changing flood frequencies. Initiatives which focus on “making space for water” also need to focus on making space for sediments.

Group 3: focused on policy, governance and management and considered whether the urban stream is a watercourse or a sewer.

- It is not ethical to carry out urban river restoration projects without health risk assessments.
- SUDS should be installed for all new developments / re-developments to meet water and sediment quality objectives.
- Relate what goes on in individual households to landscape restoration and ownership; pathways of contaminated water to sediments.
- Water company stormwater studies should be linked in with receiving water / sediment studies.
- The individual reach is part of the bigger system.
- Many projects go ahead but ignore potentially serious contamination issues. Restoration techniques should account for this – e.g. use a wetland to prevent people from getting access to contamination.