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Basin-Scale Sediment Management: Conceptual Approaches for Framing Decisions
(and some European Initiatives)

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

[1]SEA Environmental Decisions, Ltd.*

[2]Institute of Water & Environment, Cranfield University at Silsoe, UK

…Linking science and applications

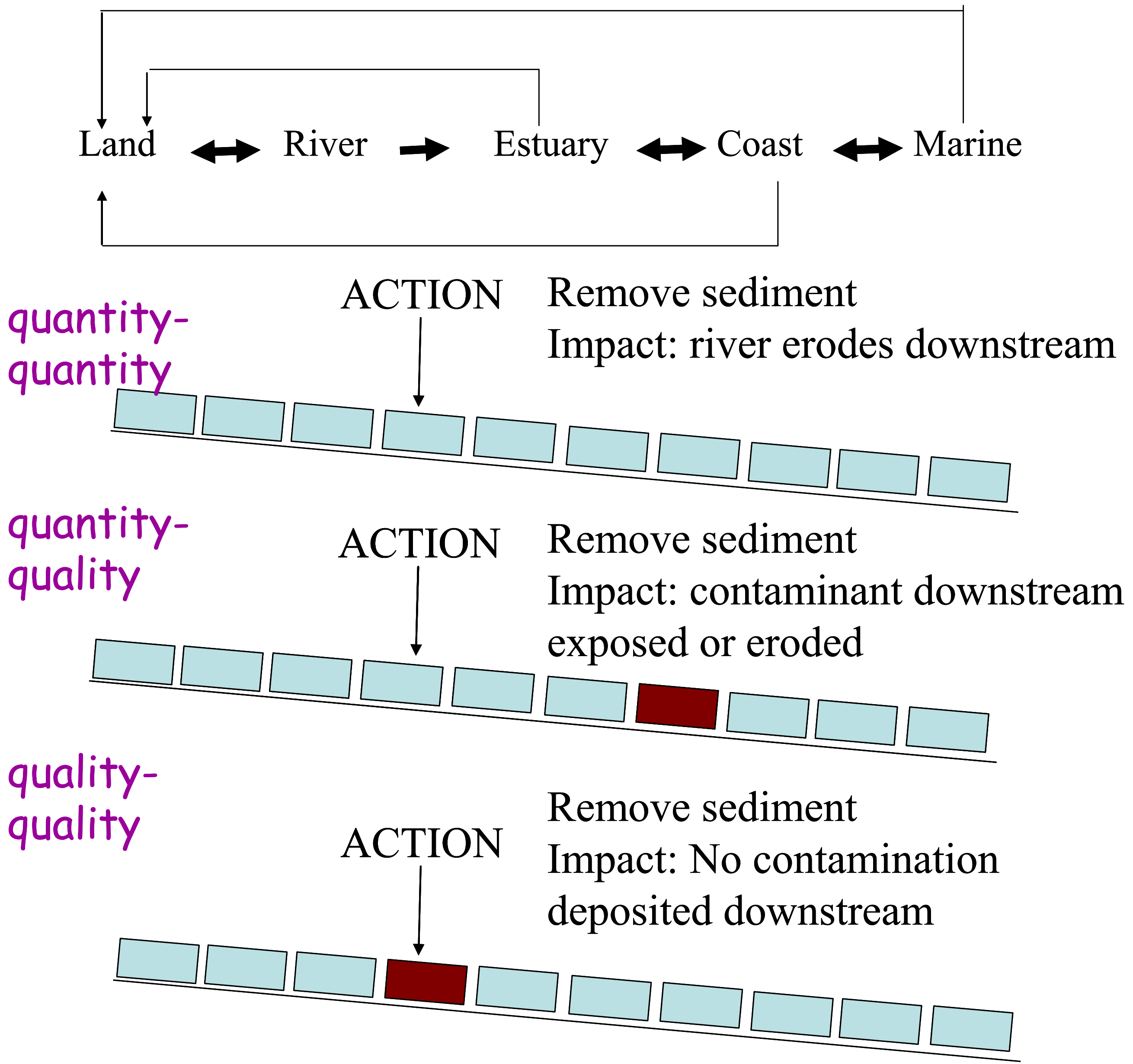
*1 South Cottages, The Ford, Little Hadham, Herts, SG11 2AT, UK; +44(0)1279 771890; drsea@cvrl.org

Sediment management has generally been divided into two basic categories

- Management of sediments to achieve socioeconomic goals (e.g., construction, navigational dredging, flood defense - managing sediment quantity, but sometimes with quality issues)
  - *Generally*, large volumes, low to moderate contaminant levels
  - Since removal is a given, assessment focuses on risks of resuspension, disposal and/or treatment options
- Management of sediment to achieve ecological goals (managing sediment quality)
  - *Generally*, smaller volumes, often higher contaminant levels
  - Assessment can focus on absolute and relative risk, as well as risks of in-place vs. removal options

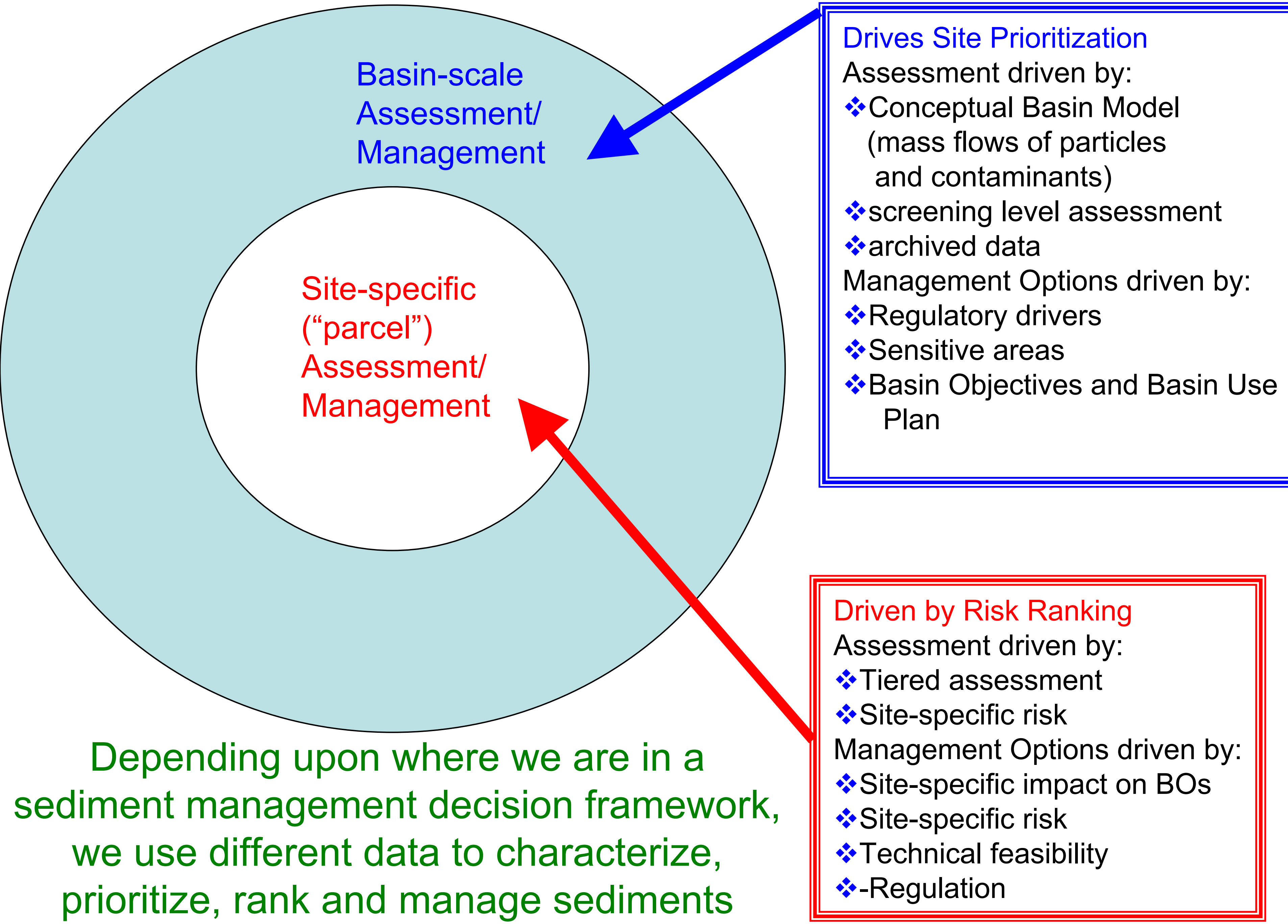
These two types of management are done by different organizations, with little interaction. Attempts to generate "universal" management frameworks have often failed due to the fundamentally different objectives of these two approaches

Sediment is part of the hydrodynamic continuum – actions on a sediment unit can affect other parcels, resulting in conflicting, counterproductive or inefficient management actions if not coordinated, regardless of goals

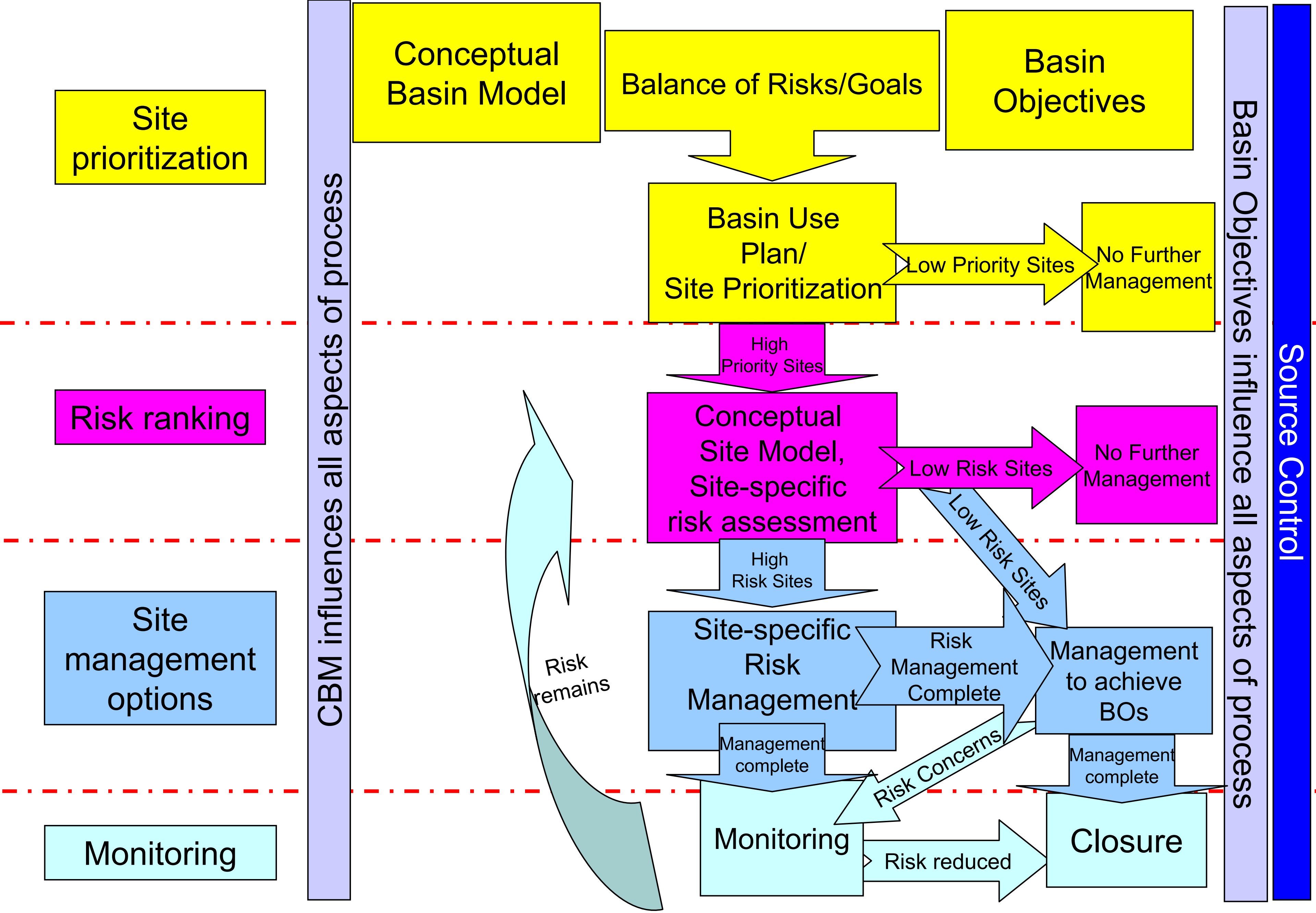


There is a need for holistic, basin-scale sediment management frameworks

- Hydrodynamically linked sediments and sources cannot be managed in isolation from one another
- For basin or watershed-scale management, quantity and quality must be managed together
- However, frameworks reviewed are very management-objective specific, and only evaluate one parcel of sediment at a time
- Holistic management will require frameworks that clearly and separately address various objectives and allow for a basin-scale, as well as a site-specific, decision process
- Universal management frameworks will require ***clear*** definitions of the hierarchy and flow of decisions, and at what level and for what purpose data are being used



Depending upon where we are in a sediment management decision framework, we use different data to characterize, prioritize, rank and manage sediments



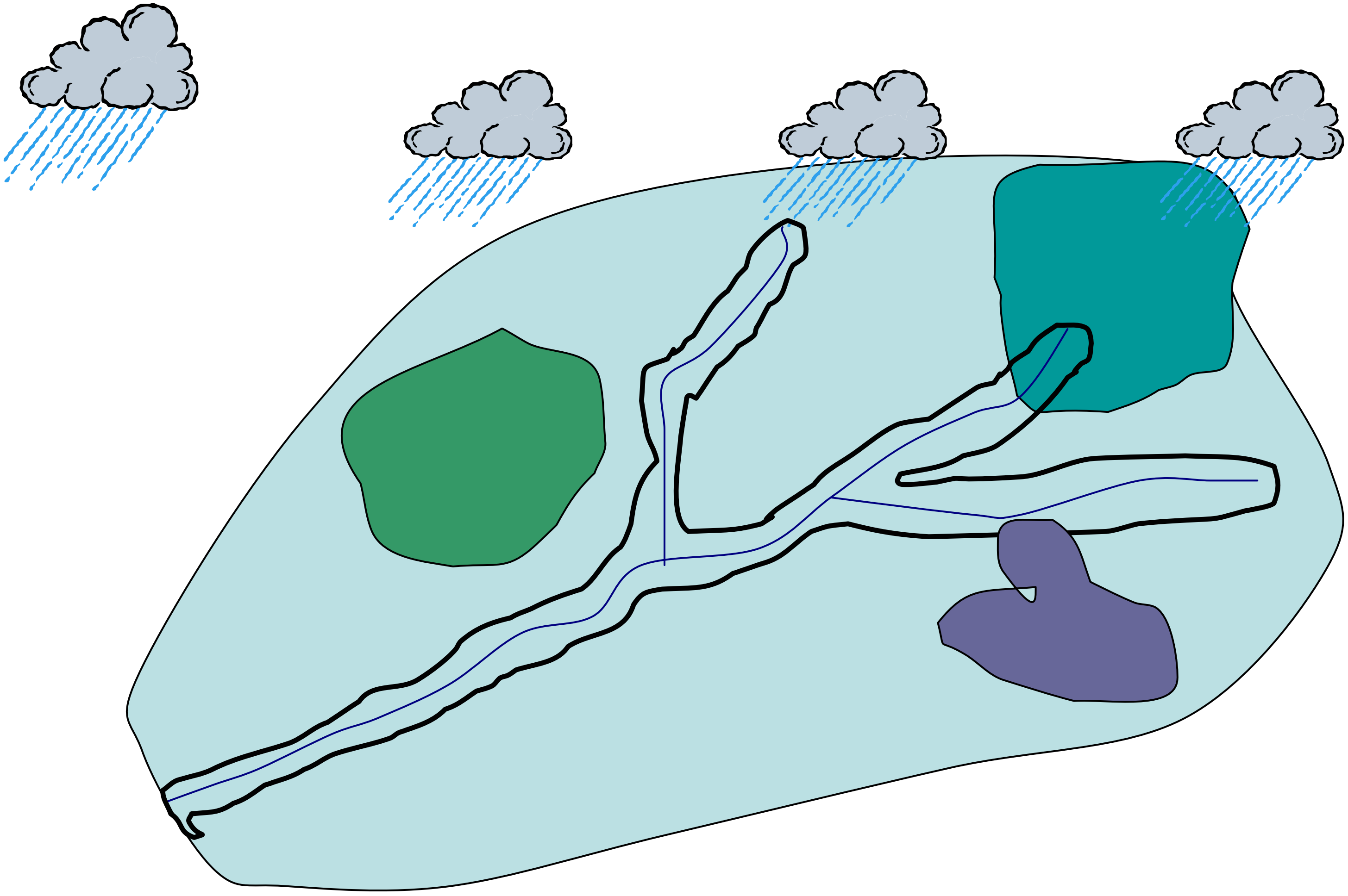
Proposed conceptual approach to basin-scale sediment management

from Apitz and White, 2003

Conceptual Basin Model (CBM)

- An understanding of the particle and contaminant mass flows within a river basin in support of basin-wide management and prioritization can be defined as a Conceptual Basin Model or CBM
- 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
- Such a conceptual model can also be used to evaluate the relative contribution of various sources and sediment parcels to either cumulative basin or down-stream risk

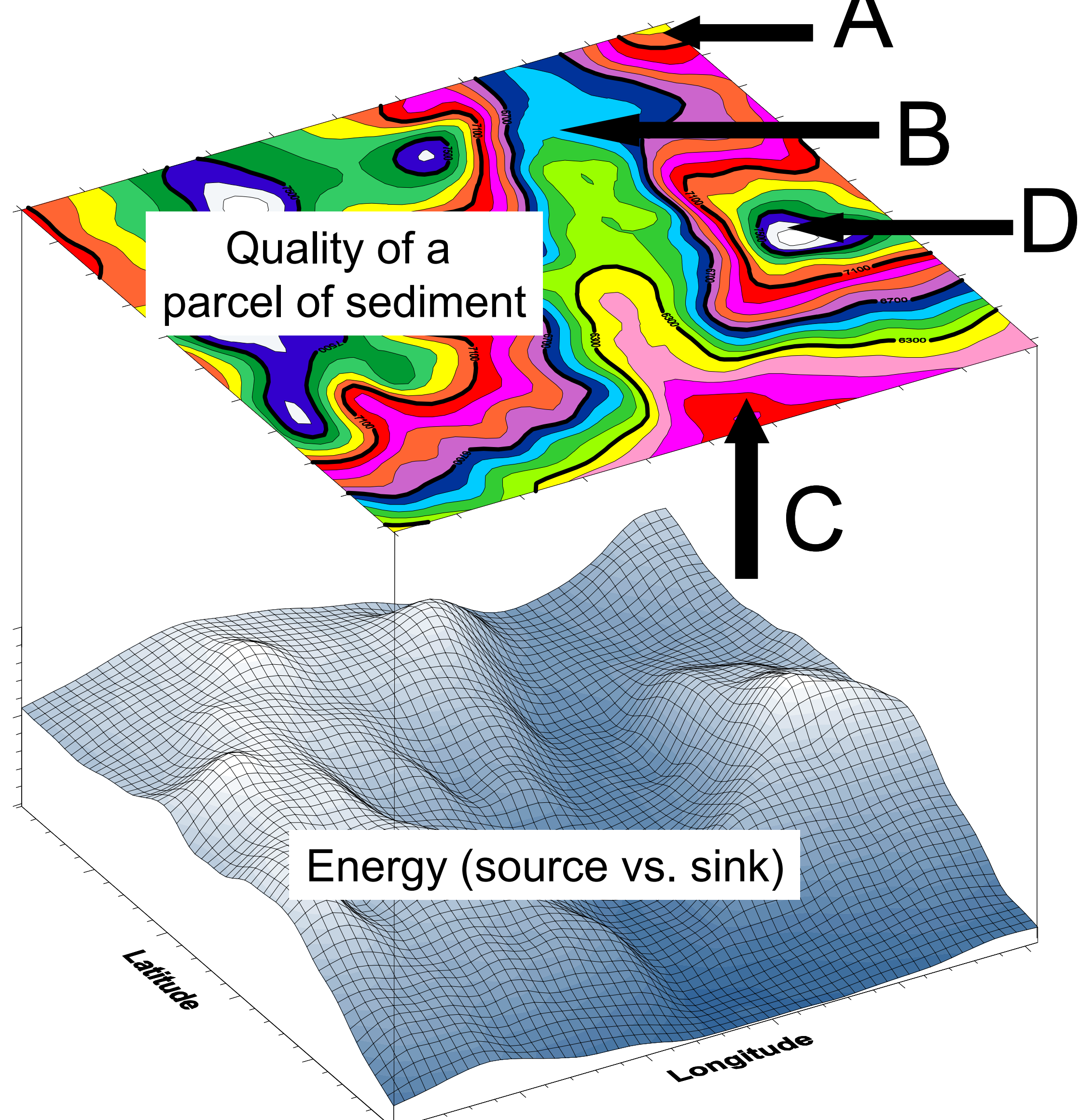
Location of source sites within a basin and relative to one another matters



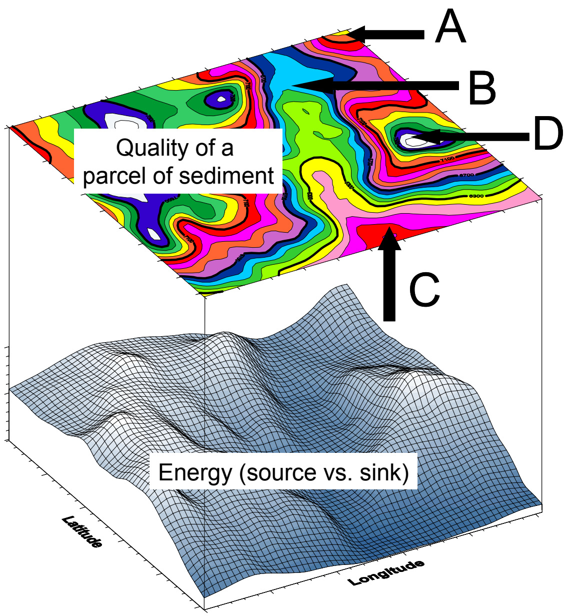
Developing Conceptual Basin Models

- We may be able to map the sediments/sources in a basin in terms of their energetic position (source to sink) and quality.
- In this example, sediment A is of poorer quality than, and is upstream of, B, thus its risk is higher than sediment C, which is downstream from cleaner sediment D, although A and C are of similar quality

conceptual diagram of projection of sediment energy (source vs. sink) and quality *potential* sediment (e.g. soil) included. In colored scale, poorer quality is indicated by warm colors, better quality by cool colors



For this scenario, one can then conclude that the relative order of management priority is: A>C>B≥D

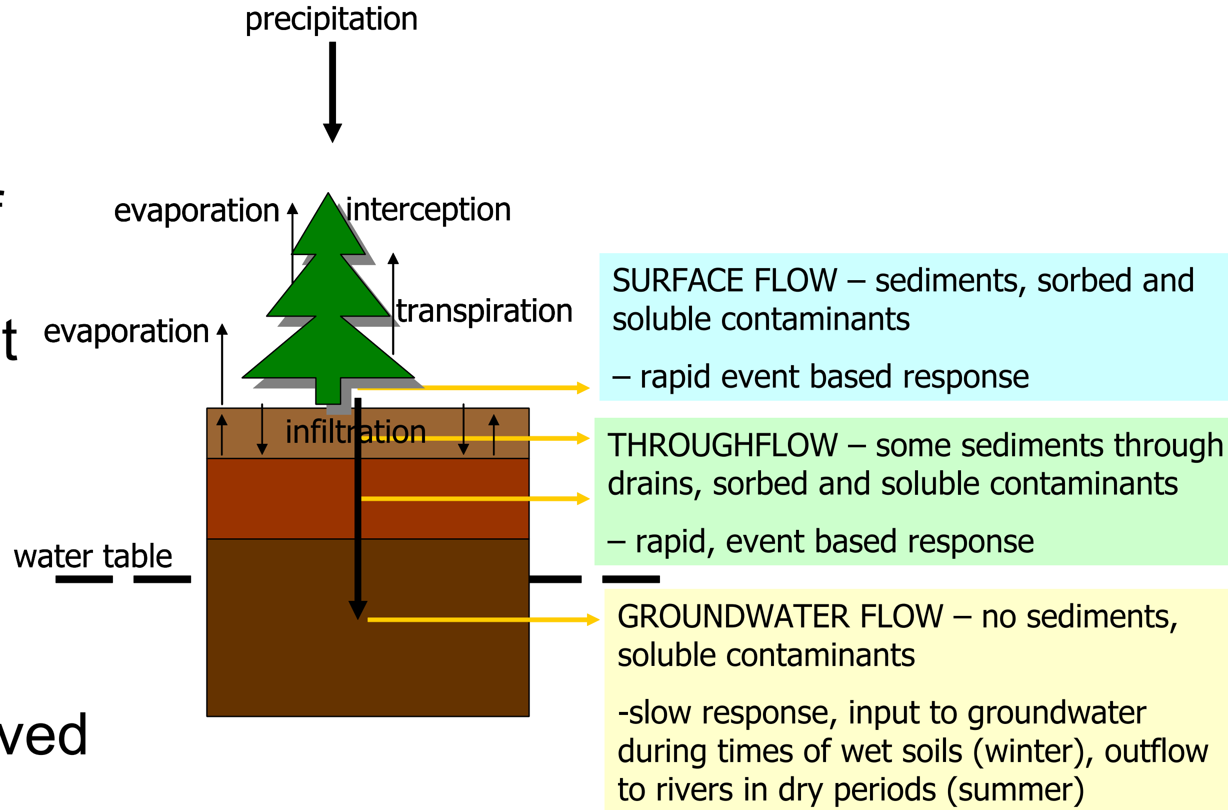


Sediment Unit	Quality	Energy	Transport risk	Transport benefit
A	low	high	high	low
B	high	low	low	high
C	low	low	moderate	moderate
D	high	high	low	high

Transport risk can be defined as the risk of contaminated sediments moving downstream to less contaminated sites. Transport benefit is the possibility that clean sediments can move onto, and possibly attenuate, downstream contaminated sites. There are other potential risks and benefits of sediment movement that can be considered as well..

Quantity/mass flow issues

- There are a number of hydrodynamic river or hydrological catchment models available to predict mass flow of particles
- Some also have the capability to track contaminants in dissolved or sorbed form



- There are a number of GIS-supported models (such as SWAT, SHE-TRAN, MIKE-SHE etc.) that might provide a model or springboard for how to map particle and contaminant mass flow in river basins
- However many of these have been developed in response to specific problems (e.g. soil erosion, sedimentation) or are hydrological models to which sediment has been added
- They are often highly data intensive, and are not optimal for CBMs

Contact: Dr. Sue White
sue.white@cranfield.ac.uk

Model capabilities

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	SWAT	SHE-TRAN	MIKE-SHE	GREAT-ER	TERRACE (uses SWAT)
Hydrology	Conceptual	Physically-based	Physically-based	Stochastic	Conceptual
Sediment	Distributed land & river	Distributed land & river	Distributed land & river	Average conc.	Distributed land phase
Contaminant	Diffuse & point	Diffuse & point	Diffuse & point	Point	Diffuse
Purpose	Land use & management	Process hydrology	Process hydrology	Point source pollution	Diffuse source pollution
Outputs	Semi distributed; Daily	Distributed; Sub-daily	Distributed; Sub-daily	PEC; Pdf	PEC; Pdf

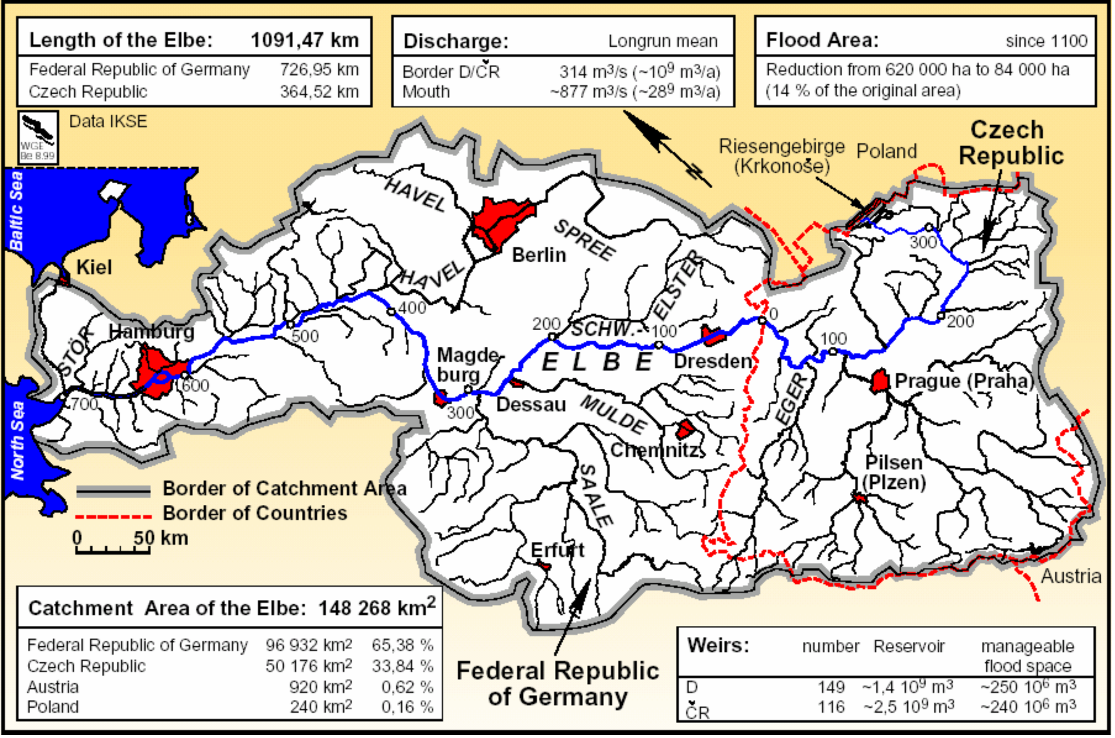
Whilst many models have sediment and contaminant modelling capability they are often too complex (and data-intensive) for prioritisation for sediment management. Work on-going at Silsoe is addressing this through the GREAT-ER+TERRACE modelling link

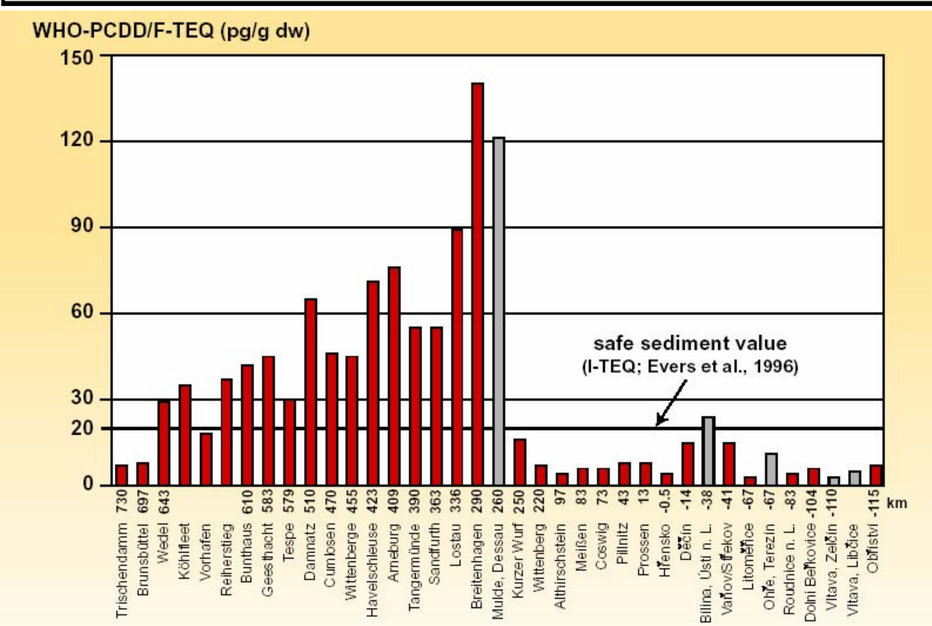
Definition of Basin Objectives (socio-economic goals)

- It is not only the components of the CBM that will drive a prioritization of sediments
- A consideration of objectives for the management of the river basin must also be included
- Factors of such a consideration include (see table)
  - meeting regulatory criteria
  - maintaining economic viability
  - protecting sensitive environments

Basin Use Plan – balancing ecological and socioeconomic goals

- A combination of the CBM and the BOs should result in the development of a Basin Use Plan (BUP)
- This plan will include a prioritization of sediment sites in terms of
  - relative risk (including quantity/quality issues) – CBM
  - relative contribution to basin risk or downstream risk
  - basin objectives
  - potential for beneficial use/resource sharing during management
- A critical component of the BUP should be a plan for source control via
  - Appropriate prioritization of sediment parcels
  - Evaluation of activities in basin that provide continuing input of contaminants or interfere with sediment balance issues





Concentrations of PCDD/F in sediment samples from the river Elbe and the mouths of its tributaries (September 2002)

River Elbe: Cross-border Risk Management

- Hamburg Harbour, a major port, spends millions annually treating dredged sediments contaminated upstream by nations that no longer exist
- Major impacts are metals from historical mining sites (300) in Czech Republic and organics (dioxins) from former East Germany
- They wanted to know which source should be managed, or if they should continue to treat downstream

Recommended Approach - **River Basin Management**

- Develop a Conceptual Basin Model for the Elbe
- Carry out a whole basin risk assessment/risk ranking, which would provide a clear picture about the relative contributions of various contaminant sources and types to cumulative risk (e.g. do 15% of sources cause 90 % of risk? Will removal of metals reduce risk, or is risk dominated by organics?)
- Site prioritization: taking into account the results of the risk attribution, public evaluation and cost-benefit analyses: develop a prioritization of sites - which should be managed first and where to allocate resources
- Decide about site-specific management options – which may be financed by an "Elbe River Fund"
- It is possible that Hamburg Harbour funds are better spent in the Czech Republic

Take-home message – a watershed cannot be managed one site at a time – it is important to understand and balance the total risks, costs and goals

- Note: this discussion only addresses the "quality" aspect of the issue. A parallel "quantity" model must also be applied

Site-Specific Risk Assessment and Management

- There are various site-specific risk assessment and management frameworks; they need not be discussed here
- This framework, being developed for Europe, like many others, is tiered
- Clearly, CBM, BO, and source control must be considered at each step

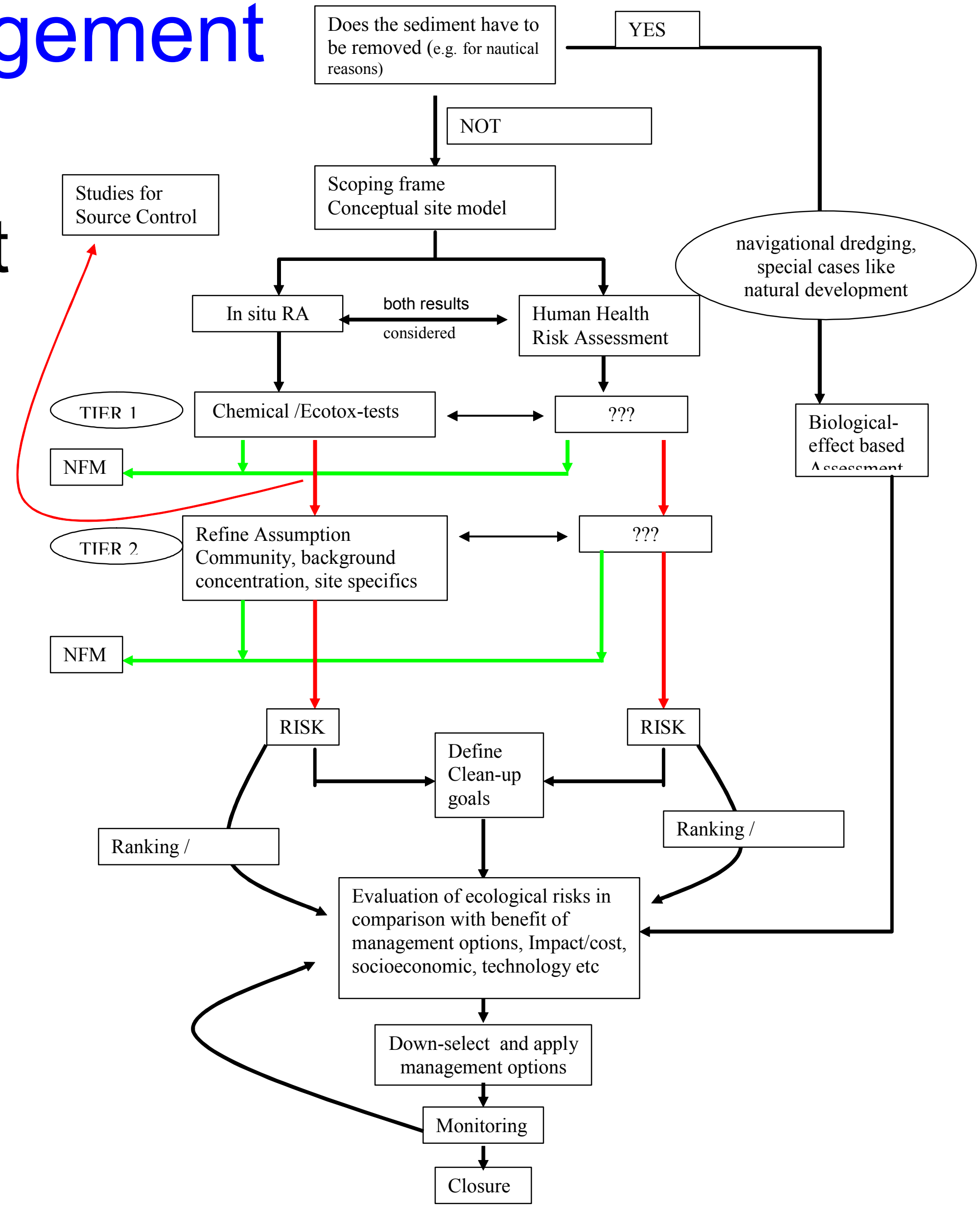
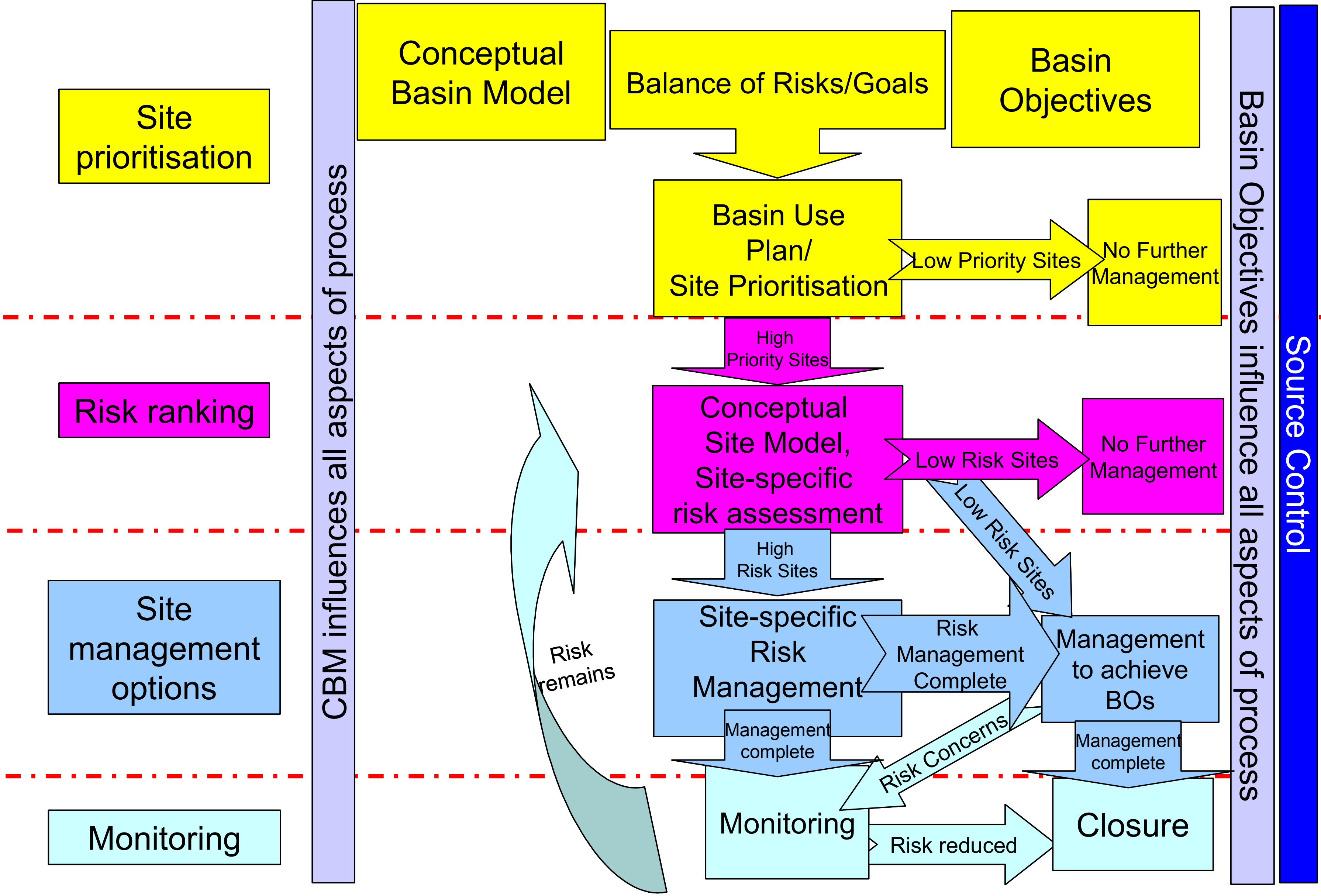


Fig. 2: Suggestion for a Risk Management Scheme (NFM = "no further measures")

Monitoring

- After management actions have been applied, monitoring must continue until risks are deemed to have reached acceptable levels
- CBMs should be either continuously updated or periodically reviewed, and re-balanced in terms of changing BO and BUPs
- Risk management will be an iterative process, but if done properly, resources can be allocated for maximum benefit



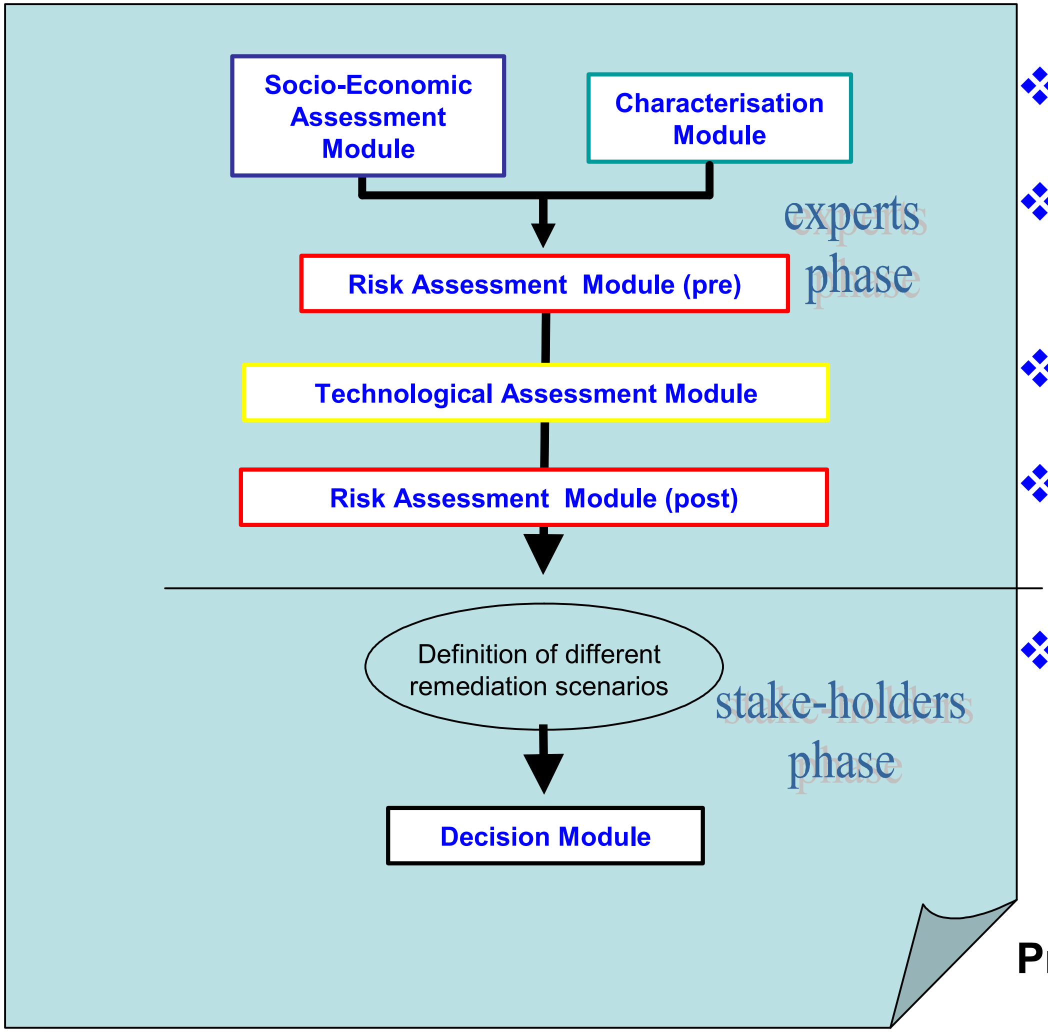
Clarifying the various levels of sediment management identifies points of intersection between seemingly unrelated activities and organizations in support of holistic management

European Initiatives

- EC Water Framework Directive mandates basin-scale water management
  - SedNet is a European network addressing basin-scale sediment management (www.sednet.org)
  - National networks forming as well (SedComUK, Spanish Sediment Network…)
- In the UK, various sediment activities are being mapped onto the basin/site framework to define a holistic UK approach to sediments
- Meeting held in Germany in March to identify river source control approaches to Bitterfeld dioxin megasite
  - Review of various approaches has resulted in the selection of “sediment covering” (POC: Prof. H Reinke, heinrich.reincke@arge-elbe.de)

DESYRE is a *GIS-based software prototype* based on a stepwise procedure, from site characterization to definition and comparison of alternative remediation scenarios

DESYRE modular structure



- *selection of target land development options*
- *management and interpretation of contaminant data*
- *analysis of the risk posed by contaminants before the intervention*
- *planning of alternative intervention scenarios*
- *analysis of the post remediation (residual) risk and associated uncertainties*
- *creation and comparison of alternative remediation scenarios*

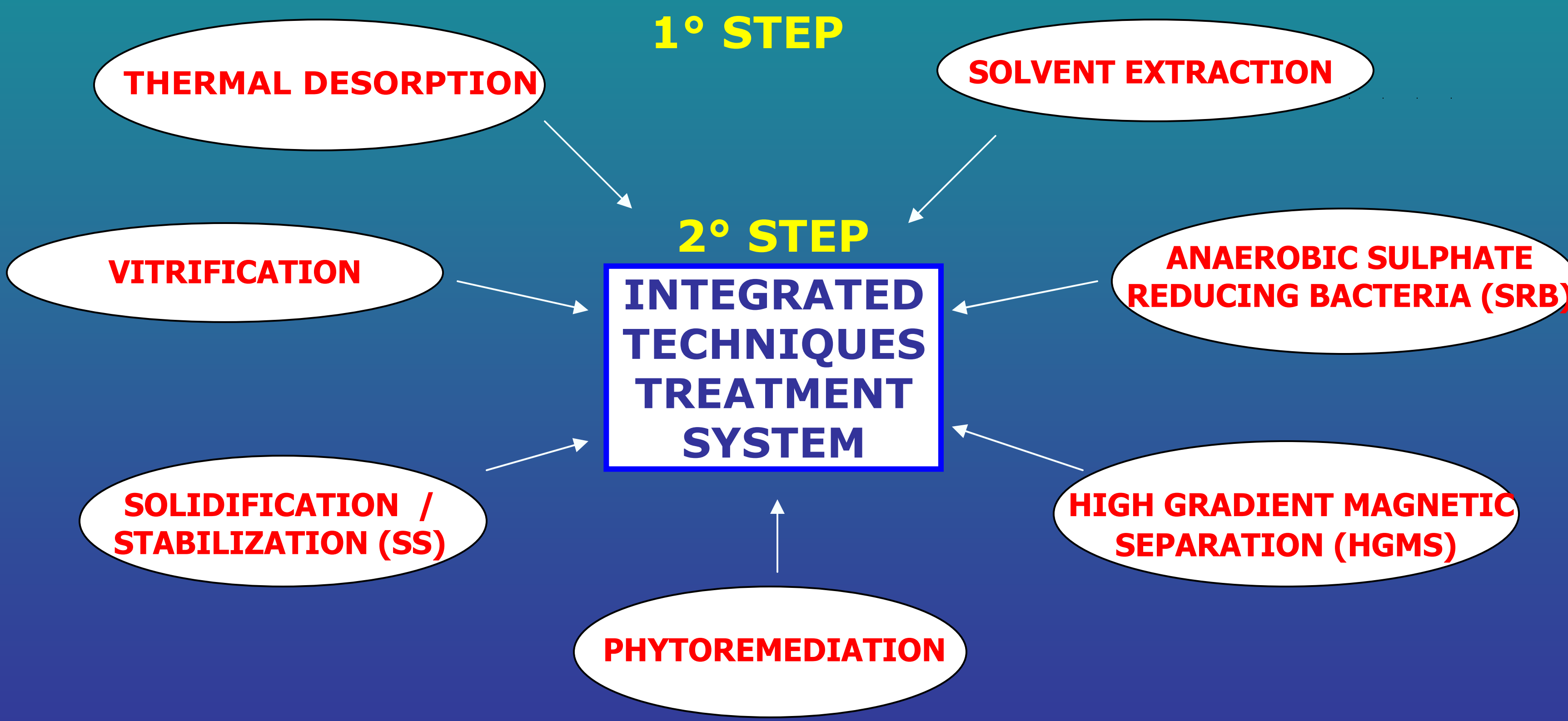
Contacts:
Dr. Claudio Carlon, Venice Research Consortium, *cla.cvr@vegapark.ve.it*
Prof. Antonio Marcomini, University of Ca' Foscari, Venice, Italy, *marcom@unive.it*

SeRTech

VENEZIA RICERCHE

SeRTech : development of an Integrated Treatment System for Contaminated Sediments of Venice lagoon

SELECTED TECHNOLOGIES



SeRTech : development of an Integrated Treatment System for Contaminated Sediments of Venice lagoon

SEQUENCES OF TECHNOLOGIES TESTED FOR SEDIMENT WITH HIGH CONTANTAMINATION LEVELS

PRETREATMENT conditioning

↓

DEWATERING

↓

SOLIDIFICATION/ STABILIZATION (SS) pelletization

↓

THERMAL DESORPTION 400-500°C

↓

INNOVATIVE VITRIFICATION

with heavy metals reduction

ADVANTAGES:

- Highly metal reduction
- Removal of organic compounds
- Reduction of the emissions
- No dust, easy handling

PRODUCTS:

Glass foam, glass fibres as isolation material in building

	Unit of measure	Sediment H (High risk)
Heavy metals		
Cu	mg/Kg dw	> 1.200
Zn	mg/Kg dw	> 9.000
Pb	mg/Kg dw	> 1.500
Hg	mg/Kg dw	> 20
As	mg/Kg dw	> 100
Cd	mg/Kg dw	> 40
Organic compounds		
PAH	mg/Kg dw	> 1.000
PCDD/F	mg/Kg TE	> 0.20
PCB	mg/Kg dw	> 20
Hydrocarbons	mg/Kg dw	> 40.000

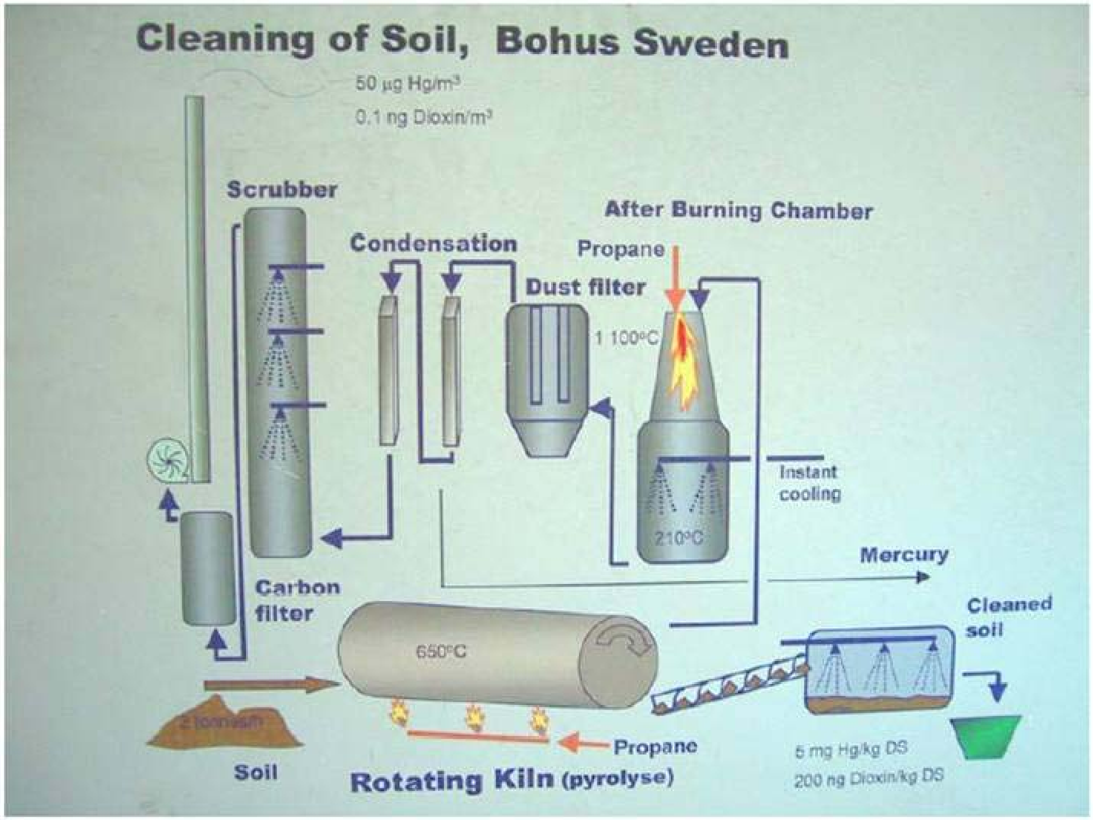
Contacts:

dr.Roberto Pippa or dr. Petra Scanferla, sp.cvr@vegapark.ve.it

Venice Research Consortium

Recent European Dioxin Treatment Papers

- Dechlorination of Recalcitrant Polychlorinated Contaminants Using Ball Milling
  - POC: Volker Birke, University of Applied Sciences-NE Lower Saxony, Suderburg, Germany, Department of Civil Engineering, birke@fhnon.de
- Mercury (and dioxin) Removal by the MERCOX Process at a Thermal Soil Remediation Plant
  - POC: Jens Korell, Forschungszentrum Karlsruhe GmbH, Institut für Technische Chemie, Bereich Thermische, korell@itc-tab.fzk.de



Thermal remediation plant for treatment of Hg and dioxin containing soil

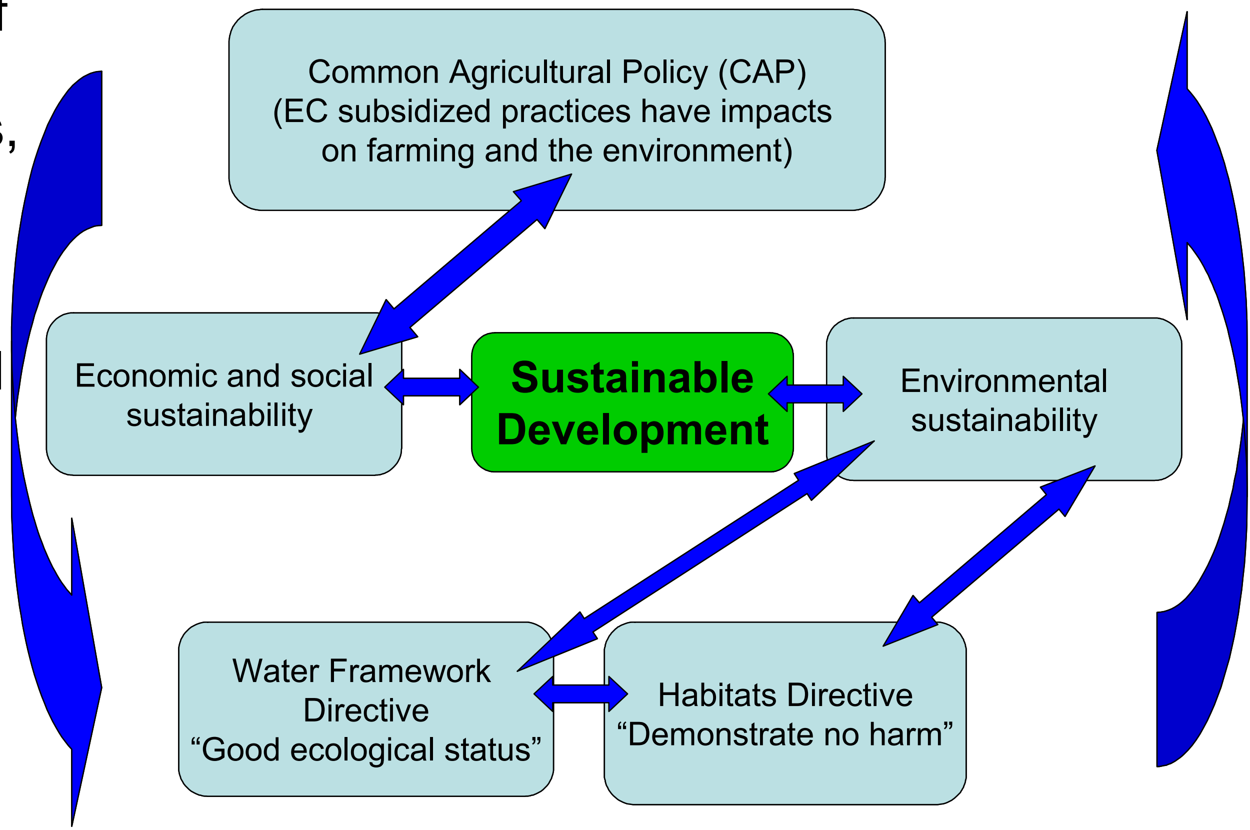
European Efforts are Ongoing to Address "Megasite" problems

- As in the US, the widespread, dynamic and multimedia aspects of these issues present cost and feasibility problems for most approaches
- Although treatment technologies exist, containment, source control and monitored natural attenuation are important parts of the remedial strategy
- Basin-scale and megasite models and frameworks are being developed to help identify and address the various interacting layers of these issues, and to facilitate decision making
- Successful strategies will require the creative collaboration of parties that generally do not work together
  - While cross-border issues make this more obvious in Europe, it is equally true for the US

Acknowledgements

- Portions of this talk were originally a white paper and presentation for SedNet Working Group 5 Workshop 2
  - Apitz, S. E. and S. White (2003) A Conceptual Framework for River-Basin-Scale Sediment Management, *Journal of Soils and Sediments, 3(3) 132-138*
- The authors acknowledge discussions with members of SedNet WG 4 and WG 5 and participants of the Holistic Sediment Management: UK Goals, Needs and Approaches Workshop
- Elbe case study from SedNet 2nd Annual Meeting in Venice
- Further information provided by Claudio Carlon and Heinrich Reincke

Economic and social issues with Environmental Implications



Environmental issues with Economic and Social Implications