Using Sediment as a Resource

Summary Report

Efficient use of resources and materials

Interreg
EUROPEAN UNION
2 Seas Mers Zeeën
USAR
European Regional Development Fund

Hoogheemraadschap van Schieland en de Krimpenerwaard

De Vlaamse Waterweg nv

Westcountry Rivers Trust

Brightlingsea Harbour Commissioners

ARMINES

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Introduction

The USAR project (Using Sediment As a Resource) aims to introduce technologies, methods and tools for the use of dredged sediments in novel ways by water managers across the 2seas area and beyond. This is a challenging aim because sediment is generally regarded as a 'waste' rather than a 'resource'. This summary report provides information on the outcomes of the project.

Key project outputs include three test pilots to validate new uses of sediments, an Inventory Catalogue (WikiSed) that collates possible uses of sediment, a Recycling Strategy that supports sediment recycling plans, and the Operational Sediment Management System (OSMS), an ICT tool that shows water managers how to use sediment as a resource!

In December 2014 five partners from four countries within the 2seas area set out to deliver this unique project, which was approved in March 2016.

Regional Water Authority of Schieland and the Krimpenerwaard	ARMINES Research Centre	Brightlingsea Harbour Commissioners	Flemish Waterways	Westcountry Rivers Trust

Contents

This document has been brought together by the partners working on the Using Sediment as a Resource project. USAR is an Interreg 2 Seas project, part-funded by the European Regional Development Fund under subsidy contract No 2S01-065, running from 2016 to 2020.

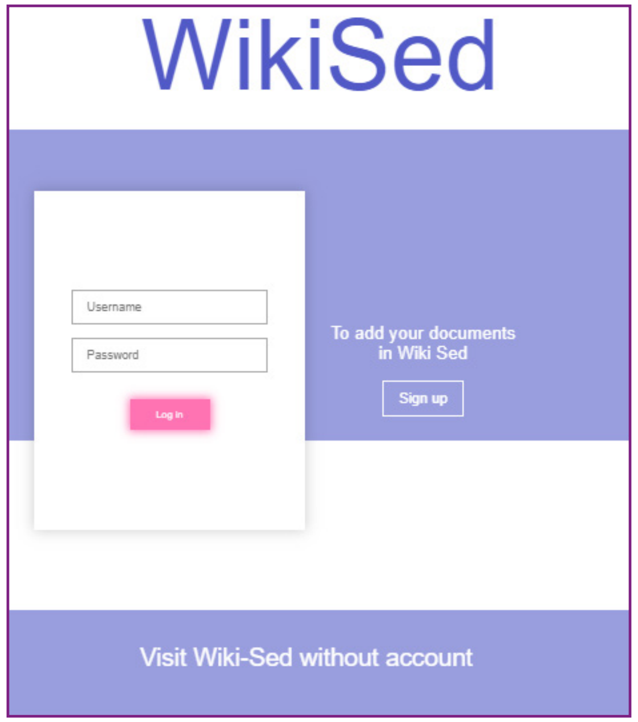
Tidal river Scheldt, extensive freshwater mudflats

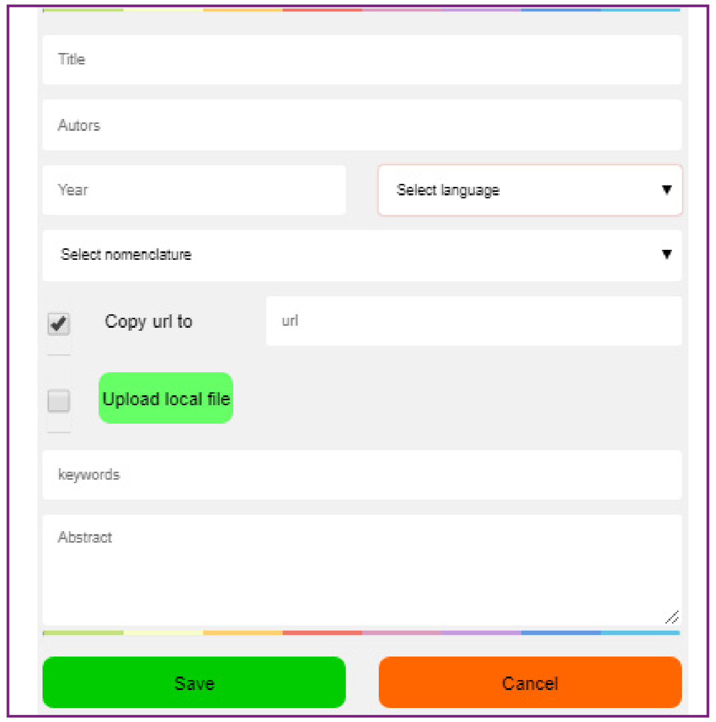
WikiSed

Introduction

The valuation of mineral materials from by-products of industrial or waste is in our society. This trend is particularly true in the context of building materials required in huge amounts annually. Moreover, the building materials have a strong development potential through specific applications leading to use of high performance materials, innovative with new features while having a controlled durability. Dredged sediments are one of the problematic waste that must be optimized for management and recovery.

For a few years' researchers and especially researchers from Armines carried out several research projects in order to find efficient solutions to the dredging sediments issue and to contribute to the promotion of their use as a resource. This implication is especially shown through the different collaborations at national, European and international levels between our research laboratory and the other scientific and industrial actors of the sediment theme and USAR project is the best illustration.





Problem

Research works shows that sediments can be used as secondary raw material in civil engineering applications, through adequate treatment. Many fields of valosization of dredging sediments were already investigated: sub-base materials for road construction, concrete, dikes, bricks and tiles, artificial and lightweight aggregates, etc.

Through USAR project, we created a numerical catalog making an inventory of all the works performed on the sediment materials. This numerical catalog constitutes a substantial source of open access documents. Through this data, we can gather a maximum of documents about dredging sediments and thus take part in the promotion of their reuse.

Case Study

WikiSed is a free numerical platform accessible via: http://wikised.phenixmat.com/

The aim of this application is to gather all the documents about sediments in order to build an extensive database accessible by researcher, economics and industrial actors. This numerical library is exclusively dedicated to sediments and their applications, from treatment to its use as resource.

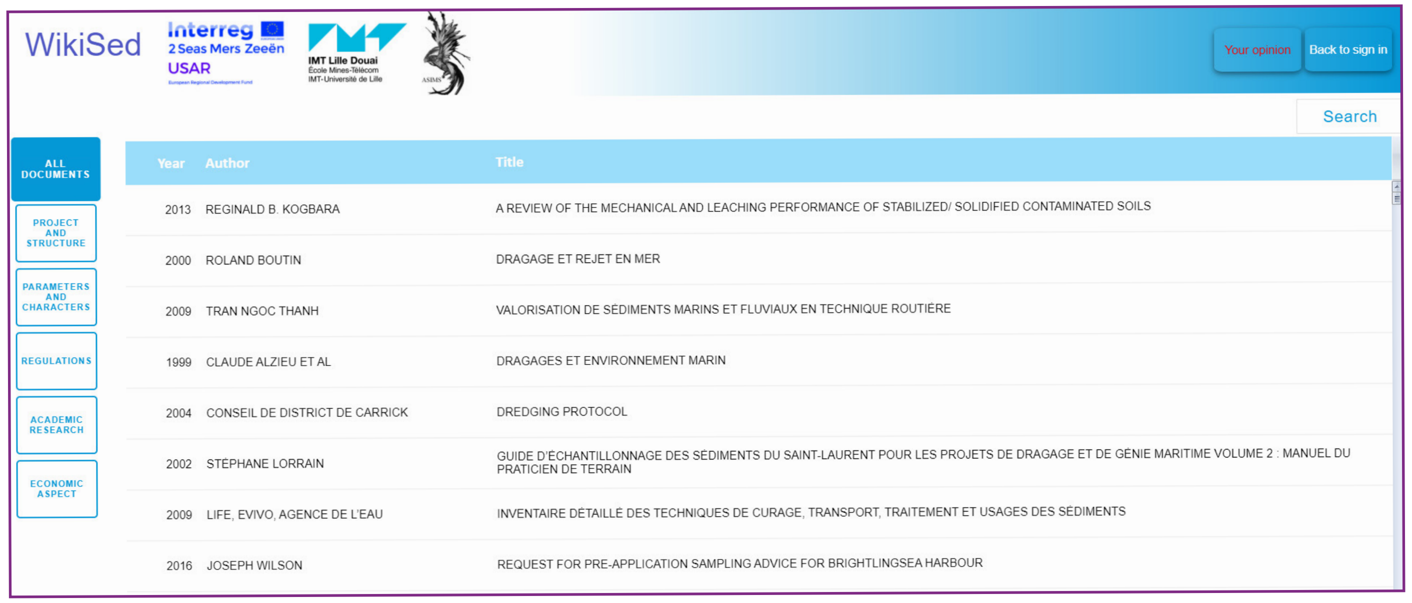
In order to contribute to WikiSed database, Armines started a significant work of research, census and classification of all the available documents concerning the management and the valorisation of dredging sediments. Some documents available on WikiSed are from the several former research works carried out within our laboratory, such as completed projects, research theses, scientific publications etc. However, the majority of the documents were collected through a thorough bibliographic search and a scientific watch.

References on WikiSed may be documents available online – thus searchable and freely downloadable in the database – but may also be searchable only if the document is not open access.

In WikiSed, documents are grouped into 5 categories:

- Project and structure
- Parameters and characterization
- Regulation
- Academic research
- Economic aspect

The grouping of documents into several rubric allows easily to find documents. Besides, documents may also be displayed in alphabetical order according to authors names or documents title.



Lesson Learned

As part of this work, Armines, in collaboration with the other USAR project partners, created WkiSed, which is a unique database related to the sediment issue. This database constitutes a substantial source of information, knowledge, consultation and sharing of documents dedicated exclusively to sediments. USAR project contributes through WikiSed to the promotion of the valorisation of dredging sediments.

Sediment Recycling Strategy

Introduction

A key aim of USAR is to test and develop ways of recycling sediment and using it in innovative ways. USAR will identify, demonstrate and test new methods and develop the business models and tools that water managers need to apply this circular approach in practice.

Currently, most dredged sediment is transported and dumped as waste, a very costly and wasteful operation.

This Regional Sediment Recycling Strategy builds on the work of all the USAR partners, and aims to provide a strategic guide to sediment managers across the Interreg 2 Seas region to help them consider options for more sustainable management of dredged material.

Policy

The use of sediment as a resource is inspired by the concept of a ‘circular economy’. A circular economy looks beyond the current linear system of ‘take, make, dispose’ to a system which is restorative and regenerative by design. Resources are kept in the system for as long as possible, reducing waste, minimising negative impacts, and building economic, social and natural capital.


Dredged sediment, a waste or a resource?

The Waste Hierarchy

The EU waste hierarchy sets out as a priorirty the prevention of waste, and the disposal as a last resort. For dredged sediment this approach hasn’t been fully adopted yet generally due to legilative hurdles.

Prevent
If you can’t prevent, then...

Prepare for reuse
If you can’t prepare for reuse, then...

Recycle
If you can’t recycle, then...

Recover other value
If you can’t recover other value, then...

Dispose
If no other alternative is available.

Prevention

The first stage of the waste hierarchy is to prevent that a waste is created. In the case of sediment, in some scenarios, this means keeping the material on the farmland, through catchment management and good soil husbandry. There are many other scenarious where sediment enters a waterway.

Small particles of sediment, like sand, silt and clay, tend to be the most problematic for managers of ports and estuaries, as it is at this point when the water travels slowly enough for this sediment to settle out of the water. As it has travelled in suspension, the sediment may have been generated a long way from where it becomes a problem. In some cases across Europe, sediment may have originated in neighbouring countries or even further afield.

Therefore, organisations responsible for keeping ports and estuaries clear of sediment should consider where it has originated from, as there may be opportunities to work with stakeholders across the catchment to reduce sediment inputs. This could reduce the level of management required at the estuary.

Treatment

When sediment is dredged from a waterway, it is rarely in a suitable state to be reused, there may be issues in its physical composition or with chemical contamination, which mean it needs treatment to allow its beneficial reuse. Often, these treatment processes account for large proportion of the cost of a project involving beneficial use of dredged sediment.

Reuse

The next stages of the waste hierarchy, if prevention is not possible, are to reuse or recycle the waste material. This is the focus of the USAR pilot projects. Just a few options for beneficial use of sediment include: agriculture, construction (stabilisation and solidification), habitat creation and flood defence. The test pilots of the USAR partners have explored these solutions in their project area.

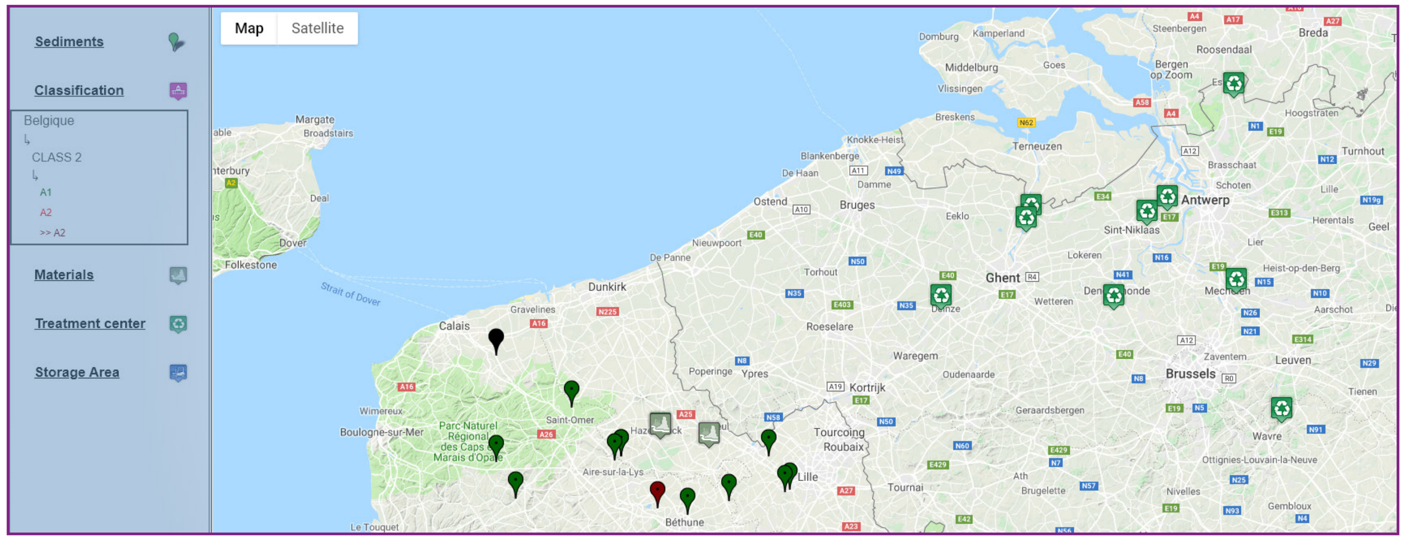

Treated dredged sediment being placed for a flood embankment for test pilot De Vlaamse Waterweg nv

Operational Sediment Management System

Introduction

In France, more than 50 million m^3 of sediments are dredged every year. Dredging operations are necessary to maintain sufficient water depth for navigation in ports and waterways. The management of dredged sediments can be problematic because of the large dredging volumes and their environmental impact. Therefore, the sediment-related environmental emergency has become a necessity and needs to be addressed in order to find alternative solutions to traditional management methods, such as dumping and storage.

Armines, through its Civil Engineering laboratory, has been working on the dredged sediments issues in order to develop innovative and eco-friendly solutions aiming at fulfilling the different constantly evolving socioeconomic requirements.

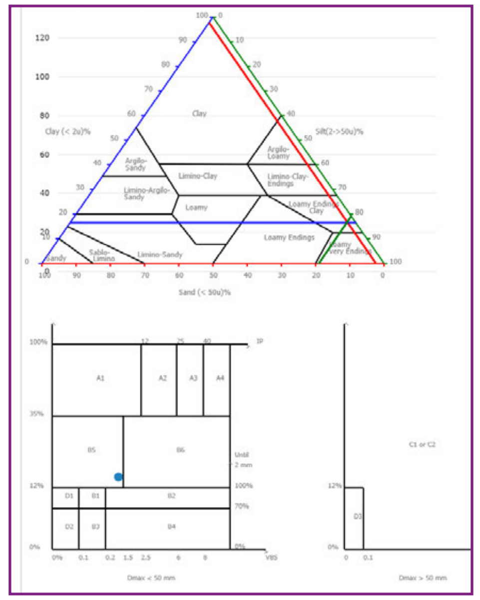


Problem

According to directive no. 2002-540 of April, 17, 2002, dredging sediments are considered as waste as soon as they are managed on land. Several ways of valorisation of sediments were developed in civil engineering, however, their use raises several socioeconomic and environmental challenges which limit it. The solution which allows to overcome these challenges is to predict the behaviour of works that incorporate sediments. The use of numerical tools seems to be a major asset, in this context IMT Lille Douai worked, in collaboration with other partners from USAR project, on the development of a numerical tools: Operational Sediment Management System (OSMS) in order to bring innovative solutions up to the challenges encountered nowadays.

Case Study

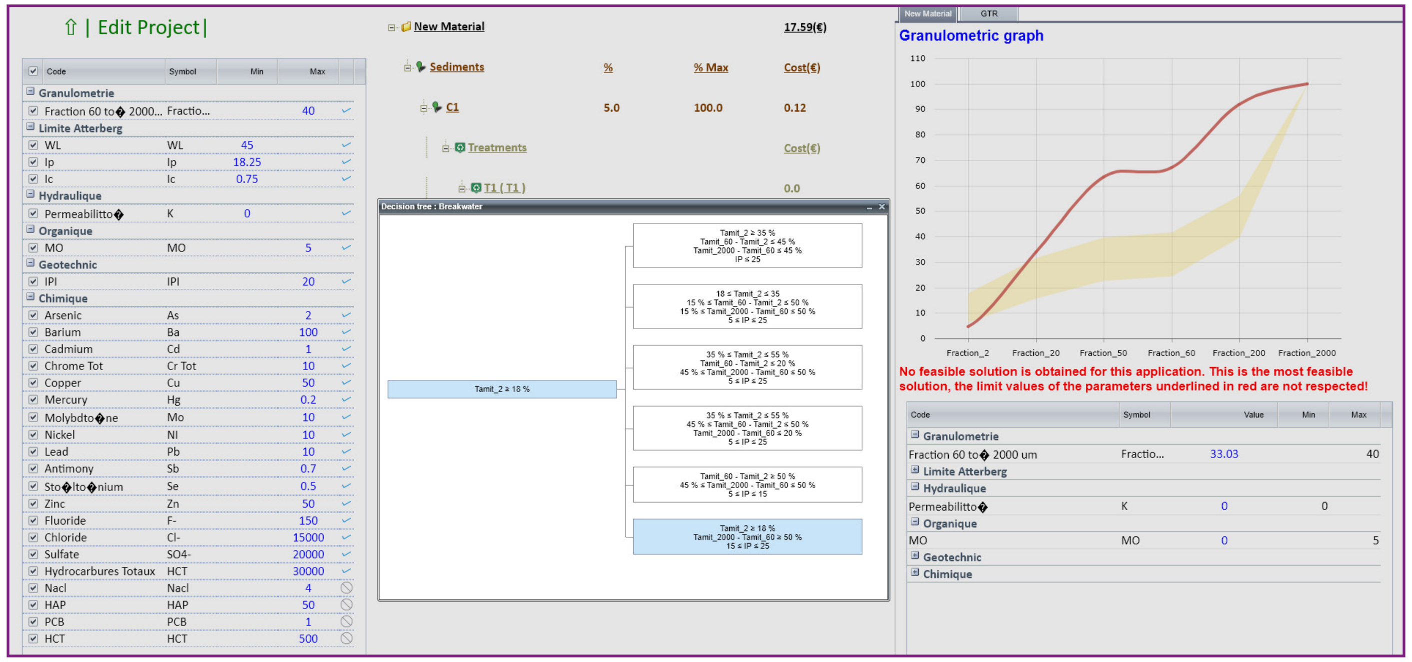
OSMS was developed to allow the optimization of the formulation and the treatment of dredged sediments by performing technical, environmental and economic analysis. The four areas concerned in this work are: road application, concrete, dike and spreading. The purpose of the OSMS software is to propose an optimal solution that meets the different technical and environmental requirements at a lower cost.



In order to reach this goal, for each application, constraints linked to the sizing of the works and materials used for each type of work were defined. (For example, to use a sediment for a road layer, it has to have a compressive strength of at least 1 MPa, and amongst the conditions of use, the organic matter content MO has to be less than 3%.) These technical and environmental constraints are modelled as mathematical equations and are then implemented in OSMS software.

Sediments and their parameters are imported into the software as an XLS file. Other materials such as sand or gravel may also be introduced into the software. OSMS allows, thanks to geolocation, displaying of sediments on a map in order to visualize them, as well as the other materials. It is also possible to add one or several classifications of each sediment. Treatment centres are inserted into the software in order to take into account possible treatments of the sediments. The geolocation of each centre, the cost of each treatment, as well as the impact of the treatment on the sediments' parameters are also introduced. The location of storage centres, as well as storage costs, are also information that the user could indicate in the software. The geolocation allows to compute the distance between each treatment centre, storage centre and location of materials (sediments and quarry) and to introduce the transportation cost into the optimization process.

Thanks to all of this information, OSMS can simulate a project computation for the four previously cited applications (route, dike, concrete and spreading). The optimal solution proposed by the software will be a new material composed of an optimal mixture of sediments and materials chosen for the project. The cost of each operation (dredging, treatment, transport, etc.) is detailed in the display of the optimal solution and the global cost of the operation is also indicated.



Lesson Learned

Given the complexity of the issue of dredged sediment management, it is necessary to have a decision support tool in order to guide the valorization domain efficiently. OSMS is a numerical tool at the heart of this procedure for dematerialisation and exploitation of numerical and IT means for the development and the promotion of the valorisation of dredging sediments.

Het hoogheemraadschap van Schieland en de Krimpenerwaard

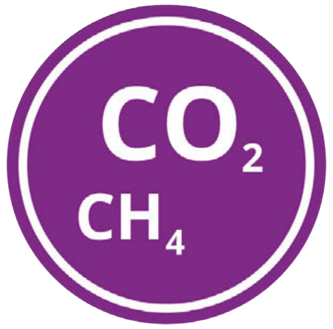
Introduction

The Water authority of Schieland en de Krimpenerwaard (HHSK) is responsible for managing quality and quantity of surface water in an area that includes a large part of the city of Rotterdam and surrounding areas with a more rural character. In order to manage an extensive network of waterways and keep them free from accumulating sediments, to reduce risks of flooding, maintain the quality of the water and to keep waterways accessible for water-based (recreational) transport HHSK has to dredge them.

150,000 cubic metres of maintenance dredging

Area of HHSK below sealevel -2 up to -6,7 mNAP

Subsidence continues (10-50cm before 2050)



GHG-emmissions due to peat oxidation in NL is equal to the exhaust of 2 million cars

HHSK dredges approximately 150.000 m^3 of sediment per year.

A high percentage of the dredged sediment is transported and dumped as waste - a very costly and wasteful operation. Today many techniques and knowledge are available on using sediment as a building material. We want to make this available so that our sediment can be used as a resource. Large areas of peatland in Dutch polders are oxidising and compacting. This results in the last decades in lowering land elevation with big consequences for water management, biodiversity, economical and ecological utility and GHG-emissions. We asked ourselves: Can't we use our sediment to counteract this problem!?

Managing organic waste streams

Case Study

In the USAR project, HHSK wants to test a circular application with a pilot in the Krimpenerwaard in which we process three local specific residues – sediment, manure and green waste – into a locally applicable product. In the project we want to test the practical applicability and effects of this new resource material on the soil conditions in different plots.

We reduce waste streams and we tackle the problem of soil subsidence in our peat pasture areas. Which has a major impact on the water management and use of the area. We are committed to improving and contributing significantly to the reduction of CO_2 emissions.

With the use of renewable resources, we can make a major contribution to a circular biobased economy:

- Reduce waste streams and volume of recycled sediment
- Devalue organic waste streams
- Counteract soil subsidence
- Reducing greenhouse gas emissions

Dutch polders; extensive peatlands

Lessons Learned:

Waste legislation remains a barrier for the circular economy and sadly this caused this opportunity of innovative solutions to be missed as part of the USAR project. The teams keep searching for innovative solutions; redefining the concept of waste.

Dredging taking place on the Dutch Polders

De Vlaamse Waterweg nv

Introduction

The Flemish Waterway manages more than 1000 kilometers of navigable waterways in Flanders, Belgium. Amongst others, the organization is responsible for watersafety. The maintenance of a river by means of dredging works is needed to guarantee the storage capacity of the river. Controlled flood areas and areas subject to depoldering, give space back to the river and protect Flanders against high water levels as a result of storm tide. Together with the increase of the crest level of more than 500 kilometer of embankments, all these measures together comprise the flood protection programme "Sigma Plan".

Within the USAR-project in the Durme Valley, The Flemish Waterway examines how polluted sediment can be used as a resource for the construction of embankments. Although many studies have been conducted on the topic, there is a limited amount of practical examples. Sediment with a high fraction of sandy material has a wide application. Reusing sediment with a high level of clay particles and especially from sites with historical pollution, is still a challenge.

The embankments within the USAR project need to be able to deal with the pressure caused by tide differences, since the Durme is a tributary of the Scheldt, which on its turn leads to the North sea and its tides. Tide differences are impressive in the Scheldt river basin. As far as 100 kilometers inland, there still exists an amplitude (difference between low and high tide) of 7 meters at spring tide.

Maintenance dredging on the tidal River Durme (copyright @Vilda)

Case Study

The Flemish Waterway will dredge 260.000 cubic metres of sediment from de river Durme and use it for the renovation of a flood area alongside the Durme. Simultaneously fresh water mud flats and marshes – being very rare in these parts of Europe - on the river banks will be restored. An extensive geotechnical and environmental research on the quality of the sediments in the Durme was carried out beforehand.

While dredged sediment typically is considered as a waste, a different approach is key within this USAR project. This method of reusing dredged sediment has advantages and limits.

Method:

Dehydration of the sediment

Blending with other materials

Immobilisation of contamination

Construction of embankments

Advantages

- ► Much less transport is needed than while constructing embankments in the traditional way with materials provided from furrows far away.
- ► Less primary resources are needed. Sand usually needs to be mined from quarry ponds. Clay and quarry-stone are supplied from furrows.
- ► The dredged sediment does not need to be transported to a landfill site for storage. Such dumping grounds tend to generate a lot of hindrance, since the sediment can provide a lot of dust, causes bad smells and a lot of truck traffic.

Limits

- ► Dredged sediment does not have the same characteristics as 'pure' materials, as it has remained in the water for many years. To turn sediment into materials which are suited to construct embankments means a technical challenge.
- ► Timing. As the dredged sediment will be used for constructing an embankment, the moment of dredging and construction needs more or less to coincide.
- ► Pollution with mineral oils and heavy metals. We need mobile installations to purify the sediment on the site, to avoid transportation to a purification center far away.

Taking samples of dredged sediment in the river Durme (copyright ID Photo Agency / Daniel Geeraerts)

Westcountry Rivers Trust

Introduction

The Westcountry Rivers Trust undertake a wide range of activities across the South West of England to enhance and protect the regions rivers and streams. Our rivers are influenced by the land around them, so a large part of our work is spent with farmers and other landowners helping them to manage the land in a water sensitive way.

Within the USAR project, Westcountry Rivers Trust have developed a Sediment Recycling Strategy – aimed at helping sediment managers understand how to prevent sediment erosion and contamination with particular reference to agriculture, legacy mining, forestry operations and highways.

Working with partners spanning from source to sea

A typical sediment trap can capture 10 cubic metres of sediment each year

Globally, an estimated 75 billion tonnes of soil are lost each year, much of it via run off to rivers

1cm of soil forms over several hundred years, it should be considered a non-renewable resource

Soil is a finite resource; we need to keep it on the land.

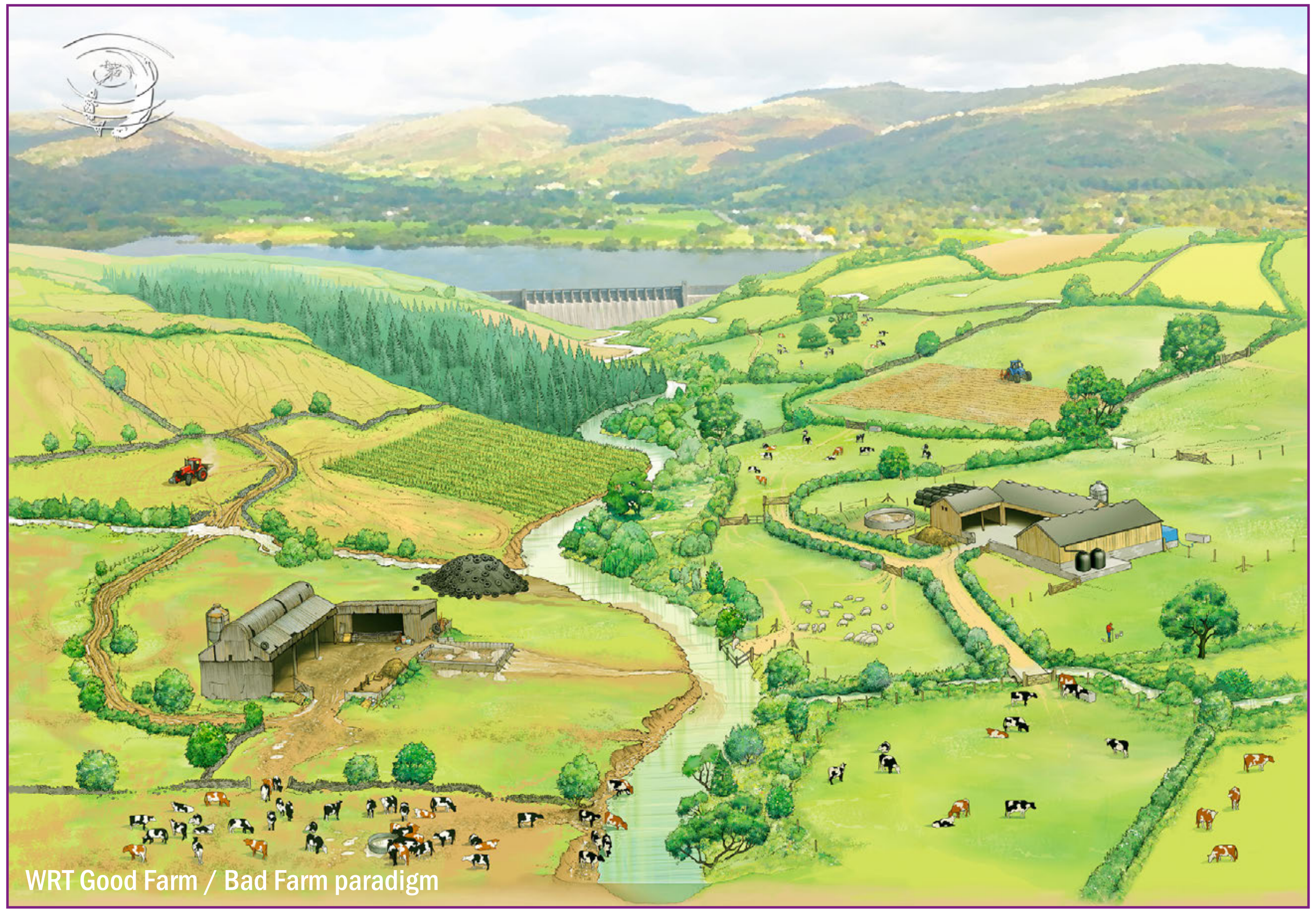
It takes many hundreds of years for nature to create just a few centimetres of topsoil, yet each time it rains tonnes and tonnes of soil is washed into our rivers on a one-way trip to the sea. This soil carries with it other pollutants such as pesticides and nutrients from agriculture, toxic metals from exposed mine spoil heaps and fuel, oil and other contaminants from our roads. Even fine sediment on its own clogs river gravels leading to low oxygen levels for invertebrates and fish spawning.

Intertidal River Fowey, extensive sediments

Case Study

In the USAR project, WRT are responsible for developing a strategic approach for reducing sediment erosion from the landscape and for minimizing contamination of that sediment by toxic chemicals. This ‘Smart Sediment Management’ approach involves assessing river catchments using geographical information systems (GIS) and detailed data layers such as topography, soil type, pollution sources and catchment assets to determine likely sources of sediment and contamination. By identifying these areas we can then propose land management solutions that will either reduce sediment erosion – keeping soil on the land, improving river health, reducing the need for dredging in downstream harbours and estuaries; or reducing the contamination levels of sediment, so that when it is removed from the watercourse it is easier to reuse.

One example was the creation of a sediment trap at a farmyard in the River Lerryn catchment. In heavy rain the farmyard was funneling fine sediment onto a road and then into the river, where it would accumulate in Fowey Harbour. A simple arrangement of two pits in series captures this sediment laden runoff. The farmer can empty the pits each year and recover 10 tonnes of material for use on his land without it entering the waste stream.



WRT Good Farm / Bad Farm paradigm

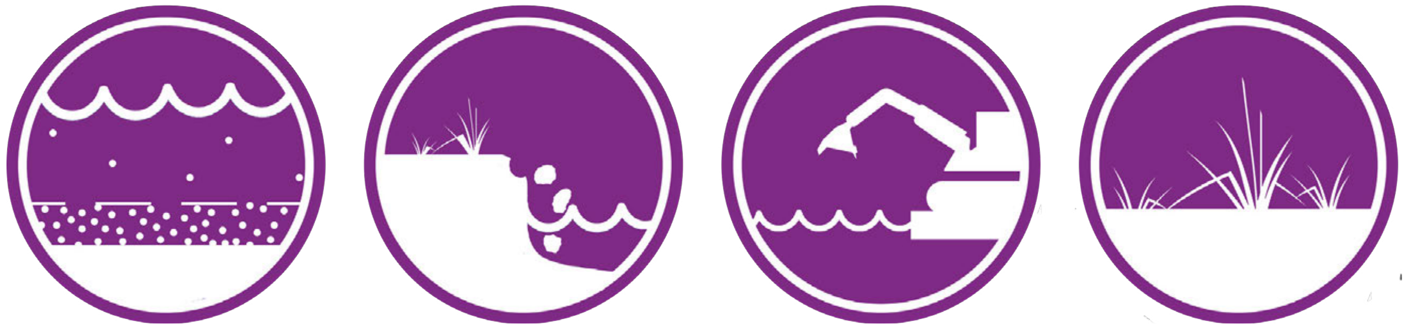
Lesson Learned

Sediment erosion and contamination of sediments is not a problem that can be solved overnight. There is no magic solution that can be applied easily, everywhere at once. It is instead a ‘diffuse pollution’ issue with thousands of small sources distributed all over the landscape. Through the use of sophisticated mapping and modelling techniques we can identify which parts of a catchment are most likely to contribute more of their fair share of sediment and/or contamination. With these ‘high risk’ areas identified; it is easier to direct remediation efforts to where they will have the greatest impact.

Brightlingsea Harbour Commissioners

Introduction

Brightlingsea Harbour is situated on the Colne Estuary in Essex, UK. This historic port dates to the 15th century and with Cinque Port designation, Brightlingsea has had an active role most notably during WW2. Today, the harbour is a small mixed leisure and commercial port. Due to its tidal nature and geomorphology, accumulation of marine sediments is an ongoing issue. The intertidal zone provides a rich habitat for wildlife attracted from as far as Africa, the Baltic and Canada for summer breeding and overwintering refuges. The harbour now turns the accumulating sediment into a resource that benefits wildlife and coastal defences through the USAR project.



Brightlingsea Creek accumulates 0.5 metres of sediment per year	3.5 ha of saltmarsh has been lost to erosion in the last 60 years	35,000 cubic metres has been dredged in order to maintain safe navigation	3 ha of saltmarsh has been directly created, restored or improved

Before USAR (2016), deep drafted vessels had to wait in the approach channel for suitable tides before entering.

The sedimentation had a significant impact on the navigational access and safety, especially for cargo ships in excess of 80 metres shipping cement, aggregates, scrap steel and wood chip. UK Coastal management strategies focus resources on populated and economically thriving areas, whilst remote communities are less of a priority. Local authorities must develop their own coastal defence strategies if they wish to maintain the current topography. Applying Working with Nature philosophy, dredged sediment can be used in coastal defences.

Filling restoration compartments with dredged sediment
(©Exo Environmental)

Case Study

The USAR project has dredged over 35,000 cubic metres of sediment (14 Olympic sized swimming pools) from navigational channels in Brightlingsea harbour. This sediment has been used to restore 3 hectares of intertidal mudflat and saltmarsh, which involves bolstering 2.8km of coastline.

Sediment was mechanically dredged and transported by shallow draft barge, and hydraulically pumped to the reuse sites spread out throughout the harbour. The reuse sites were determined via historical analysis of RAF images dating back to 1947, that assessed where saltmarsh has been lost.

Saltmarsh vegetation functions as an upside-down broom where the vegetation (bristles) slow waves down. This wave attenuation means that coastal defences can be smaller if there is a substantial (100m) saltmarsh protecting them. The reduced water velocity also causes sediment to drop out of suspension and settle on the marsh. This results in the saltmarsh growing in elevation at a rate that matches sea level rise. This nature-based solution allows coastal communities to adapt to climate change, without using virgin resources to improve coastal defences.

The USAR pilot in Brightlingsea proved that waste sediment is suitable for habitat restoration and that this nature-based solution can be adapted anywhere in the world.

Preserving:

70,000 tonnes of aggregate

5,400 homes from flooding

Supporting:

12 species of nationally scarce plants

38 specifies of vulnerable invertebrates

83 species of birds


Pumping dredged sediment
(©Exo Environmental)

Lessons Learned

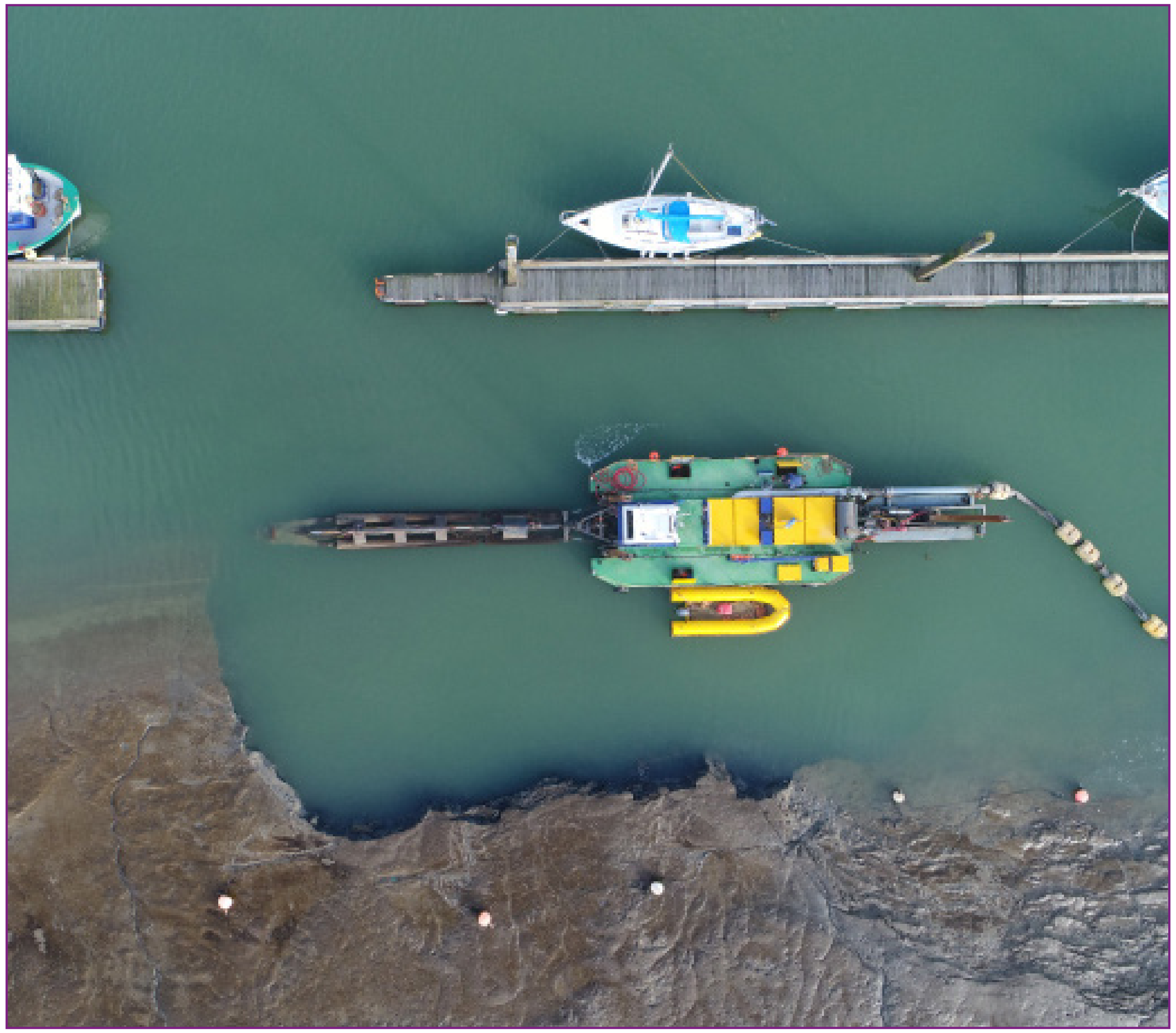
- Licences and permits for a nature-based project in a sensitive and heavily protected area are very complex and costly and they require continuous environmental monitoring.
- Consultation with members of the public and stakeholders is essential for success.
- The intertidal nature of the environment makes work on site complex and potentially risky However, tidal changes also provide an opportunity and in Brightlingsea were used to enable transport of the sediment to extensive and otherwise inaccessible mudflats and saltmarshes.
- A wide range of techniques for dredging and preparation of reuse sites is essential. Mechanical as well hydraulic dredging equipment allowed completion of the specific phases of this pilot.

Summary

The USAR project (Using Sediment As a Resource) has jointly developed technologies, methods and tools for the use of dredged sediments. These were introduced and demonstrated to water managers across the 2seas area and beyond.

Although innovative methods and unique breakthroughs were delivered, the reuse of sediment as a resource remains challenging due to the legislative barriers. Efforts continue to be made to change mindsets from regarding sediment as a waste, towards a resource with potential end products with a monetary value.

The USAR outputs as described in this report are publicly available for all water managers and engineers to adopt into their routines. Future solutions to a sediment management problem can be developed with ease due to the tools and methods made available by the USAR project.



What did we learn?

By employing the waste hierarchy, that prioritises prevention of sediment entering waterways a potentially becoming a waste, problems can be negated at an early stage. If sediment is present within a water course, the tools and methods developed within the USAR project can be employed to establish recycling and reuse plans. Depending on the type of sediment and the local environment, this can be delivered through habitat creation, agricultural spreading, construction, flood defence works and much more.

The USAR partners welcome future collaboration and further development of methods and technologies, based on the USAR results. We look forward to hearing about your solutions!

Interreg
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