GREEN INFRASTRUCTURE IN-DEPTH CASE ANALYSIS

THEME 4: FRESHWATER AND WETLANDS MANAGEMENT AND RESTORATION

Author: Leo De Nocker, leo.denocker@vito.be, +32 14 335511
Contributing author: Leonardo Mazza (IEEP)

1 Introduction

This case analysis file is concerned with Green Infrastructure policy initiatives related to freshwater and wetlands management and restoration. Rivers are like arteries for healthy ecosystems, cities and economies and the good status of water bodies is essential for man, flora and fauna. Green Iinfrastructure and the ecological status of water bodies are interlinked in a complex and dynamic way: good status of water bodies (quality and quantity) and related ecological processes is a prerequisite for adequate and efficient protection of habitats and species. But at the same time, the provision of adequate Green Infrastructure (quantity and quality) is an important instrument to achieve a good (ecological) status of water bodies.

The relevance and importance of wetlands for the wider functioning of ecosystems and protection of biodiversity is well illustrated with the concept of ecosystem goods and services. It is well documented that wetlands provide a number of regulating services and that they contribute to solving important environmental problems like water quality, eutrophication, water quantity management (flooding and drought), carbon sequestration and climate regulation. These services can be important in economic terms because they help to avoid expensive measures in different sectors to deliver similar services. Studies have shown that the economic value for society per ha of wetlands can be important and be at least as high as private economic or commercial values of other land uses (Constanza et al., 1997; Brander et al., 2006). In addition they offer direct biodiversity benefits for habitats and nurseries and play an important role in the food web. Although the importance of wetlands is well documented and studied, there is less experience with wetland restoration and its costs and effects.

Another Green Infrastructure element is related to ensuring ecological continuity along the rivers, which may require that dams are adapted or removed in order to allow migration of fish up- and downstream in rivers. In addition, Green Infrastructure elements related to natural riverbanks, wetlands and natural areas contribute to a continuous provision of nurseries, provision of food and shelter for fish and other species.

Rivers are also important to man and the economy, both for attractive cities, navigation and trade, supply of water and drainage. The good status of rivers will deliver many benefits to society, including avoided costs from floods and droughts, amenity benefits for recreation and people living near the rivers. On the other hand, competition for land may be high, and it is important to document the experiences and benefits from freshwater- and wetlands-related Green Infrastructure projects.

River and wetland restoration is an important element for the implementation of the EU Water Framework Directive (WFD) and to ensure the good status of water bodies. The WFD stresses the importance of wetlands as an integral component of river basin management. The deterioration of wetlands is for some water bodies one of the reasons for the degradation of water quality (due to higher rates of erosion and less nutrient retention), the decline in coastal and riverine flora and fauna populations, the decline in groundwater levels and an increase in flood risks. So wetlands are also important for protection, whereby measures are taken to prevent deterioration (i.e. a maintenance measure). This is relevant for flood plains and wetlands and their benefits for water management, adaptation of dams to ensure fish migration and the use of Green Infrastructure to ensure ecological continuity.

In the past, the importance of riverine Green Infrastructure was not fully accounted for in decision-making. Past river management in Europe has drained flood plain wetlands and isolated rivers from their flood plains. As an example, it is estimated that 68% of the flood plains along the Danube have been lost (WWF, 2010). Fortunately, things have changed and modern thinking about water management is that rivers cannot be managed in isolation from their flood plains, and rivers and their flood plains cannot be managed without balancing the demands put upon them by agriculture, industry, nature conservation and other interests (European Commission, 2011a). Today, river restoration is widely accepted in Europe as an effective way of alleviating both water quality and flooding problems. Many projects in Europe have been undertaken and supported by EU funds (LIFE, Phare, Tacis). Some examples are listed below, and the name of different projects clearly indicates that the common denominator is to give more room to the river. Examples include 'Space for the River' in the Loire/Allier, integrated development and management of the Saône Valley, Room for the River in the Rhine Delta, Making Space for Water in England, flood plain restoration along the river Tisza and Coastal Flood Plain Restoration on Freiston Shorein England.

For this in-depth analysis, three programmes have been selected that are very different in terms of the size of the projects, the natural conditions (coastal and inland rivers), the policy or management plan, the socio-economic context and the costs of the projects (per ha). The examples share similar types of benefits, although their relative importance differs depending on the context.

The lead example selected for the analysis relates to the Sigma Plan II in the Scheldt Estuary. It is a good example of the need for Green Infrastructure to meet the ecological restoration objectives for a modified river system, which is under high pressure from many human activities. It also illustrates that the use of Green Infrastructure to combine flood protection with nature restoration is a cost-efficient of improving the protection of Natura 2000 areas and to contribute to the achievement of the good conservation status required by the Habitats Directive and the achievement of good status of water bodies required by the WFD. This results in economic benefits in terms of avoided costs for water management and improved possibilities for recreation. Third, it also illustrates how Green Infrastructure can contribute to the management of transboundary rivers. The costs and benefits of the plan are also well documented.

The second example relates to the Lower Danube Green Corridor and is similar to the main example in terms of using Green Infrastructure (wetlands) with multiple benefits (flood protection and nature restoration) in an international river basin, but both the size (160,000 additional hectares compared to 5,000 ha in the Scheldt) and socio-economic context are very different. The benefits are well documented, with interesting comparisons with the lead case.

The third example relates to innovative measures to ensure enhanced/continued ecosystem service delivery from freshwater ecosystems in France. The focus of this example is the adaptation of infrastructure (dams) in the river and restoration of wetlands. It is complementary to the other examples since it illustrates the importance of Green Infrastructure for ecological continuity and indicates the positive benefit-cost ratios for areas with much lower costs and situations where flood safety benefits are not (or less) dominant.

2 Overview of Initiatives

2.1. Lead Initiative: Sigma Plan, Scheldt Estuary, Belgium

The Sigma Plan II refers to a long-term strategy and list of projects to manage flood protection and nature restoration of the Scheldt estuary in Belgium. It includes a series of projects in the short and longer term (2006–2030) to restore flood plains, estuarine nature and wetlands along the Scheldt and its tributaries. It will lead to 5,000 ha of extra natural areas, which is a very significant contribution to the natural areas required for ecological objectives and to ensure adequate protection and restoration of estuarine processes necessary for protection of habitats and species. Although the Sigma Plan II refers to projects in Belgium, it is part of the transnational (Belgium-Netherlands) long-term vision for the Scheldt estuary in 2030.

Compared to, for example, the Danube programme, the size of the programme is small but the costs are relatively high. The costs expressed in euro/ha are high, because of the specific conditions (creation of estuarine nature along a tidal river), as are the benefits related to flood protection. The costs of the project up to 2030 are significant (€500 million) but the expected flood protection benefits (€740 million) guarantee a positive, net economic effect. Implementation is just starting.

2.2. Secondary Initiative I: Lower Danube Green Corridor

The Lower Danube Green Corridor Agreement was signed in 2000 by the governments of Romania, Bulgaria, Ukraine and Moldova. It is a large-scale initiative which aims to coordinate biodiversity conservation and water management efforts between several countries along the Lower Danube river basin, including Bulgaria and Romania. It particularly aims to ensure the conservation of wetlands and the management of flood plains through a system of protected areas (the Lower Danube Green Corridor), which will be connected ecologically and economically to several existing Natura 2000 sites. The network includes areas that are strictly protected and areas where economic activities are possible, with buffer zones in-between.

The signatory countries to the Lower Danube Green Corridor Agreement have committed themselves to establish the Lower Danube Green Corridor composed of a minimum of 1 million ha of existing and new protected areas) and 223,608 ha of areas proposed to be restored to natural flood plain. 50,000 ha have already been implemented.

The benefits are very diverse and well studied. The initiative shares with the lead example the important benefits related to flood safety, nutrient retention, biodiversity and recreation. In addition, this initiative Illustrates the importance of wetlands for increased natural resource productivity (fish stocks, reed beds and grasslands) and for diversification of local livelihood strategies. There is, however, not enough information to compare the cost-benefit ratios. Whereas the lead example shows the benefits of wetland restoration in a highly developed region, this example shows the benefits for less developed regions.

2.3. Secondary Initiative II: Innovative measures to ensure enhanced/continued ecosystem service delivery from freshwater ecosystems, France

The projects refer to the implementation of the Grenelle II law that establishes a multiannual programme for the restoration of the ecological continuity of water bodies (art. 132) (*continuite des ecosystemes d'eau douce*), (*maintenir une couverture vegetale permanente*) and the conditions for the purchase and sustainable management of wetlands by public authorities (art. 133) (*preservation* *des zones humides*). They can be seen as a relatively consistent set of measures to make optimal use of a range of GI elements to deliver ecosystem services and benefits.

The provisions are new and implementation is starting. Costs and benefits are well documented. This initiative focuses on the importance of Green Infrastructure and ecological continuity to achieve good ecological status of surface waters and illustrates additional benefits related to reduced drought risks and angling. Whereas the lead example shows a positive benefit-cost ratio for situations where wetland restoration requires many, complex and expensive infrastructure works to ensure the flood safety benefits, this initiative shows positive benefit-cost ratios for more targeted investments with much lower costs and high benefits despite the comparatively more limited importance of flood safety benefits.

3 Sigma Plan, Belgium

3.1. General Background Information

The updated Sigma Plan II refers to a long-term strategy and list of projects to manage flood protection and nature restoration of the Scheldt Estuary in Belgium. It includes a series of projects in the short and longer term (2006–2030) to restore flood plains, estuarine nature and wetlands along the Scheldt and its tributaries, affecting 200 km of watercourses in Belgium (see Figure 3.1.1). The Sigma Plan II is closely related to the vision and plans for the whole Scheldt estuary, but refers to the projects in Flanders (Belgium)(with the exception of one transboundary a project nearby Saefthinghe (Hedwige Prosper, see 3.2 below).

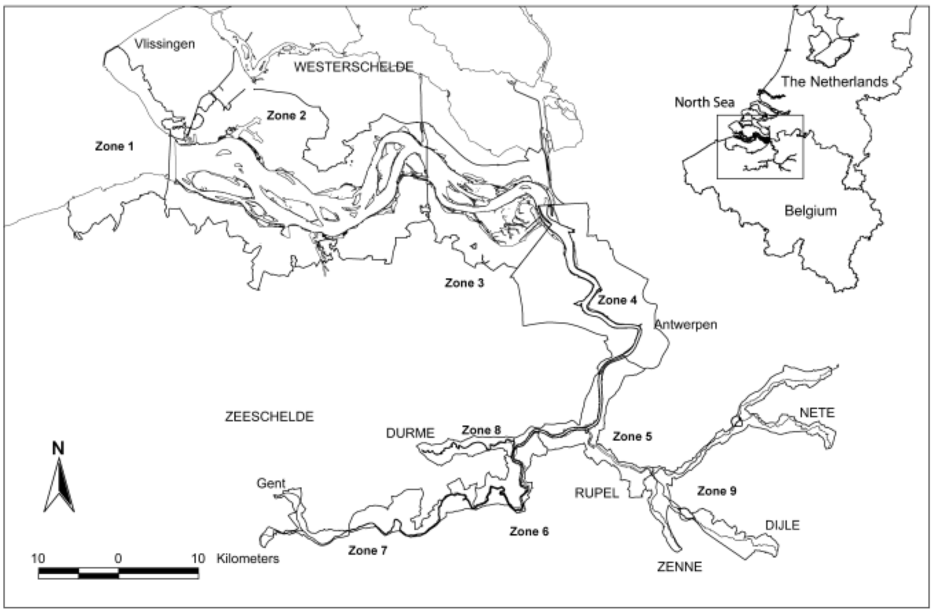

Figure 3.1.1. Map of the Scheldt estuary and tributaries to the Scheldt (Van den Bergh, 2005).

As illustrated in Figure 3.1.2, the Sigma Plan II originated in two policy challenges related to flood protection (left part) and nature restoration (right part) (Dauwe, 2010; Van Daele, 2007; IMDC-Arcadis, 2008). First, it is an update of the Sigma Plan I of 1977, which was a Belgian policy response to major floods in the Belgian Scheldt estuary in 1976. The update was considered necessary given the low level of protection following the implementation of the Sigma Plan I and higher risks following climate change, while also accounting for the new challenges and concepts for integrated river management and recreational use of the river. Second, it originated in the context of the development and implementation of a transnational long-term strategy for the Scheldt estuary, which focused on an integrated strategy for improved navigability, nature protection and flood safety in the Scheldt estuary (Western Scheldt in the Netherlands and Zeeschelde, the tidal part of the Scheldt river in Belgium). The Belgian-Dutch transnational long-term vision for the Scheldt estuary (LTV, 2001) is a basic guiding document that links objectives related to shipping, flood safety and restoration of estuarine nature. These objectives were made more specific in the development plan for the Scheldt estuary in 2030 which was approved by the Flemish government and the Dutch parliament and approved by both countries. The long-term vision envisages a healthy and dynamic estuarine ecosystem with the target year of 2030. This target refers to EU directives related to biodiversity and habitat protection as a basis for social recognition and establishment of the unique values of the estuary from the mouth to Gent: "As one of the most important estuaries with a full ebb and flood regime and complete freshwater to saline gradient in Europe, the estuarine ecosystem, with its typical habitats and communities along the salinity gradient, is preserved and where possible, strengthened."

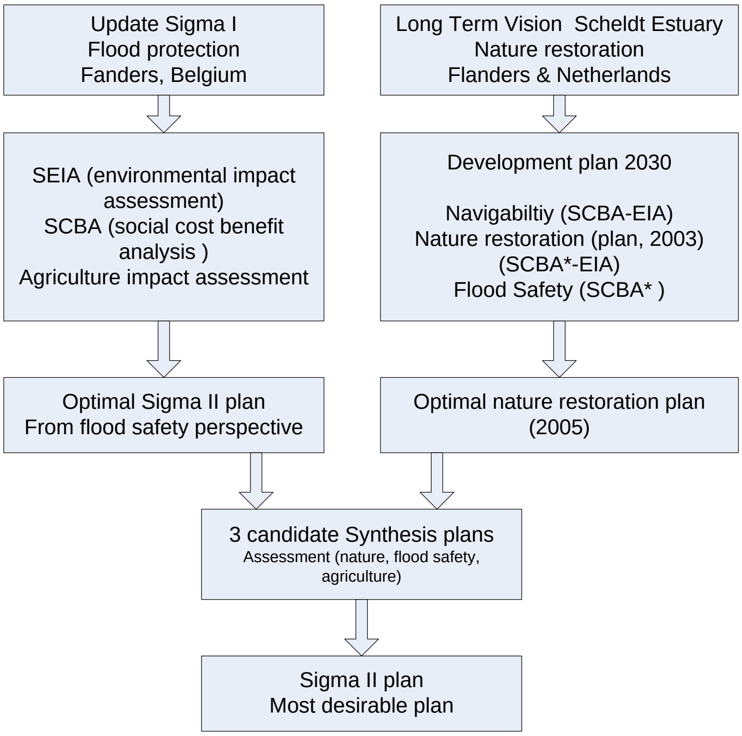

Figure 3.1.2. Overview of the pillars of the Sigma Plan II (based on Van Dale, 2007).

The Sigma Plan II was adopted in a stepped series of decisions, which reflected new directions for both the transnational management of the Western Scheldt and for the management of the Scheldt estuary in Flanders. (A full description is given in IMDC-Arcadis, 2008.) The Flemish government decided in 2004 on the main orientation of the Sigma Plan II, i.e. flood safety based on a combination of higher dykes with flood plains and wetland restoration. In a separate track, the long term vision and plan for the estuary was agreed upon. In this context, an optimal nature restoration plan was developed. This plan takes into account the necessary additional areas of mud flats, salt marshes and wetlands to restore estuarine processes to guarantee the successful protection of the important natural areas and species that are protected under various laws and agreements (see below, ecological impacts).

These two plans were merged into draft synthesis plans. After assessment of these plans and stakeholder consultation, the most desirable plan was developed. This plan, with a list of specific measures and projects, was decided upon by the Flemish government in 2005 for the Zeeschelde and Durme, and in 2006 for the other tributaries. For most projects, the location is specified but the specific implementation is subject to further study and stakeholder involvement. For the Grote Nete, the specific locations still need to be selected (850 ha in a search zone of 1,300 ha). The decision included a time planning for the projects for the period 2006–2030.

Since 2006, the two agencies responsible for flood safety (W&Z)[1] and for nature restoration (ANB[2]) work together for the implementation of the plan. To this purpose, more specific plans for each location have been or are being developed, based on stakeholder participation. An overall overview is given on the Sigma Plan website (www.sigmaplan.be). From the point of view of nature restoration, the projects in the Scheldt estuary are highlighted as one of the main projects for nature restoration in Flanders. They include, in addition to the Sigma II projects, the Sigma I project of the flood plains at Kruibeke including wetlands and reduced tidal area (KBR, see 3.2) and nature restoration projects related to the development of the port of Antwerp. The implementation of the Sigma Plan is part of "Flanders in Action", which lists the major projects and challenges of the Flemish government and coalition agreement (Flemish Government, 2010).

3.2. Specific Objectives

The Sigma Plan II contains a long list of more than 50 projects covering around 5,000 ha of nature restoration measures over the full length of the Zeeschelde and its tributaries. The map in Figure 3.2.1 gives an overview of the major projects for the short term (up to 2015). The map in Figure 3.2.2 gives an overview of projects and their objectives (restoration of estuarine nature – dark green – and wetlands – light green – and dyke realignment). Table 3.2.1 gives an overview of the different types of projects and total size. It has to be noted that this overview is simplified since every project is only linked to one measure, whereas in practice some projects include different types of measures. It shows that the project contains two major types of measures, i.e. the creation of estuarine nature with muds and marshes and the creation of wetlands. The first set of measures is required to restore estuarine processes, and they contribute to the protection of habitats and species. The second measure is required in particular to compensate for the fact that the river is and will remain very modified (e.g. for navigability) and to create habitats for species protection (Adriaensen et al., 2005).

The table shows that many of the projects contribute both to flood safety and nature restoration. For that purpose, the Flood Control Areas (FCAs) are combined with the Controlled Reduced Tide (CRT). In this case, the tidal regime is introduced inside the flood plain. During normal tidal cycles, water flows in and out of the area through culverts especially designed for these CRT areas (sluices). Inside the area, muds and marshes can develop but less dynamic compared to depoldering. During flood events, it will work as all other FCAs. FCAs are also combined with wetlands. The Sigma Plan II consists of a mix of different measures that take account of local circumstances, the need for local flood-water storage and habitat creation, and costs and benefits of different measures. The full restoration of natural marshes and mud flats (depoldering) contributes more efficiently to nature restoration goals then a CRT area, but is less efficient for flood protection. Therefore, a CRT is more suited for locations that require optimal flood-water storage.

FCAs can be combined with nature restoration or agriculture. These will be combined with nature restoration in locations where habitat creation is important and/or where agriculture is less profitable or more difficult to combine with temporary flood-water storage. In addition to projects listed in Table 3.2.1, some projects are planned that combine flood safety with agriculture (340 ha). This number is relatively low compared to the total number of ha of FCA with nature restoration, which confirms the objectives of the Sigma Plan II to combine flood safety with nature restoration.

In the overview, we have also included KBR, as it is an important project, part of Sigma I but with some adaptations part of Sigma II and which will become operational in 2012.

1 W&Z = Waterwegen en Zeekanaal NV, afdeling Zeeschelde http://www.wenz.be/WenZ/Afdelingen/Zeeschelde.html

2 ANB = Agency for nature and forest (agentschap voor natuur en bos) http://www.natuurenbos.be/nl-BE/Projecten/Scheldeproject.aspx

Table 3.2.1: Overview of types of measures and total ha per type of measure.

Type of Measure	**Size (ha)**
Depoldering New FCA (flood control area) with RTA (reduced tidal area) Turn FCA (flood control area) into RTA (reduced tidal area)	1,082 527 138
Subtotal Estuarine nature	***1,747***
FCA (flood control area) with wetland wetland dyke realignment	629 992 230
Subtotal wetlands (excl. Nete)	***1,850***
dyke realignment Nete	850
Subtotal wetlands (incl Nete)	***2,700***
Subtotal estuarine & wetlands sigma II	***4,447***
KBR (Sigma I)	600
Subtotal estuarine & wetlands sigma II	***5,047***
reconnection to the river excavation of landfill	163 36
Subtotal other measures	***199***
Total areas with GI element	**5,246**

FCA = Flood control area
RTA = Reduced tidal area
KBR = FCA-RTA at Kruibeke Bazel Rupelmonde

The major short term projects (ongoing or planned before 2015) are:

- Hedwige Proper polder (465 ha): a transnational project for salt marshes and mudflats (of which 170 ha in Flanders and 295 ha in the Netherlands), that will be integrated with the existing 'Verdronken land van Saeftinghe'.
- Kruibeke Bazel Rupelmonde (KBR): a 600-ha flood plain, part of the Sigma I projects. It includes wetlands and the first large CRT area. The project is planned to be operational in 2012.
- Durme valley: 205 ha of restoration projects for estuarine nature and wetlands.
- Vlassenbroek-Wal-Zwijn: 416 ha of flood control areas with controlled reduced tide and flood control areas combining agricultural and recreational land use.

- Kalkense Meersen: 950 ha of wetlands and meadow bird areas, flood control areas, controlled reduced tide and intertidal mud flats and marshes.
- Dijle river estuary: 207 ha of flood control areas with controlled reduced tide and flood control areas, combining agricultural and recreational land use.
- Upper Dijle river: 220 ha of flood control areas combining recreation and agricultural land use, wetlands combining recreational purposes and natural wetlands.
- Grote Nete Valley: 850 ha wet valley restoration projects.

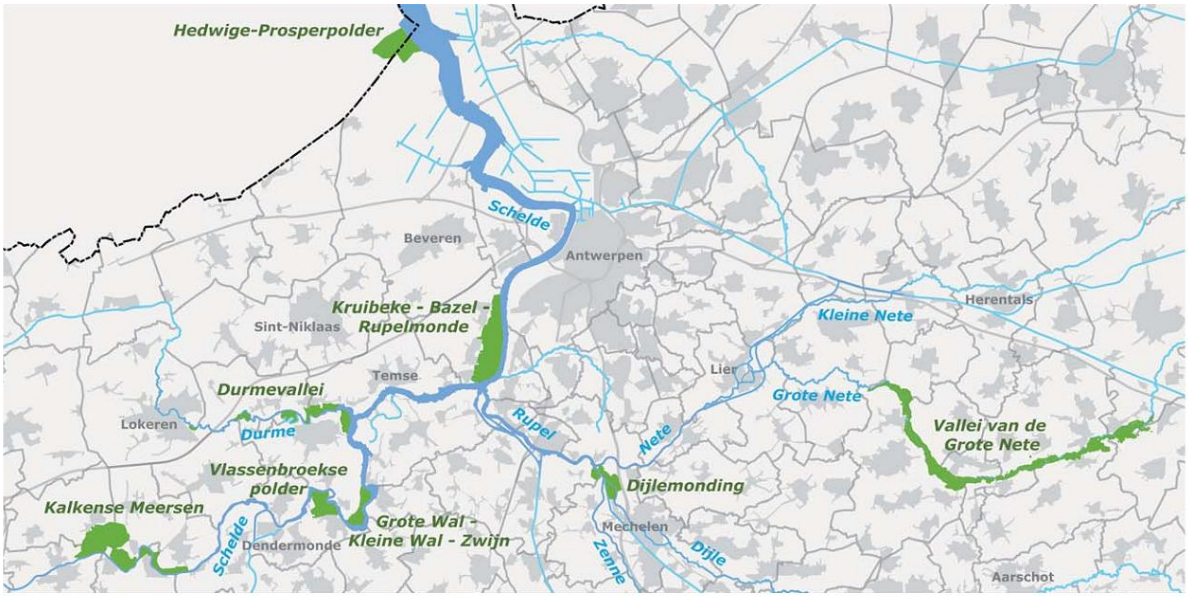

Figure 3.2.1. Overview of the major projects of Sigma Plan II and KBR (Sigma Plan I).
Source: www.sigmaplan.be.

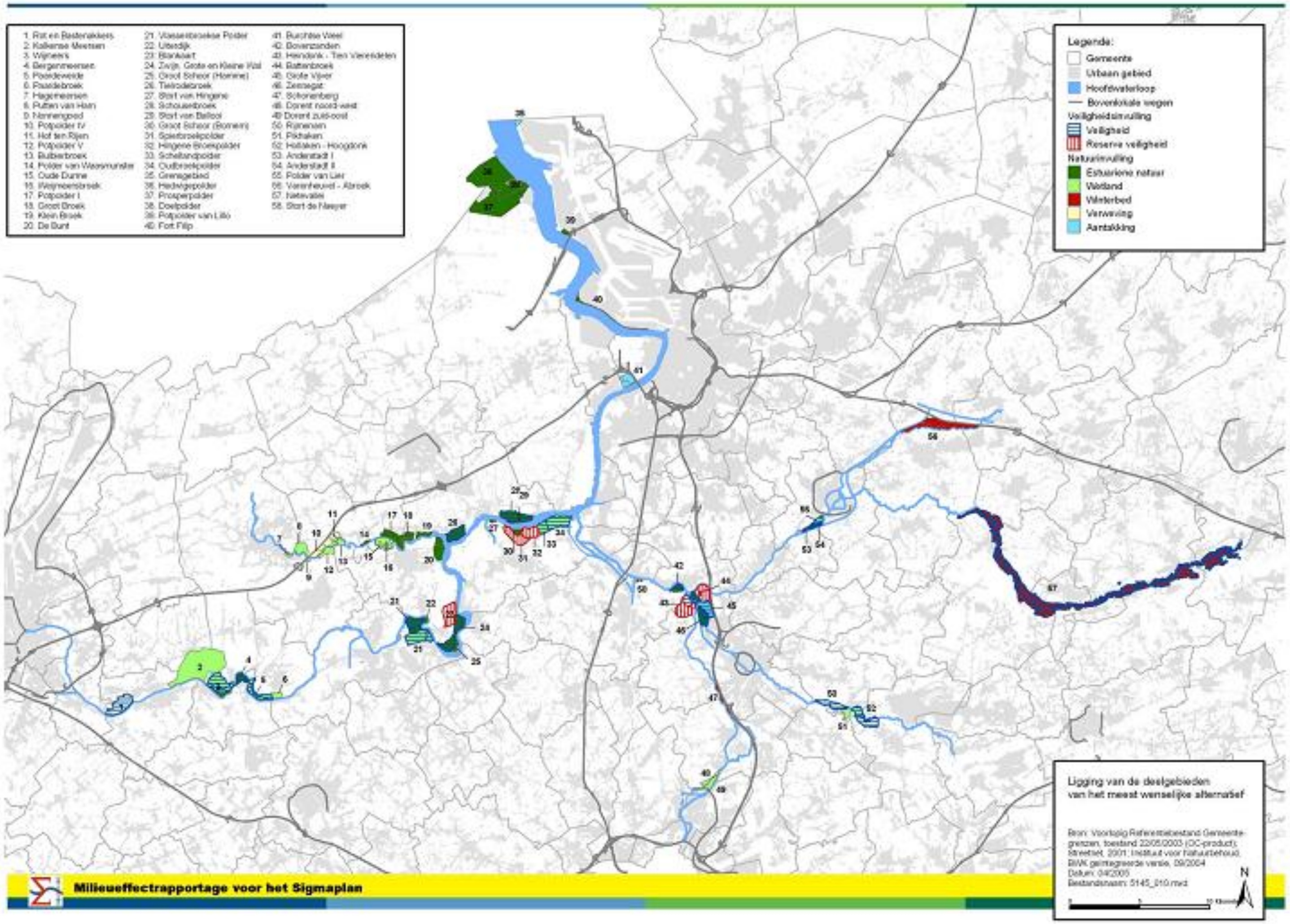

Figure 3.2.2. Overview of the projects of Sigma Plan II.
Source: IMDC-Arcadis, 2008.

3.3. Green Infrastructure Elements

Green Infrastructure Element		
Core areas		
Restoration zones	X	Habitat restoration
Sustainable use, ecosystem service zones	X	Flood protection
Green urban areas		
Natural connectivity features		
Artificial connectivity features		

The projects are listed as sustainable use, ecosystem service zones and restoration zones, where habitats will be restored along the freshwater to saline gradient. The projects will deliver ecosystem services related to flood protection, water purification and retention and recreation. Some of the measures include restoration of the natural valleys, including the winter bed.

3.4. Implementation Costs

Available Information

The cost estimates for the different projects are based on the cost estimation for budget provisions made in the context of the decision of the Flemish government as reported in IMDC-Arcadis (2008). These estimates are based on the social cost-benefit analysis (SCBA) of the flood protection measures and on additional information (e.g. for land purchase). This information gives costs per project but no details on the different components or factors that influence costs. The cost per project have been used for the further assessment of total costs. In addition, the decision of the Flemish government includes a provision for flanking policies that are not linked to specific projects but to the plan as a whole. These are added to the total costs. The additional information has been used to split these total costs into different cost categories.

As indicated in Figure 3.1.2, the different potential measures for the Sigma Plan II were subject to an SCBA. For that purpose, detailed analysis of different options were made. The requirements in terms of hectares needed or kilometres of dyke have been assessed on a detailed, specific analysis for each location. The costs have been estimated using generic indicator data, which are based on an analysis of the costs of these types of work in Flanders in the years preceding the study (in practice around 2000). An overview of these indicator data is listed below (selected from Broekx et al., 2011). This gives additional information on factors determining the overall costs. As it focuses on costs from the perspective of an SCBA, it treats costs of land-use changes as opportunity costs, not as expropriation costs.

The costs for the further development of a flood plain with Green Infrastructure has been estimated at €6000/ha, based on costs for 20 similar projects by the Flemish Land Agency (VLM).

The annual maintenance costs in Table 4.4.2 have been estimated based on data from the SCBA. Annual maintenance costs are 0.5–1.5% of infrastructure costs, with an average of around 0.8% for optimal combinations of FCA with CRT. In addition, some specific costs for nature management practices have been accounted for, with an estimated annual costs of €100–200/ha, based on information for current expenditure per hectare from the Nature Protection Agency (ANB) and the NGO Natuurpunt (Nocker et al., 2004).

Some of these projects have also been studied in the framework of a reduced SCBA of nature restoration projects, made in the context of the long-term vision of the Scheldt estuary (right part in Figure 3.1.2). The analytical framework and data are the same as those mentioned above. These reports give data per project for some of the projects (Hedwige Prosper, Kalkense Meersen). This analysis, however, does not cover a full SCBA of the complete scenarios of projects in all zones of the river.

No SCBA has been made for the final Sigma Plan II, including all the projects.

The decision of the Flemish government recognises that the Sigma Plan II will require additional administrative efforts, but does not make an overall assessment. In the first decision on the Sigma Plan II, an estimate was made for additional manpower (19 high qualified administrators)(Flemish Government, 2004), but in later decisions this amount was not specified in detail. The figure is not an estimate of total manpower required.

Cost Details

The total financial investment costs of the projects listed in Table 3.2.1 amount to €469 million, including the costs for building and adapting dykes and sluices, land purchase and creation of the Green Infrastructure. These costs are not further detailed per type of project. In addition, €49 million are estimated for flanking policies, related to agriculture (€42 million) and rural recreation plans (€8 million). For the analysis and estimate in Table 3.4.1, all these costs have been added to the costs per project. This may be an overestimation, as these costs relate to all Sigma measures, including CFA with agriculture, but there is no information to split them, and the projects in Table 3.2.1 account for the major share of land use changes.

It has to be noted that this estimate is different from the costs that the Flemish government attributes to the nature restoration part of Sigma II. In that document, projects are either linked to the flood safety objective or to the nature restoration objective, and this document reports a lower figure for nature restoration costs (€247 million). The costs for some CFA with wetlands or CRT are attributed to the flood safety part, including all extra costs related to Green Infrastructure. However, for this analysis, all the costs of projects with a GI element are included and assume that most of these projects have a benefit for flood protection. Second, the overall budget for the Sigma Plan II is estimated at €879 million, but not all these costs are related to Green Infrastructure or nature restoration. It includes costs related to finalising Sigma I projects (€272 million), other measures related to flood protection (e.g. higher dykes) and costs related to flood plains without a Green Infrastructure element.

If the total investment costs are divided by the number of hectares, an average investment cost of approx. €100,000/ha can be calculated. The costs of the flanking policies add around 10% to these costs, resulting in an average costs of approx. €110,000/ha. The cost per hectare is similar to costs used for the Sigma river basin management plans (CIW, 2009) and the costs for the FCA areas, only chosen from the flood-safety perspective.

Table 3.4.1: Overview costs (total & per Green Infrastructure element) / Cost associated with the implementation of the initiative.

	Total (Local Currency)	Core areas	Restoration areas	Sustainable use / ecosystem service zones	Green urban and peri-urban areas	Natural connectivity	Artificial connectivity features	Comments
Total Costs				€521 million				
Time covered by total costs (years)				2006–2030				
Annualised costs				€50 million				– €12 million/year on average for period 2006-2010 (start up phase) – €50 million/year (from 2010 onwards) (Decision Flemish government, 2005)
Area covered [ha]				4,646				
Cost per hectare				€112,000/ha				– = total costs/ha (excl. Grote Nete), large variation between projects, from more then €150,000/ha for projects in tidal areas to €34,000 for wetland restoration; costs Grote Nete probably lower.
Financial Costs (list any details e.g. establishing management bodies)				€469 million (1) €44 million (2) €8 million (3)				– (1) total costs infrastructure, land purchase, creation of GI – (2) additional costs for flanking measures related to agriculture and land-owners – (3) additional costs related to rural recreation
Opportunity costs (uncompensated) (list any details e.g. foregone resource use)				n.a.				–

Table 3.4.2: Detailed costs.

FINANCIAL COSTS		
	Cost (€ million)	**Comments**
One-Off Costs		
Administrative, management and information costs		Is included in cost estimate (a 5% add-on is included to account for study costs and 10% for unforeseen additional costs.
• Establishing management bodies		
• Surveys		
• Research		
• Consultation		
• Management plans		
• Land purchase:		
• Restoring GI:		
Costs of green infrastructure provision	512	
• Land purchase	200	Includes all expropriation costs (inc. buildings, farms etc.), is estimated at 50% of total costs (excl. cost flanking policies) for FCA and depoldering.
• One-off compensation payments	52	Costs of flanking policies, for agriculture (€42 million) and recreation (€8 million).
• Creation of green infrastructure elements (1)	269	
• Restoration of green infrastructure		
Ongoing Costs		
Administrative, management and information costs	n.a.	
• Running of administrative bodies		
• Monitoring		
• Ongoing management planning		
• Communications		
• Managing sites:		
Costs of green infrastructure provision		
• Maintenance of green infrastructure	3.7	Based on assumption 0.088% of investment costs (except for other measures and flanking policies).
• Costs of management agreements	n.a.	
• Costs of protective actions		

(1) includes costs for flood protection measures – dykes around the flood area, sluices (see discussion).

OPPORTUNITY COSTS (uncompensated)		
	Cost (€ million)	**Comments**
Foregone development opportunities		
Value of potential development foregone		
Foregone resource use		
• Loss of mineral extraction		
• Loss of water abstraction		
Foregone output from land management		
• Foregone agricultural output	p.m.	See discussion below, was estimated, but not added here to avoid double counting.
• Foregone forestry output		
Foregone socio-economic opportunities		
• Loss of regeneration opportunities		
• Loss of community uses of land		See discussion below.
Reductions in land values	12	Visual intrusion of dykes.
Price of land		
Total net economic cost	533	

The cost estimates for land purchase and disappropriation are based on current land use, and guidance figures for land purchase and disappropriation by government. These accounts for almost 40% of total costs of the provision of the Green Infrastructure, which is a similar share compared to earlier estimates for Sigma projects in 2004 (Flemish government, 2004). It has to be noted that costs for the flanking policies to mitigate impacts on agriculture and recreation are accounted for seperately. These costs amount to €52 million, which corresponds to 25% of the costs for land purchase and disappropriation.

The operation and maintenance costs are roughly estimated as a percentage of investment costs. The latter refer especially to maintenance for infrastructure, e.g. high dykes surrounding the area. The estimate in the table is based on an extrapolation of scenarios for optimal flood plains.

The SCBA of the projects made a rough estimate of the welfare loss for houses that will lose the open view on the polder landscape because of the construction of high dykes. The number of houses affected is estimated by calculating the number of houses situated within a buffer of 5O m and with a direct view of the dyke. The valuation of the impact is based on a study for the Netherlands (Luttik, 2000) that estimated that open space increased housing prices by 6–12%. The number of houses is extrapolated from the optimal flooding scenarios via a value per hectare. The main objective of this estimate is to demonstrate that the project still generates a positive return if this effect is taken into account.

Discussion

It has to be noted that there is a wide variation in costs per hectare between different projects, depending on location and nature type. As shown below in Table 3.4.3, depoldering and FCA with CRT or wetlands are twice as expensive per hectare then wetlands. This is logical, since the costs of the outer dyke are an important cost element. The costs of FCA with wetlands and are respectively 16% and 35% higher compared to FCA combined with agriculture. However, the annual costs for FCA with agriculture may be higher if farmers are compensated for the crop losses in case the flood plain floods. These costs depend on the crops and how often flooding of the flood plain occurs.

Costs of new dykes surrounding flood plains are an important part of total costs, and these costs are higher for the projects closer to the mouth of the Scheldt, because the tide is higher and higher dykes are required. Second, estuarine nature conservation is more expensive as it requires additional sluices to let the water in and out each day, which is not required for a freshwater wetland. In addition, some factors play a role that may be different for each project. A larger and "square" flood plain is less expensive per hectare since it fewer kilometres of dykes per hectare. The project locations have been chosen to minimise costs for land purchase and expropriation of buildings. Nevertheless, for some projects land purchase is more expensive if the flood plain has a larger share of land used for agriculture and especially for more valuable crops including fruit and vegetables. Finally, some locations face additional costs because infrastructure works (e.g. transmission lines) need relocation or adaptation. It has, however, to be noted that the objective of the Sigma Plan II was not to minimise costs per hectare but to optimise net benefits. More expensive locations may be still be interesting if flood-safety benefits are high (which is the case for flood plains just upstream of cities) and benefits for nature restoration are high. In the Scheldt case, an optimal river-long strategy also requires additional measures in different parts of the river and its tributaries.

It has to be noted that the SCBA of Sigma II flood plains looked at Green Infrastructure costs in a two-step approach. First, a set of flood plains was selected that are optimal from the point of view of flood safety, and all costs and benefits were attributed to the flood-safety objective. In addition, it compares flood plains combined with agriculture and flood plains combined with nature restoration (reduced tidal areas and wetlands). In this case, the additional costs of Green Infrastructure elements were very limited, because the high costs of surrounding dykes were attributed to the safety objective. Overall, the investment costs of flood plains with Green Infrastructure was estimated to be 4% higher compared to flood plains that maintain current agriculture land use.

Table 3.4.3: Overview of total costs and cost per ha for different types of measures.

Type of Measure	Size (ha)	Investment Costs (€ million)	Investment-Cost/ha (€/ha)
Depoldering	1,082	148	136,542
New FCA with CRT	527	81	153,242
Turn FCA into CRT area	138	9	63,847
Subtotal Estuarine nature	***1,747***	**237**	**135,847**
FCA with wetland	629	83	131,976
Wetland	992	60	60,099
Dyke realignment	230	20	87,460
Subtotal wetlands (excl. Nete)	***1,850***	**163**	**87,926**
Dyke realignment Nete	850	25	28,824
Subtotal wetlands (inc. Nete)	***2,700***	**187**	69,323
Subtotal estuarine & wetlands Sigma II	***4,447***	**425**	**95,452**
KBR (Sigma I)	600		
Subtotal estuarine & wetlands Sigma II	***5,047 (4,447)****	**425**	**95,452 ***
Reconnection to the river	163	34,4	211,484
Excavation of landfill	36	10,4	288,248
Subtotal other measures	***199***	**44,8**	**225,420**
Total areas with GI element/total costs	**5,246 (4,646)***	**469**	**101,012***
Costs of flanking policies*		52	11,192*
TOTAL COSTS*	**5,246 (4,646)***	**512**	**112,205***

FCA = Flood control area
RTA = Reduced tidal area
KBR = FCA-RTA at Kruibeke Bazel Rupelmonde
* Total area, excl. KBR (600 ha). This number is used to calculate the costs per ha, as the costs for the KBR are part of Sigma II (example: the total cost/ha = €512 million/4,656 ha = €112,205.5/ha)

For the SCBA, the forgone agricultural output has been estimated, but this information is not available for the Sigma II scenario. These costs include the relocation costs for high value crops (€10,000/ha) and 10% of loss of production in the first 10 years. For the optimal scenarios, high value crops accounted for 2–5% of the total area. For other crops, the opportunity costs refer to loss of value of low-value crops (€288/ha/year), loss of manure deposition capacity (€270/ha/year) and adaptation costs for loss of employment (€924/ha/year) (Broekx et al., 2010).

Table 3.4.4: Overview of indicator data for assessment of costs.

Cost Item	Cost (€, 2002 figures)	Remarks
Riverside dyke adaptation (€/m)	770	
Outer dyke construction (€/m)	840	
Outlet sluices (€/ha)	19,000	
Inlet Sluices (€/ha)	4,000	
Expropriation costs (€/ha)		
Residential	700,000	
Industrial	24,000	
Recreational	12,200	
Houses (€/building)		
Farms (€/building)		
Companies (€/building)		
Expropriation costs average (€/ha)	53,000	Includes land purchase and buildings (Flemish Government, 2004).
Further Development of flood plain with GI (€/ha)	6,000	IMDC-Arcadis (2008).

Source: Broekx et al. (2010); IMDC-Arcadis (2008); Flemish Government (2004).

3.5. Observed and/or Projected Impacts

Biodiversity Benefits

The Sigma Plan II is planned to contribute significantly to the conservation objectives for the Scheldt estuary. The conservation objectives have been defined for the estuary as a whole, and for Flanders the conservation objectives for the Zeeschelde and its tributaries have been defined in 2007 (Adriaensen et al., 2007; Anon, 2010). The research has indicated that the measures of Sigma II are required to meet these objectives.

The conservation objectives for the different directives have been integrated in a common analysis at three levels: ecosystem, habitats and species (Daele, 2007). The carrying capacity of the ecosystem takes a central place in this analysis. It aims at the restoration of estuarine processes and estuarine food web. In the context of the preparation of the long-term vision and management plans, ecological rehabilitation targets were defined to guarantee a healthy ecosystem with sustainable nature. These targets are a key to ensure that the important habitats are effectively protected, as required by the habitat and bird directives (Berg, 2005). The map in Figure 3.5.1 illustrates the importance of the estuary for Natura 2000 sites.

The rehabilitation targets (see right column in Figure 3.1.2) are based on scientific research that used the ecosystem health-concept approach, with the primary goal to re-establish the estuary's processes and to reinstate its organisation, vigour and resilience (Bergh, 2005).The analysis indicated a number of measures to be taken to improve these processes, including additional areas for marshes and wetlands in the different ecological zones (the zones are indicated in Figure 1). It illustrates that there is a need for these measures along the full length of the river and its tributaries.

The conservation objectives for the Scheldt estuary infer that an additional area of at least 500 ha of mud flats is needed compared to the current situation to guarantee a good carrying capacity of benthic organisms for birds and fish. Moreover it is stated that, "unless the water quality could be restored to the extent that limitation of dissolved silicon does not occur any more for diatoms, an additional area of 1,500 ha of marshes is needed in the Scheldt to address this limitation" (Anon, 2010). In addition, more wetland areas are required in order to compensate for the modified structure of the Scheldt that cannot meander.

The importance of the Sigma Plan II for estuarine nature is illustrated in the analysis in the context of the study for the definition of the good ecological potential for the Scheldt and its tributaries. The study shows that the current areas of estuarine nature (2,220 ha, excluding the Netes and accounting for quality of the areas) will double with the Sigma Plan II (2,270 ha). The analysis shows clear improvement for almost all of the water bodies (parts of ZeeSchelde and tributaries) and three of those seven bodies would rise above the GEP level boundary for the habitat area parameter. However, more areas are required in the upstream zone between Gent and the Durme and in the zone of the Zeescheldt where the Rupel flows into the Scheldt.

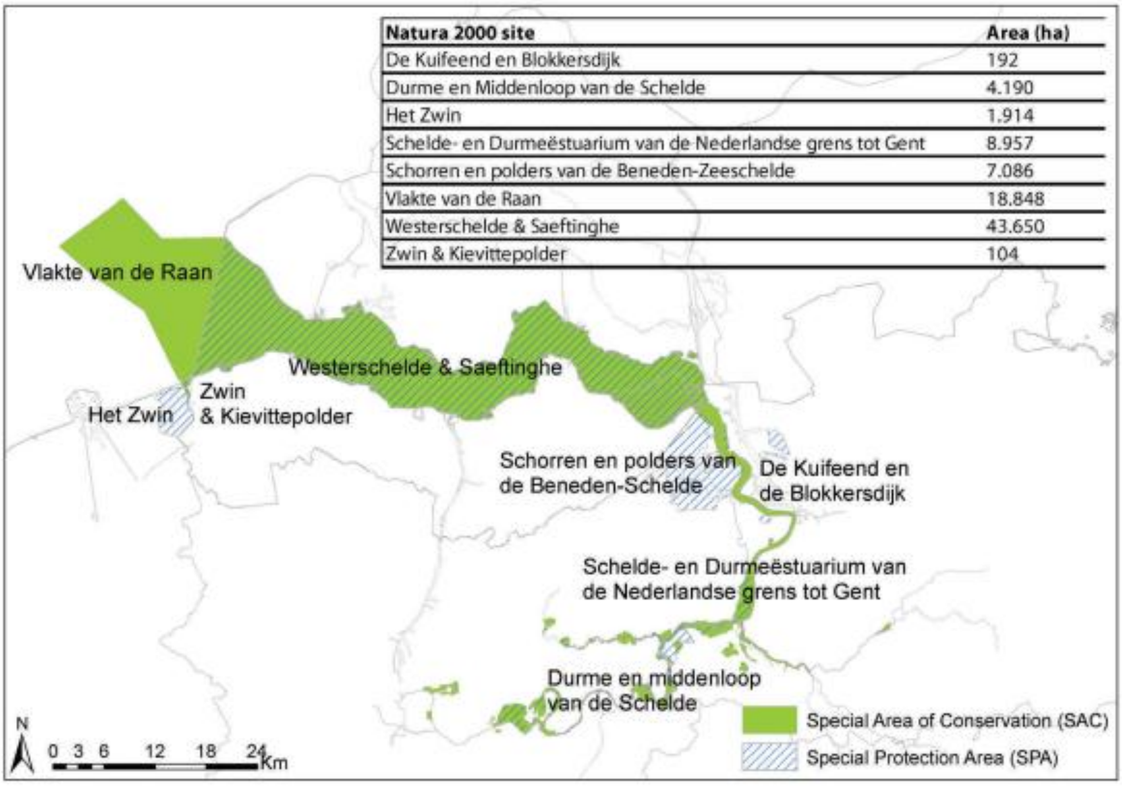

Figure 3.5.1. Map of the Special Areas of Conservation and the Special Protection Areas in the Scheldt estuary, designated as part of the Habitats and Birds Directives (situation 2009).

Source: Anon (2010), based on Research Institute for Nature and Forest (INBO); Ministry of Agriculture, Nature and Food Quality.

It has to be noted that there is still a lot of uncertainty to which extent the plan, in combination with all other ongoing plans (e.g. river basin management plans) and changes in pressures on the ecosystem, will be effective in the protection of the estuary and Natura 2000 sites. The long-term vision foresees monitoring programmes, and it is expected that the measures to be taken after 2020 will take account of these elements and the future needs for effective protection.

Table 3.5.1: List the major habitats and species that will be affected by the measures.

Overview of biodiversity A: habitats

		PA	BGR	PA
Code	Habitat type	FL: Schelde- en Durmeëstuarium van de Nederlandse grens tot Gent (BE2300006)	Flanders	NL: Westerschelde & Saeftinghe (NL9803061)
1110	**Sandbanks which are covered by sea water all the time**			
1130	**Estuaries**			
1310	**Salt tolerant plants colonizing mud and sand**			
1320	**Spartina swards**			
1330	**Atlantic salt meadows**			
2110	Embryonic shifting dunes			
2120	White dunes			
2130	Grey dunes			
2160	Dunes with sea buckthorn			
2190	Humid dune slacks			
2310	Dry sand heaths with ling			
2330	Drift sands			
3150	Natural eutrophic lakes with water soldier and pondweeds			
6410	Molinia meadows			
6430	Hydrophilous tall herb fringe communities			
6510	Lowland hay meadows			
9160	Oak-hornbeam forests			
91E0	Alluvial forests			

The most important habitats for the estuary are indicated in bold.
Explanation of colour codes:

CS-PA: orange: averaged or reduced; dark green: good; blue: excellent

CS-BGR: red: unfavourable–bad; yellow: unfavourable–inadequate; green: favourable; white: habitat type does not occur in this part of the estuary.

Source: Anon (2010)

Overview of biodiversity A: species

			CS-PA	CS-BGR	CS-PA
Code	Species group	Species name	FL: Schelde- en Durmeëstuarium van de Nederlandse grens tot Gent (BE2300006)	Flanders	NL: Westerschelde & Saeftinghe (NL9803061)
1166	Amphibians	Crested newt			
1903	Vascular plants	Yellow widelip orchid			
1134	Fish	Bitterling			
1102	Fish	Allis shad			
1103	Fish	Twaite shad			
1149	Fish	Spined loach			
1099	Fish	River lamprey			
1095	Fish	Sea lamprey			
1014	Invertebrates	Narrow-mouthed whorl snail			
1351	Mammals	Porpoise			
1365	Mammals	Common seal			
1364	Mammals	Grey seal			

Explanation of colour codes:

CS-PA: orange: average or reduced; dark green: good; blue: excellent

CS-BGR: red: unfavourable–bad; yellow: unfavourable–inadequate; green: favourable; white: species does not occur in this part of the estuary.

Source: Anon (2010)

Socio-Economic Benefits

Observed and quantified impacts include flood protection, recreational benefits, ecosystem services.

Ecosystem Service/Socio-Economic Benefits	
Provisioning	
Regulating	Flood protection: important Nutrient recycling Water purification Carbon sequestration Erosion protection
Cultural	Recreational amenities: 150,000 visitors/year
Supporting	
Wider socio-economic benefits (e.g. fuelling economic activity, job creation, health benefits)	Improved conditions for promoting rural tourism in these valleys Health benefits from improved conditions for recreation

3.6. Observed and/or Projected Economic Impacts

A cost-benefit analysis indicated flood-safety benefits in detail (Broekx et al., 2010). The recreational and ecosystem benefits for the whole project have been estimated, based on the information of optimal flood scenarios:

- Flood protection benefits: €740 million (all actualised benefits 2010–2100)
- Recreational benefits: €22 million
- Ecological benefits/ecosystem services: €130 million

Background, interpretation and additional benefits (see Table 3.5.2 for more details):

- The flood protection benefits relate to the avoided material damages to houses, infrastructure and economic sectors. The estimate is based on a detailed comparison of flood-risk maps of the current situation and after the implementation of the measures. The damages are mainly based on costs to restore buildings and their contents, infrastructure or loss of production for economic sectors.

  The flood protection benefits are high because the flood risk is high; the flood plains are well chose to protect cities and industrial areas and are constructed in a way to maximise flood risk reduction per m³ water stored.

  Some flood protection benefits could not be estimated, especially avoided impacts from flooding on ecosystems and on human health, for which impacts on morbidity and mental health may be relevant.

- The estimate for recreational benefits is relatively small because it only accounts for the additional benefits of these projects, compared to the current situation in which these areas are already intensively used for recreation and tourism, especially walking and biking. The additional benefits relate to fact that some additional paths for walking and biking will be created.

As the area is already very important for open air recreation in a semi-natural landscape, it was tested whether these people might experience a welfare loss because of the creation of new landscapes with wetlands, mudflats and marshes. To this purpose, a contingent valuation study was undertaken, that concluded that people living in that area and using it for recreation purposes have on average the same value for the old landscape and the new one.

The study did not account for additional actions that can (and will) be undertaken to improve conditions for recreation in and around these GI-elements.

- The ecosystem benefits are important, especially related to nutrient recycling and water quality. This service is especially important in Flanders as the region is under high pressure from nutrient pollution and expensive measures are required in all sectors, including agriculture. These services have been quantified using simplified ecological models. The results are case specific. The value of nutrient recycling refers to avoided costs in other sectors to reduce nutrient emissions. It should be noted that the value of these benefits uses a conservative estimate for the value of nutrient reduction, and that the real value of the contribution of Green Infrastructure to achieve good status of water bodies and limit eutrophication may be significantly higher.
- It should be noted that non-use values were not estimated or used in this SCBA, since the economic assessment based on use values already showed that flood plains combined with Green Infrastructure were the most cost-efficient type of measures.

Table 3.5.2: Overview of quantification and valuation data used for assessment of ecosystem services for newly developed ecosystems in the Flemish part of the Scheldt estuary.

Function	Quantification (unit/ha.year)					Valuation (€/unit)	
Ecosystem type *Watertype*	*FCA* *Fresh*	*CRT* *Fresh*	*CRT* *Salt-brackish*	*Wetland* *Fresh*	*Source*	*Value*	*Source*
Production functions (fish, aquaculture, wood)	pm	pm	pm	pm	pm	pm	pm
Regulation functions							
Denitrification		176 kg	107 kg	102 kg	MOSES: Soetaert and Herman (1995a, b)	2.5	CIW (1999)
Decrease in N washed away		252 kg	252 kg	252 kg	VMM (2003)	2.5	CIW (1999)
Decrease in P washed away		31 kg	31 kg	31 kg	VMM (2003)	8.5	CIW (1999)
Aeration	pm	23 mol/ha/year	10 mol/ha/year	pm	MOSES: Soetaert and Herman (1995a, b)	0.14	Witteveen and Bos (2004)
Erosion protection		2 m^3	2 m^3	2 m^3	Expert judgement	5	Witteveen and Bos (2004)
Climate		6.8 ton/ha/reed	6.8 ton/ha/reed	pm	Goosen et al. (1996)	66	Bickel and Friedrich (2005)
Regulation functions only first 15 years after construction							
Sedimentation		200 m^3	200 m^3	4 m^3	Expert judgement	5	Witteveen and Bos (2004)
C-burial		1.5 ton	1.5 ton	pm	MOSES: Soetaert and Herman (1995a, b)	66	Bickel and Friedrich (2005)
N-burial		148 kg	148 kg	pm	MOSES: Soetaert and Herman (1995a, b)	2.5	CIW (1999)
P-burial		25 kg	25 kg	pm	Dennhardt and Meyerhoff (2002)	8.5	CIW (1999)
Recreational amenities	25 Visits/day/km dyke				Witteveen and Bos (2004)	1.68	Witteveen and Bos (2004)
Non-use value						*pm*	

Source: Broekx et al. (2010)

Comparing costs with benefits:

- The SCBA analysis concluded that the benefits outweigh the costs and that the protection of the Scheldt estuary using a "room-for-the-river" approach is less costly than the construction and maintenance of a storm surge barrier near Antwerp (Broekx et al., 2010).

- The SCBA analysis also showed that the net benefits were higher for a scenario where the FCA are combined with nature restoration compared to a scenario where they were combined with agriculture. This is because the benefits of ecosystem services of wetlands in the flood plains are higher compared to the net value of the crops currently grown on these farmlands and accounting for crop losses in case the flood plain floods.

3.7. Recent Developments and Outlook

The decision of the Flemish government has classified the projects into four groups, according to the date the works are planned. The first group of projects (2,500 ha) will be developed first (starting before 2010), the second group (1,100 ha) starting before 2015. Some projects are planned to start later (2020 and 2025). An overview is given in Figure 3.7.1.

The review of the implementation of the Sigma Plan by the Flemish government (as a follow up to the Flanders in Action programme) and follow-up of implementation of the long-term vision indicate that until now the project has experienced some delay compared to the planned timing foreseen (Flemish Government, 2010).

For the projects in the first group, the necessary studies, stakeholder consultations and legislative work in Flanders has been done to allow the projects to start from 2010 onwards. The review also indicates, however, that the start for work related to depoldering, flood plains and wetlands has been delayed because the necessary budgets are not fully available (Flemish Government, 2010).

For one project on the border with the Netherlands (Hedwige-Prosper polder), collaboration with the Dutch government is required, and the future of this project is uncertain. The Dutch government has indicated that it may reconsider the use of this location and has proposed alternative plans.

Recent developments can be accessed atn www.sigmaplan.be.

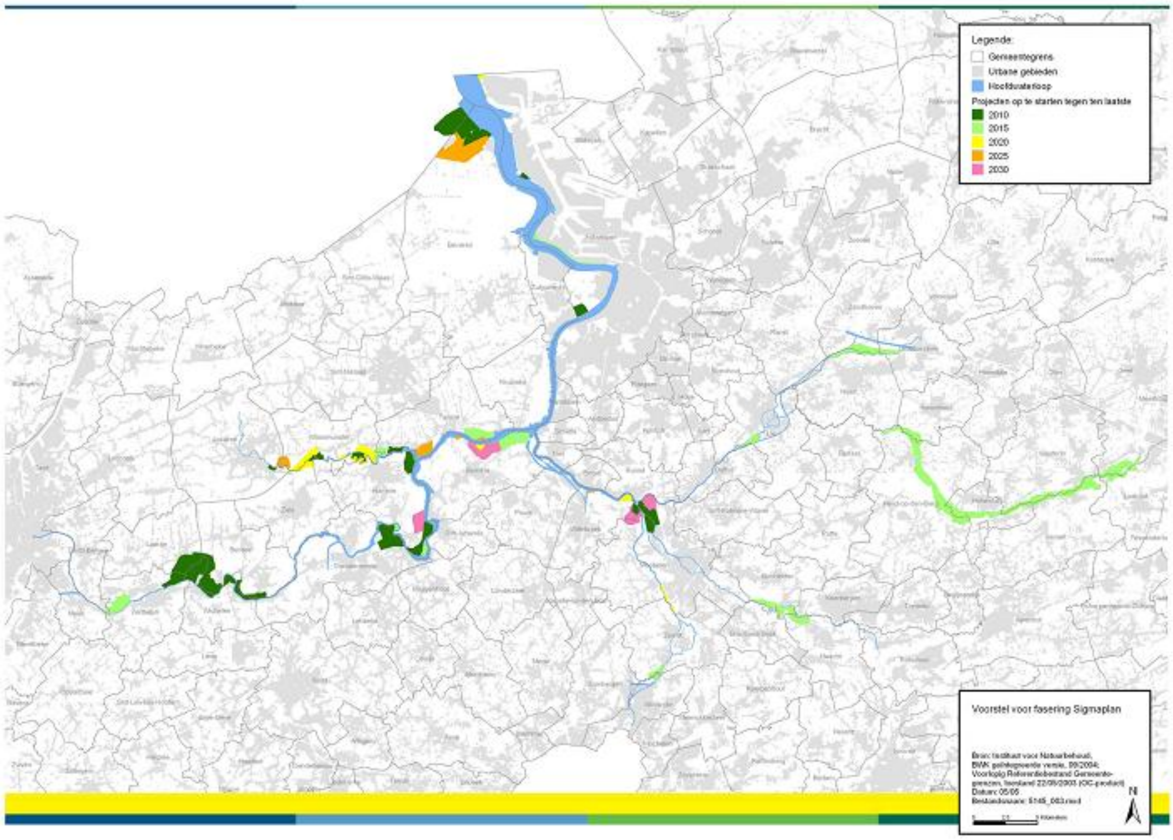

Figure 3.7.1. Timing for the different projects of the Sigma Plan II.

3.8. Summary

GREEN INFRASTRUCTURE BENEFITS	
Ecosystem resilience	✓
Climate change adaptation	✓
Disaster prevention	✓
Ecosystem service provision	
Main indicators for measuring ecosystem service provision	
1. Flood safety	
2. Biodiversity (conservation objectives)	
3. Nutrient retention	
4. Recreation	

3.9. Contact Details

Wim Dauwe
W&Z
Waterwegen en Zeekanaal NV
Afdeling Zeeschelde
Lange Kievitstraat 111–113
Bus 44
2018 Antwerpen
+32 3 2246711
www.sigmaplan.be

4 Comparable Initiatives

1. **Policy Initiative**

Lower Danube Green Corridor

2. **General Background Information**

The Lower Danube Green Corridor Agreement was signed in 2000 by the governments of Romania, Bulgaria, Ukraine and Moldova, recognising a need and shared responsibility to protect and manage in a sustainable way one of the most outstanding biodiversity regions in the world.

The Lower Danube Green Corridor is a large-scale initiative which aims to coordinate biodiversity conservation and water management efforts between several countries along the Lower Danube river basin, including Bulgaria and Romania. It particularly aims to ensure the conservation of wetlands and the management of flood plains through a system of protected areas (the Lower Danube Green Corridor), which will be connected ecologically and economically to several existing Natura 2000 sites. The network includes areas that are strictly protected and areas where economic activities are possible, with buffer zones in-between. Monitoring of the quality of water and aquatic ecosystems and of the effectiveness of the project will be maintained and the knowledge gained will be shared. The international nature of the project recognises that the best results will be achieved through cooperation as individual actions are not sufficient. The project also seeks cooperation and assistance from international organisations and the governments of other member states to ensure that the network functions as effectively as possible. The project illustrates best practice in achieving regional cooperation for the conservation of a large scale ecosystem and in the establishment of a system of different levels of protection for specific areas.

3. **Specific Objectives**

To restore and protect Danube flood plains and associated habitats, reconnect Lower Danube tributaries, implement sustainable flood management and provide new member states with tools for successful Natura 2000 management.

The Lower Danube Green Corridor Agreement's countries have agreed to establish the Lower Danube Green Corridor composed of a minimum of (WWF, 2011):

- Protection for 1 million ha of existing and new protected areas: 773,166 ha of existing protected areas + 160,626 ha of proposed new protected areas;
- Restoration of 224,000 ha of natural flood plain;
- Promotion of sustainable use and development along the lower Danube.

According to the Agreement, the Green Corridor is to include following areas:

- Areas with strict protection regime;
- Buffer zones with differentiated protection regimes, in which human activities could be permitted and degraded areas restored;

- Areas where sustainable economic activities could be developed.

4. Green Infrastructure Elements

Protected areas and sustainable use areas/ restoration zones.

5. Implementation Costs

EU Phare Multibeneficiary Programme forthe Environment. Donations made by:

- MAVA Foundation;
- Deutsche Bundesstiftung Umwelt (DBU);
- The Global Environment Facility (GEF donated €2.93 million to the Danube River Pollution Reduction Programme) (iwlearn.net).

The costs for restoration of wetlands in the lower Danube has been estimated based on figures from literature. Swartz (2006) estimated costs at a low figure of €200/ha but this does not include the larger infrastructure works (such as polder in- and outlets) and compensation to farmers. Overall costs have been estimated on an average cost of €5,000/ha.

6. Observed and/or Projected Impacts

By the year 2008, 7,714 km^2, 88% of the initial objective of the LDGC (existing and new proposed protected areas), had been put under protection (WWF, 2008). As of 2010, the level of achievement with regard to protection was higher than the target since some 1.4 million ha has been brought under protection. WWF has identified potential flood plain restoration sites throughout the Danube basin that coincide with biodiversity conservation priorities, whose restoration offers dual biodiversity conservation and flood control benefits (Schwarz et al., 2006). In 2008 469 km^2 (14.4% of the initial objective of the LDGC Declaration) of flood plains along the Danube had been restored or were undergoing restoration (approximately 10,500 km^2 remains and a further 7,000 km^2 have been identified as potential restoration areas) (WWF, 2008).

Current projects include (WWF, 2011):

- Dry and unproductive land in the Danube Delta has been transformed through restoration projects. It been has turned into a mosaic of habitats that offer shelter and food for many species, including rare birds and valuable fish species, like pike and carp. The economic benefits of the restoration works in Babina and Cernovca (two major islands of 3,680 ha in Romania which had dry, unproductive land have been "returned to the river/turned into a mosaic of habitats that offer shelter and food for many species") relate to increased natural resources productivity (fish stocks, reed beds, grasslands) and tourism.
- Flood plains in the south of Romania will be reconnected to the Danube and land use changes will be promoted to offer a potential for sustainable tourism, natural reed harvesting, fishing and other sustainable economic activities.
- A pilot project to demonstrate integrated management of the flood plain forest combining nature conservation and sustainable use of natural resources will be launched on the Danube islands.

7. Observed and/or Projected Economic Impacts

In 2006, the potential for flood plain restoration and the potential costs and benefits of using "soft infrastructure" for flood protection along the Danube were assessed by WWF (Schwarz et al., 2006). If the 2000 LDGC agreement to restore a total area of 2,236 km^2 is fully implemented, potential flood control benefits would be large. The restoration of flood plains and former side channels along the entire Danube, not just in the LDGC area, would provide nearly 2,100 million m^3 in flood retention capacity and would lower Danube extreme flood peaks by 40 cm (Schwarz et al., 2006).

The value of the various benefits from the Danube flood plains is estimated to be at least €500/ha/year. (ICPDR, 2010) The wide array of benefits provided by wetlands include flood and drought management through holding and slowly releasing water and water purification through filtration. Wetlands are also areas rich in resources such as fish and reeds.

The economic benefits of the restoration works (3,680 ha) in terms of increased natural resources productivity (fish stocks, reed beds, grasslands) and tourism, is about €140,000 per annum (WWF, 2011). Progress with restoration is also moving forward on the Lower Danube islands from Calarasi to Braila (WWF, 2010).

From a development perspective, flood plain restoration appears to enhance local livelihoods. Reduced vulnerability to floods by restoring the retention capacity of the flood plain, especially by reconnecting side arms and widening the flood plain upstream of settlements, is a major benefit for communities (Ebert et al,. 2009).

Based on data from Stiuca et al. (Staras, 2000, in Ebert et al., 2009), restoration of the Babine and Cernova pilot polders in Romania resulted in a diversification of livelihood strategies towards fishing, tourism, reed harvesting and livestock grazing on seasonal pasture, activities that deliver benefits on average of €26/ ha/year and €9,000 per annum for both polders. From an ecosystem perspective, each hectare of restored wetland is calculated to produce 34 kg of commercial-sized fish per year and in the Babina and Cernovca polder, the restored fisheries provide jobs for 20–25 people (Staras, 2000, in Ebert et al., 2009). At Katlabuh Lake, improved water quality will enhance access for 10,000 local residents to drinking and irrigation water. Natural wetland habitats have returned to Tataru Island after dykes were removed. Kettunen and ten Brink (2006) estimate the large-scale benefits of nutrient reduction, provision of fish, reeds, crops, vegetables, animals and tourism at €1,354/ha/year. Schwarz et al. (2006) estimate economic benefits from nutrient reduction in flood plains at €870/ha/year. Another WWF study calculates the value from provision of fish, forestry, animal fodder, nutrient retention as well as recreation and gives an estimate of about €383/ha/year. Based on these very diverse economic values, an average value was calculated to be around €500/ha/year (Schwarz et al., 2006). Recent assessments in Romania show an economic value of €360/ha/year for areas intensively used for agriculture. If the total pledged flood plain area in the LDGC were restored, the value of the resulting additional ecosystem services have been estimated at €111.8 million annualy (225,000 ha x €500/ha) (Ebert et al., 2009).

If the order of magnitude of these diverse estimates of benefits is compared with the estimated restoration costs (€5000/ha), the investment in restoration will be paid back within 10 to 20 years.

8. Recent Developments and Outlook

By early 2008, the protection target has been reached with over 1 million ha of wetlands protected. Restoration projects are moving forward slowly, many of them directly involving WWF – over 50,000 ha have been restored to date, roughly a quarter of the area envisaged. (WWF, 2011).

9. Summary

GREEN INFRASTRUCTURE BENEFITS	
Ecosystem resilience	✓
Climate change adaptation	✓
Disaster prevention	✓
Ecosystem service provision	
Main indicators for measuring ecosystem service provision	
1. Flood protection	
2. Provisioning services (fish, reed, animal fodder)	
3. Nutrient retention	

1. Policy Initiative

"Innovative measures to ensure enhanced/continued ecosystem service delivery from freshwater ecosystems".

Article 132 of the Grenelle II law establishes a **multiannual programme for the restoration of the ecological continuity of water bodies**.

Article 133 of the Grenelle II law establishes the condition for the purchase and sustainable management of wetlands by public authorities.

The two new legal provisions described below have not been "marketed" as a single "green/blue infrastructure initiative" but were adopted at the same time and can all be seen as relying on the further development of a blue infrastructure (on land) for the delivery of multiple ecosystem service benefits. Taken together, they can therefore be seen as a relatively consistent set of measures to make an optimal use of a range of Green Infrastructure elements to deliver ecosystem services/benefits.

2. General Background Information

All three measures were introduced or further developed by the adoption of the Grenelle II law: Article 132 – continuity of freshwater ecosystems (*continuite des ecosystemes d'eau douce*) Article 133 – conservation of wetlands (*preservation des zones humides*) & 138 – permanent riparian vegetation (*maintenir une couverture vegetale permanente*).

Article 132: According to the assessment of the state of river basins required by the Water Framework Directive (WFD), half of the water bodies which may not reach good ecological status have been considered to miss that status because of a lack in ecological continuity. Re-establishing ecological continuity within river basins has therefore been identified as a main conditions for successfully implementing the WFD. Re-establishing such ecological continuity may require the use of solutions ranging from technological responses (e.g. fish ladders at dams), management responses or the partial or total destruction of the infrastructure.

Article 133: This article is meant to allow water agencies to actively buy land. The management of the purchased land can then be set within the framework of the long term leases (*baux ruraux*). When the lease is renewed, clauses can be inserted to request that the farmer preserve the wetland character of the land under scrutiny in exchange of a lower fee. If he refuses, the water agency can decide not to renew the lease and compensate the farmer for the loss this may result in.

3. Specific Objectives

Article 132: The legal measures also allow the water agencies or local authorities to take responsibility for carrying works on infrastructure which cross water courses (of which 90% are no longer in use and are no longer taken care of by their owners) to restore ecological continuity of water courses. This needs to have the owner of the infrastructure's consent.

Article 133: To allow for the preservation of more wetlands, the law foresees that the water agencies and the Conservatoire du littoral (see next box for more information on this institution) should purchase 20,000 ha of wetlands until 31 December 2015 (which is rather modest in view of the 1.5 million ha still existing in France). The ultimate objective is not ownership of those wetlands but a management ensuring their long term conservation.

4. Green Infrastructure Elements

Article 132: Restoration zones (e.g. restoration of natural connectivity of rivers).

Article 133: Sustainable use areas – wetlands are bought to ensure their sustainable management but farmers may continue to use it for their activities as long as they comply with the conditions set in the lease.

5. Implementation Costs

Article 132: The impact assessment carried out on this measure estimated that in its first five years, the initiative would cost approximately €80 million, corresponding to the financing of:

- A first range of orphaned pieces of infrastructure removals (about 1,000 pieces with a cost of €45,000 for each one).
- The removal of three larger infrastructures which are at the end of their contract ("concession") and where renewal of the contract does not appear to be useful.

Annually, the additional need would be of €16 million/year to be added to the programmes already foreseen for the restoration of ecological continuity. For the implementation and the monitoring of this ecological restoration of water bodies, the needs in personnel are estimated at one full-time equivalent in each district (department) for the enforcement of this policy (i.e. 100 overall) and 10–15 full-time equivalents in the water agencies to supervise the removal of the abandoned infrastructure.

Article 133: The cost per ha is variable:

- The plots whose value is about €7,000 represent about one-third of the targeted land.
- The plots where the value is about €3,000 represent about two-thirds of the targeted land.

The cost of personnel necessary to implement this policy is 24 full-time equivalents, with a cost of €1.3 million/year.

Assuming a purchase rate of 3,000 ha/year (1,000 ha/year for €7,000/ha and of 2,000 ha/year for €3,000/ha), the annual cost of this initiative would be €14.3 million. The total cost for 2009–2013 is around €71.5 million, of which 17% would be paid from the state's budget and 83% from specialised public bodies (water agency and the Conservatoire du Littoral). The total costs to purchase 20,000 ha is €86.7 million.

The annual maintenance cost is estimated to vary between €251 and €521/ha/year. The total costs over a 50-year period for purchase and management of 20,000 ha of wetlands is estimated at €200,4–318,6 million.

If purchase costs are depreciated over the first years, the cost of their purchase and their management are estimated to be €800/ha/year. The costs to restore between 2009 and 2015 20,000 ha of wetlands would thus be in the range of €110 million. The additional cost of these measures represents 0.42% of the budget of the water agencies.

6. Observed and/or Projected Impacts

Article 132: This is meant to contribute significantly to bringing the water quality to a good status and therefore contribute to compliance with the WFD since half of the water bodies at risk of not meeting this quality are thought to be at this risk because of their lack of ecological continuity.

Article 133: Given the ecological, hydrological and biogeochemical functions of wetlands, the expected environmental impacts are:

- The preservation of biodiversity (habitats, species and ecosystems);
- Better flood control and flood prevention (through a slowing down and retainment of the floods through natural expansion);
- Slower streaming of water;
- Natural protection against erosion;
- Prevention of water shortages (by supporting underground aquifer recharge);
- The reduction of pollution (withholding of sediments, recycling and storing of pollutants, regulation of triphic cycles of nitrogen, carbon and phosphorus).

A government-sponsored study (MEEDDM, 2009) on ecosystem services provided by a specific wetland estimated the value of the economic benefits of the services delivered by ecosystems at between €2,800 and €3,100, putting the costs of their purchase and management by the state into perspective.

7. Observed and/or Projected Economic Impacts

Article 132: The additional cost of this measure would be of €16 million/year, to be added to the costs of the programmes already foreseen for the restoration of ecological continuity. For the implementation and the monitoring of this programme for the restoration of ecological continuity of water bodies, the staff needs have been estimated to be one full-time equivalent per district (departement) for the implementation of this policy and 10–15 full-time equivalents in the agencies to supervise the removal of the abandoned infrastructures.

Article 133: Positive environmental impacts resulting from the purchase of 20,000 hectares of wetlands:

1. Avoided costs of treatment in view of achieving drinking water quality thanks to the water purification ecosystem function of wetlands: i.e. approx. €1,950 per ha (see IA for more detail).
2. Revenues from fishing and hunting: about €400/ha.
3. Flood protection, storm damage control: The effects of avoided flooding of town and villages further downstream, through natural spreading and stocking of sudden water level rise: €150–490/ha/year, depending on the location.

These values are based on an analysis from 15 case studies in France on the benefits of wetlands. The more extended analysis shows a wider range from €450 to €13,000/ha/year. Benefits for water provision are an important category, but as this is not applicable to all wetlands, a figure without this category has also been produced, leading to a more narrow margin of €900 to €3,000/ha/year, which is in the same range as the average from an international meta analysis (€1,600 ha/year: Brander et al., 2003).

If the best estimates are applied, the annual benefit is in the range of €2,760 to €3,100/ha/year. As costs for purchase of wetlands vary between €3,000 to €7,000/ha, these investments will on average be paid back in one to three years.

The total benefits over 50 years for 20,000 ha amount to €1,280 million to €1,450 million. These benefits can be compared to the cost data for purchase and maintenance over that period. The purchase of 20,000 ha of wetland would lead – over a 50-year period - to a net benefit (benefits minus costs) of €960–1,250 million. This corresponds to a net benefit of between €42.9 million and€ 56.0 million per year. This is equivalent to a net benefit of €2,150–2,802/ha/year.

8. Recent Developments and Outlook

These two initiatives have been adopted recently and they can be expected to be progressively implemented in the years to come. To further refine the results on the benefits of investing in wetlands, another economic valuation study of three wetlands will be carried out. This study is also meant to provide the water agencies with further arguments for preserving the wetlands to put forward when discussing with different stakeholders.

9. Summary

GREEN INFRASTRUCTURE BENEFITS	
Ecosystem resilience	✓
Climate change adaptation	✓
Disaster prevention	✓
Ecosystem service provision	
Main indicators for measuring ecosystem service provision	
1. Flood safety	
2. Water quality (nutrient retention, drinking water provision)	
3. Recreation (including angling and hunting)	

10. Contact Details

Nadine Barthélémy
Chargée de mission eau at the MEEDDM

5 Conclusions

5.1 Overview of the Initiatives

This case analysis is concerned with Green Infrastructure policy initiatives related to freshwater and wetlands management and restoration. The case studies confirm the importance of the good ecological status of rivers for healthy ecosystems, cities and economies and show how Green Infrastructure and the good status are interlinked. The case studies illustrate that the concept of ecosystem goods and services is well suited to indicate, quantify and value the relevance and importance of Green Infrastructure, and especially wetlands.

The lead example selected for this analysis relates to the Sigma Plan II in the Scheldt estuary. It is a good example of the need for Green Infrastructure to meet the ecological restoration objectives for a modified river system, which is under pressure from many human activities in a highly developed region. It also illustrates that the use of Green Infrastructure that combines flood protection with nature restoration is a cost-efficient way of improved protection of Natura 2000 areas, that in addition will deliver benefits in terms of avoided costs for water management and improved possibilities for recreation.

The second example is similar to the main example in terms of using Green Infrastructure (wetlands) with multiple benefits (flood protection and nature restoration) in an international river basin, but both the size (160,000 additional ha compared to 5,000 ha in the Scheldt) and socio-economic context are very different. This initiative in addition Illustrates the importance of wetlands for increased natural resources productivity (fish stocks, reed beds, grasslands) and importance for diversification of local livelihood strategies.

The third example relates to “Innovative measures to ensure enhanced/continued ecosystem service delivery from freshwater ecosystems” in France. The focus of this example on adaptation of infrastructure (dams) in rivers and the restoration of wetlands. It is complementary to the other examples as it illustrates the importance of Green Infrastructure for ecological continuity and indicates the positive benefit-cost ratios for areas with much lower costs and situations where flood safety benefits are not dominant.

5.2 Achievements and Successful Measures

The case studies were successful for :

- The protection of riverine habitats and restoration of riverine habitats and biodiversity, including legal protection, and improved ecological continuity along the rivers.
- The delevopment of short- and long-run management plans for ecological restoration and more integrated river management plans, especially to integrate flood protection management and investment with ecological restoration and protection.
- The restoration and/or protection of wetlands that can provide important benefits for flood protection and water quality improvements. This allows savings on costs for water management, especially related to flood-protection measures (e.g. dykes or storm surge barriers, costs of waste-water management or costs to limit nutrient emissions, costs of dredging, cost of maintenance of orphaned or superfluous infrastructures.

- The envisaged measures will lead to improved conditions for recreation and tourism, and related local economic impacts. Increased natural resources productivity (fish stocks, reed beds, grasslands) and importance for diversification of local livelihood strategies.

There is information available on the economic benefits of these wetlands, which can be compared on a euro/ha basis. These benefits cover the value of the different goods and services delivered by the wetlands (e.g. fish stocks, flood protection, water purification). They cover the use benefits but do not include the non-use benefits of these Green Infrastructure elements, bearing in mind that important ecosystems and species are better protected and preserved for future generations. The figures on the use values illustrate the diversity of goods and services delivered. The annual average benefits for the Danube have been estimated at €500/ha. For France, the benefits are estimated around €2,500–3,000 ha/year. For the Scheldt case study, the economic benefits of improved regulation functions are estimated around €1,600/ha and for recreation around €300/ha year. In addition, the flood-safety benefits per hectare are much higher, with an average of €20,000/ha/year for controlled flooding areas.

These benefit figures indicate that the investment in wetlands deliver net benefits to society. For the French wetlands case, a study indicates relatively short pay-back times (one to three years). The Scheldt case study illustrates that the high costs per hectare for restoration of estuarine nature are compensated because the flood protection benefits of well-designed and well-located measures are also high for this densely populated and industrialised region with high flood risks.

5.3 Weaknesses of the Initiatives

The analysis has not especially looked for unsuccessful measures that may have been considered in the context of these initiatives. Some points can nevertheless be highlighted that will need consideration:

- The case studies illustrate the need to account for ecological continuity for some of the measures. This may seem evident for restoration and protection of riverine ecosystems, such as removing barriers for fish migration, but it may be more complicated if a wider scope of biodiversity protection is taken into account. Taking account of connectivity may be complicated if cost-effectiveness is applied, because in some areas only the more expensive measures may be available. In the Scheldt case study, the evaluation process accounted for specific restoration measures in different ecological zones of the river and its tributaries. Studies have also indicated that for some zones there is still a need for additional measures.

- As the measures are part of larger programmes and implementation is on-going, it is too early to assess what they will achieve in practice in terms of biodiversity protection. It is therefore important that the programmes foresee monitoring of their effects. This is particularly important for the first Green Infrastructure measures to be taken, so lessons can be learned for the rest of the programme. This also indicates the need for flexible programmes that account for new external developments (e.g. related to water quality improvements) and for the effects of the measures.

5.4 Potential to Contribute to Green Infrastructure

The lead example, cases studied and other examples in the database well illustrate the importance of Green Infrastructure for integrated river management and vice versa. First, they illustrate the need to use Green Infrastructure elements for the achievement of good ecological status of water bodies, as required by the European Water Framework Directive. On the other hand, adequate protection of habitats and species requires water bodies with a good ecological status which favour natural processes that support basic needs, such as food and protection for the species. The case studies illustrate that Member States have recognised these links and are developing specific programmes and measures to promote and implement this type of Green Infrastructure.

The case studies do not allow generic conclusions to be drawn related to what type of measures are required and the costs and effects of specific type of measures. They indicate instead the need to make specific analysis and plans that account for the specific needs of the river ecosystem and the obstacles to achieve good status. For example, the problem assessment highlighted the need in France to improve ecological continuity and the need to improve the opportunities for fish to traverse dams. The analysis should not only focus on the river itself, but also account for the importance of the river ecosystem for habitat and species protection. In the Danube case, the programme identified potential flood plain restoration locations throughout the Danube river basin that are also important for biodiversity protection. The Scheldt case study showed that additional areas with mud flats, marshes and wetland were required to restore (or compensate for affected) ecological processes in the river that are important for the species protection. This analysis may be needed where protected areas mightbe expanded (as illustrated in the Danube case) and to ensure a more effective protection (as illustrated in both the Scheldt and Danube case).

5.5 Lessons for a Potential EU Green Infrastructure Strategy

The case studies show that there is a need for specific Green Infrastructure programmes and plans in this field. The Sigma Plan II and Lower Danube Green Corridor illustrate that wetland restoration and development is not only important for integrated river management (delivering benefits for flood protection and water provision, water quality and ecological status of the river), but they are also important for biodiversity in a broader sense and protection of a wider range of species. Although these programmes are important for integrated river basin management, their scope is larger and specific actions, legal initiatives, combined budgets and expertise from different ministries and agencies may be necessary. The Scheldt case is a clear example of integrated planning combining objectives related to flood management and ecological and biodiversity objectives, where a combined programme may be different from programmes optimised from the perspective of a single objective. The French case study illustrates that Green Infrastructure elements related to river management may require additional and specific legal provisions.

Specific analysis is also needed to identify the most effective and cost-efficient protection measures. In the French case, for example, ecological continuity can be improved by removing orphaned constructions in the river, which is a cost-efficient measure but requires a legal and administrative framework. All the examples confirm that the costs of wetlands are case- and site-specific. It is worth investing in ex-ante surveys and studies to identify the most cost-efficient locations and types. The French analysis shows that for two-thirds of the wetland restoration programmes the costs are limited to €3,000/ha. The Scheldt case study shows that cost-efficient programmes may also include measures with much higher costs, (€100,000/ha on average). In this case, this reflects local conditions (tidal river) and the need to build high outer dykes. Nevertheless, the measures are cost-efficient as they prevent floods in nearby cities and allow other expensive flood safety measures (storm surge barriers) to be avoided.

The case studies also illustrate the additional economic benefits of these Green Infrastructure elements related to, for example, flood protection, recreation, improved regulation functions and provision of goods. They show that these benefits of wetlands are very diverse and that their economic return for society is important and depends on local circumstances. For benefits related to flood protection, recharge and water quality improvements, they depend on physical factors related to water management and the efficiency of alternative measures, whereas recreational benefits depend on nearby population densities and accessibility. The benefits for nature development depend on the habitat types created (which may vary from unique tidal systems to more common wet nature types). The economic benefits will depend on the type of nature and the socio-economic context (e.g. what type of recreation activity may be suitable and/or important and the importance of the provision of goods).

6 References

Adriaensen, F et al. (2005) *Instandhoudingsdoelstellingen Schelde-estuarium*. Ecosystem Management Research Group Report ECOBE, 05-R82. Universiteit Antwerpen, Antwerp.

Anon. (2010) *Status of Species and Habitats. Indicators for the Scheldt Estuary.* Commissioned by the Maritime Access Division, project group EcoWaMorSe, Flemish-Dutch Scheldt Commission. VLIZ Information Sheets, 226. Flanders Marine Institute (VLIZ), Ostend.

Ballaer, B Van, et al. (2007) *Landschapsecologisch en ecohydrologisch onderzoek ten behoeve van de uitwerking van een ecosysteemvisie van Grote en Kleine Nete in het kader van de actualisatie van het SIGMA PLAN. Deel II: Ontwikkelen scenario's voor de vallei van de Grote Nete*. Onderzoeksgroep Ecosysteembeheer ECOBE 07-R100. Universiteit Antwerpen, Antwerp.

Bergh, E Van den et al. (2005*),* Ecological Rehabilitation of the Schelde Estuary (The Netherlands-Belgium); Northwest Europe: Linking Ecology, Safety against Floods, and Accessibility for Port Development, *Restoration Ecology*, 13 (1), 204–214.

Brander, L, Florax, R J, and Vermaat, J (2006) The Empirics of Wetland Valuation: A Comprehensive Summary and a Meta-Analysis of the Literature. *Environmental & Resource Economics*, (33) 223–250.

Broekx S, et al. (2011) Designing a Long-Term Flood Risk Management Plan for the Scheldt Estuary Using a Risk Based Approach. *Natural Hazards*, 57 (2), 245–266, http://www.springerlink.com/content/e43138836415t02n/.

Costanza, R S C (1989) Valuation and Management of Wetland Ecosystems. *Ecological Economics*, (1), 335–361.

Couderé, K, et al. (2005. *Geactualiseerd Sigma Plan voor veiligheid en natuurlijkheid in het bekken van de Zeeschelde: synthesenot*a. Waterwegen en Zeekanaal NV, Antwerp.

Daele, T Van, et al. (2007) Focus Zeescheld. In: Dumortier, M, et al. (eds) (2007) *Natuurrapport 2007. Toestand van de natuur in Vlaanderen : cijfers voor het beleid. Mededelingen van het Instituut voor Natuur- en Bosonderzoek*, (4), 264–280.

Dauwe, W (2010*) Sigma plan, participatief beleid*. Presentation at the VVBB conference "Participatie en complexe besluitvormingsprocessen", Brussels, 16 December 2010.

European Commission (2011a) *Annex: Towards Better Environmental Options for Flood Risk Management. Introduction to Background Notes*. European Commission DG ENV, Brussels.

European Commission (2011b), *Integrating Biodiversity and Nature Protection into Port Development*, Commission Staff Working Document, SEC(2011) 319 final, Brussels.

Ebert, S, Hulea, O, and Strobe DI (2009) Flood Plain Restoration Along the Danube. In: *Lessons for Climate Change Adaptation from Better Management of Rivers*, Pittock, J (ed) Earthscan, London.

Flemish Government (2004) *Actualisatie van het Sigma Plan*, Kabinet van Vlaams Minister van Mobiliteit, Openbare werken en Energie.

Flemish Government (2005) *Actualisatie van het Sigma Plan*, VR/2005/22.07/DOC.0718 BIS.

Flemish Government (2006) *Actualisatie van het Sigma Plan*, VR/2006/2104/DOC.0354).

Flemish government (2010) *Monitoring Regeerakkoord – Vlaanderen in Actie, Stand van zaken uitvoering 2010* http://ikdoe.vlaandereninactie.be/wp-content/uploads/2011/02/Monitoring_ViA_regeerakkoord_december_20102.pdf.

ICPDR (2010) *Ten Years of the Green Corridor*, http://www.icpdr.org/icpdr-pages/dw1001_p_17.htm.

IMDC-Arcadis (2008), *Inventarisatie en vergelijking van het beleid inzake veiligheid tegen overstromen in het Schelde-estuarium op Nederlands en Vlaams grondgebied*, Studie in opdracht van Proses 2010.

LTV (2001) *Langetermijnvisie Schelde estuarium*. Ministerie van de Vlaamse Gemeenschap/ Ministerie van Verkeer en Waterstaat.

Luttik, J (2000) The Value of Trees, Water and Open Space as Reflected by House Prices in the Netherlands. *Landscape Urban Planning*, 48, 161–167.

MEEDDM (2009) *Evaluation des benefices environnement aux des zones humides dans le cadre du Grenelle Environnement*, http://138.102.82.2/appli/pmb/exemplaires/expl_SIAFEE003956.pdf.

Nocker L de, Liekens, I, and Broekx, S (2004) *Natte natuur in het Schelde-estuarium. Een verkenning van de kosten en baten*. ProSes research report.

Schwarz, U, et al. (2006) *Floods in the Danube River Basin: Flood Risk Mitigation for People Living along the Danube and the Potential for Flood plain Protection and Restoration*. WWF Danube-Carpathian Programme, Vienna, http://assets.panda.org/downloads/2006_floods_in_the_danube_river_basin_wwf_working_paper.pdf.

Schwarz, U (2010) *Assessment of the Restoration Potential Along the Danube and Main Tributaries: Working Paper for the Danube River Basin*. Draft report, WWF Danube-Carpathian Programme, Vienna.

Tucker, G, Kettunen, M, and McConville, A (2010) *Valuing and Conserving Ecosystem Services: a Scoping Case Study in the Danube Basin.* http://www.ieep.eu/assets/734/Putting_TEEB_into_practice_in_the_Danube_basin_-_WWF_study_V2.6_2-12-10_FINAL_REVISED_2.pdf.

UN-WWAP (2009) *Ecosystem Management Case Studies: Water security and ecosystem services – The Critical Connection*. Case study on the Lower Danube River and Danube Delta, http://www.scribd.com/doc/32393987/Case-Study-Ecosystem-Management.

VNSC (2010) *Opvolging vooruitgang uitvoering ontwikkelingsschets 2010*, http://pro.vnsc.eu/werkgroepen/os2010/voortgang/actualisatie-van-het-Sigma Plan/.

Waterwegen en Zeekanaal NV, Agentschap Natuur en Bos (2009) *Sigma Plan, ontmoet de schelde*. D/2009/3241/099.

WWF (2011) *Europe's Most Ambitious Wetland Project.* http://wwf.panda.org/what_we_do/where_we_work/black_sea_basin/danube_carpathian/our_solutions/freshwater/flood plains/lower_danube_and_danube_delta/.

WWF (2010) *A Decade On, Lower Danube Exceeds Green Corridor Targets*. http://wwf.panda.org/who_we_are/wwf_offices/hungary/?189121/A-decade-on-lower-Danube-exceeds-green-corridor-targets.