Supplementary material

This document provides the details of the calculation realized in the article. For each site we will present the calculation of DSAYs associated to benefits of the project and the calculation of costs of projects.

Calculation of DSAYs associated to restoration project will be conducted according to formula (1). Calculation will be explained so as to underline what are the elements necessary for calibration of the model and for calculation.

(1)

***VR*** designate the value of the services produced on the restoration site, we don’t apply any modifier for the value of services (***VR*** = 1).

***Rt*** is the intensity of restoration at year t, it designates the level of services gained through the project, usually it is calculated as the value of the gains associated to the state of the metrics at year t (the difference between initial and final state) divided by the value of the metric on the reference site. The variation of ***Rt*** during time is called maturity curve. The difference between initial and final state is selected to catch the effect of the restoration project, the difference between the situation without restoration action and the situation with the action.

***r*** is the discount rate, we apply a value of 3%.

Calculation is done for each year between the initiation of the project (i) and a selected horizon (n). In our calculations, the initiation date correspond to the year of the initiation of the project, for coherence, all calculation will be conducted on a 25 years period.

For all examples, information needed to the calculation will be summarized in tables, the first one will presents the assumptions needed for the calibration of the model to a specific objective, the second one will present the maturity function (the rate of intensity of restoration during time) and the third one will present the matrix of calculation of DSAYs.

# Libellule® Zone

## Tertiary treatment measured through dissolved oxygen

|  |  |
| --- | --- |
| Project | Libellule® Zone |
| Objective | Tertiary treatment |
| Metric | Dissolved oxygen |
| Reference state | Level of metric in the Or lagoon |
| Maturity curve | The project is initiated in 2007, production of services starts in 2010 and reaches its maximum level of services in 2011 and we have data on the metric for 2010 and 2011 (Table 1.1.2) |
| Initiation year | 2007 |
| Final year | 2032 |

Table .1.1 - Assumptions and information needed for calculation of DSAYs to value the benefits of Libellule® zone toward its objective of tertiary treatment

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Dissolved oxygen at the entrance of Libellule zone | Dissolved oxygen at the exit of Libellule zone | Dissolved oxygen in the Or Lagoon | Value of the metric |
| 2007 - 2009 | No data | Supposedly unchanged | No data | 0 |
| 2010 | 9,2 | 9,9 | 10 | 0,074 |
| 2011 | 9,1 | 9,9 | 9,9 | 0,079 |
| 2012 - 2032 | 9,1 | 9,9 | 9,9 | 0,079 |

Table 1.1. - Maturity curve of the restoration project, values of the metric of dissolved oxygen values during time

We can then calculate the benefit associated to the objective of tertiary treatment using the dissolved oxygen as proxy of the level of ecological services (Table 1.1.3).

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | **Level of services gains associated to the project** | | **Mean gain of services** | **Discount factor** | **Unitary gains** |
|  | **(Input/Output) Dissolved oxygen / Dissolved oxygen in the Or lagoon** | | **(3) = (1) + (2) / 2** | **(4) = (1+r)(2007-t)** | **(5) = (3)x(4)** |
|  | **Initial (1)** | **Final (2)** |
| **2007** | 0,000 | 0,000 | 0,000 | 1,00 | 0,000 |
| **2008** | 0,000 | 0,000 | 0,000 | 0,97 | 0,000 |
| **2009** | 0,000 | 0,074 | 0,037 | 0,94 | 0,035 |
| **2010** | 0,074 | 0,079 | 0,077 | 0,92 | 0,070 |
| **2011** | 0,079 | 0,079 | 0,079 | 0,89 | 0,071 |
| **2012** | 0,079 | 0,079 | 0,079 | 0,86 | 0,069 |
| **2013** | 0,079 | 0,079 | 0,079 | 0,84 | 0,067 |
| **2014** | 0,079 | 0,079 | 0,079 | 0,81 | 0,065 |
| **2015** | 0,079 | 0,079 | 0,079 | 0,79 | 0,063 |
| **2016** | 0,079 | 0,079 | 0,079 | 0,77 | 0,061 |
| **2017** | 0,079 | 0,079 | 0,079 | 0,74 | 0,059 |
| **2018** | 0,079 | 0,079 | 0,079 | 0,72 | 0,057 |
| **2019** | 0,079 | 0,079 | 0,079 | 0,70 | 0,056 |
| **2020** | 0,079 | 0,079 | 0,079 | 0,68 | 0,054 |
| **2021** | 0,079 | 0,079 | 0,079 | 0,66 | 0,053 |
| **2022** | 0,079 | 0,079 | 0,079 | 0,64 | 0,051 |
| **2023** | 0,079 | 0,079 | 0,079 | 0,62 | 0,050 |
| **2024** | 0,079 | 0,079 | 0,079 | 0,61 | 0,048 |
| **2025** | 0,079 | 0,079 | 0,079 | 0,59 | 0,047 |
| **2026** | 0,079 | 0,079 | 0,079 | 0,57 | 0,045 |
| **2027** | 0,079 | 0,079 | 0,079 | 0,55 | 0,044 |
| **2028** | 0,079 | 0,079 | 0,079 | 0,54 | 0,043 |
| **2029** | 0,079 | 0,079 | 0,079 | 0,52 | 0,041 |
| **2030** | 0,079 | 0,079 | 0,079 | 0,51 | 0,040 |
| **2031** | 0,079 | 0,079 | 0,079 | 0,49 | 0,039 |
| **2032** | 0,079 | 0,079 | 0,079 | 0,48 | 0,038 |
|  |  |  |  | **DSAYs** | **1,26** |

Table 1.1. - Calculation of the DSAYs to value the benefits of Libellule® zone toward its objective of tertiary treatment

## Offset production for habitat measured through vegetation coverage

|  |  |
| --- | --- |
| Project | Libellule® Zone |
| Objective | Offset production (Habitat) |
| Metric | Coverage of hydrophytes |
| Reference state | Hypothetical maximum coverage of 100% |
| Maturity curve | The project is initiated in 2007, production of services starts in 2010 and reaches its maximum level of services in 2011 and we have data on the metric for 2010 and 2011 (Table 1.2.2) |
| Initiation year | 2007 |
| Final year | 2032 |

Table 1.2.1 - Assumptions and information needed for calculation of DSAYs to value the benefits of Libellule® zone toward its objective of offset production for habitat

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Coverage of hydrophytes without Libellule zone | Coverage of hydrophytes in the Libellule zone | Hypothetical maximum of 100% coverage | Value of the metric |
| 2007 - 2009 | 0 | 0 | 1 | 0 |
| 2010 | 0 | 0,41 | 1 | 0,41 |
| 2011 | 0 | 0,61 | 1 | 0,61 |
| 2012 - 2032 | 0 | 0,61 | 1 | 0,61 |

Table 1.2.2 - Maturity curve of the restoration project, values of the metric of hydrophytes coverage values during time

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | **Level of services gains associated to the project** | | **Mean gain of services** | **Discount factor** | **Unitary gains** |
|  | **% Coverage of hydrophytes / 100** | | **(3) = (1) + (2) / 2** | **(4) = (1+r)(2007-t)** | **(5) = (3)x(4)** |
|  | **Initial (1)** | **Final (2)** |
| **2007** | 0,00 | 0,00 | 0,00 | 1,00 | 0,00 |
| **2008** | 0,00 | 0,00 | 0,00 | 0,97 | 0,00 |
| **2009** | 0,00 | 0,41 | 0,21 | 0,94 | 0,19 |
| **2010** | 0,41 | 0,61 | 0,51 | 0,92 | 0,47 |
| **2011** | 0,61 | 0,61 | 0,61 | 0,89 | 0,54 |
| **2012** | 0,61 | 0,61 | 0,61 | 0,86 | 0,53 |
| **2013** | 0,61 | 0,61 | 0,61 | 0,84 | 0,51 |
| **2014** | 0,61 | 0,61 | 0,61 | 0,81 | 0,50 |
| **2015** | 0,61 | 0,61 | 0,61 | 0,79 | 0,48 |
| **2016** | 0,61 | 0,61 | 0,61 | 0,77 | 0,47 |
| **2017** | 0,61 | 0,61 | 0,61 | 0,74 | 0,45 |
| **2018** | 0,61 | 0,61 | 0,61 | 0,72 | 0,44 |
| **2019** | 0,61 | 0,61 | 0,61 | 0,70 | 0,43 |
| **2020** | 0,61 | 0,61 | 0,61 | 0,68 | 0,42 |
| **2021** | 0,61 | 0,61 | 0,61 | 0,66 | 0,40 |
| **2022** | 0,61 | 0,61 | 0,61 | 0,64 | 0,39 |
| **2023** | 0,61 | 0,61 | 0,61 | 0,62 | 0,38 |
| **2024** | 0,61 | 0,61 | 0,61 | 0,61 | 0,37 |
| **2025** | 0,61 | 0,61 | 0,61 | 0,59 | 0,36 |
| **2026** | 0,61 | 0,61 | 0,61 | 0,57 | 0,35 |
| **2027** | 0,61 | 0,61 | 0,61 | 0,55 | 0,34 |
| **2028** | 0,61 | 0,61 | 0,61 | 0,54 | 0,33 |
| **2029** | 0,61 | 0,61 | 0,61 | 0,52 | 0,32 |
| **2030** | 0,61 | 0,61 | 0,61 | 0,51 | 0,31 |
| **2031** | 0,61 | 0,61 | 0,61 | 0,49 | 0,30 |
|  |  |  |  | **DSAYs** | **9,57** |

Table 1.2.3 - Calculation of the DSAYs to value the benefits of Libellule® zone toward its objective of offset production for habitat

## Security of the wastewater treatment plant’s rejects through the surface of wetland

|  |  |
| --- | --- |
| Project | Libellule® Zone |
| Objective | Security of the wastewater treatment plant’s rejects (WWTP) |
| Metric | Surface of wetland in the total Libellule® zone |
| Reference state | Hypothetical maximum surface of 100% |
| Maturity curve | The project is initiated in 2007, production of services starts in 2010 and reaches its maximum level of services in 2011 and we have data on the metric for 2010 and 2011 (Table 1.3.2) |
| Initiation year | 2007 |
| Final year | 2032 |

Table 1.3.1 - Assumptions and information needed for calculation of DSAYs to value the benefits of Libellule® zone toward its objective of security of the WWTP’s rejects

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Area of wetland without the Libellule® zone | Area of wetland in the total Libellule® zone | Hypothetical maximum of 100% area of wetland | Value of the metric |
| 2010 | 0 | 6500 | 15000 | 0,43 |
| 2011 | 0 | 6500 | 15000 | 0,43 |
| 2012 - 2032 | 0 | 6500 | 15000 | 0,43 |

Table 1.3.2 - Maturity curve of the restoration project, values of the metric of wetland area values during time

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | **Level of services gains associated to the project** | | **Mean gain of services** | **Discount factor** | **Unitary gains** |
|  | **% Area of wetland / 100** | | **(3) = (1) + (2) / 2** | **(4) = (1+r)(2007-t)** | **(5) = (3)x(4)** |
|  | **Initial (1)** | **Final (2)** |
| **2007** | 0,00 | 0,00 | 0,00 | 1,00 | 0,00 |
| **2008** | 0,00 | 0,00 | 0,00 | 0,97 | 0,00 |
| **2009** | 0,00 | 0,43 | 0,22 | 0,94 | 0,20 |
| **2010** | 0,43 | 0,43 | 0,43 | 0,92 | 0,40 |
| **2011** | 0,43 | 0,43 | 0,43 | 0,89 | 0,39 |
| **2012** | 0,43 | 0,43 | 0,43 | 0,86 | 0,37 |
| **2013** | 0,43 | 0,43 | 0,43 | 0,84 | 0,36 |
| **2014** | 0,43 | 0,43 | 0,43 | 0,81 | 0,35 |
| **2015** | 0,43 | 0,43 | 0,43 | 0,79 | 0,34 |
| **2016** | 0,43 | 0,43 | 0,43 | 0,77 | 0,33 |
| **2017** | 0,43 | 0,43 | 0,43 | 0,74 | 0,32 |
| **2018** | 0,43 | 0,43 | 0,43 | 0,72 | 0,31 |
| **2019** | 0,43 | 0,43 | 0,43 | 0,70 | 0,30 |
| **2020** | 0,43 | 0,43 | 0,43 | 0,68 | 0,30 |
| **2021** | 0,43 | 0,43 | 0,43 | 0,66 | 0,29 |
| **2022** | 0,43 | 0,43 | 0,43 | 0,64 | 0,28 |
| **2023** | 0,43 | 0,43 | 0,43 | 0,62 | 0,27 |
| **2024** | 0,43 | 0,43 | 0,43 | 0,61 | 0,26 |
| **2025** | 0,43 | 0,43 | 0,43 | 0,59 | 0,25 |
| **2026** | 0,43 | 0,43 | 0,43 | 0,57 | 0,25 |
| **2027** | 0,43 | 0,43 | 0,43 | 0,55 | 0,24 |
| **2028** | 0,43 | 0,43 | 0,43 | 0,54 | 0,23 |
| **2029** | 0,43 | 0,43 | 0,43 | 0,52 | 0,23 |
| **2030** | 0,43 | 0,43 | 0,43 | 0,51 | 0,22 |
| **2031** | 0,43 | 0,43 | 0,43 | 0,49 | 0,21 |
| **2032** | 0,43 | 0,43 | 0,43 | 0,48 | 0,21 |
|  |  |  |  | **DSAYs** | **6,92** |

Table 1.3.3 - Calculation of the DSAYs to value the benefits of Libellule® zone toward its objective of security of the WWTP’s rejects

## Offset production for biodiversity measured through species richness of odonates

|  |  |
| --- | --- |
| Project | Libellule® Zone |
| Objective | Offset production for biodiversity |
| Metric | Indicator of the number of species of dragonflies inventoried on the site |
| Reference state | Maximum of species inventoried on one area in France[[1]](#footnote-2) from 1970 to 2006 |
| Maturity curve | The project is initiated in 2007, production of services starts in 2010 and reaches its maximum level of services in 2011 and we have data on the metric for 2010 and 2011 (Table 1.4.2) |
| Initiation year | 2007 |
| Final year | 2032 |

Table 1.4.1 - Assumptions and information needed for calculation of DSAYs to value the benefits of Libellule® zone toward its objective of offset production for biodiversity

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Species richness of odonates without the Libellule zone | Species richness of odonates on the Libellule® zone | Maximum species richness observed on one territory in France from 1970 to 2006 | Value of the metric |
| 2007 - 2009 | 3 | 0 | 70 | -0,04 |
| 2010 | 3 | 28 | 70 | 0,36 |
| 2011 | 3 | 34 | 70 | 0,44 |
| 2012 - 2032 | 3 | 34 | 70 | 0,44 |

Table 1.4.2 - Maturity curve of the restoration project, values of the metric of species richness of odonates values during time

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | **Level of services gains associated to the project** | | **Mean gain of services** | **Discount factor** | **Unitary gains** |
|  | **(Before/After) Species on the site / Maximum species in France** | | **(3) = (1) + (2) / 2** | **(4) = (1+r)(2007-t)** | **(5) = (3)x(4)** |
|  | **Initial (1)** | **Final (2)** |
| **2007** | -0,04 | -0,04 | -0,04 | 1,00 | -0,04 |
| **2008** | -0,04 | -0,04 | -0,04 | 0,97 | -0,04 |
| **2009** | -0,04 | -0,04 | -0,04 | 0,94 | -0,04 |
| **2010** | -0,04 | 0,36 | 0,16 | 0,92 | 0,14 |
| **2011** | 0,36 | 0,44 | 0,40 | 0,89 | 0,36 |
| **2012** | 0,44 | 0,44 | 0,44 | 0,86 | 0,38 |
| **2013** | 0,44 | 0,44 | 0,44 | 0,84 | 0,37 |
| **2014** | 0,44 | 0,44 | 0,44 | 0,81 | 0,36 |
| **2015** | 0,44 | 0,44 | 0,44 | 0,79 | 0,35 |
| **2016** | 0,44 | 0,44 | 0,44 | 0,77 | 0,34 |
| **2017** | 0,44 | 0,44 | 0,44 | 0,74 | 0,33 |
| **2018** | 0,44 | 0,44 | 0,44 | 0,72 | 0,32 |
| **2019** | 0,44 | 0,44 | 0,44 | 0,70 | 0,31 |
| **2020** | 0,44 | 0,44 | 0,44 | 0,68 | 0,30 |
| **2021** | 0,44 | 0,44 | 0,44 | 0,66 | 0,29 |
| **2022** | 0,44 | 0,44 | 0,44 | 0,64 | 0,28 |
| **2023** | 0,44 | 0,44 | 0,44 | 0,62 | 0,28 |
| **2024** | 0,44 | 0,44 | 0,44 | 0,61 | 0,27 |
| **2025** | 0,44 | 0,44 | 0,44 | 0,59 | 0,26 |
| **2026** | 0,44 | 0,44 | 0,44 | 0,57 | 0,25 |
| **2027** | 0,44 | 0,44 | 0,44 | 0,55 | 0,25 |
| **2028** | 0,44 | 0,44 | 0,44 | 0,54 | 0,24 |
| **2029** | 0,44 | 0,44 | 0,44 | 0,52 | 0,23 |
| **2030** | 0,44 | 0,44 | 0,44 | 0,51 | 0,22 |
| **2031** | 0,44 | 0,44 | 0,44 | 0,49 | 0,22 |
| **2032** | 0,44 | 0,44 | 0,44 | 0,48 | 0,21 |
|  |  |  |  | **DSAYs** | **6,44** |

Table 1.4.3 - Calculation of the DSAYs to value the benefits of Libellule® zone toward its objective of offset production for biodiversity

# Environmental measures of Port 2000

## Compensatory measures: repositories for shorebirds

|  |  |
| --- | --- |
| Project | Environmental measures of Port 2000 |
| Objective | Ecological neutrality of Port 2000 on the shorebirds in the estuary |
| Metric | Abundance of shorebirds in the estuary |
| Reference state | Number of shorebirds in the estuary in 1997 |
| Initial state | Difference between the number of shorebirds in 1997 and the number of shorebirds in 2005. |
| Maturity curve | Works begin in 2001 on the dune repository and 2004 on the islet. We assume that we can start to measure the effects of the compensatory measures at the end on the first phase of works of Port 2000, in 2005. Calculation of gain will thus begin in 2005. The value of the metric is assumed using the variation of the total population of shorebirds on the estuary. From 2005, all variation of shorebird population is associated to the compensatory measure. Using the work of Aulert et al. (2009) we know the variation of the population of shorebirds from 1997 to 2008. We assume that after 2007, the level of service will reach the 1997 baseline in 2010 with a linear growth. |
| Initiation year | 1997 is the reference year associated to the impact |
| Final year | 2030 |

Table 2.1.1 - Assumptions and information needed for calculation of DSAYs to value the benefits of repositories for shorebirds in the Seine estuary

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Number of shorebirds on the estuary | Number of shorebirds without the project (2004) | Number of shorebirds on the estuary in 1997 | Value of the metric |
| 2004 | 7000 | 7000 | 16000 | 0 |
| 2005 | 7000 | 7000 | 16000 | 0 |
| 2006 | 7000 | 7000 | 16000 | 0 |
| 2007 | 5000 | 7000 | 16000 | -0,13 |
| 2008 | 8700 | 7000 | 16000 | 0,11 |
| 2009 | 12400 | 7000 | 16000 | 0,34 |
| 2010 - 2030 | 16000 | 7000 | 16000 | 0,56 |

Table 2.1.2 - Maturity curve of the restoration project, values of the metric of abundance of shorebirds on the estuary

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | **Level of services gains associated to the project** | | **Mean gain of services** | **Discount factor** | **Unitary gains** |
|  | **Number of birds due to action / Number of birds in 1997** | | **(3) = (1) + (2) / 2** | **(4) = (1+r)(2005-t)** | **(5) = (3)x(4)** |
|  | **Initial (1)** | **Final (2)** |
| **2005** | 0,00 | 0,00 | 0,00 | 0,79 | 0,00 |
| **2006** | 0,00 | 0,00 | 0,00 | 0,77 | 0,00 |
| **2007** | 0,00 | -0,13 | -0,06 | 0,74 | 0,00 |
| **2008** | -0,13 | 0,11 | -0,01 | 0,72 | 0,00 |
| **2009** | 0,11 | 0,34 | 0,22 | 0,70 | 0,00 |
| **2010** | 0,34 | 0,56 | 0,45 | 0,68 | 0,01 |
| **2011** | 0,56 | 0,56 | 0,56 | 0,66 | 0,01 |
| **2012** | 0,56 | 0,56 | 0,56 | 0,64 | 0,01 |
| **2013** | 0,56 | 0,56 | 0,56 | 0,62 | 0,01 |
| **2014** | 0,56 | 0,56 | 0,56 | 0,61 | 0,01 |
| **2015** | 0,56 | 0,56 | 0,56 | 0,59 | 0,01 |
| **2016** | 0,56 | 0,56 | 0,56 | 0,57 | 0,01 |
| **2017** | 0,56 | 0,56 | 0,56 | 0,55 | 0,01 |
| **2018** | 0,56 | 0,56 | 0,56 | 0,54 | 0,01 |
| **2019** | 0,56 | 0,56 | 0,56 | 0,52 | 0,01 |
| **2020** | 0,56 | 0,56 | 0,56 | 0,51 | 0,01 |
| **2021** | 0,56 | 0,56 | 0,56 | 0,49 | 0,01 |
| **2022** | 0,56 | 0,56 | 0,56 | 0,48 | 0,01 |
| **2023** | 0,56 | 0,56 | 0,56 | 0,46 | 0,01 |
| **2024** | 0,56 | 0,56 | 0,56 | 0,45 | 0,01 |
| **2025** | 0,56 | 0,56 | 0,56 | 0,44 | 0,01 |
| **2026** | 0,56 | 0,56 | 0,56 | 0,42 | 0,01 |
| **2027** | 0,56 | 0,56 | 0,56 | 0,41 | 0,00 |
| **2028** | 0,56 | 0,56 | 0,56 | 0,40 | 0,00 |
| **2029** | 0,56 | 0,56 | 0,56 | 0,39 | 0,00 |
| **2030** | 0,56 | 0,56 | 0,56 | 0,38 | 0,00 |
|  |  |  |  | **DSAYs** | **0,131** |

Table 2.1.3 - Calculation of the DSAYs to value the benefits of repositories for shorebirds in the Seine estuary

## Accompanying measures : rehabilitation of mudflats

|  |  |
| --- | --- |
| Project | Environmental measures of Port 2000 |
| Objective | Rehabilitation of 100 ha of mudflat |
| Metric | Surface of mudflats |
| Reference state | Objective of mudflat rehabilitation (100 ha) |
| Initial state | Null |
| Maturity curve | Project is associated to the rehabilitation of 60 ha of mudflats in 2012. Using the work of Aulert et al. (2009), we know that the project can be associated to the rehabilitation of 45 ha in 2008. Works ended in 2005, we assume linear growth of the surface of mudflat from 2006 to 2008 (45 ha) and from 2008 to 2012 (60 ha). |
| Initiation year | 2005 is the beginning of the works |
| Final year | 2032 |

Table 2.2.1 - Assumptions and information needed for calculation of DSAYs to value the benefits of the rehabilitation of mudflats in the Seine estuary

|  |  |  |  |
| --- | --- | --- | --- |
|  | Surface of mudflats that appeared | Objective of 100 ha of rehabilitation project | Value of the metric |
| 2005 | 0 | 100 | 0 |
| 2006 | 15 | 100 | 0,15 |
| 2007 | 30 | 100 | 0,3 |
| 2008 | 45 | 100 | 0,45 |
| 2009 | 48,75 | 100 | 0,4875 |
| 2010 | 52,5 | 100 | 0,525 |
| 2011 | 56,25 | 100 | 0,5625 |
| 2012 - 2030 | 60 | 100 | 0,6 |

Table 2.2.2 - Maturity curve of the restoration project, values of the metric of surface of mudflats rehabilitated

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | **Level of services gains associated to the project** | | **Mean gain of services** | **Discount factor** | **Unitary gains** |
|  | **Area of mudflat due to action / Area of mudflats expected** | | **(3) = (1) + (2) / 2** | **(4) = (1+r)(2005-t)** | **(5) = (3)x(4)** |
|  | **Initial (1)** | **Final (2)** |
| **2005** | 0,00 | 0,00 | 0,00 | 1,00 | 0,00 |
| **2006** | 0,00 | 0,15 | 0,08 | 0,97 | 0,07 |
| **2007** | 0,15 | 0,30 | 0,23 | 0,94 | 0,21 |
| **2008** | 0,30 | 0,45 | 0,38 | 0,92 | 0,34 |
| **2009** | 0,45 | 0,49 | 0,47 | 0,89 | 0,42 |
| **2010** | 0,49 | 0,53 | 0,51 | 0,86 | 0,44 |
| **2011** | 0,53 | 0,56 | 0,54 | 0,84 | 0,46 |
| **2012** | 0,56 | 0,60 | 0,58 | 0,81 | 0,47 |
| **2013** | 0,60 | 0,60 | 0,60 | 0,79 | 0,47 |
| **2014** | 0,60 | 0,60 | 0,60 | 0,77 | 0,46 |
| **2015** | 0,60 | 0,60 | 0,60 | 0,74 | 0,45 |
| **2016** | 0,60 | 0,60 | 0,60 | 0,72 | 0,43 |
| **2017** | 0,60 | 0,60 | 0,60 | 0,70 | 0,42 |
| **2018** | 0,60 | 0,60 | 0,60 | 0,68 | 0,41 |
| **2019** | 0,60 | 0,60 | 0,60 | 0,66 | 0,40 |
| **2020** | 0,60 | 0,60 | 0,60 | 0,64 | 0,39 |
| **2021** | 0,60 | 0,60 | 0,60 | 0,62 | 0,37 |
| **2022** | 0,60 | 0,60 | 0,60 | 0,61 | 0,36 |
| **2023** | 0,60 | 0,60 | 0,60 | 0,59 | 0,35 |
| **2024** | 0,60 | 0,60 | 0,60 | 0,57 | 0,34 |
| **2025** | 0,60 | 0,60 | 0,60 | 0,55 | 0,33 |
| **2026** | 0,60 | 0,60 | 0,60 | 0,54 | 0,32 |
| **2027** | 0,60 | 0,60 | 0,60 | 0,52 | 0,31 |
| **2028** | 0,60 | 0,60 | 0,60 | 0,51 | 0,30 |
| **2029** | 0,60 | 0,60 | 0,60 | 0,49 | 0,30 |
| **2030** | 0,60 | 0,60 | 0,60 | 0,48 | 0,29 |
|  |  |  |  | **DSAYs** | **9,12** |

Table 2.2.3 - Calculation of the DSAYs to value the benefits of the rehabilitation of mudflats

# Kervigen marsh

|  |  |
| --- | --- |
| Project | Kervigen marsh |
| Objective | Reduction of 50 kg nitrate per year through restoration of marshes |
| Metric | Absorbed nitrate |
| Reference state | Nitrate reduction objective (50 tons per year) |
| Initial state | Absorbed nitrate without the marsh (null) |
| Maturity curve | Purification performance associated to the latest measures in 2008, it gives a performance between 2 and 4 kg per day per hectare, we present result for the lowest value. |
| Initiation year | 2010 is the beginning of the works |
| Final year | 2035 |

Table 3.1.1 - Assumptions and information needed for calculation of DSAYs to value the benefits of the rehabilitation of Kervigen marsh

|  |  |  |  |
| --- | --- | --- | --- |
|  | Performances of nitrate mitigation (t/year/ha) | Objective of mitigation of 50 t/year | Value of the metric |
| 2012 - 2030 | 0,22 | 100 | 0,044 |

Table 3.1.2 - Maturity curve of the restoration project, values of the metric of nitrate mitigation performance

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | **Level of services gains associated to the project** | | **Mean gain of services** | **Discount factor** | **Unitary gains** |
|  | **Nitrate mitigation capacity of the marsh / Total objective of mitigation** | | **(3) = (1) + (2) / 2** | **(4) = (1+r)(2012-t)** | **(5) = (3)x(4)** |
|  | **Initial (1)** | **Final (2)** |
| **2012** | 0 | 0,0044 | 0,0 | 1,00 | 0,002 |
| **2013** | 0,0044 | 0,0044 | 0,0 | 0,97 | 0,004 |
| **2014** | 0,0044 | 0,0044 | 0,0 | 0,94 | 0,004 |
| **2015** | 0,0044 | 0,0044 | 0,0 | 0,92 | 0,004 |
| **2016** | 0,0044 | 0,0044 | 0,0 | 0,89 | 0,004 |
| **2017** | 0,0044 | 0,0044 | 0,0 | 0,86 | 0,004 |
| **2018** | 0,0044 | 0,0044 | 0,0 | 0,84 | 0,004 |
| **2019** | 0,0044 | 0,0044 | 0,0 | 0,81 | 0,004 |
| **2020** | 0,0044 | 0,0044 | 0,0 | 0,79 | 0,003 |
| **2021** | 0,0044 | 0,0044 | 0,0 | 0,77 | 0,003 |
| **2022** | 0,0044 | 0,0044 | 0,0 | 0,74 | 0,003 |
| **2023** | 0,0044 | 0,0044 | 0,0 | 0,72 | 0,003 |
| **2024** | 0,0044 | 0,0044 | 0,0 | 0,70 | 0,003 |
| **2025** | 0,0044 | 0,0044 | 0,0 | 0,68 | 0,003 |
| **2026** | 0,0044 | 0,0044 | 0,0 | 0,66 | 0,003 |
| **2027** | 0,0044 | 0,0044 | 0,0 | 0,64 | 0,003 |
| **2028** | 0,0044 | 0,0044 | 0,0 | 0,62 | 0,003 |
| **2029** | 0,0044 | 0,0044 | 0,0 | 0,61 | 0,003 |
| **2030** | 0,0044 | 0,0044 | 0,0 | 0,59 | 0,003 |
| **2031** | 0,0044 | 0,0044 | 0,0 | 0,57 | 0,003 |
| **2032** | 0,0044 | 0,0044 | 0,0 | 0,55 | 0,002 |
| **2033** | 0,0044 | 0,0044 | 0,0 | 0,54 | 0,002 |
| **2034** | 0,0044 | 0,0044 | 0,0 | 0,52 | 0,002 |
| **2035** | 0,0044 | 0,0044 | 0,0 | 0,51 | 0,002 |
| **2036** | 0,0044 | 0,0044 | 0,0 | 0,49 | 0,002 |
| **2037** | 0,0044 | 0,0044 | 0,0 | 0,48 | 0,002 |
|  |  |  |  | **DSAYs** | **0,079** |

Table 3.1.3 - Calculation of the DSAYs to value the benefits of the rehabilitation of Kervigen marsh

# Vurpillères stream

|  |  |
| --- | --- |
| Project | Vurpillères stream |
| Objective | Ecological restoration of the site to its initial state |
| Metric | Species richness of plecoptera, trichoptera and ephemeroptera |
| Reference state | Species richness in 2007 |
| Initial state | Number of species before restoration |
| Maturity curve | According to the work of Redding [2009], we select the number of observed species in 1993, 1998, 2002 and 2007, we assume linear growth between observations. |
| Initiation year | 1997 is the beginning of the works |
| Final year | 2022 |

Table 4.1.1 - Assumptions and information needed for calculation of DSAYs to value the benefits of the rehabilitation of Kervigen marsh

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Species richness without project | Species richness on the site | Species richness at reference (1967) | Value of the metric |
| 1997 | 25 | 25 | 48 | 0 |
| 1998 | 25 | 25 | 48 | 0 |
| 1999 | 25 | 29 | 48 | 0,08 |
| 2000 | 25 | 29 | 48 | 0,08 |
| 2001 | 25 | 30 | 48 | 0,10 |
| 2002 | 25 | 30 | 48 | 0,10 |
| 2003 | 25 | 31 | 48 | 0,13 |
| 2004 | 25 | 34 | 48 | 0,19 |
| 2005 | 25 | 37 | 48 | 0,25 |
| 2006 | 25 | 40 | 48 | 0,31 |
| 2007 | 25 | 44 | 48 | 0,40 |
| 2008 - 2018 | 25 | 48 | 48 | 0,48 |

Table 4.1.2 - Maturity curve of the restoration project, values of the metric of species richness

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | **Level of services gains associated to the project** | | **Mean gain of services** | **Discount factor** | **Unitary gains** |
|  | **(Input/Output) Dissolved oxygen / Dissolved oxygen in the Or lagoon** | | **(3) = (1) + (2) / 2** | **(4) = (1+r)(2012-t)** | **(5) = (3)x(4)** |
|  | **Initial (1)** | **Final (2)** |
| **1997** | 0,00 | 0,00 | 0,00 | 1,00 | 0,00 |
| **1998** | 0,00 | 0,08 | 0,04 | 0,97 | 0,04 |
| **1999** | 0,08 | 0,08 | 0,08 | 0,94 | 0,08 |
| **2000** | 0,08 | 0,10 | 0,09 | 0,92 | 0,09 |
| **2001** | 0,10 | 0,10 | 0,10 | 0,89 | 0,09 |
| **2002** | 0,10 | 0,13 | 0,11 | 0,86 | 0,10 |
| **2003** | 0,13 | 0,19 | 0,16 | 0,84 | 0,13 |
| **2004** | 0,19 | 0,25 | 0,22 | 0,81 | 0,18 |
| **2005** | 0,25 | 0,31 | 0,28 | 0,79 | 0,22 |
| **2006** | 0,31 | 0,40 | 0,35 | 0,77 | 0,27 |
| **2007** | 0,40 | 0,48 | 0,44 | 0,74 | 0,33 |
| **2008** | 0,48 | 0,48 | 0,48 | 0,72 | 0,35 |
| **2009** | 0,48 | 0,48 | 0,48 | 0,70 | 0,34 |
| **2010** | 0,48 | 0,48 | 0,48 | 0,68 | 0,33 |
| **2011** | 0,48 | 0,48 | 0,48 | 0,66 | 0,32 |
| **2012** | 0,48 | 0,48 | 0,48 | 0,64 | 0,31 |
| **2013** | 0,48 | 0,48 | 0,48 | 0,62 | 0,30 |
| **2014** | 0,48 | 0,48 | 0,48 | 0,61 | 0,29 |
| **2015** | 0,48 | 0,48 | 0,48 | 0,59 | 0,28 |
| **2016** | 0,48 | 0,48 | 0,48 | 0,57 | 0,27 |
| **2017** | 0,48 | 0,48 | 0,48 | 0,55 | 0,27 |
| **2018** | 0,48 | 0,48 | 0,48 | 0,54 | 0,26 |
| **2019** | 0,48 | 0,48 | 0,48 | 0,52 | 0,25 |
| **2020** | 0,48 | 0,48 | 0,48 | 0,51 | 0,24 |
| **2021** | 0,48 | 0,48 | 0,48 | 0,49 | 0,24 |
| **2022** | 0,48 | 0,48 | 0,48 | 0,48 | 0,23 |
|  |  |  |  | **DSAYs** | **5,79** |

Table 4.1.3 - Calculation of the DSAYs to value the benefits of the restoration of Vurpillères stream

# Calculation of cost of projects

For each project cost are calculated based on the fixed cost of project and the yearly variable cost associated to monitoring and management. Results are summarized in table 5.1

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Project | Fixed cost (.ha-1) | Variable cost (.ha-1) | Variable cost on 25 years (.ha-1) | Total cost (.ha-1) |
| Libellule® Zone | 233,000 | 60,000 | 1,105,000 | 1,338,000 |
| Environmental measures of Port 2000 - Mudflats rehabilitation | 77,000 | 0 | 0 | 77,000 |
| Environmental measures of Port 2000 - Repositories | Dune repository (97% in 1 ha):  42,200  Islet repository (3% in 1 ha):  5,300,000 | 0 | 0 | 213,000 |
| Kervigen marsh | 8,600 | 273 | 5,000 | 13,600 |
| Vurpillères stream | 10,600 | 0 | 0 | 10,600 |

Tableau 5.1 - Calculation of costs per hectare for each project

1. Société française d'odonatologie, source: INVOD, ESRI. [↑](#footnote-ref-2)