The Ecological Offset on the BPL HSL, a French Linear Railway Infrastructure

Eiffage, France – A Case Study (2018)

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About Eiffage

Eiffage is one of Europe's leading construction and concessions companies. The Group's business activities include: construction, real estate and urban development, civil engineering, metal, roads, energy and concessions.

Unique by nature, universal by vocation, Eiffage is based on a structural balance between the Construction and Concessions businesses. Its multiple areas of expertise allow it to propose innovative solutions and to fund, design, construct, operate and maintain buildings, sites and infrastructures in France and throughout the world.

Thanks to the experience of more than 65,000 employees, Eiffage generated €15 billion in 2017, 21% of which came from other countries.

The Eiffage Group joined the Business and Biodiversity Offsets Programme (BBOP) in 2013.

Available from https://www.eiffage.com/en/home

See also http://www.developpementdurable.eiffage.com/en/

About the project

The Bretagne-Pays de La Loire High Speed Rail Line (BPL HSL) is a 182 km high speed railway junction between Le Mans and Rennes situated in the west of France. It is the Eiffage Group's most extensive project. Eiffage was entrusted with the final design, construction and maintenance of the railway in 2011 and until 2036 is engaged in a public-private partnership agreement with the SNCF Réseau (formerly the RFF), which manages the French rail network.

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Abstract

The Bretagne-Pays de la Loire (BPL) high-speed railway line's application of the mitigation hierarchy, including biodiversity offsets, has benefitted from almost 20 years of planning, assessment and optimisation of mitigation measures to limit impacts on biodiversity. The project's aim was to follow best practice and goes beyond the requirements in the 2012 French regulation (**Mitigation Doctrine, 2012**).

This case study explains and demonstrates the project's key avoidance, minimisation and compensation measures. In particular, the case study details the predicted residual impacts and associated compensation requirements for all species and habitat types listed in relevant water and protected species legislation. It also sets out the kinds of compensation measures being implemented, where and how they are taking place and how monitoring is undertaken.

The outcome of an assessment of the BPL project relative to the 10 BBOP principles is summarized. This work was done to see whether the project could meet international standards for No Net Loss and identify lessons learnt and areas for improving mitigation practice in future Eiffage projects in France and internationally.

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Table of acronyms

BPL: Bretagne - Pays de la Loire
CIAF: Commission Intercommunale d'Aménagement Foncier / Intercity Commissions for Land Development
CRPF: Centre Régional de la Propriété Forestière / Regional Forest Property Centers
DPU: Declaration of Public Utility
EIA: Environmental Impact Assessment
ERE: Eiffage Rail Express (Eiffage' subsidiary)
HSL: High-Speed Line
INRA: Institut National de Recherche Agronomique / French National Institute of Agronomic Research
KBC: Key Biodiversity Components
LOTI: Loi d'Orientation sur les Transports Intérieurs / Inland Transport Orientation Law
LPO: Ligue de Protection des Oiseaux / Birds Protection League
ONF: Office National des Forêts / National Forestry Office
PAOG: Plan d'Aménagement et d'Orientaiton de Gestion / Development, Orientation and Management Plan
RFF: Réseau Ferré de France / French rail network company
SAFER: Land Development and Rural Settlement Society
SDAGE: Schéma Directeur d'Aménagement et de Gestion des Eaux / Master Plan for Water Planning and Management
SEPNB: Société pour l'Etude et la Protection de la Nature en Bretagne / Society for the Study and Protection of Nature in Brittany
SNCF: Société Nationale des Convois Ferroviaires Français / French National Railway Company
SRCE: Schéma Régional de Cohérence Ecologique / Regional Ecological Coherence Scheme
ZNIEFF: Zone Naturelle d'Intérêt Ecologique, Faunistique et Floristique / Natural Areas of Fauna and Flora Interest

I

Introduction

Introduction

The Bretagne-Pays de la Loire (BPL HSL) is a new high-speed railway line that responds to the need for rapid travel between the regions of Brittany, the Pays de la Loire and Paris, while serving the localities crossed (Figure 1 & Figure 2).

This new 182 km line between the cities of Le Mans and Rennes was the Eiffage Group's largest project. Eiffage was entrusted with the final design, construction and maintenance of the railway in a public-private partnership agreement with the SNCF Réseau (formerly the RFF) that ends in 2036.
Construction of the line took four (2012-2016) years but it is the result of 25 years of collaboration between the SNCF Réseau, Eiffage Rail Express (ERE - an Eiffage subsidiary dedicated to the project), authorities and local actors.

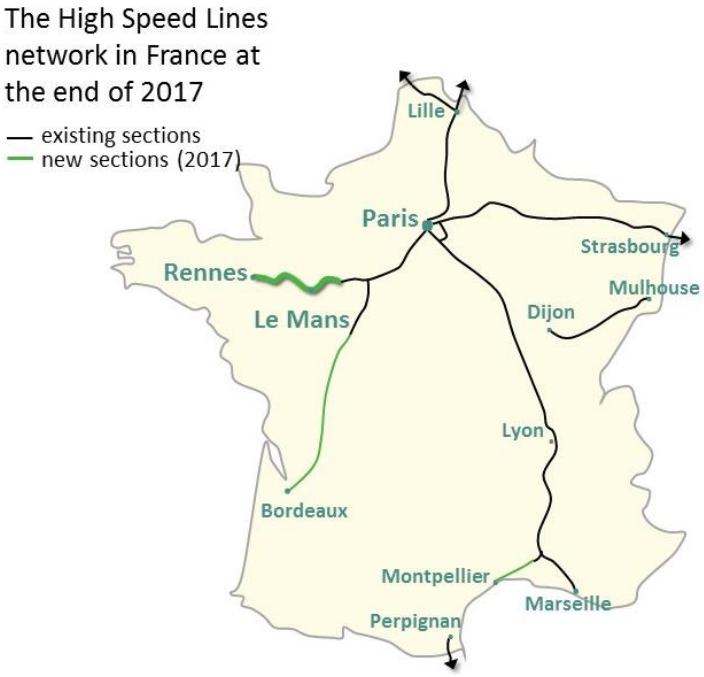


Figure 1: The Integration of the BPL HSL in the French high-speed railway Network (Source: Eiffage)

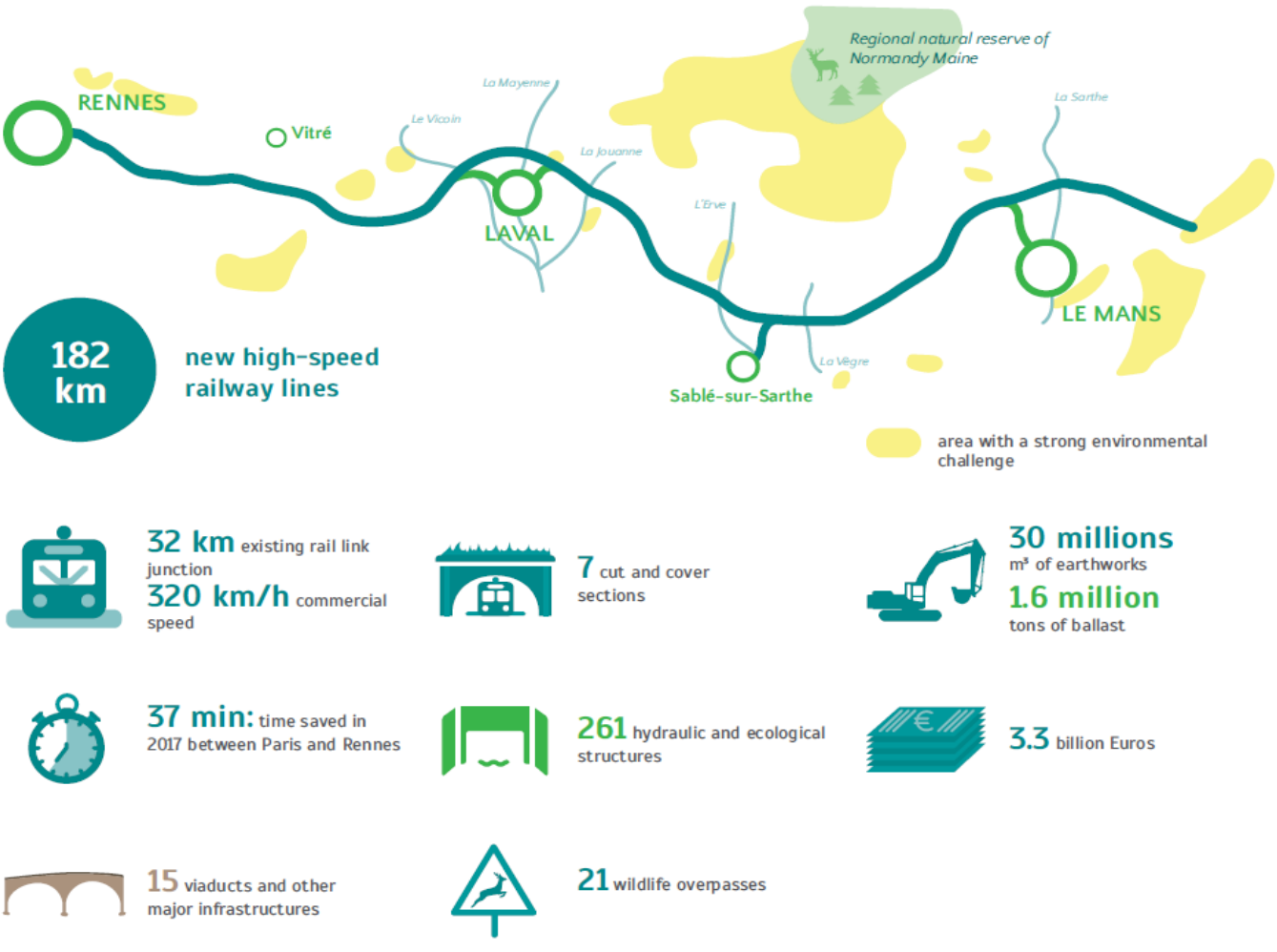


Figure 2: The route of the BPL HSL and key figures (Source: Eiffage)

A multi-criteria assesment was conducted, and iteratively refined until 2011, in order to choose a route with the least amount of environmental, social and economic impacts, among others.
To design relevant measures for the territory, ERE consulted numerous stakeholders in the three departments involved, namely: land planners, environmental studies offices, local associations for the protection of nature, chambers of agriculture and expropriation associations.

More than 80% of the environment concerned by the project is agricultural (farming and other types of husbandry). The meadows are typically surrounded by networks of hedges (called "*bocage*"), apart from certain areas where some totally disappeared during a movement of land consolidation in the 1960's. Natural protected areas like forestation zones, groves and wetlands are also part of the region's landscape. Forest density in these mostly rural territories vary: very weak in the department of Ille et Vilaine, weak in the department of Mayenne with the exception of the periphery of Laval, intensifying sharply in the department of Sarthe.

Strong peri-urbanization, an important environmental issue

In 2007, French law clearly stated that mitigation hierarchy was to be adhered to in any project that impacted the environment. It was reaffirmed with the adoption of the Grenelle Law in 2009 and 2010.
French law has changed since the construction of the project, and along with the development of the notion of "No Net Loss " of biodiversity now strictly requires offset measures before the impacts appear (Biodiversity Law, Loi Biodiversité, 2016).

As a showcase of the Eiffage Group's know-how in terms of sustainable development and turnkey projects, the BPL HSL illustrates all of the stages of the mitigation hierarchy: avoidance, minimization, restoration of any temporary impacts, compensation during the design, construction and maintenance phases of the project. Eiffage is committed to preserving biodiversity in accordance with the (SNCF Réseau) National Strategy for Biodiversity (SNB) and developed its own corporate commitment to the SNB and environmental charters for sustainable development, biodiversity and water. The SNCF Réseau and Eiffage signed a specific sustainability agreement specific to the BPL project that was beyond French regulatory obligations in 2013.

Adjustments of the right-of-way, works optimisations and technical adaptations are part of the measures enforced to avoid and reduce the project's impact on the environment. The Office Nationale des Forêts (ONF - National Forestry Office), the principal natural areas manager in France, designed the compensation measures to offset the residual impacts of the project with the objectives to respect the ecological equivalence principle, implement the measures at an ecologically functional distance of the impacted sites, support the farming activities on offset sites and implement the offset before the line was commissioned in July 2017.

Dervenn, a small Breton firm, executed the compensation works and to ensure the effectiveness of the measures will also monitor them until 2036 (the date set by the local authorities and also that of the termination of the partnership contract). An observatory of the environment[1] was also established to follow-up on the side effects of the line (e.g., possible cut-off effects of the line on amphibian displacements). These studies on the direct and indirect effects have been part of the observatory from the beginning and go beyond the legal requirements.

Evaluation of the project's offset with 'No Net Loss of Biodiversity'

This case study describes how Eiffage and its partners approached and determined the expected impacts of the BPL HSL ('the project') and how the design and mitigation measures were implemented in line with the mitigation hierarchy. The purpose of the case study is to review the project with the 10 BBOP principles in order to assess the BPL HSL in the light of international best practices. This will help us to:

- better understand the internationally recognized mitigation standards in order to evaluate our practices within this demanding standard;
- experiment and share the complexities of applying of all of these standards on linear infrastructure projects of this magnitude;
- see how we can improve our project design and work organisation in order to improve our "weak" points.

[1]http://www.ere-lgv-bpl.com/environnemental

The ten Principles on Biodiversity Offsets were developed by members of the BBOP Advisory Group, who support them and recommend them as the basis for the design and implementation of high-quality biodiversity offsets. The Principles also provide the structure for the international Biodiversity Offset Standard, released in 2012 by BBOP.

1. **Adherence to the mitigation hierarchy**
2. **Limits to what can be offset**
3. **Landscape context**
4. **No net loss**
5. **Additional conservation outcomes**
6. **Stakeholder participation**
7. **Equity**
8. **Long-term outcomes**
9. **Transparency**
10. **Science and traditional knowledge**

To go beyond compliance

Firstly, it is important to note that the BPL HSL was designed to comply with French and EU laws and regulations and not with the BBOP Standard. Aside from a few special circumstances, achieving the BBOP Standard of "No Net Loss of Biodiversity, and, where possible a Net Gain" was a goal but not required by French and EU laws and policies until 2016. Nonetheless, the standard is a key to how to manage impacts on biodiversity and was set as the BPL's target. Secondly, the BPL HSL project design had been underway since 1994, well before the BBOP Standard was published in 2012 (Figure 3). The detailed design was led in 2010 until 2012 by Eiffage and its engineering Setec. The assessment of the project against the Standard was only undertaken in 2017-2018. Consequently, the aim of the assessment was to appraise both the quality of the project's mitigation measures and how closely they approach an outcome of 'No Net Loss'. The BPL HSL project has always aspired to not just comply with international best practices but to align itself as closely as possible to them. This is the objective of this review.

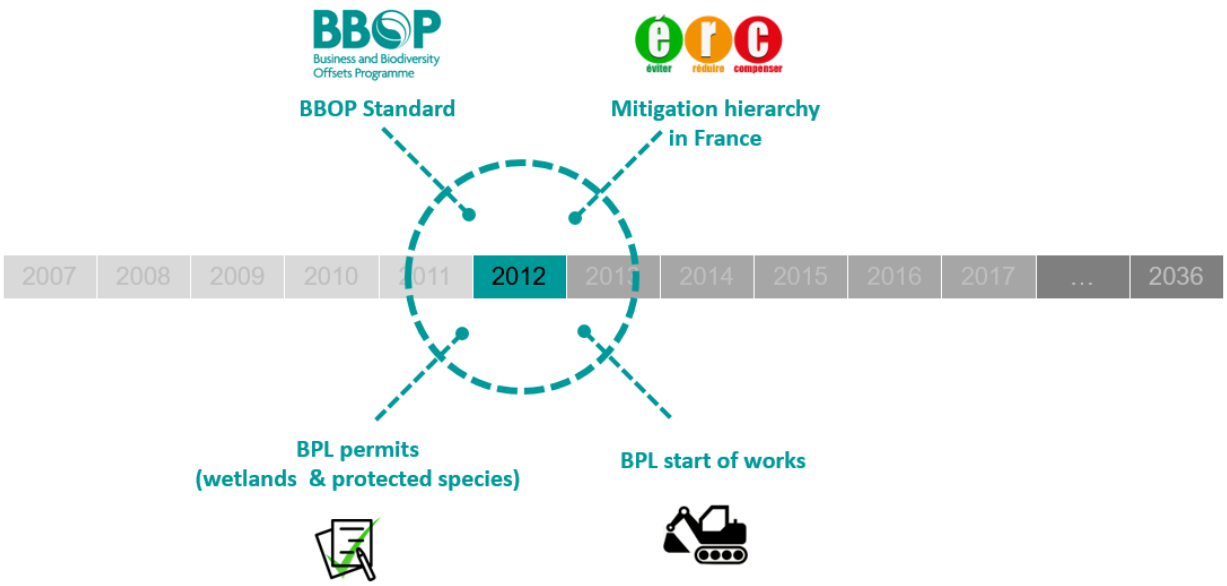


Figure 3: 2012, a key year for the BPL project

1

The first steps of the application of the mitigation hierarchy to the BPL project : Avoidance and minimization

1. The first steps of the application of the mitigation hierarchy to the BPL project : Avoidance and minimization

Hedgerows, well maintained in some sectors but generally more or less unstructured in others, largely separate the lands concerned by the project. The meshes of dense hedges enclose meadows and crops. The area crossed includes small woodlots that rarely cover more than 50 ha, lakes, ponds and several valleys that shelter wet habitats.

Many of the small available offset sites were located in the surplus of the land reserves intended for the construction of the line. It was thus chosen to compensate by taking "Japanese steps", (i.e., habitats close enough to each other to form an ecological network/path for the species) on 240 sites along the 182 km of the HSL. This option was tricky because it required managing many small sites across the territory as opposed to less larger sites, a practice more common for compensation. One of the advantages of this design was that these sites were included in the regional ecological corridors; measures implemented in favour of green and blue corridors (hedges, grass strips, fallow fields, etc.) and serve as biodiversity reservoirs or relay sites.

The assumption made was that a multitude of sites would contribute to maintaining a certain ecological transparency of the line. It permitted a wider distribution of habitats and species within the landscape rather than their concentration within it and could dilute the barrier effect caused by the railway line. With smaller distances to cross, the different species could move more readily from one plot to another.

Thanks to the securing of land ahead of time, 80% of the compensation sites are located within 2 km of the HSL right-of-way. Some offsets meant for forestation are among the 20% located further away. For example, concerning the habitats of the chiropteran, closer proximity to the HSL of their forest habitats could have lead to excess mortality of individuals seeking to cross the line.
The securing of land was carried out fairly quickly and as a result some of the offset works were begun in 2013, before impact occurrence, and all of the works could be finished by 2016, before the line became active.

1.1 Early stages avoidance

The general avoidance approach is the result of early planning and iterative environmental and technical studies mainly led by the SNCF Réseau, prior to the Declaration of Public Utility (DPU) in 2006.

The preliminary studies carried out from 1994 to 2001 made it possible to refine the definition of the project and to avoid the most sensitive habitats and find the shortest and least expensive route in terms of earthworks.
In 1996, a set of spindles for the line's route, grouped by "families", was studied through a comparative analysis (Figure 4) including environmental impact assessments. The State services, elected representatives, socio-economic actors and associations were consulted in 1999. The route was chosen based on the variant analyses, taking into account the environmental stakes of the territory.

All of the studies commissioned by the SNCF Réseau formed the basis for the Declaration of Public Utility (DPU), which included the Environmental Impact Assessment (EIA) of the refined route drawn by Egis Rail in 2006. A list of species and sites of ecological interest (natural areas of fauna and flora interest (ZNIEFF), Natura 2000) was established, and the potential impacts at a macroscopic scale (1000 to 1500 m from either side of the right of way) were assessed. This first analysis made it possible to determine which groups of species could be potentially impacted by the project: amphibians, reptiles, bats, fish, insects, invertebrates, birds, wildlife; and to identify the potentially impacted outstanding sites: ZNIEFFs and wetlands[2].

[2] Relatively to :
- Directive 2008/32/EC of the European Parliament and of the Council of 11 March 2008 amending Directive 2000/60/EC establishing a framework for Community action in the field of water policy, as regards the implementing powers conferred on the Commission
- Council Directive 92/43/EEC of 21 May 1992 on the conservation of natural habitats and of wild fauna and flora
- Directive 2009/147/EC of the European Parliament and of the Council of 30 November 2009 on the conservation of wild birds

Route adjustments were again conducted at the end of this large-scale preliminary study in 2006, and Ecosphère conducted a more detailed environmental impact assessment (EIA) in 2011.
The DPU was declared on this EIA, which also formed the basis for the drafting of the compensation chapter of the call for tenders written by the SNCF Réseau.

The route thus avoids the main sectors with dense forests and hedgerows, usually areas that shelter a rich biodiversity. They are identified as nodal areas, or reservoirs of biodiversity, and preserve the main regional biological hotspots identified (Figure 5).
Some major environmental impacts were avoided because of the choices made during the three major study phases, such as:

- The regulated protected zones or areas of scientific inventories: all regulated protection perimeters for biodiversity were avoided: Natura 2000 sites, Sensitive Natural Spaces, Protected Areas For Biodiversity, nature reserves, as well as most of the ZNIEFF;
- Some highly functional wetlands: the Fayelle pond (ZNIEFF of type 1), thanks to the abandonment of the northern passage of Vitré, and the "Bog of Glatigné" (ZNIEFF of type 1) north of Laval;
- Some wooded areas with high stakes: the Forest of Pertre and the surrounding “bocage” areas south of Vitré; the Pincé Forest (ZNIEFF of type 2), and Grip woods, thanks to the abandonment of the connection south of Sablé-sur-Sarthe to Angers;
- A high-stake grassland: the Chopinière meadow in Précigné.

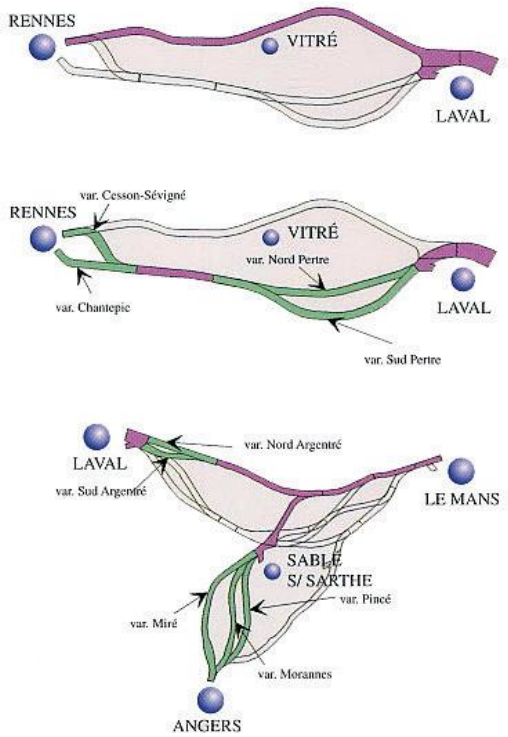


Figure 4 : Examples of the route spindles families analysed (Source: EIA, SNCF Réseau)

- Code de l'environnement, Livre II : Milieux physiques, Titre Ier : Eau et milieux aquatiques et marins , Article L210-1 and following + Livre IV : Patrimoine naturel, Titre Ier : Protection du patrimoine naturel and Titre III : Pêche en eau douce et gestion des ressources piscicoles (Article L430-1) (French Code of the Environment)
- Local master plans for water planning and management (SDAGE : Schéma directeur d’aménagement et de gestion des eaux) for each watershed : Huisne (adopted in 10/2009), Sarthe Amont (adopted in 12/2011), Mayenne (adopted in 06/2007), Oudon (adopted in 09/2003), Vilaine (adopted in 04/2003).

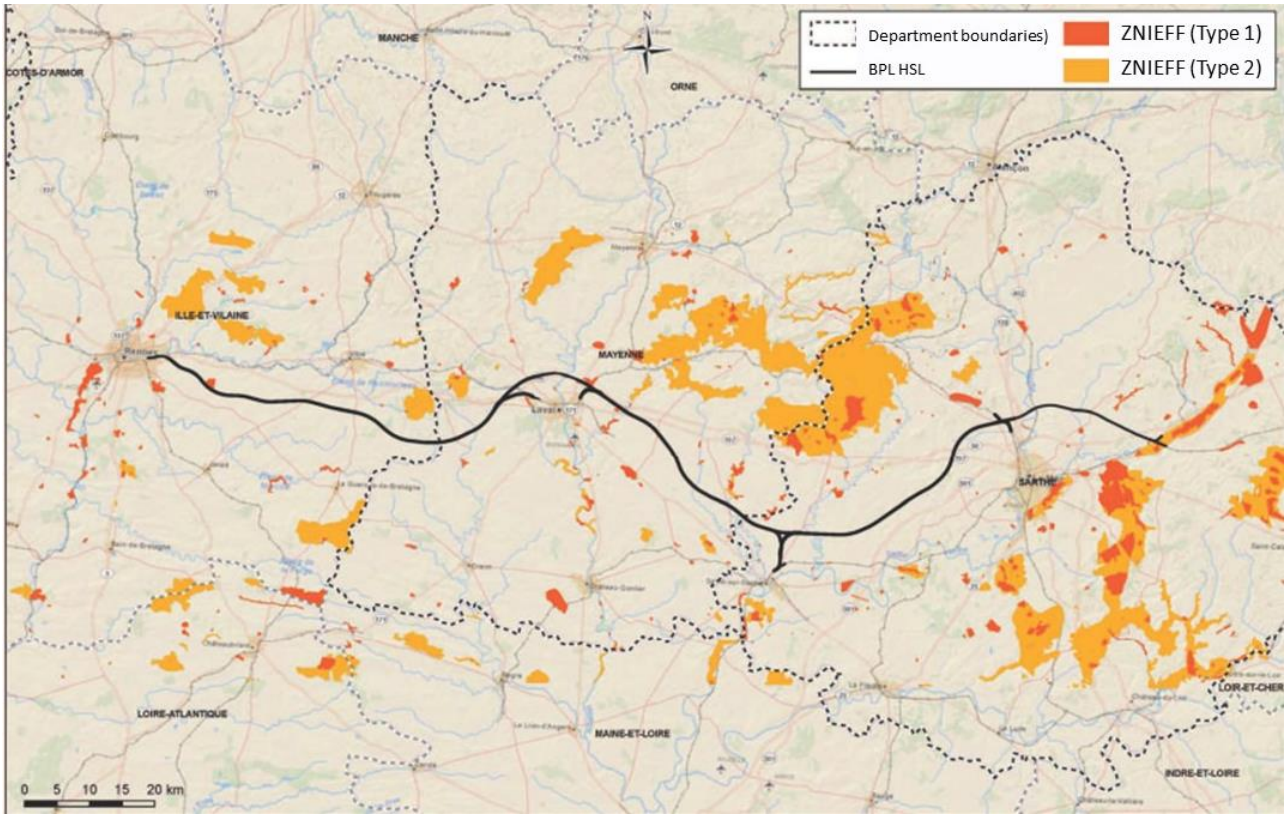


Figure 5: the BPL HSL and the large protected natural areas (Source: DREAL Bretagne and Pays de la Loire)

At the time, the potential impacts within the DPU band were:

	ZNIEFFs of type 1	ZNIEFF of type 2
Number crossed	4	1
Area	42.41 ha	29.84 ha

1.2 To know the potential impacts of the project on biodiversity is to mitigate them better

The detailed studies continued largely after the DPU with the SNCF Réseau's updates of the environmental inventories during the call for tenders (2009–2010) for the Partnership Contract and with ERE's project optimizations that began in 2011.

1.3 Ecological continuities analysis and the establishment of the Key Biodiversity Components (KBC)

In order to comply with French law, the SNCF Réseau had to make complementary assessments to the EIA because of a new requirement added in 2007, operational in 2010-2011: the ecological continuities (called "green and blue corridors"). Several elements define these continuities in order to assess the impact of any project on them, of which, the landscape, the populations concerned, their ecological requirements and their mobility.

Ecosphère, an ecology-engineering firm, defined the key biodiversity components (KBC) in its assessment made in 2011. The KBC were defined according to the species' sensitivity to fragmentation and their status of conservation in international, national, regional and local lists of threatened species (IUCN Red List of Threatened Species, endemic species list[3]).
The most important habitats taken into account are: the hedgerows, the woods, the ponds and the bottomland wetlands. Maintaining connections with other habitats such as crops, plantations, or surroundings around built-up areas, were a more limited issue.

[3] At the European, National and regional scales.

The criteria used to select the indicator groups are detailed in the following table:

Risk to the species from fragmentation			
Characteristics of the species	**Risk**		
	Low	**Moderate**	**High**
Occurrence	Common	Average	Rare
Individual home range	Little to median	Median	Big
Ecological niche	Large (non-specialist)	Narrow (specialist)	
Mobility/dispersion ability	High	Moderate to high	Low to moderate
Reproductive potential	High	Low	
Population fluctuations	Low	High	

A species was considered at risk with one high-risk characteristic out of the six. Different species of a same group could thus be considered at risk causing the whole group to be treated as a KBC.
Few species or groups of species met the high-risk criteria in the sector affected by the BPL HSL. Intensive agriculture practices and dispersed habitats had already fragmented the lands crossed by the HSL causing the species present on the sites to more or less adapt to the situation; ecological functioning was also poor.
The following groups of species were considered at risk of fragmentation and thus selected as KBC.

Thus, five indicator groups were defined:

KBC	Indicator species	Habitats concerned
Bats	Species using the tree frame. High-flying migratory species have been excluded	Hedgerows, forests and for certain species, rivers, lakes, wetlands and associated habitats (buildings, bridges)
Semi-aquatic mammals	Otter, Southwestern water vole, Neomys	Large or medium sized rivers
Nesting forest bird	Species with relatively strict requirements: Black woodpecker and Middle spotted woodpecker	Mainly old hardwood plantations relatively high up
Amphibians	All species potentially sensitive to the cutting effect: common toad and natterjack toad, common parsley frog, common frog and agile frog, European tree frog, newts and fire salamander.	Mainly ponds, small lakes (less than 1 ha) and associated habitats (more or less damp meadows and woods)
Saproxylic beetles	Great Capricorn beetle and Hermit beetle	Hedgerow system and forestation with old trees

1.4 Detailed studies

Already aware of the main biodiversity issues of the project, Eiffage launched additional studies between February and September 2011, before the Public Private Partnership (PPP) signature. These consisted of making naturalist inventories, focused on the project's footprint – comprising direct and indirect impacts – which were refined during the call for tender in order to better estimate the impact of the project on the environment. The definition of these impacts helped give a better estimate of the residual impacts of the project and propose avoidance and reduction measures.

Experts were called upon to carry out the complementary studies for two reasons:

- To know the environmental stakes precisely to be exemplary in face of the regulations related to the destruction of protected species.
- To involve the associations and local design offices that master specific and localized subjects and that have brought their respective know-how into this complex project.

Design consultancy	Service
ASCONIT (wetland engineering consultants)	Ecology of aquatic environments: - flows (Appendix 12) - wetlands (Appendix 10) - ponds and water bodies (Appendix 11)
DERVENN	- flora - amphibians (in partnership with the ONF (French National Forest Office) (Appendix 7) - insects (Saproxylic insects, odonates, butterfly) (Appendix 4) - hedgerows (Appendix 9)
GREGE (Research and Study Group for the Management of the Environment)	- small terrestrial and semi-aquatic mammals (Appendix 5)
LPO (Birds Protection League - Sarthe department)	- birds' complementary inventory (Little Owl and Montagu's harrier) (Appendix 2) - collection of existing data on birds in the Sarthe (Communal scale)
Bretagne Vivante – SEPNB (Associations)	- bat inventories in Ille-et-Vilaine (Appendix 3) - collection of existing data on the fauna in the Sarthe
Mayenne Nature Environnement	- bat and bird inventories in the Mayenne (Appendixes 3 and 2) - collection of existing data on the fauna in the Mayenne (communal scale)
Centre Permanent d'Initiatives pour l'Environnement, Vallées de la Sarthe et du Loir	- bat inventories in the Sarthe (Appendix 3)
Conservatoire des Espaces Naturels de la Sarthe	- collection of existing data other than birds (communal scale)
Hydrosphère (consulting firm specialized in watercourses)	- inventories of fish fauna from May to June 2011 (Appendix 6)

This evaluation was key in determining the vulnerability of the inventoried species and the need to be offset. When available, information about the associated values was also given. A description of the direct and indirect impacts was finalized in order to propose avoidance/reduction measures. The conclusions of these studies are detailed below for each species.

1.5 Avoidance: The choice of a path of least impact

The SNCF Réseau and ERE detailed studies, once declared a public utility, allowed for environmental impact avoidances since the beginning of 2011, through the project's optimizations by ERE:

- By route shifting: for example, north of Laval (the commune of Louverné), the route was slightly shifted to the south to avoid the southern end of the unique ZNIEFF impacted by the route of the DPU, the "Quarries and Louverné lime kiln ";
- By changing the profile length: it has been optimized to limit the movement of land. When compared to the initial project excess material was halved limiting the need for deposit areas;
- By paying particular attention to the rights of way: The location of landscape models, permanent deposits, water basins and ancillary equipment within the rights of way was studied in order to avoid areas of environmental concern including floodplains and wetlands.
  In addition, the technical rights of way have been optimized to avoid sensitive sites or stations as much as possible. The number of ponds impacted by the project could thus be reduced by this detailed design work.

The impact on the 4 type 1 ZNIEFFs was thus avoided, and the impact on the only type 2 ZNIEFF was reduced (it still presented residual impact after the early stage avoidance).

1.6 Minimization

Reduction measures were sought and applied to reduce the residual impact of the project.

Without being exhaustive, the main measures are:

- Ecological transparency measures, including hydraulic ones, to preserve the functional connectivity of species habitats: works to restoring transparency to the new infrastructure, but also to various plantations

and vegetation structures in order to enhance the attractiveness of a passage. Fences adapted to the ecological stakes on both sides of the HSL were built in order to prevent intrusions and collisions.

- Preservation of the ecological function of the natural habitats around the line, in particular the wetlands, ponds, watercourses as well as the "bocage" fields (mainly networks of hedges), and the restoration of wooded edges.
- Ecological management and maintenance of green "dependencies" in the HSL's operating policy.
- Targeted ecological engineering measures: the ecological development of riverbanks for certain insects subservient to riparian environments, the creation of permanent artificial shelters for reptiles, the development of relay ponds for amphibians, etc.

The measures are detailed for each species and habitat concerned in the second part of this paper.

1.7 Residual impact and offset requirement assessment

The BPL HSL project is an ambitious one and despite all of the best efforts to avoid and reduce impacts on biodiversity, there will be residual impacts on the natural habitats and on a certain number of species. Compensation measures must be taken.

Thanks to the detailed studies it was possible to calculate the residual impact on each of the impacted species, in terms of the surface of the habitat impacted, and for each protected area impacted (watercourses, wetlands and ponds).

The offset requirement calculated was based on the residual impact and used expert-derived multipliers, which took the following criteria into account:

1. The protection and conservation status of each species
2. The stakes of the territory crossed
3. The repartition and scarcity of the population of the species along the route of the project
4. Species sensitivity toward fragmentation
5. Ecological function of the impacted sites

The following two tables detail the residual impacts after the avoidance and reduction measures, the offset ratios used, and the offset requirement for the species and protected areas. They are extracted from the appendix 0 that explains their origin and justification.

1.7.1 For protected species

Species impacted		Residual impact	Offset ratio	Offset requirement[4]	
Birds		**Field crops**	**Offset ratio**	**Plot without seeds**	**Cultural conversion**
Eurasian thick-knee	***Burhinus oedicnemus***	85.15 ha	nc	24 (72 ha)	25 ha
Montagu's harrier	***Circus pygargus***	13.81 ha	nc		25 ha
Total		**91.14 ha**		**24 (72 ha)**	**50 ha**
Bats		**Hedges, afforestation and ecological corridors**	**Offset ratio**	**Hedges, forestation and ecological corridors**	
Bechstein's bat	***Myotis bechsteinii***	4.87 ha	*4	19.48 ha	
Barbastelle	***Barbastella barbastellus***	10.75 ha	*3	32.25 ha	
Common long-eared bat	***Plecotus auritus***	5.83 ha	*2	11.66 ha	
Whiskered bat	***Myotis mystacinus***	17.46 ha	*2	34.92 ha	

[4] Stated in terms of what needs to be achieved, including mostly restoration interventions as well as some habitat protection

Kuhl's pipistrelle	***Pipistrellus kuhlii***	11.97 ha		*2	23.94 ha		
Natterer's bat	***Myotis nattereri***	5.49 ha		*2	10.98 ha		
Serotine bat	***Eptesicus serotinus***	0.61 ha		*1	0.61 ha		
Common pipistrelle	***Pipistrellus pipistrellus***	12.58 ha		*1	12.58 ha		
Total		**22.7 ha**		**(*2.7 average)**	**61 ha**		
Insects		**Trees**		**Offset ratio**	**Tree requirements**		
Hermit beetle	***Osmoderma eremita***	8 trees / 320 ml		*8	2560 lm / 2,6 ha		
Great capricorn beetle	***Cerambyx cerdo***	153 trees / 6120 lm	2322 lm	*3	18360 lm /18.3 ha	6966 lm / 7 ha	
Total		**6440 lm**	**2322 lm**		**27 900 lm / 27,9 ha**		
Terrestrial and semi-aquatic mammals		**Riparian buffer**		**Offset ratio**	**Riparian buffer**		
Miller's water shrew	***Neomys anomalus***	8.07 ha		*3	24.21 ha		
Eurasian water shrew	***Neomys fodiens***	8.07 ha		*2	16.14 ha		
Eurasian otter	***Lutra lutra***	3.75 ha		*2	7.5 ha		
European beaver	***Castor fiber***	1.44 ha		*2	2.88 ha		
Total		**8.07 ha**			**25 ha**		
Fish		**Spawning ground**		**Offset ratio**	**Spawning ground requirement**		
Brown trout (spawning ground)	***Salmo trutta***	214 lm /0.05 ha		*2	418 lm /0.1 ha		
Amphibians		**Terrestrial habitat**	**Number of ponds**	**Offset ratio**	**Terrestrial habitat requirement**	**Ponds requirement**	
Natterjack Toad	***Bufo calamita***	11.76 ha	3 / 1.17 ha	*1 terr. habitat *5 ponds	11.76	15	
Common Toad	***Bufo bufo***		27	*1 ponds		27	
Edible Frog	***Pelophylax esculentus***		2	*1 ponds		2	
Agile Frog	***Rana dalmatina***	107.6 ha	30 / 5.42 ha	*1 terr. habitat *1 ponds	107.6	30	
European Tree Frog	***Hyla arborea***	23 ha	12 / 0.2 ha	*1 terr. habitat *3 ponds	23	36	
Fire Salamander	***Salamandra salamandra***		14	*2 ponds		28	
Northern Crested Newt	***Triturus cristatus***	42.69 ha	25 / 0.71 ha	*1 terr. habitat *4 ponds	42.69	100	
Marbled Newt	***Triturus marmoratus***	9.29 ha	28 / 0.10 ha	*1 terr. habitat *2 ponds	9.29	56	
Palmate Newt	***Lissotriton helveticus***		6	*5 ponds		30	
Alpine Newt	***Ichthyosaura alpestris***		12	*4 ponds		48	
Smooth Newt	***Lissotriton vulgaris***		9	*5 ponds		45	
Northern Crested Newt	***Triturus cristatus***		2	*4 ponds		8	
Common Midwife Toad	***Alytes obstetricans***	3.7 ha	8 / 0.31 ha	*1 terr. habitat *4 ponds	3.7	32	
Common Parsley Frog	***Pelodytes punctatus***		5	*4 ponds		20	
Total		**137.95 ha**	**68 ponds**		**137.95 ha**	**213 ponds**	

Flora		Ponds	Offset ratio	Ponds requirement
Soft Hornwort	***Ceratophyllum submersum***	2 ponds /0.06 ha	*2	4 ponds
Floating Water-Plantain	***Luronium natans***			
Total		**2 ponds /0.06 ha**		**4 Ponds**

1.7.2 For protected areas

Habitat impacted		Residual impact	Offset ratio	Offset requirement
Wetlands				
Level 1	/	70.46 ha	See methodology detailed in Appendix 10	140.92 ha
Level 2		40.36 ha		40.36 ha
Level 3		93.23 ha		46.615 ha
Level 4		50.39 ha		12.59 ha
Total		**254 ha**		**240.5 ha**
Ponds				
Level 1	***Fungible with amphibians and flora***	0.5 ha	See methodology detailed in Appendix 11	1 ha
Level 2		1.25 ha		1.25 ha
Level 3		2.4 ha		1.2 ha
Total		**4.2 ha / 110 ponds**		**3.45 ha**
Watercourses				
Waterway	/	7200 lm	*1 water act	7200 lm
Riparian forest	***Fungible with fish and aquatic mammals***	8.07 ha	*2 water act *2 (cuff fish offset) = 0.05ha*2 *2.9 (mammals average) = 8.07ha*2.9	25 ha
Spawning ground	***Fungible with fish***	214 lm	*2 water act *2 (cf fish offset)	428 lm

2

The offset requirement

2. THE OFFSET REQUIREMENT

The Office Nationale des Forêts (ONF – the National Office of Forestry) was primarily in charge of the offset design. It identified the potential offset sites, designed the first compensation “sketches”, and proposed management plans for each of them in order to clear the ecological requirement.

The purpose of the compensatory measures is to compensate for the significant direct or indirect adverse effects of the project:

- They are implemented primarily near the sites impacted by the BPL project, to ensure their features in a sustainable manner;
- They must make it possible to globally conserve, and when possible to improve, the environmental quality of the environments;
- They must be carried out as quickly as possible, that is to say, for some of them before the implementation of the key works and for all of them, before the commissioning of the line. As the full efficiency of the restoration actions may take time, they must be effective as soon as possible: for this reason, land control, already initiated on this project, was crucial.

Dervenn then adjusted the work by the ONF, in order to comply with farmers’ needs (see 3.1).

2.1 General principles

In order to remedy the residual impacts compensation aimed at an "in-kind" repair of them.
This approach is an analysis of the equivalence between the losses related to the impacts and the gains made by the compensatory measures and to target and size the compensatory measures adapted to the residual impacts. This reading grid makes it possible to verify through monitoring and control that the compensatory measures respond well to the objectives sought in the long term.
Different ecological criteria coupled with a dynamic spatial and temporal approach were used within the framework of the project. The notion of "equivalence", achieving a balance, or a significant gain at the relevant territorial scale while taking into account the environmental recovery time was pursued.

Regulations provided some clarifications that were initially used as scoping elements :

- Thus, for the compensation of the "wetlands", both the circular of 24 December 1999 and the SDAGE Loire Bretagne insist on the need to compensate for wetlands "equivalent in terms of function and biodiversity",
- In accordance with Article L311-4 of the Forest Code, the administrative authority may authorize clearing under one or more conditions; the Forest Code mentions the particular ranges of the areas to be afforested in hectares, depending on the ecological or social quality of the woods targeted by the clearing;
- Finally, in the case of biodiversity compensation, the decrees of 4 January 2007 (amending the Environment Code - articles R.411-1 to 16) and 19 February 2007, amended by the decree of 28 May 2009, and the circular of 21 January 2008, define the procedures applicable to obtaining an exemption. The ecological equivalence selected for the project embraces all components of biodiversity: the conservation of species and habitats as well as ecological features.

Thus, compensation for biodiversity was considered to be a transversal and structuring axis insofar as the proposed compensation actions for biodiversity damage, and more particularly for the protected species, were aimed at maintaining and even improving the conservation status of the habitats, species and functions of ecological continuities.

2.2 Risks that the residual impacts cannot be offset

This equivalency approach is an analysis of the equivalence between the losses related to the impacts and the gains made by the compensatory measures. As the project progressed it became possible to verify that the foreseeable residual impact could be compensated. The biological conditions of the populations of each species was analysed and the risk of non-offset ability was assessed given the "good health" of the local/regional populations, the presence of threatened or unthreatened species and the presence of sites favourable for compensation. Non-offset ability for each of the impacted species, as for their habitats, was considered low on this project. The strong avoidance strategy implemented before the project allowed for the low risk of non-offset ability (see 1.2.2).
After this verification, it was possible to target and size the compensatory measures adapted to the residual impacts for each species and area impacted.

2.3 Offset measures

A biodiversity offset aims to address the residual impacts related to the project, to achieve no net loss and preferably a net gain of biodiversity. With this objective in mind, the project established equivalency criteria between losses (induced by the project) and gains (provided through the offset measures). Equivalency has to target the same components of biodiversity, qualitatively and quantitatively.

Offset measures can be:

1. Creation: the idea is to create a habitat that did not originally exist on a site. The creation of a habitat may involve physical work (hydraulic, soil reconstitution) and biological techniques (ecological engineering, re-vegetation, etc.).
2. Restoration and rehabilitation: the aim is to restore pre-existing habitats that have been destroyed, have evolved or degenerated.
3. Preservation and enhancement, especially through management measures: these are actions aimed at ensuring the preservation of environments that could be threatened without this intervention, (land pressure, changing context, uses and management modes, etc.).

All of the species impacted by the High Speed Line are compensated; offset measures are positioned after an analysis of the landscape and its functions (respect for the biotope, ecological connectivity and so on) and as often as possible the offset is set near the impact. The challenge and objective are to avoid offset measures that are non-viable and that are disconnected from the biological processes.
When the protected species are locally impacted in a limited way because of a large and stable population, the offset measure efforts are concentrated on the more isolated sites to reinforce the more threatened populations.

The offset should be implemented before the occurrence of the impact in order to ensure the continuity of the environmental quality. This is why Eiffage chose to analyse the environmental stakes by having additional studies made before signing the partnership agreement in July 2011.

It is important to remember that the offset measures aim at coherency with the land development plans of the local communities.

2.4 Offset on-site intensification

Offset measures concerning the field of biodiversity are defined by various legal procedures: authorization is required under the Environment Code (Code de l'Environnement), exemption requests for the destruction / movement of protected species also come under the Environment Code, and the authorization to clear is under the Forestry Code (Code Forestier).
As mentioned above, the measures taken under these various procedures were considered and worked on by all involved with a view of enhancing their convergences and complementarities, and thus obtaining the greatest possible environmental benefits.

2.4.1 Fungibility concept: intensive compensation over land consumption

One of the peculiarities of this project is the nature of the land crossed: the line impacted many farms and it was difficult to secure available land for the implementation of offset measures before the validation of land development (2014).

The basic principle that led to the adoption of fungibility follows. Actions that aim at a significant net gain, that improve the quality of the environment and contribute to the return to a favourable state will, in most cases, benefit a significant number of species, almost always more than the number of species targeted (Figure 6). Given the specific linear nature of the project, its impacts and compensation measures, this was an innovation.

Three regulations govern the ecological compensation actions in France. These are:

1. the Forestry Act for land clearing and afforestation;
2. the Water Act, in terms of impacts on watercourses, groundwater and aquatic environments;
3. the Environment Code that prohibits the movement and destruction of protected species in the case of impacts on biodiversity.

The BPL High Speed Line combined these regulations on impact compensation to create leverage in terms of achievement and ultimately increase the ecological benefits of the proposed offset.

Indeed, whether they be technical measures such as the restoration, rehabilitation and preservation of the natural habitats, or measures of site conservation management in the medium and long term, the same ground compensation action responds to different impacts: this is the principle of fungibility. The advantage of fungibility is that it does not outweigh space consumption at the expense of other land uses, including agriculture. For example, the compensation schemes for the wetlands on the BPL High Speed Line were conceived in line with those of the breeding or resting habitats of amphibians. The re-naturation of watercourses was thought out to jointly develop favourable habitats for certain protected species such as the Southern Damselfly and to promote water supply in associated wetland areas.
Finally, the rate of fungibility achieved with this operation is about 25% between the woodlands compensated and the compensated protected species, notably bats, as well as between the water component — wetlands — and protected species compensation, especially for amphibians. The fungibility among these different measures was imperatively justified by the interest it represented for the species concerned.
The BPL HSL is the first example in France to have such an intensive compensation scheme, fungibility measures, validated by the competent authority. However, there is some international debate, for example in the USA and Australia, about whether and when this type of 'fungibility' approach is appropriate and justified. It should be applied with caution[5].

[5] See von Hase, Amrei and Cassin, Jan. 2018. Theory and Practice of 'Stacking' and 'Bundling' Ecosystem Goods and Services: a Resource Paper. Business and Biodiversity Offsets Programme (BBOP). Forest Trends, 2018, Washington, D.C.

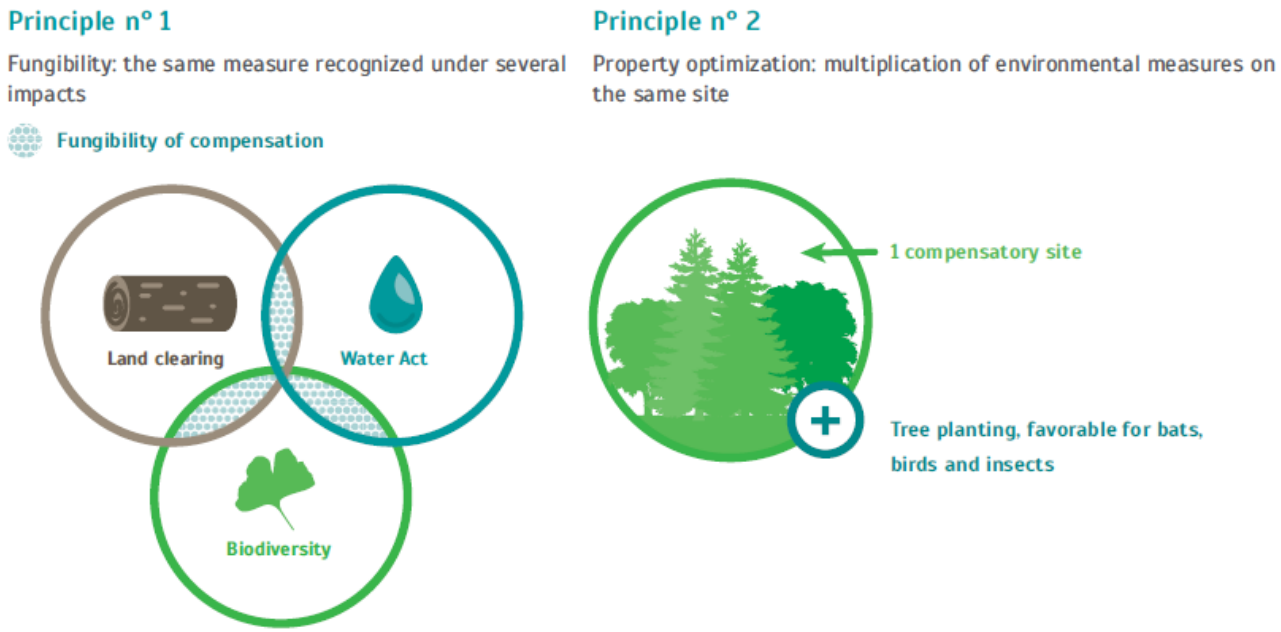


Figure 6: Illustration of the concept and implementation of fungibility (Source: Eiffage)

2.4.2 Biological complementarities

In addition a “biological complementarities” approach was also implemented for offset design.
An initial analysis classified the "biological objects" (species and habitats) for which there was a residual impact according to their presence in the major types of environment. The analyses of the residual impacts revealed the biological complementarities and synergies between the biological objects’ properties, taking into account that they could use some or all of the other types of environment.
It is therefore a question of identifying the biological objects that share their habitats with the greatest number of others and, when possible, show a high sensitivity evaluated in the light of the accumulation of the protection statuses and rankings; and this for each of the selected types of environment.

The biological objects selected, as far as possible, are "umbrella species": the high level of their ecological requirements allows for the presence of many other animal or plant species, from the most ordinary to the most remarkable. In other words, the compensatory measures that maintain or favour the targeted species potentially benefit a wide range of species with which they share their habitat complementarities.
By preserving the connectivity of the environment, maintaining and restoring the habitats of these groups of umbrella species, in the form of a network, also makes it possible to meet the goal of preserving the blue frame (ponds and wetlands) and the green frame (bog areas: meadows, hedgerows).

Three structuring analyses axes have been identified. The objective is to anticipate the best operational measures to be implemented for the highest ecological benefits that can be reasonably expected:

1. Amphibians dependent on three major types of environments: the wetlands for breeding grounds, forest and hedgerow environments for wintering and foraging environments.
2. Saproxylic insects (including Osmoderma eremita and Cerambyx cerdo), dependent on two main types of environment: the horticultural environments and the forest environments.
3. Bats occupy various ecological niches for their habitats (hibernacula, mating grounds, transit lodgings, calving grounds) and their hunting area.

This functional approach to the environment is an important point in the design and implementation of compensatory measures. The structure of the methodology of the three axes does not exclude compensation actions for the benefit of other species: vegetation, bird life, bats, terrestrial and semi-aquatic mammals, fish fauna, reptiles, molluscs and insects.

Further study expanded to integrate all of the other impacted species and habitats so as to determine more thoroughly which actions were to be undertaken with which appropriate monitoring methods.

The proposed compensatory measures involve:

- Technical measures of implementation: restoration / rehabilitation, preservation / enhancement of habitats, creation.
- Management measures to ensure the conservation of habitats and species, as well as the sustainability of the technical actions performed.

2.5 Site selection

To obtain the equivalence between the losses caused by the impacts and the gains made by the compensatory measures imply knowing and securing the offset sites early.

Three principles guided the search for sites eligible for compensation and to ensure the sustainability of the measures:

- Compensation as close as possible to the impact;
- The identification of a pool of sites in excess of the compensation needs estimate: 1,900 ha were thus pre-identified in 2011 in order to counteract the random nature of land negotiations;
- For easier management, in the search for eligible offset sites priority was given near the line (in the right of way of the line, and secondly in the perimeter of land development). This land prospection was fulfilled within very short deadlines.

2.5.1 Anticipation

To achieve compensation measures it was urgent to obtain the control of the necessary sites. As soon as the Partnership Agreement was signed in July 2011, discussions were initiated with the specialized parties such as land operators, natural area managers and environmental associations. The land operators were commissioned as of 2011 to preempt land near the HSL right-of-way and to ensure that land control was compatible with these deadlines.

Indeed, these measures had to be fulfilled within a timetable compatible with the objective of avoiding any net ecological loss. Thus, in the spring of 2012, a number of ponds were implanted for amphibians near the ponds that would soon be impacted by the works.

2.5.2 Land securing strategy

Securing land is essential for an efficient long-term implementation of offset measures. The legal compensation duration requirement on this project is for 25 years (until 2036).

Whenever possible, compensation actions were established within the project boundaries that did not require land-related acquisitions. When it was not possible, the securing of land sites and spaces was conducted through the acquisition and / or agreement with the owner / occupier and / or the site manager (Figure 7).
Numerous contacts with the local associations and managers, feedback from the consultation phases with the local authorities and local residents constituted an important pool of useful resources.

To ensure securing land for the sites located within the perimeter of land development, land and forest geometers and operators from the local General Councils were called in to identify the favourable plots.

Despite the sensitivity of the agricultural players to any new impact on land, the approach and the identification of sites were positively received during the meetings conducted by ERE and the ONF in 2011:

- with the Associations of Expropriates (ADE) of the 3 departments;

- with the “chambers of agriculture” of the 3 departments;
- with the land services of the 3 departments in charge of land development, and the land surveyors in charge of their implementation;
- with the 3 SAFERs (Land Development and Rural Settlement Society) in charge of the land reserves;
- with the Intercity Commissions for Land Development (CIAF) for land development sectors, with the ADE for non-land development sectors;
- with mayors and some residents.

In 2011, SAFER, a French real estate operator of public interest, was asked to purchase all the available properties needed for the construction of the line and the associated land planning. 5 to 10% were acquired using their pre-emptive rights, the other through amicable negotiations. In 2011 the reserve represented 3,700 ha; over 2,000 ha were destined for the HSL right-of-way.
An estimation of the quality of the land was conducted on the sites and the less fertile lands were proposed as potential offset sites to the ONF, the operator mobilized by ERE.
The expertise of the ONF was called upon to confirm the interest of the pre-identified sites in view of the compensation obligations and definitions of the potential measures. This analysis was made formal with a PAOG (a development, orientation and management plan), whose content and format were validated in July 2012, after the first meeting of the working group on compensation measures. The group was composed of the local authorities concerned (DREAL, DDT (M)), the public institutions in charge of environmental policies (ONEMA, ONCFS), a national and regional scientific council and the client.

In 2013, in order to stay attractive to farmers and achieve the offset objectives, the SAFER services adjusted the chosen sites to the associated PAOG.
After that phase, in 2015, SAFER called out for farmers to apply to lease and manage a site for the symbolic sum of 1 euro, keeping in mind the recommendations of the PAOG.

Four specifications and various measures that regulate the agricultural practices authorized on the sites concerned were defined in close collaboration between ERE, the agricultural profession, the departmental associations of the expropriated (ADE), the State services and the National Forestry Office (ONF). The use of the sites by the operators had to be compatible with the maintenance of the restored ecological functions and with a viable agricultural activity. The sites mobilized for the implementation of the ecological compensation of the residual impacts of the HSL BPL are not, for the most part, located on land of better agricultural quality (INRA, 2018).

More candidates responded than lands were available. The candidates were chosen according to their reliability and their interest in biodiversity.

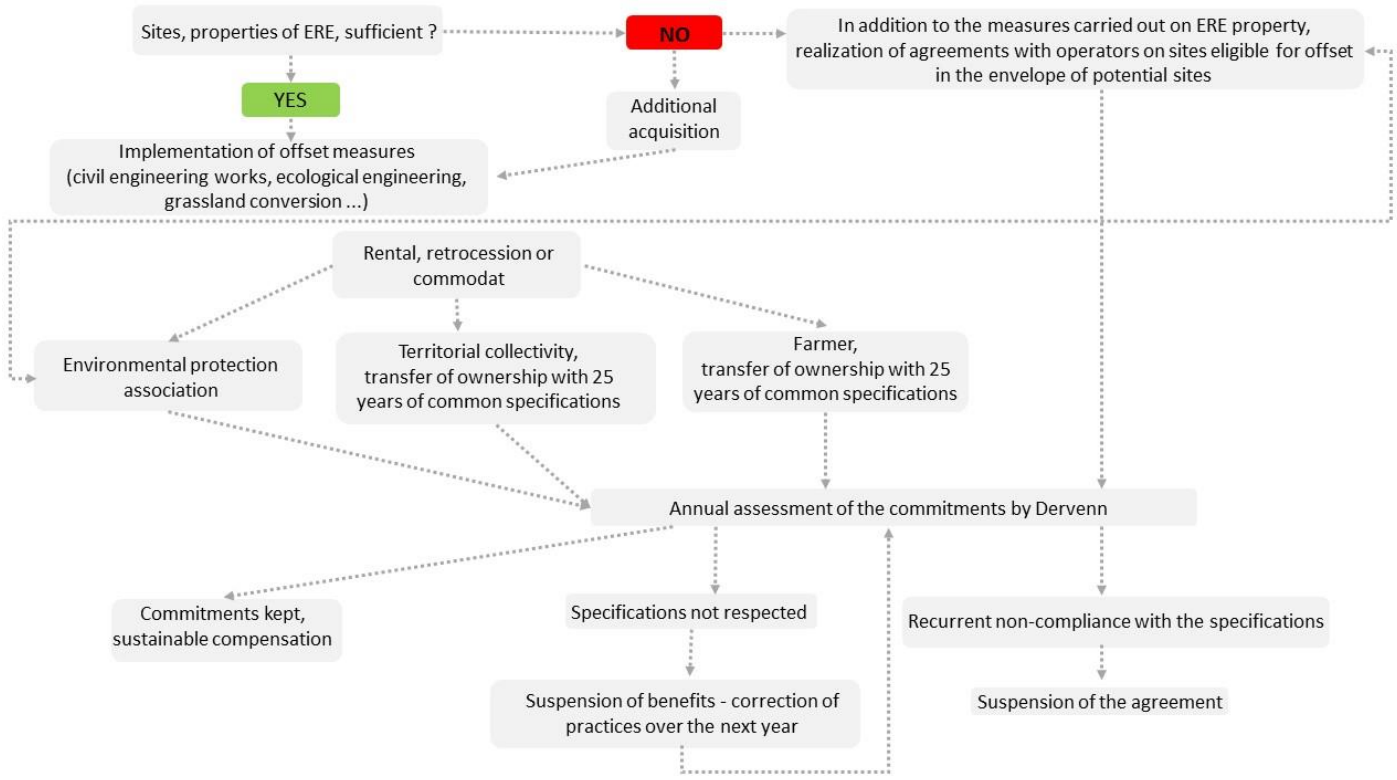


Figure 7: The Implementation process of ecological offset (Source: Eiffage)

2.5.3 Sites secured

Because of anticipation 100% of the land was secured by early 2014, and all of the immediate compensation ponds (91) were implanted by 2012, before impact occurrence.

In total, compensation measures were implemented on 240 sites, representing 816 ha, mostly located in a 2 km band around the line (Figure 8). The mean area of the sites is 3 ha and the biggest is 20 ha.
Eiffage owns 80% of the sites, 95% of which are managed by farmers (115 rural environmental leases with local farmers); Dervenn manages two sites.
The remaining 20% of the sites are under contract (90% in agricultural management and 10% directly managed by Dervenn).
Because of this strategy agricultural activity was maintained on 94% of the number of compensation sites.

Figure 8 : Location of the offset site (Source: Eiffage)

3

Offset implementation and survey

3. OFFSET IMPLEMENTATION AND SURVEY

Offsetting of the impacts is a regulation that comes after the avoidance and minimization steps. Eiffage committed to implementing this offset before the commissioning of the line in July 2017 and to managing the sites until 2036, end date of the PPP contract. The implementation and surveying processes are detailed in the following paragraphs.

3.1 PAOG (development, orientation and management plan)

For each of the compensation sites, a development, orientation and management plan (PAOG, Figure 9) was set up by the ONF with the help of independent experts (ecology experts, agronomists) and in consultation with local stakeholders (associations, chambers of agriculture, farmers, etc.).
This document detailed:

- The initial state of the site: species present and nearby, characterization and localization of natural habitats and wetlands;
- Compensation actions to be implemented: location, nature, legislation ruling each action (water law, clearing, protected species exemption);
- Management constraints, periods and frequency of intervention.

These management plans are established to ensure the achievement of long-term compensation objectives.

3.2 Offset works

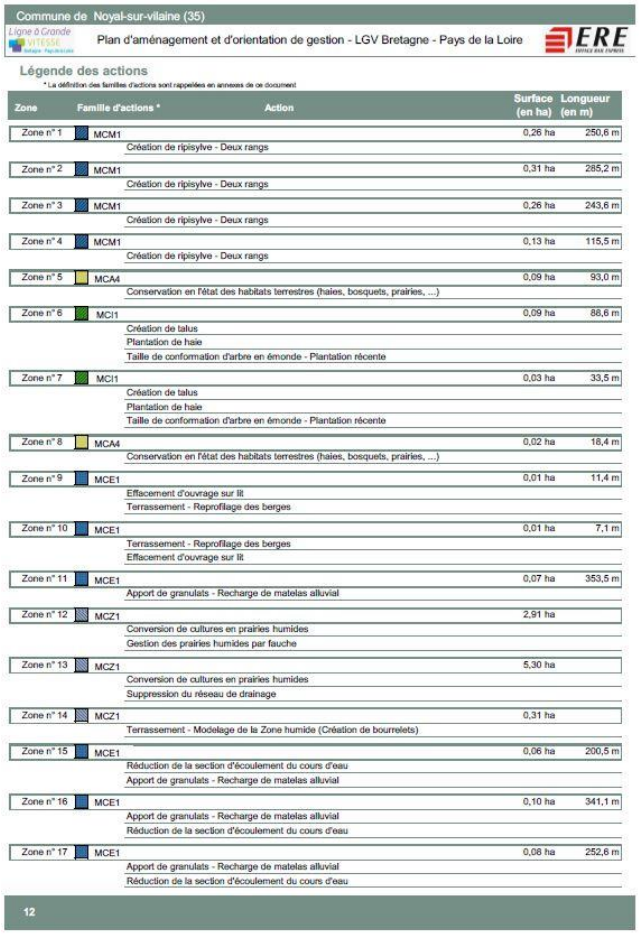


Figure 9 : Extract from a compensation site PAOG – BPL HSL (Source: ONF ; ERE)

In July 2014 ERE selected a consortium of companies to implement the compensatory measures (Figure 10) required by the construction of the BPL HSL.

They are: Dervenn (Figure 10**Erreur ! Source du renvoi introuvable.**) (works, studies and the conduct of ecological engineering projects), Cardin TP (Civil Engineering), Ouest 'Am (ecological design office) and Ter-Qualitechs (agronomist council).

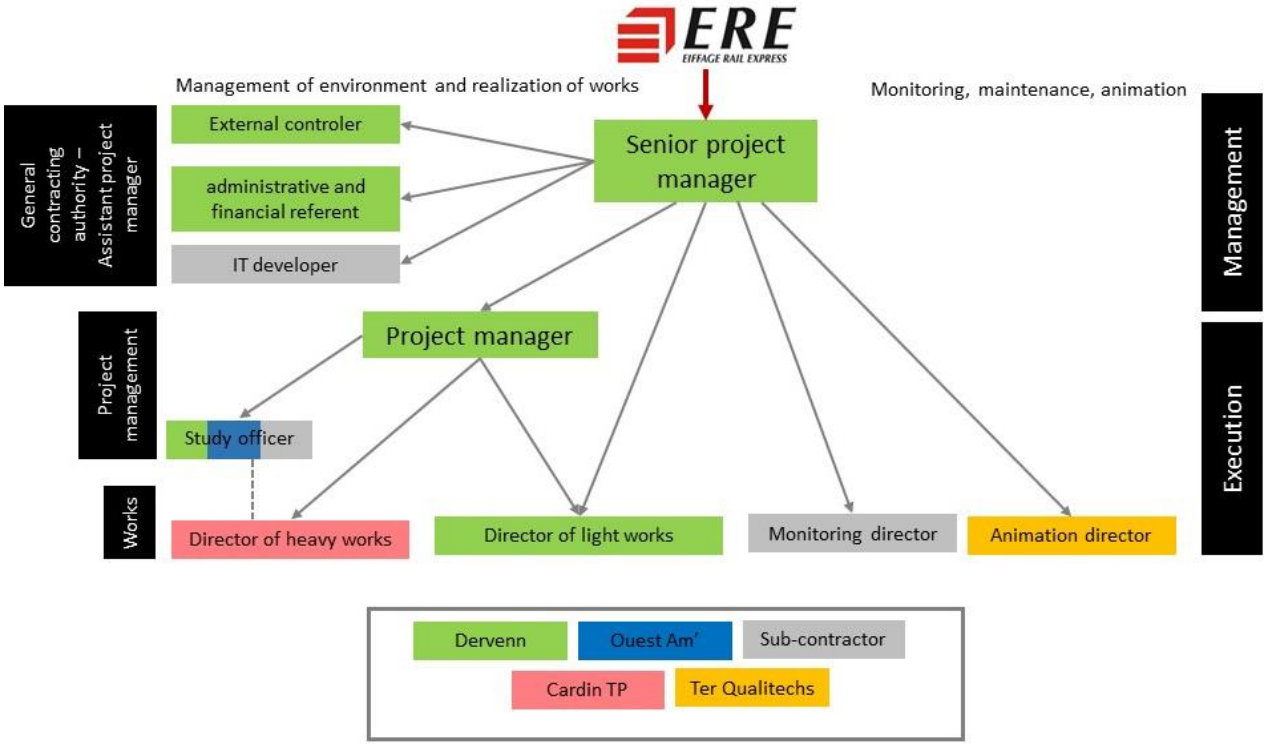


Figure 10: Organization of the consortium of companies led by Dervenn (Source: ERE)

ERE decided to choose a single consortium for the implementation and survey of all the compensation measures, in order to:

- contribute to the coherence and synergy of the proposed measures
- make them readable for the stakeholders of the territory
- facilitate their implementation and their survey.

This choice of a single operator also benefits the local stakeholders of the territory, sought by Dervenn, for the definition, the operational implementation through the works, the plantation activities, the ecological engineering and the long-term management of the compensatory measures.

A transparent report is annually provided to the administrations in charge of environmental policies so they can monitor the concrete implementation of the measures and the on-site results.

100% of the compensatory measures were implemented by mid-2016, almost one year before the commissioning of the line in July 2017.

3.3 Effective implementation of the offset requirement

The offset set up represented 920 hectares of compensation for the species and habitats impacted. This very large area represents almost half of the HSL's footprint.

The details of the offset and what has actually been implemented are in Appendix 0, species by species and habitat by habitat. This makes it possible to compare the requirements and the effective implementation of the measures, leading to the following conclusions:

Item	Effective offset implemented compared to the offset required
Bird habitats	**+ 3%**
Bat habitats	**+ 25%**
Insect habitats	**=**
Semi-aquatic mammal habitats	**=**
Fish habitats	**=**
Flora (habitats)	**+ 200%**
Wetlands	**+ 3%**
Ponds	**+ 29%**
Watercourses	**+ 67%**
Riparian linears	**=**
Spawning grounds	**=**

It is to note that the habitats offset for wetlands, ponds and watercourses are always qualitatively equivalent to the impacted sites and usually present a higher ecological potential.
Consequently, these results allow us to consider that for these items the ecological equivalency principle was respected suggesting that a No Net Loss of biodiversity should be achieved.
For the other habitats, no quantitative data was available on the impacted sites and on offset sites. We thus cannot conclude about the achievement of a NNL objective.

3.4 Long-term management

An ecology expert regularly monitors and follows up on the effectiveness of the measures according to the objectives given in the PAOG (Figure 11) for the duration of the PPP contract (i.e., 20 years). The PAOGs can be updated as soon as a drift is observed in the objectives or in order to recalibrate the measures towards a more ambitious goal.

- Dervenn is involved in the implementation and ecological monitoring of the compensation parcels. However Ter-Qualitech's support seems necessary for the proper implementation of management processes and monitoring.
- Species monitoring is done by expert counting, Dervenn and the ONF.
- Follow-up by naturalists is necessary on some measures: wetlands, hermit beetle
- Dervenn is committed to compensation results: followed-up by Mayenne Nature environment and the Sarthe Birds' Protection League (LPO). The results are then sent to the National Forest Office.

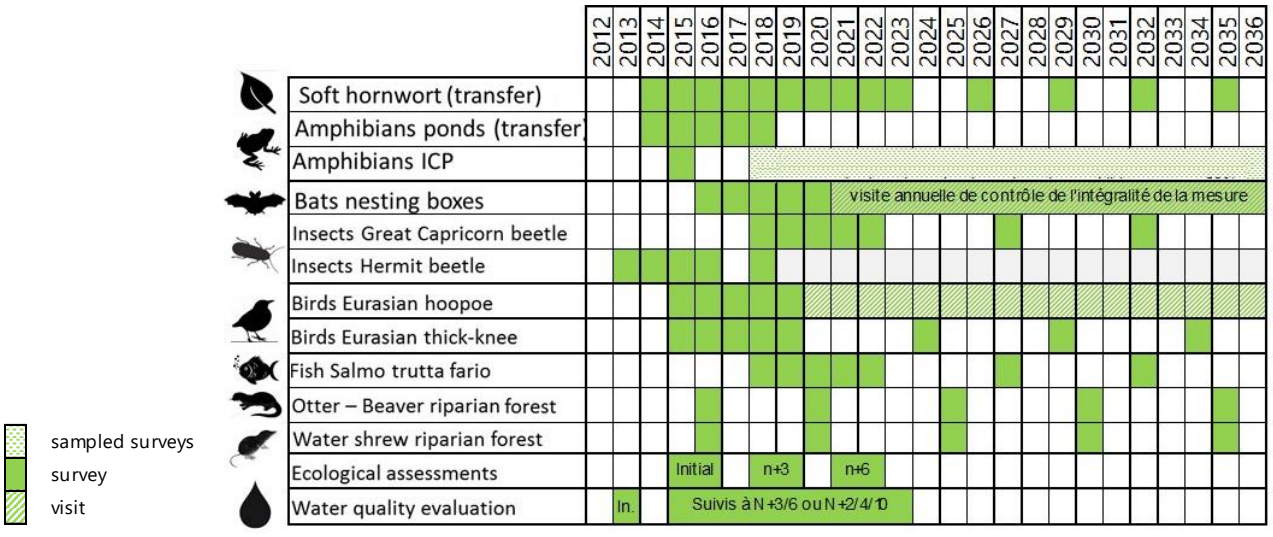


Figure 11: Schedule of the follow-ups (Source: Dervenn)

4

Analysis of the project within the BBOP Standard

4. Analysis of the project within the BBOP Standard

Following the overall presentation of the offset project above, this part of the document focuses on the compliance of the project with the BBOP standard and the ten principles listed in the introduction.
This compliance check is based on "Figure 2: principles, criteria and indicators: illustrative chronology presenting the project" (see Appendix 13), from the document "Standard on Biodiversity Offsets" (BBOP, 2012).

4.1 The offset design

This first table is built chronologically from the commitments made to sustainable development and biodiversity conservation adapted to the project, to the design phase and the integration of avoidance, minimization and compensation measures.
A multi-criteria analysis is proposed to assess compliance at each step of the design phase without neglecting the important role of the stakeholders and commitment to No Net Loss, key point of the BBOP Standard.

The elements that demonstrate No Net Loss (KBC, risk assessment, offset ability) and the project's answers to the impacts and the ecological compensation operational transcription are given in detail.

ORIENTATION AND PLANNING	
P1. Adherence to the mitigation hierarchy **1-1-1: Impact assessment undertaken with stakeholders**	**P1. Adherence to the mitigation hierarchy** Ecosphère, a consultant firm, conducted an impact assessment in 2006 (part of the EIA) and completed it with another assessment of the Green and Blue corridors in 2011 in order to avoid as many potential impacts as possible and refine the HSL route within the DPU band. In accordance with French regulation, the impact assessment was undertaken in adhesion to the mitigation hierarchy at all of its stages. As explained in 1.1, many experts were consulted in different domains: - Human environment (Egis rail, ACOUSTB, Ecopshère) - Agriculture and forestry (SNCF Ingénierie) - Natural environment (Ecosphère, Ecothème, Mayenne Nature Environnement, Ligue de Protection des Oiseaux) - Culture heritage (Pierre Lebrun) - Landscape (Pierre Lebrun) -Hydrogeology and geotechnics (Scetauroute-Ouest Infra-Technosol, Hydrosphère) - Hydraulic (Ecosphère-Egis Rail)
P4. No net loss (NNL) **4-1-1: Public commitment to NNL** **4-2-1: Key Biodiversity Components identified**	**P4. No net loss (NNL)** Eiffage's corporate sustainability charter on the preservation of biodiversity and habitats targets the environmental excellence of our projects. A public statement of the commitment to NNL is available on **ERE's website.** Moreover, a **voluntary agreement on sustainable development** was signed in 2013 between the SNCF Réseau and ERE in order to promote their mutual commitment in favour of biodiversity beyond the mandatory regulations. The key biodiversity components (see 1.3) were identified during the EIA thanks to the on ground environmental inventories made by experts, based on the Red Lists at the international, European, national and local levels and the local lists of the endangered species and habitats at the regional, departmental or very local scales. Other tools were taken into account like the protected areas: ZNIEFFs (Natural areas of flora and fauna) and Natura 2000 areas.

P2. Limits to what can be offset **2-1-1: Risk assessment of non-offset-able impacts**	**P2. Limits to what can be offset** During the impact assessment, the residual impact on each of the potentially impacted populations of species was evaluated according to its sensitivity, to the potential breeding and resting area impacted, and to the sensibility level in the Red List and the regional/local representation of the species. Each residual impact was qualified according to a regulation scale of "very strong", "strong", "medium" "low" or "insignificant" impacts at local and regional levels. "Very strong" corresponds to the destruction of a species with a very high patrimonial value and a high endemic nature that lives on a site of high ecological value. This early assessment prevented the destruction of the protected habitats and all the species in critical danger of extinction (risk of "very strong" and "strong" residual impacts). Because a surplus of land was secured for the right-of-way of the line, the volume of the sites available and potentially eligible for compensation during the design stage largely exceeded the compensation needs. Most of the offset sites were secured before earthworks began in 2013. The risk of non-offset-ability was thus reduced.
P6. Stakeholder participation **6-1-4: FPIC from indigenous peoples whose rights are affected by the project and/or the offset**	**P6. Stakeholder participation** The project was subject to public inquiry in 2012 (Water Act), during which prior and informed consent was solicited and given freely (FPIC). The FPIC was obtained through public meetings organised by ERE during the offset design phase. These meetings aimed at presenting the project to the inhabitants and landowners and to taking their informed opinions and remarks into account. Moreover, the landowners impacted by the project were identified and advised on how to obtain legal advice or financial arrangements to compensate the ecological impacts (leases, financial compensation, relocation).
LANDSCAPE and IMPACT CHARACTERISATION	
P1. Adherence to the mitigation hierarchy **1-1-2: Mitigation measures documented, implemented, monitored**	**P1. Adherence to the mitigation hierarchy** Mitigation hierarchy was the thread through all of the studies carried out by either the SNCF or by Eiffage. The application of the mitigation hierarchy is detailed in the regulation files (Protected species and Water legislation) drawn up by Eiffage, Setec and the ONF in 2012. Each regulatory procedure is divided into at least three stages: • Avoidance • Minimization/residual impact • Offset design and measures The ecological corridors' assessment was an impact study of the line on the landscape and could propose measures to maintain the landscape's ecological dynamics. Numerous complementary inventories also helped to gain more knowledge on the impacted sites and fuel the mitigation strategy. ⇨ **Exact information on the impacted territory (landscape ecological dynamics, field inventories) is key to developing an efficient offset program** An assessment and a follow-up of the efficiency of the offset measures are scheduled in the context of the LOTI report (LOTI = Inland Transport Orientation Law) and concern the minimization and offset measures. In addition, ERE established **a socio-economic and environmental observatory** that goes beyond the required follow-ups. It evaluates some of the effects of the HSL on the territory on a larger scale like the impacts on otter displacements within the country, impacts on the fragmentation of bats, impacts on farm landscape dynamics, among others.

P2. Limits to what can be offset **2-1-2: Offset-ability demonstrated**	**P2. Limits to what can be offset** Offset-ability was demonstrated by not significantly impacting highly vulnerable/endangered species and protected habitats such as the ZNIEFF and Natura 2000 zones. This could be accomplished thanks to the avoidance and minimization phases that reduced the residual impacts on heritage habitats.
P1. Adherence to the mitigation hierarchy **1-2-1: Residual losses described in the Biodiversity Offset Management Plan (BOMP)**	**P1. Adherence to the mitigation hierarchy** The residual losses considered having significant adverse effects are detailed in Appendix 0. For the protected species they are expressed in terms of the surfaces of habitats lost per species and in terms of surfaces impacted for the wetlands, ponds, hedgerows, etc. It is a synthesis of all the regulation documents submitted by Eiffage for the project (water law, protected species, clearings' files).
P6. Stakeholder participation **6-1-1: Stakeholders identified, informed of the plan to design, implement offset** **6-1-2: Records of informed consultation and participation of stakeholders**	**P6. Stakeholder participation** During the High Speed Line design phase, the SNCF Réseau identified which stakeholders would be impacted by the project (stakeholders close to the right-of-way of the line, or those indirectly linked to the construction and the offset). These consultations were carried out in two phases as the studies progressed, in 1997 and in 2000, and included the analysis of contrasting variants that fostered questions and debates. There were three phases to the public inquiry file: - the design of the route, which involved broad consultation with the population (end of 2002 - beginning of 2004), under the auspices of a Monitoring Committee set up on the recommendation of the National Commission for Public Debate; - consultation of the State services (Spring 2004); - consultation with the elected representatives, socio-economic actors and associations representing interests concerned by the project (November 2004 to March 2005). Based on the owner's proposals, the Minister in charge of transportation approved the Preliminary project summary (APS) in a ministerial decision of 26 January 2006 and asked the SNCF Réseau to put the project to public inquiry. Insofar as impacts in agricultural and forest areas were expected, the following bodies were consulted under the Rural Code (Article L. 112-3): - Chambers of Agriculture - Regional Forest Property Centers (CRPF) New investigations and parcel surveys were carried out under the Code of Expropriation in 2011 in order to pinpoint which parcels were to be acquired and which beneficiaries were to be financially compensated. The owners were informed by individual notification or, when they could not be identified, notification was posted in the city hall. All the elements of this public inquiry are available **here**. In addition to the public inquiry, once the contract between the SNCF Réseau and Eiffage was signed and the offset designer designated, Eiffage and Dervenn organised public meetings for the stakeholders (farmers and landowners, among others) to explain the ins and outs of the project and compensation. SAFER selected offset sites that could be managed by farmers motivated by and interested in the ecological approach. The result is guaranteed by Terqualitechs (in charge of land animation) and the sites benefit from a 1 € lease. SAFER, chambers of agriculture and farmers were consulted to define the management measures compatible with maintenance by farmers.

P9. Transparency
9-1-1: Information regularly reported to stakeholders
9-1-2: Independent review mechanism for offset design, implementation

P9. Transparency

Different means of communication were used to make the project and its progress/evolution known:

- ERE's website: **general information, press releases, press kits**
- **Quarterly news magazine** published by Eiffage concerning the major steps of the ongoing implementation of the project
- Information about the **mitigation hierarchy** and annual assessments of the implementation of the mitigation measures and offset for each department.
- Articles and publications in newspapers such as **Ouest France** (Special edition for the LGV BPL) in 2017.

Many public conferences and seminars were organized. In order to reach an even wider audience, a mobile trailer presenting the project circulated throughout the cities crossed during the 5 years the project lasted.

The ERE/ONF designed the offset but it was closely watched by local authorities that validated all of the 242 PAOG of the offset sites. This guaranteed compliance with the offset principles.

P4. No net loss (NNL)
4-2-2: Methods for NNL, equivalence identified, basis for selection explained
4-1-4: Equivalence methods address equity in type, condition, location, timing
4-2-4: Loss-gain (L-G) metrics identified, explained, and used for calculations
4-1-2: Residual losses quantified, pre-project biodiversity condition characterized

P4. No net loss (NNL)

The methodology used for assessing NNL is not the equivalency method suggested by the BBOP.

(1) Impacted site before impact		**(3) Offset site before impact**
Δ	**=**	**Δ**
(2) Impacted site after impact		**(4) Offset site after impact**

(1) Indeed, for this project, residual losses were quantified in terms of surface or linear impacted for species habitats and protected areas. An evaluation of the quality of the impacted sites was made only for the wetlands, ponds and water bodies (30% of the impacts in terms of surface), using a project-specific method developed by experts. The calculation of residual impact for each species and protected area is detailed in the appendices 2 to 8.
(2) The state of the impacted sites was never assessed after impact so it was considered that the site did not conserve any ecological functionality after the impact (worst case).
(3) (4) As for the offset sites, the state before and after impact was assessed with the same criteria as the impacted site before impacts.

→ The data available on wetlands, ponds and water bodies allows us to demonstrate No Net Loss for those areas
→ But, currently, the lack of quality data on the species habitats makes us unable to give an exact equivalency calculation and thus demonstrate the achievement of No Net Loss for species

In terms of equivalence, all the sites address equity:

- in type, the principle of "like for like", e.g., compensate a wetland with a wetland
- in condition, by providing, at least, the same habitats with the same ecological functionality
- in location, by compensating near the impacts (most of the offset sites are within a 2 km band around the line (see figure 7 in 2.4.3).

	→ **As the project is 182 km long, with an offset program designed globally and in a fungible context, we cannot relate a specific impacted site with a specific compensation site.** → **We plan to analyse the localisation of the impacted and compensated sites in terms of habitat types and ecological functionality, as part of the BPL HSL environmental observatory.** → **There are 920ha of compensation distributed on 242 compensation sites** In terms of timing, even if some of the offset sites were implemented before the works began (see 2.5.3 - Immediate compensation ponds), most of the sites were implemented after the occurrence of the impact. → Now, the "Biodiversity Act" passed in France in 2016 makes this principle a strong requirement. → **This is one of the most complex aspects for such a linear infrastructure projects. During the design-building process the responsibility for offset design, site identification/contracting and offset works is often delegated to the design-builder, who, in turn, must wait for the project to be attributed before actively searching for offset sites. Thus, the implementation of the compensation has to be made in a short time before the beginning of the line's works.** → *To implement offset works before the impacts, we anticipated the offset design and the search for land as much as possible even before the project was attributed.* → **At date, the BPL project cannot claim No Net Loss of biodiversity but can affirm a No Net Loss approach**
SELECTION OF OFFSET ACTIVITIES and LOCATIONS	
P5. Additional conservation outcomes **5-2-1: Leakage assessment undertaken**	**P5. Additional conservation outcomes** Leakage assessment was not undertaken for the project.
P3. Landscape Context **3-1-1: Landscape level planning for offset locations** **3-2-1: Future developments considered in offset design** **3-1-2: Offset contributes to regional goals** **3-2-2: Government invited to incorporate offset in plans**	**P3. Landscape Context** An effort was made to assure that each site was integrated into the ecological network (ponds, hedge networks) and the biodiversity reservoirs/hubs in order to increase each one's ecological potential and to facilitate the movement of species. The ecological networks were determined during the EIA in the landscape component realized in 2011 for the SNCF Réseau by Ecosphère. Regional ecological coherence schemes existed and were taken into account when relevant for connecting or re-connecting it so that species could mix genetically. → **To our knowledge, the compensation sites have not been integrated back into the planning documents as "ecological areas"** → **However, since 2018, French regulation requires that offset sites be localized in a free-access national database to make planning more readily accessible** The future development of cities crossed by the linehas also been taken into account for the offset locations. Indeed, no offset measures were implemented in the immediate vicinity of the three major cities crossed by the high-speed line. The potential changes and expansions of these cities were addressed more specifically with the local departments' authorities in the "Railway junctions" file, in order to determine and plan urban sprawl zones so as to not compromise offset measures in the short, medium and long terms. → **Future development projects other than urban sprawl have not been integrated given that no other structuring project in the vicinity of the line was known at that time**

P4. No net loss (NNL) **4-1-3: Gains calculated relative to without offset condition, which is characterized** **4-2-5: Application of L-G metrics, equivalence methods in offset design shows NNL** **4-1-4: BOMP describes offset design and evidence on assumptions** **4-3-1: Sources of risk, uncertainty and measures to address them documented** **4-3-2: Milestones for progress to NNL established and monitored**	**P4. No net loss (NNL)** Concerning the metrics used, for this project, a surface and ecological functionality approach was used. Each residual impact on a species' habitat after the avoidance and minimization phase was defined in terms of surface "to be offset" and in terms of functionalities for the ecological requirement. Offset ratios were thus determined, being more or less important as per the vulnerability of the species, the type and heritage of the habitats (see offset ratio use details in each part of Appendix 0). **→ These expert-made ratios made it possible to define the offset debt** **→ The lever of improvement here is to better explain the ratios used on the offset measures, showing how they take the uncertain success of the on-site offset measures into account. More globally, explain the uncertainty associated with the ecological trajectories of the offset sites and how this risk is addressed.** All the sites will be monitored until 2036 (see 3.4). The PAOG (development, orientation and management plan) (see 3.1) can be adapted every 5 years. Dervenn, the offset project manager selected by Eiffage to design, implement and monitor the offset until 2036, lead the consortium that realised these documents. In addition, regular scientific surveys will be made to assess the success of the measures (functionality of the habitats, inventoried species, etc.)
P5. Additional conservation outcomes **5-1-1: Evidence that 'with minus without' offset gains are additional** **5-2-2: Leakage risks addressed in implementation**	**P5. Additional conservation outcomes** Does not apply to this project.
RECORD OFFSET DESIGN	
P10. Science and traditional knowledge **10-1-1: Use of best available science in offset design, implementation documented in Biodiversity Offset Management Plan** **10-1-2: Use of relevant traditional knowledge documented, with approval**	**P10. Science and traditional knowledge** Several scientific experts worked on the offset design and its implementation. - Asconit and Hydrosphère are experts in hydraulics and hydrogeology: they worked on the elaboration of the offset methodology for the wetlands, ponds, water bodies and watercourses using the reference methodologies adapted to this project. - Dervenn, Setec and the ONF contributed their expertise in the dimensioning of the compensation through the naturalist inventories they made, but also from their separate experiences in the field of compensation. The consortium led by Dervenn drafted an offer with a component specifying the use of expert knowledge (on-ground experience) combined with scientific knowledge for the design and implementation of the offset.

4.2 The offset implementation

This second table shows the operational extension of the offset project.
Again, taking into account the important role of the stakeholders and people impacted, a multi criteria analysis is proposed to assess compliance at each step of the implementation process.
Finally, the project's long-term management is demonstrated and outcomes assessed.

IMPLEMENTATION, MONITORING, ADAPTIVE MANAGEMENT, REPORTING	
P6. Stakeholder participation **6-1-3: Implementation roles of stakeholders defined in Biodiversity Offset Management Plan** **6-2-1: Grievance mechanism in operation**	**P6. Stakeholder participation** The roles of the stakeholders in the implementation of the offset are clearly defined in the Dervenn run consortium offer. Dervenn is the project manager and designer of the offset. The consortium is composed of - Ter'Qualitechs, an agronomist and land development officer - Ouest'am, a planning consultant - Cardin TP, an earthworks company also in charge of the landscaping - Dervenn: an ecological engineering company and design office. A centralized system for processing and resolving grievances was set up in the form of spreadsheets sent by Dervenn to the contracting authority (Eiffage) every month until 2036. Grievances are prioritized by importance. The most sensitive are treated first. Each grievance resolved is noted and archived in the table, which gives an overview of the procedures in progress.
P7. Equity **7-1-1: Biodiversity Offset Management Plan references stakeholder agreements** **7-1-2: Evidence of indigenous people, local communities satisfied, rights respected** **7-1-3: Loss of people's uses and values compensated**	**P7. Equity** The agreements between the stakeholders are not clearly referenced except those between - the SNCF Réseau – the French State and delegates – and Eiffage; - the SNCF Réseau and Eiffage concerning the voluntary agreement for sustainable development on the project; - Dervenn and Eiffage for the offset design and implementation; - Eiffage and the farmers (rural environment leases) based on the voluntary will to maintain and preserve, in some places, agricultural activity on the compensation sites. These leases are based on a "give-and-take" approach; strict rules of use and maintenance are defined for the farmer who in return enjoys the usufruct of the plot. Public meetings held during the design of the compensation project and even after its implementation revealed that farmers were satisfied with this system. The farmers are the most impacted by the offset project. However, an INRA (French National Institute of Agronomic Research) study, one of the studies of the BPL observatory, shows that 72% of the farmland used for compensation had less agronomic value than the average farmland redistributed to farmers after the land reclamation.
P8. Long-term outcomes **8-1-1: Evidence of implementers' requisite management and technical capacity** **8-1-2: Legal and financial mechanisms for long**	**P8. Long-term outcomes** Dervenn, the company responsible for the implementation of the offset, had to demonstrate its technical and management capacities during the call for tender made by Eiffage in 2014. The other important aspect was the ability to manage the offset for a period of 25 years (until 2036). Long-term financial management is secure because it was included in the total calculations of work. A schedule was also set for the 25 years of evaluation and monitoring.

term implementation in place **8-2-1: Risk management and mitigation (Ref: Indic 1-3-1) implemented** **8-2-3: Monitoring, Evaluation and Adaptive Management** **8-2-2: Independent auditing of outcomes**	The mitigation hierarchy and offset measures were implemented between 2012 and 2017, in accordance with the contractual commitment between Eiffage and the SNCF Réseau. Each site is monitored at least once a year and a scientific/technical assessment of the efficiency of the measures will be made regularly until 2036 (see 3.4) Dervenn and the ONF audit the sites annually. Dervenn then reports a synthesis of the audit. All of the possible defects are noted and the means put into place for their resolution are indicated in the report of the following year. Success indicators such as the re-colonization by a plant or animal species are ways of verifying that offset has met its objectives. In the event of failure, corrective measures are implemented as many times as needed until they succeed. This is a clause of the contract. If necessary, the method of management of the site concerned will be adapted via a revision of the management plan (PAOG).

C

CONCLUSION

Conclusion

Realizing this study was a good way to get to know the BBOP standard better. It enabled us to analyse and compare Eiffage's practices with the 10 principles and identify progress axis in our approach. It let us take a step back and analyse and better understand the specificity and complexity of the mitigation hierarchy implementation on linear infrastructure projects, given the wide volume of compensation and the design/implementation temporality compared to main works planning.

To assess this project against the BBOP standard while not having directly taken it into account during the offset design (due to the chronology) required a synthesis of the fifty documents we had in our possession, and a critical analysis of the global offset project.

A long process of avoidance and minimization permitted the reduction of the residual impact to the minimum and ensured that offset measures would be efficient and sustainable. Among the most remarkable avoidance measures is the way the route was adapted to avoid natural areas at stake. This gave the line a particular shape. Different types of minimization measures were implemented but the one with the most impact is the one to preserve the existing ecological transparency by the construction of 248 structures to maintain the hydraulic and terrestrial corridors for fauna and flora.
Offset measures were implemented for the impacts we were not able to avoid or reduce: 247 ha of wetlands of high ecological functionality, 213 ponds of high ecological functionality with 213 ha of terrestrial habitat for amphibians, 12 km of watercourse restoration, 36 km of riparian forest creation, 44 km of hedges planted or restored are some examples.

In total, compensation measures were implemented on 242 sites that represent 920 ha, each site gathering various measures. To ensure the sustainability of the measures, a long-term management and monitoring plan has been scheduled until 2036.

All the steps of the mitigation hierarchy were executed with great attention and most of them are in line with the key provisions of the BBOP Standard.
The BPL HSL goes beyond the French laws of the time, but given that it was designed before the publication of the BBOP standard, it did not follow all of the principles. No Net Loss assessment, based on the ecological equivalency principle can only be justified for the wetlands and ponds. For the other species habitats, No Net Loss can only be proved in terms of volume of habitat offset but not in terms of quality. Therefore, the achievement of NNL for the whole project cannot be proved but we can say that the project followed a NNL approach, beyond regulatory obligations.

The assessment of the project against the standard was very useful because it helped us to methodically analyse the application of the mitigation hierarchy to the line and define axis of improvement for current and future projects.
It also highlights that some criteria are complicated to implement on huge linear projects conceded: the proximity to impact and the implementation before the impacts. This is due to the high volume of land necessary for the offset, the high land pressure on agricultural lands, and to the (short) time available to build and implement the offset project. All this in a context where the infrastructure works must begin as rapidly as possible after contracting.
The only solution to fulfilling (or partially fulfilling) these objectives is to anticipate the issues from the tendering stage, hand in hand with the design teams. A detailed knowledge of the areas involved and early structuring of the environmental management (during studies, works and maintenance) are also keys to the success of the mitigation hierarchy application.

This work will clearly contribute to upgrade our skills on French and international projects and put forward our motto, "make the difference".

A

APPENDICES

Appendix 0: Detailed data for all impacted species and habitats

1. For habitats

1.1. Wetlands

- Provisional impact before avoidance and reduction

313 plots of wetlands were identified in the DPU band. The level of each of them was qualified after the analysis of 3 functions: hydraulic, purifying, biologic (Appendix 10)

	Level 1 wetland[6]	Level 2 wetland[7]	Level 3 wetland[8]	Level 4 wetland[9]	Total
Number of wetlands concerned in the DPU area	117	56	80	60	**313**
Surfaces of wetlands concerned in the DPU area (ha)	225.28	178.69	250.21	181.52	**836**

- Avoidance and minimization measures

The location of landscape forms, permanent soil deposits, hydraulic basins and annex equipments within the rights-of-way was studied in order to avoid the areas of environmental concern, particularly the identified floodplains and wetlands.
In addition, the technical rights of way were optimized to avoid sensitive sites or stations whenever possible.

To minimize the impacts, the project tended toward preserving the ecological functionings of the natural habitats near the line, especially the wetlands, ponds, watercourses; the "*bocage*" (primarily a network of hedges and the wood edges were restored.

- Residual impact assessment

The project's total residual impacts is composed of 254 ha of which 80% are on wetlands, levels 1 to 3:

	Level 1 wetland	Level 2 wetland	Level 3 wetland	Level 4 wetland	Residual Impact
Residual impact	70.46 ha	40.36 ha	93.23 ha	50.39 ha	**254 ha**

- Offset design

Concerning the re-creation or restoration of wetlands, the SDAGE of the Loire-Bretagne, the regional direction of water development and management, recommended that the compensation measures be implemented within the same watershed, functionally equivalent in terms of the quality of biodiversity. Failing this, the compensation should cover an area equal to at least 200% of the area removed. The long term management and maintenance of these wetlands had to be guaranteed.

[6] Level 1 corresponds to a very functional wetland with regard to the three functions
[7] Level 2 corresponds to a moderately functional wetland with regard to the three functions
[8] Level 3 corresponds to a poorly functional wetland with regard to the three functions
[9] Level 4 corresponds to a non-functional wetland with regard to the three functions

Wetland compensation can be implemented on non-humid plots, or on areas whose ecological value is limited and likely to be favourably modified for flora and fauna and for wetland functions (phytopurification, buffering role against diffuse pollution, denitrification, flood expansion zones, flow control and minimum water level). Some parcels of high ecological interest can also be used for compensation sites with provisions for sustainable maintenance.

ERE's stated intention was to implement "wetland" compensatory measures with the re-creation or restoration of wetlands that were at least functionally and ecologically equivalent.

To determine the equivalence, a standardized methodology was used to “rate” the impacted wetlands and then to recreate wetlands with, if not the same rating, a better one.

The restoration goal is to maintain or upgrade wetlands to Level 1 or to at least Level 2. Because of the high stakes of the Level 1 habitat, ERE voluntarily increased the ratio traditionally used in France for Level 1 wetland impacts: for 1 ha of level 1 impacted, the offset is of 1 ha of level 1 + 1 h of level 2 instead of only 1 ha of level 1.

The following ratios were thus applied:

Impacted wetland	Offset ratios
1ha Level 1	**1 ha** Level 1 **+ 1 ha** Level 2
1ha Level 2	**0.5 ha** Level 1 **Or 1 ha** Level 2
1ha Level 3	**0.25 ha** Level 1 **Or 0.5 ha** Level 2
1ha Level 4	**0.25 ha** Level 2

- Offset requirement

In total, by applying the previous ratios, the offset requirement for 240.5 ha is: 70.5 ha of wetland level 1 and 170 ha of wetland level 2:

Impacted wetland	Level 1 wetland	Level 2 wetland	Level 3 wetland	Level 4 wetland	Total Impact
Residual impact	**70.46**	**40.36**	**93.23**	**50.39**	**254 ha**
Total offset per wetland type	70.46 ha Level 1 + 70.46 ha Level 2	40.36 ha Level 2	46.615 Level 2	12.59 Level 2	
Total offset requirement (surface)	**240.5 ha**				

- Offset design and implementation

Wetlands being an incredible reservoir of biodiversity, the offset is pooled with an offset for protected species, as described in 1.1.9 (fungibility principle) and in the species detailed offset explanations.
In total, 247 ha of wetlands were implemented, almost equal to the impacted surface while increasing the associated functionalities.

Wetlands	Residual impact	Requirement	Offset implemented
Functionality	Level 1 to 4	Level 1 to 2	Level 1 to 2
Surface in ha	254ha	240.5 ha	247 ha

Different kinds of measures were implemented for the wetlands (Figure 12):

1. Conversion of plots for cultivation and the preservation of it into wet meadows

Wetlands have been exploited since ancient times and this anthropic dynamic has created subnatural environments. Some of these wetlands were drained; others were ploughed and reseeded to enhance their agricultural production. A compensation measure consists of converting cultivated plots to wet meadows. The elimination of the drains of the cultivated plots, which dried up the original wetland, makes for a restoration of a wetland. Agricultural management conventions of these plots can be of extensive grazing types, with or without fertilization, or late mowing meadow types.

2. Conversion of poplar plantations into megaphorbia or alluvial forest

In the rural landscape, poplars are occasionally planted at the bottom edges of the wet valleys. These plantations occasionally exist in natural environments. The poplars, which consume a lot of water, tend to reduce the floristic diversity of wetlands.

The conversion of these poplar plantations is an interesting compensatory measure to look at. Depending on the potential of the station, the restoration of the wetland can be directed towards megaphorbia (high grass prairie on cool wet soil) or alluvial forest regeneration.

3. Wetland reopening or rehabilitation

Some wetlands owned by farmers cannot be drained or easily used for pasture. Land abandonment appears and leads to woody colonisation.

These wetlands are often small in size but are of a high patrimonial interest.

Reopening or rehabilitating them offers offset opportunities.

4. Redevelopment of wetlands by clearing a pond

In order to improve the ecological continuity (fish and sediments) of the rivers, some artificial ponds whose source came from rivers were eliminated.

These often unauthorized lakes were created in topographic depressions or on wetlands.

These measures make it possible to compensate wetlands and to improve the quality of the watercourses in the watersheds.

5. Layout of the major bed

This measure restores the river's more natural flow within slopes of less than 3% that allows the creation of permanent or intermittent wetlands.

Where water was already more present, this measure constituted an improvement of its quality.

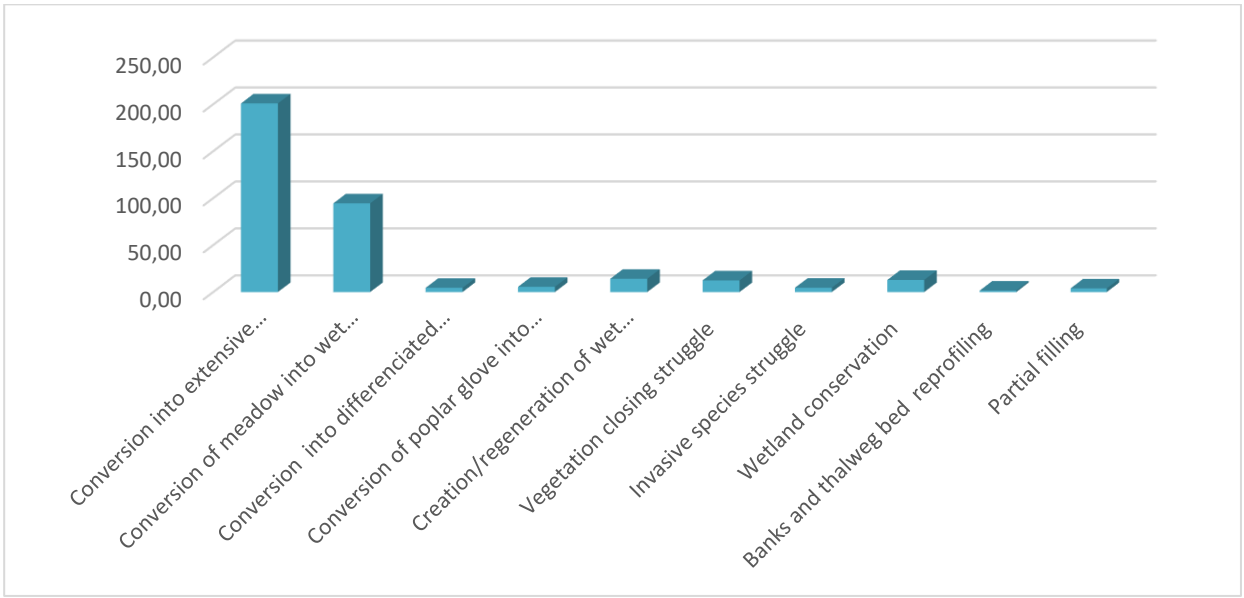


Figure 12: Main offset measures occurrence (ha) (Source: Eiffage)

These measures are pooled on the 247 ha of wetland offset.
For example, the invasive species struggle is often associated with the implementation of a reed bed and the vegetation closing struggle, and the conversion into a wet meadow is often associated with drainage.

1.2. Ponds and water bodies

- Projected impact before avoidance and reduction

280 ponds and 149 water bodies were identified in the DPU band. The level of each impacted pond and lake was determined according to the number of species it hosted and the density of its aquatic vegetation. As for the wetlands, level 1 corresponds to a very functional pond/water body, level 2 to a moderately functional pond/water body and level 3 to a pond/water body in poor condition (i.e., eutrophication). See methodology detailed in Appendix 11.

Number and surface of ponds impacted:

Ponds	Level 1	Level 2	Level 3	Total
Number	20	43	217	280
Surface in ha	**0.75**	**1.37**	**7.52**	**9.64**

Number and surface of water bodies impacted:

Water bodies	Level 1	Level 2	Level 3	Total
Number	3	13	133	149
Surface in ha	**0.97**	**6.80**	**35.27**	**43.04**

- Avoidance and minimization measures

Figure 13: Example of a provisional fence and awareness panel (Source: Eiffage)

Phase	Measures proposed
Design	- Strict limitation of the rights of way on the sites of ecological concern for amphibians - Adaptation of the work period outside of the migration and reproduction periods
Construction	- Provisional fences and panels (Figure 13) were positioned near the resorts with strong ecological stakes (outstanding wetlands, botanical stations, amphibian ponds), to prevent vehicles from entering and to avoid the destruction of the habitats outside of the necessary rights of way - Control of discharges caused by the installation of capping basins

- Residual impact assessment

Thanks to avoidance and reduction within the DPU band, only 110 ponds, out of the 280, presented residual impacts, 91 of which host native or protected amphibian species. Thus, impact on 170 ponds was avoided, representing a total of 5.4 ha:

Ponds	Level 1	Level 2	Level 3	Residual impact
Number	na	na	na	**110**
Surface in ha	**0.5**	**1.25**	**2.4**	**4.2 ha**

For water bodies, almost 30 ha were avoided over 149 impacted initially:

Water bodies	Level 1	Level 2	Level 3	Residual impact
Number	na	na	na	na
Surface in ha	**0.97**	**5.1**	**7.8**	**13.9 ha**

- Offset requirement

The ratios were the same as those applied for ponds and water bodies.

- The “water law” offset requirement for ponds:

Impacted pond	Level 1	Level 2	Level 3	Total Impact
Residual impact	0.5	1.25	2.4	4.2 ha
Total offset per wetland type	0.5 ha Level 1 + 0.5 ha Level 2	1.25 ha level 2	1.2 level 2	
Total offset requirement	3.45 ha			

Ponds often being of a high biodiversity interest, this offset implementation was fully pooled with the offset requirement for the impacts on protected species (see part 2.4.1 on fungibility and amphibian offsets).

- The “water law” offset requirement for water bodies:

Impacted water bodies	Level 1	Level 2	Level 3	Total Impact
Residual impact	0.97	5.1	7.8	13.9 ha
Total offset requirement	/			

The water law offset was considered only on sites where no protected species were detected. Illegal water bodies were not recreated, especially those set up along the rivers. This measure is in line with the objectives of the SDAGE Loire-Bretagne, in terms of water quality and restoration of ecological continuities.

The impacts on water bodies were not considered in the final ecological requirement because they were globally considered non significant regarding ecological functions.

However, their presence presented an opportunity for wetlands offset. Thus, partially or indirectly impacted water bodies were rehabilitated into wetlands, through partial or total land filling. Likewise, this erasure of water bodies set up along the river could be an offset for species habitats loss.

- Offset design and implementation

Proposals for offsets of the impacted ponds and water bodies located on the route of the line are different as they are destined to disappear. They are also different for those on the near periphery, as they can be indirectly impacted during the construction and operation phases.

- For ponds

The offset ponds are landscaped ponds designed to host spontaneous hygrophilous vegetation, which favours re-colonisation by amphibians and semi-aquatic insects. These ponds were created, when compatible with earthworks planning, the year before the beginning of the construction phase so they would be full during the amphibians' reproduction period in spring.

"Immediate" compensation ponds for those directly impacted were created as close as possible to the impact, and when possible for those within the project's right-of-way and with a significant heritage (presence of protected species). 91 immediate compensation ponds were thus created. The integration of these ponds within the right of way of the project provided a transitory habitat for amphibian species before the destruction of the impacted ponds.

These ponds were established with the equivalent surface, hydrological and biological functionalities as the impacted ponds. The surface of each had to be between 50 and 500 m². Indeed, in terms of efficiency for the reception of amphibians, it seemed preferable to create several small ponds than a large pond of 1000 m2. The depth of each pond varies between 20 and 50 cm. A deeper area (1 to 2 m) prevents it from drying out too frequently. Amphibian habitats (also hibernaculum for reptiles), made of piles of wood and/or stones, complete the functional feature around the ponds.

The offset was first and foremost sought within a restricted radius of 600 m around the impacted pond. The immediate compensation pond was located as close as possible to the impact and as far as possible from the project footprint (Figure 14). Depending on the land constraint (availability of land eligible for compensation) offset proposals could be made up to a radius of 1800m (maximum movement distance of amphibians) around the impacted pond.

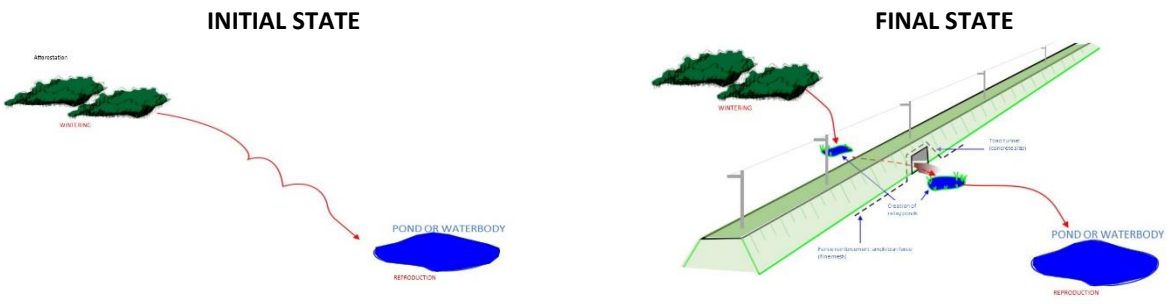


Figure 14 : Pond and water body offsets (Source: Eiffage)

The immediate compensation ponds were built before the works began to allow time for the water quality to stabilize and for the growth of vegetation and sufficient food sources for amphibian larvae. Samples and transfers of water, sediments, aquatic plants and amphibians (at the beginning of the breeding season) were taken from the impacted ponds to initiate biological activity in the newly created pools.

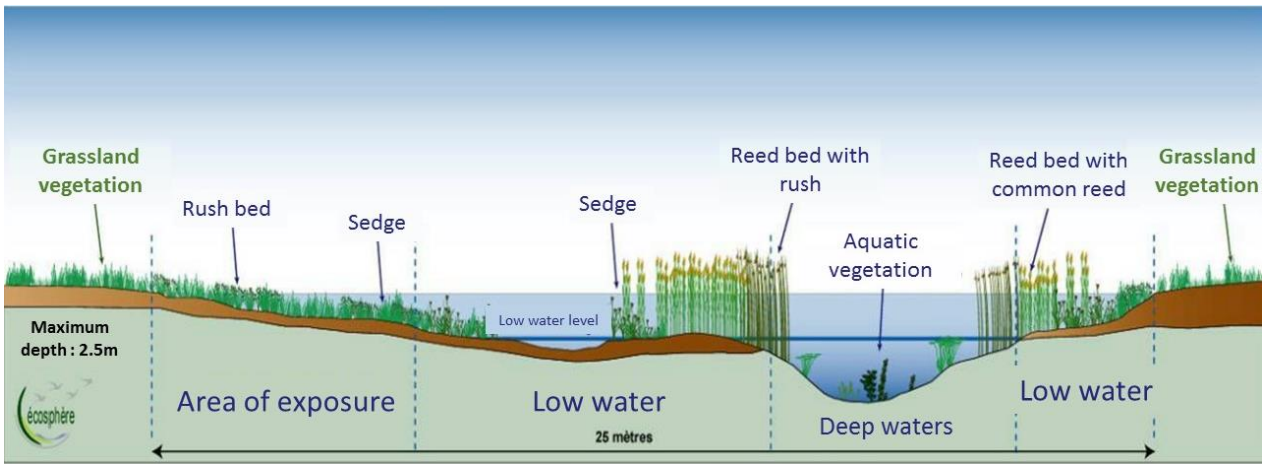


Figure 15: Offset ponds design principle (Source: Ecosphère)

When an immediate compensation pond could not be created within the project's right of way, new ponds, or restored existing ponds, were set up in a more remote perimeter, but not further than 500m away from the line.

These ponds were established to compensate the impacts on amphibian populations and on their breeding grounds. The number of ponds was calculated according to the ratios defined by the regulatory offset measures for the destruction of protected species. They were called "substitute ponds" and were positioned in order to compensate for the lack of ecological continuities for the amphibians due to the line's right-of-way. They correspond to the 122 ponds created in addition to the 91 immediate compensation ponds. Hedges were added to create ecological corridors for the amphibians and for semi-aquatic mammals, insects and bats (Figure 16).

The ponds created after the impact occurrences were positioned according to the ecological conditions of the stations concerned. The existing networks of ponds and local populations of amphibians determined by the species inventories were also taken into account (data from the impact studies and complementary inventories).

In order to secure all of the offset ponds, ERE-ONF registered with the Local Urban Plan and established a charter of good maintenance of the ponds with the pond owners.

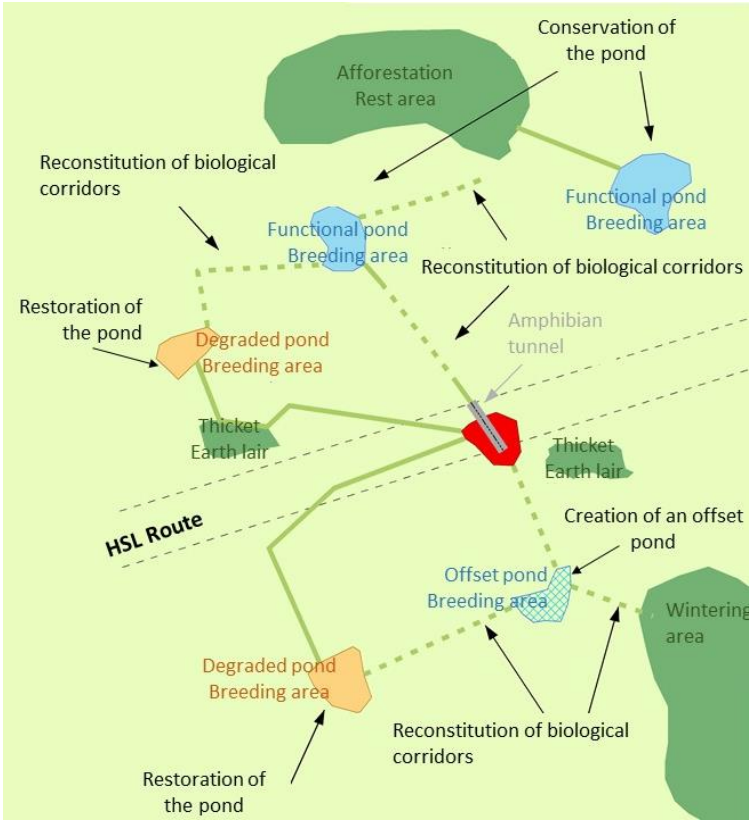


Figure 16: Connection principle between landscape biological elements (Source: ONF)

In total, the offset ponds represent:

Ponds	Residual impact	Requirement	Offset implemented
Number	**110**	na	213
Surface in ha	**4.2 ha**	**3.45 ha**	**4.45 ha**

We can note that the surface of the offset implemented is almost 30% higher than the ecology "water law" requires and 6% higher than the residual impacts, increasing the habitat's global quality.

1.3. Watercourses

- Provisional impact before avoidance and reduction

To have a better estimate of the project's impact and anticipate the regulations before the PPP attribution, Eiffage had further studies conducted by Asconit to complement the first ones done by the SNCF Réseau and by Ouest Aménagement.
The functionality of the 110 water flow zones impounded by the line, (in agreement with the criteria of the Water Development and Management Scheme (SAGE)) were qualified according to a standardized methodology detailed in Appendix 12.

Every watercourse was thus given a functionality rating from "Very Good" to "Very Bad" thanks to 4 criteria: the flow, the bank profiles, the differentiated substrate and the aquatic organisms observed.

	Very Good	Good	Average	Bad	Very Bad
Total	/	**6**	**30**	**69**	**5**

The project thus impacts mostly average and bad quality water-flows.

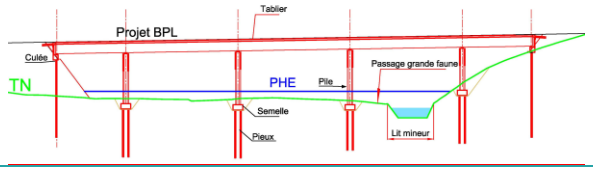
- Minimization measures

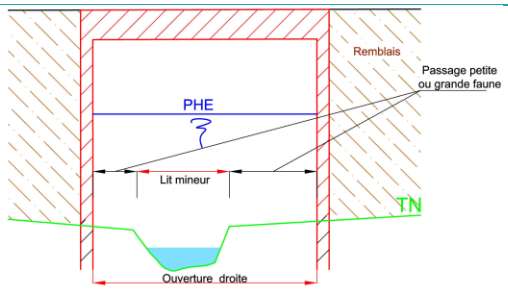
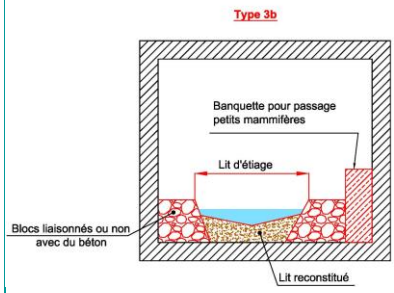
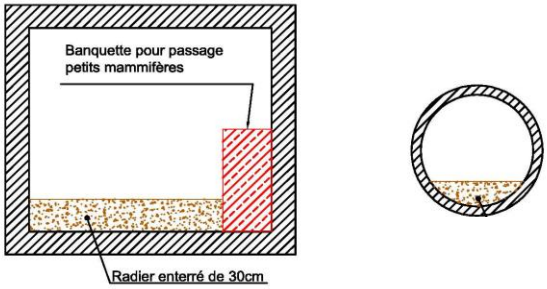
The project was designed to ensure the best hydraulic and ecological transparency of the infrastructure, keeping in mind the planning documents: the Water Development and Management Scheme (SAGE), the flood risk prevention plan (PPRI) and a circular of the Ministry of Ecology and Sustainable Development (24 July 2002).

Two kinds of measures are to be distinguished: measures during the design phase and those during the work phase.

Phase	Minimization measure proposed
Design	- Implantation of the viaduct piers outside the minor bed - Adaptation of the hydraulic structures depending on the context (tunnel, viaduct, nozzle)
Construction	- Definitive derivations were favoured over temporary derivations to limit the disturbance of the environment - A network to collect, decantate/filtrate and restore rainwater helped to protect the water resource: collection basins, ditches and the like. The basins were sized according to the local environmental stakes. This network was largely conserved for the operation phase of the line.

During the design phase, a focus on the upkeep of the hydraulic and ecological continuities led us to implement four types of crossing-structures, minimising the final impacts on more than 8 km of water-flows.

Type of works		Minimization measure / purpose
Viaduct ***Type 1***		- implantation of the viaduct piers outside the minor bed - hydraulic transparency

Tunnel crossing structure (Strong stake) ***Type 2***		- hydraulic transparency - preservation of the banks and the minor bed (including during the construction phase) - maximum shortening of the length of the structure to limit the shadow
Tunnel crossing structure (Low to medium stake) ***Type 3***		- hydraulic transparency - fish transparency - presence of a bench for the passage of the small fauna - concrete slab covered with a reconstituted bed (low-flow bed)
Hydraulic nozzle (without issue) ***Type 4***		- hydraulic transparency during flooding - presence of a bench for the passage of the small fauna

Synthesis of the structures for the restoration of hydraulic surface continuities:

Type of structure	1	2	3	4
Number of each type of structure	6	5	100	137

- Residual impacts

Residual impacts, when a hydraulic work bridge or nozzle is implanted on the watercourses, destroy the aquatic habitat, especially the spawning grounds and degrade the daytime circulation of fish (behavioural blocking at light / dark transition).

	Residual impact
Watercourse impacted	7200 lm
Riparian forest (aquatic mammals + fish)	8.07 ha
Spawning grounds (fish)	214 lm

- Offset design

Various offset measures were advocated:

1. Tools and techniques to upkeep, restore and maintain spawning ground sites for aquatic fauna in minor or major water-beds:

- Re-establish a functional hydraulic connection between the spawning grounds and rivers during the flood periods:

- Restoration and maintenance of ditches (cleaning, decluttering of logs, restoration of tadpole trees on the riverbanks)
- Construction and/or restoration and/or maintenance of hydraulic structures
- Land securing and sites environmental management
- Signature of ecological maintenance contract

- Recreate various flow facies by bringing materials with a granulometry adapted to targeted species

⇨ **200 m² of created/restored spawning grounds for 100m² destroyed**

2. Upkeep or restoration of ecological continuities

Some already existant hydraulic structures did not allow ecological transparency (wrong location, bad sizing, structures no longer in use, etc.).
Offset involved replacing, repositioning or eliminating some of the structures to re-establish the ecological continuity (with the agreement of the structure's owner or keeper). This offset is coupled with upstream and/or downstream restoration measures.

⇨ **100 linear meter functionality restored for 100 linear meters of habitat loss**

3. Watercourse re-naturation

Many small water flows have been previously interfered with which often leads to a complete disappearance of the species habitats.
The meandering can lengthen the watercourse, reduce the slopes and restore the initial sinuous morphology and associated functionalities (flood expansion, species habitats, water purification, sediment decantation, etc.). This technique calls for mechanical excavator works, material disposal and plant-based engineering techniques.

⇨ **100 linear meters of re-naturated watercourses for 100 linear meters of habitat loss**

4. Waterside vegetation

The vegetation alongside the watercourse provides a diversified and specific habitat for a community of insects and birds; the underwater roots also contribute to habitat diversification of water fauna. Above all, the shadow provided by the trees incites the return of animal and vegetal species, by cooling the water temperature and favouring its oxygenation.

⇨ **200 linear meters of riparian forest restoration/creation for 100 linear meters impacted**

- Offset requirement

The ratios applied here refer only to the water law offset ratio and not to the protected species law ratio.

	Residual impact	Offset ratio	Offset requirement
Watercourse impacted	7200 lm	*1	7200 lm
Riparian forest (aquatic mammals + fish)	8.07 ha	*2	16.14ha
Spawning ground (fish)	214 lm	*2	428 lm

- Offset implementation

This offset comes under the water law and is closely related to the fish and aquatic-mammals offset under the prohibition of protected species destruction derogation procedure.
Fungibility measures allowed for the total offset implementation of:

	Offset requirement	Offset implementation
Watercourse impacted	7200 lm	12075 lm
Riparian forest (aquatic mammals + fish)	16.14ha	36056 lm / 25ha
Spawning grounds (fish)	428 lm	428 lm

1.4. Linear hedges

- Provisional impact before avoidance and reduction

A detailed inventory of hedgerows was conducted on the project's footprint perimeter (including excavations and refilling) plus on 50 m of buffer area on both sides, representing a prospection area of 3,927 hectares.

According to the methodology presented in Appendix 9, the following potential impacts were found:

<table>
<tr><th colspan="2">1407 hedges inventoried</th><th colspan="2">191 km long</th><th colspan="2">46 species</th><th>3 invasive species</th></tr>
<tr><td colspan="4">Tree hedges
75%</td><td colspan="3">Shrub hedges
25%</td></tr>
<tr><td colspan="4">Common Oak (Quercus pedunculata) in 87% of the hedges.

Other species: Wild Cherry (Prunus avium), Ash (Fraxinus excelsior), Sweet chestnut (Castanea sativa), Field maple (Acer campestre), present in 25 to 35% of the hedges.</td><td colspan="3">Dominated by Blackthorn (Prunus spinosa) (75%) and common hawthorn (Crataegus monogyna) (68%)

Other species: Dog Rose (Rosa canina), Common Hazel (Coryllus avellana), Black Elder (Sambucus nigra), present in a medium to high abundance, from 19 to 50% of the hedges)</td></tr>
<tr><td colspan="2">Complete structure
shrubs, trees: multi stratum 65%</td><td colspan="2">Tree hedge (degraded with no shrubs due to the repeated passage of animals or gear) 10%</td><td colspan="3">Shrub structure only
25%</td></tr>
<tr><td colspan="7">65% of the hedges are in ditches and /or 50% are on embankments</td></tr>
</table>

- Minimization of the linear of hedges

Some of the impacts on the hedges in the 50m bands around the project's route were avoided because of the project's reduction/optimisation of the land footprint and protection during the work phase; this reduction was marginal, however, given that the "bocage" structure is very dense in these areas.

- Residual impact

	Potential impact	Residual impact
Hedges for amphibians and insects	191000	44610 lm /44.61 ha

- Offset requirement and implementation

Hedges need to be offset only when they are useful for protected species. The offset is thus designed according to the amphibian and insect offsets (see 2.3 and 0). Of the 191 km of hedges within the project's footprint plus the 50m buffer areas on both sides, 44.6 km are considered to be residual impacts for protected species.
The offset requirement concerning the hedges is detailed species by species below. It was defined according to the methodology used for each species (Appendix 4 and 9).

	Residual impact	Offset requirement	Offset implementation
Hedges for amphibians and insects	44.61 ha	21.3 ha for amphibians 7 ha for insects	44.61 ha (21.3 for amphibians, 21.6 ha for insects)

- Offset design

The hedges were planted to fill in the rows of the relictual hedges (Figure 17). The new or restored hedges are planted for the landscape but also serve biodiversity compensation for amphibians and insects. Compensation concerns direct habitat destruction or indirect connectivity between habitats.

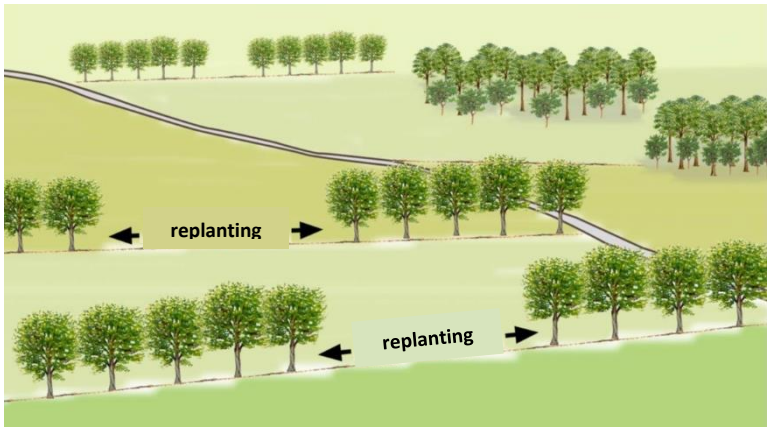


Figure 17: Hedgerows plantation principle (Source: Eiffage)

New hedgerows have therefore been planted to complete the continuities and to recreate the "bocage" network, an outstanding landscape feature of the areas crossed. Hedgerows were positioned as close as possible to the nuclei of the populations of the known species. These hedgerows are dotted with trees with high jets. The species selected were among those naturally present in the departments crossed and when possible plants purchased came from local strains.

By default, some impacts on isolated trees were transcribed in linear terms, which corresponded to width from the line's right-of-way (i.e., 40 m per tree).

In addition, 100m of hedges per compensation pond were voluntarily planted, pooled for certain species of amphibians, insects and chiroptera. These measures contributed to the temporal and spatial continuity of habitats.

2. Species

2.1. Birds

- Provisional impact before avoidance and reduction

The impact assessment and the complementary studies included a total of 70 protected bird species present, or likely to be present, in the project area or nearby.

23 of these species were particularly at stake (very rare locally, regionally or even nationally) and formed the subject of a detailed study. The impacted surfaces represent the potential nesting or resting sites within the project footprint:

Use name	Scientific name	Number of individuals	Number of sites impacted	Surface impacted
European honey buzzard	*Pernis apivorus*	5	1	5.5 ha
Hen harrier	*Circus cyaneus*	138	2	4.3 ha
Wood lark	*Lullula arborea*	148	4	3.52 ha
Common grasshopper warbler	*Locustella naevia*	121	1	0 ha
Common firecrest	*Regulus ignicapilla*	49	0	0 ha
European nightjar	*Caprimulgus europaeus*	64	3	21.6 ha
Eurasian hobby	*Falco subbuteo*	76	1	6.2 ha
Hawfinch	*Coccothraustes coccothraustes*	19	2	2.1 ha
Short-eared owl	*Asio flammeus*	21	1	3.25 ha
Sand martin	*Riparia riparia*	68	0	0 ha
Eurasian hoopoe	*Upupa epops*	208	3	0.65 ha
Eurasian thick-knee	*Burhinus oedicnemus*	176	18	85.13 ha
Black woodpecker	*Dryocopus martius*	161	1	8.5 ha
Common house martin	*Delichon urbica*	138	6	/
Red-backed shrike	*Lanius collurio*	207	1	/
Lesser spotted woodpecker	*Dendrocopos minor*	75	3	15 ha
Montagu's harrier	*Circus pygargus*	10	2	13.80ha
Little owl	*Athene noctua*	50	19	12.65ha
Zitting cisticola	*Cisticola juncidis*	/	1	0.7 ha
Cetti's warbler	*Cettia cetti*	/	6	3.4 ha
Long-eared owl	*Asio otus*	/	4	14.3 ha
Eurasian sparrowhawk	*Accipiter nisus*	360	4	17 ha
Common kingfisher	*Alcedo atthis*	/	3	0.4 ha
Total				**218 ha**

- Avoidance and reduction measures

Use name	Proposal for mitigation
European honey buzzard	- phasing of works: outside of the period from May to August (breeding period) - regeneration of selvedges with local species to avoid the cut-off effect
Hen harrier	- phasing of works: outside of the period from March to August (breeding period) - plantations on either side of the line to facilitate its crossing
Wood lark	No impact expected → no mitigation
Common grasshopper warbler	- clearing work carried out outside the nesting periods which are from May to July
Common firecrest	- clearing work carried out outside the nesting periods which are from April to July
European nightjar	- clearing work carried out outside the nesting periods which are from April to August - regeneration of selvedges with local species to avoid the cut-off effect
Eurasian hobby	- adaptation of the route - clearing work carried out outside the nesting periods which are from April to August - viaduct construction to maintain corridor functionality
Hawfinch	- clearing work carried out outside the nesting periods which are from April to July - regeneration of selvedges with local species (especially chestnut trees) to avoid the cut-off effect
Short-eared owl	No impact expected → no mitigation
Sand martin	No impact expected → no mitigation
Eurasian hoopoe	- clearing work carried out outside the nesting periods which are from April to August - installation of birdhouses before the beginning of the works
Eurasian thick-knee	- phasing of works: from 1 April to 31 August - protection perimeter - preliminary identification of potential breeding areas
Black woodpecker	- clearing work carried out outside the nesting periods which are from April to the middle of August - regeneration of selvedges with local species to avoid the cut-off effect
Common house martin	The destruction of the couples' housing took place outside the species' nesting period (i.e., outside the period from April to August)
Red-backed shrike	No impact expected → no mitigation
Lesser spotted woodpecker	- clearing work carried out outside the nesting period, which is from March to July. - regeneration of selvedges with local species to avoid the cut-off effect
Montagu's harrier	- phasing of works: from 1 April to 31 August - protection perimeter - preliminary identification of potential breeding areas
Little owl	- Felling of trees and buildings outside the period from March to August (breeding period) - installation of birdhouses - follow-up on breeding pairs
Zitting cisticola	- clearing work carried out outside the nesting periods which are from April to August - viaduct construction to maintain corridor functionality
Cetti's warbler	- works on the banks carried out before the nesting period (end of April to August) - viaduct construction to maintain corridor functionality
Long-eared owl	- clearing works carried out outside the nesting periods which are from March to August - regeneration of selvedges with local species to avoid the cut-off effect - viaduct construction to maintain corridor functionality - plantation of hedges parallel to the HSL to limit the risk of collision
Eurasian sparrow hawk	- clearing works carried out outside the nesting periods which are from March to August
Common kingfisher	- works on the banks carried out before the nesting period (end of April to August) - viaduct construction to maintain corridor functionality

- Residual impacts assessment

Because of avoidance and reduction measures, including landscape design, residual impacts were cut down to 2 bird species. The local and regional residual impacts are detailed in Appendix 2.
The residual impacts only concerned agricultural lands.

Species		Residual impact assessment			
Use Name	**Latin name**	**Local scale**	**Regional scale**	**Yes/No**	**Surface impacted**
European honey buzzard	*Pernis apivorus*	Low	None	No	
Hen harrier	*Circus cyaneus*	None	None	No	
Wood lark	*Lullula arborea*	Low	Low	No	
Common grasshopper warbler	*Locustella naevia*	Low	None	No	
Common fire crest	*Regulus ignicapilla*	None	None	No	
European nightjar	*Caprimulgus europaeus*	Low	Low	No	
Eurasian hobby	*Falco subbuteo*	Low	None	No	
Hawfinch	*Coccothraustes coccothraustes*	Low	None	No	
Short-eared owl	*Asio flammeus*	None	None	No	
Sand martin	*Riparia riparia*	None	None	No	
Eurasian hoopoe	*Upupa epops*	Low	None	No	
Eurasian thick-knee	*Burhinus oedicnemus*	Average	Average	Yes	85.15 ha
Black woodpecker	*Dryocopus martius*	Low	None	No	
Common house martin	*Delichon urbica*	Low	None	No	
Red-backed shrike	*Lanius collurio*	None	None	No	
Lesser spotted woodpecker	*Dendrocopos minor*	Low	Low	No	
Montagu's harrier	*Circus pygargus*	Average	Average	Yes	13.81 ha
Little owl	*Athene noctua*	Low	Low	No	
Zitting cisticola	*Cisticola juncidis*	Low	None	No	
Cetti's warbler	*Cettia cetti*	Low	None	No	
Long-eared owl	*Asio otus*	Low	None	No	
Eurasian sparrowhawk	*Accipiter nisus*	Low	None	No	
Common kingfisher	*Alcedo atthis*	Low	None	No	
Total					**91.14 ha**

Avoidance and minimisation measures reduced the area affected by almost 60% and also avoided impact on 21 species that would otherwise have been affected.

	Potential impact	Residual impact
Number of species	23	2
Surface impacted	218 ha	91.14 ha

- Offset requirement and implementation

The Eurasian thick-knee and the Montagu's harrier nest within intensive crops in the two departments concerned. The choice was made not to compensate for the potential breeding environment impacted with the same type of environment. Given that intensive cultivation is not threatened in this region, it does not seem advisable to encourage the practice which may present an interest for certain species but which, in general, rather undermines biodiversity by standardizing landscapes.
Given the different nature of the elements considered, this approach leads to the non-application of a ratio sensu stricto between the quantification of compensation measures and the quantification of impacts.

Compensation therefore aims to reinforce the existing potential breeding sites and to diversify the food source by converting cultivation to grassland. According to the bibliography, the density of the Eurasian thick-knee varies from 1 to 4 couples per 100 ha. In theory therefore, the impacted area corresponds to the territories of about 3 Eurasian thick-knee couples. To strengthen the nesting sites, it was proposed to create 8 untilled plots per potential territory (couple), i.e., 24 plots in total. The uncultivated 24 plots are distributed so as to improve the breeding success of the Eurasian thick-knee equivalent to 85 ha of territory favourable to its nesting.
The diversification of the resources improves the quality of the Eurasian thick-knee's habitat. 5 ha of herbaceous wasteland or crop conversion are proposed per potential territory, i.e., a total of 25 ha.

The Montagu harrier will also benefit from these new herbaceous zones. An additional 25 ha were proposed specifically for this bird.

	Residual impact	Offset requirement	Offset implementation
Eurasian thick-knee	85.15 ha	24 plots without seeds (72 ha) + 25 ha culture conversion	**24 plots without seeds (72 ha) + 53.5 ha cultural conversion**
Montagu's harrier	13.81 ha	+ 25 ha culture conversion	
Total	**91.14 ha**	**24 plots without seeds (72 ha) + 50 ha culture conversion**	

- Offset measures

The 2 species with residual impacts particularly sensitive to the loss of habitat and feeding resources decreased. The proposed offsetting measures aimed to respond to both of these damages.

1. Direct destruction of individuals and broods avoided = 72 ha

The breeding season of the Oedicnemus begins at about the same time as the soil is laboured for late crops, which significantly heightens the risk of nest destruction. The parcels intended for late-growing crops (usually sunflowers), located outside the LGV right-of-way, were offset. The offset consisted of delimiting 40 m X 20 m plots with no seeding along the planted lines so that potential breeding sites were preserved and to encourage birds to settle there. The Oedicnemus appears to be a species that can easily change its spawning spots. These plots are also preferential sites for surrogate breeding. An ecology expert chose the positions of the plots.
In order to convince an operator to accept this work constraint (non-incentive subsidy), the measure had to be combined with an improvement of the quality of the habitat, such as the conversion of cultivation to meadow.

2. Improvement of the food web and habitat quality = 53.5 ha

The success of bird breeding is closely linked to the availability of food sources. In general, the compensatory measures seek to improve the birds' food webs.
Actions to improve the quality of the habitats of many of the species nurture food dynamics:
- Conversion of crops to grasslands or herbaceous wastelands
- Diversification of the resources (grasses, legumes).
Herd management has two advantages in meeting both nesting and feeding requirements.
These actions must be accompanied by a policy of reducing inputs, both chemical herbicides, insecticides and nitrogen fertilization. Limiting inputs can result in financial compensation for the farmers but also in alternative proposals to homogenize the landscape, such as by rotating crops and by alternating annual and perennial crops. Here again, proximity to the agricultural world is crucial to ensure the credibility of the measures and the sustainable appropriation of new farming techniques.

2.2. Bats

- Provisional impact before avoidance and reduction

16 species of bats were identified during the impact assessment; all are protected. Inventories were conducted throughout the potential habitats within the project's route: woods (old trees with cavities), churches, castles, and old buildings with attics, barns, or basements.

Species		Number of sites where it was observed
Use Name	*Latin name*	
Common pipistrelle	*Pipistrellus pipistrellus*	*3*
Grey long-eared bat	*Plecotus austriacus*	*1 or 2*
Kuhl's pipistrelle	*Pipistrellus kuhlii*	*1*
Greater horseshoe bat	*Rhinolophus ferrumequinum*	*1*
Geoffroy's bat	*Myotis emarginatus*	*1*
Greater mouse-eared bat	*Myotis myotis*	*1*
Lesser horseshoe bat	*Rhinolophus hipposideros*	*1*
Bechstein's bat	*Myotis bechsteinii*	*1*
Daubenton's bat	*Myotis daubentonii*	*1*
Barbastelle	*Barbastella barbastellus*	*1*
Common long-eared bat	*Plecotus auritus*	*1 or 2*
Natterer's bat	*Myotis nattereri*	*1*
Serotine bat	*Eptesicus serotinus*	*1*
Common noctule	*Nyctalus noctula*	*/*
Whiskered bat	*Myotis mystacinus*	*1*
Alcathoe bat	*Myotis alcathoe*	*/*

- Avoidance and reduction measures

Species	Measures
All the species of bats	- Worksite installation at more than 1000 m from the bats living places - No buildings to be destructed during the birthing period (1 June to 15 September) or in winter (15 November 15 to 15 March) - Route crossing structures implementation in the right of way of chiropteran corridors (viaducts, hydraulic structures) + hedges landscaping to lead to the crossing structures - Anti-collision hedge and a final 2 m high fence on both sides of the line

- Residual impacts assessment

After avoidance and reduction, direct and indirect impacts on each of the species was assessed, according to the species' sensitivity, flight behaviour, collision risk and disruption of displacement corridors.

Among the 16 species inventoried, 8 are subject to residual impacts that concern wood surface impacts. The risk of collision was the reason to classify the species with an average local impact but with no residual impact. Given that this issue affects few colonies, the residual impact at the population scale is considered to be low, with no incidence on the population subsistence, thus no residual impact was taken into account.

Species		Evaluation of the residual impact on the populations			
Use Name	**Latin name**	**Local scale**	**Regional scale**	**Residual impact?**	**Surface impacted**
Common pipistrelle	*Pipistrellus pipistrellus*	Low	None	Yes	12.58 ha
Grey long-eared bat	*Plecotus austriacus*	Low	None	No	
Kuhl's pipistrelle	*Pipistrellus kuhlii*	Low	None	Yes	11.97 ha
Greater horseshoe bat	*Rhinolophus ferrumequinum*	Average	Low	No	
Geoffrey's bat	*Myotis emarginatus*	Average	Low	No	
Greater mouse-eared bat	*Myotis myotis*	Low	Low	No	
Lesser horseshoe bat	*Rhinolophus hipposideros*	Average	Low	No	
Bechstein's bat	*Myotis bechsteinii*	Average	Low	Yes	4.87 ha
Daubenton's bat	*Myotis daubentonii*	Low	Low	No	
Barbastelle	*Barbastella barbastellus*	Average	Low	Yes	10.75 ha
Common long-eared bat	*Plecotus auritus*	Low	Low	Yes	5.83 ha
Natterer's bat	*Myotis nattereri*	Low	Low	Yes	5.49 ha
Serotine bat	*Eptesicus serotinus*	Low	None	Yes	0.61 ha
Common noctule	*Nyctalus noctula*	Low	None	No	
Whiskered bat	*Myotis mystacinus*	Low	Low	Yes	17.46ha
Alcathoe bat	*Myotis alcathoe*	Low	Low	No	
Total					**69.56ha (22.7 ha mutualised)**

- Offset requirement

Bats		Residual impact: Hedges, forestation and ecological corridors	Offset ratio	Offset requirement Hedges, forestation and ecological corridors
Common pipistrelle	*Pipistrellus pipistrellus*	12.58 ha	1	12.58 ha
Kuhl's pipistrelle	*Pipistrellus kuhlii*	11.97 ha	2	23.94 ha
Bechstein's bat	*Myotis bechsteinii*	4.87 ha	4	19.48 ha
Barbastelle	*Barbastella barbastellus*	10.75 ha	3	32.25 ha
Common long-eared bat	*Plecotus auritus*	5.83 ha	2	11.66 ha
Natterer's bat	*Myotis nattereri*	5.49 ha	2	10.98 ha
Serotine bat	*Eptesicus serotinus*	0.61 ha	1	0.61 ha
Whiskered bat	*Myotis mystacinus*	17.46 ha	2	34.92 ha
Total		**69.56 ha (22.7 ha mutualised)**	**(*2.7 mutualised)**	**146.42 ha (61 ha mutualised)**

Thus, 61 ha of woods (biological trees), senescence wood islands, hedges and artificial shelters had to be created.

- Offset implementation

Bats	Offset requirement	Offset implementation
All species	61 ha	31.9 ha of woods 44.61 ha of hedges 43 artificial lodgings
Total	**61 ha**	**76.5 ha**

The three biological compartments necessary for the optimal fulfilment of the life cycle of bats were heeded: breeding sites, resting sites and the presence of physical or biological elements deemed necessary for the reproduction of the species considered to have biological connections with the bats.

Proposals to offset the impact on chiropteran have therefore been articulated around the following axes:

- Provide breeding lodgings by planting new woodlots, establishing islands of senescence, building habitats specific to bats close to the line.
- Create/protect resting places with **new forestation**s encourage the **implantation of "islands of aging", or senescence**, and **make specific arrangements** for sustainable access to the buildings near the line.
- Create/restore/protect biological connections and hunting grounds: riparian forest, hedgerows, permanent meadows and pastures.

Thus, the four main offset measures are:

- The plantation of woodlots or groves
  Hardwood plantations are part of the clearing obligations. Forests sere most often planted near existing woodlots or when disconnected from a forest are larger than 4 ha.
  Additional forest areas were planted specifically for bats. They are a priority in the continuity of forestation under clearing obligations and as often as possible near impacted forests.
  Priority is given to the projects near the forestation sites impacted by the HSL.
  The sizes of the groves vary as per the available areas but remain under one hectare. Above one hectare a grove becomes a forest.
  Oak (pedunculate and sessile) is the preferred species for afforestation but edaphic and stationary constraints bring other species into consideration. The indigenous species are always given preference along with the selection of plants from local strains.

- Senescence, or the creation of "islands of aging"
  Implanting islands of old wood is beneficial to a large procession of species that thrive on old wood. Bats, cavity nesters, reptiles, small mammals and some birds like the *picus* are some of them.
  An island of senescence is a small place left to evolve freely and preserved until its natural end, that is, until the final collapse of the trees. These islands are composed of trees with a particular biological value (large cavities, aging wood). For security reasons, they are chosen in areas unfrequented by the public.
  An island of senescence is highly recommended for the compensation of this group because it offers the optimum habitat for a majority of the chiropteran family.

- The installation of artificial lodgings
  These breeding and/or hibernation sites meant for a large number of bat species are generally found in buildings, but also in forest areas. They provide the essential habitats that ensure the life cycle of bats.
  This measure is particularly important for the Kuhl's pipistrelle and the common pipistrelle bat, species closely related to a constructed environment and significantly impacted by the destruction of the buildings along the line's right-of-way.
  The lodgings were proposed to improve and facilitate the reception of bats in buildings (e.g., residences, farms, barns) close to the HSL's track. Access to the "cottages" is limited by the installation of grids (horizontal bars) and specific nest boxes (Figure 18). These were affixed primarily on the buildings located near the impacts.
  Three buildings near the right-of-way are specifically set aside for biodiversity compensation, especially for bats. The buildings also benefit other compatible groups, including birds.

Figure 18: Artifical lodging for bats (Source: ERE)

- The plantation of hedges to create and restore biological connections necessary for species displacement and feeding

2.3. Insects

- Provisional impact before avoidance and reduction

Of the 20 insect species inventoried along the project's route, 3 are protected by the regulations of protected species (the Southern damselfly, the Hermit beetle and the Great Capricorn beetle).
Additional field studies were carried out in the extended 200 m band around the route planned by ERE to refine the impacts:

Species		Number of sites where it was observed
Use Name	***Latin name***	
Southern damselfly	*Coenagrion mercuriale*	4 watercourses 70 stations, favourable 2,556 lines, favourable (m)
Hermit beetle	*Osmoderma eremita*	200 cavity trees with potting soil 18 trees with presence indicators
Great Capricorn beetle	Cerambyx cerdo	32 sites 153 trees impacted 2,322 m lines of hedges

- Avoidance and reduction measures

Species	**Proposals for mitigation**
Southern Damselfly	- Concerning the destruction of individuals: Habitat avoidance was the best solution. In the case where avoidance was impossible, the most favourable period for cleaning works was from September to November. A rotation of work over 3 years was recommended to limit the impact on the populations. - Loss of habitats: • Rehabilitation of certain areas located in close proximity to the impacted area. Bank landscaping work to clarify the tree layer and to create "gaps" (minimum 10m.) favourable to the Southern Damselfly in order to connect the various favourable sectors was supposed to be much more beneficial than the loss of a few dozen meters of habitat. • Conservation of the most favourable sunny shoreline areas. An annual mowing can also be implemented on very scrubby streams with the export of vegetation. • Recreation or conservation of grass strips of 10 meters wide along the banks. These should not be crushed or mown during the main emergence period of imagos (early May to mid-July), to avoid their direct destruction. In general, it would be desirable to ○ Conserving the grassland areas bordering the watercourses. ○ Permanent re-watering of ditches under favourable conditions and according to opportunities, primarily on linear close to core populations to optimize the chances of colonization by the species. - Cutting of the axes of movement When unavoidable, the cutting of a displacement axis was compensated by the reconnection of certain peripheral sectors and/or by rehabilitating the hydrographical network.
Hermit beetle	- Since there is no proven impact, no tree movement or population is planned. On the other hand, the potting soil in the trees with traces of the presence of the species has been transferred to other tree cavities close to the right-of-way. - Plantation of hedges in connexion to the existing ones with ecological functionality and a continuity of the ecological corridors

Great Capricorn beetle	- Plantation of hedges in connexion to the existing ones, an ecological functionality (for the saproxylic insects) and a continuity of the ecological corridors - Fencing during the works phase to enforce the rights of way

It was planned to plant hedges in connection to the remaining hedges. These hedges would have an ecological function (for the saproxylic insects) and would also ensure a functional continuity of the ecological network.
Preference was given to planting tall tree and shrub species indigenous to the area and already present in hedgerows.

The potting soil from the 8 trees showing trace presence of the Hermit beetle species, impacted directly by the project, was moved to other tree cavities near the impacted trees.

- Residual impact assessment

The avoidance and reduction measures for the Southern damselfly allowed for no residual impact on this species.

Species		Evaluation of the residual impact on the populations			
Use Name	**Latin name**	**Local scale**	**Regional scale**	**Residual impact?**	**Linear impacted**
Southern damselfly	*Coenagrion mercuriale*	Low	Low	No	
Hermit beetle	*Osmoderma eremita*	Average	Low	Yes	320m
Great Capricorn beetle	*Cerambyx cerdo*	Average	Low	Yes	8442m
Total					**8602m**

2,322 m of hedges sheltering the great Capricorn beetle were impacted, and 153 isolated trees were cut down during the works (Figure 19). By default, the impact on isolated trees is transcribed into a linear corresponding to the width of the right-of-way of the line at the point of impact considered, i.e., on average approximately every 40 m. The linear corresponding to these 153 trees is therefore 6,120 m. Added to this is the linear impacted hedges, or 2,322 m. We obtain a total of 8,442 linear meters impacted for the great Capricorn beetle.
To translate the impact on the Hermit beetle into a linear of “bocage”, the linear corresponding to the width of the right-of-way of the line at the point of impact, i.e., 40 m, was used by default. Thus the impacted linear corresponding to these 8 trees is 320 m.

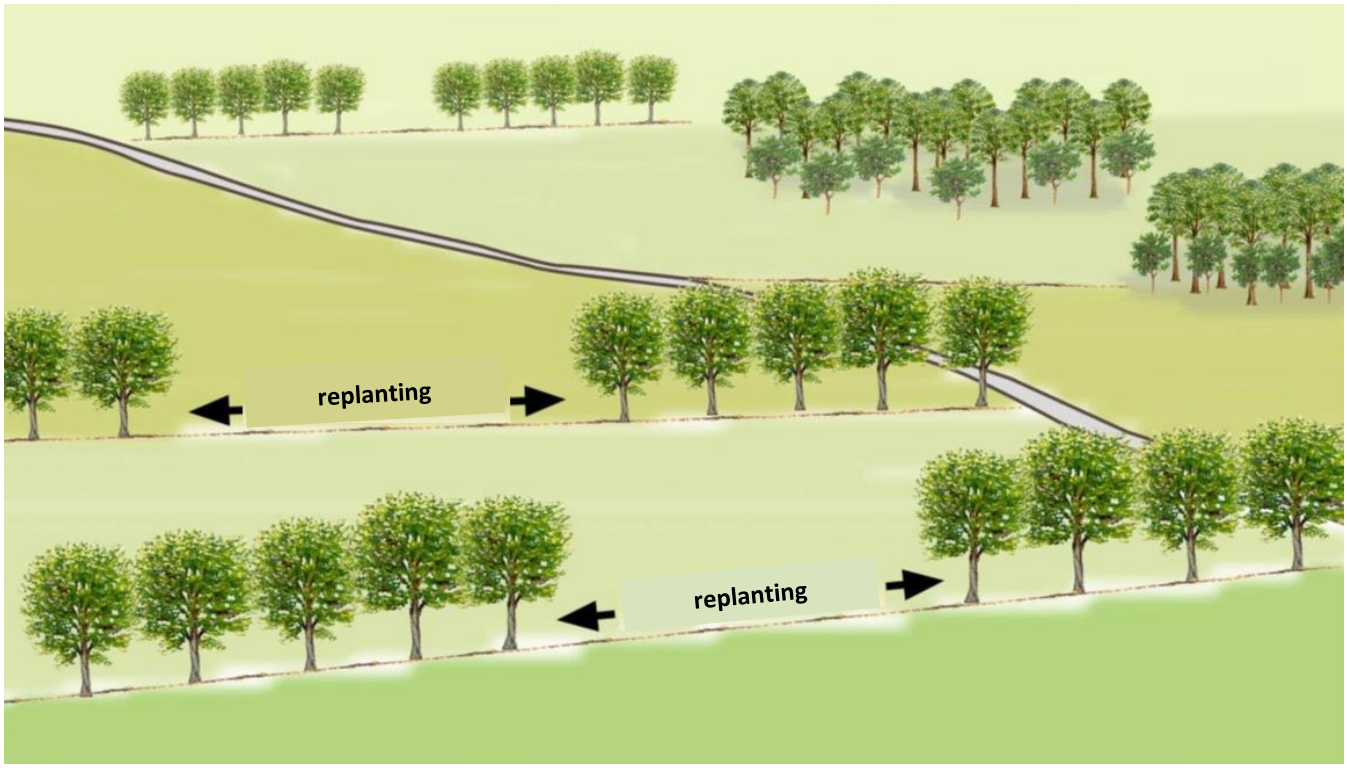


Figure 19: Hedges offset principle (Source: Ecosphère)

- Ecological requirement

The great Capricorn beetle is common along the route. Its relative abundance in the departments crossed by the HSL and its colonization dynamics in the northern departments of the Loire justifies an average level of compensation (x3), less than the Hermit beetle.

The Hermit beetle remains a very sensitive species within the woodland environment because of the scarcity of its habitat. A strong ratio (x8) was used for the calculation of the requirement.

	Residual impact	Offset ratio	Ecological requirement
Osmoderma eremita	320 lm	8	2600 lm
Cerambyx cerdo	8442 lm	3	25300 lm
Total			**27900 lm / 27.9 ha**

- Offset implementation

On the field, 27.9 ha of offset have effectively been implemented, divided as follows (Figure 20):

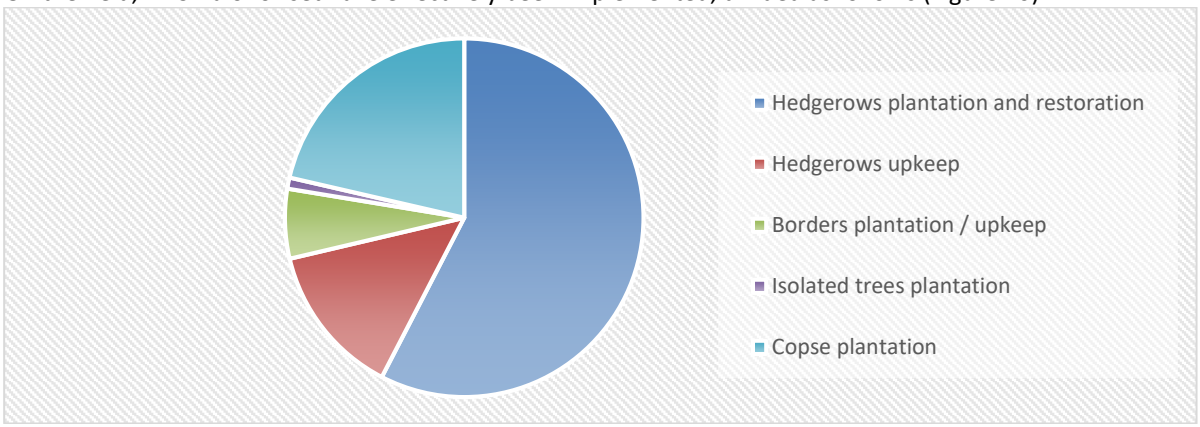


Figure 20: Distribution of the measures concerning the offset hedges (Source: Eiffage)

Hedgerows and borders take up a total of 21.6ha (21,600 lm) and isolated trees and copse take up 6.3 ha.

The compensatory measures are aimed at controlling the main sources of regression of the Hermit and Great Capricorn beetles by improving the spatial and temporal continuity of their habitat. These two insects have low dispersal abilities, especially the Hermit beetle, whose movements hardly exceed a few tens of meters. Offsets must ensure habitat breeding near the known breeding sites with a viable initial population by implanting deep-cavity trees and senescent trees. The supply of potential habitats must also be renewed with plantations over time to ensure the long-term sustainability of the environment.

Thus, the offset of the saproxylic beetles is based on two major sets of measures:

- Actions related to the “bocage” environment:

  - **Planting of hedgerows and isolated trees (both species: the great Capricorn beetle and the Hermit beetle)** in the immediate vicinity or in the continuity of the site affected by the works of the project. The choice of plantation sites is oriented towards sectors where the populations are known or are coherent with the existing "bocage" network in order to fill its discontinuities.
  - **Restoration or conservation of hedgerows and isolated trees (both species).** Restoration occurs when the hedge is not dense enough to be functional as opposed to a hedge to be conserved that does not require any intervention during the first year of the implementation of the offset measures.
  - **Maintenance of hedgerows, isolated trees (both species)** to minimize the risk of a break in the continuity of tree cavities and increase the potential of existing hedgerows over time.
  - **Orchard plantations (Hermit beetle):** The Hermit beetle, unlike the Great Capricorn beetle that is dependant on oak, is not as selective of the choice of plant species.
  - **Conversion of crops to grasslands or creation of grass strips:** The environment adjacent to the hedgerows plays an important role in the proper integration of the offset measures in the species’ environment: a culture can become a hostile environment for the moving individuals.

- Actions related to the forest environment:
  - **Plantations of deciduous forests and groves (both species):** Action implemented on farmland relatively close to a local population of saproxylic insects (Great Capricorn and/or Hermit beetle).
  - **Treatments of the edges (both species):** The sunnier edges are often very attractive to the saproxylic insects, which prefer and seek the trees that are well exposed to the rays of the sun.
  - **Establishment of islands of aging (Hermit beetle):** Small populations having exceeded the optimal criteria of economic exploitability benefit from prolonged silvicultural cycles.
  - **Establishment of islands of senescence (Hermit beetle):** Small standing trees left to evolve freely until their end, that is, until they collapse.

These measures of creating and restoring offsets of hedges for the saproxylic insects also benefit the reproduction and movements of the amphibians nearby.

2.4.Terrestrial and semi-aquatic mammals

- Provisional impact before avoidance and reduction

While considering the DPU band, the following potential impacts were estimated:

Use name	*Latin name*	Number of sites impacted	Surface of riparian forest impacted (Ha)	Linear of watercourses /banks impacted M (ha)	Surface of forest impacted (Ha)	Linear of hedges impacted (m)	**Total estimated impact (ha)**
Eurasian otter	*Lutra lutra*	27	3.75	6103 (1.22)			**4.97 ha**
European beaver	*Castor fiber*	/	1.44	427 (0.09)			**1.53 ha**
Eurasian water shrew	*Neomys fodiens*	8	8.07	19950 (3.99)			**16.14 ha**
Miller's water shrew	*Neomys anomalus*	14	8.07	19950 (3.99)			**16.14 ha**
Common dormouse	*Muscardinus avellanarius*	24			87	45000m (22.5 ha)	**109.5 ha**
Eurasian red squirrel	*Sciurus vulgaris*	/			150.9	112850 m (56.4 ha)	**150.9 ha**
European hedgehog	*Erinaceus europaeus*	/			150.9	112850m (56.4 ha)	**150.9 ha**

- Avoidance and reduction measures

More than 1000 basins were built and maintained throughout the main works to treat the water before it ran into the watercourse. Depending on the sensitivity of the site, the basins were equipped with filtration systems to prevent accidental pollution. 245 Modul'AP® prefabricated filtration modules were used on the construction sites. Eiffage patented the device and the Institute of Roads, Streets and Infrastructures awarded its efficiency in 2014 for mobility (IDRRIM) in the "clever initiatives" category. The basins are permanent structures and are used today for the storage and decantation of runoff water.

Species	Proposals for mitigation
Eurasian otter	- Impact reduction measures in the design phase: Adaptations made on hydraulic structures - Measures to limit the risk of collision: the mesh holes of the fence that separate the rivers from the tracks are all less than 5 cm wide. - Measures to reduce mortality during the construction phase: adaptation of the earthworks to favourable periods. - Measures to ensure the functionality of transparency works
European beaver	- Measures to reduce mortality in the construction phase: Systematic recession of earthworks rights-of-way, identification of potential burrows in the final project rights-of-way, establishment of habitat opening techniques, implementation of protection mark-up
Eurasian water shrew	- Measures to reduce mortality during the construction phase: Clearance of rights-of- way at the most favourable time, measures to limit the partitioning of shrews, measures to limit the risk of polluting the living environments of the species - Measures to limit the partitioning of shrews: Keep the elements structured on the banks and in the beds. Preservation of natural banks - Measures to limit the risk of polluting the species' living environments: measures to limit any alteration of the physic-chemical quality of the wetlands, whether during construction or the operating phase.
Miller's water shrew	

Common dormouse	- Measures to reduce mortality during the construction phase: Preparatory work, in particular deforestation and hedge felling, carried out outside of the breeding season, as well as before the hibernation period, between August and November. - Measures to increase the transparency of structures: • Installation of a hedge continuum on the higher wildlife crossings • Preservation of the banks and elements of the environment (vegetation) under hydraulic structures
Eurasian red squirrel	Transparency structures were developed to meet the challenges of ecological continuity (hydraulic structures allowing the passage of terrestrial wildlife, small wildlife passages and crossings with large fauna).
European hedgehog	Transparency structures were developed to meet the challenges of ecological continuity (hydraulic structures allowing the passage of terrestrial wildlife, small wildlife passages and crossings for large fauna).

All of these measures helped reduce the primitive impacts, which caused for smaller residual impacts.

- Residual impact, definition

After the avoidance and the reduction on the habitats of these species (rest, reproduction, feeding) an analysis of the risk of mortality during the construction phase and the corridors of displacement identified only four of the seven species initially concerned as impacted by the project and requiring compensation: The Eurasian otter (*Lutra lutra*), the European beaver (*Castor fiber*), the Eurasian water shrew (*Neomys fodiens*), and the Miller water shrew (*Neomys anomalus*).

The residual impact only concerns the impacts on the riparian forest.

Species		Residual impact assessment			
Use Name	**Latin name**	**Local scale**	**Regional scale**	**Yes/No**	**Surface impacted**
Eurasian otter	*Lutra lutra*	Average	Average	Yes	**3.75 ha**
European beaver	*Castor fiber*	Average	Average	Yes	**1.44 ha**
Eurasian water shrew	*Neomys fodiens*	Average	Low	Yes	**8.07 ha**
Miller's water shrew	*Neomys anomalus*	Average	Low	Yes	**8.07 ha**
Common dormouse	*Muscardinus avellanarius*	Low	Low	No	
Eurasian red squirrel	*Sciurus vulgaris*	Low	Low	No	
European hedgehog	*Erinaceus europaeus*	Low	Low	No	
Total					**24.21 ha (on a global 8.07 ha area)**

- Offset requirement

The 8.07 ha of impacted habitats concerning the two Shrews are within the rivers in the right-of-way of the HSL. The impacts on the Otter and the Beaver are also within this linear. Thus, the offset provided for the two Shrew species includes the expected offset both for the Otter and the Beaver in terms of area, i.e., 25 ha. The average compensation level applied to mammals is 3.1.

Species	Residual impact on riparian forest	Offset ratio	Offset requirement
Eurasian otter	3.75	2	7.5 ha
European beaver	1.44	2	2.88 ha
Eurasian water shrew	8.07 ha	2	16.14 ha
Miller's water shrew	8.07 ha	3	24.21 ha
Cumulated surface	**21.33 ha**		**50.7 ha**
Raw surface	(On a global **8.07 ha** area)	**3.1 (average ratio)**	**25 ha**

- Offset Implementation

The establishment of diversified riparian forests improves the quality of the habitats of the riverbank species and has effects the quality of the water. These niches represent important resources for the semi-aquatic mammals. The offset for mammals focuses on this action.

Watercourses are chosen for compensation according to their potential for the Shrew's habitat. Their location is close to the watercourses where the presence of these mammals has been proven. The proximity of the sites of proven presence makes it possible to favour the extension of the distribution of the species and to consolidate the current populations.
The offset measures for the otter and the beaver were proposed close to where their appearances were recorded during the complementary studies.

This offset, by way of the derogation of the prohibition of protected species destruction procedure, is closely related to the fish and to the watercourse offsets, by the way of the water law.
The measures benefiting mammals in these procedures were thus fungible and allowed for a total offset implementation of:

	Offset requirement	Offset implemented
Riparian forest	23.4ha	36,056 lm / 25ha

2.5. Fish

- Provisional impact before avoidance and reduction

5 of the 26 fish species discovered in the project's area are protected by a national decree and are on the protected species list.

Species			
Usual name	***Latin name***	**Status of sensitivity**	**Number of watercourses impacted**
Northern pike	*Esox lucius*	Very sensitive	13
Brook lamprey	*Lampetra planeri*	Moderately sensitive	4
Common dace	*Leuciscus leuciscus*	Slightly sensitive	3
Amur bitterling	*Rhodeus sericeus*	Moderately sensitive	5
Brown trout	*Salmo trutta*	Moderately sensitive	11

- Avoidance and minimization measures

Fish populations	- Safeguard fisheries were installed to save as many Northern pikes as possible. The safeguard fisheries were realized in accordance with the Fishing Federation and water administrations. - Protection of the water flows during construction to filter fine particles that pollute water (Figure 21)

Figure 21: Temporary sanitation (Eiffage patent: Modulap®)

- Residual impact assessment

Regulations protect only the fish breeding areas, namely the spawning grounds.
After avoidance none of the Northern pike, Brook lamprey, Common dace and Amur bitterling spawning grounds were directly impacted. The potential indirect impacts (clogging of watercourses, pollution, etc.) were managed through watercourse protection measures.
Some direct residual impact could not be avoided for the Brown trout. Even if the impact was low and potentially nil because of the mobility of the spawning grounds, it was esteemed that the project could destroy 2 specifically Trout spawning grounds.

Species		Residual impact assessment			
Usual name	**Latin name**	**Local scale**	**Regional scale**	**Residual impact**	**Value**
Northern pike	*Esox lucius*	Low	None	No	
Brook lamprey	*Lampetra planeri*	Low	None	No	
Common dace	*Leuciscus leuciscus*	Low	None	No	
Amur bitterling	*Rhodeus sericeus*	Low	None	No	
Brown trout	*Salmo trutta*	Low	None	Yes	0.05 ha (214 m) of riparian forest and 0.05 ha (214 m) of spawning ground

- Offset requirement

The level of compensation applied is deliberately moderate because the conservation issue for the Brown trout remains limited due to the absence of a wild strain identified during the impact studies. The trout recorded during the inventories were taken from the local fishing hatcheries.

Habitats impacted	**Residual impact**	**Offset ratio**	**Offset requirement**
Riparian forest	0,05 ha (214 m)	2	0.1 ha (428 m)
Spawning grounds	0,05 ha (214 m)	2	0.1 ha (428 m)

- Offset measures

The purpose of the offset is to implement tools and techniques to maintain, restore and manage the spawning sites in the minor bed:

1. By restoring a functional hydraulic connection between the spawning grounds and the river during floods:
   - restoration and maintenance of ditches (cleaning, uncluttering of ice jams, restoration of tadpole trees on the banks);
   - creation and/or restoration and/or management of hydraulic structures;
   - development of management agreements;
   - land control and environmental land management.
3. By reconstituting various flow facies by adding granulometry materials specific to the Brown trout (Figure 22)

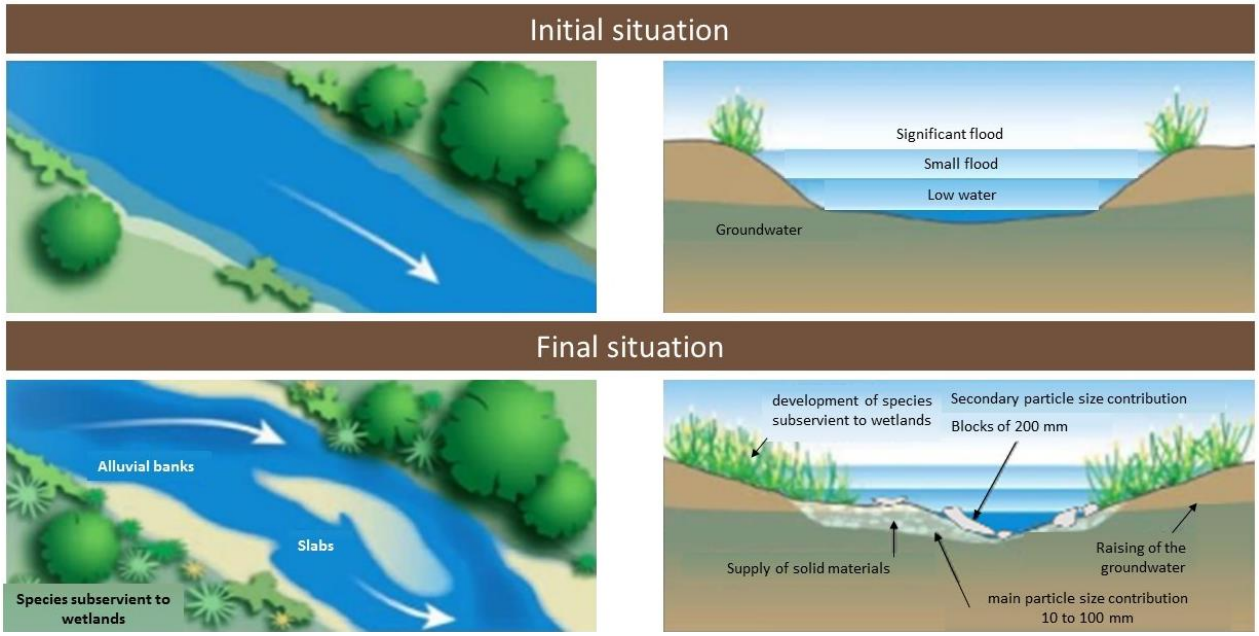


Figure 22: Creation of habitats in the watercourses (Source: ONF)

- Offset implementation

The fish offset, by way of the derogation to the prohibition of protected species destruction procedure, is closely related to the watercourse offset, by way of the water law.
The measures that benefit fish in both procedures are fungible and allow for a total offset implementation of:

	Offset requirement	Offset implemented
Riparian forest	428 lm / 0.1 ha	36056 lm / 25 ha
Spawning grounds	428 lm / 0.1 ha	428 lm

2.6. Amphibians

- Provisional impact before avoidance and reduction

The design office ECOSPHERE had already done studies on the impact of the project on the natural environment during the Pre-Project preparation and the public inquiry file prior to the DPU; the SNCF Réseau then did specific inventories between 2009 and 2010.
Here we focus on the complementary study of the amphibian populations impacted by the project carried out by the design office DERVENN. The study is limited to amphibian breeding and development sites (ponds and water bodies), and does not include migration routes or overwintering sites. The objective was to draw up an exhaustive list of the amphibian species present in each pond impacted by the project, and their respective numbers.

The 78 ponds in the project footprint (right-of-way + 12 meters on each side) were studied through an exhaustive quantification of the individuals of each of the amphibian species. 56 of the ponds host protected species:

- 15 presented a very high heritage interest (presence of at least 3 species of newts and/or nesting sites of importance for common and agile frogs)
- 53 showed an average or low heritage interest (presence of one or more of the amphibian species, and attested breeding site)
- 6 did not present any species
- 4 were not prospected (because of access difficulties)

Of the 15 species of amphibians inventoried, 14 are on the UICN red list in France, classified Low concern. Five of them are classified Near Threatened.

Species		Number of stations where observed /78	Conservation status
Use Name	***Latin name***		
Common Midwife Toad	*Alytes obstetricans*	5	LC
Common Toad	*Bufo bufo*	30	LC
Natterjack Toad	*Bufo calamita*	0	LC
Agile Frog	*Rana dalmatina*	48	LC
Edible Frog	*Pelophylax esculentus*	38	NT
Common Parsley Frog	*Pelodytes punctatus*	4	LC
European Tree Frog	*Hyla arborea*	17	NT
Fire Salamander	*Salamandra salamandra*	14	LC
Alpine Newt	*Ichthyosaura alpestris*	10	LC
Northern Crested Newt	*Triturus cristatus*	26	NT
Marbled Newt	*Triturus marmoratus*	6	NT
Palmate Newt	*Lissotriton helveticus*	29	LC
Smooth Newt	*Lissotriton vulgaris*	8	NT
Blasius Newt	*Triturus x blasii*	2	LC

- Avoidance and minimization measures

Species	Proposals for mitigation
All the species of amphibians	- Rehabilitation of habitats and reproduction sites (ponds, bodies of water) as close as possible to the habitat destroyed - Choosing a suitable work period. The optimal intervention period for backfilling-impacted ponds extends from October to January (common toads and common frogs are likely to be in the water as of January). The problem remains for 4 species that spend the winter in the water in larval form: the common Midwife toad, the Edible frog, the common Parsley frog and the Fire salamander. These 4 species are present in 50 of the 78 inventoried ponds. Amphibians could be present in these 50 ponds during the autumn and winter; it was best to rescue the larvae present before destroying the pond. - Avoid the destruction of individuals by preventing them from returning to the pond during the breeding season. Simply placing a fence around the pool in winter or autumn can do this. - In the event that the route crosses an identified migration route, the construction of crossing structures for amphibians (batrachoduc type) had to be considered.

- Residual impact assessment

78 of the 280 ponds within the DPU band hosted heritage or protected species. After avoidance and reduction, 110 ponds were impacted, among which 68 hosted heritage or protected species.
The analysis of the direct and indirect impacts (species sensitivity, protection, impacts on habitat, resting, breeding, displacement corridors, etc.) on these ponds and the associated habitats permitted a definition of the amphibian residual impacts.

Of the 14 species impacted:
- 6 species are impacted by article 2 of the "Habitat-Fauna-Flora" European directive, that is, their reproduction and rest areas are protected;
- 7 are impacted by article 3 of this directive, that is, only the individuals are protected, not their habitat.

Of the 68 impacted ponds, 42 were concerned by "article 2 species" and 26 by "article 3 species".

Species		Residual impact assessment				
Use Name	**Latin name**	**Local scale**	**Regional scale**	**Yes/No**	**Number of ponds impacted**	**Surface impacted (ha)**
Common Midwife Toad	*Alytes obstetricans*	Low	Low	Yes	8 (0.31ha)	3.70
Common Toad	*Bufo bufo*	Low	Low	Yes	25	
Natterjack Toad	*Bufo calamita*	Average	Low	Yes	3 (1.17ha)	11.76
Agile Frog	*Rana dalmatina*	Low	None	Yes	30 (5.42ha)	107.06
Edible Frog	*Pelophylax esculentus*	Low	None	Yes	2	
Common Parsley Frog	*Pelodytes punctatus*	Average	Low	Yes	4	
European Tree Frog	*Hyla arborea*	Low	Low	Yes	12 (0.42ha)	23.01
Fire Salamander	*Salamandra salamandra*	Low	None	Yes	14	

Alpine Newt	*Ichthyosaura alpestris*	Average	Low	Yes	12	
Northern Crested Newt	*Triturus cristatus*	Average	Low	Yes	25 (0.71ha)	42.96
Marbled Newt	*Triturus marmoratus*	Average	Low	Yes	6 (0.1ha)	9.29
Palmate Newt	*Lissotriton helveticus*	Low	None	Yes	30	
Smooth Newt	*Lissotriton vulgaris*	Average	Low	Yes	9	
Blasius Newt	*Triturus x blasii*	Average	Low	Yes	2	
Total					**68 ponds**	**137.95ha**

- Offset requirement

The species under article 3 of the “Habitat-Fauna-Flora” European directive are considered "umbrella" species with very important ecological functionalities. Their offset was not a legal obligation but Eiffage took it upon itself to take these species into account. Indeed, at this scale, the landscape is vegetal and eutrophication is low which is conducive to favourable amphibian displacements, thus a high probability of their presence. The ZNIEFF considers all of the amphibian species in Brittany decisive; given the species heritage value and sensitivity to the project works, they were also offset.

Compensation ratios for impacts on both breeding ponds and terrestrial habitats were therefore proposed for each species according to their sensitivity and national and regional protection status. Their frequency of appearance in the departments crossed by the High Speed Line as well as their conservation status in the close perimeter of the line was also taken into account (data extracted from the results of the inventories carried out during the impact studies and the complementary studies at the definition of offset measures).

Species		Ponds requirement			Terrestrial habitat requirement		
Use Name	Latin name	Number of ponds impacted	Ratio	Offset requirement (number of ponds)	Terrestrial habitat (ha)	Ratio	Offset requirement (ha terrestrial habitat)
Common Midwife Toad	***Alytes obstetricans***	8 (0.31 ha)	4	32	3.70	1	3.70
Common Toad	***Bufo bufo***	25	1	25			
Natterjack Toad	***Bufo calamita***	3 (1.17 ha)	5	15	11.76	1	11.76
Agile Frog	***Rana dalmatina***	30 (5.42 ha)	1	30	107.06	1	107.06
Edible Frog	***Pelophylax esculentus***	2	1	2			
Common Parsley Frog	***Pelodytes punctatus***	4	4	16			
European Tree Frog	***Hyla arborea***	12 (0.42 ha)	3	36	23.01	1	23.01
Fire Salamander	***Salamandra salamandra***	14	2	28			
Alpine Newt	***Ichthyosaura alpestris***	12	4	48			
Northern Crested Newt	***Triturus cristatus***	25 (0.71 ha)	4	100	42.96	1	42.96
Marbled Newt	***Triturus marmoratus***	6 (0.1 ha)	2	12	9.29	1	9.29

Palmate Newt	***Lissotriton helveticus***	30	5	150			
Smooth Newt	***Lissotriton vulgaris***	9	5	45			
Blasius Newt	***Triturus x blasii***	2	1	2			
Cumulated total (number)		**182**	**(average = 3)**	**541**	**198**	**(average = 1)**	**198**
On ground total (fungible for amphibians)		**68**	**(average = 3.1)**	**213 ponds**	**137.95ha**	**(average = 1)**	**137.95 ha**

- Offset design

The design characteristics of the ponds are described in 2.1.2.

It was voluntarily decided to accompany the newly created or restored ponds with amphibian-friendly terrestrial habitats of an average surface area of 1 hectare. In addition, 100 m of hedgerows per pond were proposed in order to aid integration into the green and blue corridors and to promote the movement of amphibians in the landscape.

Furthermore, in order to limit the impacts on amphibians during the works, immediate compensation ponds were constructed/restored before the works began. The individuals present in the "to be impacted" ponds were transferred to the new ones. These ponds share the same design characteristics as some described in paragraph 2.1.2 concerning ponds offset, but their surface is a maximum of 25 m².
These ponds are intended to support and favour the amphibian transparency structure's efficiency. Providing ponds on both sides of the amphibian structures (whatever their type may be) reinforces their attraction.

- Offset implementation

	Offset requirement	**Offset implemented**
Ponds offset	213 ponds	213 ponds
Terrestrial habitat offset	137.95 ha	213 ha
Hedgerows	/	21300 lm

2.7. Reptiles

- Provisional impact before avoidance and reduction

Only two of the seven following protected species potentially in the route of the project were specifically inventoried in the study area. However, given the potential use of the study area by other common protected reptilian species and a phase of work that will inevitably result in their habitat destruction, the following species, unobserved in the study area during inventories, may be affected:

Species		**Number of stations where it was observed /78**
Use Name	***Latin name***	
Aesculapian snake	*Zamenis longissimus*	2
Western green lizard	*Lacerta bilineata*	1
Common wall lizard	*Podarcis muralis*	n/a
Grass snake	*Natrix natrix*	n/a
The slowworm	*Anguis fragilis*	n/a
Sand lizard	*Lacerta agilis*	n/a
Western whip snake	*Hierophis viridiflavus*	n/a

- Avoidance and reduction measures

Two out of the seven species were identified as impacted by the complementary assessments. Avoidance and reduction measures are proposed for both of them.

Species	Mitigation measures
Aesculapian snake	- Replantation of woods - Crossing-structures for small fauna - Protection measures in case of accidental discovery: capture or displacement with a specialized ecologist (during spring-summer) - Reconstitution of favourable habitats (swath, scree)
Western green lizard	- Protection measures in case of accidental discovery: capture or displacement with a specialized ecologist (during spring-summer) - Reconstitution of favourable habitats (swath, scree)

- Residual impact assessment

The main wooded massifs of the regions crossed were avoided in the DPU band chosen during the preliminary studies and then in the route's definition during the pre-project studies, which is an important measure of avoidance.
The Western Green Lizard is not a particularly endangered species as its distribution is extensive.
The Aesculapian snake, although one of the key ZNIEFF species in Brittany and considered "declining" in the region, is common in the Pays de la Loire department. It was identified in 2 nearby sites though its habitat, resting and breeding areas are difficult to locate. Given this and taking into account the fact that the slopes of the HSL will constitute important habitats of predilection for the Aesculapian Snake, the project is in fact likely to maintain or improve the conservation of the population. As it does not require important regular movements, the impacts of the HSL on the species' movements will also be limited.

Species		Residual impact assessment		
Use Name	**Latin name**	**Local scale**	**Regional scale**	**Yes/No**
Aesculapian snake	*Zamenis longissimus*	Low	Low	No
Western green lizard	*Lacerta bilineata*	Low	Low	No
Common wall lizard	*Podarcis muralis*	None	None	No
Grass snake	*Natrix natrix*	None	None	No
The slowworm	*Anguis fragilis*	None	None	No
Sand lizard	*Lacerta agilis*	None	None	No
Western whip snake	*Hierophis viridiflavus*	None	None	No

Therefore, no residual impact was considered, and no compensatory measures are needed.

2.8. Plants

- Potential impact before avoidance and reduction

Of the 46 plant species inventoried in the DPU band (500 m large) since 2003, seven are protected but, according to the initial impact assessment study, only one is directly concerned by the project (Soft Hornwort—*Ceratophyllum submersum*).
ERE, however, decided to conduct additional studies on two other protected species (Floating Water-Plantain and Large Bitter-Cress) and on 14 non-protected heritage species, previously identified on the site or close to the impacted sites.

The detailed inventories on the project's footprint perimeter (including excavation and refilled areas) + 50m of buffer area on both sides were conducted in 2011 by Dervenn and gave a better estimate of the project's impact on the flora. The conclusion of the studies was that no non-protected species' population were threatened by the project. Thus, they were not taken into account in the offset requirement.

The stations and ponds close to the route, which can be impacted directly and indirectly by the project, were thus inventoried. The 3 protected species only are shown here:

Species		Number of stations where it was observed
Use Name	***Latin name***	
Soft Hornwort	*Ceratophyllum submersum*	5 ponds
Floating Water-Plantain	*Luronium natans*	0[10]
Large Bitter-Cress	*Cardamine amara*	1 station

- Avoidance and reduction measures

Species	Avoidance measures	Reduction measures
Soft Hornwort	For the 3 not directly impacted ponds: - putting up fences to the right of the ponds to avoid the straying of the machines - temporary sanitation to protect the ponds set up at the start of the works (temporary collection ditches, fine geotextile filters, straw filters), to avoid damage to the environment	For the 2 directly impacted ponds: - Species displacement carried out closely (to the existing or to be created ponds), equivalent in surface, quality and durability of the level of the water. Moving this species is compatible with compensation measures for amphibians.
Large Bitter-Cress	For the unique station, not directly impacted: - Installation of a secure space delimited by poles and wires in the existing pond in order to avoid the passage of gear on the identified site. - Prohibition of embankments and drainage close to the site	No reduction measure. The station was not directly impacted

- Residual impact assessment

The measures avoided impact on the Soft Hornwort for three ponds and on the Large Bitter-Cress in the only habitat.

Species		Residual impact assessment			
Use Name	**Latin name**	**Local scale**	**Regional scale**	**Yes/No**	**Number of ponds impacted**
Soft Hornwort	*Ceratophyllum submersum*	Average	None	Yes	2 ponds
Floating Water-Plantain	*Luronium natans*	None	None	No	
Large Bitter-Cress	*Cardamine amara*	None	None	No	

- Offset requirement

	Residual impact	Ratio	Offset requirement
Soft Hornwort	2 ponds	*2	4 ponds

[10] The presence of this species had been noted in a station during the EIA but disappeared since and was therefore not observed.

- Offset design

The Soft Hornwort is threatened by the disappearance of ponds, wetlands drainage, the massive introduction of herbivore-fish and water pollution. To compensate the residual impacts, two types of measures were implemented: the creation and/or restoration of ponds (see ponds offset for more details).
The design of the offset ponds to be created depended on the initial Soft Hornwort station size. The average size of the hosting ponds was 50 to 200 m², favourable to the plant but not to fish species which prefer larger spaces.
Given that the Soft Hornwort likes eutrophic waters with few herbivore-fish and vegetation (to avoid any competition), the objective of pond restoration was to recreate hosting potentialities by

- partially dredging the ponds (to reduce the existing vegetal species),
- cutting and uprooting woody elements (to avoid habitat closure)
- Electric fishing

To aid the re-colonisation of the ponds, individuals (Figure 23) were transplanted to the immediate compensation ponds. The offset was implemented in eight ponds instead of four because of the risk factors.

Figure 23: Transfer of the Soft hornwort (Source: Eiffage)

	Offset requirement	Offset implementation
Soft Hornwort	4 ponds	213 ponds in total, 8 ponds with species transfer

- Accompanying measures

Even though residual impact for the Floating Water-Plantain was undetected, its status in the region is threatened; ERE thus voluntarily decided to favour the long term conservation of this species with the:

- creation of two ponds near the ones where the Floating Water-Plantain had been spotted less than five years ago with a transfer of the sediment extracted from them (Figure 24)
- restoration of two ponds where the Floating Water-Plantain is present.

Figure 24: Transplantation of the Soft hornwort in an offset pond (Source: Eiffage)

Appendix 1: Synthesis of the conclusions of the environmental impact assessment (EIA)

In terms of biodiversity, the EIA synthesized:

Species covered by the Habitats Directive, i.e., species of community interest at the European level that require strict protection (listed in Annex II and/or IV of the Habitats Directive) and have been inventoried in or near the study area[11].

We have found:

- 17 species of birds
- 10 species of bats
- 3 species of invertebrates
- 3 species of fish
- 6 species of amphibians
- 3 species of reptiles
- 1 plant species

[11] At the regional scale:
- Two red lists exist in the Pays de la Loire: priority birds and priority mammals, amphibians and reptiles.
- There is no red list in Brittany but a list of species considered to be decisive in the designation of ZNIEFFs that shows the regional status of the conservation of species or groups of species.
➔ These lists have no regulatory scope but take the heritage identity into account.

From a regulations point of view, the following texts guided the offset project:

- Birds: The Directive 2009/147/EC of the European Parliament and of the Council of 30 November 2009 on the conservation of wild birds + the Order of 29 October 2009 amending the decree of 17 April 1981 that establishes the list of protected birds in the territory and the methods for their protection.
- Mammals: The Order of 23 April 2007 amending the decree of 17 April 1981 establishes the list of protected mammals throughout the territory and the methods of their protection.
- Insects: The Order of 23 April 2007 amending the decree of 22 July 1993 that establishes the list of protected insects in the national territory and the methods of their protection.
- Amphibians and reptiles: The Order of 19 November 2007 amending the decree of 22 July 1993 that establishes the list of protected amphibians and reptiles throughout the territory and the methods of their protection
- Fish and shellfish: The Order of 8 December 1988 that lists the protected fish throughout the national territory + the Order of 23 April 2008 that identifies the fish and crustacean species and the characteristic grain size of the spawning grounds.
- Crayfish: The Order of 18 January 2000 amending the Decree of 21 July 1983 on the protection of native crayfish.
- Molluscs: The Order of 23 April 2007 amending the Decree of 7 October 1992 that establishes the list of protected molluscs in France,
- Protected plant species in France: The Order of 20 January 1982 (published in the OJ of 13 May 1982, then amended by the Decree of 31 August 1995) which establishes the list of the protected plant species throughout the national territory,
- Protected plant species in Brittany: The Order of 23 July 1987 fixes the list of the protected plant species in Brittany and completes the national list,
- Protected plant species in the Pays de la Loire: The Order of 25 January 1993 lays down the list of protected plant species in the Pays de la Loire region and supplements the national list.

1. Birds

Among the 17 species of heritage interest birds identified during the inventories, 7 are a part of the hedge landscape. Others were:

- species related to wetlands (watercourses)
- two species related to wide open and cultivated areas
- three forest species
- a crop related species

2. Bats

According to the data transmitted by the Mayenne Nature Environment (MNE), at least 7 remarkable bats were recorded in the study area during the winters between 1997 and 2003, particularly in the north of Laval (Argentré, Louverné) in the Mayenne. The specific bat surveys carried out in June and September 2005 in the Erve Valley and the southern part of the ZNIEFF in Louverné made it possible to refine the presence of bats outside of the hibernation period.

17 bats species in the study area	10 protected on the European scale	7 protected on the national or regional scale

3. Insects

Some species of entomological interest identified in or near the study areas included Odonata (dragonflies), Orthoptera (locusts, grasshoppers, crickets) and beetles.

- Dragonflies (or Odonata): Field surveys identified 3 species of dragonflies, infrequent in the region.
- Orthoptera (locusts, grasshoppers): Field surveys identified 5 species of Orthoptera, infrequent in the region.
- Coleoptera: Two nationally protected and regionally vulnerable species were identified.
- Lepidoptera rhopalocères (butterflies): It should be noted that no remarkable butterflies were identified in the areas studied nor did the local naturalist associations indicate any particularly remarkable species. Only one species from Annex 4 of the Habitats Directive, classified as rare and vulnerable in the region, was reported on the limestone slopes of the Erve Valley. However, there was no suitable natural habitat for this species in the areas studied.

13 insects species in the study area	3 protected at the European scale	10 protected at a national or regional scale	3 species of odonata 5 species of orthoptera 2 species of coleoptera

4. Wild fauna

3 species were identified throughout the study area.

3 species of the wild fauna in the study area

5. Fish

The Hydro biological and Fish Network (HFN) makes it possible to annually monitor the state of the fish populations at a national level. Over the entire route, six watercourses have a monitoring station that belong to this network:

- in Ille-et-Vilaine: the Vilaine;
- in Mayenne: Oudon, Mayenne and Erve;

- in Sarthe: the Vègre and the Sarthe.

According to the data collected by the HFN and the Departmental Federations for Fisheries and the Protection of the Aquatic Environment, 9 remarkable species were recorded from all the rivers that cross the study area. Beyond the species present, the rivers could be classified in categories of fish families present, or not, in the particular natural environment of the waterway. This ranking is an indicator of the quality of the aquatic environments. Among the 73 rivers identified in the study area, sufficient information on 25 of them could characterize ecological sensitivity (18 of them on the inventory database and the other 7 based on specific assessments carried out in 2005). The rivers crossed by the HSL in Ille-et-Vilaine do not present a major fish challenge (no impacts were predicted). On the other hand, the rivers were of medium to high sensitivity in the Mayenne and in the Sarthe.

9 fish species in the study area	3 protected at the European scale	73 watercourses inventoried

6. Amphibians

Seven remarkable amphibian species, determinants of ZNIEFF, were inventoried in the study area. The main axes of amphibian movements were identified, prioritized and mapped.

13 amphibians species in the study area	6 protected on the European scale	7 protected on a national or regional scale

7. Reptiles

In total, 6 reptile species were observed throughout the study area. Two of them are of heritage interest because of their lower regional frequency.

9 reptiles species in the study area	3 protected on the European scale	6 protected on a national or regional scale

8. Plant species concerned by national and regional decrees

These decrees aim to "prevent the disappearance of threatened plant species and to allow the conservation of the corresponding biotopes". They stipulate that "the destruction, cutting, mutilation, grubbing, picking or removal, hawking, use, offering for sale, sale or purchase of all or part of the wild specimens" of the listed species are forbidden.

- 6 supplementary plant species

Remarkable plant species across the 3 departments with a stake in the study area bring the total number of plant species to 43, and 36 extra species if we move to more local bylaws.

43 plants species in the study area	1 protected at the European scale	66 protected at a national or regional scale	36 protected at a departmental scale

9. ZNIEFF type 1 or 2.

As a reminder:

- Type I ZNIEFFs correspond to generally small sized areas, characterized by the presence of rare or remarkable species or environments (e.g., those that are covered by the Habitats Directive) that are characteristic of the national or regional heritage. Very often they present protected species stations at regional or national levels.

- ZNIEFF types 2 are large natural complexes (forest massifs, valleys, plateaus, and estuaries) rich and/or little modified by human activities, or which offer significant biological potential. Type 2 ZNIEFFs can therefore integrate one or more type 1 ZNIEFFs within their perimeter. In the study area, 4 type 1 ZNIEFFs were identified on the route, a total of 42.41 potentially impacted hectares. A type 2 ZNIEFF was inventoried with an area of 29.84 ha.
- Cumulative total of 72.25 ha of intended impact.

An area of 72.25 ha of predicted total impact	4 ZNIEFFs of type 1 crossed representing 42.41ha of intended impact	1 ZNIEFF of type 2 crossed representing 29.84ha of intended impact

10. Wetlands

A number of wetlands and ponds for private use (gardens, livestock watering, irrigation) or for fishing were identified as directly affected by the project; these wetlands are particularly suitable habitats for many species, especially for amphibians.

Appendix 2: Description of the predicted direct and indirect impacts on birds

Birds		Direct impacts	Indirect impacts	Status		
				Regional[12]	Protection[13]	
Eurasian thick-knee	Burhinus oedicnemus	- **18 couples**, spread over the departments of Sarthe (13 couples, i.e., 13% of the estimated department population) and Mayenne (5 couples, i.e., 7 to 8% of the estimated department population) - Potentially favourable agricultural areas (corn and sunflower crops) = 85.15 ha	Embankments > 3m = affects bird couples nests	EN/CR	Nat.	
Montagu's harrier	Circus pygargus	Nesting or resting sites (**13.81 ha** of impacted arable field crops)	n/a (not applicable)	CR	Nat.	I-III
European honey buzzard	Pernis apivorus	n/a	n/a	NT	Nat.	I
Hen harrier	Circus cyaneus	N/a	n/a	VU	Nat.	
Wood lark	Pullula arboré	n/a	n/a	EN/CR	Nat.	I
Common grasshopper warbler	Locustella naevia	n/a	n/a	EN	Nat.	
Common firecrest	Regulus ignicapilla	n/a	n/a	LC	Nat.	II
European nightjar	Caprimulgus europaeus	- destruction of a wood (favourable to the species)[14] - collision with the trains	- population decline due to the fragmentation and destruction of its habitats	EN	Nat.	I
Eurasian hobby	Falco subbuteo	- destruction of favourable habitat - cut-off of ecological corridors	n/a	EN	Nat.	
Hawfinch	Coccothraustes coccothraustes	- destruction of hedges in communication with afforestation	n/a	DD	Nat.	II

[12] Regional status of the species on the Red List
[13] Protection status on the national and international scale
[14] For somes species, the area destroyed was not available, just the type of impact

Short-eared owl	Asio flammeus	- collision with trains	n/a	NA	Nat.	I-II
Sand martin	Riparia riparia	n/a	n/a	VU		
Eurasian hoopoe	Upupa epops	- destruction of hedges in connection with other hedges - collision with trains	n/a	NT		
Black woodpecker	Dryocopus martius	- collision with trains - cut-off effect	n/a	DD	Nat.	I
Common house martin	Delichon urbicum	- Destroyed building	n/a	DD	Nat.	II
Red-backed shrike	Lanius collurio	n/a	n/a	VU	Nat	I
Lesser spotted woodpecker	Dryobates minor	- Rupture of the continuities used during the nesting period for foraging - fragmentation of forestation - collision with trains	n/a			
Little owl	Athene noctua	- destruction of the “bocage” (destruction of the habitat) - destruction of some breeding areas	n/a	VU	Nat.	
Zitting cisticola	Cisticola juncidis	- alteration of the function of ecological corridor	n/a	LC	Nat.	III
Cetti's warbler	Cettia cetti	- fragmentation of the habitat - cut-off of hunting areas, shelters, and corridors	n/a	VU		
Long-eared owl	Asio otus	- fragmentation of hunting territories - destruction of hedges/ecological corridors connecting woods	n/a	LC	Nat.	II-III
Eurasian sparrowhawk	Accipiter nisus	- reduction of the favourable habitats	n/a	LC	Nat.	II-III
Common kingfisher	Alcedo atthis	- cut-off of the hydraulic continuity	n/a	LC		I

Appendix 3: Determination of the predicted direct and indirect impacts on bats for residual impact estimation

Bats		Direct impacts	In direct impacts	Status		
				Regional	Protection	
Bechstein's bat	Myotis bechsteinii	Rest and breeding lodges + hunting areas (**4,87 ha** of forestation)	Emb ankment = barrier	DD	Nat.	II-IV
Barbastelle	Barbastella barbastellus	Impacts on resting and wintering areas (**10.75 ha** of forestation)	Impacts on hunting territories and movement corridors	VU	Nat.	II-IV
Common long-eared bat	Plecotus auritus	Resting and breeding area (**5,83 ha**) and corridors	Alteration of hunting grounds and corridors	LC	Nat.	II-IV
Whiskered bat	Myotis mystacinus	Destruction of **17.46 ha** of forestation (= cutting of the edges)	Risk of collision in embankment areas	LC	Nat.	II
Kuhl's pipistrelle	Pipistrellus kuhlii	Birthing shelter destroyed by the project **11.97 ha**	n/a (not applicable)	VU	Nat.	IV
Natterer's bat	Myotis nattereri	Deforestation of **5.49 ha** = Rest and breeding lodgings	Risk of collision	DD	Nat.	IV
Serotine bat	Eptesicus serotinus	0.61 ha	n/a	DD	Nat.	IV
Common pipistrelle	Pipistrellus pipistrellus	12.58 ha	n/a	DD	Nat.	IV

Appendix 4: Determination of the predicted direct and indirect impacts on insects for residual impact estimation

Insects		Direct impacts	Indirect impacts	Status		
				Regional	Protection	
Hermit beetle	Osmoderma eremita	- Destruction of trees: 18 trees impacted + 8 trees with ancient evidence of the presence of the species directly impacted by the passage of the route: • 2 trees on the "Tricouillère" site, in Domagné, • 3 trees in the "Haie du Fontaine" site, in Brielles, • 2 trees on the site of "Les Cormiers", in Coulans-sur-Gée. • 1 tree at "Bon Accueil et La Vannerie" at the edge of town between Coulans- sur-Gée and La Quinte. - The elimination of old trees in agricultural environments - The grooming of the forests by eliminating the decayed subjects during the cuts 8 trees / 320 lm	- The impacts induced by the land development procedure - The impact on dispersal and movement corridors - Potential impact on the state of conservation of the population - The abandonment of silvopastoral practices such as pollarding or pruning trees in favour of the formation of habitats propitious to its development. In some sites, the number of trees of this type is important but they are all the same age giving rise to the crucial long term renewal of the habitat of this species	DD	Nat.	II-IV
Great capricorn beetle	Cerambyx cerdo	- **153 trees** impacted - **6,120 linear** meters of hedges impacted	- Habitat loss as a result of land development and the increase in the size of farmland (hedge clearance) as well as current silvicultural practices (shortening the duration of exploitation, absence of dead or dying trees in the forest).	VU	Nat.	II-IV

Appendix 5: Determination of the predicted direct and indirect impacts on semi-aquatic mammals for residual impact estimation

Terrestrial and semi-aquatic mammals		Direct impacts	Indirect impacts	Status		
				Reg.	Protection	
Miller's water shrew	Neomys anomalus	Loss of 2 types of sites for resting and reproduction: - Surface habitats: riparian forest (3m wide), hygrophilous woodland, water bodies and ponds and poplar plantations = **3.99 ha** - Linear habitats: ditches, streams, small rivers with single riparian or narrow shrub layers less than 3 m wide = **19,950 m** = 8.07 ha in total	n/a	DD	Nat.	III
Eurasian water shrew	Neomys fodiens	Loss of 2 types of sites for resting and reproduction: - Surface habitats: riparian forest (3 m wide), hygrophilous woodland, water bodies and ponds and poplar plantations = **3.99 ha** - Linear habitats: ditches, streams, small rivers with single riparian or narrow shrub layer less than 3m wide = **19950 m** = 8.07 ha in total	n/a	DD	Nat.	III
Eurasian otter	Lutra lutra	Loss of 2 types of sites for resting and reproduction: - Surface habitats: riparian forest (3 m wide), hygrophilous woodland, water bodies and ponds and poplar plantations = **3,75 ha** - Linear habitats: ditches, streams, small rivers with single riparian forest or narrow or narrow shrub layer less than 3 m wide = **6,103 m**	n/a	LC	Nat.	II-IV
European beaver	Castor fiber	Surface habitats: poplar plantations, riparian forests of alders, willows and ash trees = 1.44 ha Linear habitats: on a 2 m band (**427 m** or **0.09 ha**)	n/a	EN	Nat.	II-III-IV
Common dormouse	Muscardinus avellanarius	- Destruction of habitats - Destruction of individuals	- Fragmentation due to the intensification of agriculture, urbanisation	NT	Nat.	III-IV

		- Destruction of resting and breeding habitats	- Land development - Partitioning of habitats and populations			
Eurasian red squirrel	Sciurus vulgaris	- Destruction of habitats	- Fragmentation and artificialisation of the natural habitat - breaking of ecological continuities and displacement corridors	LC	Nat.	III
European hedgehog	Erinaceus europaeus	- Destruction of habitats - Destruction of individuals	- Fragmentation of habitats - Drowning - Decrease in the food resource linked to the use of pesticides	LC	Nat.	III

Appendix 6: Determination of the predicted direct and indirect impacts on fish for residual impact estimation

Fish		Direct impacts	Indirect impacts	Status		
				Reg.	Protection	
Brown trout (spawning ground)	Salmo trutta	5 potential spawning sites exclusively related to brown trout were identified. 2 of them were impacted. The direct impact on brown trout spawning grounds is estimated at **214 lm /0.05 ha**	n/a (not applicable)	VU	Nat.	
Northern pike	Esox lucius	No northern pike's spawning grounds were identified in the study area.	Indirect impacts by clogging flood-prone grasslands due to the loss of fine particles during construction are therefore possible.	VU	Nat.	
Brook lamprey	Lampetra planeri	No brook lamprey's spawning grounds were identified in the study area.	Indirect impacts by clogging the banks and the bottom of the minor bed are therefore possible. They are, in any case, difficult to quantify, or even to highlight when too far from the project.	VU	Nat.	II-IV
Common dace	Leuciscus leuciscus	No common dace's spawning grounds were identified in the study area.	Indirect impacts by clogging of watercourse bottoms are therefore possible, although difficult to quantify, or even to highlight when too far from the project.		Nat.	
Amur bitterling	Rhodeus sericeus	No common dace's spawning grounds were identified in the study area.	Indirect impacts by clogging of watercourse bottoms are therefore possible, although difficult to quantify, or even to highlight when too far from the project.	VU	Nat.	II-IV

Appendix 7: Determination of the predicted direct and indirect impacts on amphibians for residual impact estimation

Amphibians		Direct impacts	Indirect impacts	Status		
				Regional	Protection	
Natterjack Toad	Bufo calamita	- Aquatic habitats: breeding area (3 bodies of water in old gravel pits) (**1.17ha**) - Terrestrial habitats: open and sandy environments (gravel and pebble areas) (**11.76 ha**)	n/a (not applicable)	EN	Nat.	IV
Common Toad	Bufo bufo	27 ponds and water bodies	- fragmentation of the habitats	LC	Nat.	III
Edible Frog	Pelophylax esculentus	2 ponds impacted	n/a	DD	Nat.	III-IV
Agile Frog	Rana dalmatina	30 ponds and water bodies: - breeding areas: aquatic habitats (**5.42 ha)** - resting areas: terrestrial habitats = **107.06 ha** (forestation (38.2 ha), hedgerows (38.63 ha) and wetlands (30.23 ha)	n/a	LC		IV
European Tree Frog	Hyla arborea	12 impacted ponds: - breeding areas: aquatic habitats = **0.2ha** - resting areas: terrestrial habitats = **23 ha** (forestation 5.63 ha, hedgerows 14.89 ha and wet meadows 2.49 ha)	n/a	LC	Nat.	II-IV
Fire Salamander	Salamandra salamandra	14 ponds	n/a	LC	Nat.	III
Northern Crested Newt	Triturus cristatus	25 ponds: - terrestrial habitats: rest (**42.69 ha**) = hedges (14.58 ha), forestation (15.07 ha), wet meadows (13.04 ha) - aquatic habitats: reproduction (0.71 ha). Deep ponds	n/a	VU	Nat.	II-IV
Marbled Newt	Triturus marmoratus	28 ponds: - terrestrial habitats: rest (**9.29 ha**)	n/a	EN	Nat.	IV

		- aquatic habitats: **0.10 ha**				
Palmate Newt	Lissotriton helveticus	6 ponds impacted	n/a	LC	Nat.	II
Alpine Newt	Ichthyosaura alpestris	12 ponds impacted	n/a	NT	Nat.	III
Smooth Newt	Lissotriton vulgaris	9 ponds impacted	n/a	NT	Nat.	III
Common Midwife Toad	Alytes obstetricans	8 ponds impacted - breeding areas (aquatic habitats = **0.31 ha**) - rest areas (terrestrial habitats = **3.7 ha**)	n/a	VU	Nat.	IV
Common Parsley Frog	Pelodytes punctatus	5 ponds impacted	n/a	VU	Nat.	

Appendix 8: Determination of the predicted direct and indirect impacts on reptiles for residual impact estimation

Reptiles		Direct impacts	Indirect impacts	Status		
				Regional	Protection	
Aesculapian snake	Zamenis longissimus	n/a (not applicable)	Impacts on the displacements	Vulnerable	Nat.	II-IV
Western green lizard	Lacerta bilineata	n/a	n/a	Quite Common	Nat.	III-IV

Appendix 9: Methodology of the description of the hedges

1. Location of the hedges

A census of the linear of hedges was made by photo interpretation.

2. Characterization of the hedge (method developed for the project)

2.1. Typology of hedges according to their position in the landscape and/or land form

- Presence of an embankment
- Presence of a ditch
- Hedge located at the boundary of the parcel
- Cutting regime (frequency at which it is cut)

2.2. Composition of the hedge

- Nature of strata
- Age of subjects
    - Less than 20 years
    - 20 to 50 years of age
    - 50 to 100 years of age
    - Over 100 years
- Density
    - 1: very low
    - 2: low
    - 3: average
    - 4: dense
- Number of rows
- Thickness of the hedge
- Characterization of the species (covering rate)
    - 1st class: the species covers less than 10% of the hedge (minority species)
    - 2nd class: the species covers from 10 to 50% of the hedge (well represented species)
    - 3rd class: the species covers from 50 to 75% of the hedge (very represented species)
    - 4th class: the species covers from 75 to 100% of the hedge (dominant species)
- Sanitary state (are the subjects ill or attacked by pests)
- Presence of cavities

Appendix 10: Methodology of the description of the wetlands

The wetland habitats were described in 2011 by Asconit, a design consultancy specialized in these types of studies.

1. Hydrological descriptors

The parameters related to hydrology taken into account during the field diagnoses were:

- the frequency and extent of the submergence of the wetland parcel
- the inflow and outflow of water observed, as well as their permanence
- the identification of the hydraulic functions ensured by the parcel and their level of interest
- the identification of potential purifying functions
- an overall assessment of the hydrological functioning

1.1. The descriptors of the purifying functions

The purifying functions of wetlands can be dissociated according to the biological and physical criteria they present. These criteria make it possible to define the capacity of the wetlands to intercept suspended matter (physical criterion) and to regulate nutrients (biological criterion).

1.2. The descriptors of biology

The biological data consists of lists of the species of the plants and animals present and observed on site during the field visit. The biological diagnosis was determined by identifying the biological functions associated with a value highlighting the interest of the wetland with regard to this function.

Five main functions were chosen to be identified in the field:

- ecological corridor
- feeding, breeding and reception area for wildlife
- biodiversity support
- heritage interest of a species or habitat
- carbon storage

The values of each function were evaluated based on the operator's field observations.

1.3. Descriptors of context (use & socio-economic activity)

The context of the location of the wetland was described by identifying the activities present in and around the wetland. Their qualification was established by associating them with a level of interest.
However, the descriptors “uses and socio-economic activities” were not considered in the prioritization of the wetlands.

1.4. Descriptors of disturbances in the area

The identification of the disturbances on the wetlands makes it possible to perceive the alterations already present in the territory. This analysis made it possible for the project owner to add additional elements to the strategic choices to be made in the methods of how the work is carried out and which conservation or corrective measures must be put into place. This data is a diagnostic element linked to hydrology, biology and the state of conservation. However, the disturbance descriptors were not considered in the prioritization of wetlands.

	Function	No	Low	Medium	High
Hydraulic functions	Natural support of low water	Insufficient surface (riparian strip)	Limited area and/or isolated wetland	Medium area and marked hydromorphy	Large area and strong hydromorphy (seepage observation)
	Natural regulation of floods	Absence of a flood expansion zone or inappropriate topography	Limited surface and inappropriate topography	Average surface and favourable topography	Large surface and very favourable topography
	Erosion protection	Vegetable cover or unsuitable positioning	Adapted plant cover and limited surface	Adapted plant cover, positioning or favourable surface	Adapted plant cover, favourable positioning and surface
	Storage of surface water	Unsuitable plant cover	Adapted plant cover and steep slope	Adapted plant cover and low slope	Adapted plant cover and very dense and zero slope
	Groundwater recharge	Inadequate surface and very little marked hydromorphy	Reduced surface and weak hydromorphy	Medium to strong wetland area and/or marked hydromorphy	Very large wetland area and strong hydromorphy
Purifying functions	Regulation of nutrients	Absence of vegetation cover (cultivated area) and/or lack of flow storage capacity	Limited vegetation cover and/or area with low flow storage capacity	Adapted plant cover and/or favourable flow storage capacity	Adapted plant cover and favourable storage area
	Interception of M.E.S.	Vegetable cover absent (cultivated area) and/or inappropriate positioning	Limited vegetation cover and/or unfavourable positioning	Plant cover adapted and/or favourable positioning	Adapted plant cover and favourable positioning
Biological functions	Ecological Corridor	The area does not host wetland flora or fauna and is not a transition zone within a network of plots	Some wetland plant species but a weak transition zone within a network of plots (riparian forest, grassed strip)	Diverse wetland habitat but a weak transition zone within a network of parcels (riparian forest, grassed strip)	A diverse wetland habitat. It ensures the transition with other adjacent parcels
	Feeding area, breeding and home for wildlife	The area does not host reproduction or feeding	A habitat that can host reproduction or feeding of a group of species (birds, amphibians, mammals, insects, etc.)	A habitat that can provide reception, reproduction or feeding of two to three groups of species (birds, amphibians, mammals, insects, etc.)	A habitat that can provide reception, reproduction and feeding of more than three species groups (birds, amphibians, mammals, etc.)
	Biodiversity support	The area does not present a habitat that is a source of biodiversity	The area has a habitat that increases biodiversity very slightly (some plant species)	The area supports a habitat that increases the number of plant and animal species	The area supports a habitat that greatly enhances local biodiversity
	Heritage interest of species or habitat	Absence of a species or heritage habitat	Presence of some species of patrimonial interest	Presence of heritage species over a large area	Presence of many species within a large area or habitat with a high heritage value
	Carbon storage	Zone without organic matter storage capacity	Area with low storage capacity: herbaceous vegetation cover (reed beds) or exploited poplar	Zone with accumulation of organic matter in a forest environment	Zone with strong accumulation of organic matter (marshy saussaie, peat bog, etc.)

As a result of all these indicators and scores, the wetlands are classified in 4 levels:

Level 1: the best level in terms of functionalities (score between 36 and 26)
Level 2: good level in terms of functionalities (score between 25 and 16)
Level 3: low level in terms of functionalities (score between 15 and 9)
Level 4: bad level in terms of functionalities (score between 8 and 5 = low and score between 4 and 1 = very low)

<table>
<tr><th></th><th>Level 1</th><th>Level 2</th><th>Level 3</th></tr>
<tr><td rowspan="2">Habitats (described in the decree of 24th June 2008)</td><td>→ Wetland habitat</td><td rowspan="2">Classification according to cumulative scores of the functions observed
(score > or = to 16)
→</td><td rowspan="2">1. Classification according to the cumulative scores of the functions observed
2. (16 > score ≥ 9)
→</td></tr>
<tr><td>(other habitats)
↓
2. Functions</td></tr>
<tr><td></td><td></td><td></td><td>↓
Level 4
Cumulative scores between 0 and 8</td></tr>
</table>

Appendix 11: Methodology of the description of the ponds and water bodies

1.1. Descriptors of morphology

Different sizes were identified to describe the morphology of the ponds and bodies of water:

- Average and maximum depth,
- Length and width,
- Slope of the banks
- Nature of the contour (concrete or stone, bare or vegetation)
- Observation of a filling

1.2. Hydrological descriptors

The parameters related to hydrology taken into account during the field diagnosis, were:

- the inflow and outflow of water observed, as well as their permanence
- an overall assessment of the hydrological functioning
- the census of associated hydraulic structures

1.3. The descriptors of biology

The biological data consists of lists of plant and animal organisms observed on the spot. They were supplemented by the amphibian input data processed by Dervenn and the National Forest Office in 2011.

1.4. The descriptors of the context

The contexts of the pond or bodies of water were described by identifying the activities present in and around them. Their qualification has been established by associating them with a level of interest.
The identification of the attacks on the pond or the water bodies made it possible to perceive the alterations already present on the territory. This analysis made it possible for the project owner to add additional elements to the strategic choices to be made in the methods of how the work is carried out and which conservation or corrective measures must be put into place.

1.5. Functional score calculation

The ranking of ponds and water bodies is based on the combination of the number of species observed with the aquatic vegetation density surveys.
The priority criterion is the "number of amphibian species"; the "aquatic vegetation density" criterion is secondary as it modulates the levels of hierarchy that take the habitats constituted by the aquatic vegetation into account.

Level 1 corresponds to the sites for which:

- the number of species encountered is greater than 5, or
- the number of species encountered is between 3 and 5 and with a density of strong to very strong aquatic vegetation.

Level 2 corresponds to the sites for which:

- the number of species encountered is between 3 and 5 and with zero to medium aquatic vegetation density, or
- the number of species encountered is less than 3 and with a medium to very high aquatic vegetation density.

Level 3 corresponds to sites with a species count of less than 3 and a medium to low aquatic vegetation density.

By default, all ponds and water bodies without amphibian data were ranked in level 3.

Each function is characterized by a by level of interest and with a score value.

The cumulative scores of all 12 functions (listed in the table below) determine the overall functional score value of each zone. The maximum potential value for a wetland is 36 (Level 1). It is based on the following three main functions (on the left of the table):

- Hydraulic functions
- Purifying functions
- Biological functions

No	Low	Medium	High
0	1	2	3

Number of species	Density of aquatic vegetation	Level
< 3	Low	3
	Medium	2
	High	2
From 3 to 5	Low	2
	Medium	2
	High	1
> 5	Low	1
	Medium	1
	High	1

	Function	No	Low	Medium	High
Hydraulic functions	Natural support of low water	Insufficient surface (riparian strip)	Limited area and/or isolated wetland	Medium marked hydromorphic area	Large and strong hydromorphic area (see page observation)
	Natural regulation of floods	Absence of flood expansion zone or inappropriate topography	Limited surface and inappropriate topography	Average surface and favourable topography	Large surface and very favourable topography
	Erosion protection	Vegetable cover or unsuitable positioning	Plant cover adapted, limited surface	Adapted plant cover, positioning or favourable surface	Adapted plant cover, favourable positioning and surface
	Storage of surface water	Unsuitable plant cover	Adapted plant cover and steep slope	Adapted plant cover and low slope	Adapted very dense plant cover and zero slope
	Groundwater recharge	Inadequate surface and very little marked hydromorphy	Reduced surface and weak hydromorphy	Medium to strong wetland area and/or marked hydromorphy	Very large wetland area and strong hydromorphy
Purifying functions	Regulation of nutrients	Absence of vegetable cover (cultivated area) and/or lack of flow storage capacity	Limited vegetation cover and/or area low flow storage capacity	Adapted plant cover and/or favourable flow storage capacity	Adapted plant cover and favourable storage area
	Interception of M.E.S.	Vegetable cover absent (cultivated area) and/or inappropriate positioning	Limited vegetation cover and/or unfavourable positioning	Plant cover adapted and/or favourable positioning	Adapted plant cover and favourable positioning
Biological functions	Ecological Corridor	The area does not host wetland flora or fauna and is not a transition zone within a network of plots	Some wetland plant species and constitutes a weak transition zone within a network of plots (riparian forest, grassed strip)	A diverse wetland habitat. But a weak transition zone within a network of parcels (riparian forest, grassed strip)	A diverse wetland habitat that ensures the transition to other adjacent parcels
	Feeding area, breeding and home for wildlife	The area does not allow host, reproduction or feeding	The habitat can provide either hosting, reproduction or feeding for a group of species (birds, amphibians, mammals, insects, etc.)	The habitat can provide reception, reproduction or feeding for two to three groups of species (birds, amphibians, mammals, insects, etc.)	The habitat can provide reception, reproduction and feeding for more than three species groups (birds, amphibians, mammals, etc.)
	Biodiversity support	The area does not present a habitat that is a source of biodiversity	The area has a habitat that increases biodiversity very slightly (some plant species)	The area supports a habitat that increases the number of plant and animal species	The area supports a habitat that greatly enhances local biodiversity
	Heritage interest of species or habitat	Absence of a species or heritage habitat	Occasional presence of some species of patrimonial interest	Presence of heritage species over a large area	Presence of many species in a large area or habitat with a high heritage value
	Carbon storage	Zone without organic matter storage capacity	Area with low storage capacity: herbaceous vegetation cover (reed beds) or exploited poplar	Zone with accumulation of organic matter in a forest environment	Zone with strong accumulation of organic matter (marshy saussaie, peat bog, etc.)

Appendix 12: Indicators of the potentially impacted water flow zones

4 indicators defined the water flow zones:

- A “physical” description of the water flow: width, substrate, facies, morphology, and presence of hydraulic works on the bed.
- Identification of land use, pollution and alterations.
- Ecological description: aquatic vegetation, riparian, presence of aquatic organisms, and presence of spawning grounds.
- Identification and description of hydraulic structures.

Appendix 13: principles, criteria and indicators: an illustrated chronology