Pilot project « Walphy » : Walloon experimentation of river restoration

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I. Context & objectives of the project

Water bodies are required to achieve the « good ecological status » by 2015

Pilot project « Walphy » - Design of a decision tool for hydromorphological restoration of water bodies in Walloon Region (LIFE07 ENV/B/000038)

Objectives:

- To develop a structured approach aiming at improving morphological quality of the upstream Meuse basin in order to achieve the “good ecological status” (WFD)
- To carry out experimental river restoration works on several risk water bodies
- Ecological and geomorphological monitoring of the restored river systems
- To develop a useful and suitable methodology to determine and schedule river restoration works in Wallonia
II. River restoration work

Bocq:
- Catchment area: 233 km²
- Average slope: 4.8 %
- $\omega \sim 85$ W/m²
- Many obstacles

Disruption of the longitudinal continuity

Obstacle:
- Minor
- Medium
- Major
- Insurmountable

Water system:
- Navigable watercourse
- Un navigable watercourse
  - 1st class
  - 2nd class
  - 3rd class

Urbanized area

Source: SPW, 2007
River restoration work

Improvement of the river continuity

<table>
<thead>
<tr>
<th>Type of work</th>
<th>Date of work</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dam removal</td>
<td>2010</td>
</tr>
<tr>
<td>Fish ladder</td>
<td></td>
</tr>
<tr>
<td>Pre weirs</td>
<td></td>
</tr>
<tr>
<td>Bypass channel</td>
<td></td>
</tr>
<tr>
<td>Rock ramp</td>
<td></td>
</tr>
<tr>
<td>Undetermined</td>
<td></td>
</tr>
</tbody>
</table>

Water system
- Navigable watercourse
- UnNavigable watercourse
- 1st class
- 2nd class
- 3rd class

Source: SPW, 2007
River restoration work

Eau Blanche:
- Catchment area: 249 km²
- Average slope: 2.3 °
- $\omega \sim 20 \text{ W/m}^2$
- Straightened river

Poor stream-floodplain connectivity

MNT – LIDAR (LAser Detection And Ranging), 2001

Elevation above water level (cm)

Violet: Watercourse from 1910 (IGM, 1948)
Blue: Current watercourse (SPW, 2004)
Varied restoration techniques

Flow deflectors and gravel re-introduction

Woody debris

Low level berm
River restoration work

Meandering channel

Reconnecting remnant meander
III. Monitoring: data collection and analysis

Good ecological status (WFD)

Monitoring process

- Biology
  - Macrophytes index (IBMR)
  - Macroinvertebrates indexes
  - Electrofishing & fishes index (IBIP)

- Chemistry
  - Seq-Eau index
    (Agences de l’Eau, FR)

- Morphology
  - Microhabitat survey
  - IAM index (Téléos, 1999)
  - Tronçon index (Téléos, 1999)

- Geomorphology
  - Topographic survey and cross sections
  - Sediment transport
  - Clogging of the gravel bed
  - Flood effect on restoration works

Aim: assessing the success of restoration projects
**Biology:**

**Macrophytes:** IBMR index (Haury et al., 1998) based on:
- cover,
- ecological amplitude,
- trophic level of taxa.

**Macroinvertebrates:** indexes based on:
- abundance,
- diversity,
- species richness,
- specific pollution sensitivity index,
- habitat quality, ...

**Electrofishing and IBIP index** (Didier, 1997, Kestemont et al., 2001) based on:
- abundance,
- density,
- species richness,...

**Feedback:**
- For long-term monitoring
- Reflects the quality of water and substrates

Multiple indexes
- Optimized data analysis
Morphology:

Microhabitat mapping

a) Water depth model

Field survey of the stream channel:

- Stream bed boundary
- Stream bed elevation
- Water surface elevation

- Stream bed DEM
- Water surface DEM

Water depth model
b) Water velocity model

Bocq at Senenne
September 10th 2009
Q = 0.9 m³/s at Spontin station

c) Dominant substrate class
Morphology:

Microhabitat mapping

<table>
<thead>
<tr>
<th>Substrate</th>
<th>Clay</th>
<th>Silt</th>
<th>Pebbles</th>
<th>Cobbles</th>
<th>Boulders</th>
<th>Algae</th>
<th>Bryophytes</th>
<th>Hydrophytes</th>
<th>Helophytes</th>
<th>Tree roots, logs</th>
<th>Coarse organic debris</th>
</tr>
</thead>
<tbody>
<tr>
<td>Area (%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Water velocity (cm/s)</td>
<td>v &lt; 5 cm/s</td>
<td>5 &lt; v &lt; 25 cm/s</td>
<td>25 &lt; v &lt; 75 cm/s</td>
<td>v &gt; 75 cm/s</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0 - 5</td>
<td>1.2</td>
<td>3.5</td>
<td>1.9</td>
<td>3.3</td>
<td>0.6</td>
<td>0.2</td>
<td>0.2</td>
<td>0.2</td>
<td>0.4</td>
<td>0.5</td>
<td></td>
</tr>
<tr>
<td>5 - 25</td>
<td>0.9</td>
<td>2.1</td>
<td>4.9</td>
<td>19.9</td>
<td>2.2</td>
<td>1.1</td>
<td>2.8</td>
<td>4.6</td>
<td>1.0</td>
<td>1.0</td>
<td></td>
</tr>
<tr>
<td>25 - 75</td>
<td>0.3</td>
<td>0.3</td>
<td>2.0</td>
<td>28.2</td>
<td>3.6</td>
<td>1.7</td>
<td>7.3</td>
<td>4.6</td>
<td>0.3</td>
<td>1.6</td>
<td></td>
</tr>
<tr>
<td>&gt; 75</td>
<td>0.1</td>
<td></td>
<td>0.2</td>
<td>1.2</td>
<td>1.5</td>
<td>1.7</td>
<td>1.7</td>
<td>0.3</td>
<td>1.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>12.8</td>
<td>35.3</td>
<td>47.1</td>
<td>4.9</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

Feedback:
- Good accuracy of the mapping
- Time consuming (field survey)
- Influence by the season (vegetation growth)
- Influence by the discharge (water velocity and depth)

Taken into account when monitoring (before and after restoration work)
Morphology:

**Morphodynamic attractivity index (IAM)** (Teleos, 1999)

\[ IAM_{calculated} = \left( \sum_{i=1}^{n} (Si \times Attract.(subs.)) \right) \times Var(subs.) \times Var(he) \times Var(v) \]

- \( Si \) = Area of the i substrate
- \( Attract. \) = Attractivity of the i substrate for the fish
- \( n \) = Number of substrate
- \( Var(subs.) \) = Number of substrate
- \( Var(he) \) = Number of depth class
- \( Var(v) \) = Number of water velocity class

“IAM calculated” compared to “IAM reference”

<table>
<thead>
<tr>
<th>Substrate</th>
<th>Attractivity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Root wads, woody coarse debris</td>
<td>100</td>
</tr>
<tr>
<td>Undercut banks</td>
<td>90</td>
</tr>
<tr>
<td>Hydrophytes</td>
<td>80</td>
</tr>
<tr>
<td>Boulders (with fish caches)</td>
<td>60</td>
</tr>
<tr>
<td>Cobbles</td>
<td>50</td>
</tr>
<tr>
<td>Helophytes</td>
<td>40</td>
</tr>
<tr>
<td>Root mats</td>
<td>40</td>
</tr>
<tr>
<td>Boulders (without fish caches)</td>
<td>30</td>
</tr>
<tr>
<td>Mix of pebbles and cobbles</td>
<td>25</td>
</tr>
<tr>
<td>Pebbles</td>
<td>20</td>
</tr>
<tr>
<td>Organic debris</td>
<td>10</td>
</tr>
<tr>
<td>Sands</td>
<td>8</td>
</tr>
<tr>
<td>Clay and silt</td>
<td>4</td>
</tr>
<tr>
<td>Mud</td>
<td>3</td>
</tr>
<tr>
<td>Concrete surface and slab</td>
<td>1</td>
</tr>
<tr>
<td>Affluents, spring</td>
<td>+25%</td>
</tr>
</tbody>
</table>

**Feedback:**
- Easily calculated from the microhabitat mapping
- Same remarks as for the microhabitats
- Provides fish habitat predictions
- Index with a fish orientation
- Useful for monitoring
**Morphology:**

**Tronçon index** *(Teleos, 1999)*

<table>
<thead>
<tr>
<th>Heterogeneity (H)</th>
<th>Attractivity (A)</th>
<th>Connectivity (C)</th>
<th>Stability (S)</th>
<th>PHYSICAL QUALITY</th>
</tr>
</thead>
<tbody>
<tr>
<td>score of 111</td>
<td>score of 90</td>
<td>score of 130</td>
<td>score from -60 to +40</td>
<td>(= (H + A) \times C \times K)</td>
</tr>
<tr>
<td>Score of 30 600</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- **A** ≥ 50
- **B** 40 - 49
- **C** 28 - 39
- **D** 14 - 27
- **E** ≤ 13

**Attractivity**

Spawning ground, hiding places, presence of backwaters,...

**Connectivity**

Obstacles, banks, riparian areas,...

<table>
<thead>
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<tr>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

**Feedback:**

- Uneasy-to-use codage file
- Semiquantitative method
- Index with a fish orientation
- Useful subindexes to define problems (pre project) and for monitoring
Monitoring: data collection and analysis

Geomorphology: Topographic survey and cross sections

Cross section 60 m

- Topographic survey - 2009
- Weir removal - Dec. 2010
- Flood - 7/01/2011 (Q= 33,8 m³/s ; T~ 11 yrs)
- Topographic survey - Nov. 2011

Cross section 25 m
Geomorphology: Sediment transport

Evaluating bedload mobility using traced pebbles and PIT-tags

**PIT tagged pebbles** placed in rivers at:
- reference reaches
- reaches impacted by obstacle (e.g. upstream of weir) ➡️ enable to highlight restoration of free movement of sediment
- reaches with spawning gravel reintroduction ➡️ enable to characterize the mobility of new spawning gravel

**Feedback:**
- Allows particles with b-axis of 20 mm to be traced
- Do not contain a battery
- Great recuperation rate (more than 80%)
- Requires expensive equipment
- Provide useful information (bedload movement discharge, distances travelled, granulometric indexes)
Geomorphology: Clogging of the gravel bed

**Sediment traps** buried into the gravel bed on:
- reference reaches
- reaches impacted by restoration work
- reaches with gravel reintroduction

*Feedback:*
- Susceptible to loss (flood, scour,...)
- Cannot be used in water deeper than 0.8m
- Time-consuming (laboratory analysis)
- Installation does not provide natural conditions (breaking of the armour layer)

➤ Suitable to evaluate short period of work

**Wooden stakes** inserted into the gravel bed on:
- reference reaches
- reaches with gravel reintroduction

*Feedback:*
- Qualitative method
- Simple technique to implement
Restoration works and their stability and resistance to erosion: related to flood characteristics (discharge, recurrence, specific stream power, shear stress)

Leignon - Haljoux: restoration work (2010)

Leignon - Haljoux: Bankful discharge (January 7th 2011)

Leignon - Haljoux: Trash lines survey

Geomorphology:

Flood effect on restoration works

Slope of the water surface

Geometrical characteristics of the wetted cross-section

- Specific stream power
- Shear stress

Discharge
Thank you for your attention

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ULg / LHGF : Alexandre Peeters – Eric Hallot – François Petit
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