**Fish migration system with metal spring flaps and rubber membranes**

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There are a multitude of pouring discharge sills, made of various materials, through which the flow of the watercourse is carried out through a crenel of various forms (rectangular, triangular, trapezoidal, etc.). The first step in the realization of the solution designed for the migration of the fish is the realization in the discharge sill of a crenel through which all the river flow will flow through it. As an example, there will be three discharge thresholds (fig.1 a, b, c) on the Feernic river located in Transylvania, Romania. The first picture a) represents the first discharge sill (upstream), b) the middle discharge sill and c) the last discharge sill (downstream). But the solution is designed to be functional for many spillways, from different parts of the World, with a height below 2.5 meters. There may be particular cases for overflow thresholds larger than 2.5 meters that will be built systems composed of modules.

a(1)

b(2)

c(3)

Figure 1 The discharge sills on the Feernic river - a, b, c (photo Răzvan Voicu)

**Discharge sill 2(b)**

From a structural point of view, all three discharge sills will increase in height, leaving a semicircular or rectangular crenel on the middle. In the case of the discharge sill 2 (b) which has a height of about 70 cm, the maximum height of the water in the crenel will be approximately 30 cm (fig. 2). The distance between the maximum height of the discharge sill and the maximum water level in the crenel is about 30cm. (Figure 2). In all three discharge sills will be built crenels with water height of about 30cm. The width of these crenels will be the same in all three discharge sills and will be 45cm. Upstream, on the outside of the crenel, a metal frame with the bottom in the form of a semicircle is attached to the discharge sill 2 (b) (fig. 2). Inside this metal frame is fixed a metal weir with vertical sliding. The slide can be moved vertically by sliding on the metal frame due to a threaded metal bar and a manually operated gearbox (fig.3). At the time of closure of the slide all the water of the Feernic river will pass over the discharge sill 2 (b). (Figure 3).

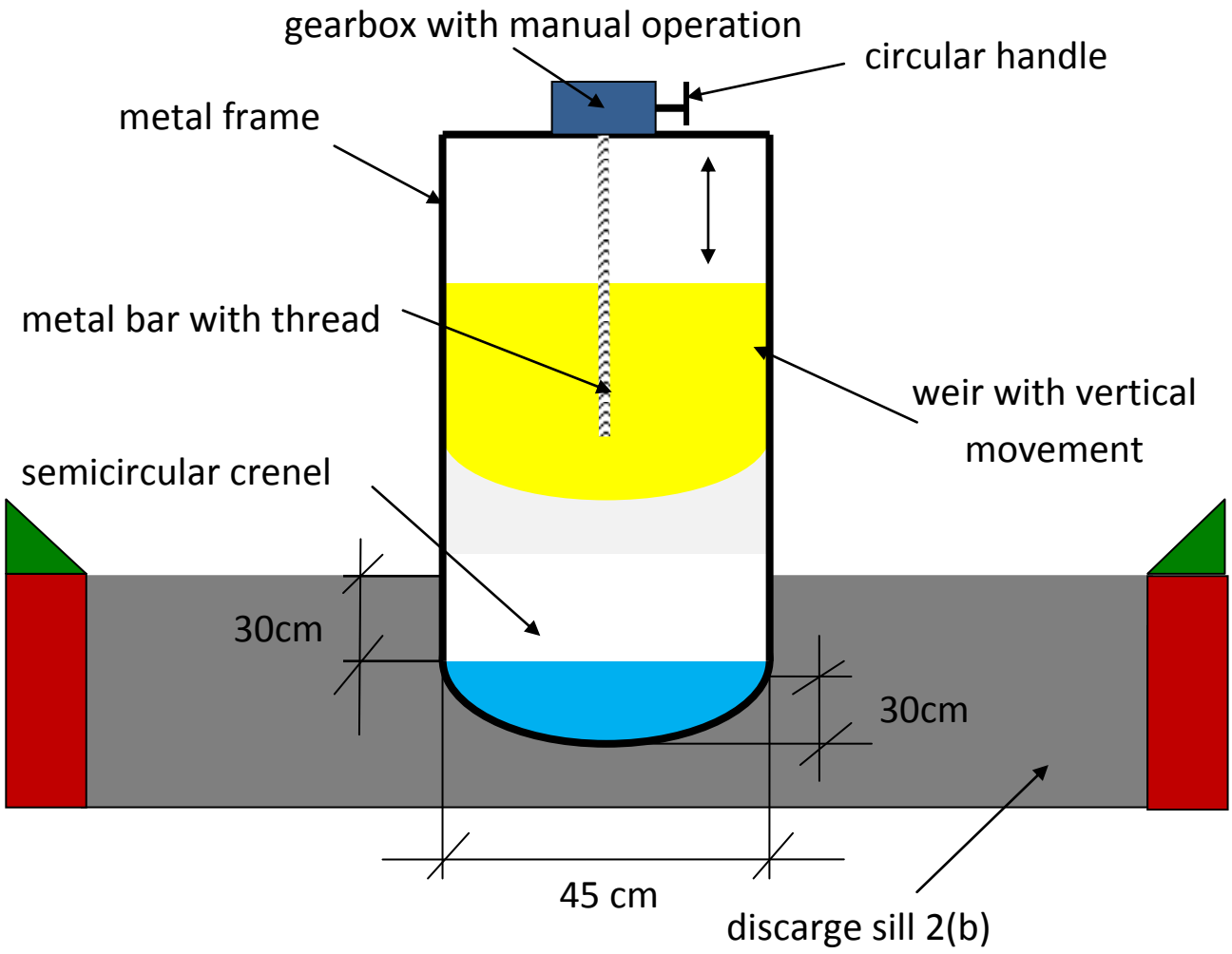



Figure 2 Position of the semicircular crenel in the discharge sill 2(b) - indicative scheme

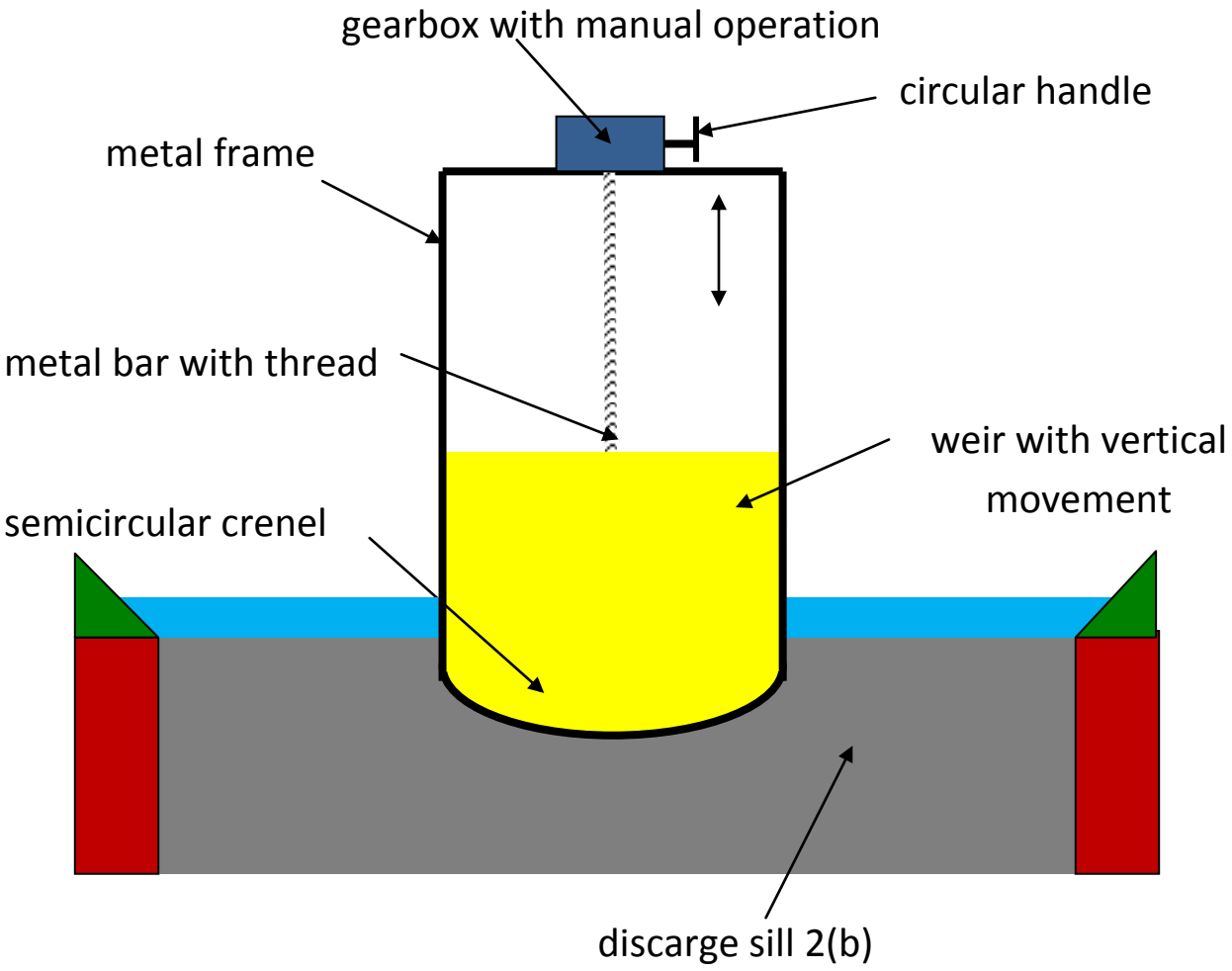



Figure 3 Closure the weir with vertical movement- indicative scheme

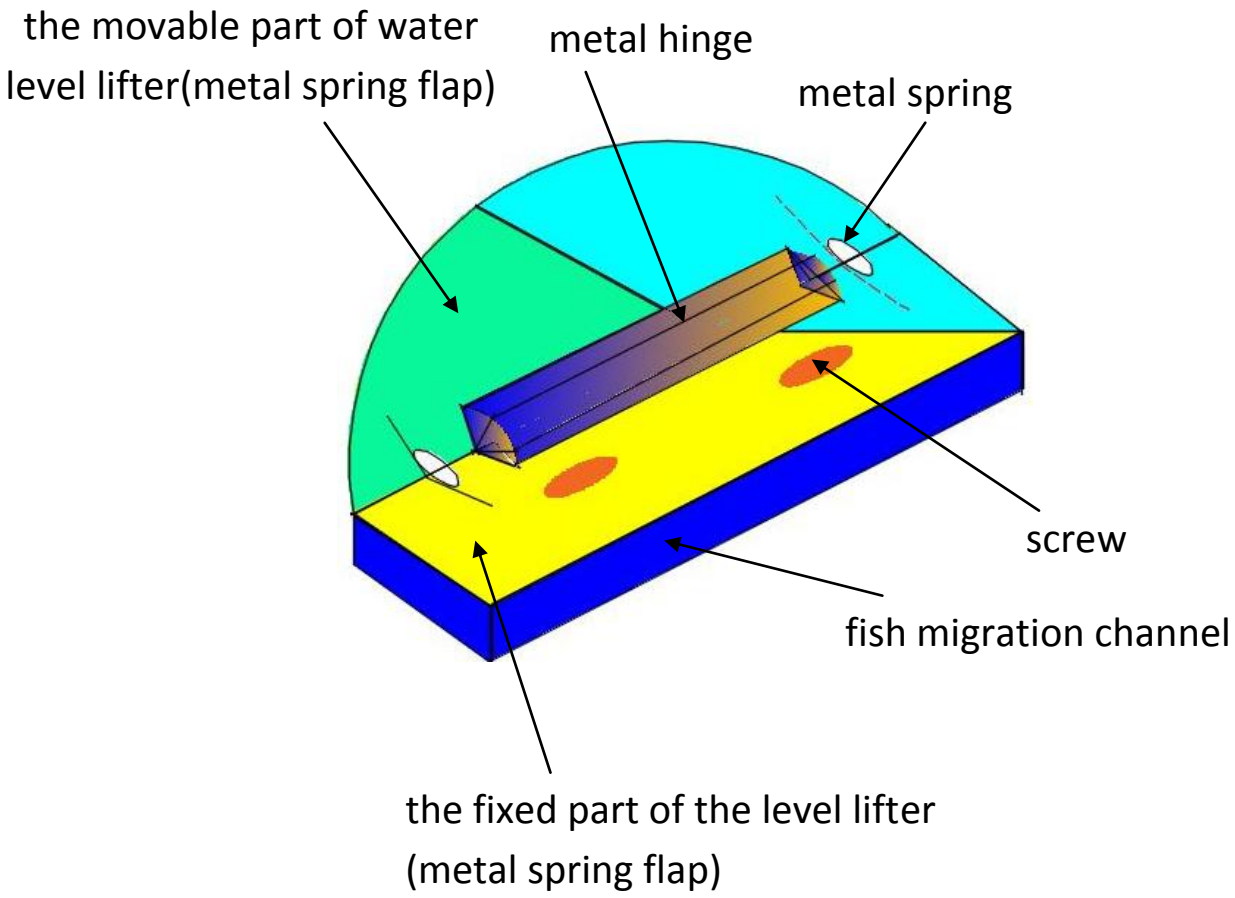
Inside the semicircular crenel (up to the middle of it) a surface of approximately 2 cm thick is cut. Inside the cut surface a semi-cylinder fitted with a rubber membrane is fastened. Through this semi-cylinder with a rubber membrane, which will have a direct connection with the Feernic River, downstream of the discharge sill , it will pass the entire flow of the Feernic River located upstream of the

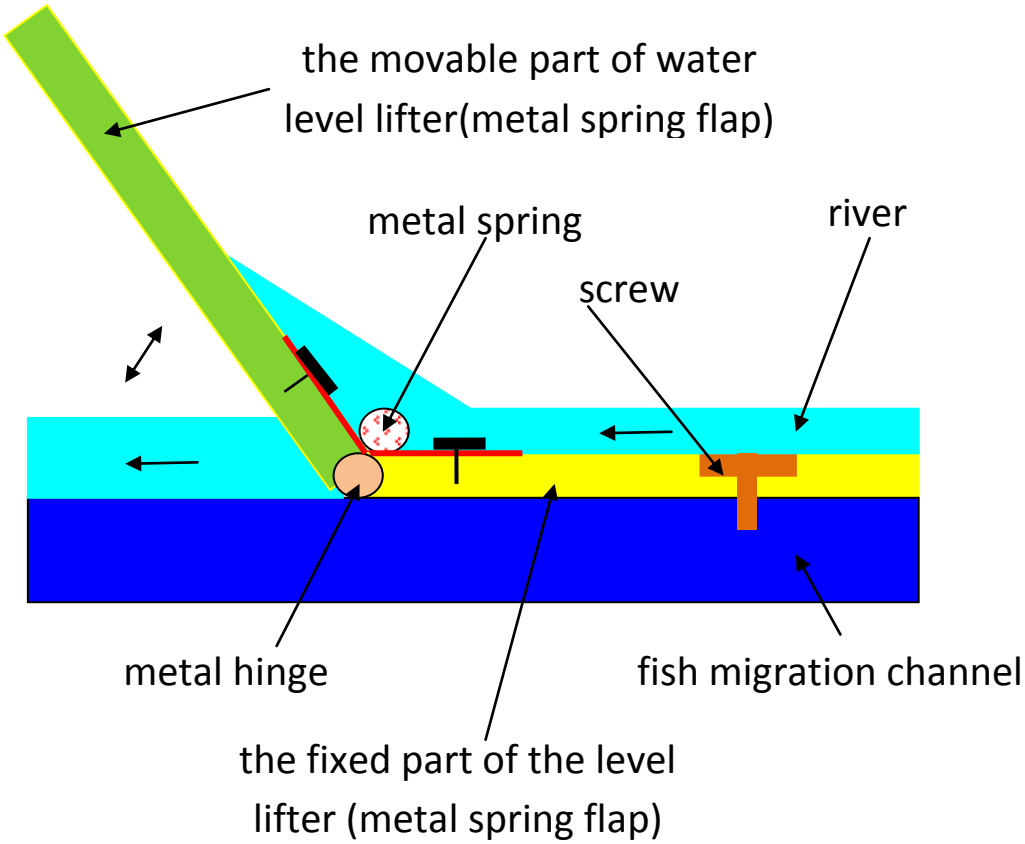
discharge sill 2 (b). Due to the rubber membrane, the semi-cylinder can change its slope (variable geometry) depending on the target species of migratory fish. Inside the semicircular channel for fish migration, rubber or plastic surfaces called flanges with metal springs are fixed on two rows (fig. 4).

These rubber surfaces increase the water level around them (fig. 4), thus creating the possibility for fish to climb between them upstream of the spillway. These flanges with metal springs are used by fish and as a screen (rest area) useful in continuing the road until they pass the upstream end of the semicircular or rectangular channel. The rubber membrane will be positioned near the downstream end of the battens (fig.5).

**Most systems for migrating fish over river basins are fixed, which allows them to be damaged by the watercourses in a short time (several years). Some flood systems are completely destroyed, others partially destroyed. The variable geometry of the proposed system helps it to adapt to the dynamics of water movement, including during floods.**

On a fish migration channel, they will be fixed by screws the water level lifters (metal spring flaps) that facilitates the passage of fish. The water level lifters can be made of plastic or durable rubber. The part that is fixed by channel screws is rectangular and the movable part is in the form of a semicircle. A metal hinge fixed the movable part to the fixed part (fig. 4). Two springs are fixed to both the movable and the fixed side of the flap (fig. 4).




the movable part of water level lifter(metal spring flap)
metal spring
river
screw
metal hinge
the fixed part of the level lifter (metal spring flap)
fish migration channel

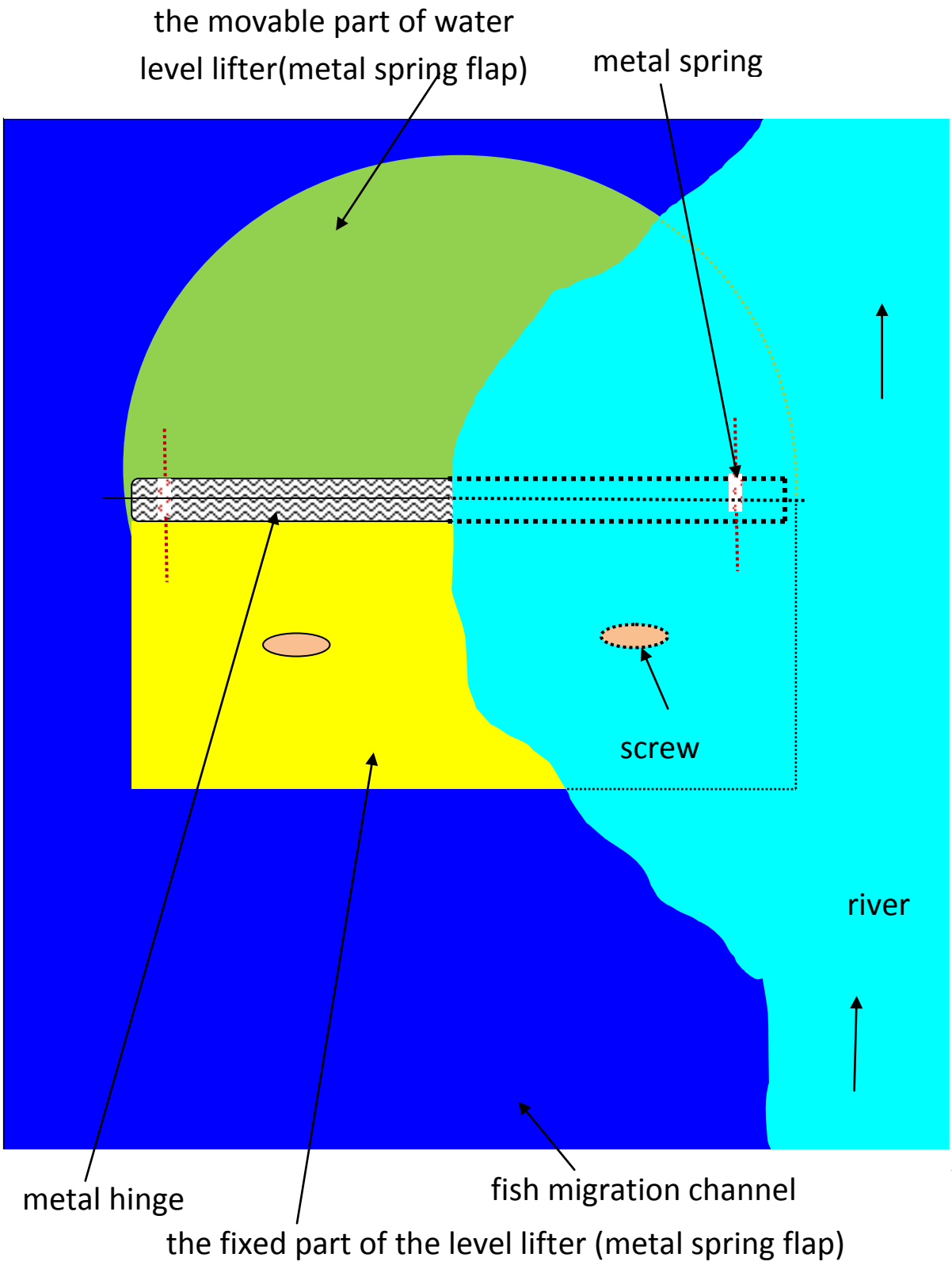



Figure 4 Characterization of metal spring flaps - indicative schemes

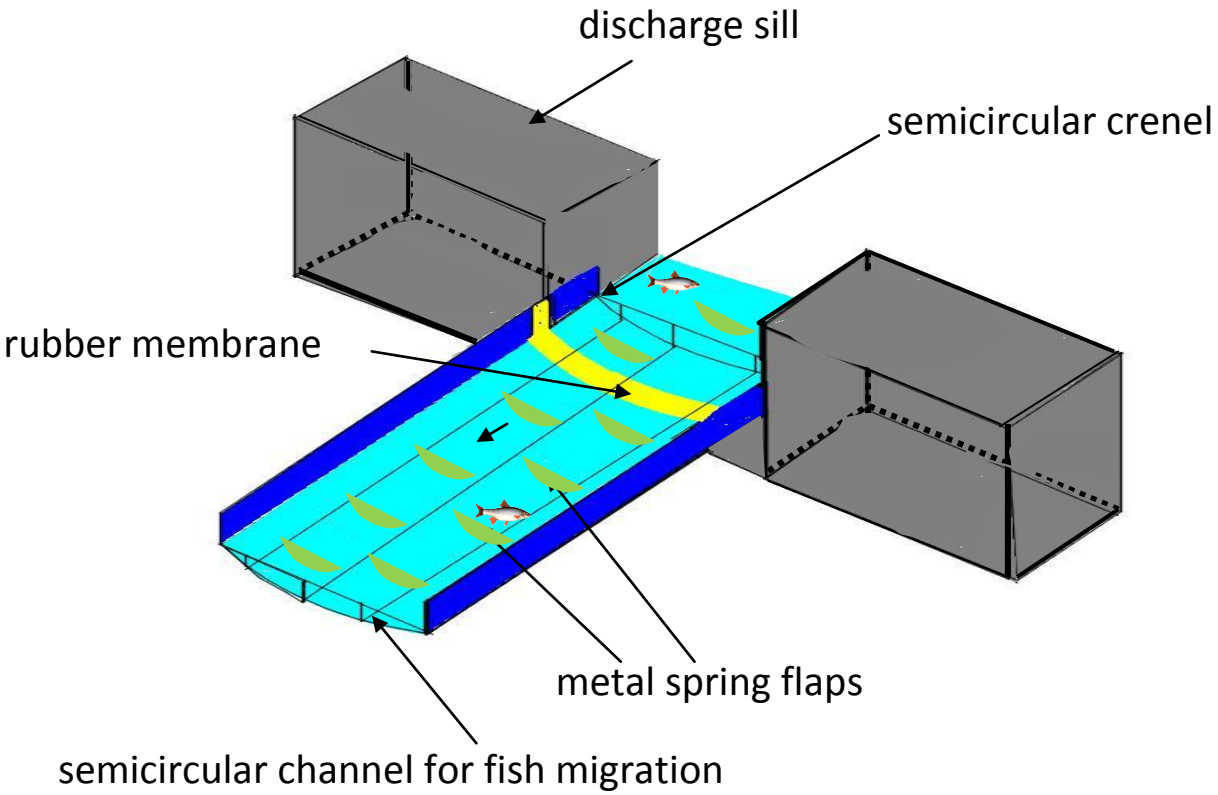



Figure 5 Positioning of the semicircular channel inside the downstream as well as downstream of this - indicative scheme

In order to prevent the system from being blocked by various floats but also for the fish to be safely directed upstream of the discharge sill, two metallic fences (metal grating will be attached to the spillway (at the three discharge sills) as well as in the riverbed of the Feernic river (fig.6). At the upstream end of these grilles another metal grille with a window in the middle is fixed perpendicular to them. The window represents two thirds of the metal grid between the two metal fences (metal grilles) (fig.6). Downstream of the discharge sill 2 (b), the river flow area will be reconstructed so that it has a direct connection with the semicircular channel for fish migration (fig. 7). The water from the Feernic river is redirected into the system for the migration of two concrete sheet piles that are symmetrical to the semicircular crenel (fig. 7).

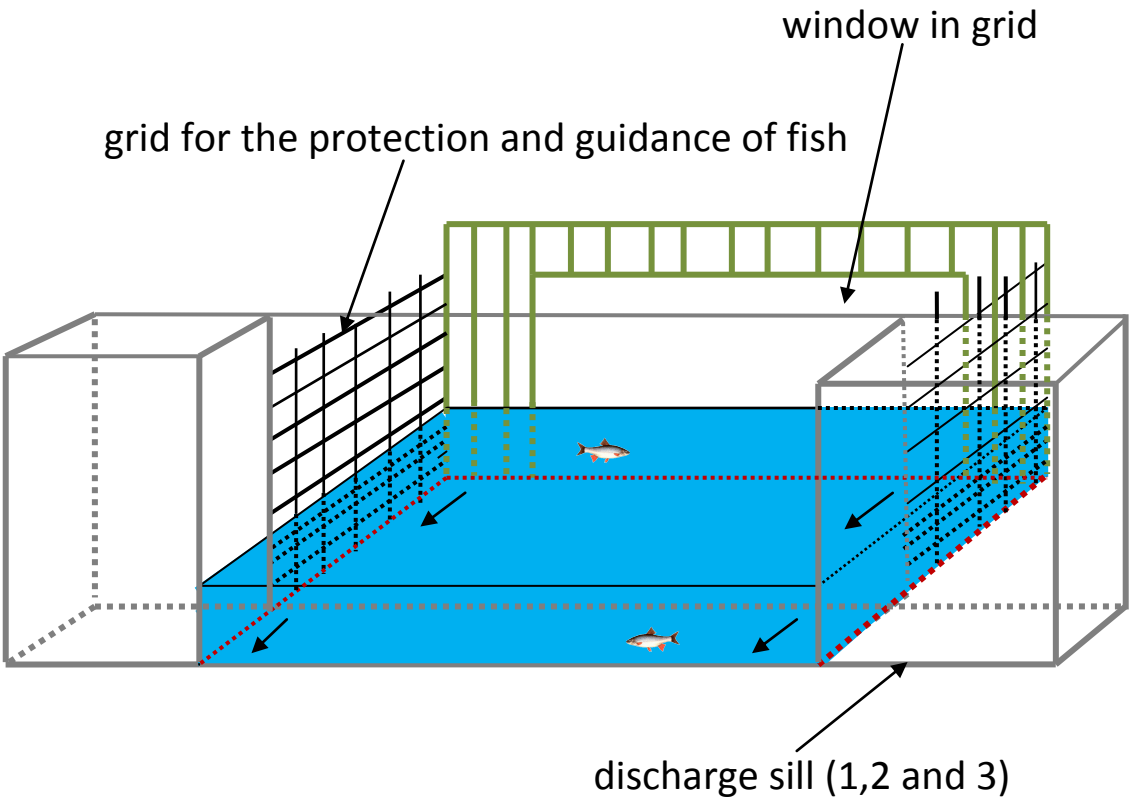



Figure 6 Position of the window situated the grid surface - indicative scheme

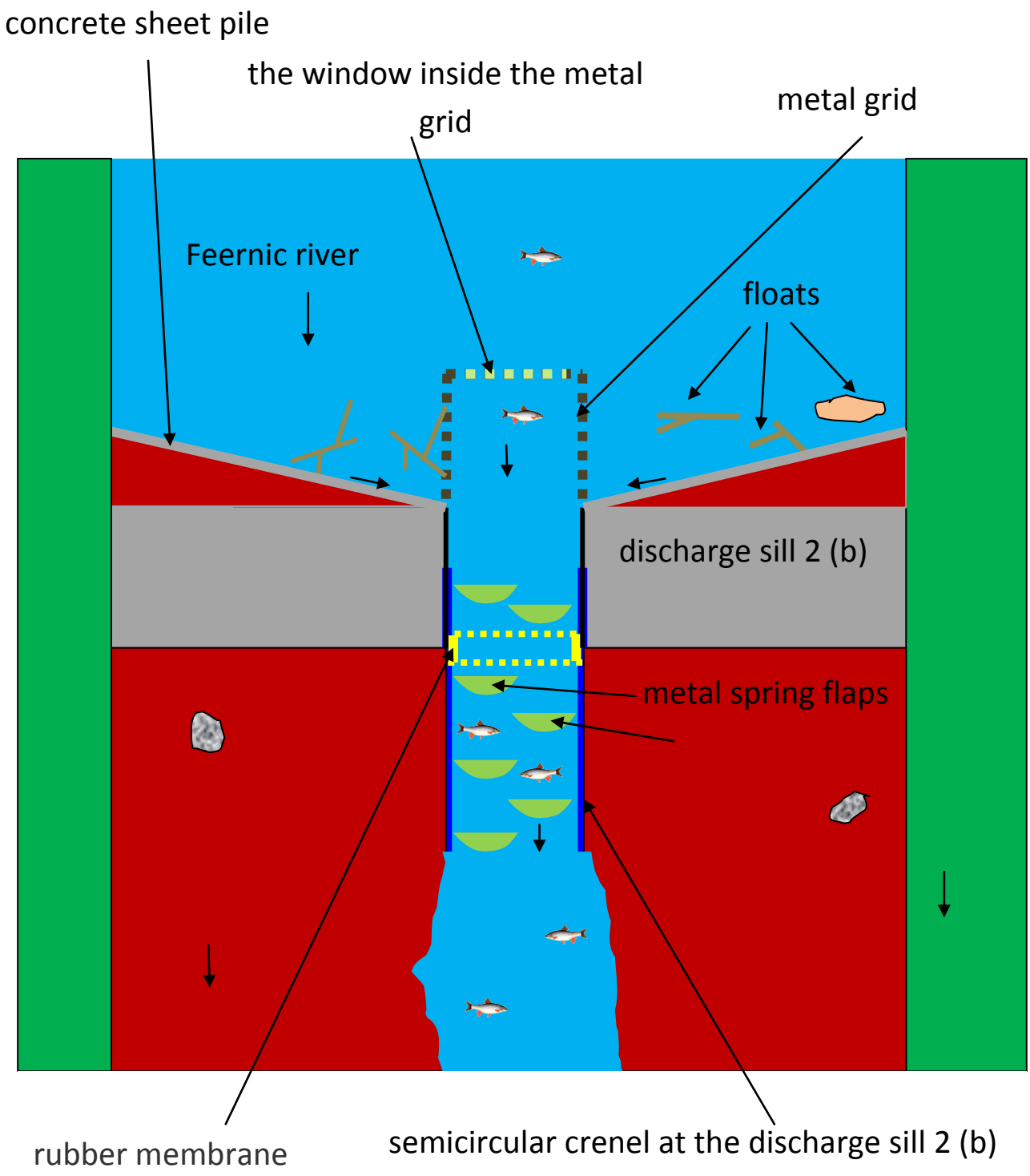



Figure 7 General scheme of the fish migration system for the discharge sill 2 (b) - indicative scheme

**Discharge sill 3(c)**

In the spillway threshold 3 (c) a rectangular crenel is built but before the spillway threshold 3 is built, it rises on the entire surface (crown) by approximately 30 cm. In the case of the threshold 3, which has a height of about 60 cm, the maximum height of the water, in the crenel will have about 30 cm (fig.8). The distance between the maximum height of the spillway threshold and the maximum water level in the crenel is about 30cm. On the outside of the battens, upstream, from the spillway threshold 3 a metal frame with the lower part is fixed in the form of a rectangle (fig.8). Inside this metal frame is fixed a metal slide with vertical sliding. The rod can be moved vertically by sliding on the metal frame due to a threaded metal bar and a manually operated gearbox (fig.3). At the time of the closure all the water of the river Feernic will pass over the threshold 3 (c). (Figure 9).

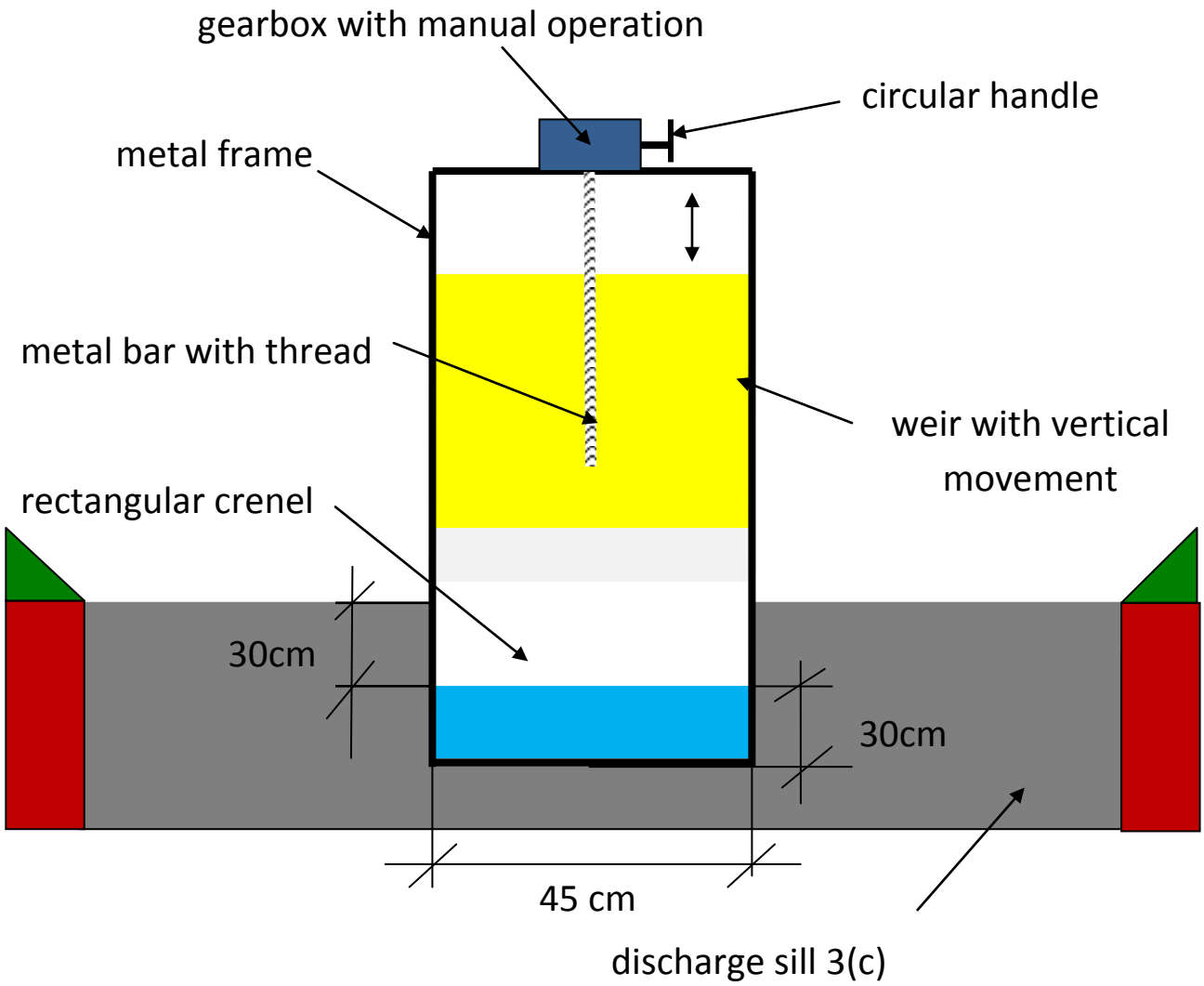



Figure 8 Positioning the rectangular crenel in the discharge sill 3 (c) - indicative scheme

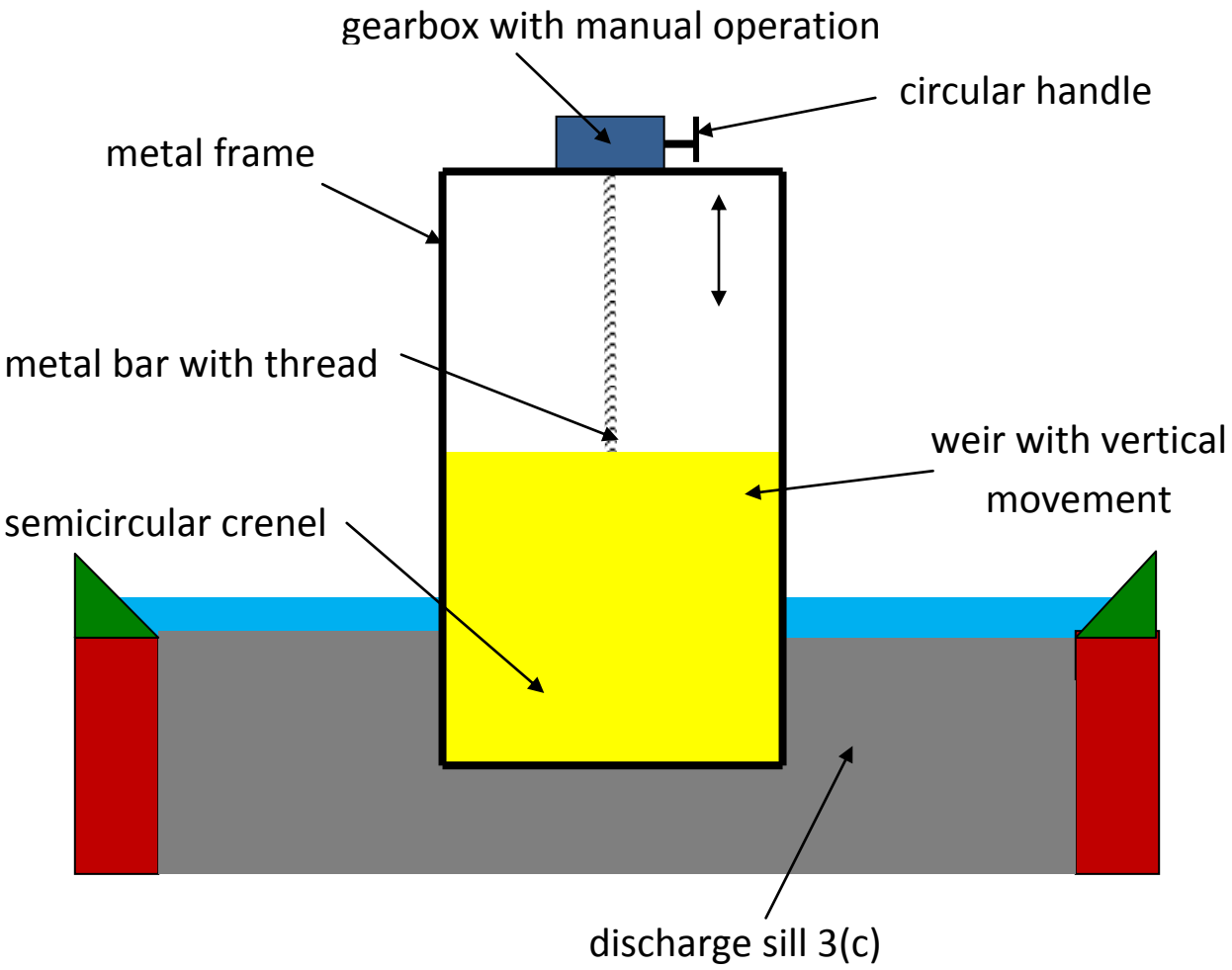



Figure 9 Vertical slide closure - indicative scheme

After the discharge sill has expanded vertically about 30 cm, a concrete sheet pile about 10 cm thick will be fixed by the discharge sill and the right bank of the Feernic river (fig. 10). A rectangular crenel with a width of 45 cm (fig.10) will be made in the discharge sill. Near the discharge sill 3 (c) on the left bank of the Feernic river will be linearized, extended vertically and consolidated with a wooden sheet pile (fig.11).

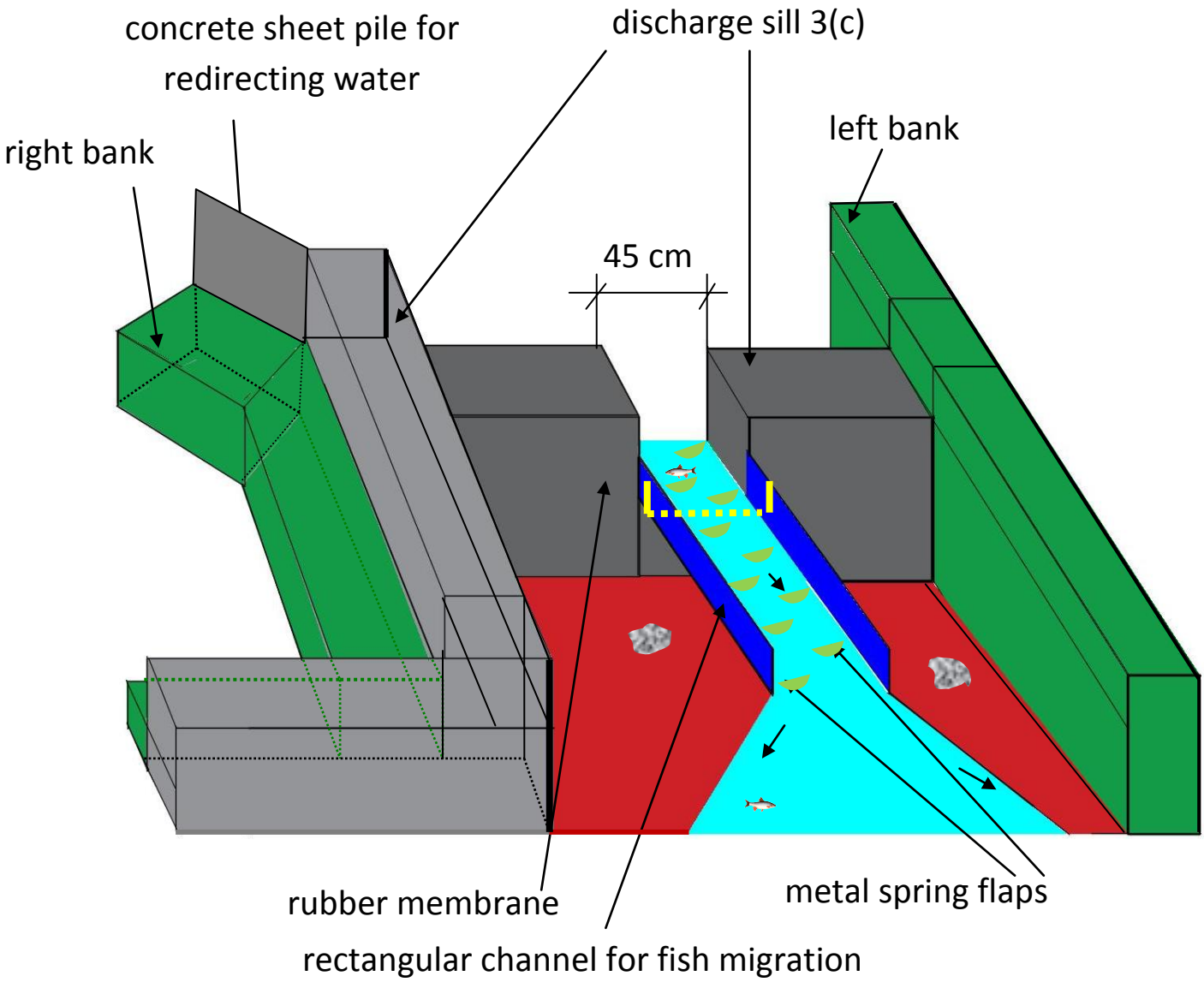



Figure 10 Positioning of the rectangular battens in the discharge sill 3 (c) - indicative scheme

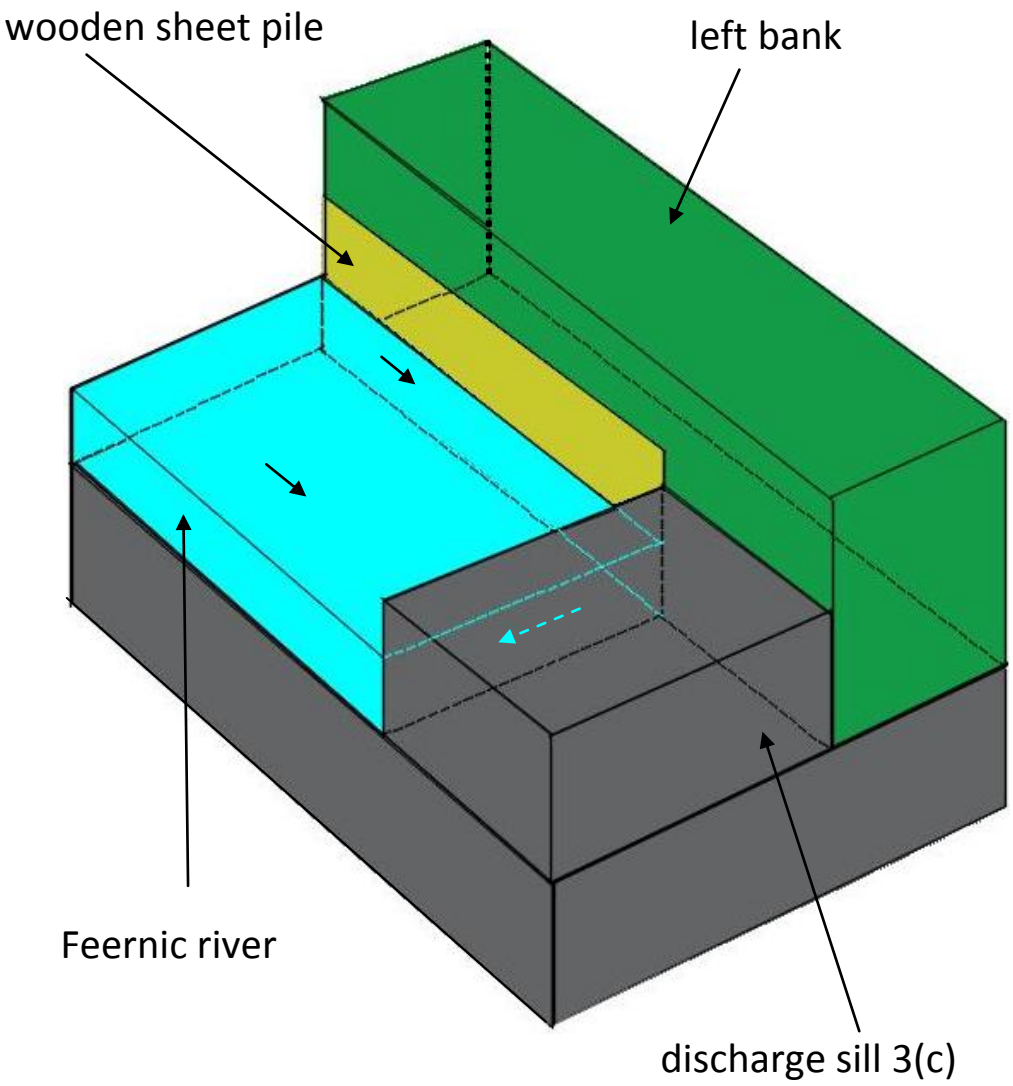



Figure 11 Positioning of the wooden sheet pile on the straight and verticalized bank - indicative scheme

Both the concrete sheet pile and the wooden sheet pile are meant to avoid erosion of the banks but also to direct the Feernic river course to the rectangular crenel (fig.12). In order to prevent the system from being blocked by various floats but also for the fish to be safely directed upstream of the discharge sill, two metal fences (metal grating) will be attached to the spillway as well as to the Feernic river bed. Figure 6). At the upstream end of these grilles another metal grille with a window in the middle is fixed perpendicular to them. The window represents two thirds of the metal grid between the two metallic fences (metal grilles) (fig.6).

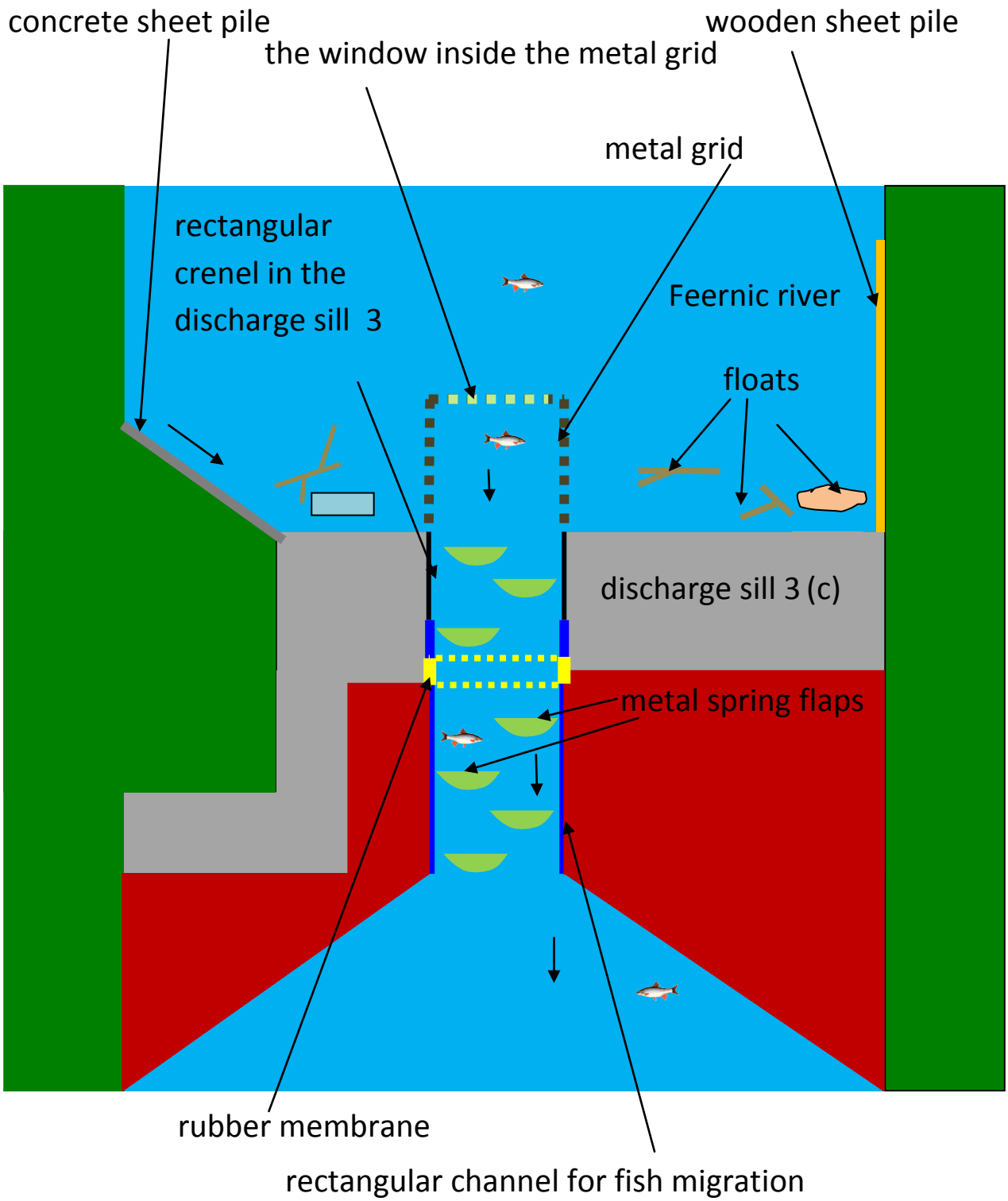



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Figure 12 General scheme of the fish migration system for the discharge sill 3 - indicative scheme

After the spillway has expanded vertically by about 30 cm, a concrete sheet pile approximately 10 cm thick will be fixed by the spillway and the right bank of the Feernic River. (Figure 10). A rectangular crenel with a width of 45 cm (fig.10) will be made in the spillway. Near the spillway threshold 3 (c) the left bank of the Feernic river will be linearized, extended vertically and consolidated with the wooden sheet pile (fig.11 and fig.12).

**Discharge sill 1(a)**

As at the discharge sill 2 and in the discharge sill 1, a rectangular crenel is built but before the threshold is reached, the discharge sill will be raised on the entire surface (crown) by approximately 30 cm. As with the other pouring discharge sills, the crenel will have an oblique surface that facilitates the flow of water through it. The maximum height of the water in the crenel will be about 30cm (fig.8). The distance between the maximum height of the discharge sill and the maximum water level in the crenel is approximately 30 cm. On the outside of the battens, upstream of the spillway threshold 3 (c), a metal frame is fixed with the bottom in the form of a rectangle (fig.8). Inside this metal frame is fixed a metal slide with vertical sliding. The slide can be moved vertically by sliding on the metal frame due to a threaded metal bar and a manually operated gearbox (fig.8). At the time of the closure all the water of the river Feernic will pass over the threshold 3 (fig.9). Inside the crenel, on the oblique surface, a surface of approximately 2 cm thick is cut. Inside the cut surface is fixed a rectangular channel of resistant plastic and equipped with rubber membrane. Through this rectangular channel with rubber membrane, which will have a direct connection with the Feernic river, downstream of the discharge sill , the entire flow of the Feernic river located upstream of the spillway will pass 1. Due to the membrane, the rectangular channel can change its slope (variable geometry) depending on the target species of migratory fish. Inside the rectangular channel for the migration of fish are fixed on two rows rubber surfaces called flap with metal springs (fig. 4).

Downstream of the discharge sill 1(a) the river flow area will be reconstructed so that it has a direct connection with the rectangular channel for fish migration (fig. 13). Given that the proposed fish migration system for the discharge sill 1 has a length of about 10m (the height of the spillway is 1.6m) it is necessary to construct within this rectangular channel at least two semicircular basins for resting the fish. The resting basins will be constructed of galvanized trusses and will be symmetrical (fig.14). The other rectangular systems for migrating fishes proposed for thresholds 2 and 3 do not require the construction of resting basins for fish because both have a length of about 3.5m and both are constructed of concrete or metal sheet piles 3 cm thick. The end of each migration system from the three discharge sills is framed by a metal frame and rests on two metal springs (fig. 15). The metal springs are fixed by means of screws on a concrete surface fixed in the riverbed (fig. 15). The concrete surface is approximately 30 cm deep, 30 cm wide and 65 cm long and is fixed in the riverbed. And the metal springs are half their length located in the river Feernic. The vertical surfaces of the rectangular (semicircular) channel for fish migration are welded (fixed) by a metal sheet (fig.8). From the metal frame is fixed the metal sheet which due to a discharge sill bar and a manually operated gearbox can move vertically. At the time of the displacement, the slope of the rectangular channel for movement

varies, which comes in support of the juveniles and older specimens of the target migratory species. The variation of the slope also helps other species of non-migratory fish to climb or descend on this presented system. The water from the Feernic river is redirected into the system for the migration of two concrete sheet piles that are symmetrical to the rectangular crenel (fig. 16).

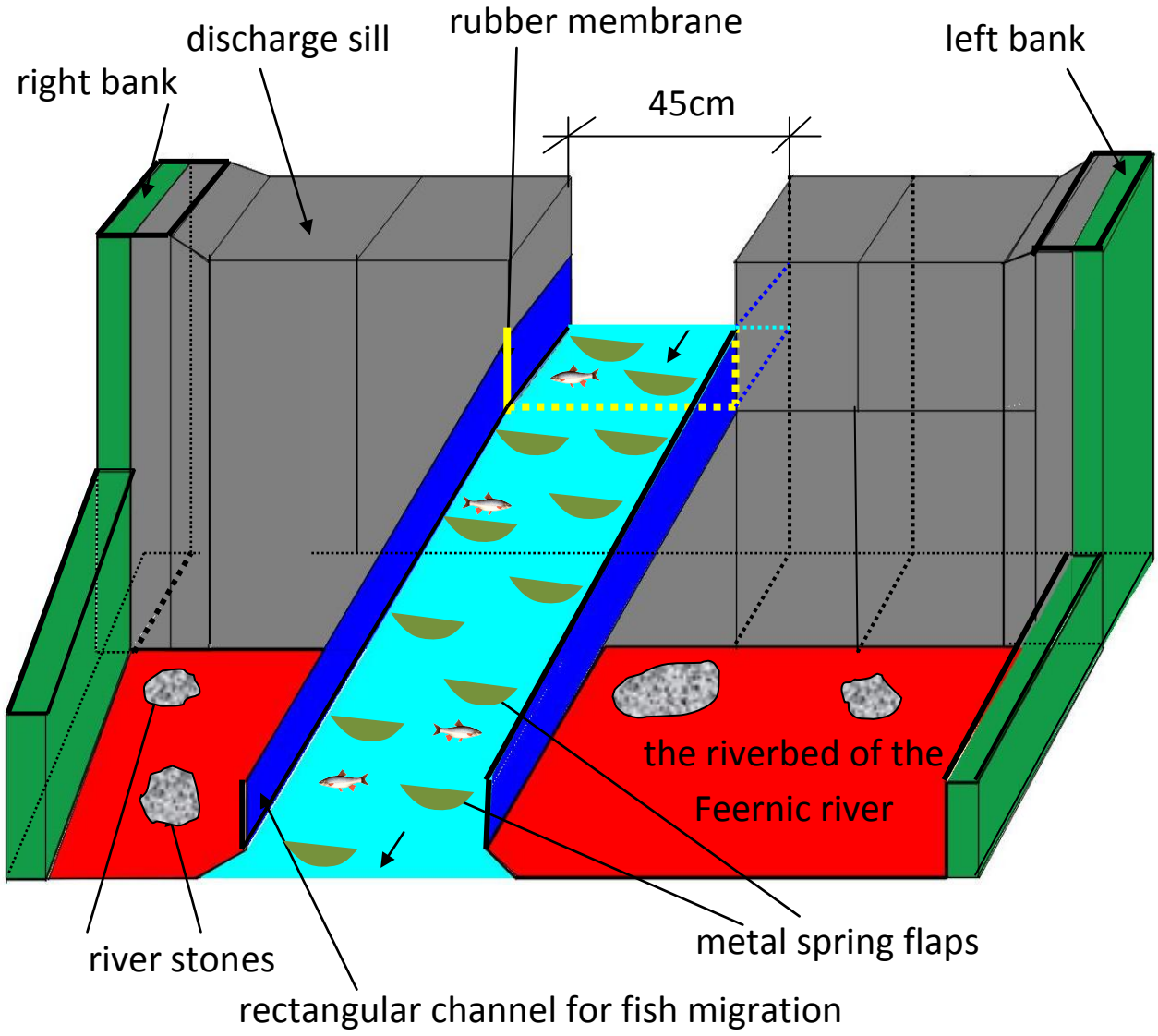


Figure 13 Reconstruction of the riverbed and direct connection with the rectangular channel for fish migration- indicative scheme

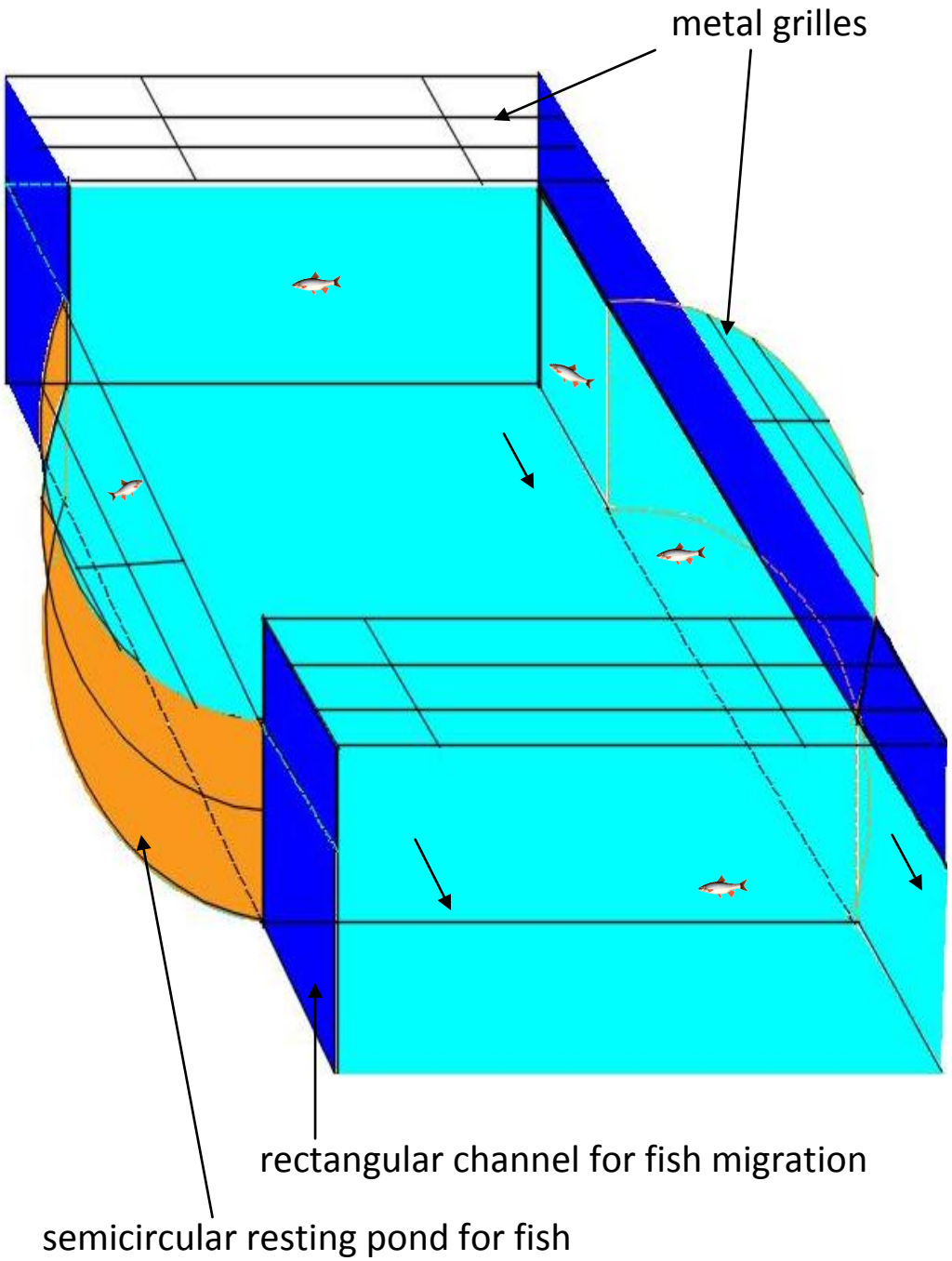


Figure 14 Positioning of semicircular rest basins for fishin the fish migration channel - indicative scheme

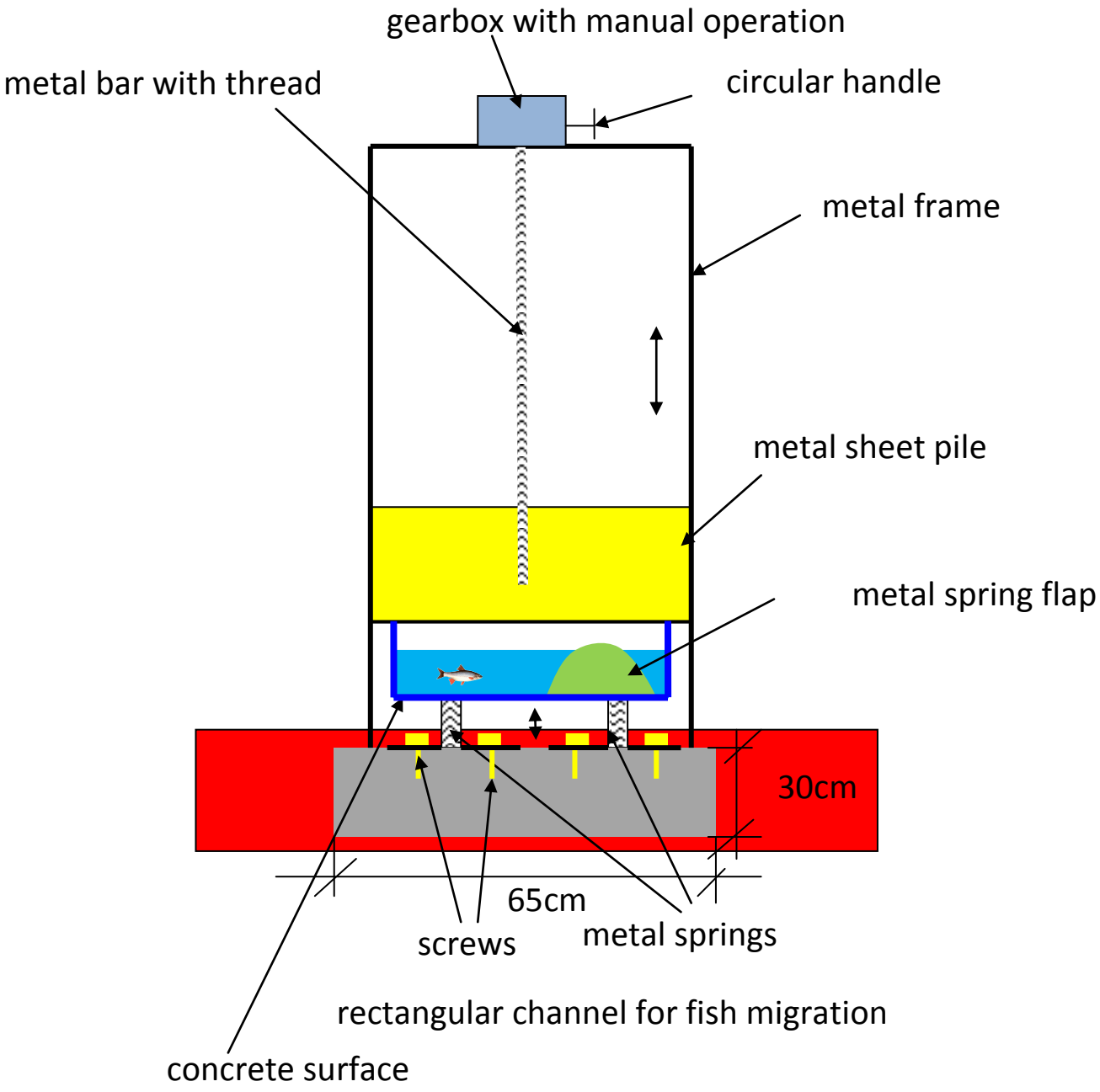


Figure 15 Positioning of metal springs - indicative scheme

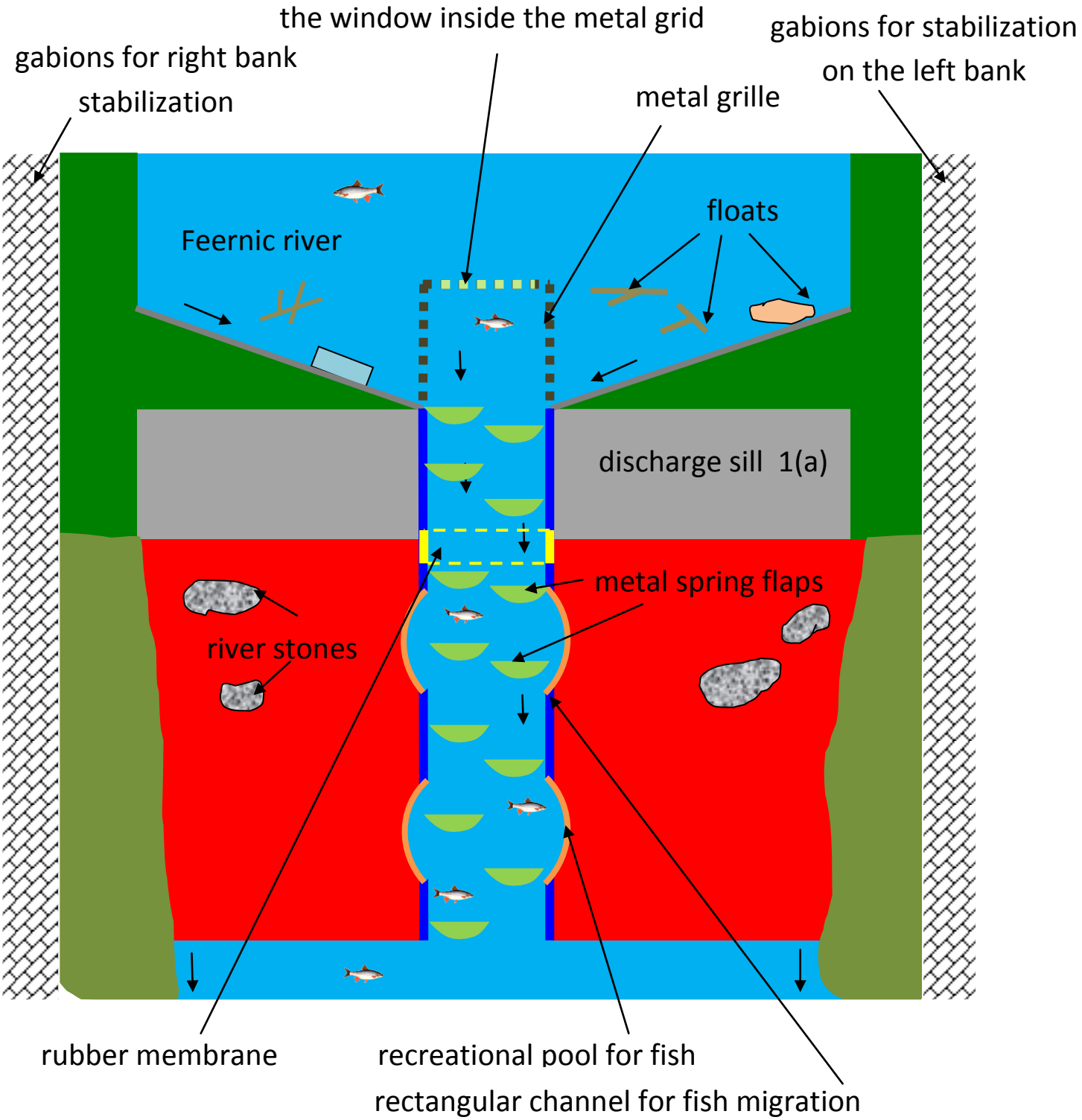


Figure 16 General scheme of the fish migration system for the discharge sill 1(a)

## Conclusions

The solution designed for the three discharge sills has small features that are due to the size of the discharge sills and the amount of alluvium that passes over each discharge sill . Over the second discharge sill, most alluvium (the nature of the substrate) passes through and so the semi-cylindrical shape of the fish migration channel was chosen. For the discharge sills 1 and 3, the rectangular shape of the fish migration channel was chosen with the difference that at the discharge sill 1, given that it has about 10 m, it is also equipped with semi-cylindrical basins for resting the fish. Semicircular surfaces called flaps with metal springs help to lifter the water level in their vicinity, facilitating fish migration and do not represent a floodplain. The grids that are fixed by the discharge sill but also in the Feernic river bed, besides directing the fish upstream from the discharge sill, also direct the floaters outside the system. The variable geometry of the system that is made by the rubber membrane and the metal springs supports the juveniles and older specimens of the migratory target species. The smaller slope helps other non-migratory fish species to climb or descend on this presented system. In case of damage, any component of the system can be replaced. The construction of the components of the system from good quality anti-corrosion materials results in a long-term maintenance.


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