

04 | Bank protection (Riprap)

Environmental impact	2/3
Risk protection	3/3
Durability	3/3
Affordability	2/3

Intro

The protection of riverbanks and coasts aims to decrease the overall water velocity and to reduce (soil) erosion. It stabilizes the slopes through a cover of unconstrained and angular rocks or stones along channels, rivers, or waterbodies, often called “riprap”. Riprap can also be installed at slopes exposed to weathering and where it is not possible to plant vegetation. They can be built with natural material (e.g., stones) or artificial (e.g., concrete blocks), and can be either graded or uniform. The first includes stones of mixed size, while uniform riprap uses only one stone size. Graded riprap is usually preferred to uniform stones because it is easier and less costly to install. Bank protections can also be achieved with other construction methods such as gabion walls (see Measure 05).

Benefits and Risk

The benefits of riprap include its simple installation and maintenance. While well designed riprap allows shrubs to grow, larger vegetation such as trees should be removed because they may cause the riprap to collapse. Generally, if the riprap is not placed properly or along too steep slopes, there is a risk of stone movement. Moreover, riprap comes with the risk of creating scour in the lower parts of the installation. Compared to using vegetation for erosion reduction, riprap is more expensive and provides fewer habitats for other species. However, snakes tend to use the riprap as a habitat which needs to be communicated to the residents of the refuge settlements.

Good practice

Vegetated riprap.

Vegetated riprap incorporates a combination of rock and native vegetation in the form of live cuttings. It provides shade, cover, and input of small organic debris to the stream. At the same time, it improves the fish habitat and supports bank protection through root mass development. An additional benefit of vegetated riprap is a potential fodder supply for local animal populations. Note that well-graded riprap will form a dense and flexible cover that can adapt well, even on uneven surfaces, better than uniform riprap. Even if riprap is ranked as engineered works, when vegetated, it may become similar to the natural banks. Riparian vegetation fosters the slowing down of the flow. Overall, the risk mitigation of vegetated riprap has a positive effect. However, in some specific cases, you may want to accelerate the flow (which induces a lowering of the flow depth).

Artificial riprap for flash flood mitigation.

When the soil and the embankment are loose, one could consider using artificial concrete elements for “armoring” the riverbed. These elements form a flexible layer, mimicking a large boulder. Their shape allows them to interlock and avoid large erosion.

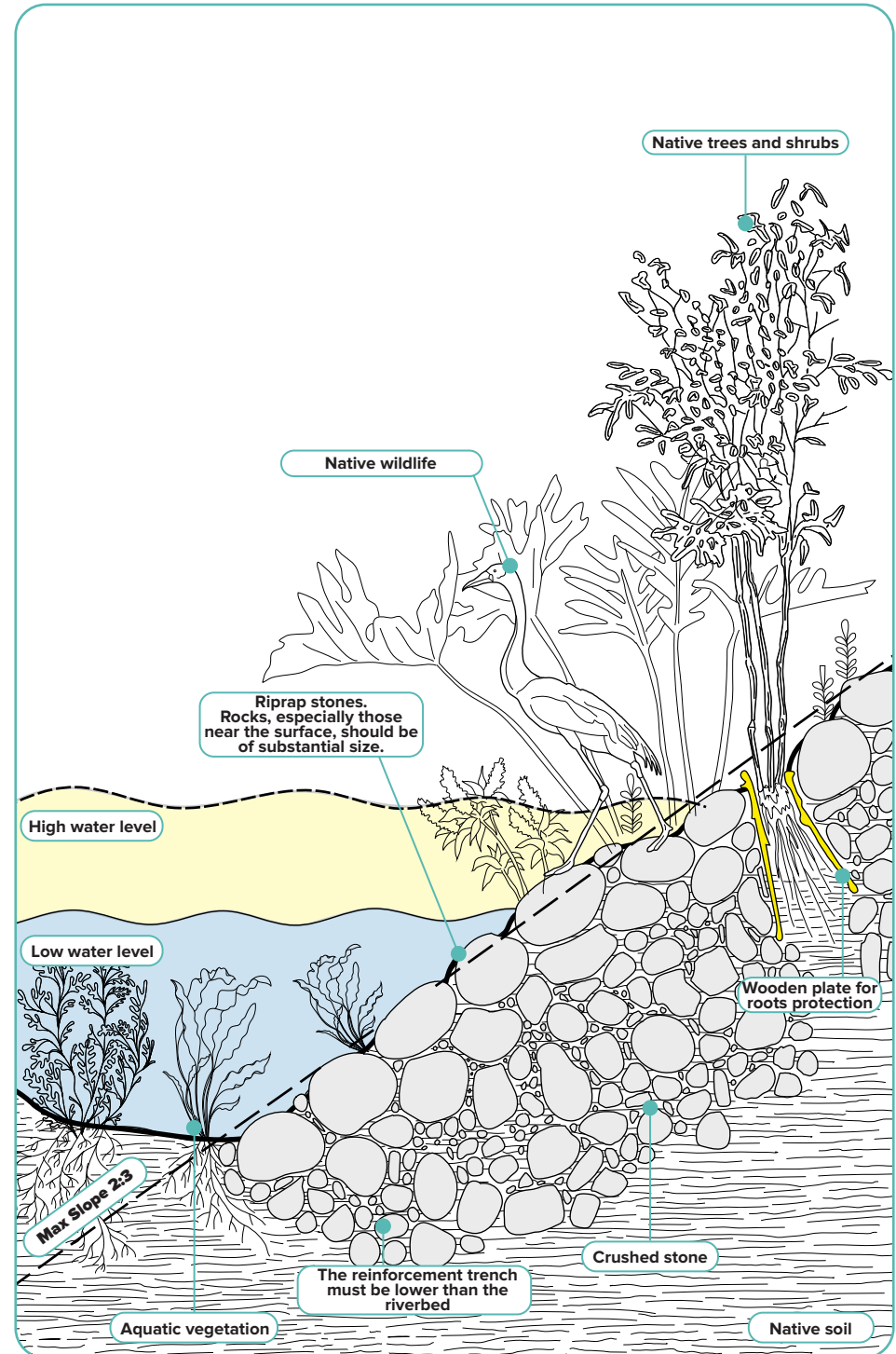




Fig. 05: Well-designed riprap can help shrub vegetation to grow (Big trees can cause riprap to collapse and must be removed). Eric Bardou, UNHCR 2022.



Fig. 06: Example in a small creek in Switzerland. Eric Bardou, UNHCR 2022.

Overview of Criteria

Type of intervention:

Engineered, Hybrid.

Scale of Intervention:

Settlement, Supra-settlement.

Materials:

Unconstrained/angular rocks, filter material (e.g., sand, gravel, crushed stone or filter fabric), sometimes concrete for artificial ripraps.

Environmental Impact:

Although riprap uses non-engineered materials (rocks), it is not considered as environmentally friendly because it requires high transport emissions for placing the rocks at the chosen location. Riprap also traps heat between the rocks which may affect the water temperature of the adjacent waterbody. The increasing water temperature can result in thermal pollution and changing aquatic ecosystems. Chemicals to avoid weed on the riprap can also harm the environment.

Targeted Natural Hazard:

Coastal/Riverine Flood

Targeted Vulnerable Assets:

Buildings, Transport, Land Cover.

Strategy Type:

Reduce Hazard Magnitude.

Implementation Time:

Short (1 day - 1 month).

Effect Duration:

Long-term (>10 years).

Investment Costs:

Medium

Maintenance Costs (yearly):

Low (<10% investment costs).

Annual check-ups, or after major weather events, concerning damages, obstructions, or woody vegetation (which needs to be removed) are necessary in terms of riprap maintenance.

Massachusetts Clean Water Toolkit (2023:04:51)

Riprap. Available online at
<https://megamanual.geosyntec.com/npsmanual/riprap.aspx>, updated on 9/29/2023:04:51.

Flexamat (2022)

Negative Impacts of Riprap on Lakeshores.
 Available online at:
<https://www.flexamat.com/post/negative-impacts-of-riprap-on-lakeshores>

Dale's Marine Construction Inc. (2021)
 How to install riprap and have a good defining
 line between yard and riprap.
 Available online at:
<https://www.youtube.com/watch?v=627XcUllf10>



Flood Risk in Humanitarian Settlements: Compendium of Mitigation Measures

Spatial Development and Urban Policy, SPUR

ETH Zurich - Institute for Spatial and Landscape Development

Bruna Rohling, David Kostenwein, Mona Gairing, David Kaufmann

Geneva Technical Hub, co-convened by UNHCR and SDC

Ammar Al-Mahdawi, Emilie Schmid, Eric Bardou

External Experts

Mrudhula Koshy, Diego Bermúdez, Jonathan Parkinson

Layout and Drawings

Santiago Beaumé, Paola Pabón

Cite as

Rohling, Brunna; Kostenwein, David; Gairing, Mona; Al-Mahdawi, Ammar; Schmid, Emilie; Bardou, Eric; Kaufmann, David (2023) Flood Risk in Humanitarian Settlements: Compendium of Mitigation Measures. Zürich: ETH Zürich, UNHCR. DOI: 10.3929/ethz-b-000645680

ETH zürich

SPUR

Spatial Development and Urban Policy

