

Selecting Technical-Biological Bank Protection Measures



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September 2025

Overview

- A history of varying typologies of bank protection
- A functional categorization of bank protection measures (WG128, Part 3)
- A process for selecting bank protection methods (“7 steps” from WG128)

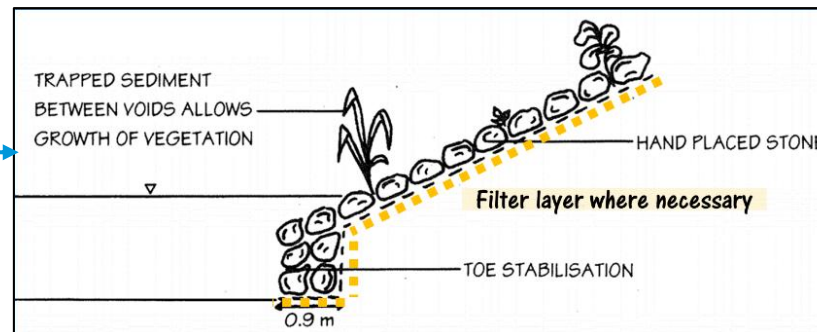
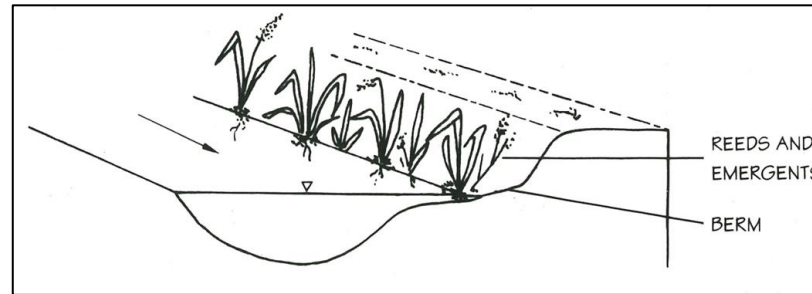


Figures: Permeable palisades with reed planting close to Essel Town, Germany (Berhard Söhngen), Shallow-water zone protected by parallel dam for the Canal Ghent–Bruges, Belgium (Jeroen Verbelen)

A brief review of bank protection resources

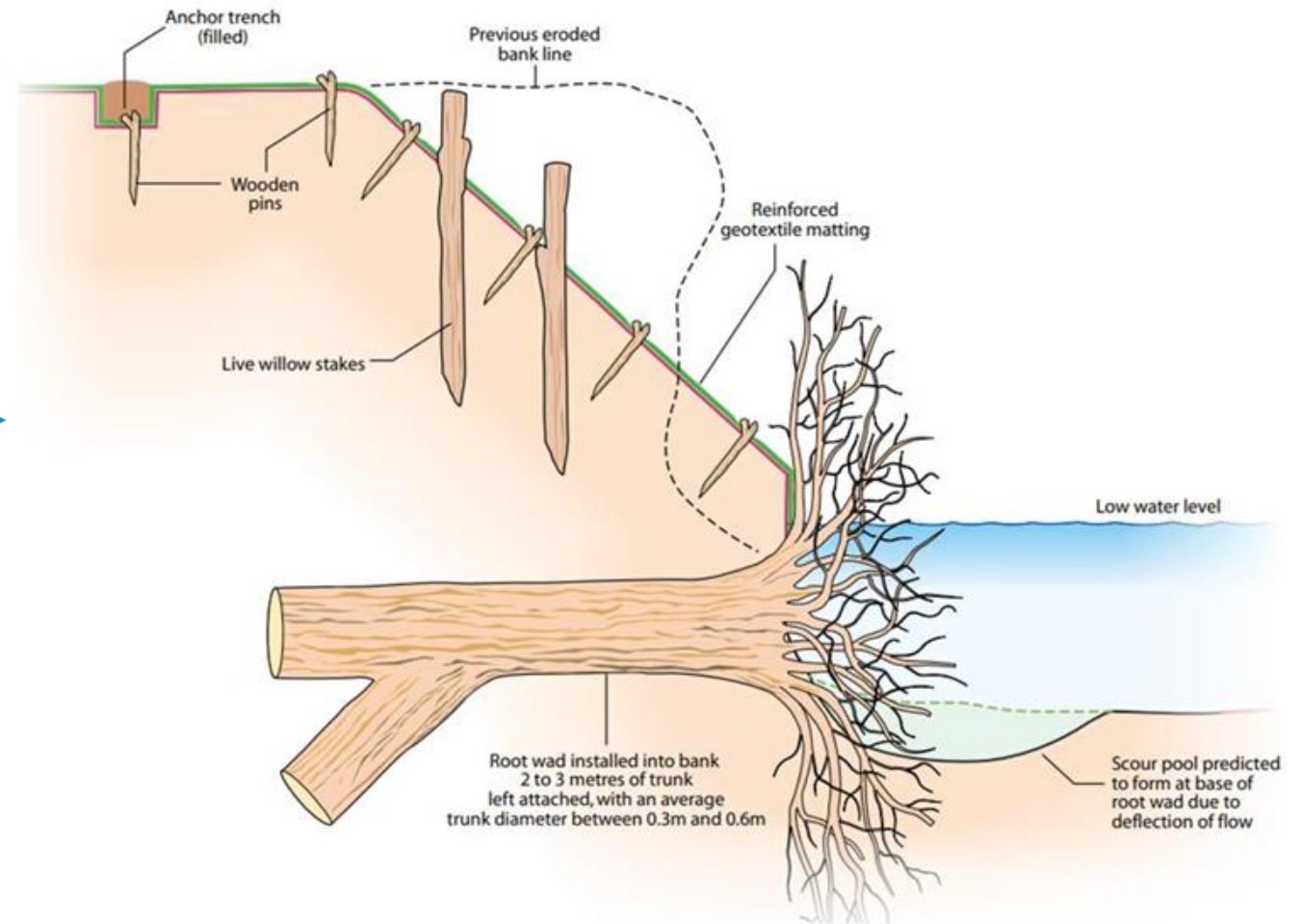
British Waterway Management Guide (1999)

- Grass revetment
- Reed planting
- Live willow on toe and bank
- Grassed composites
- Toe rolls
- Toe geotextiles, fibre rolls
- Rock and fibre rolls
- Vegetated open-cell revetment
- Vegetated stone revetment and toe protection
- Vegetated concrete-units revetment



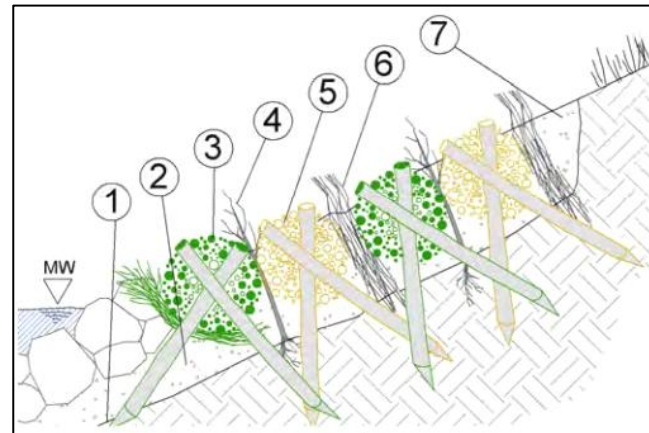
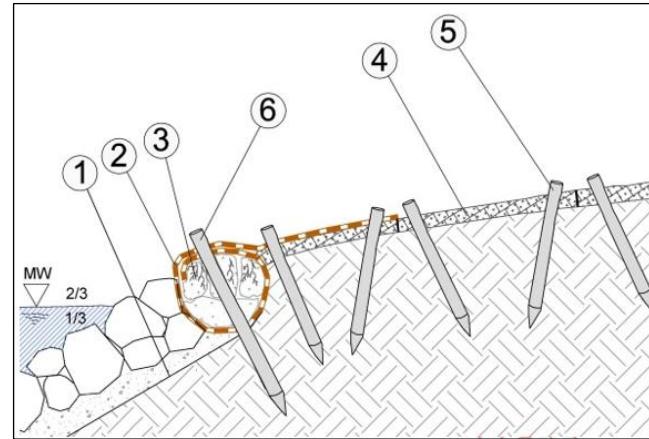
UK Green Approaches in River Engineering (2017)

- Willow spiling and bundles
- Turf or vegetated reinforced mattresses and seeded geotextile with rock rolls as toe protection
- Live root wads
- Willow-brush mattresses on coir matting with stick bundles, rock rolls, and logs as toe protection



Recommended measures from German DWA-M 519 code of practice on technical-biological bank protections for inland waterways (2016)

- Reed mat with vegetation roll as foot protection
- Pre-vegetated slope mat with grass
- Pre-vegetated slope mat with hardwood cuttings
- Willow weave
- Living fascine with hardwood cuttings
- Vegetated geotextile bodies with (hedge) brush (bush) layers
- Chamber revetment (vegetated stone mattresses, reed gabions)
- Willow brush mattresses with heavy riprap as toe reinforcement
- Vegetated riprap

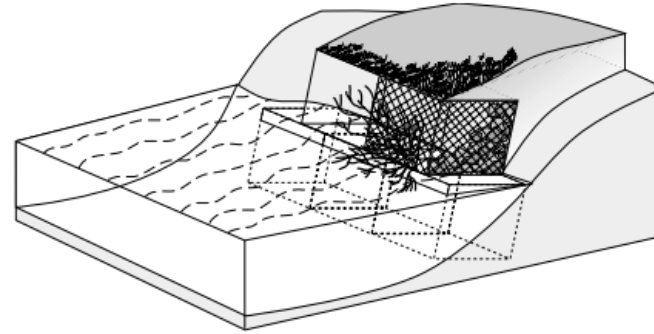


Figures: Schematic of reed mat with vegetation roll (DWA-M 519), installed reed mat at the Rhine section at Worms (WG128, Part 2), live fascine with hardwood cuttings (DWA-M 519), realization at small flowing waters without navigation (WG128, Part 2)

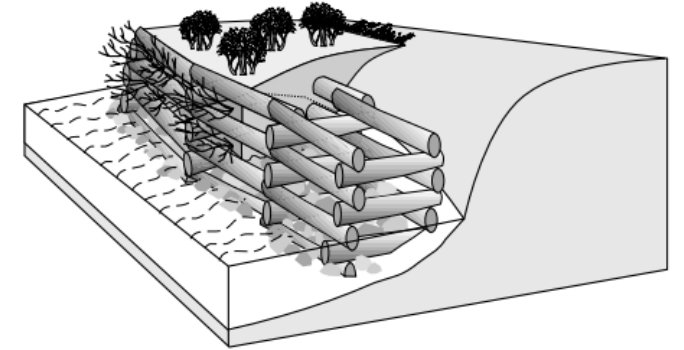
US Federal Interagency Stream Restoration Working Group (1997)

- Bank shaping and planting
- Branch packing
- Brush mattresses
- Coconut fiber roll
- Dormant post plantings
- Vegetated gabions
- Joint plantings
- Live cribwalls
- Live stakes
- Live fascines
- Log, rootwad, and boulder revetments
- Riprap
- Stone toe protection
- Tree revetments
- Vegetated geogrids

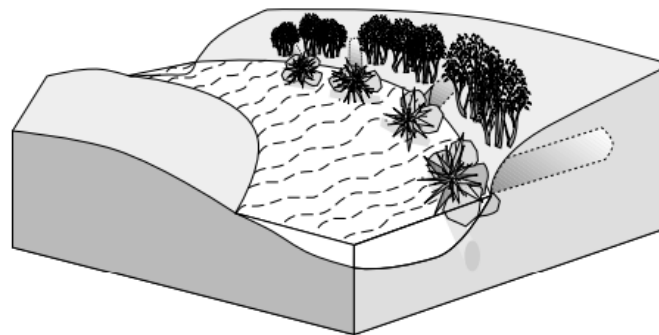
Vegetated Gabions



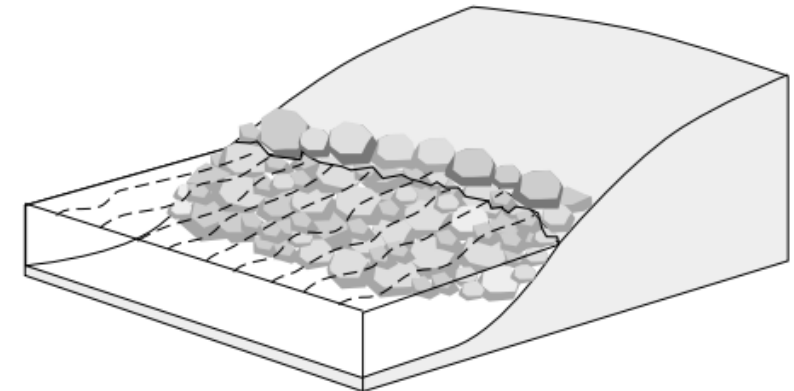
Live Cribwalls



Log, Rootwad, and Boulder Revetments



Stone Toe Protection



Environmentally Sensitive Channel- and Bank-Protection Measures (McCullah and Gray 2005, NCHRP 544)

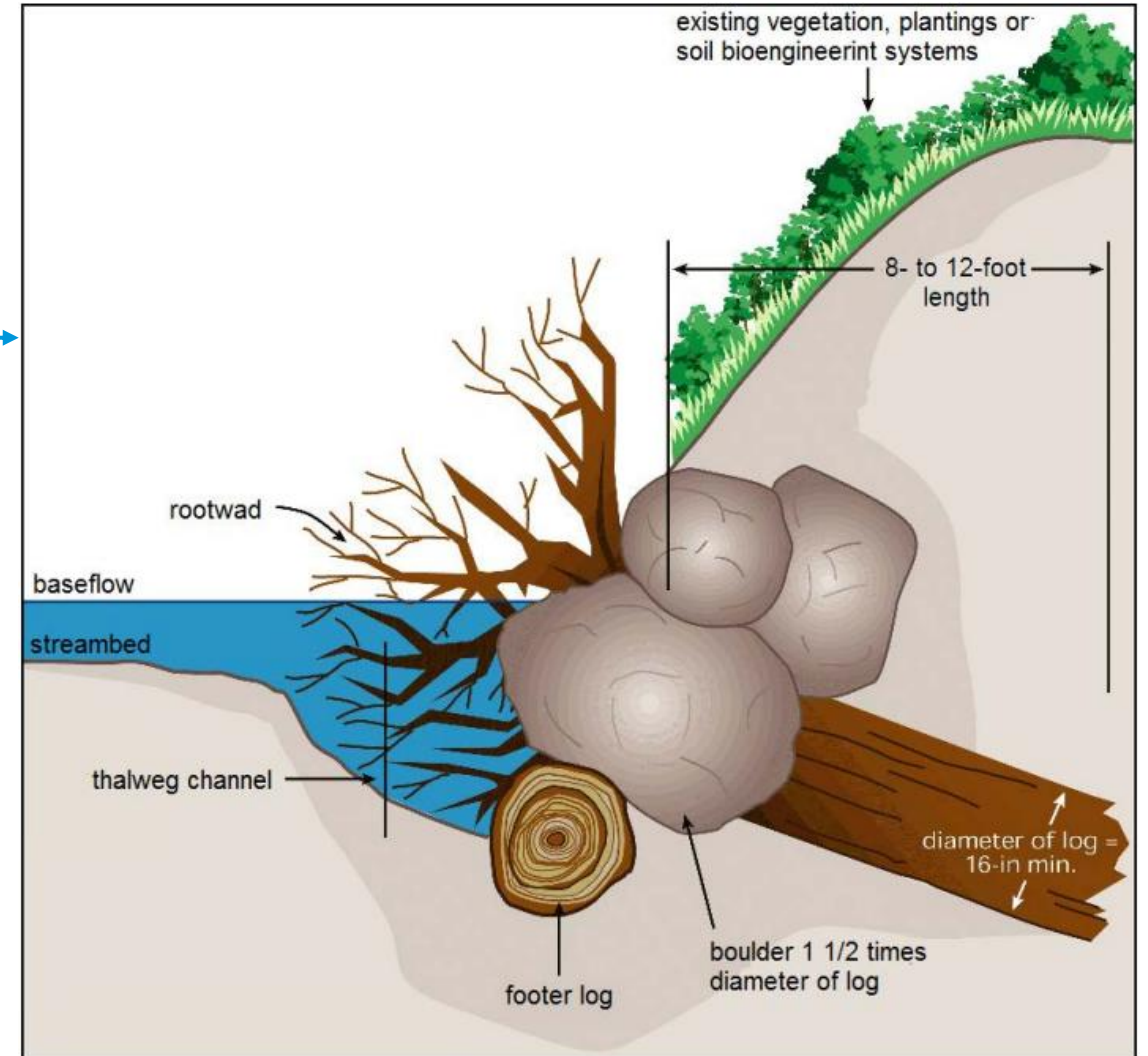
Category	Technique	Level
River Training		
<i>Transverse Structures</i>	Spur dikes	I
	Vanes	I
	Bendway weirs	I
	Large woody debris structures	II
	Stone weirs	II
<i>Longitudinal Structures</i>	Longitudinal stone toe	I
	Longitudinal stone toe with spurs	I
	Coconut fiber rolls	II
	Vegetated gabion basket	I
	Live cribwalls	II
	Vegetated mechanically stabilized earth	I
	Live siltation	II
<i>Channel Planform Measures</i>	Live brushlayering	I
	Vegetated floodways	II
	Meander restoration	II
Bank Armor and Protection		
<i>Groundcovers</i>	Vegetation alone	II
	Live staking	I
	Willow posts and poles	II
	Live fascines	I
	Turf reinforcement mats	II
	Erosion control blankets	II
<i>Revetments</i>	Geocellular containment systems	II
	Rootwad revetments	II
	Live brush mattress	I
	Vegetated articulated concrete blocks	I
	Vegetated riprap	I
	Soil and grass covered riprap	II
	Vegetated gabion mattress	II
	Cobble or gravel armors	II
	Trench fill revetment	II

Category	Technique	Level
Riparian and Stream Opportunities		
<i>Top-of-Bank Treatments</i>	Live gully repair	III
	Vanes with J-hooks	I
<i>In-Stream Habitat Improvements</i>	Cross vanes	I
	Boulder clusters	II
	Newbury rock riffles	II
Slope Stabilization		
<i>Drainage Measures</i>	Diversion dike	II
	Slope drain	II
	Live pole drain	III
	Chimney drain	II
	Trench drain	II
	Drop inlet	II
	Fascines with subsurface drain	II
<i>Bank Regrading</i>	Slope Flattening	II
<i>In-Situ Reinforcement</i>	Stone-fill trenches	II

Bank protection actions are presented alongside other river management actions.

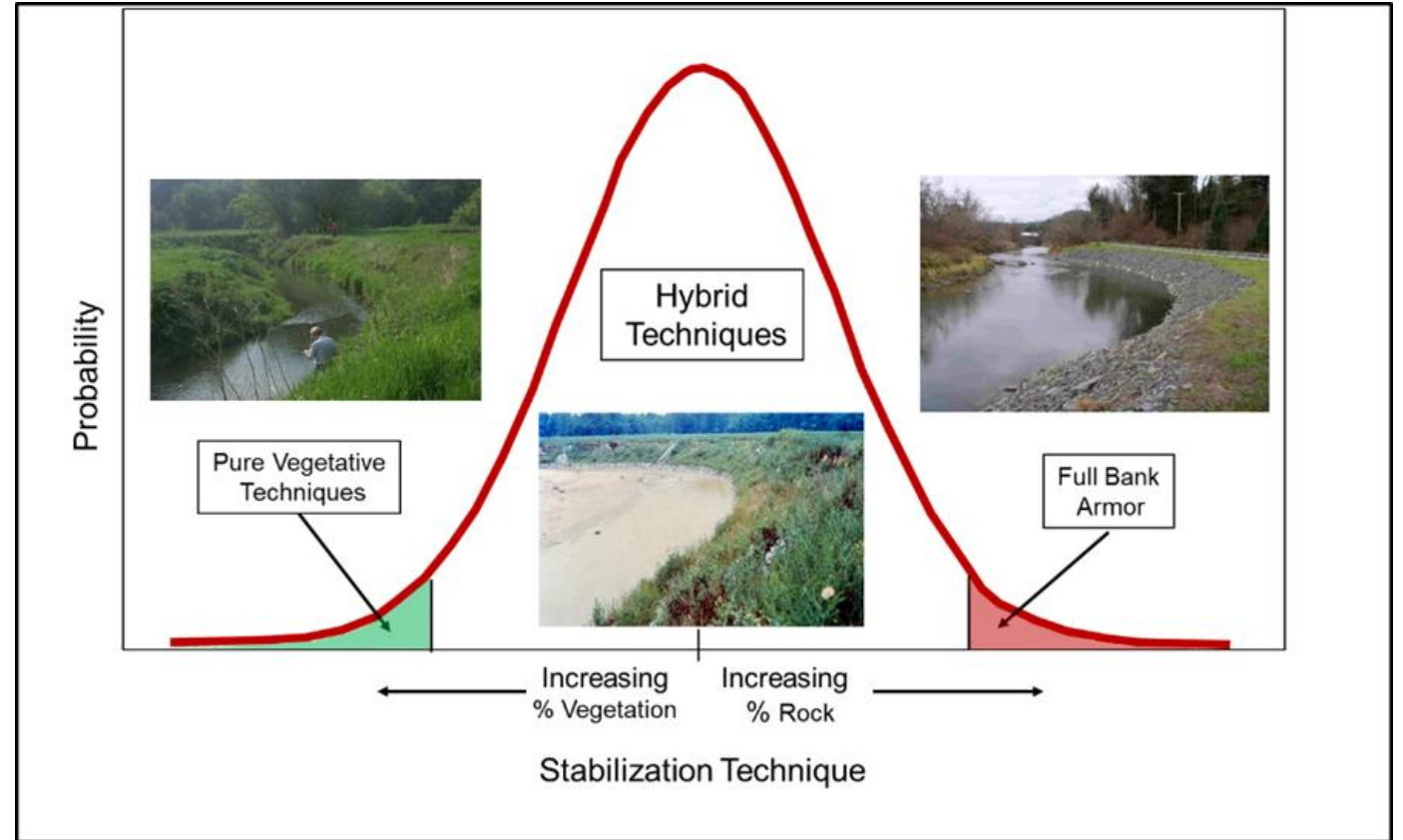
Bank Stabilization Design Guidelines for Bureau of Reclamation (Baird et al. 2015, SRH-2015-25)

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13.5	Longitudinal Peak Stone Toe	269



What can we take home from prior guidance documents?

- Bank protection actions are embedded in the context of a broader set of river management actions.
- Bank protection involves some combination of materials.
 - Steel / concrete / rock
 - Soil stabilizers / textiles
 - Bank vegetation
 - In-water vegetation
 - Large wood
- Technical-biological bank protection includes a huge spectrum of how materials are combined (and named).



**A functional
categorization of bank
protection measures
(WG128, Part 3)**

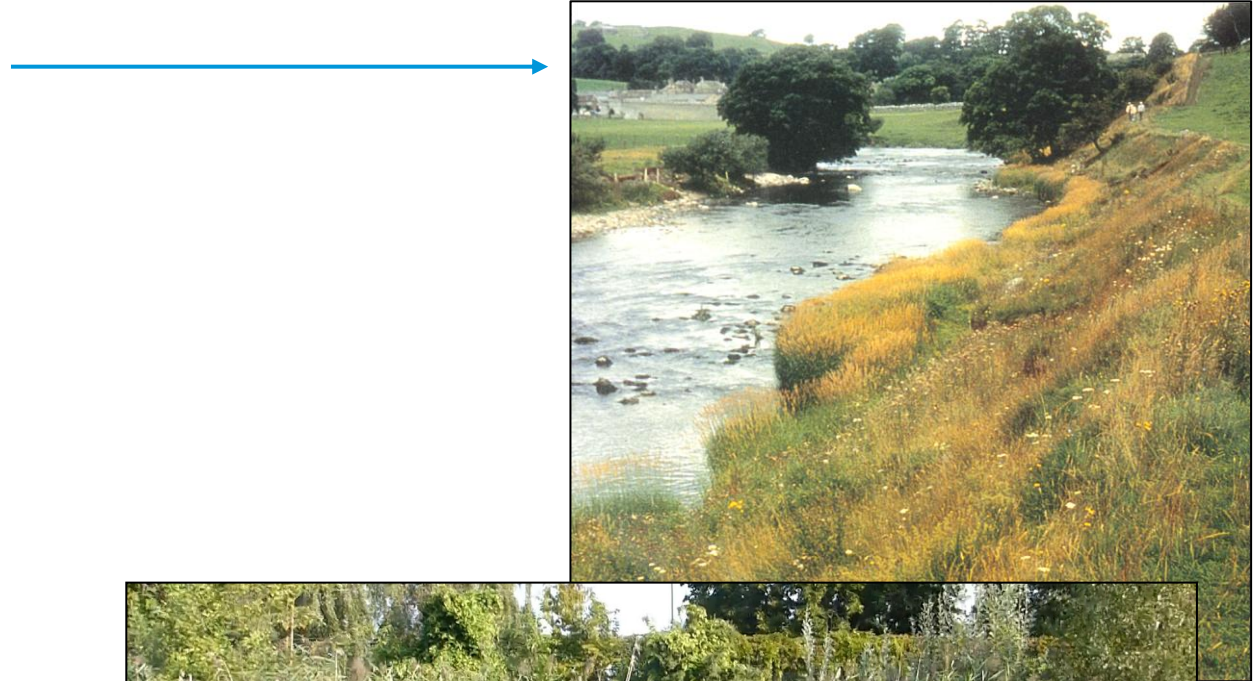
According to the position of the measure

- **Direct measures:** The bank protection is constructed directly on the surface of the bank slope (more information see Chapter 3.1 in Part 1).
- **Indirect measures:** The bank is protected by measures, generally dams or palisades, repelling or reducing impacts (e.g., wave breakers).
- **Combined measures:** These are combinations of both direct and indirect measures or those using technical and elements and living plants.



According to the protecting matter

- **Bioengineering measures:** The protection-effect is implemented predominantly by plants, preferably living plants (e.g. grass, reed or willows).
- **Bio-technical engineering:** There is a significant number of technical elements used (e.g., dead wood, steel wires, plastic mats, fibre rolls, geotextiles, stones), but the flow-deflecting, reducing and protecting function is still achieved predominantly by living plants (e.g., vegetated rock and fibre rolls, vegetated geotextile bodies).
- **Vegetated structural engineering:** The protection function will be achieved predominantly by technical elements as gabions, concrete mats or riprap, but the measures offer at least somewhat ecological upgrade.
- **Conventional technical solutions:** Not in the scope of WG128. See PIANC (1987) or GBB (2010).



Figures: Grass revetment from the WMG (© Canal River Trust, UK) and Measure 3.2.3.1 at Charlottenburg, Berlin (Berhard Söhngen)

According to the extent of the protection

Linear measures: In waters with low water level changes, where the impact zone on the bank slope is small, it may be appropriate to protect only a small part of the bank or the bank zone.



Planar (or bank slope covering) measures: Especially in case of large water level fluctuations, where the impact zone, depending on the water level, varies over a large part of the bank slope, the latter is covered planarly by the measures.



Figures: Wattle Fence at Gernsheim, Rhine (WG128) and root wads with longitudinal peak stone toe protection (Chris Haring)

According to the primary purpose of the measure

- ***Erosion protection***: The majority of measures considered in this report are designed to protect the bank against erosion or at least to reduce erosion rates.
- ***Ecological upgrade***: These measures are technically not necessary to fulfill the bank protection function, but they improve the ecology.



Figures: Boulder Creek (Chris Haring) and Rhone, Beauchastel (WG128)

According to the essence of the measure

Engineering Measures
(for bank protection)



Flanking Measures
(river “training”)



Mitigation Measures



Management Measures



Cross-walking different bank protection actions with these functional categories

Main (single) measure type	Position (function)		Extension		Protecting matter (content of plants)			Essence of the measure				Major application hints (Δw = water level changes, H = wave height/impact, E = excess pore water pressure)
	Pre-embankment (indirect) – wave-breaking and creation of shallows	Bank slope (direct protection of the slope)	Linear (impact-reducing)	mainly planar protection	Bioengineering (dead or living plants – green)	biotechnical engineering ('green-grey', technical elements, 'green-grey')	Predominantly technical elements	Engineering measures	Flanking measures	Mitigation or at least reduction of impacts	Management strategies	
Wall or dam (e.g. sheet pile) with under water openings	X		X					X				Low up to average Δw , even high H and E (depending on flooding depth at HSW)
Sheet pile wall with top openings	X		X					X				Low Δw , average H, even high E (depending on flooding depth at HSW)
(Vegetated) rip rap protected dam with top openings	X		X		X			X				Low Δw , average H, even high E (depending on flooding depth at HSW)
(Vegetated) gabion dam with top openings	X		X		X			X				Low Δw , low - average H, even high E (depending on flooding depth at HSW)
Palisades, poles, wooden barriers (permeable)	X		X		X			X				Low Δw , low - average H, low E
Poles and fascines (less permeable)	X		X		X			X				Low Δw , low - average H, low E
(Vegetated) berms	X	X	X		(X)	X		X				Low Δw , low - average H, low E
Helophyte/willow fascines		X	X		X			X				Low Δw , low - average H, no E
Wattle fence		X	X		X			X				Low Δw , low - average H, no E
Faggots		X	X		X			X				Low Δw , low H, no E
Vegetated rolls		X	X		X			X				Low Δw , low H, no E (for toe)
Geotextile rolls		X	X		X			X				Low Δw , aver. H, no E (for toe)
Rock rolls		X	X		X	X		X				Low Δw , aver. H, no E (for toe)
Root wads		X	X		X			X				Ecological upgrade
Willow weave		X	X		X			X				All Δw , aver. H, no E (for toe)
Willow spilling ...		X	X	X		X		X				All Δw , aver. H, no E (for toe)
Reed planting (reed belt)		X		X	X							Low Δw , low H, no E
Reed mat		X		X	X	X		X				Low Δw , low - average H, no E
Grass "revetment" (seed)		X		X	X							All Δw , low H, no E
Grass mat		X		X	X	X		X				All Δw , low - average H, no E
Grassed geotextile		X		X	X			X				All Δw , low - average H, no E

Main (single) measure type	Position (function)		Extension		Protecting matter (content of plants)			Essence of the measure				Major application hints (Δw = water level changes, H = wave height/impact, E = excess pore water pressure)
	Pre-embankment (indirect) – wave-breaking and creation of shallows	Bank slope (direct protection of the slope)	Linear (impact-reducing)	mainly planar protection	Bioengineering (dead or living plants – green)	biotechnical engineering ('green-grey', technical elements, 'green-grey')	Predominantly technical elements	Engineering measures	Flanking measures	Mitigation or at least reduction of impacts	Management strategies	
Plant mats		X		X	X	X		X				Average Δw , low H, no E
Mat with hardwood cuttings		X		X	X	X		X				Average Δw , low - aver. H, no E
Brush layers (e.g. from willows)		X	X	X	X			X				Average Δw , low - average H, low E
Willow brush mattresses		X		X	X			X				Up to high Δw , medium H, low E
Geotextile bodies		X	X	X		X		X				Up to high Δw , medium H, low E
Chamber revetments		X	X	X		X	X	X				Up to high Δw , aver. H, large E
Vegetated gabions		X	X	X		X		X				Up to high Δw , aver. H, large E
Vegetated rip rap		X		X		X		X				Up to high Δw , aver. H, large E
(Veget.) open cell revetments		X		X		(X)	X	X				Up to high Δw , aver. H, low E
(Veget.) concrete units (mats)		X		X		(X)	X	X				Up to high Δw , aver. H, aver. E
Speed limit										X		All conditions, except high Δw
Increased ship-bank distance										X		All conditions
Permission restrictions, e.g. concerning draught, powering										X		All conditions (check feasibility)
Parallel dykes	X					(X)		X	X			Average Δw , high H, high E
Spur dykes (groynes)	X					(X)		X	X			All conditions, but reduced wave-damping effect, high E
Artificial islands	X					(X)		X	X			All conditions, but reduced wave-damping effect, high E
Monitoring erosion progress and 'spot repair'											X	Low erosion speed on restricted channel length
Tree management											X	Helps under all conditions
Fencing ...											X	Human and animal pressure

A process for selecting bank protection methods

(the “7 steps” from WG128 Part 3)

Overview of the process for selecting a bank protection method

1. Identify relevant functionality demands and objectives.
2. Evaluate design-relevant boundary conditions.
3. Select potentially applicable measures.
4. Collect data and information on potential measures.
5. Consider “knockout” criteria.
6. Define and specify variants on design options (including hybrid features).
7. Compare designs and recommend the “best” variant.



Figures: Peking-Fluss, China and
Charlottenburg, Berlin (WG128 Measure 3.2.3.1)

Step 1: Identify relevant functionality demands and objectives.

- What are desired outcomes?
 - Key features to be protected
 - Acceptable rates of erosion
 - Ecological outcomes
 - Recreational access

- What are performance goals?
 - Time to establishment and peak performance
 - Risk tolerance
 - Acceptable degrees of intervention and management
 - Changes in future boundary conditions

Category	No. of AHP-Criterion	Demands
Technical demands	1.2: Stability and sustainability	High sustainability needed concerning stability and durability of construction materials as well as to avoid maintenance efforts. Moderate erosion stability needed as impacts are restricted; timely shortening of initial phase. Reduce the discrepancy between available und necessary space by flattening the slope as far as possible. Ensure compatibility with the waterway type, e.g. by using the advantages of restricted water level changes by using pre-embankment components.
	1.3: Avoiding efforts	Choose cost-effective solutions, both for construction and maintenance. Ensure good access at least from the land side. Enhance monitoring (as it is a test section) and use endemic vegetation as far as possible.
Social and legal demands	2.1: Human	Enable the view from water side towards the hinterland and backwards (water-touristic aims).
	2.2: Landscape and preservation issues	Increase the scenic beauty in general; ensure the legal demands of navigation (safety and ease).
	2.3: Legal issuers and acceptance	Respect the demands of various stakeholders, e.g. the private owners. Respect especially the legal demands of navigation and nature protection. Consider the possibilities and limitations of administrative support.
Ecological demands	3.2: Taxa	Enhance the water-bound habitats, especially for corresponding macrophytes and fish. Enhance also the habitats of riparian vegetation.
	3.3: Habitat	Create shallow water zones with varying water depths, grain sizes and structural elements, as there are general deficits concerning these habitats in an impounded river with mostly protected banks. Improve plant zonation and vegetation complexity as far as possible, as the existing vegetation is very uniform and consists of a few plant species only, increase the development potential towards an almost natural bank zone, e.g. by widening and flattening the bank area.

Table 6-9: List of most important, design-relevant demands for the Weser example

Step 2: Evaluate design-relevant boundary conditions.

- What is the waterway type?
 - e.g., pool vs. free-flowing, traffic
- What is the severity of erosion?
 - e.g., bank angle, rate of retreat
- What are the causes of bank erosion?
 - e.g., water level fluctuation, wave action
- What is the ecological context?
 - e.g., growing season, connectivity to other ecosystems, soils
- What is the social context?
 - e.g., river usage, consequences of erosion



Step 3: Select potentially applicable measures.

- This step is **guided by WG128 Part 2** (the library of measures):





- 25 basic types of measures
- 34 fact files on case studies
- 6 detailed case studies

- Spreadsheet tools to rapidly screen potential measures based on technical and ecological factors.

- Feasibility check:** How well would designs from the library translate to this site? Are boundary conditions the same?
- Suitability check:** Does this method align with the project objectives?

TABLE DET (Table 1):
Pre-Selection of appropriate measures – BOUNDARY CONDITIONS (BC's), technical issues
DESIGN-CASE-example (DC): Weser, Stolzenau, Field 10 (blue-colored boxes)
Remark: There is only one DC allowed in using all the pre-selection tools in the entire EXCEL-Sheet

DESIGN CASE (DC):	Stability of existing, fictitiously unprotected bank (DC) or realized bank (AC)								Waterway type	Climate		Group BC
	(A) Ship-induced impacts	(B) Average slope (MW/hinterland)	(C) erodibility (soil at bank)	(D) Excess pore water pressure	(E) Hinterland dimensions ("to work with")	(F) Water level fluctuations MW-MHW or HSW	(G) Vegetation growth conditions	(H) Icy conditions		Single BC		
<p>Specification of Boundary Conditions (BC's) at planners site (Design Case)</p> <p>The importance of the boundary conditions shall be assessed by using main two crosses ("X"), both on the "Group" and "Single" level (DC-Weights W), see light blue boxes. Not a cross means the criterion is not important, 1 of 'average' importance and 2 'very' important.</p> <p>The score S_{DC} in the blue boxes assesses the accordance with the selected boundary conditions at planners site.</p> <p>The accordance-score S_{DC} score is 1, if the blue-coloured boundary conditions were existing at DC site (considered as if there were no measures taken) and 0, if the red coloured boundary conditions are true at DC site. Interpolate in between where appropriate.</p> <p>Tackle the boundary conditions as if there would be no measures taken (fictitious unprotected bank), but consider possible natural vegetation.</p> <p>Scoring for Feasibility Check: $S_{DC} = 1 - 2 \times d$, with $d = S_{DC} - S_{DC}$ $S_{DC} = 1 - 2 \times (W \times S_{DC}) / W$</p>	Weak Large bank distance, small cargo volume, low recreation boating	Flat ($\leq 1:10$)	High erosion resistance (soil = gravel, silts, cohesive clay)	Soil not sensitive to excess pore water pressure (cohesive soil, high conductivity as gravel) or orientation is not relevant	Wide (little erosion speed, local damages acceptable or can be countered by maintenance) as well as: orientation is not relevant	Low (< 0.5 m): Still water, lake, impounded river, pits just upstream of the barrage	Humid climate, low wind speed, optimal growth conditions	No ice, steady, if any, non-drifting ice	DC (X) (DC-Weight W) (DC-Score S _{DC})	DC (X) (DC-Weight W) (DC-Score S _{DC})	DC (X) (DC-Weight W) (DC-Score S _{DC})	
	Strong Small bank distance, high cargo volume, frequent recreation boating	Very steep (height difference between hinterland and MW-level, divided by distance)	Low erosion resistance (soil = sand, non-cohesive silt)	Soil very sensitive to excess pore water pressure (non-cohesive soil, low conductivity)	Very small (steep slope, even local damages are not acceptable, buildings just behind)	High (> 3 m): free flowing river, pre-embankment measures generally not applicable	Arid climate, high wind speed, hot summer	Ice drift, frost heaving	DC (X) (DC-Weight W) (DC-Score S _{DC})	DC (X) (DC-Weight W) (DC-Score S _{DC})	DC (X) (DC-Weight W) (DC-Score S _{DC})	
DC (A)	User-defined importance of the criterion (cell scores of the two levels = weight)	Group X Single 2	Group X Single 1	Group X Single 2								
DC (B)	Degree of accordance to the specified BCs for the Design Case = score S_{DC} Row below column: A-D: Average Suitability Score S_{DC} = sum of weights times S_{DC} -Score / corresponding sum of weights The below column: DC (B) Necessary stability score S_{DC} = sum of weights times S_{DC} -score / corresponding sum of weights										0.60	

Technical Suitability of Realized Measures			
A-S	SCORE	NAME	ICON
RANKED RESULTS			
3.2.1.2	0,58	FF Branches layers and helophyte fascines - left bank of the Rhône River - Saint-Vallier - France	
3.2.2.4	0,47	FF Wood barriers, reed plantings, softwood planting – Aller, near Essel, Germany	
3.1.2.4 (1)	0,45	FF Palisades protecting reed belts and bank slopes in the impounded Lower Havel River at Berlin, Germany - site 1 (Pichelsdorf)	
4.3.1	0,42	CS Vegetated riprap, erected 2011 on the right bank of the River Rhine near Worms, Germany	

Step 4: Collect data and information on potential measures.

- Compile information about how the potentially applicable measures have performed elsewhere.
 - Boundary conditions
 - Physical performance
 - Ecological outcomes
- This step is **guided by WG128 Part 2** (the library of measures):
 - 25 basic types of measures
 - 34 fact files on case studies
 - 6 detailed case studies

Local boundary conditions and projections		
Water-level changes and flow velocities		
Mean high water (MHW)	MW + 0.0 m (<1 m)	0.0 m/s
Highest shipping (upper operational) level	MW + 0.2 (<1 m)	0.2 m/s
Mean water level (MW)	MW - 0.2 m	0.2 m/s (not relevant)
Mean low water (MLW)	MW - 0.3 m (not below -0.5 m)	≈0.0 m/s (not relevant)
Climate and weather		
Precipitation	570 mm (not relevant)	
Bank orientation	South facing (not relevant)	
Climate type	Humid, continental (not relevant)	
Temperature and ice	10 frost days per year, frequent ice drifts and freeze-over (not relevant)	
Wind	Very strong	
Waterway properties and navigation		
Type	Delta river and estuary lakes (also in waters with low water-level changes)	
CEMT class	Vb	
Cargo volume	2 × 10 ⁶ to 3 × 10 ⁶ t/a (not relevant)	
Fairway-bank distance	30 m (all distances more than 30 m)	
Speed limit	9 km/h (because of the waterway crossing Natura 2000)	
Vessel types producing greatest impacts	Big sailing boats, recreational boats, and deep draft cargo vessels, also short-	
Bank properties related to stability		
Bank location related to sediment transport	Wide shallow wetlands c	
Slope (bed-terrain)	Very gentle slope	
Suspended load	Low	
Hinterland space	4 km	
Erosion resistance related to soil properties	Light conventional prote	
Resistance against excess pore water pressure	Not relevant	
Bank properties related to ecology (unprotected bank or, if already areas)		
Vegetation and fauna characteristics	Hard- and softwood cov lily close by)	
Aquatic and terrestrial habitat quality	Poor from lack of oxygen	
Reserve or conservation legal status	Bank area part of a Nat area	

Demands versus properties and benefits	
Key technical demands versus properties and benefits	
Required bank stability	Moderately little morphologic activity acceptable because of stable situation
Compatibility – waterway type	Delta rivers, estuaries and wide wetlands, low current
Compatibility – climate	No special requirements (especially meant for sea climate)
Required access to bank zone	Only accessible by boat (must be left alone)
Maintainability and administrative support	Great effort (easy maintainability, no frequent adaptations required)
Key economical demands versus properties and benefits	
Administrative support	Administration ensures optimal support (average support required)
Budget versus expenses	Beneficial use of dredged material makes the construction and maintenance very economic (reed transplant was expensive because of lack of pre project research, but lower costs in future are forecasted)
Required degree of sustainability	Not really required because of optional administrative support (average sustainability achievable)
Key ecological demands versus properties and benefits	
Aquatic habitats (a.h.) – generally bank area below MW	Improve or create site-specific a.h. (increase of aquatic biodiversity, native animals and plants) (especially supports reed and sedges)
Terrestrial habitats (t.h.) – generally bank above MW	Improve or create site-specific t.h. (increase of aquatic biodiversity, native animals and plants) (slope is clay protected all delta vegetation can survive)
Vegetation complexity (v.c.)	Transplant and create v.c. complexity (native plants and vegetation of local provenance, well adapted to climatic, soil, and hydrological conditions on-site) (predominantly reed)
Habitat connectivity (h.c.)	Increase h.c. (lateral, longitudinal, step-stone habitats) (predominantly fish habitats, amphibians, insects, birds)
Maintenance efforts and related negative effects (m.e.)	Assure minimum m.e. without disruptive effects for local habitats (maintenance can be performed from water side with low disruptive effects)
Terrestrial animals	Support of site-specific terrestrial animals
Ecosystem services (e.s.) except social aims	Support e.s. (water, air, and soil quality, climate regulation) (especially improves water quality and local climate)
Key social demands versus properties and benefits	
Access for humans	Prevented (human access is generally possible)
Exploration of water area	Not relevant (generally possible, but contradicts with ecological aims)
Landscape	Improve scenic beauty, connectedness, and congruence (upgrade possible)

Step 5: Consider “knockout” criteria.

Constraints are always a key aspect of engineering design!

- Ice-effects
- Strong stability demands
- Significant excess pore water pressure
- Very small riparian area
- Discrepancy between available and necessary space
- Discrepancy between costs and budget
- Very high bank
- Bank is part of a levee
- ...



Figures: Spree, Berlin (WG128 Case Study 4.2.1)

Step 6: Define and specify variants on design options.

Potentially applicable measures (from Step 3)

Combination of potentially applicable measures

Variant 1: Living willows brush mattresses

2.2.3 - Life willow on toe and bank (W), incl. willow fascine, mattress, spinning / laying




2.1.8 - BW 8: Willow brush mattresses with heavy riprap as toe reinforcement



4.3.3 - Rhine, Worms, living willow brush mattresses

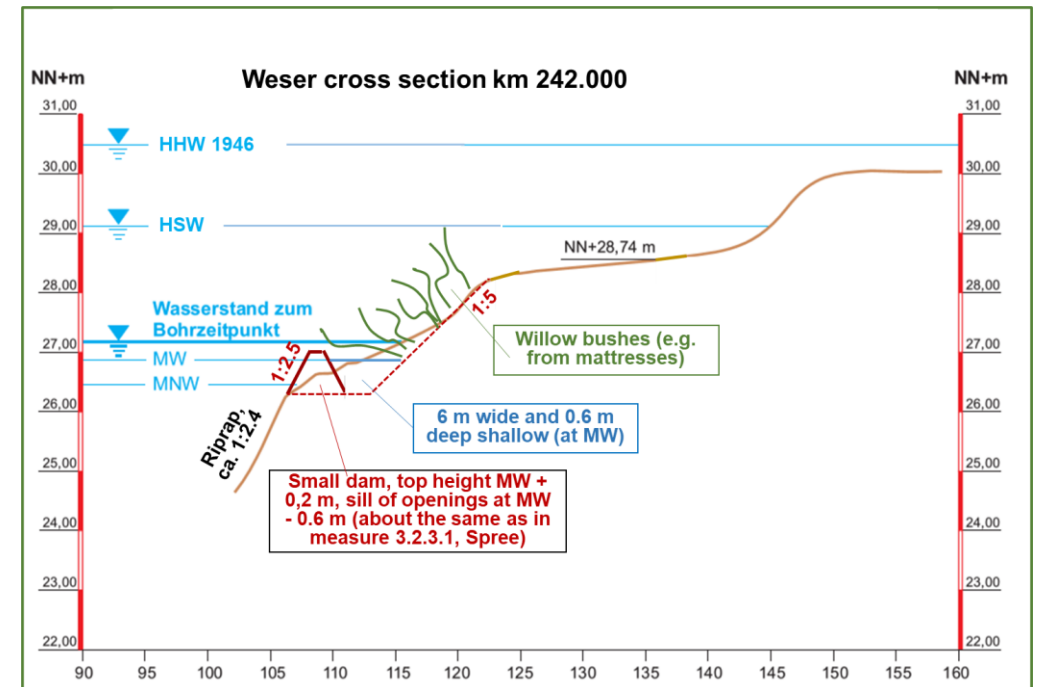


Variant 2: Longitudinal dam

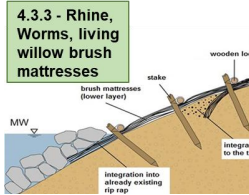


3.1.1.2 - Beauchastel, Helophytes and willows behind riprap dike

Variant 3: Living willows + longitudinal dam



Step 7: Compare designs and recommend the “best” variant.



- Comparison of potential measures based on the Analytical Hierarchy Process (AHP)
- Relative ranking of variants
- Qualitative comparison provides a point of dialog with planners, ecologists, and other project stakeholders

Site-specific weights for the location in question	Group 1: Technical Functionality	$W_1 =$ 0,47	Subgroup 1.1: Accordance with boundary conditions and adaptability ...	$W_{1,1} =$ 0,48	$S_{1,1} =$ 0,17 → 0,37
			Subgroup 1.2: Stability and sustainability	$W_{1,2} =$ 0,41	$S_{1,2} =$ 0,02 → 0,23
			Subgroup 1.3: Restriction of efforts, e.g. for construction and maintenance ...	$W_{1,3} =$ 0,11	$S_{1,3} =$ 0,22 → 0,36
	Group 2: Social Functionality	$W_2 =$ 0,06	Subgroup 2.1: Demands of human beings, e.g. leisure activities ...	$W_{2,1} =$ 0,10	$S_{2,1} =$ -0,05
			...Subgroup 2.2: Demands concerning landscape and nature conservation ...	$W_{2,2} =$ 0,45	$S_{2,2} =$ 0,08
			Subgroup 2.3: Legal issues and getting acceptance ...	$W_{2,3} =$ 0,45	$S_{2,3} =$ 0,34
	Group 3: Ecological Functionality	$W_3 =$ 0,47	Subgroup 3.1: Accordance with boundary conditions and adaptability ...	$W_{3,1} =$ 0,45	$S_{3,1} =$ 0,10 → 0,15
			Subgroup 3.2: Potential functionality concerning selected taxa (e.g. fish or bank vegetation) ...	$W_{3,2} =$ 0,10	$S_{3,2} =$ -0,11 → -0,05
			Subgroup 3.3: Potential functionality of selected habitats	$W_{3,3} =$ 0,45	$S_{3,3} =$ -0,19 → -0,11

Variant-specific scores of the criteria.

Thanks for your time!

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