Bioengineered designs

In bioengineered designs, plants are essential for the long-term integrity of the water's edge. Certain hard elements may be included, such as driven wooden piles, but their functions are short-term, often to provide initial protection for plants to establish or grow. They do not form part of the design for long-term flood risk management. Unless there are considerations such as development in close proximity, hydrological forces from structures in close proximity, significant erosive wave action, land level changes, then such edges should not need any more reinforcement.

A bioengineered solution is quite likely to be effective if a bank already exists that is fully stabilised by vegetation near the site of interest. Where existing plant cover is failing near the site, purely bioengineered solutions may not be appropriate.

Even in highly built-up urban locations with high land values, bioengineered solutions can be used. For example, if the land rises steeply away from the river or there are washlands/floodplain on the estuary to take some of the velocity from the flood waters, or the underlying geology provides support.

In some cases there may be fast tidal currents, but vegetation can thrive and contribute significantly to the overall flood risk management function if initially helped to take root. In such cases the approach can be to stabilise the substrate only as long as it takes strong estuarine plant species such as Common Reed or Sea Aster to become established. This approach is illustrated in Case Study 1 where an anchored biodegradable coir (coconut fibre) erosion control blanket was used, which was planted with pre-grown estuary grown Common Reed. This technique may also be appropriate on infrequently inundated upper slopes where there is a risk of erosion eddies (see Case Study 3).

In other cases, the environment may be considerably more saline and the water more silt-laden. Where there is not a high risk of major wave action, the main aim here may be to ensure that the river edge achieves net balance between accretion and erosion, by initially favouring the deposition of sediment. Techniques designed to achieve this are illustrated in Case Study 2 where 300mm diameter bundles of cut branches (generally Hazel) were laid on the substratum to a depth of some 300–500mm. This 'brushpacking' technique promotes rapid sedimentation.

Case Study 2 also illustrates the technique of 'brushwood fascine' (or 'brushwood faggot)' installation on steeper upper slopes less frequently inundated by the tide. Brushwood fascines are bundles of cut branches, tied with cord and entrenched in a woven pattern between closely placed driven poles to create quite robust low 'fences'. Again, sediment rapidly accumulates between the fascines where the technique has been correctly selected.

Coir rolls, coir matting, synthetic soil cells, turf reinforcement mats, even gabion mattresses need to be adequately anchored to the bank. Depending on the river flow (that is, whether the flow speed is fast or slow, whether the slope of the bank is steep or shallow and whether there is boat wash from passing vessels), the required number of stakes and their lengths will vary. The faster the flow, steeper the bank and greater the height and frequency of the wash, the longer the stakes that will be required. Willows, Hazel, Sweet Chestnut or Ash can be used for stakes. The length will vary from 1–1.5m and the diameter from 40–60mm. It is common practice to incline the stakes at about 60 degrees to the vertical. The mat or roll manufacturer's guidance should be sought where necessary. Consideration should also be given to possible erosion of the bank and any resulting bank slip leading to collapse of the bioengineering elements. In addition to anchoring these elements, scour protection of the bank – either using horizontal timber planks and vertical timber

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uprights/stakes or some other installation – may need to be put in place where the high flow and boat wash is known to erode the banks.

The success of, and need for, planting or seeding varies strongly between sites. In the example in Case Study 1, the pre-grown reeds were expected to establish rapidly and within the lifespan of the protection matting and hence planting was essential. Where there is likely to be considerable sediment accretion, as in the case illustrated in Case Study 2, early planting can fail due to smothering, and there is a strong case for waiting to see whether natural colonisation can be sufficient. The example shown in Case Study 3 shows that where seeding is undertaken it may be advantageous to install an enriched starting substrate for the seeds.

One important point illustrated by the examples in Case Studies 2 and 3 is that the use of bioengineering techniques can be applied close to or adjacent to river barriers or bridges where traditional concerns regarding erosion eddies and backwash has led to the almost universal application of hard engineering techniques to prevent damage to bridge or structure foundations.

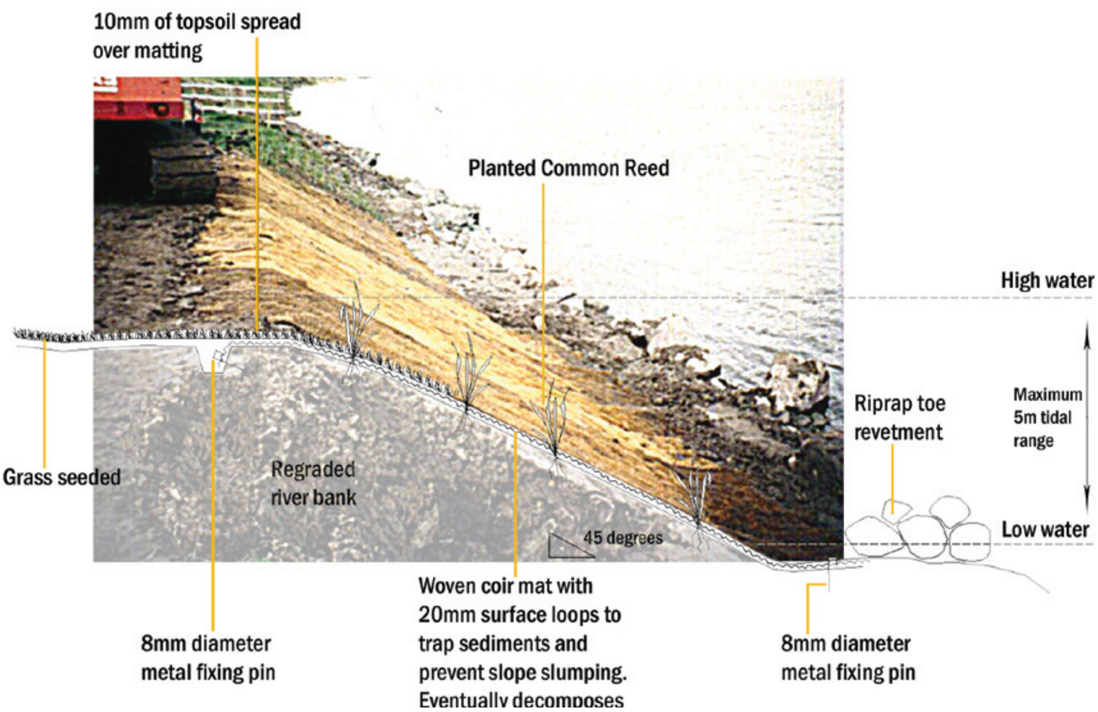
Case Study 1: River Severn, Longney, Gloucestershire (completed 1997) Grid Reference: SO 756 106

The site

- Around 50m section of river bank, 45 degree slope and 5m maximum tidal range. River 230m wide locally.
- Subject to the erosive forces of the Severn Bore, with maximum current speeds in excess of 3 m/s.
- Salinity brackish.
- Active erosion zone with little vegetation, unlike the adjacent areas.

What the developers did

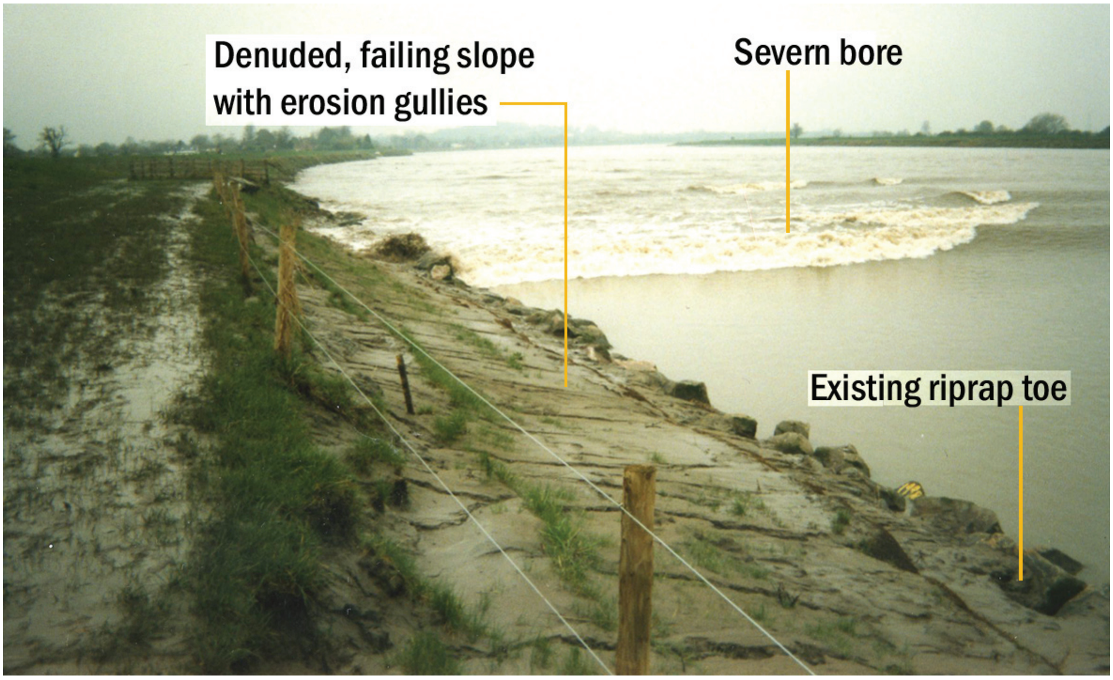
- Three-dimensional woven coir matting with an initial 9 kN tensile strength applied to the re-profiled slope and anchored top and bottom.
- Toe revetment of riprap retained as hard engineering element, but main slope completely bioengineered.
- Locally collected Common Reed rhizomes planted through the matting.



River Severn, Longney: Installation of loop mat planted through with pre-grown Common Reed

The result

- Common Reed established well, continuing to stabilise the substrate after the decomposition of the coir matting.
- Design considered highly successful, cost-effective and appropriate to location.



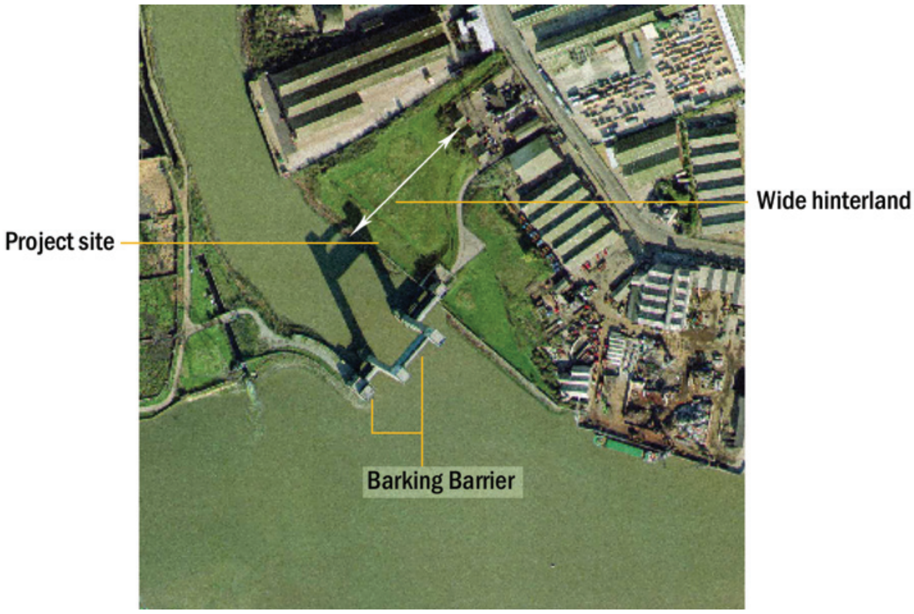
River Severn, Longney: The slope above the riprap toe several months after installation showing sediment accretion

River Severn, Longney: Successful restoration

Case Study 2: Barking Creek at Barking Barrier (completed March 2006)
Grid Reference: TQ 455 818

The site

- Scheme to create an ecologically rich, attractive new intertidal embayment and educational area on Barking Creek, 100m upstream of Barking Barrier on the north bank of the Thames.
- River over 50m wide and subject to 7m tidal range.
- Low risk of wave-wash from vessels.
- High sediment load in water column.
- Large area of riverside available.
- Relatively low flood risk in the event of loss of integrity of the design.



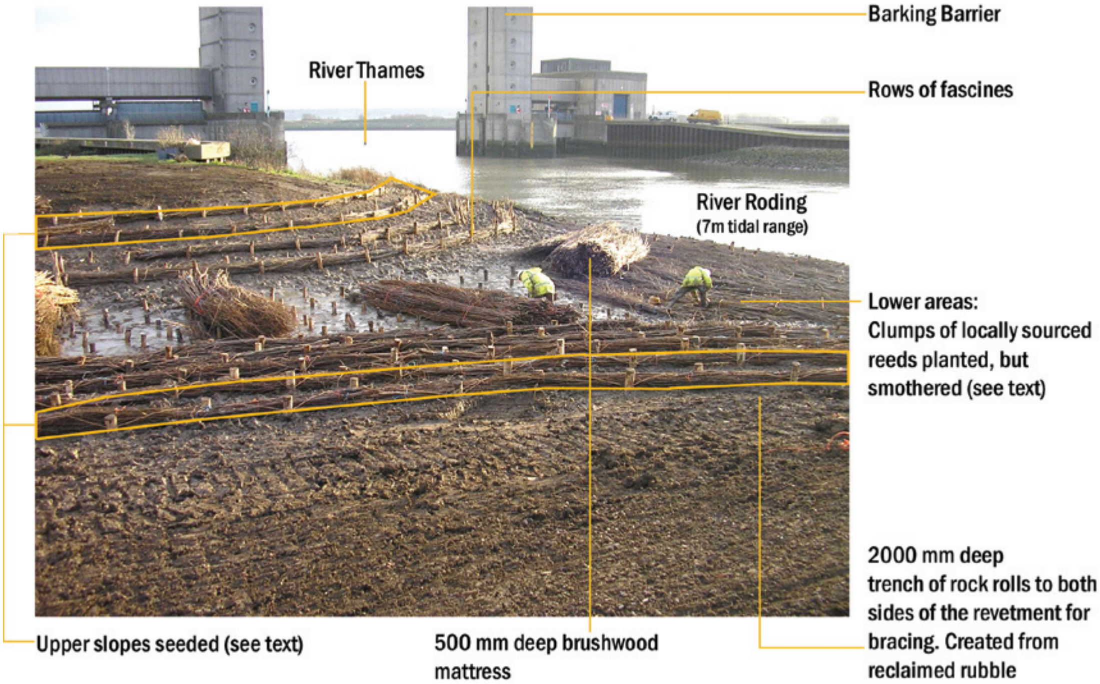
Barking Creek at Barking Barrier: Before creation of intertidal embayment

What the developers did

- Existing land profile excavated away to slopes less than 1:7 and clay capped.
- Sweet Chestnut posts installed and brushwood bundles delivered.
- 'Brushpacking' (500mm brushwood fascines packed over whole mud surface) installed between 2500mm long Sweet Chestnut posts (installed at 600mm centres) retained by biodegradable tensioned coir twine on slopes up to Mean High Water Neaps. Fascine diameter graded down to 200mm at low tide mark.
- Clumps of locally sourced cell-grown Common Reeds introduced on lower slopes smothered with some 40cm of sediment in just six months.
- Steeper upper slopes retained by brushwood bundles installed as fascines between Sweet Chestnut posts on alternate sides at 600mm centres. Diameter of faggot bundles used increasing from 200mm to 500mm down the slope. Retained by biodegradable tensioned coir twine.
- Upper fascine-stabilised slopes seeded with proprietary seed mix at 2 g/m^2 augmented with locally collected seed of Red Fescue, Sea Aster and Sea Arrow-grass.
- Trench of rock rolls at top of each side of revetment slopes for bracing, but still essentially a bioengineered design.
- Wider site includes subsoil-based wildflower meadow, eco-centre and interpretation boards for visitors.

Barking Creek at Barking Barrier: After creation of intertidal embayment

Barking Creek at Barking Barrier: Delivery of brushwood bundles



Barking Creek at Barking Barrier: Brushwood fascines installed on upper slopes and brushpacking being installed on lower slopes

Barking Creek at Barking Barrier: Fixing detail of brushpacking

The result

- Natural colonisation of Sea Club-rush extensive on the upper slopes, stabilising the substrate but overwhelming the planting.
- After 16 months, a wide variety of plants present, with abundant self-sown Sea Aster and strongly spreading Common Reed at higher tidal levels.
- Plentiful supply of fine sediment and net accretion/erosion balance achieved at lower tidal levels.
- Stable vegetation establishment anticipated in the long term, the lowest fringe being colonised by Sea Club-rush.
- Extensive use of the embayment by juvenile fish, especially Sea Bass.
- Considered highly successful and beneficial in ecological, social and economic terms.

Lower slopes of Barking Creek bank at Barking Barrier showing 40cm of sediment accretion on six months

Upper slopes of Barking Creek at Barking Barrier showing rapid establishment of Sea Club-rush

Case Study 3 : Barking Creek at A13 - Frogmore (completed May 2006)
Grid Reference: TQ 444 830

The site

- Site adjacent to the A13 road bridge on the tidal River Roding.
- The channel here over 50m wide with a 3m tidal range at the site.
- Surrounding bridge walls, etc. provide second line of flood risk management.
- Bank loadings and flood risk were assessed as ‘medium’.

Barking Creek at A13: View of river edge before and after scheme implementation

What the developers did

- Existing wall broken out and/or truncated and capped with concrete.
- Slopes re-graded and clay capped and fascine revetment installed.
- Coir erosion control blanket installed over upper slope to prevent sediment loss for up to two years during plant establishment – covered with ‘blinding layer’ of soil and seeded with wildflower mix. Additional saltmarsh seed added in zone between mean high Neap and Spring Tides.
- Biodegradable Hazel/brushwood fascines placed in rows 1m apart to promote sedimentation at low- to mid-tidal levels.
- New rock rolls in trenches to anchor fascine rows at each end but revetment still essentially bioengineered.
- Kingfisher burrows installed in the truncated concrete river wall.

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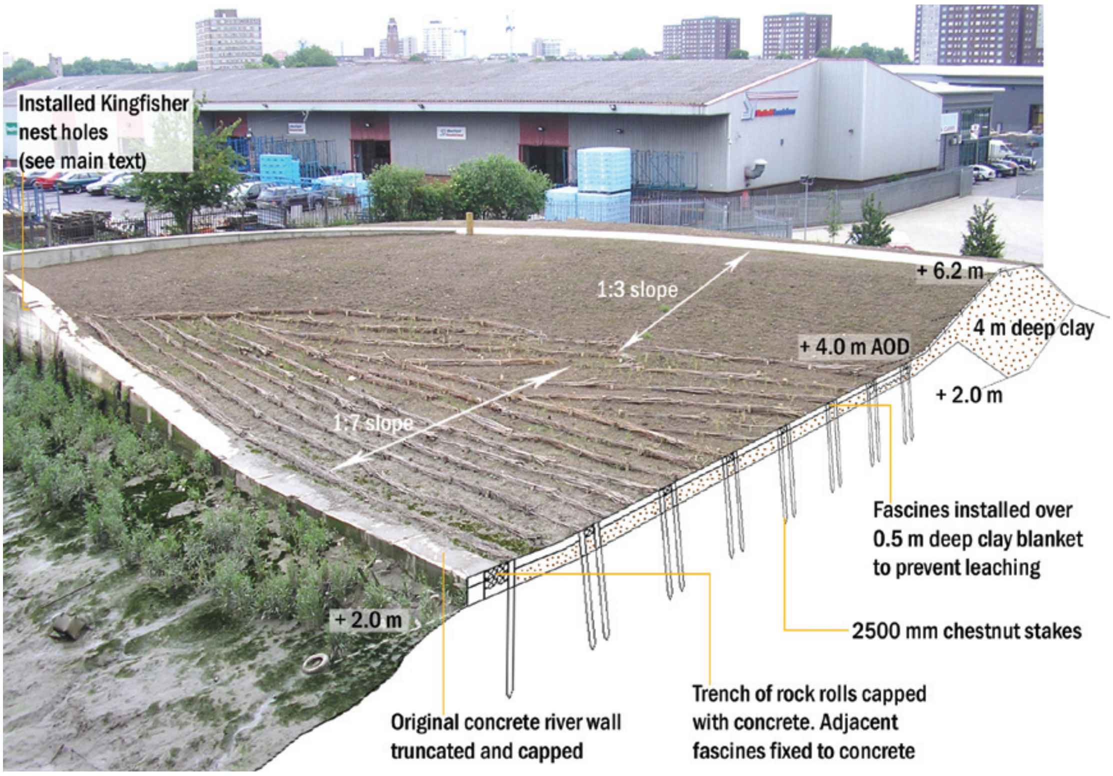
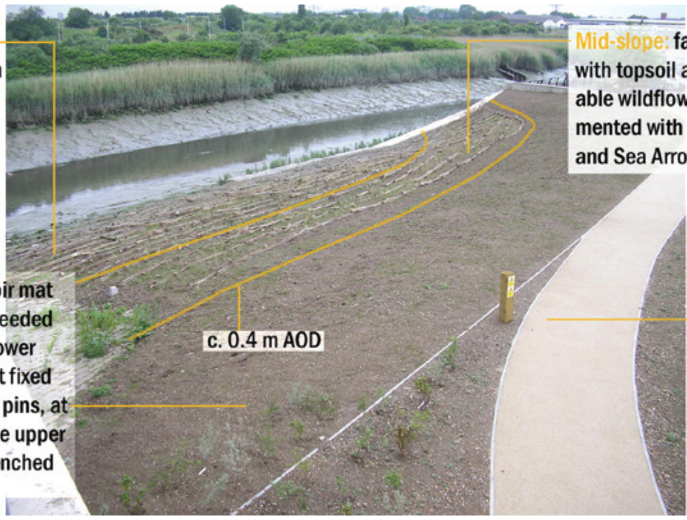
Barking Creek at A13: Demolition of river wall



Barking Creek at A13: Newly regraded and protected slopes with toe detail

Barking Creek at A13: Details of fascine installation near bridge



Barking Creek at A13: Indicating different planting proposals and surface treatments

The result

- In the first 12 months no erosion occurred on the slope and the coir matting and brushwood fascines had not been damaged.
- Cell-grown Common Reed planted on the lower slope largely unsuccessful but subsequently started to colonise naturally.
- Grassland vegetation establishment from seeding the upper slopes successful despite limited sedimentation.
- Introduced growing medium on the upper slopes considered to have helped establishment.
- Close proximity of a bridge did not prevent a bioengineered design.
- Greatly improved local visual amenity, with far better relationship to nearby semi-natural habitats.
- Considered very successful in ecological, social and economic terms.

Barking Creek at A13: Vegetation establishment after 14 months

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