Soil Bioengineering Applications for Stream Bank Erosion Protection, Fish and Wildlife Habitat Creation

Terra Erosion Control Ltd.
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Pierre Raymond,
March 2012

Terra Erosion Control Ltd.

Presentation Outline

Background and Introduction

- Terra Erosion Control's background
- What is Soil Bioengineering
- Benefits of Soil Bioengineering
- History and development throughout the world
- Site assessment of stream bank
- Description of techniques, soil amendment and specialized equipment

Stream Bank Protection and Riparian Enhancement

- City of Edmonton, protection of storm water outfalls # 101, 56 and 13, enhancement of fish habitat using vegetated riprap and L.W.D.
- Environmentally sensitive approach to minimize footprint on construction sites
- Teck Metals, Trail, BC vegetated riprap application, Columbia River
- European examples of stream bank protection

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Background on Terra Erosion Control Ltd.

- A Bonded Environmental Services Company
- Biotechnical slope stabilization / soil bioengineering.
- Training, consulting and project implementation.
- Control of accelerated erosion while re-establishing native vegetation and restoring surface hydrology.

"We are dedicated to the principles of sustainable land use and restoration of natural ecosystems"

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What is Soil Bioengineering?

- Use of live vegetation for soil erosion control and reduction of sediment delivery and habitat enhancement.
- Use of native shrub and tree species that have the ability to grow roots and shoots from dormant live cuttings.
- Often combined with conventional engineering structures such as rock, geogrids and large woody debris.

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Benefits of Soil Bioengineering

- More natural and aesthetically pleasing than other conventional erosion control treatments.
- Provides habitat for fish and wildlife by creating shade, cover and small organic debris input when adjacent to a watercourse.

- Can negate or reduce the amount of habitat alteration compensation required by regulators.

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Benefits of Soil Bioengineering

- The established vegetation becomes a structural component.
- Flexible and not affected by slight movements from ground settlement, shifting and frost heaves.
- Cost effective in comparison to other conventional engineering methods.
- Can be combined with conventional engineering methods.
- Minimal maintenance required.

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Objective of Successful Applications

- After only a few years there is no apparent sign of remedial intervention.

Preconstruction
February 2005

New Development, New Bridge & Growth Established
Spring 2007

Growth & Vegetation Establishment
June 2010

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Objective of Successful Applications

Pre-construction
February 2005

Spring 2007

June 2010

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History of Soil Bioengineering

Early development occurred in the mountainous areas of Austria and southern Germany

- Developed in response to extensive deforestation
- Financial restrictions of pre-war years (1930's) in Germany and Austria favoured the use of low cost local materials and traditional construction methods

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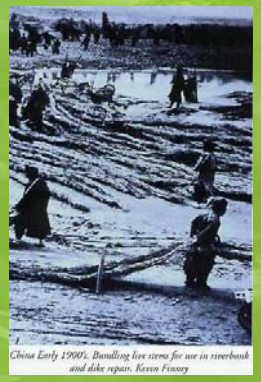
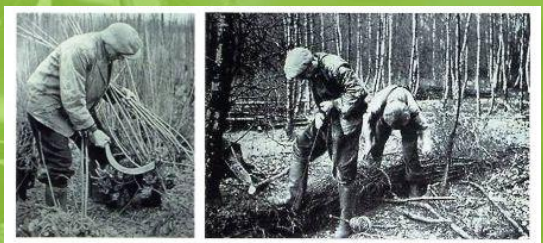
History of Soil Bioengineering

Documented use of techniques in China and Europe at turn of the 20th century.



China Early 1900's. Bundling live stems for use in riverbank and dike repair. Kevin Finney



Europe Early 1900's. Cutting and collection of live stems for soil bioengineering. Kevin Finney

(Lisa Lewis, U.S.D.A. 2000)

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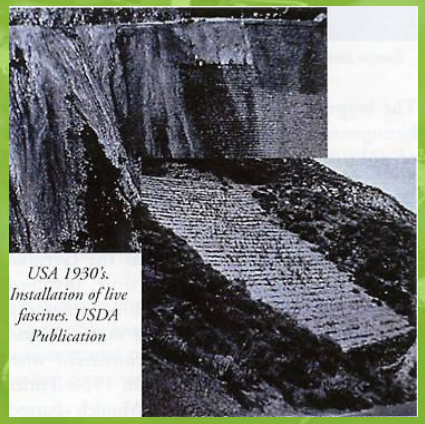
History of Soil Bioengineering

Used by the US Department of Agriculture in 1930's.



USA 1930's. Installation of live fascines. USDA Publication

(Lisa Lewis, U.S.D.A. 2000)

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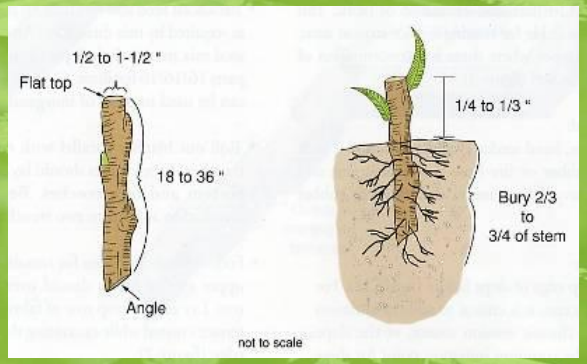
Soil Bioengineering Techniques



Live Stake

(Lisa Lewis, U.S.D.A. 2000)

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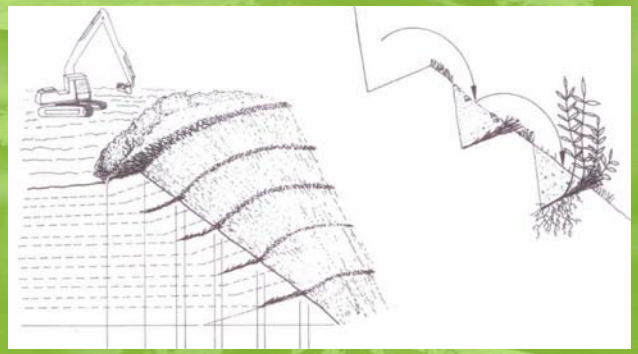
Soil Bioengineering Techniques



Brush Layers

(Helgard Zeh 2007)

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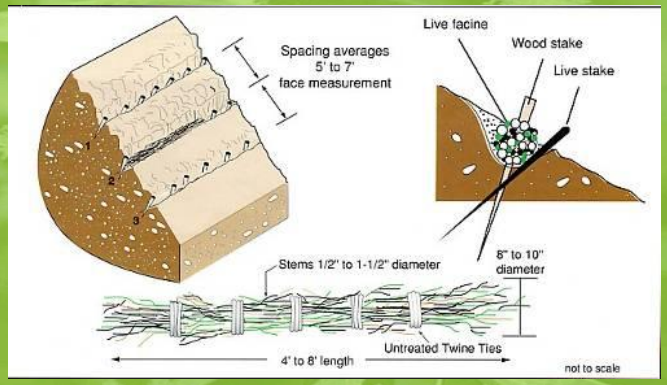
Soil Bioengineering Techniques



Live Fascines

(Lisa Lewis, U.S.D.A. 2000)

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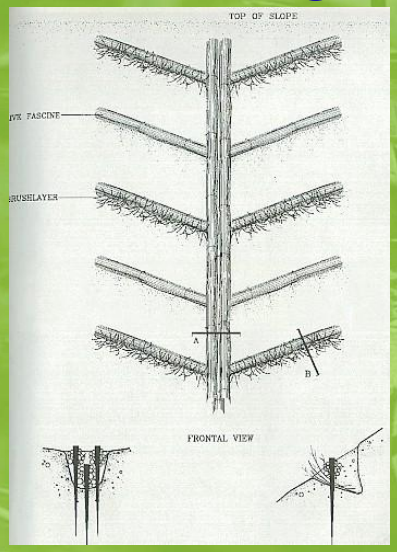
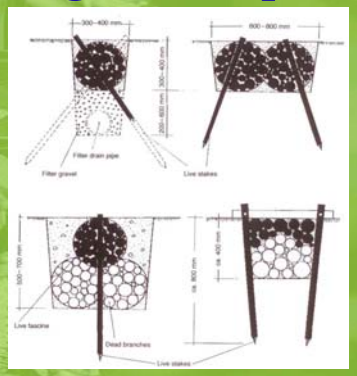
Soil Bioengineering Techniques





Live Pole Drain / Contour Fascines

(from *Donald H. Gray, and Robbin B. Sotir 1996)*

(H.M.Schiechtl and Stern 1996)

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Soil Bioengineering Techniques

Branch Packing

(Lisa Lewis, U.S.D.A. 2000)

Vegetated Geotextile lifts

(Lisa Lewis, U.S.D.A. 2000)

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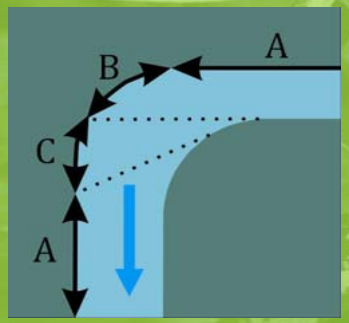
Site Assessment for Stream Banks



A: Parallel or Nearly Parallel to Flow (0 to 10)
B: Moderate Angle to Flow (10 to 45)
C: Directly Facing Flow (45 to 90)

Other Factors

- Hydrologic and Morphologic Considerations
- Ice Processes
- Riparian Considerations
- Geotechnical Considerations
- Bank Height, Aspect
- Public Uses: i.e. Park, Pedestrian Path etc.

Schematic for Determining Angle of Attack on Bank

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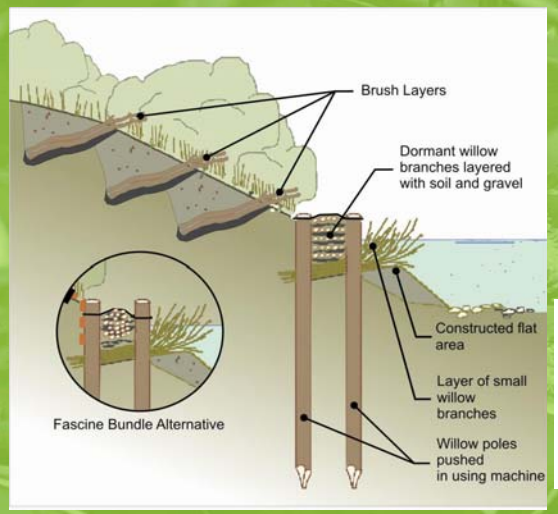
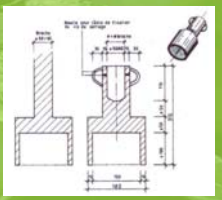
Soil Bioengineering Techniques





Fascines with Double Willow Poles
Adapted from Bernard Lachat, Ingenieurbiologie, Bulletin No.4 (December 2009).

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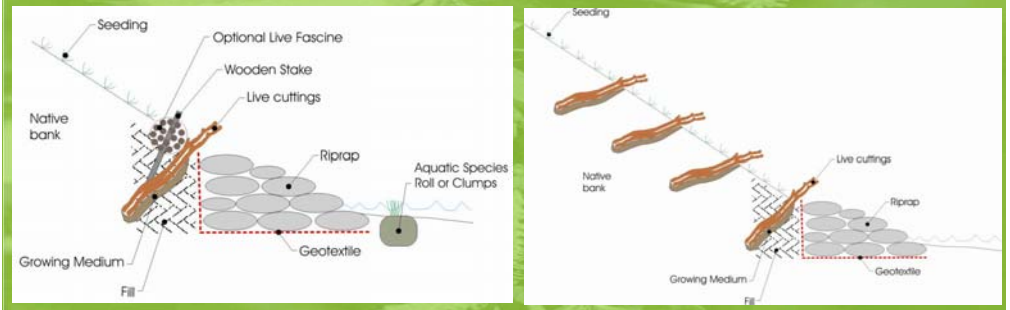
Soil Bioengineering Techniques



Rock Toe with One or Multiple Rows of Brush Layers
(Optional Live Fascine & Aquatic Roll)

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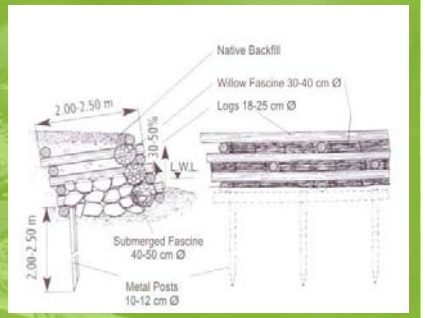
Soil Bioengineering Techniques

(Philippe Adam, et al., Biotec Biologie appliquée.)



Live Crib Wall for Stream Application
(Florin Florineth 2007)

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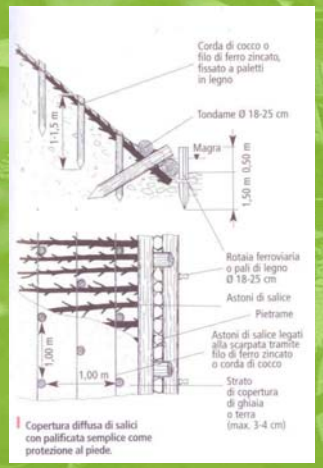
Soil Bioengineering Techniques



Live Brush Mattress

- **Narrow channel / steep stream bank**
- **Reduced rock requirement**

(Florin Florineth 2007, Helgard Zeh 2007)

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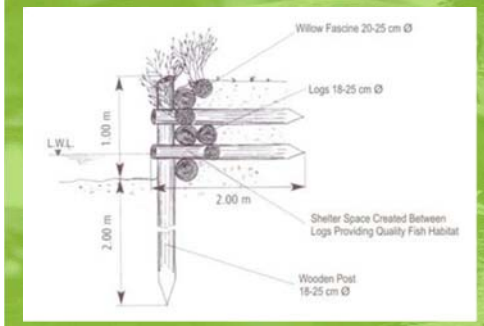
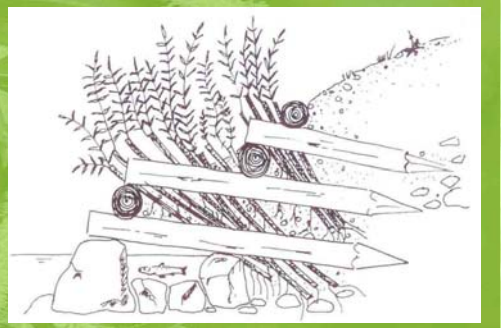
Soil Bioengineering Techniques





Fish Shelter Habitat and Bank Protection

- Shallow (less than 1 m high) undermined shorelines with high fish habitat value. (Florin Florineth 2007, Helgard Zeh 2007)

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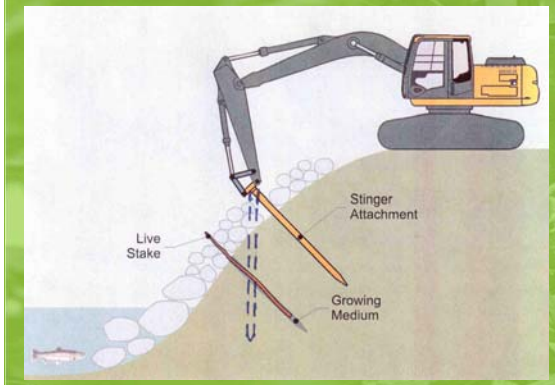
Soil Bioengineering Techniques



Live Staking of Existing Riprap (stinger or bucket)

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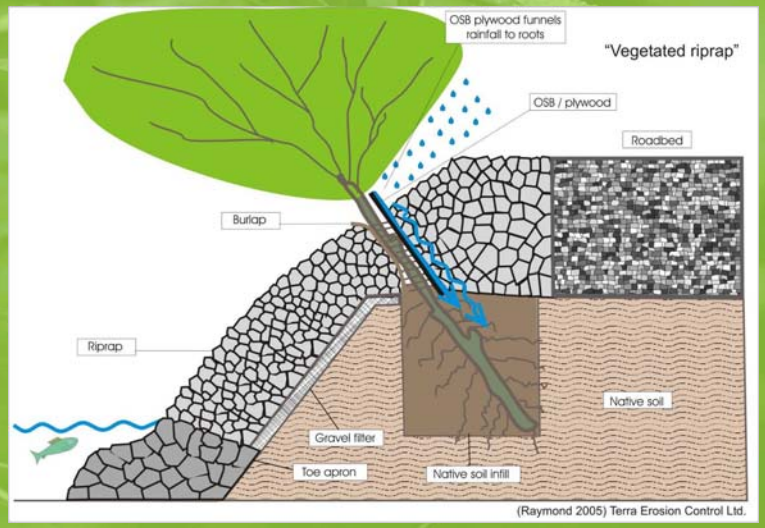
Vegetated Riprap: Road-Side Application



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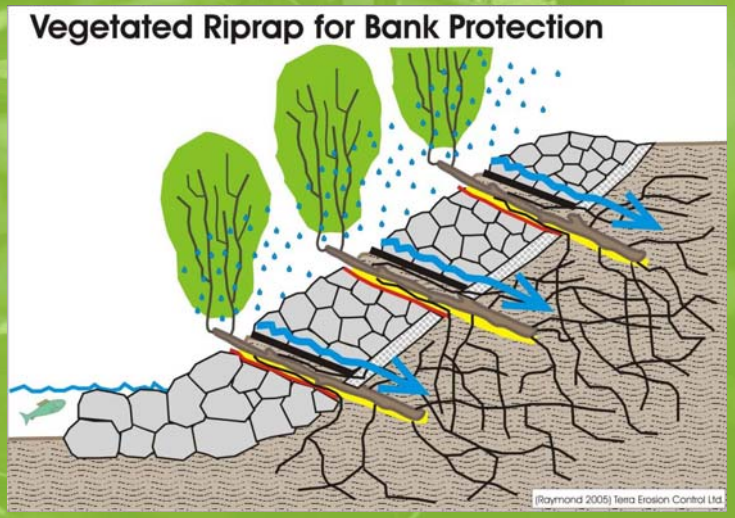
Vegetated Riprap: Slope Application



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Soil Bioengineering Process

- Harvesting / Processing & Storage of Live Material
- Harvesting / Processing & Fall Installation (no storage)

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Soil Bioengineering Process

Soaking of live material

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Terra Erosion Control Custom Soil Amendment

- Added during planting to promote growth.
- Contains:
  - Organic fertilizers
  - Sphagnum peat moss and / or humus and / or compost
  - Cultured mycorrhizae (ecto & endo)
  - Humic complexes (acids)
- Compost tea (replenishment of soil micro-organisms in depleted soil)

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Specialized Equipment

Equipment suited for low impact work and difficult access. Equipment working in or near fish habitat has to have environmentally friendly, biodegradable lubricants such as Panolin HLP Synthetic.

Presentation Outline

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Specialized Equipment

Temporary access ramp and working within riparian zones.

Presentation Outline

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Specialized Equipment

Overhead cable system used to transport materials on slopes.

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Specialized Equipment

Technology to reduce potential cause of injuries and streamline production. Fascine bundling benches to reduce back strain and materials handling cart for heavy loads in areas with limited access.

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Specialized Techniques





Specialized technique to reduce site disturbance.

Presentation Outline

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Stream Bank Protection using Vegetated Riprap

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Vegetated Riprap Description

- Vegetated riprap incorporates a combination of riprap and native vegetation in the form of live cuttings.
- The cuttings are planted in conjunction with the placement of rock along watercourses.
- Establishment of vegetation will improve fish habitat and provide added bank protection through the development of root mass.
- Provides a softer more natural appearance to the installed rocks.

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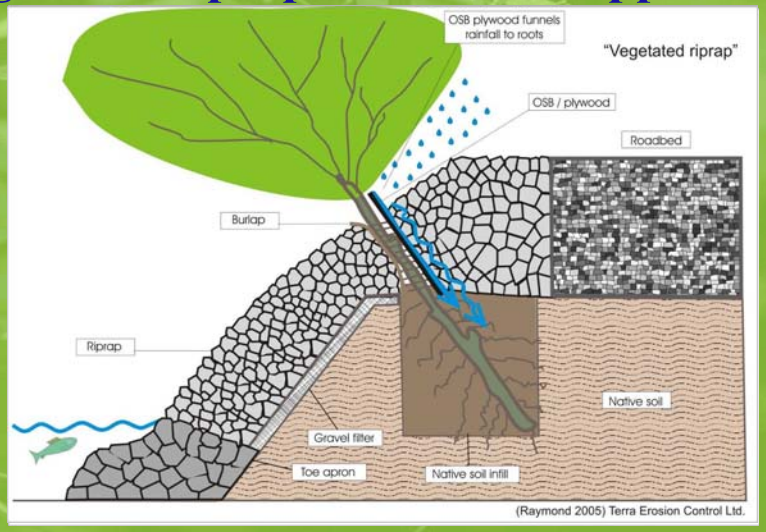
Vegetated Riprap: Road-Side Application



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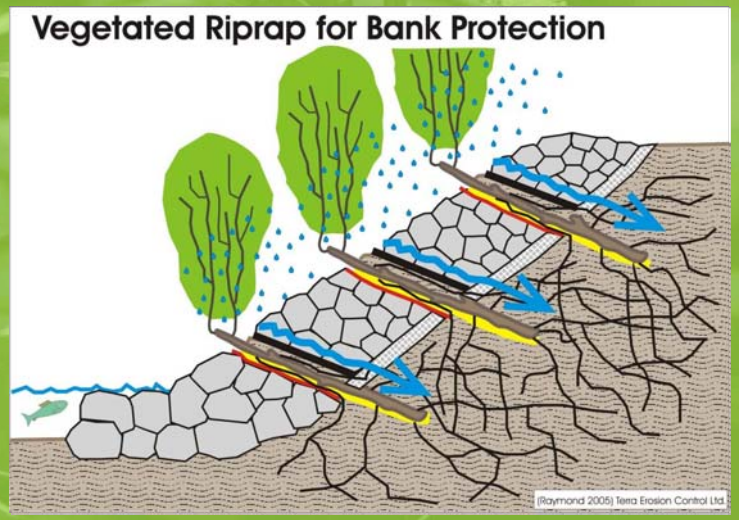
Vegetated Riprap: Slope Application



Presentation Outline

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Storm Water Outfall 56 Vegetated Riprap

Before Treatment.

Presentation Outline

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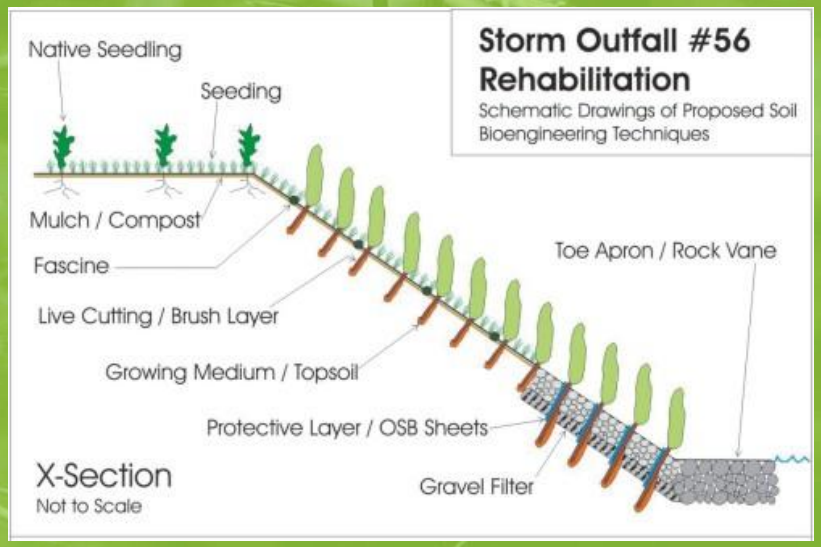
Storm Water Outfall 56
Design Elements



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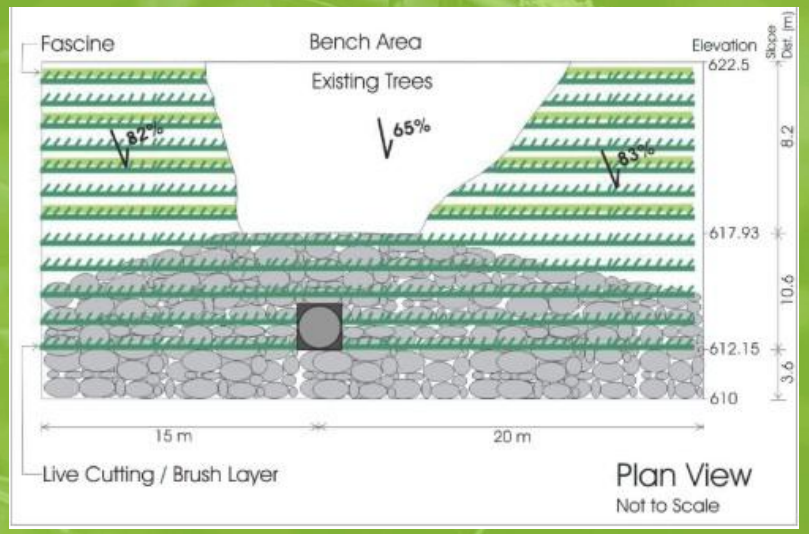
Storm Water Outfall 56
Design Elements



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Storm Water Outfall 56
Vegetated Riprap

Installation of rock vane anchor & floating turbidity curtain
(US Army Corps of Engineers / DOT Type 2 - 3ft/s)

Presentation Outline

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Storm Water Outfall 56
Vegetated Riprap

Temporary erosion and sedimentation control and riprap toe construction at bottom of bank in river.

Presentation Outline

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Storm Water Outfall 56 Vegetated Riprap

Trench excavated into bank behind riprap.

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Storm Water Outfall 56 Vegetated Riprap

Harvested (2.3 to 3 m) long live cuttings. Cuttings placed in trench with burlap between cuttings and riprap.

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Storm Water Outfall 56 Vegetated Riprap

Trench is backfilled using adjacent soil. Some soil is also placed over upper portion of cuttings; the burlap strip holds this in place.

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Storm Water Outfall 56 Vegetated Riprap

Protective wooden sheets placed over cuttings.

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Storm Water Outfall 56 Vegetated Riprap

A layer of filter gravel is applied to the slope and the next "lift" of riprap is placed above.

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Storm Water Outfall 56 Vegetated Riprap

Completed vegetated riprap.

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Storm Water Outfall 56 Vegetated Riprap

Fall 2008

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Storm Water Outfall 56 Vegetated Riprap

June 2009

Terra Erosion Control Ltd.

Storm Water Outfall 56 Vegetated Riprap

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Storm Water Outfall 56 Vegetated Riprap

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Storm Water Outfall 101
Vegetated Riprap

Before Treatment.

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Storm Water Outfall 101
Basic Project Requirements

- **Assessment & Preliminary Engineering**
- **Detailed Design**
- **Regulatory Application and Compliance**
- **Construction**

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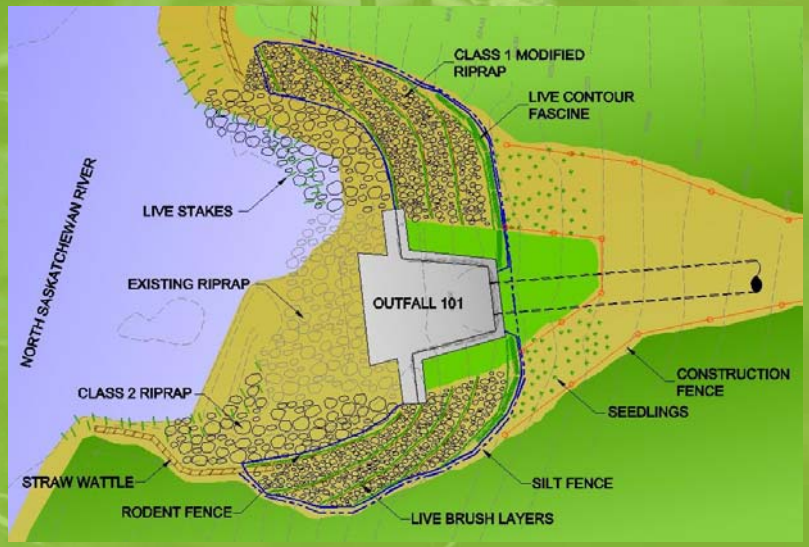
Storm Water Outfall 101
Design Elements



Stantec Design based on Previous TEC Work

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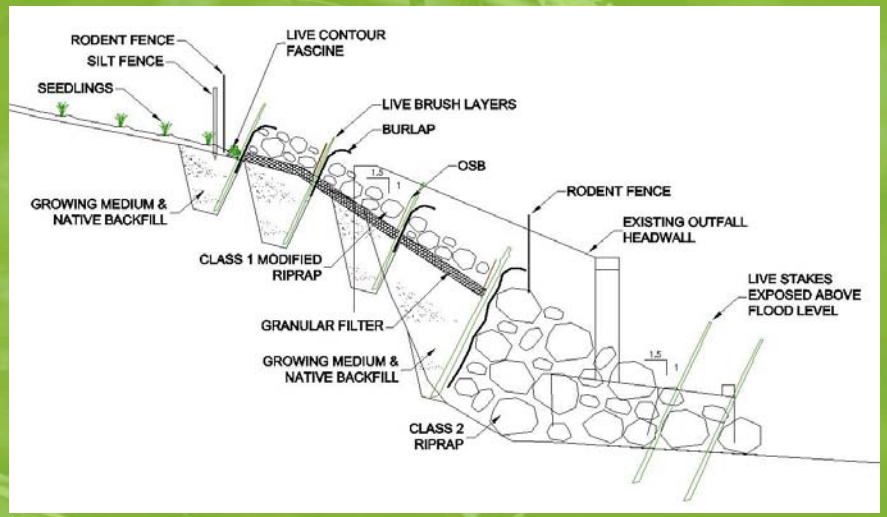
Storm Water Outfall 101
Design Elements



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Storm Water Outfall 101 Vegetated Riprap

Cuttings placed in trench with burlap between cuttings and riprap.

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Storm Water Outfall 101 Vegetated Riprap

Long (2.3 m) live cuttings laid out along trench. Trench backfilled and wooden sheets put in place.

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Storm Water Outfall 101
Vegetated Riprap

Implementation of work.

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Storm Water Outfall 101
Vegetated Riprap

Completed vegetated riprap (November 2008).

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Storm Water Outfall 101
Vegetated Riprap

September 2009

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Storm Water Outfall 101

September 2009

Terra Erosion Control Ltd.

Storm Water Outfall 101

June 2010

Presentation Outline

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Storm Water Outfall 101

June 2010

Presentation Outline

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Storm Water Outfall 13

City of Edmonton

Edmonton, Alberta

Conventional Rock Riprap with Root Wads, Sensitive Riparian Area

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Storm Water Outfall 13

Associated Engineering's design prescribed protection of Outfall 13 for stabilization of Wolf Willow Creek Ravine with traditional rock riprap.

October 2007

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Storm Water Outfall 13

Access to the site, 400 m along the North Saskatchewan River.

The existing path layout was revised and carefully constructed using a walking excavator (Spyder Hoe) to minimize cut height and soil disturbances.

November 2008

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Storm Water Outfall 13

Excess material was transported out of the ravine and construction materials were transported into the ravine using two Komatsu tracked dump trucks.

November 2008

Terra Erosion Control Ltd.

Storm Water Outfall 13

Creek dewatering was carried out using two coffer dams constructed with sandbags and filled with clay material. 4" plastic gravity pipes and pumps were used to divert water to a settling pond.

November 2008

Terra Erosion Control Ltd.

Storm Water Outfall 13

Barriers made of straw bales and silt fencing were used as a sediment trap to the North Saskatchewan River.

November 2008

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Storm Water Outfall 13

Channel and bank regrading. Placement of geotextile and riprap.

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Storm Water Outfall 13

Bank regrading. Placement of geotextile and riprap.

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Storm Water Outfall 13

Bank regrading. Placement of geotextile and riprap. Finished work.

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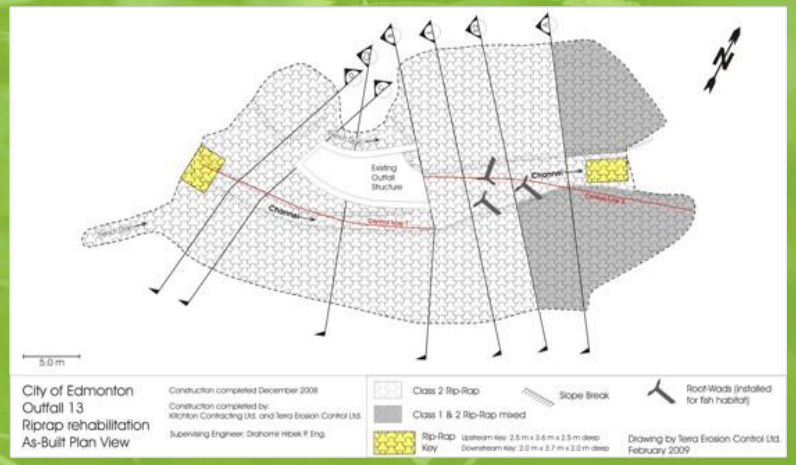
Storm Water Outfall 13



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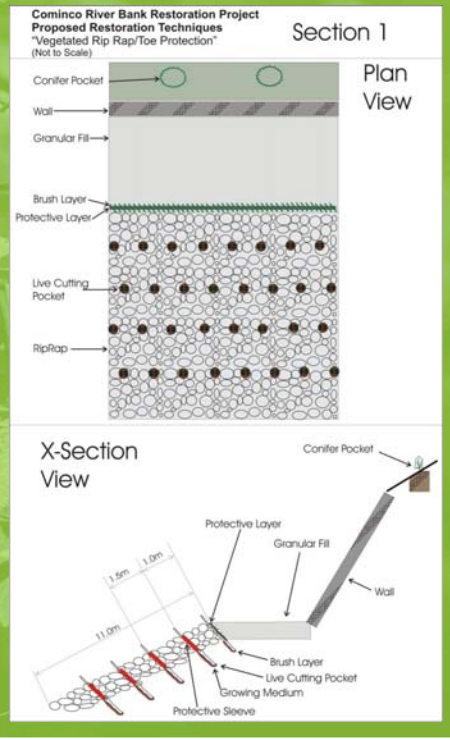
Riverbank Restoration Project (Riverbank Sections)

Teck Cominco Metals Ltd.
Trail, British Columbia

Terra Erosion Control Ltd.

Riverbank Restoration Project Section 1 Vegetated Riprap

Vegetated riprap design was a collaboration between AMEC Earth Environmental and Terra Erosion Control.



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Riverbank Restoration Project
Section 1 Vegetated Riprap

Riprap toe apron constructed at base of the bank to support the riprap placed on the bank above.

Spring 2006

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Section 1 Vegetated Riprap

First “lift” of riprap placed above toe apron.

Note riprap placed over gravel filter layer spread on bank.

Spring 2006

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Section 1 Vegetated Riprap

Checking elevation of riprap before placing 3rd row of pockets.

Spring 2006

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Section 1 Vegetated Riprap

After all 4 rows of pockets were installed on the bank, a trench was excavated behind the riprap next to the road.

Spring 2006

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Vegetated Riprap Installation

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Section 1 Vegetated Riprap

Long (2.3 m) live cuttings laid out along trench.

Tips protrude above riprap.

Spring 2006

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Section 1 Vegetated Riprap

Topsoil spread over base of live cuttings.

Trench then filled, covering lower 1 m of cuttings.

Spring 2006

Terra Erosion Control Ltd.

Section 1 Vegetated Riprap

Protective wooden sheets placed over portion of live cuttings to be covered with riprap.

Spring 2006

Terra Erosion Control Ltd.

Section 1 Vegetated Riprap

Riprap placed, bringing road up to final subgrade elevation.

Spring 2006

Terra Erosion Control Ltd.

Section 1 Vegetated Riprap

Summer 2006

Section 1 Vegetated Riprap Brush Layer

May 2007

Terra Erosion Control Ltd.

Section 1 Vegetated Riprap

Summer 2008

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Section 1 South Vegetated Riprap

September 15, 2010

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Section 1 North Vegetated Riprap

September 15, 2010

Terra Erosion Control Ltd.

Section 1A Vegetated Riprap

Trench excavated in riprap placed for road subgrade, then long (2.3 m) live cuttings laid out along trench.

Spring 2008

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Section 1A Vegetated Riprap

Live cuttings laid out along trench.
Note strip of burlap used here.

Spring 2008

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Section 1A Vegetated Riprap

Sand was placed over live cuttings before backfilling trench to provide good rooting medium.

Spring 2008

Terra Erosion Control Ltd.

Section 1A Vegetated Riprap

Protective wooden sheets put into position and riprap placed up to final road subgrade.

Spring 2008

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Section 1A Vegetated Riprap

Completed Section 1A with road surface in place.

Spring 2008

Terra Erosion Control Ltd.

Section 1A Vegetated Riprap

Early Summer 2008

Terra Erosion Control Ltd.

Section 1A Vegetated Riprap

Late Summer 2008

Presentation Outline

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Section 1A Vegetated Riprap

September 15, 2010

Presentation Outline

Terra Erosion Control Ltd.

Section 1A Vegetated Riprap

September 15, 2010

Presentation Outline

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Section 1 & 1A Vegetated Riprap

2011

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European Examples of Vegetated Shorelines Protection

(By Others)

Terra Erosion Control Ltd.

Brush Mattress Vienna Austria

(Photo, Dr. Hans Peter Rauch, Universität für Bodenkultur)

Terra Erosion Control Ltd.

Brush Mattress Vienna Austria

Terra Erosion Control Ltd.

Live Crib Wall Vienna Austria

(Photo, Dr. Hans Peter Rauch, Universität für Bodenkultur)

Terra Erosion Control Ltd.

Live Crib Wall
Vienna Austria

Presentation Outline

Terra Erosion Control Ltd.

Vegetated Riprap
Danube River

Presentation Outline

Terra Erosion Control Ltd.

Vegetated Riprap Danube River

Presentation Outline

Terra Erosion Control Ltd.

Thank you for your attention!

Additional project information is available at
www.terraerosion.com