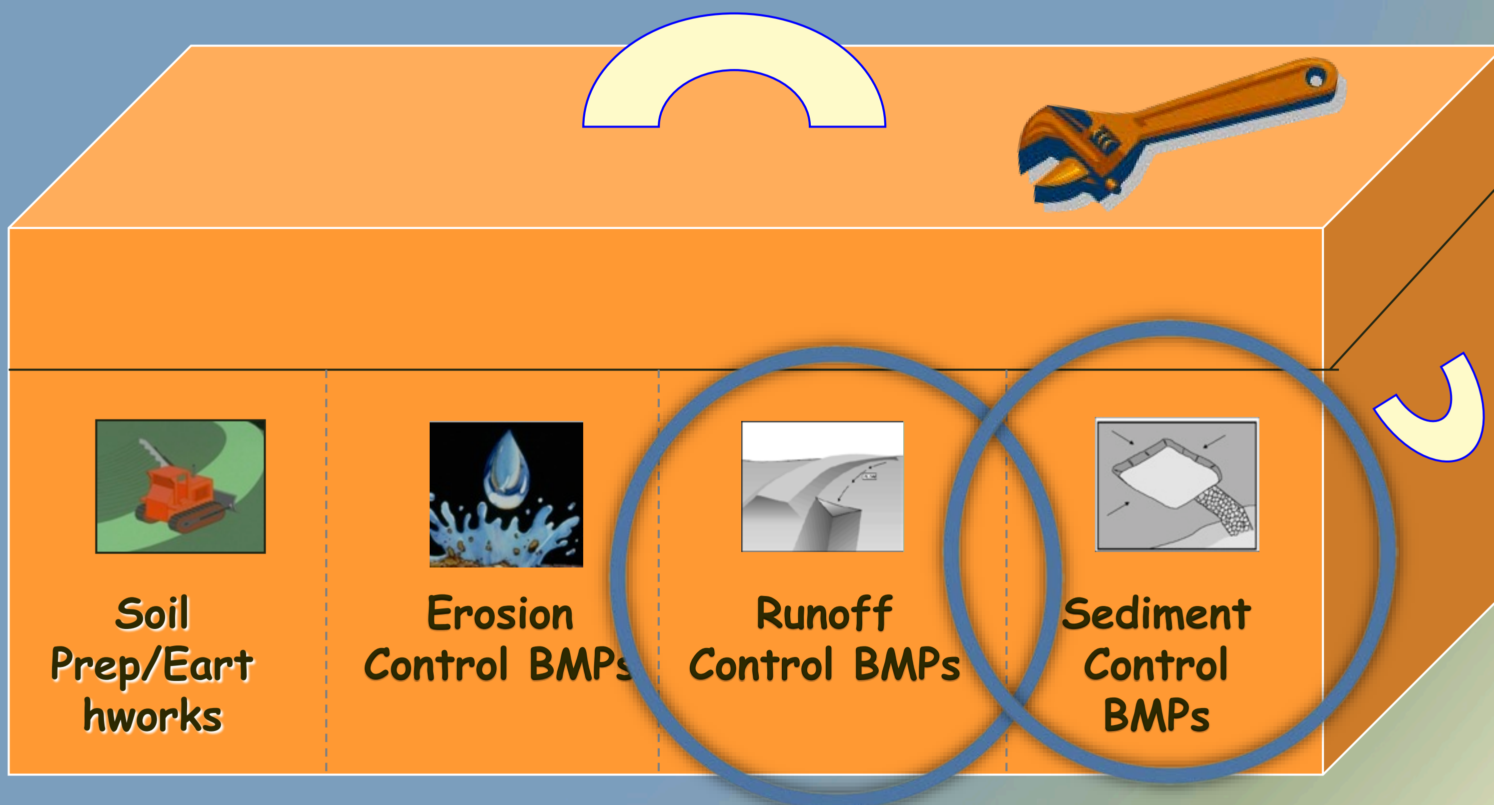
Mission Impossible-
Advanced Methods for Steep Slopes

And More

Runoff Control BMPs

Sediment Control BMPs

Stabilized Construction Entrance




ADVANCED
SUSTAINABLE
EROSION CONTROL
CTSW-OT-11-255.13.1.D9

How Do We Define Sustainability?

Vegetation

Water

Soil

Sustainable erosion control meets or exceeds stormwater quality requirements and minimizes life cycle costs by 1) creating long-term soil health, 2) establishing the most appropriate vegetation, and 3) achieving permanent soil stabilization.

Notice of Termination (NOT)

Methods for Documenting Final Stabilization of Disturbed Soil Areas (DSA)

- 70% Cover Method
- RUSLE or RUSLE2 Method
- Custom Method

Inspection and Certification

- Site Inspection
- Certification for Resident Engineer

Methods for Documentation-NOT

70% Cover Method Applies When

Construction is completed and permanent erosion control is in place and functional

Functional: A uniform vegetative cover equal to 70% of the native background vegetation coverage or equivalent stabilization measures have been employed

Until NOT is Submitted *

- The SWPPP must remain on Construction Site
- Site Inspections continue
  - before storms, after storms, during storms, daily-weekly depending
- Notice of Discharge requirements
- REAP (II and III)
- Quarterly Reports
- Annual Certificate of Compliance

Summary of Big Differences

- District Director is Legally Responsible Party – LRP
- SWPPP is viewable on-line
- Minimum BMPs required
- Inspections (sampling) required all year
- Discharges must be reported
- Permit Coverage continues until permanently "stabilized"
  - All Construction is complete
  - Final Stabilization is complete
- Implications
  - Caltrans takes more responsibility
  - BMPs MUST be effective
  - Techniques and BMPs must be updated as necessary
  - Final stabilization must be effective and timely
- Notice of Termination is very important

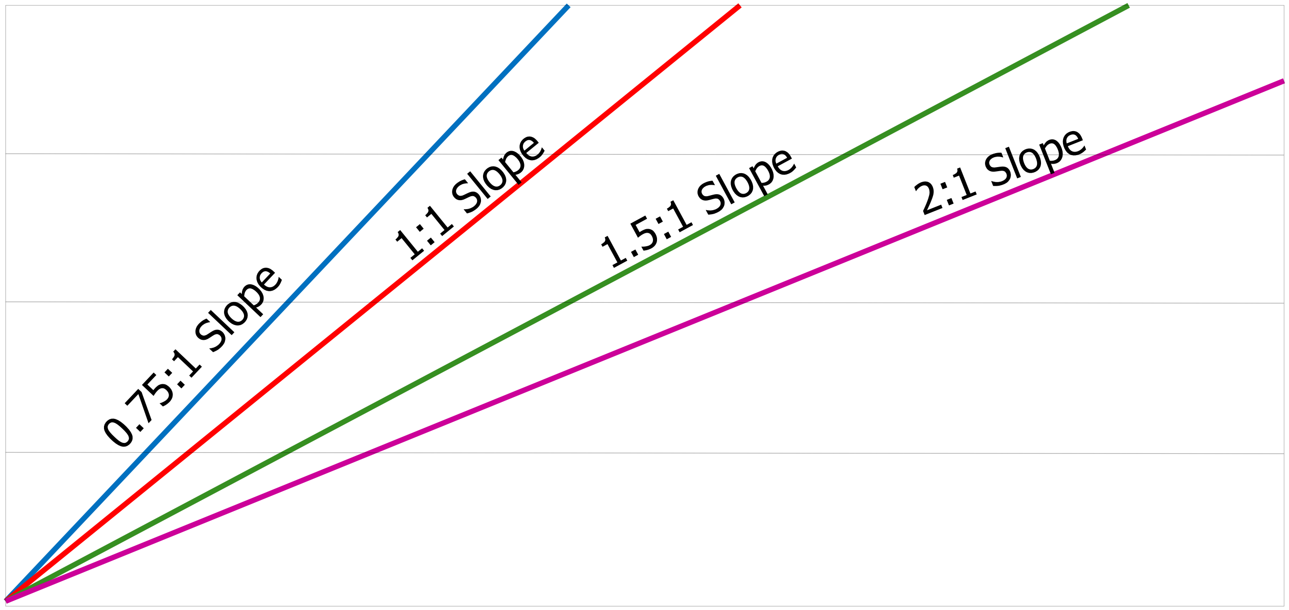
How Do We Define Steep Slopes?

What are the challenges we face in dealing with slopes steeper than 2:1?

Slope Stability

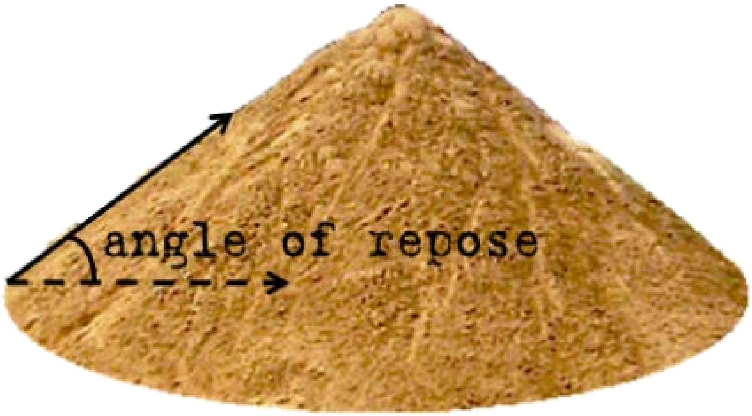
Vegetation Establishment

Erosion and Sedimentation



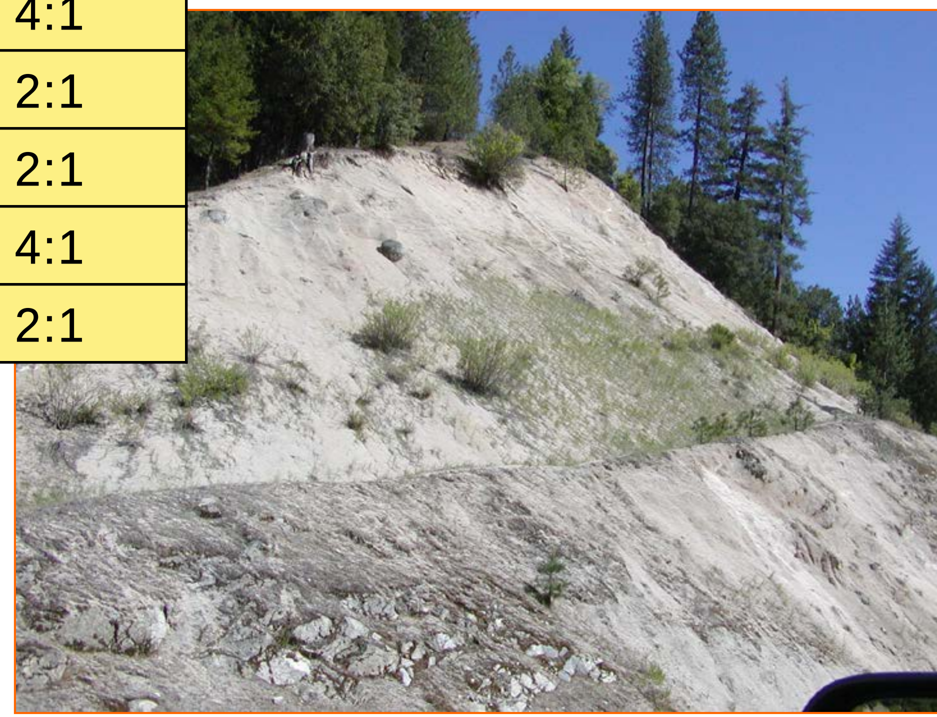
Angle of repose (aka Angle of Friction)

- Maximum slope granular material is stable
- Related to density, grain size angularity, water content,



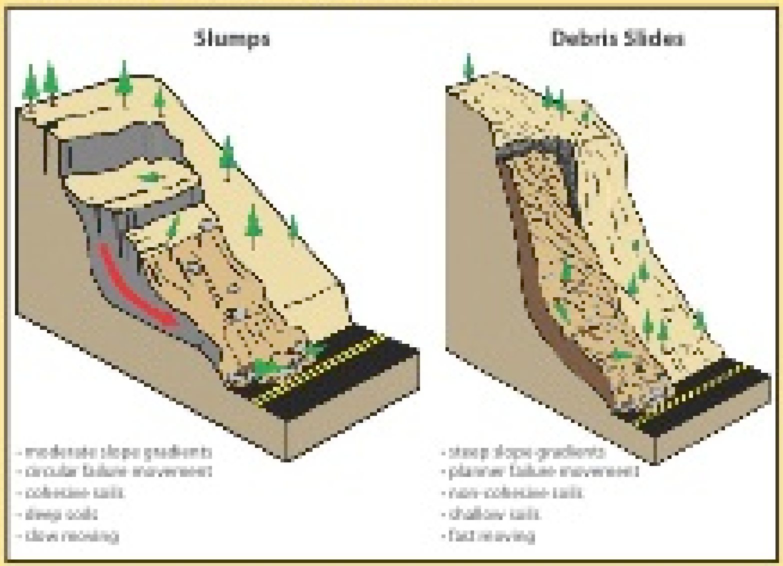
Angle of repose

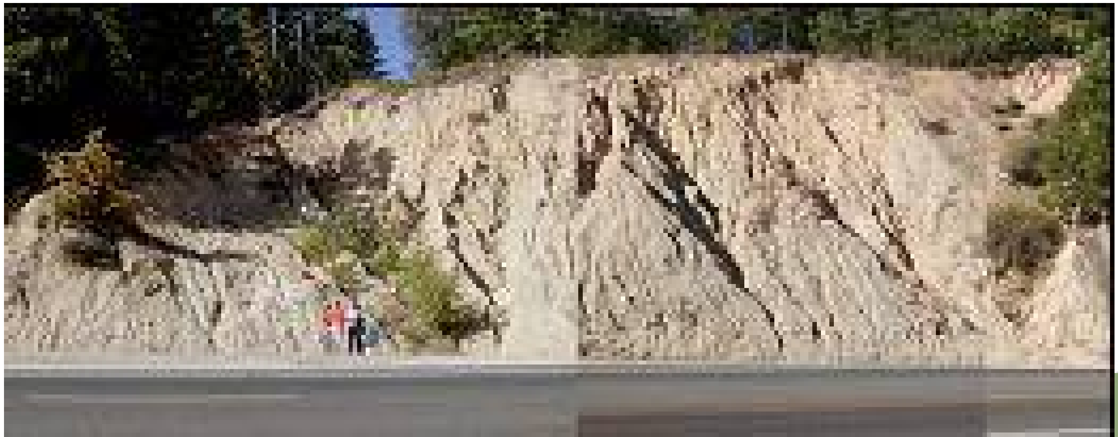
Material	angle	ratio
Sand (dry)	34	2:1
Sand (wet)	45	1:1
Sand (water filled)	15-30	4:1
Shale (broken)	35	2:1
Clay (dry clump)	25-40	2:1
Clay (wet excavated)	15	4:1
Granite	35-40	2:1



Common slope problems associated with Roads *

Figure 5.55 - Common landslides typically associated with road construction. Modified after Varnes (1978) and Bedrossiand (1983).





Site challenges

New constructed short cut slope 1.25:1 after first heavy rains. There was some grass growing prior to shallow failure. Not track walked, outer slope was loose.

Site Challenges

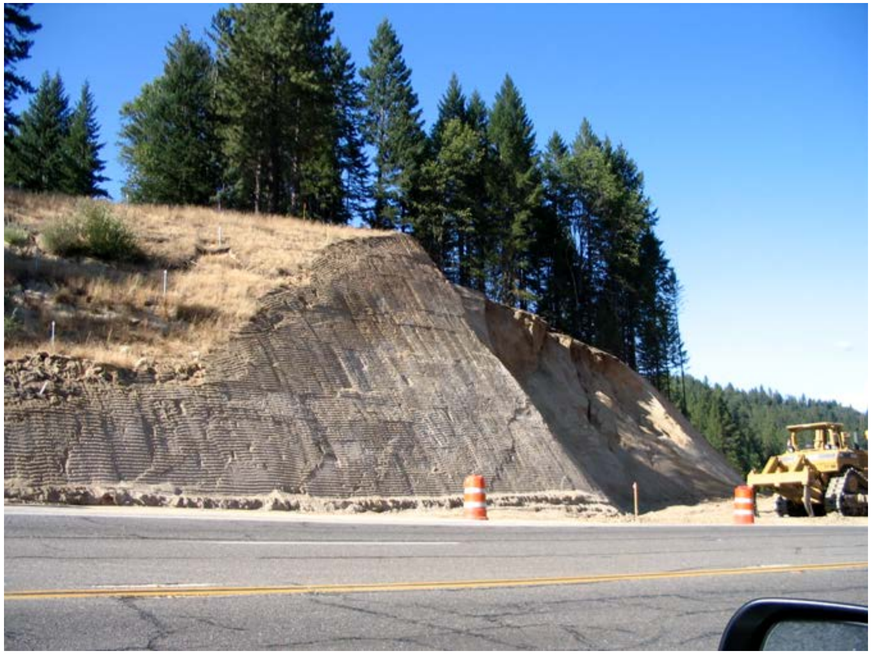
1.5:1 slope: Debris flow at base of fill due to surface infiltration in coarse-grained material after first heavy rain. Very loose outer fill material, no track walking.

Site Challenges

Same location as previous slide, prior to complete failure of outer slope. Very loose to 3-foot depth, based on probe penetration.

Hard Costs

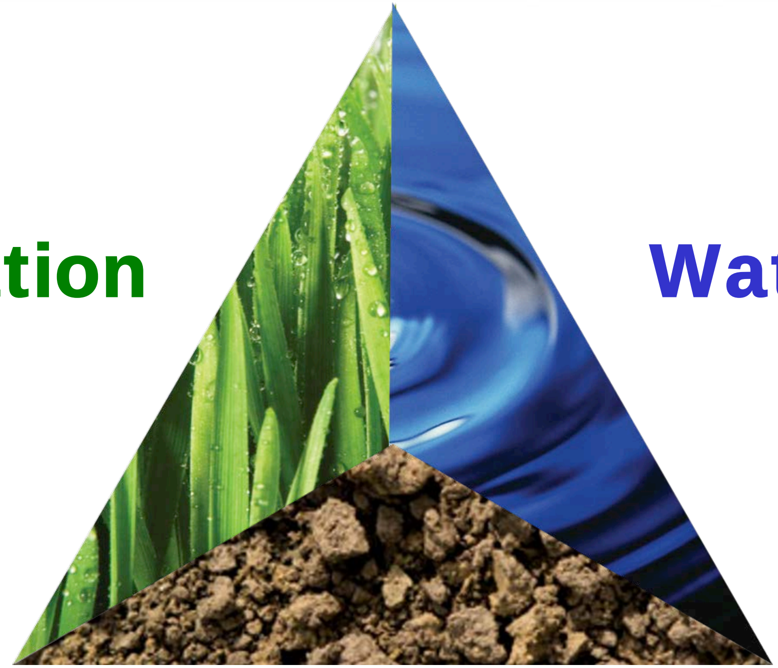
46 million dollars worth of emergency contracts were issued in the winter of 2004-2005



Many of these contracts were related to repairing slopes with site challenges

How do we best control erosion?

Vegetation



Water

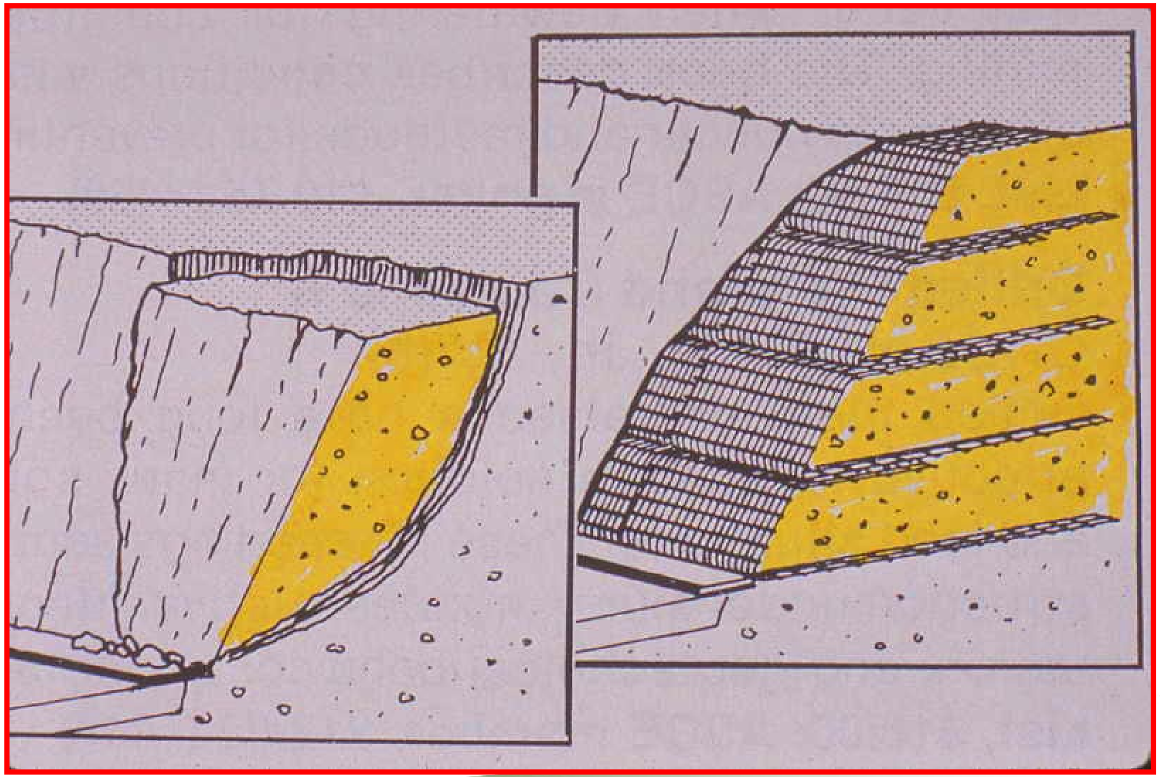
Soil

Sustainable erosion control meets or exceeds stormwater quality requirements and minimizes life cycle costs by 1) creating long-term soil health, 2) establishing the most appropriate vegetation, and 3) achieving permanent soil stabilization.

Examples of an Innovative Solution *

- Additional Geotechnical Reinforcements may be necessary if increased infiltration or soil roughening is desired.

- Mechanical Earth Reinforcements
- Geogrids
- Brushlayering
- Gravity Toe Wall
- Cellular Confinement
- Wire Mesh Confinement



Infiltration Topics

- Steep slopes with high infiltration rates can be stable when all stabilizing reinforcements are considered:
  - Optimum compaction 85-90% range
  - Root reinforcement – Varied length and type
  - Cohesion - OM can increase cohesion
  - Geotextile reinforcements as needed

Infiltration Constraints

Soil types and infiltration

Hydrologic Soil Group Descriptions

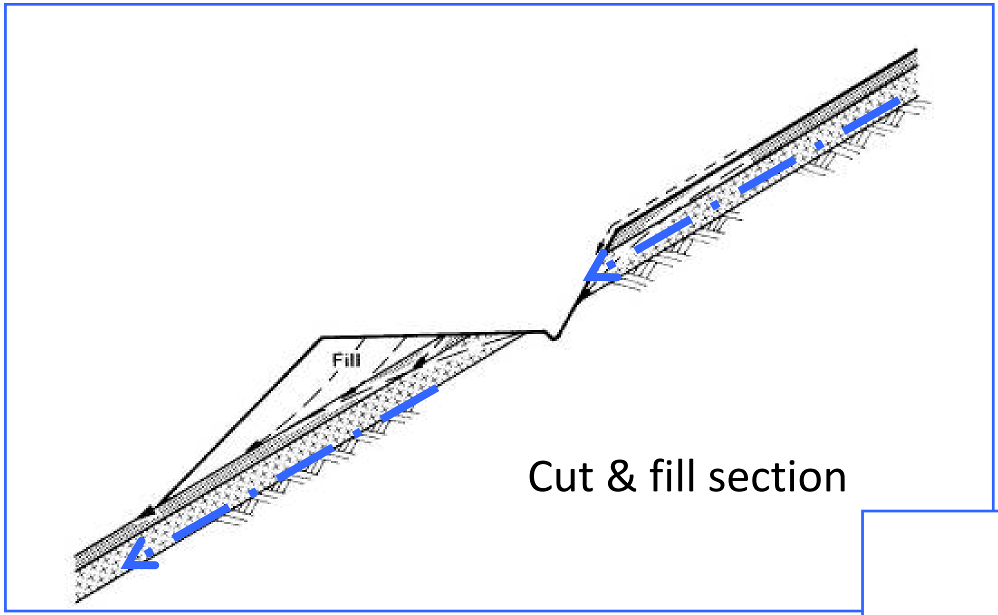
A -- Well-drained sand and gravel; high permeability.

B -- Moderate to well-drained; moderately fine to moderately coarse texture; moderate permeability.

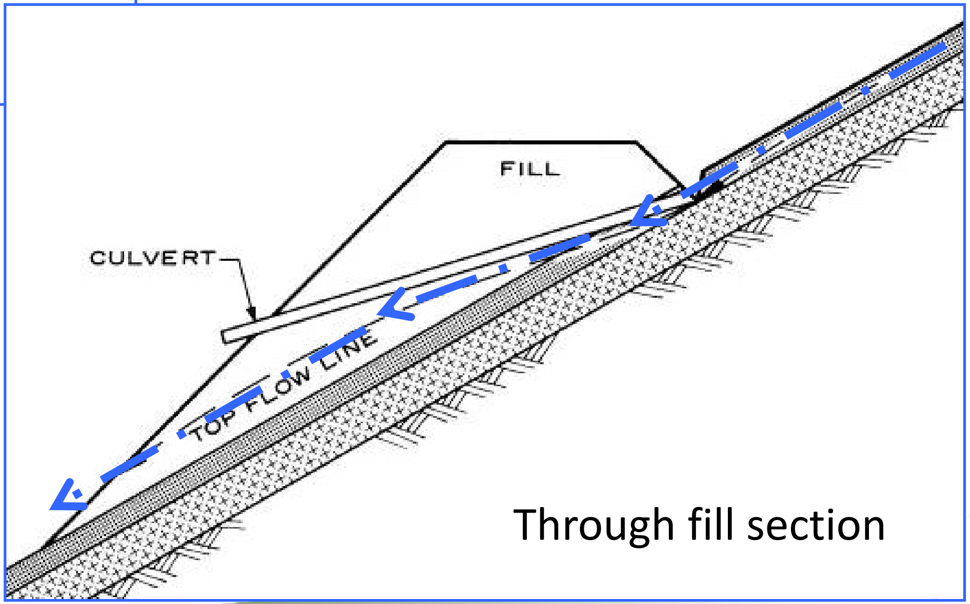
C -- Poor to moderately well-drained; moderately fine to fine texture; slow permeability.

D -- Poorly drained, clay soils with high swelling potential, permanent high water table, claypan, or shallow soils over nearly impervious layer (s).

Both Drainage and Earth Reinforcement Can Be ** Important in HSG A and B



Either infiltrating road runoff or seepage from blocked road ditch can saturate and destabilize road fill.



Granitic soils with little or no cohesion are very susceptible to surficial and seepage erosion

Root Strength - Geotechnical Benefits of Vegetation ***

- Root Reinforcement – roots mechanically reinforce a soil by transfer of shear stress in the soil to tensile resistance in the roots
  - Roots tensile strengths have been measured.
  - Strength becomes cumulative with time
  - Shrub roots have tensile strengths equivalent to trees
  - Grasses with fine, fibrous roots have high tensile strength and superior pullout resistance.

- Buttressing and Arching – Anchored and embedded stems can act as "buttress piles" or arch abutments to counteract downslope shear forces.

Geotechnical Benefits of Vegetation ***

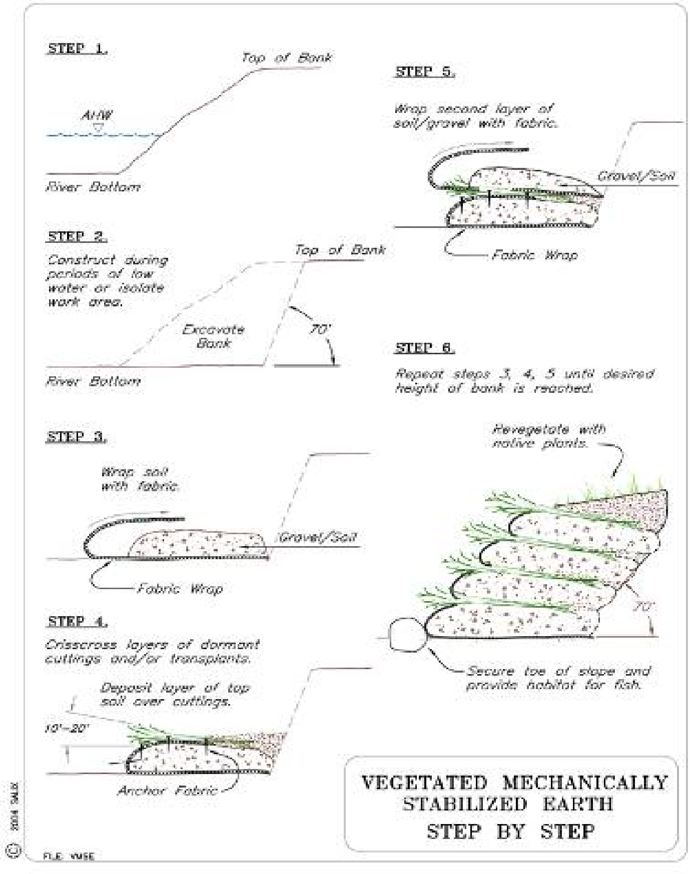
Root Reinforcement

- These roots have grown in less than 1 yr!

Over **100'** of root in **9** months from **one** stake

During Construction vs Post Construction ***

- Integrated Approach – Installed during construction. Integrating structural and vegetative components in a mutually-reinforcing manner
- Revegetation approach - Installed post-construction.



Example of a Biotechnical Approach ***

Vegetative and structural components working in a mutually reinforcing manner

Brushlayering helps to both reinforce and drain slopes **

Figure 5.58 - Groundwater moves downslope above restrictive soil layers. Seeps are seen in road cuts where the restrictive layer is exposed. Increased soil water that occurs above restrictive layers can increase slope instability.

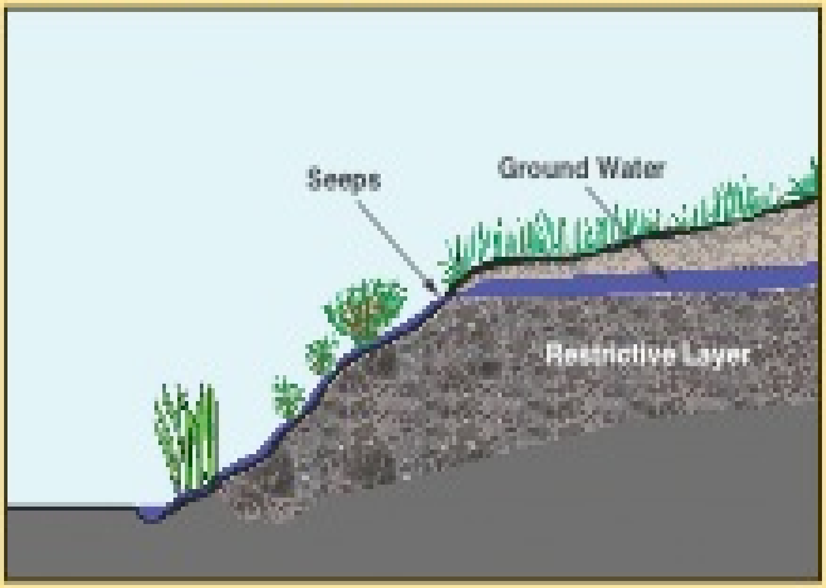
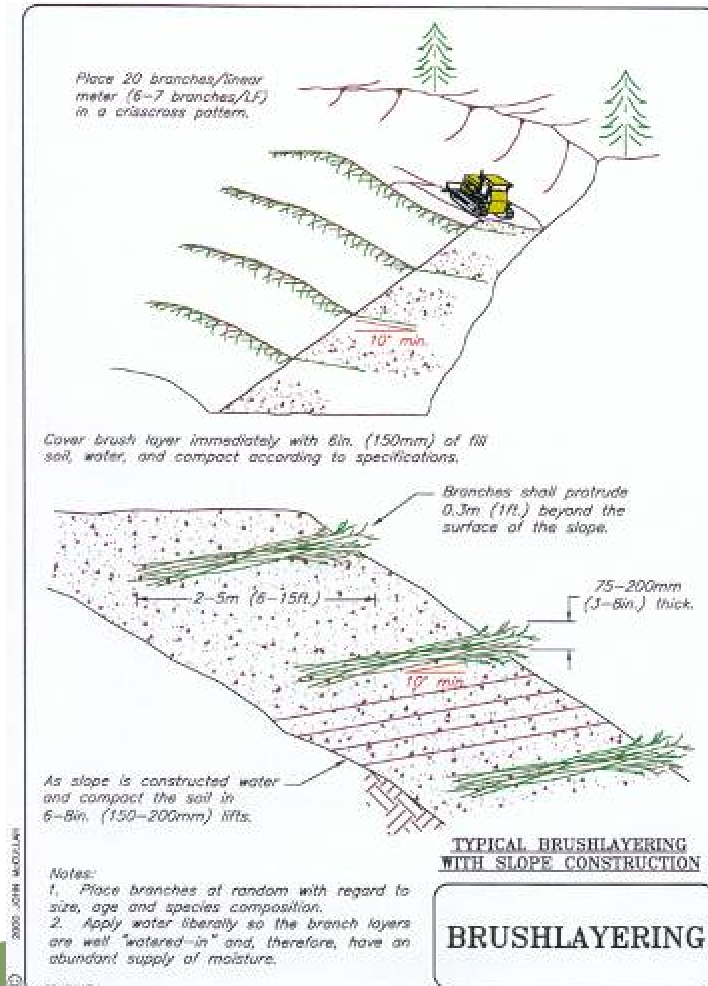


Figure 5.57 - In this photograph, a restrictive layer is very close to the soil surface. During a rain storm, water moved through the shallow soil layer and encountered a restrictive layer. Water then moved downslope, building up pressure, until the increased pore pressure and soil weight exceeded the strength of the soil to resist these forces. At this point, mid to lower slopes failed.

SR 299W SHA 1991 **

- Slope #2 biotechnical slope reinforcement method



SR 299W SHA 1991 **

- Brushlayering was installed in September.
- Temperatures were over 100°
- Branches were not soaked (5-10 days current recommendation)
- Watering fill for compaction probably aided survival

SR 299W SHA 2008 **

Mechanical Approach **

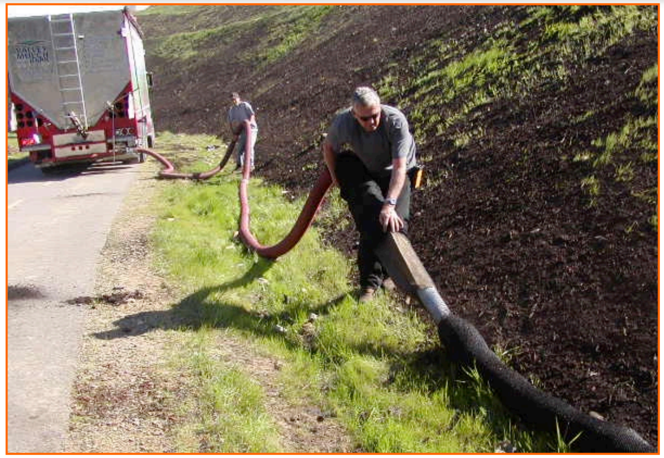
Engineered Solution for Improved Shear Strength

- Required when vegetation alone cannot stabilize slope
- This should include some vegetation component
- Yields: Full stability and Revegetation upon installation

Adding Organics *

Many ways to add organic materials

- Duff/Topsoil
- Mulch
- Compost
- Organic Fertilizers
- Mychorrizae fungi
- Soil microorganisms



Mycorrhizal Fungi – Endo / Arbuscular Mycorrhizae

- AM Fungi availability imperative for native grass establishment

Mychorrizae Inoculums
$200 per bag

Steep Slope Solutions

Advanced BMPs

- BMP Selection Process
- RECP Wrap
- RECP Flap
- Brush Layering
- Stepped Slopes
- Soil Filled RSP

Other Steep Slope Options

Proceed with

Steep Slopes Solutions

Advanced BMPs

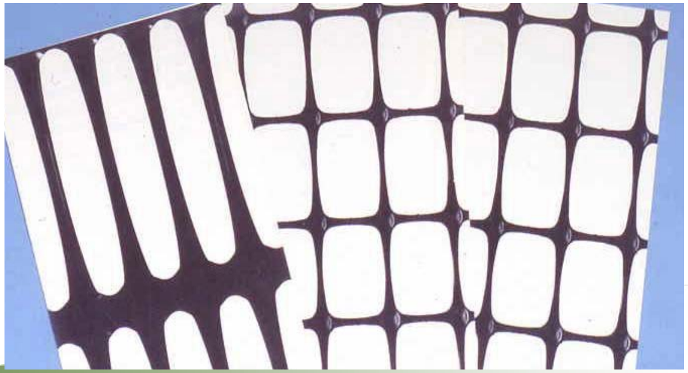
Best Management Practice	Specification
RECP Wrap (For Fills)	SSP Under Development
RECP Flap (For Cuts & Fills)	SSP Under Development
Brush Layering	Nonstandard Specification
Stepped Slopes (For Cuts)	SSP Section 19 Earthwork HDM (Chapter 300 Topic 304.5)
Rock Slope Protection (RSP) with Soil	Nonstandard Specification

* **R**olled **E**rosion **C**ontrol **P**roduct

Steep Slope Solutions

RECP Wrap Materials

- Netting – Biodegradable Coconut (**Coir Netting**)
- Erosion Control Blankets (**ECBs)**
  - Temporary or Permanent
  - Biodegradable filler
  - Not as strong or durable
- Turf Reinforcement Mats (**TRMs)**
  - TRMs have a permanent component (Polypropylene)
  - TRMs have higher strengths
- Alternative using polymeric **Geogrid** as wrap component



Steep Slope Solutions

Coir Netting:

400 g/m² **

- Large openings, can be hydroseeded
- Not too strong, degrades 1-3 yrs*

700 g/m²

- Medium strength , degrades 2-5 yrs*

900 g/m²

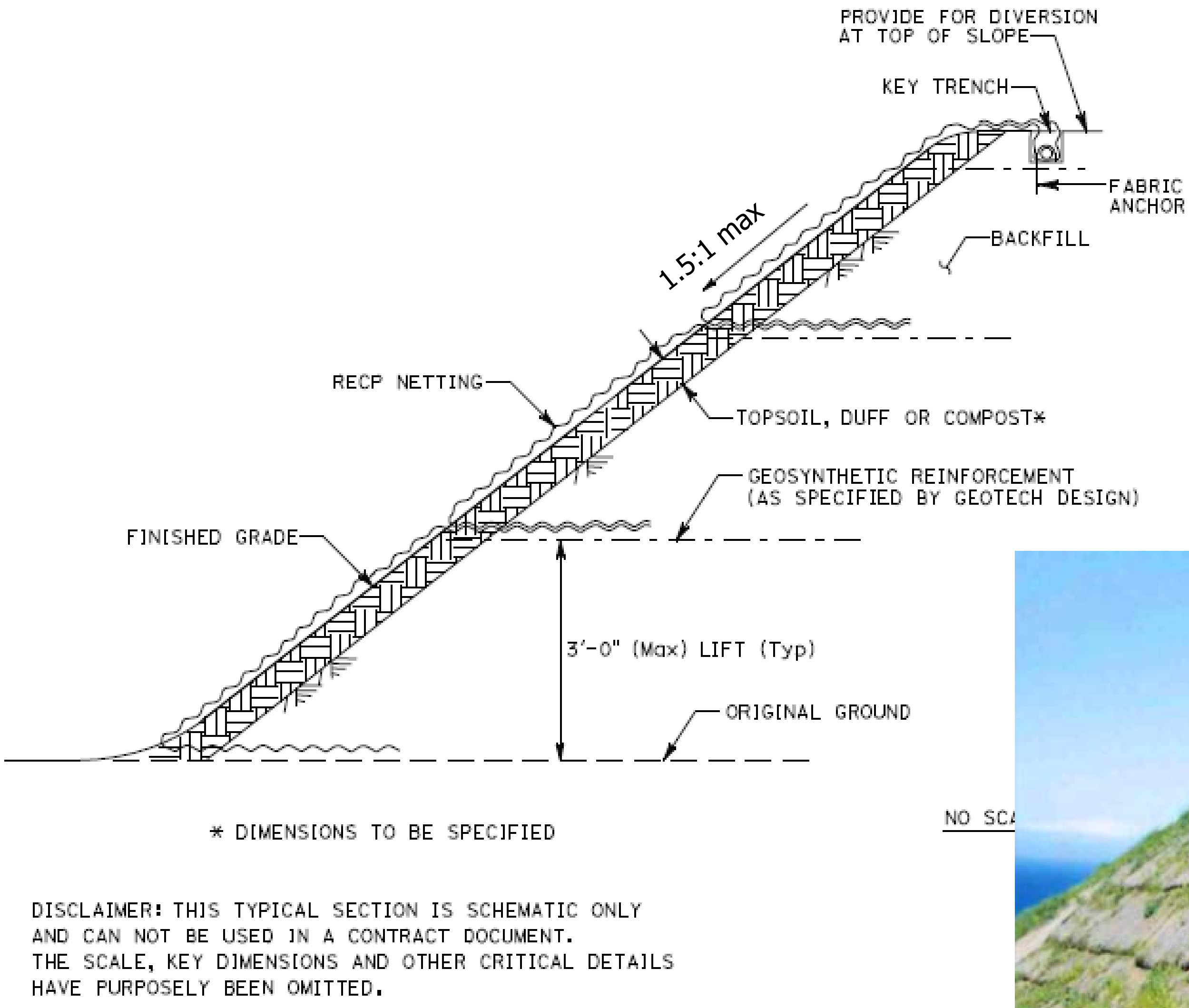
- Small openings, cannot be hydroseeded
- High shear strength, degrades 4-10 yrs *
- Specified for RECP Wrap

** Stronger and more durable than jute

* Biodegradation rate dependant on climate, soil microbes, etc.

RECP Wrap Materials

Steep Slopes Solutions (Advanced BMPs)



RECP Wrap

RECP Wrap Materials

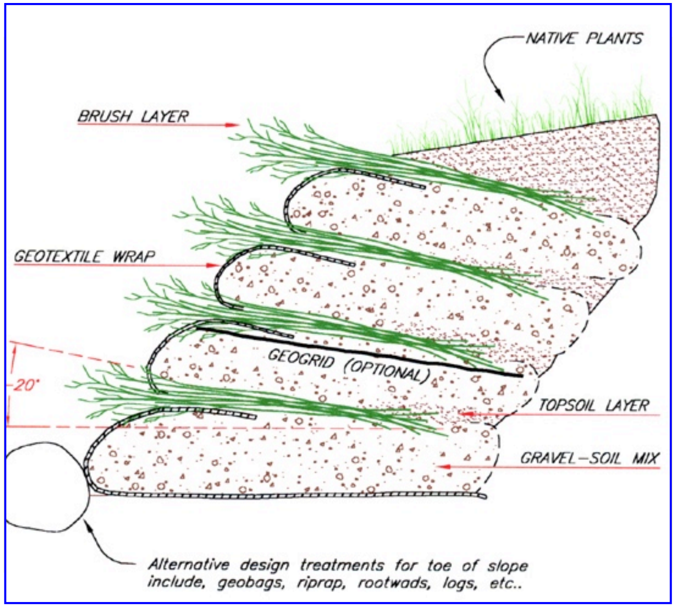
- Using biaxial geogrid
- Planted with grasses

Need method to pull wrap tight or build form or ??

Steep Slope Solutions

RECP Wrap – Case Study

- Slope failure of <u>road fill</u>
- A "coconut composite" * TRM was selected for reinforcement and wrap



* 3-layers high tensile, permanent polypropylene with biodegradable coir "filler" to hold moisture for seeds

Steep Slope Solutions

RECP Wrap – Case Study

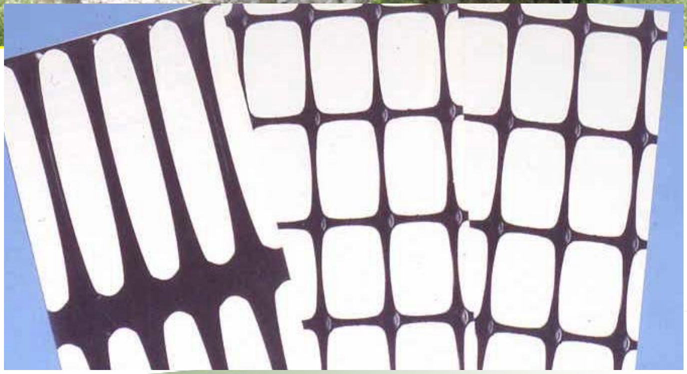
4’ vertical lifts with brushlayering

Geotextile was placed atop brushlayers

Compaction achieved by track walking

Highway 330 to Big Bear – RECP Wrap w Geogrid

Approx 2007

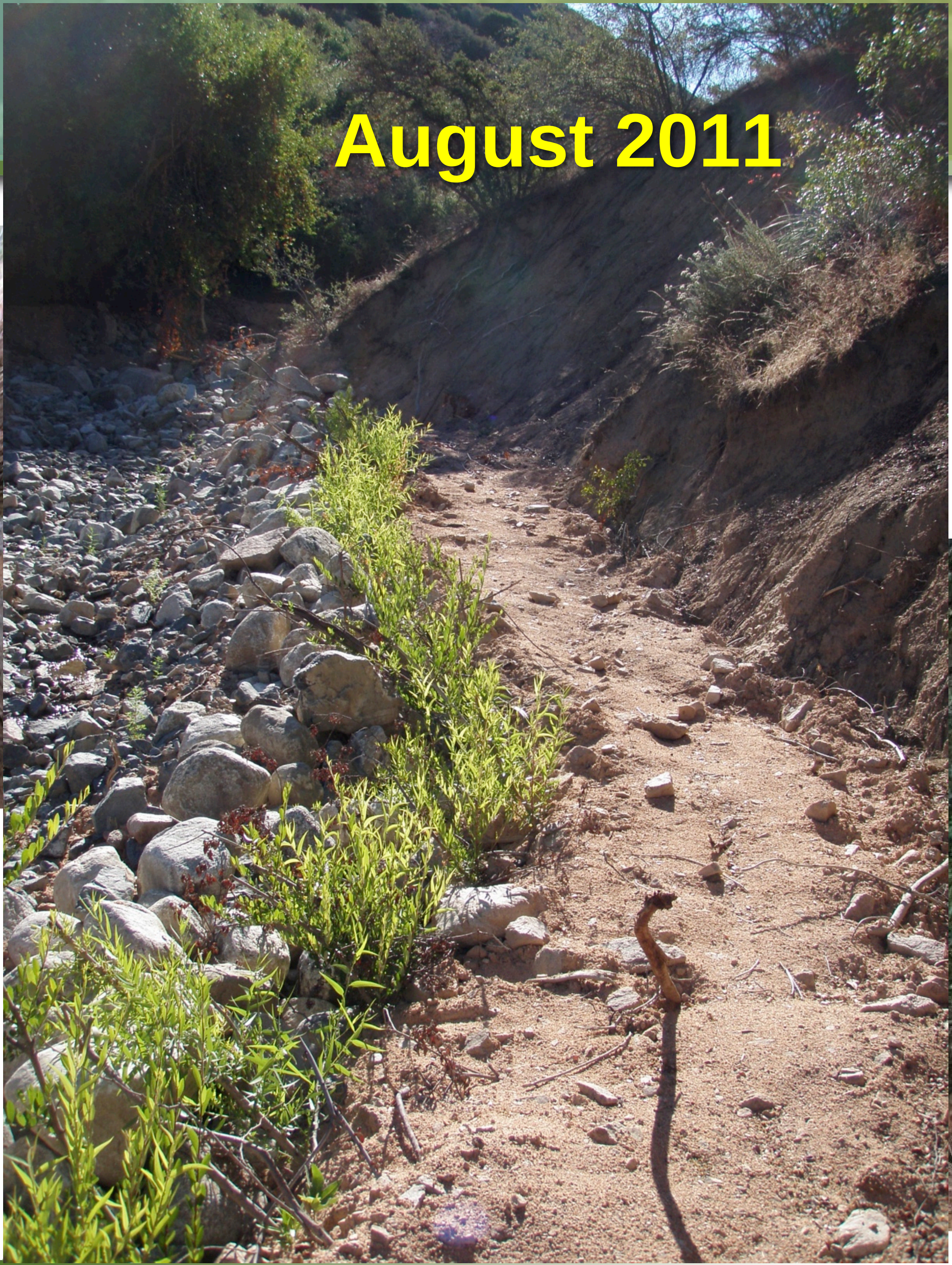


Hwy 330 – San Bernardino

RECP Wrap – Case Study – Wire Mesh Reinforced section (upper) and Soil Flap Section (lower)

- Estimated 60K CY failed, SKANSKA removed 15K CY.

May 2011

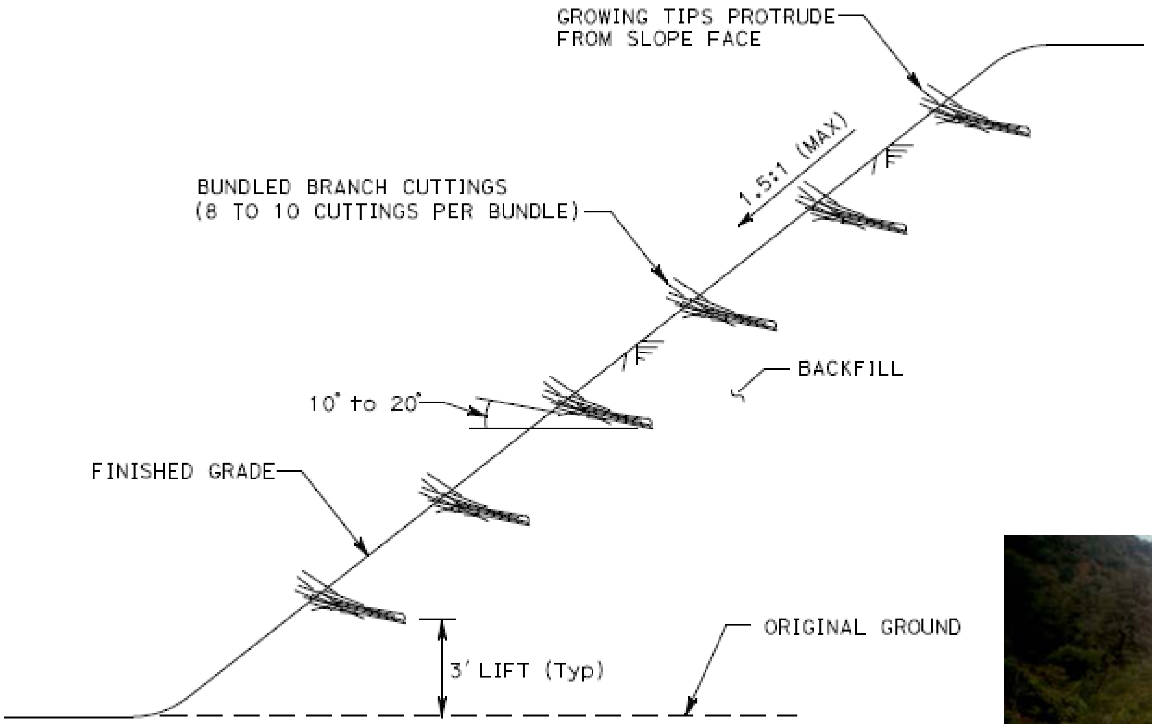


RECP Flap / Geogrid / Brushlayering


HITACHI


August 2011

Steep Slope Solutions



DISCLAIMER: THIS TYPICAL SECTION IS SCHEMATIC ONLY
AND CAN NOT BE USED IN A CONTRACT DOCUMENT.
THE SCALE, KEY DIMENSIONS AND OTHER CRITICAL DETAILS
HAVE PURPOSELY BEEN OMITTED.

Brush Layering

Steep Slope Solutions

Brush Layering – SHA 299, 1991

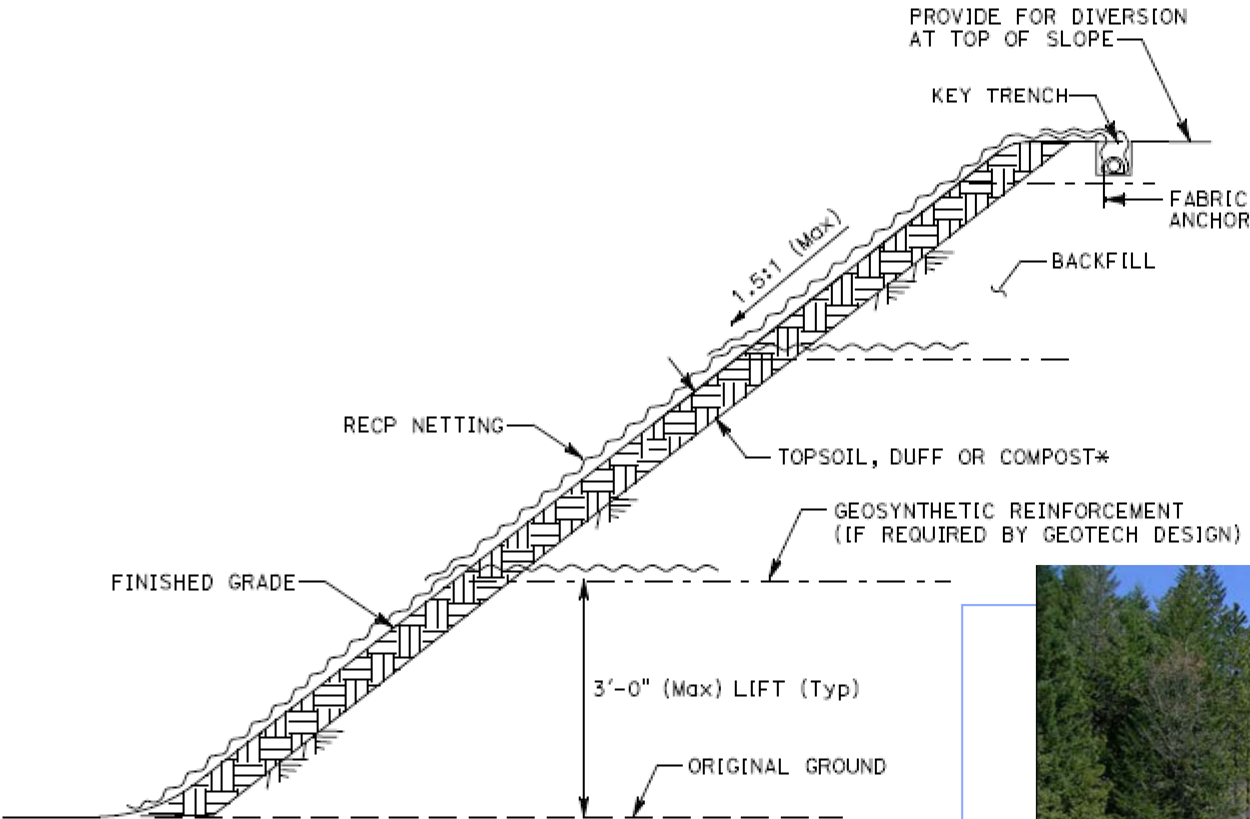
- Installed in September.
- Temperatures over 100˚
- Branches were not soaked (5-10 days current recommendation)
- Watering aided survival

VENTURA HIGHWAY So. CA
16" avg. annual rainfall

After 2 years

After 6 years

Steep Slope Solutions



* DIMENSIONS TO BE SPECIFIED

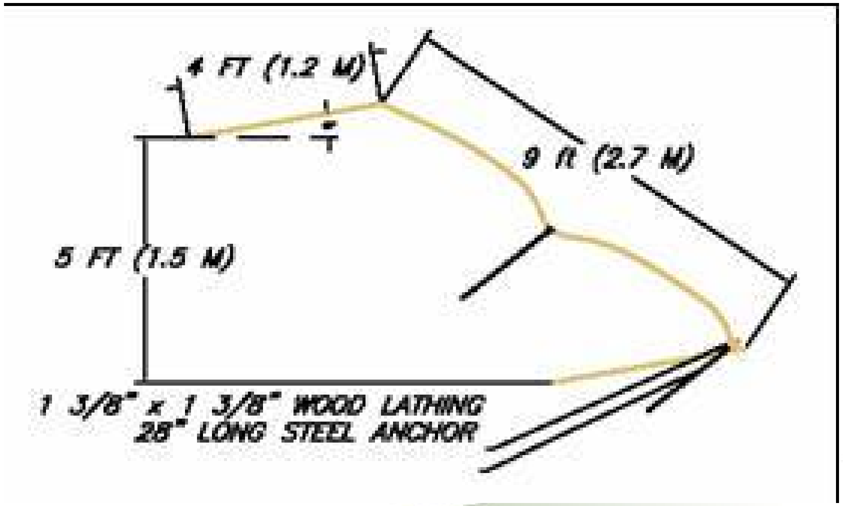
DISCLAIMER: THIS TYPICAL SECTION IS SCHEMATIC ONLY AND CAN NOT BE USED IN A CONTRACT DOCUMENT. THE SCALE, KEY DIMENSIONS AND OTHER CRITICAL DETAILS HAVE PURPOSELY BEEN OMITTED.

RECP Flap

ESenSS

RECP Flap


Finished slope


4 FT (1.2 M)
9 ft (2.7 M)
5 FT (1.5 M)
1 3/8" x 1 3/8" WOOD LATHING
28" LONG STEEL ANCHOR

RECP Flap

Mixing soil and compost

Spreading compost

Laying coir blanket

Lift construction


DRESSER


JUL 3 2006

Coastal Bluff Repair
Santa Cruz, California

John McCullah

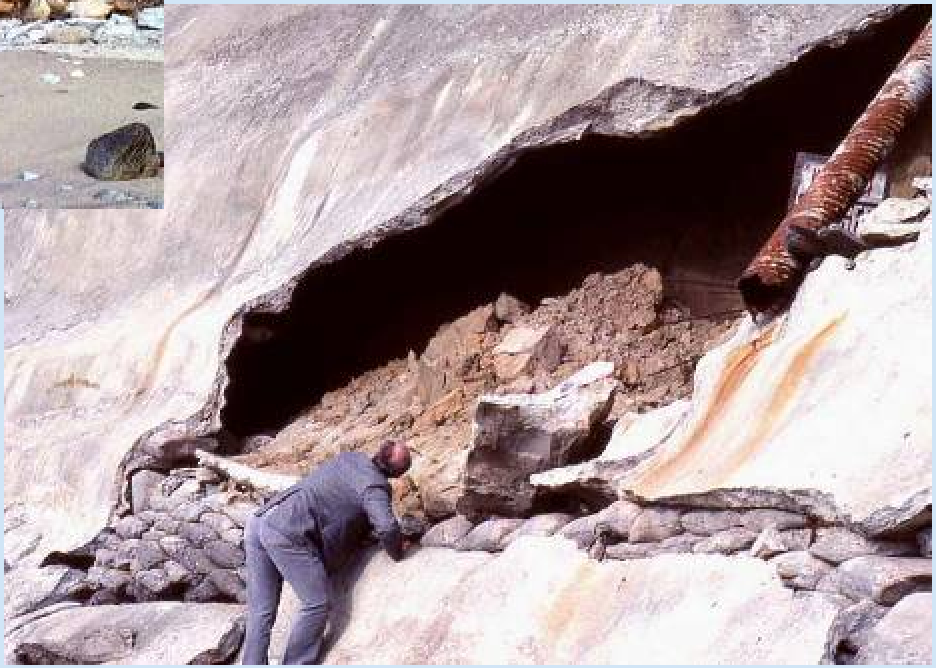
President

Salix Applied Earthcare LLC

Pleasure Point

How <u>Not</u> to Repair Coastal Bluff

<---failed concrete (gunnite) protective curtain



Curtain was blown out as a result of unrelieved pore-water pressure build up in bluff behind curtain

Eroded Bluff (before repair)

<---looking South towards
Monterey Bay

looking North along coast--->

Bluff Repair Sequence

Preparing to install (drape) Enka mat over bluff face

Enka Mat anchored 1’ oc

Anchoring (“nailing”) Enka mat to bluff face

<---Enka mat anchored to bluff face


While willow stakes were cut Alex takes a nap! Notice willow, 35 yrs old, on neighbors cliff

Installing Willow Stakes

Inserting (tamping)--->
live cuttings thru
mat into bluff face

Bluff Repair Sequence (cont)

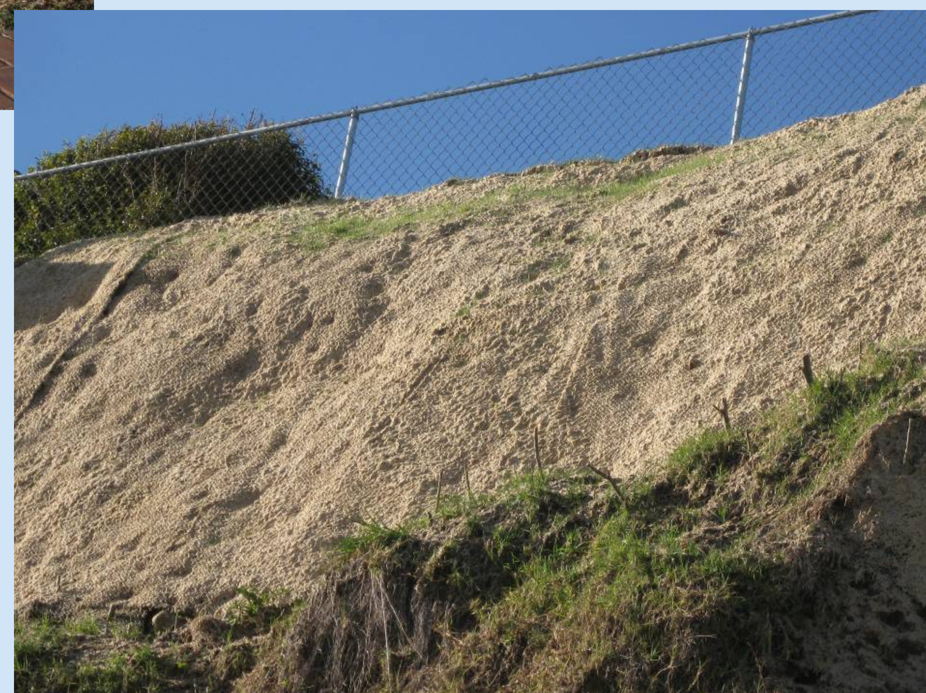
- Flexterra @ 4000# /ac
- Native Grass seeds (Maritime)
- Jumpstart (Profile) humic acid
- BioPrime (Profile) mychorrizae,

Applying (spraying) hydroseed solution to bluff face -------------->

Green Armor System

Spraying hydro mulch--->
over (& thru) Enka mat

7” rain in the first week after construction



1st Month

After 1 year

November 2009



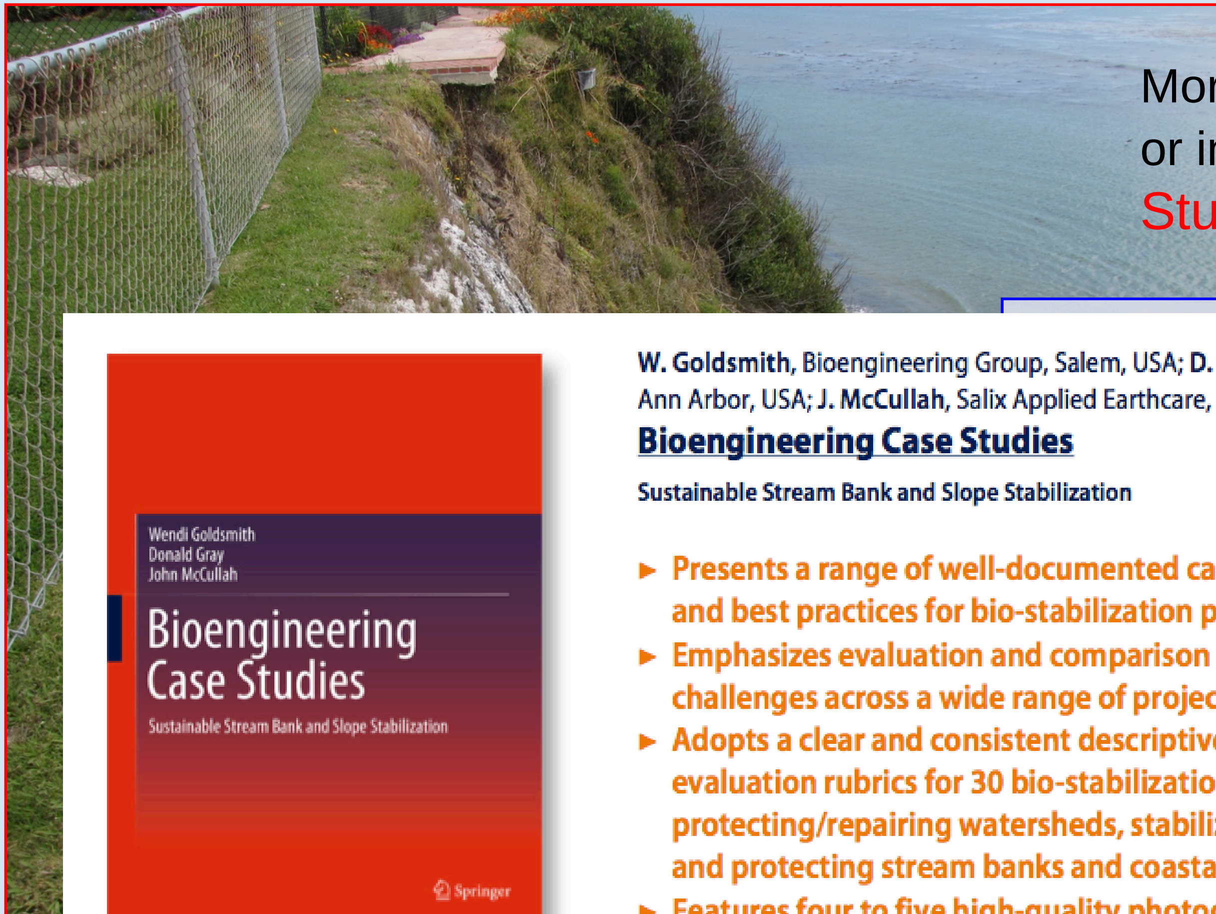
After 2 year

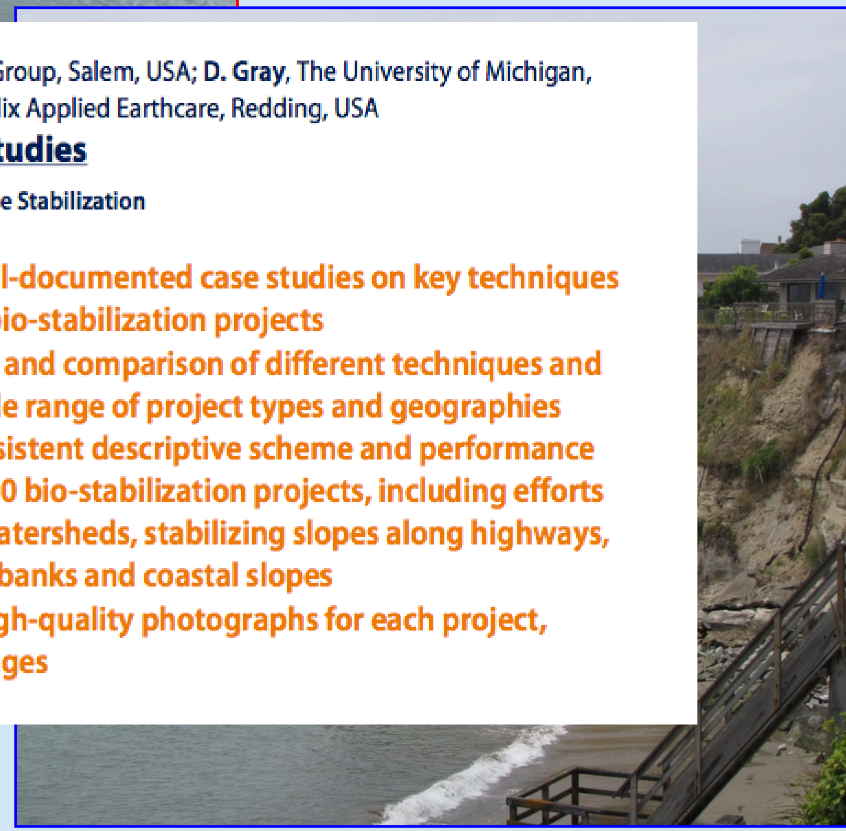
East Cliff Drive up coast prepares for $$million fix, soil nails

Jack O'Neills House


HYUNDAI

More at Dirttime.tv archive or in Bioengineering Case Studies





2014, X, 202 p. 241 illus., 85 illus. in color.

W. Goldsmith, Bioengineering Group, Salem, USA; **D. Gray**, The University of Michigan, Ann Arbor, USA; **J. McCullah**, Salix Applied Earthcare, Redding, USA

Bioengineering Case Studies

Sustainable Stream Bank and Slope Stabilization

- ▶ Presents a range of well-documented case studies on key techniques and best practices for bio-stabilization projects
- ▶ Emphasizes evaluation and comparison of different techniques and challenges across a wide range of project types and geographies
- ▶ Adopts a clear and consistent descriptive scheme and performance evaluation rubrics for 30 bio-stabilization projects, including efforts protecting/repairing watersheds, stabilizing slopes along highways, and protecting stream banks and coastal slopes
- ▶ Features four to five high-quality photographs for each project, totaling nearly 150 images

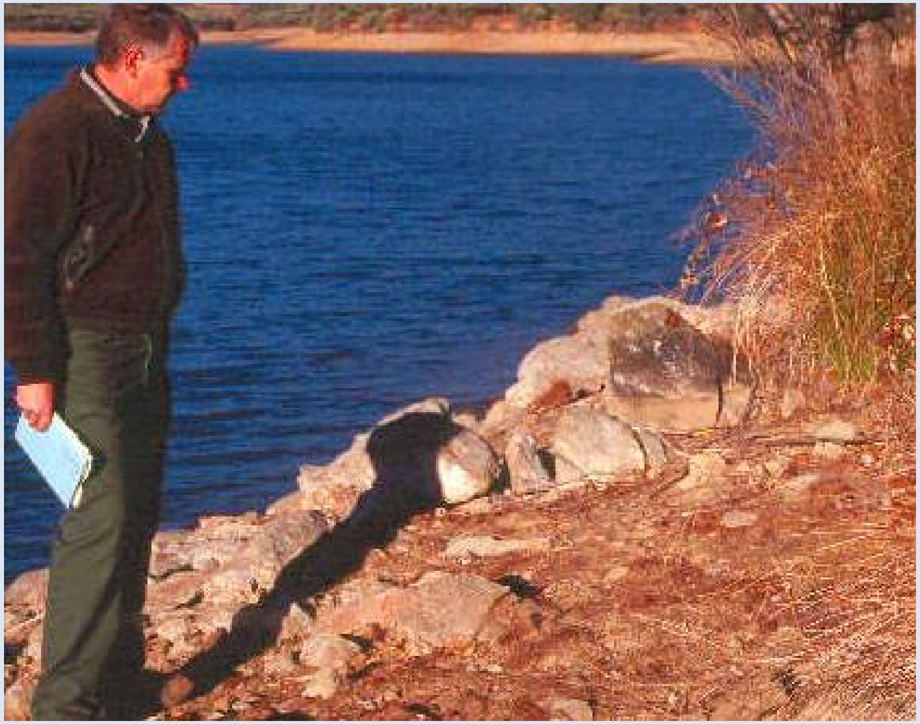
https://dirttime.tv/2014-8-9-project-opal-cliffs-chapter-from-bioengineering-case-studies-html/

Root Architecture and Types

Sand dune permeated by roots of woody dune vegetation. Roots reinforce the soil and increase the coherence and stability of sandy slopes.

Fine red willow roots exposed on streambank and streambed, often seen after high flows wash gravels away.

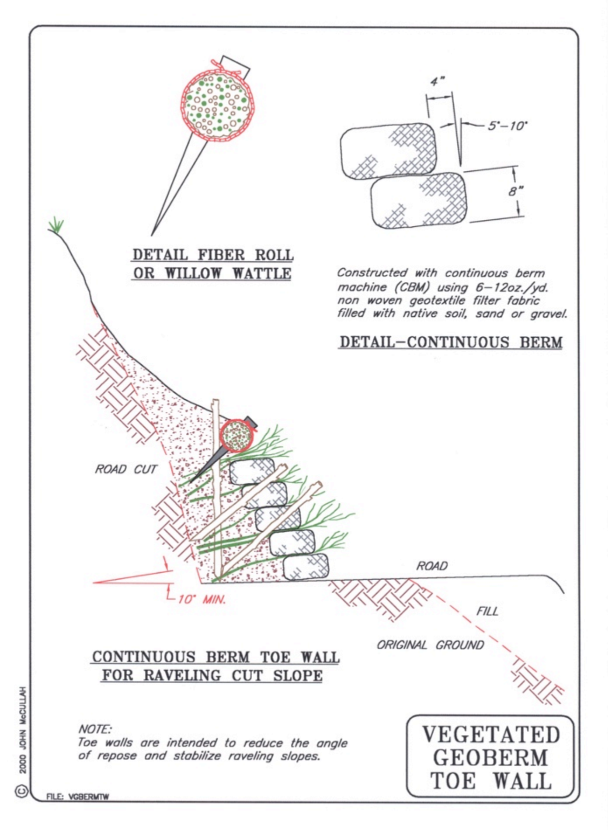
Willow Roots

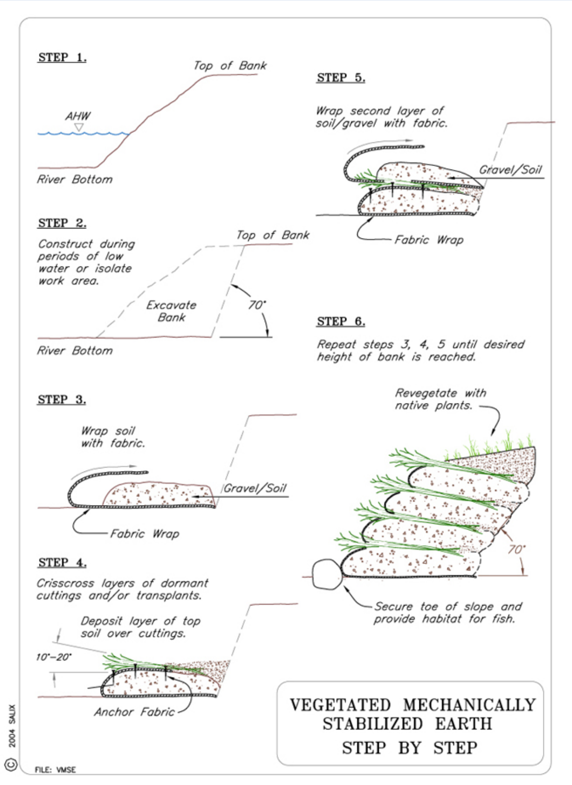


BLUFFS Project – high bank to Sacramento River

Root reinforcement knowledge was utilized in developing design criteria for this current project.

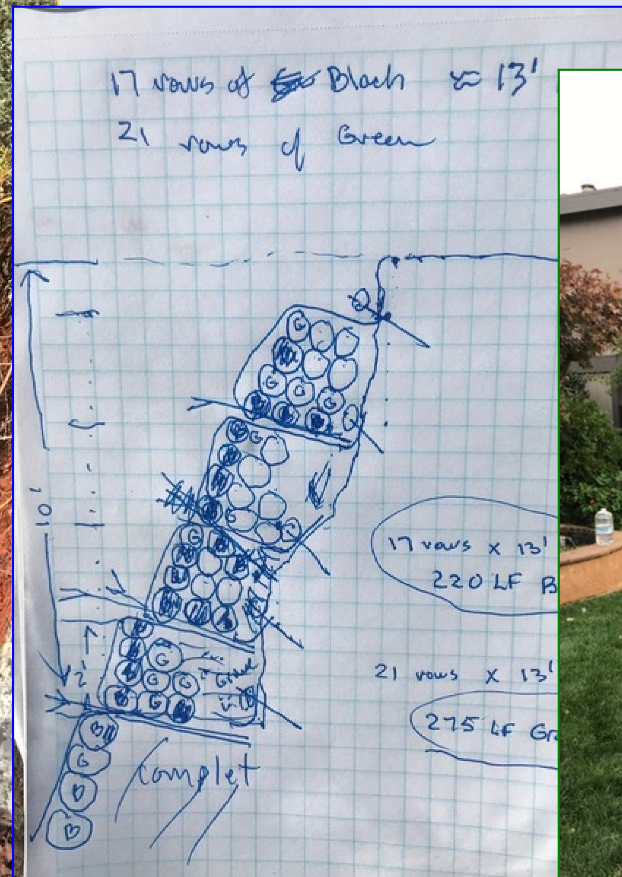
Bluffs – VMSE Design considerations





Had experience designing and building similar gravity-type, VMSE toe walls before

Bluffs –SITE Factors and LIMITATIONs



Willow and native grasses exist nearby! “Reference Site Concept”

Very steep and access by hand labor and wheelbarrow only

Bluffs VMSE Contd.

Two courses of Coir Logs w/
Brushlayering was used at base.

Bluffs VMSE Contd.

Biaxial Geogrid added for structural reinforcement

Gripple Anchor System used to tieback geogrid to slope – 500 lbs. working strength

Bluffs VMSE Contd.

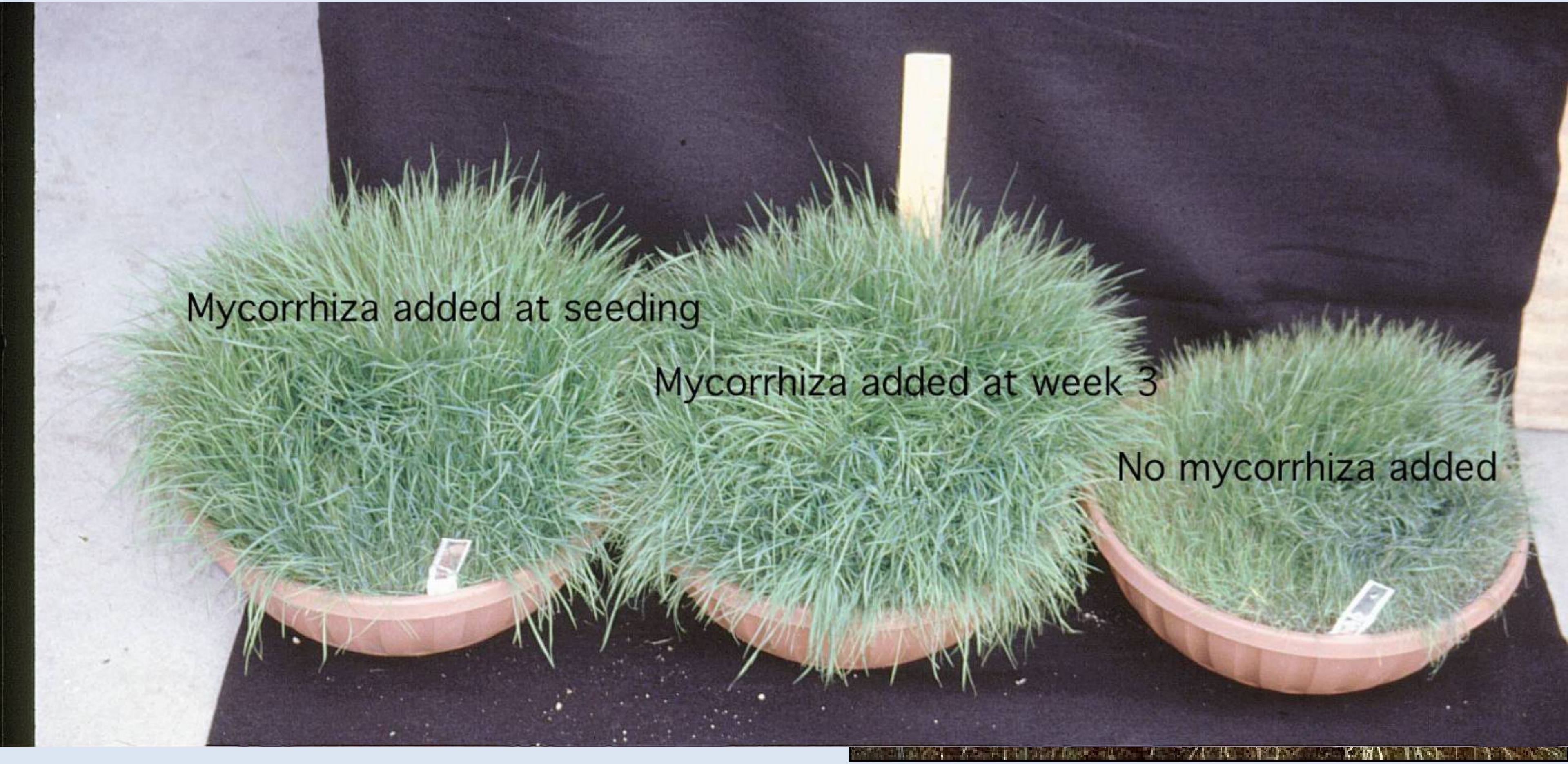
3.5 days w/ 3 workers

Bluffs VMSE Contd.

Elymus glaucus - Blue Wildrye

Nassella pulchra - Purple needlegrass

Bluffs VMSE Contd. Root Reinforcement



AM Mychorrizae – Glomus. AM120

Hyphae network on immature plant

Bluffs VMSE Contd.

Bluffs VMSE Contd.

July 2019


RAD POWER BIKES
RADCITY


got dirt?