Planning and Design of Smart Infrastructure for Biodiversity Protection

Soil Bioengineering, Hydrology and Drainage in Linear Infrastructure

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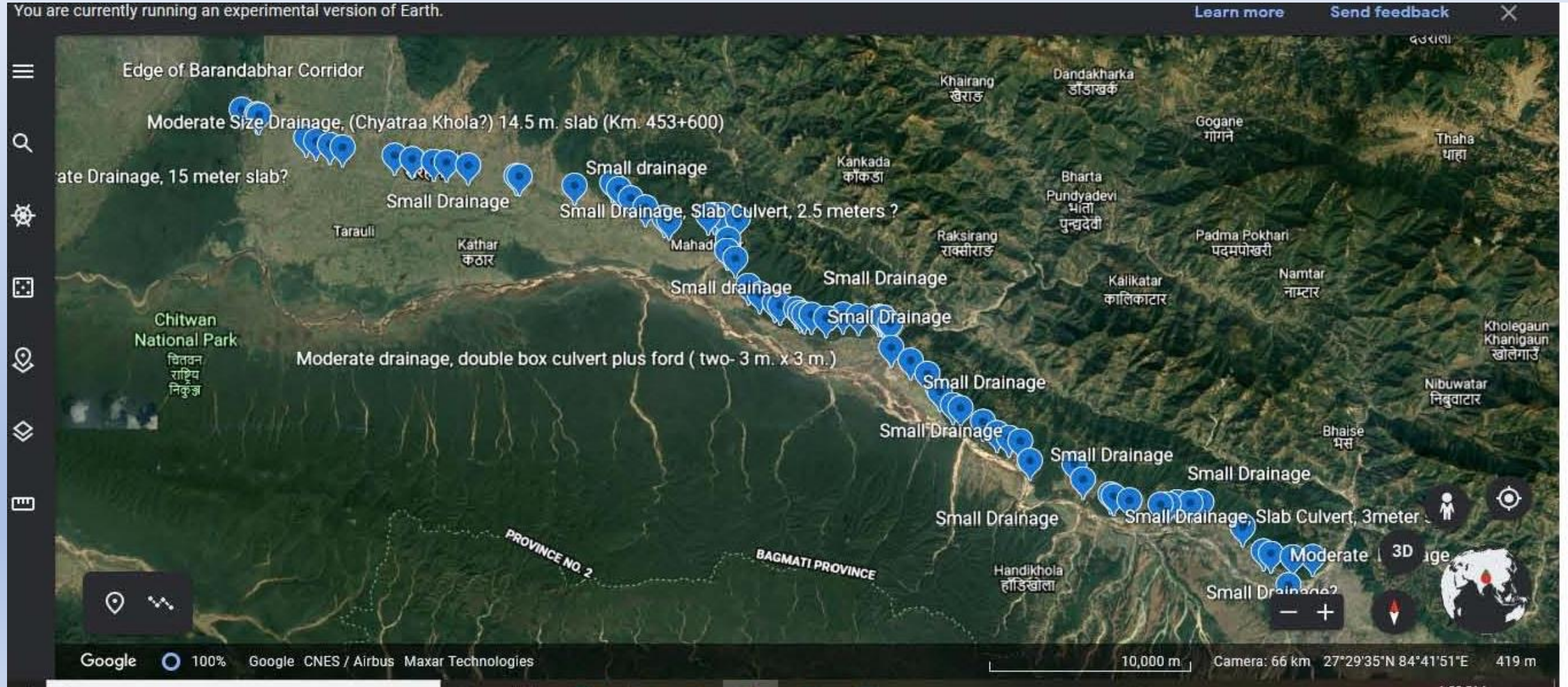
25 April 2022

Sauraha, Nepal

Drainage Structures for Hydrology and Wildlife Movement



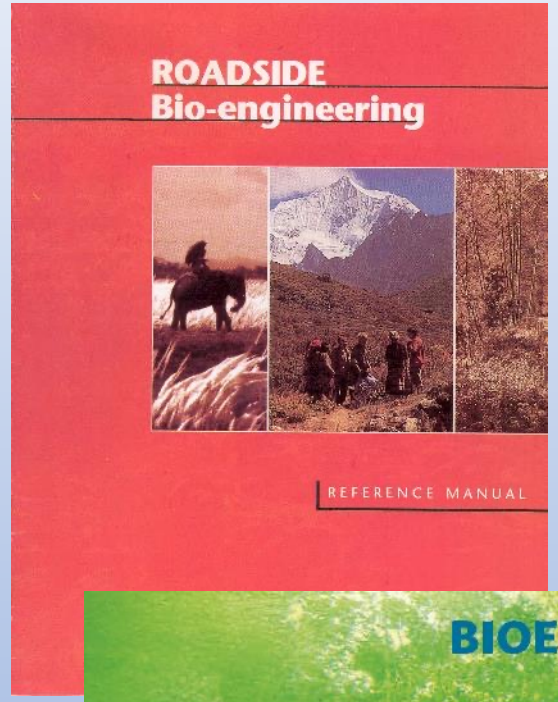
220 Km. of Roads and Vegetation

Soil Bioengineering and Biotechnical Slope Stabilization

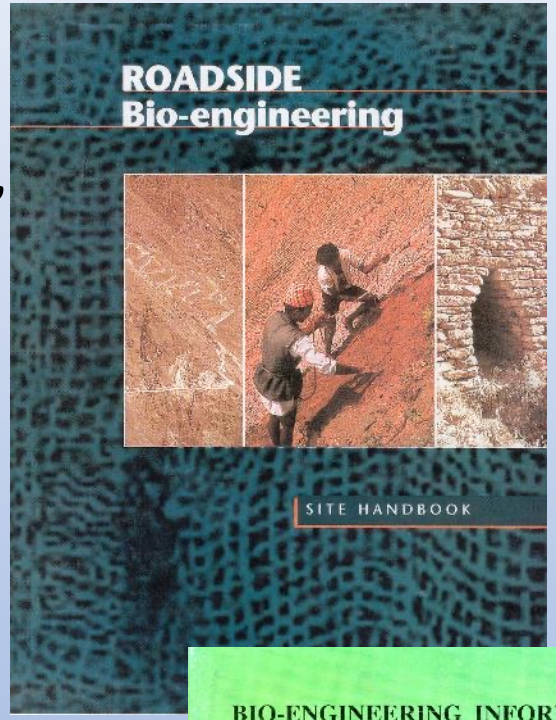
- ***Soil Bioengineering-*** **A technology that uses integrated ecological principles to assess, design, construct, and maintain living vegetative systems to repair damage caused by erosion and slope failures**

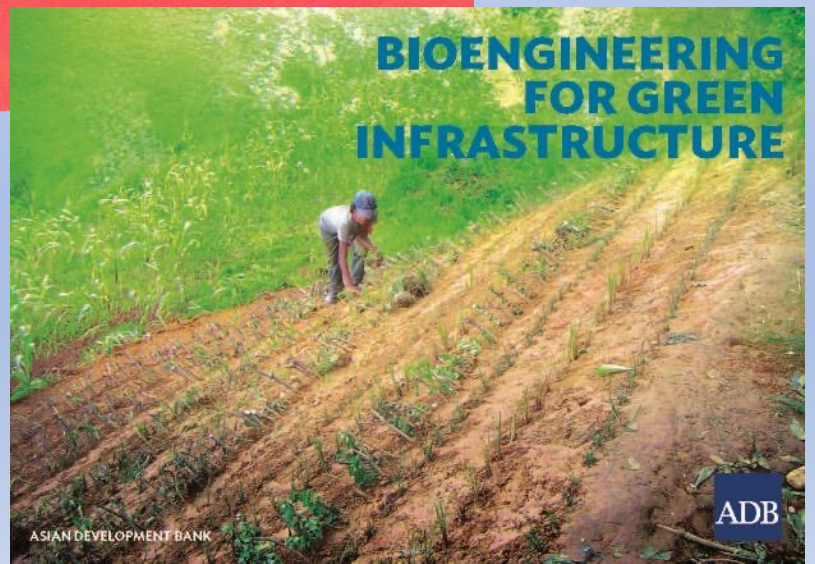
- ***Biotechnical Slope Stabilization-*** ***A*** **technology that combines the use of vegetation with other physical structures, such as vegetated gabions, rock walls, or vegetated reinforced soil slopes to create structures for slope stabilization.**

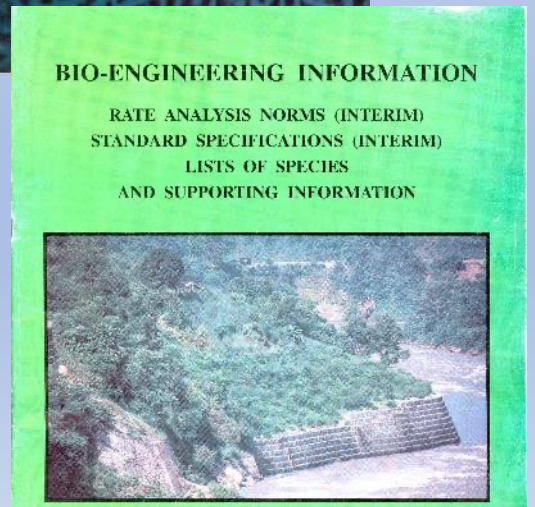
Soil Bioengineering in Nepal



John Howell, DOR, DFID







Environmental Management (2013) 51:354–364
DOI 10.1007/s00267-012-0003-7

PROFILE

Soil Bioengineering Application and Practices in Nepal

Yam Prasad Dhital · Rijan Bhakta Kayastha · Jiancheng Shi

Received: 22 December 2011 / Accepted: 12 December 2012 / Published online: 22 December 2012

Abstract The small mountainous country Nepal is situated in the central part of the Himalayas. Its climate varies

and record-keeping and evaluation of the work are indeed essential.

Use of plants in Soil Bioengineering

Selection of species appropriate for each Soil Bioengineering technique

Method of propagation, biological and social consideration, establishment, vigor growth and persistence, site suitability, potential value to local farmer, availability.

Plant Ecology of Nepal

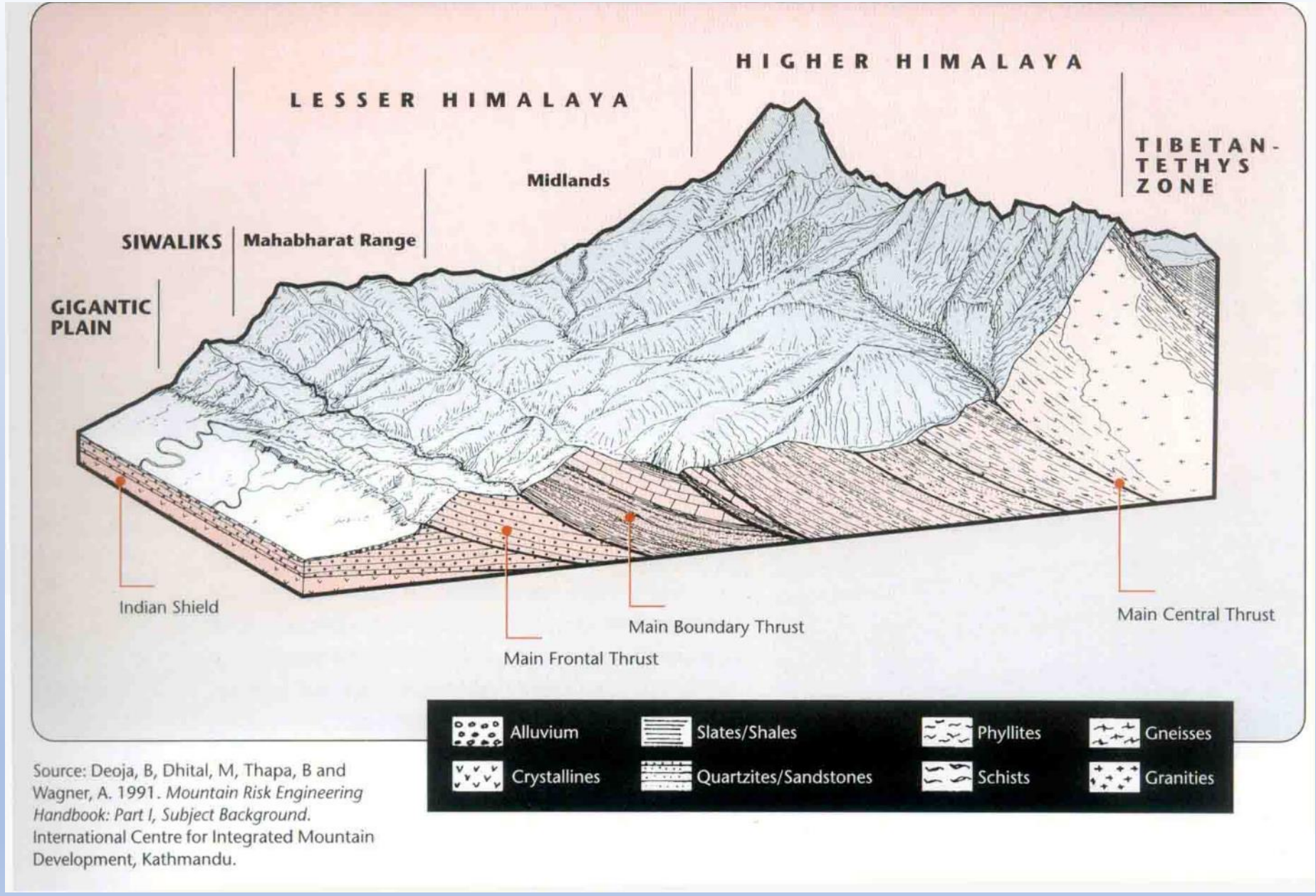
Study of plants in relation to the environment in which they grow. Governing factors: the availability of moisture, temperature and the amount of sunlight; and the availability of nutrients. These are in turn determined in Nepal by altitude, aspect, other factors controlling the distribution of rainfall and site moisture, geology, geomorphology and soils.

Dr. Tara Nidhi Bhattarai, NDRI

The north facing slope is well shaded and therefore retains moisture, making it excellent for plant growth. In contrast the south facing slope across the valley is much drier and the land is consequently less productive. Drought tolerant species are desirable!

North facing slope

South facing slope



Source: Deoja, B, Dhital, M, Thapa, B and Wagner, A. 1991. *Mountain Risk Engineering Handbook: Part I, Subject Background.* International Centre for Integrated Mountain Development, Kathmandu.

Vegetation type goes on changing from West to East

Details of the Main Soil Bioengineering Species

Grasses: Amliso, Babiyo, Dhonde

Dubo: Dubo, Kans, Katara Khar, Khar, Khus, Narkat, Padang Bans, Phurke, Sito, Tite Nigalo Bans

Shrubs and small trees: Areri, Assuro, Bainsh, Bhujetro, Dhanyero, Dhusun, Kanda Phul, Keraukose, Kettuke, Namdi Phul, Saruwa/Bihaya, Simali, Tilka

Large trees: Bakaino, Chilaune, Dabdabe, Gobre Salla, Kalo Siris, Khanyu(Khosro), Khayer, Lankuri, Painyu, Phaledo, Rani (Khote) Salla, Rato Siris, Seto Siris,Sisau, Utis

Large clumping bamboos: Choya/Tama Bans, Dhanu Bans, Kalo Bans, Mal Bans, Nibha/Ghopi/Lyas Bans, Tharu Bans

TABLES FROM HOWELL

SPECIES SUITABLE FOR SHRUB AND THEE SEEDING

Main species used for **direct seeding**

Local name	Botanical name	Altitude range	Sites summary
Shrubs			
Areri	*Acacia pennata*	500 - 1500 m	Hot and dry; harsh
Bhujetro	*Butea minor*	500 - 1500 m	Hot and dry; harsh
Keraukose	*Indigofera atroturpurea*	Terai - 2000 m	Hot and dry; harsh

Main species used for **broadcasting**.

Local name	Botanical name	Altitude range	Sites summary
Shrubs			
Areri	*Acacia pennata*	500 - 1500 m	Hot and dry; harsh
Bhujetro	*Butea minor*	500 - 1500 m	Hot and dry; harsh
Keraukose	*Indigofera atroturpurea*	Terai - 2000 m	Hot and dry; harsh
Trees			
Bakaino	*Melia azedarach*	Terai - 1800 m	Hot and dry; harsh
Gobre salla	*Pinus wallichiana*	1800 - 3000 m	Dry; varied
Khanyu (khosro)	*Ficus semicordata*	Terai - 2000 m	Hot and dry; varied
Khayer	*Acacia catechu*	Terai - 1000 m	Hot and dry; harsh
Rani (khote) Salla	*Pinus roxburghii*	500 - 1950 m	Hot and dry; varied
Sisau	*Dalbergia sissoo*	Terai - 1400 m	Varied
Utis	*Alnus nepalensis*	900 - 2700 m	Varied and moist

SPECIES SUITABLE FOR PLANTED GRASSES: RANDOM PLANTING

Local name	Botanical name	Altitude range	Sites summary
Amliso	*Thysanolaena maxima*	Terai - 2000 m	Varied
Babiyo	*Eulaliopsis binata*	Terai - 1500 m	Hot and dry
Dhonde	*Neyraudia reynaudiana*	Terai - 1500 m	Hot and dry
Kans	*Saccharum spontaneum*	Terai - 2000 m	Hot and dry; moist
Katara khar	*Themeda* species	Terai - 2000 m	Varied
Khar	*Cymbopogon microtheca*	Terai - 2000 m	Hot and dry; varied
Khus	*Vetiveria lawsoni*	Terai - 1500 m	Varied
Narkat	*Arundo clonax*	Terai - 1500 m	Hot and dry; varied
Phurke	*Arunduella nepalensis*	700 - 2000 m	Varied; stony
Sito	*Neyraudia arundinacea*	Terai - 1500 m	Varied

SPECIES SUITABLE FOR LARGE BAMBOO PLANTING

Local name	Botanical name	Altitude range	Sites summary
Traditional planting method only			
Mal bans	*Bambusa nutans*	Terai - 1500 m	Dry/varied
Nibha/ ghopi/ lyas bans	*Ampelocalamus patellaris*	1200 - 2000 m	Varied
Tharu bans	*Bambusa nutans*	Terai - 1500 m	Varied
Either traditional planting method or rooted single-node culm cutting method			
Choya/ tama bans	*Dendrocalamus hamiltonii*	300 - 2000 m	Moist
Dhanu bans	*Bambusa balcooa*	Terai - 1600 m	Varied
Kalo bans	*Dendrocalamus hookeri*	1200 - 2500 m	Varied

Bank cutting and or sediment deposition

Soil erosion slope failure

Possible problems in each sites (pictures).

Soil Bioengineering use depends on:
Elevation, eco-climatic zone, precipitation, aspect, soil thickness and its fertility, availability of species (nursery), etc.

NHP Highway Applications

Basic Applications

Erosion Control & Drainage

- Grass Carpet, Turfing
- Fascines
- Fascine Pole Drains

Slope Stabilization

- Live Stakes
- Brush Layering
- Live Slope Grating
- Vegetated Walls
- Vegetated Reinforced Soil Slopes

Erosion Control & Drainage

Turfing & Clumping Grasses

Fascines

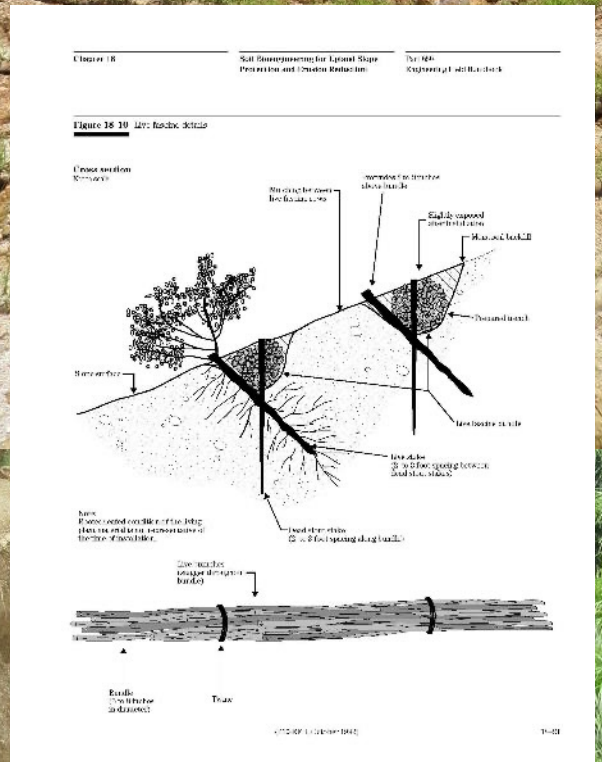
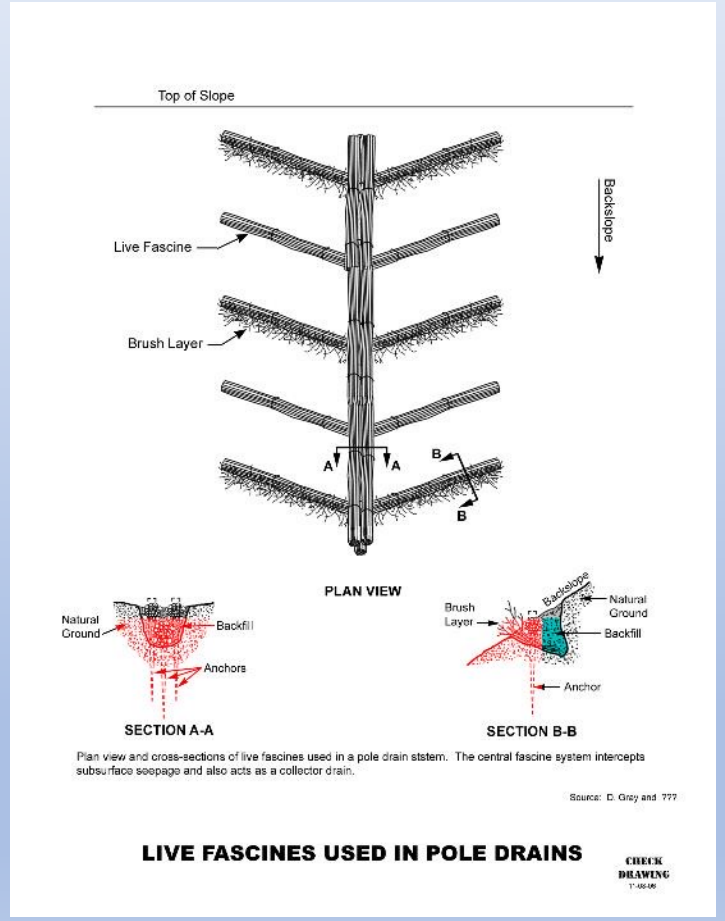


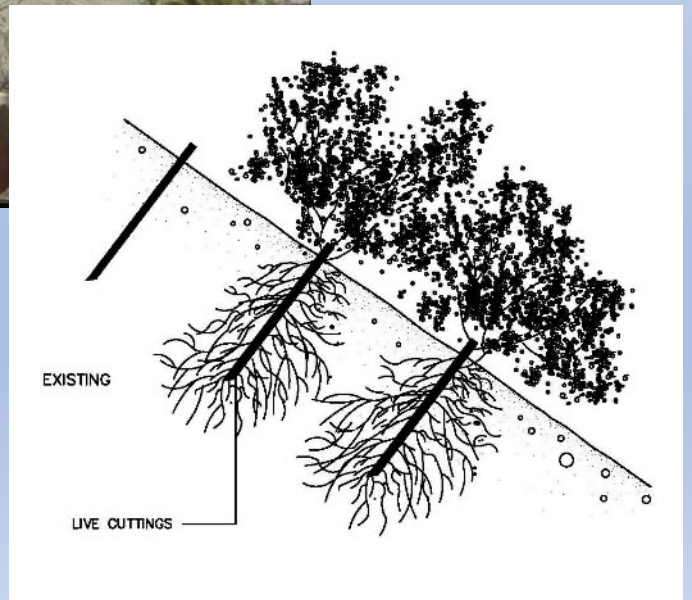
Figure 18.10

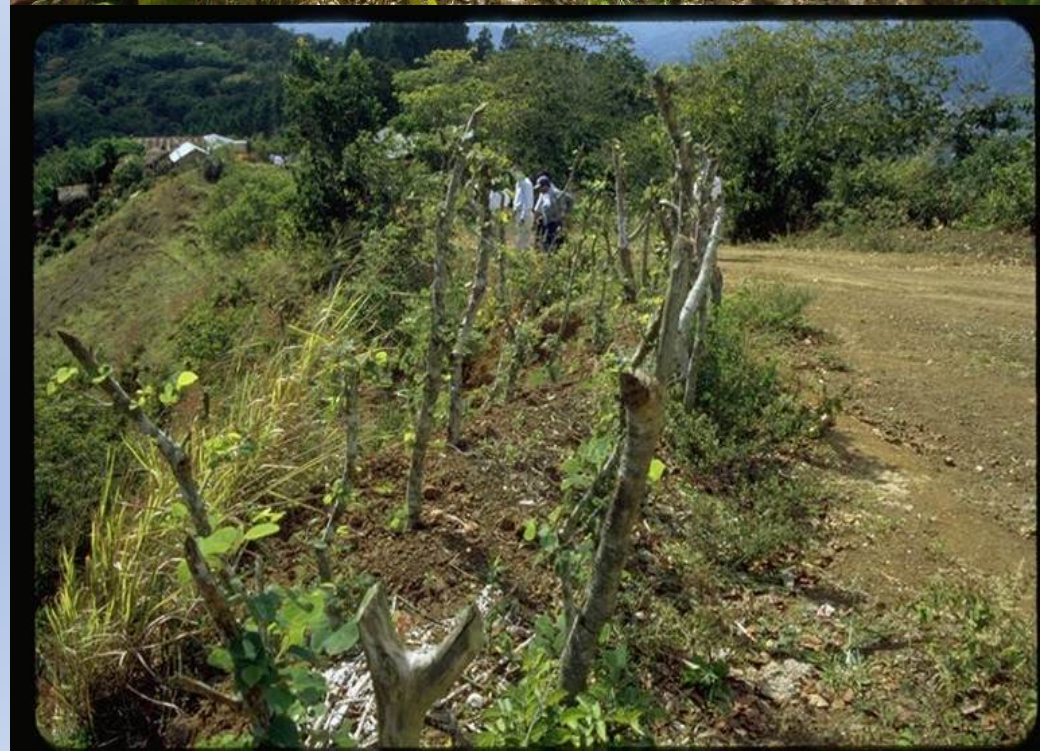
Fascine Pole Drains



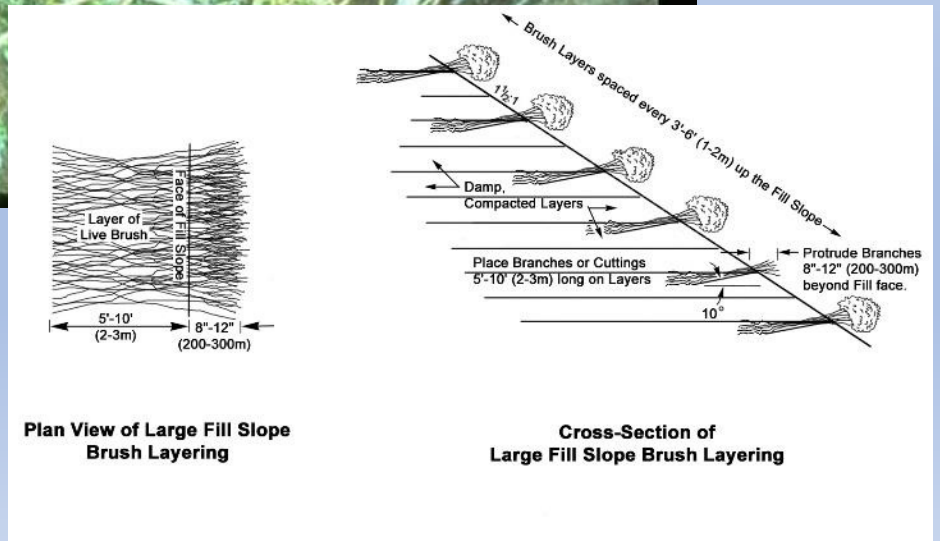
Slope Stabilization

Live Stakes





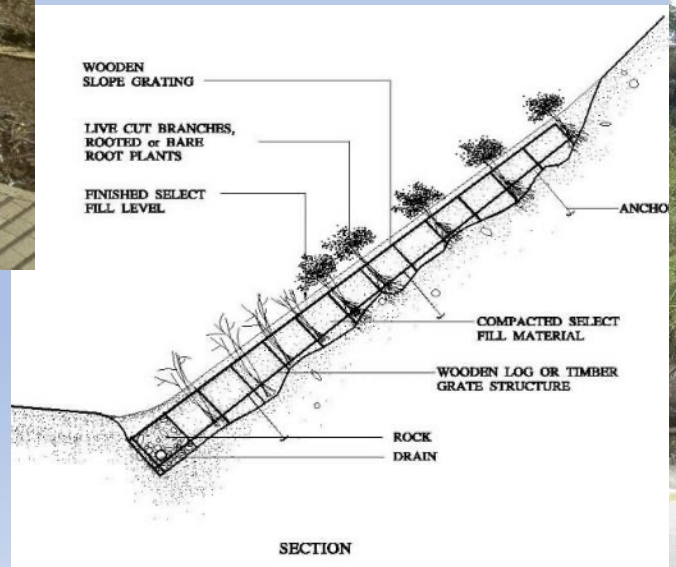
Brush Layering



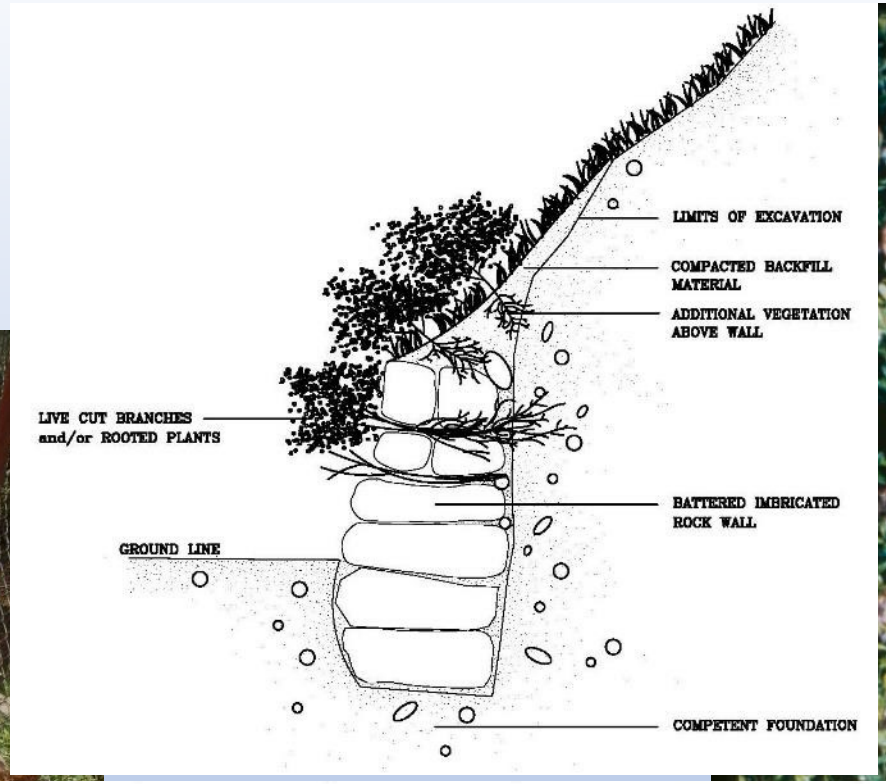
Plan View of Large Fill Slope Brush Layering

Cross-Section of Large Fill Slope Brush Layering

Live Slope Grating



Vegetated Walls



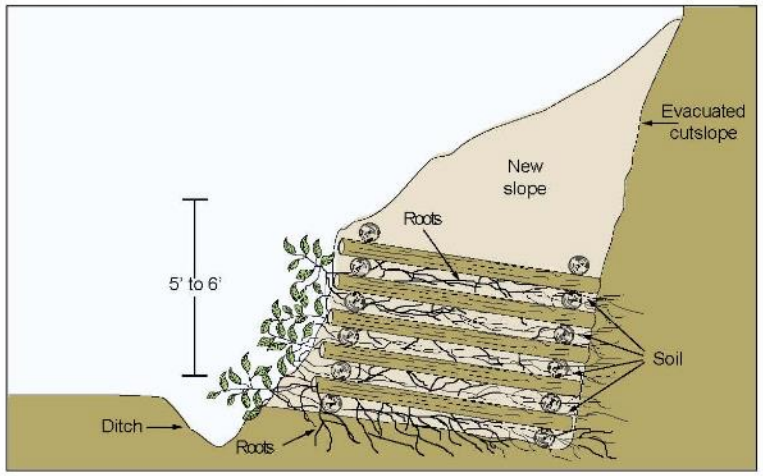
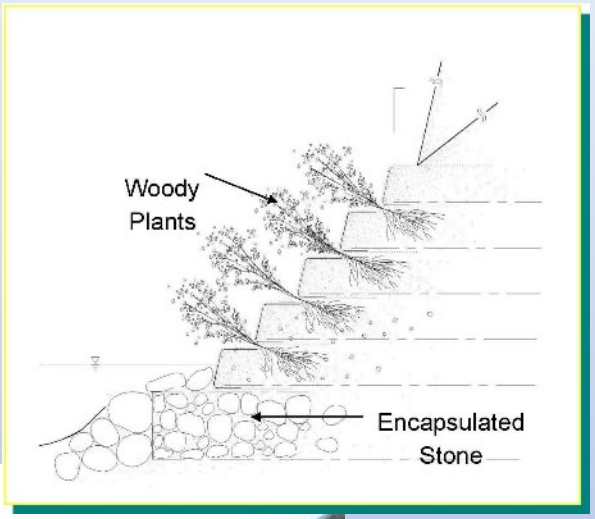


Figure 8–Live cribwall battered construction.

Vegetated Reinforced Soil Slopes



Back to Hydrology and Drainage

FUNCTIONS OF DRAINAGE STRUCTURES

- **Accomodate and Disperse Surface Drainage**
- **Pass the Design Flow dfrom Rivers and Streams (25-100 Year Events)**
- **Accommodate or Pass Sediment and Debris**
- **Reflect and Design For Increased Flows from Climate Change**
- **Provide Wildlife Crossings and promote wildlife Movement and Connectivity**

DRAINAGE DESIGN TOOLS

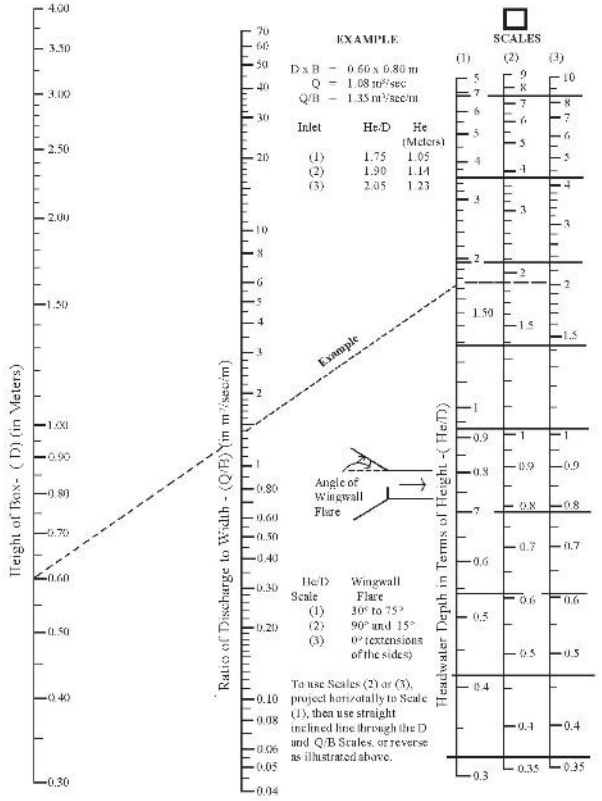
- Hydrology & Hydraulics
  - Rational Method
  - Dicken's Formula
  - Manning's Formula
  - -Guaging Stations
  - -Statistical Methods
- Riprap/Gabion Design
- Use of Filters and Geotextiles

CLIMATE CHANGE PROJECTIONS

- Temperature records show a warming trend, with projected increases of between 1.8 and 5.8 degrees (Centigrade) by the 2090s
- Annual precipitation is projected to decrease by 10 to 20 percent, with dryer winters but wetter monsoon summers
- Extreme flow events, increased rainfall intensities, and climate variability– increased flood design recurrence intervals.
- Sequences of drought and storms, as well as warmer temperatures- more fires, increased erosion, more landslides.
- Increased climate variability and more extreme conditions.

DETERMINING SIZE OF THE STRUCTURE

Figure 8.7c Headwater depth and capacity for concrete box culverts with inlet control. *(Adapted from FHWA, HDS5, 1998)*



WILDLIFE UNDERPASS SIZE CLASS GUIDELINES

Underpass Size Class	Target Wildlife Species from BBA	Minimum Dimensions			
		ADB Guidelines[1]		Nepal Guidelines[2]	
		Width (m)	Height (m)	Width (m)	Height (m)
Very Large	Asian elephant	12.0	5.5	8.0	6.5
Large	Tiger Rhino Sambar Common leopard Blue bull	10.0	4.0	4.0 to 5.0	4.0 to 5.0
Medium	Spotted deer Barking deer Jungle cat Leopard cat Hyena Wild boar	6.0	3.0	4.0 to 6.0	3.0 to 3.5
Small	Small Indian civet Large Indian civet Herpetofauna	2.0	2.0	N/A	

Bridges

Culverts

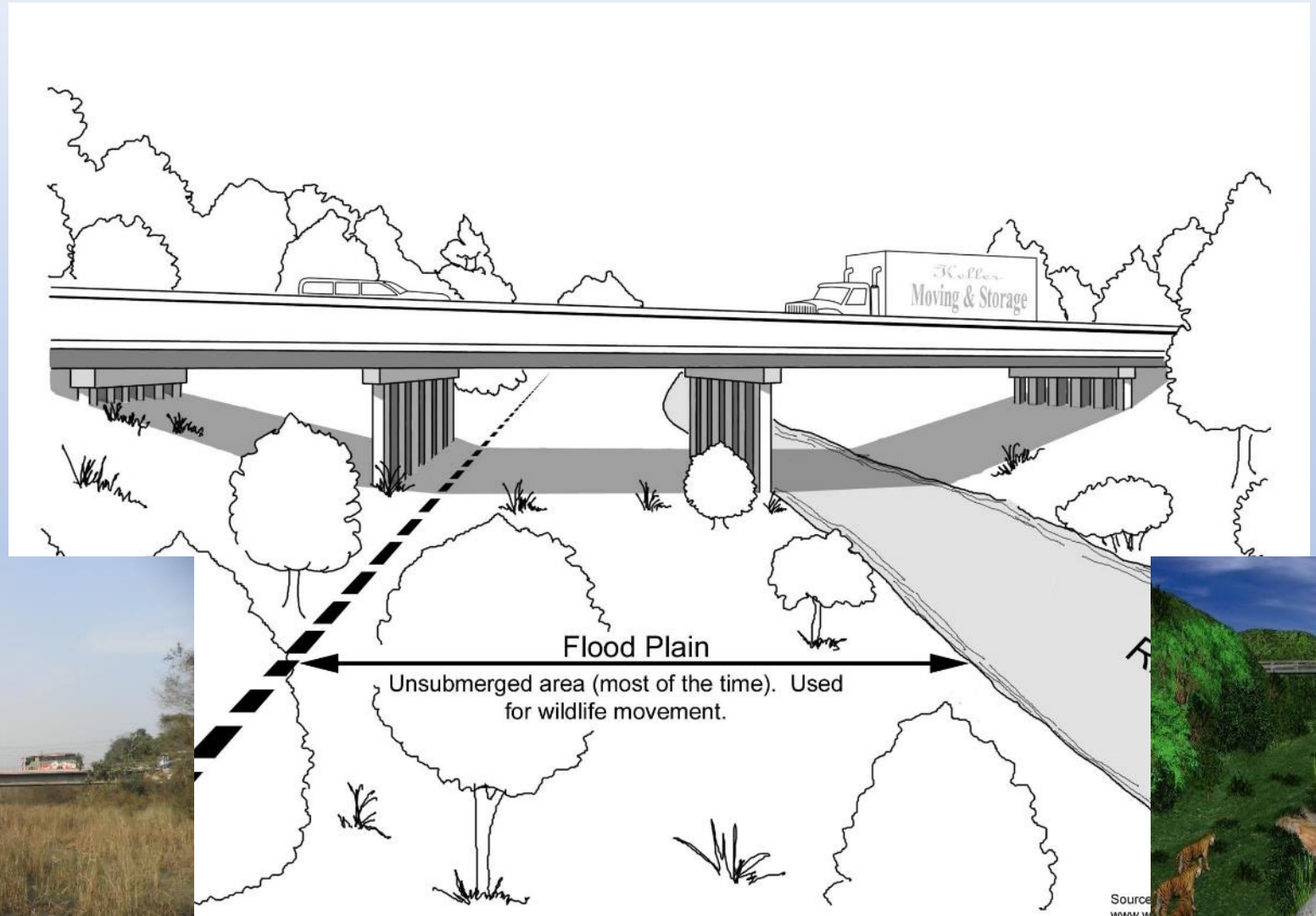
Surface Drainage

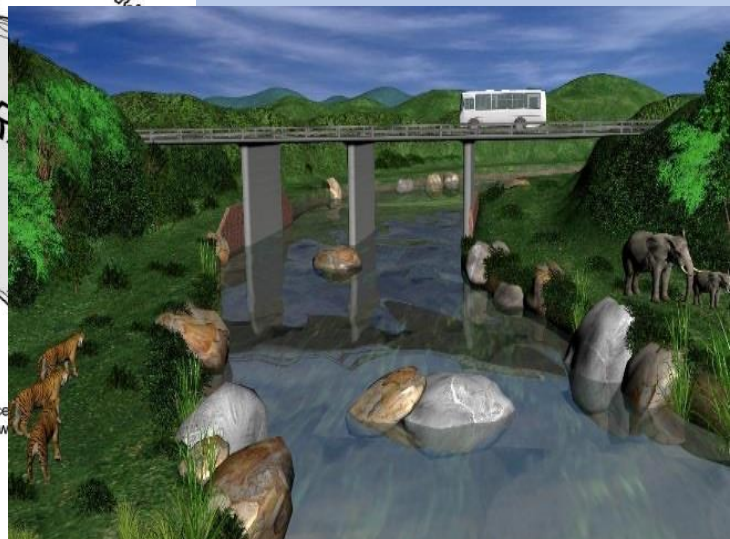
Fords/Drifts

Aquatic Organism Passage

A somewhat natural stream inside a culvert for fish passage

IDEAL WILDLIFE UNDERPASS- A BRIDGE

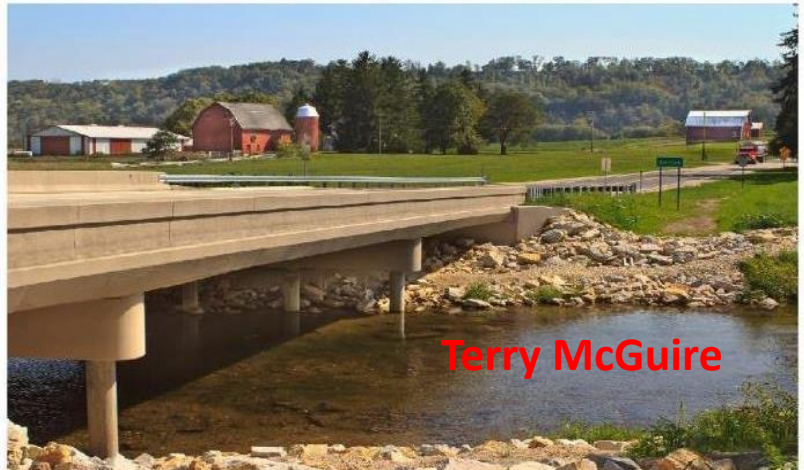




LONG, SINGLE OR MULTIPLE SPAN BRIDGES

(I-35 Straight River, Steele County MN)

(County 16 Fillmore County MN)



Movement through Bridges

Movement Through Culverts

Barriers in Bridges and Culverts

Lack of Space or Capacity

BETTER- MORE SPACE!!

Other Barriers for Movement of Wildlife

Barriers in Box and Inlet Structures

Barriers/Traps in Ditches and Canals

POOR

OK

Conclusions

-Both good vegetative management and drainage design can help wildlife and facilitate wildlife movement/connectivity.

-Adequate size is critical in drainage structures to both pass flood waters plus debris/sediment, and

-Structure size adequate to pass a wide variety of wildlife or target species.

THANK YOU!!

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