RESILIENT INFRASTRUCTURE: LANDSLIDE TRIGGERED BY ROAD CONSTRUCTION AND WAY FORWARD

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BACKGROUND

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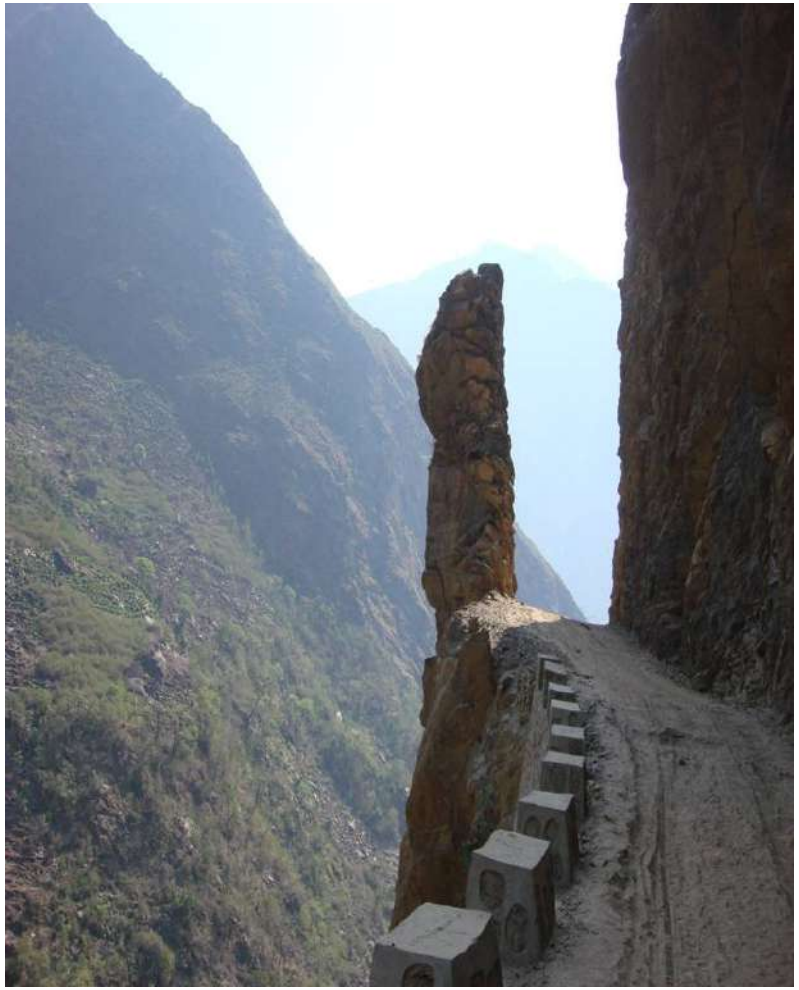
- Nepal's road network has experienced significant expansion in the past three decades.
- The Road Network has grown from 4,000 km to 1,00,000 km.
- Currently, 11,000 km of National Highways (NH) have been built, with a target of reaching 15,000 km in the future.
- The majority of these roads are constructed in hilly terrain, comprising approximately 70% of the total road network.
- The hilly terrain features lengthy, steep slopes that are minimally stabilized.
- Inadequate resiliency of structures, insufficient study during road design and construction, incorrect construction approaches, and neglect of land use patterns are the primary causes of landslides triggered by road construction.
- The occurrence of landslides could have been avoided through improved engineering input during road planning and construction.

OUR ROADS



OUR ROADS

EXISTING ROAD CONSTRUCTION PRACTICE

DONOR FUNDED VS GON FUNDED

Donor Funded

- Geotechnical studies of the site are required before design and construction
- Projects are more tightly controlled
- Every area of road design and construction, such as slope design, construction methods, spoil management, drainage management, slope protection and stabilization work, cut slope treatment etc. are relatively better.
- The reason behind this being agreement with donors which mandates proper study and good practices

Government Funded

- Solely based on civil engineering.
- Few to no geological and geotechnical investigations.
- This leads to dangerous slope design/cut slope angle, drainage design, and ultimately landslide.
- Un-Engineered roads developed (Local Level)

Understanding Landslide triggering Road Construction

LANDSLIDE TRIGGERING ROAD CONSTRUCTION

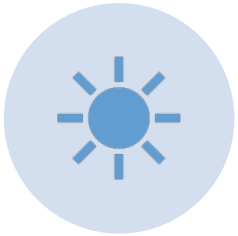
a phenomenon where road construction activities can cause or increase the occurrence of landslides on a slope.

FACTORS AFFECTING LANDSLIDE OCCURRENCE

SLOPE CONDITIONS DESCRIBED / GEOMETRY

SOIL COMPOSITION

STRUCTURE AND SOIL PARAMETERS



HYDROGEOLOGICAL, CLIMATE AND VEGETATION

GEOLOGY

CAUSE OF LANDSLIDE TRIGGERED BY ROAD CONSTRUCTION

- Excavation and slope destabilization
- Changes in water drainage patterns
- Increase in surface erosion due to construction activities
- Poor design and construction practices

EXCAVATION AND SLOPE DESTABILIZATION

- Removing rocks and soil from the lower parts of the slope can reduce the resisting forces that counteract the downward pull of gravity on the upper parts of the slope
- Altering the drainage patterns of the slope can increase the hydraulic gradients of groundwater flows and decrease the run-off surface water coefficients, which can increase the pore water pressure and reduce the shear strength of the soil
- Exposing the slope to erosion by wind and water can remove the protective vegetation cover and weaken the soil structure
- Creating overhangs or overburden on the slope can increase the driving forces that cause the landslide material to move down the slope
- Triggering vibrations or shocks on the slope by heavy traffic or blasting can destabilize the existing cracks or fissures in the rock or soil

CHANGES IN WATER DRAINAGE PATTERNS

- Road construction can reduce the run-off of surface water and increase the infiltration of water into the soil, which can increase the pore water pressure and reduce the shear strength of the soil
- Road construction can alter the groundwater flows and create hydraulic gradients that can push the soil particles down the slope
- Road construction can erode the soil and rock by water and wind, which can weaken the slope structure and create gaps or cracks that can fill with water

INCREASE IN SURFACE EROSION DUE TO CONSTRUCTION ACTIVITIES

- Road construction can remove the vegetation cover that protects the soil from water and wind erosion
- Road construction can expose the soil and rock to weathering and weakening by water and wind erosion
- Road construction can create gaps or cracks in the slope that can be filled with water and increase the pore water pressure
- Road construction can reduce the soil cohesion and increase the susceptibility to mass movement

POOR DESIGN AND CONSTRUCTION PRACTICES

- Road construction can cut into the slope and reduce its stability and resistance to sliding
- Road construction can store excavated material on the downslope side of the road and increase the weight and driving force on the slope
- Road construction can damage natural drainage and allow water to seep into the soil and rock, increasing the pore water pressure and reduce the shear strength
- Road construction can damage or remove the vegetation cover that protects the slope from erosion and provides root reinforcement
- Road construction can induce vibrations or shocks by traffic or blasting that can trigger or reactivate existing landslides

SOME OF THE WAYS THAT ROAD CONSTRUCTION CAN TRIGGER LANDSLIDES ARE

Cutting the mountain or slope to create the road alignment, which reduces the shear strength and stability of the slope.

Storing or disposing the excavated material on the downslope side of the road, which adds weight and pressure to the slope and can cause debris flows.

Blocking or altering the natural drainage of the slope, which increases the water accumulation and seepage in the soil and weakens its cohesion.

Increasing the soil erosion and sediment transport by removing the vegetation cover and exposing the bare soil to rainfall and runoff.

SOME OF THE WAYS THAT ROAD CONSTRUCTION CAN TRIGGER LANDSLIDES ARE

Inadequacy in resilience structures

Insufficient study during road design and construction

Incorrect construction approaches

Neglect of land use patterns

RESILIENT STRUCTURE

RESILIENT INFRASTRUCTURE

What?

The ability of critical infrastructure to prepare for, absorb, recover from, and adapt to adverse events such as geohazards.

Why?

Geohazards such as earthquakes and landslides can cause severe damage to transportation networks, especially in rural and mountainous areas.

Road construction can trigger landslides by altering the slope stability, increasing the soil erosion, and blocking the natural drainage.

Climate change has increased the frequency and intensity of extreme and localized rainfall, which increases the terrain's susceptibility to landslides.

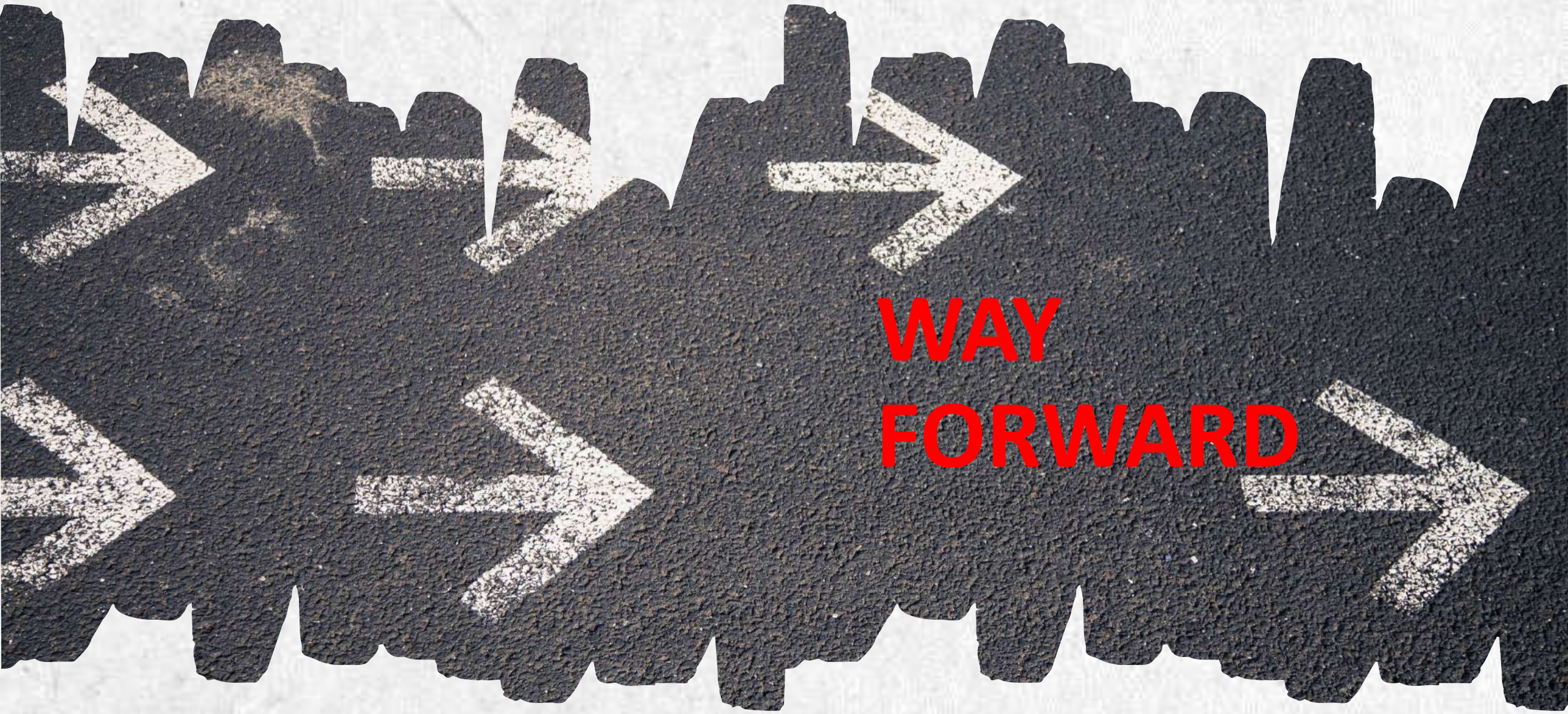
RESILIENT STRUCTURE

Design and implementation of road infrastructure that can withstand and recover from extreme weather events, such as high temperatures, heavy rainfall, floods and droughts.

Essential for the economy and society, as they ensure uninterrupted availability of the road network and reduce maintenance costs and environmental impacts.

KEY ASPECT OF RESILIENT STRUCTURE

- Climate proofed standards for road design, construction and maintenance that account for the current and projected climate scenarios and risks for the given territory
- Selection of appropriate materials and technologies for road pavement, such as bituminous binders with higher softening point, polymer modification of bitumen, stronger aggregate skeleton, geosynthetics, recycled materials and warm mix asphalt
- Life-cycle reliability, risk and resilience analysis of structures and infrastructure systems, such as bridges and road networks, under uncertainties


WAY
FORWARD

PROPER ROUTE CORRIDOR SELECTION

- During route corridor selection, corridors with minimum effect on slope instability based on hazard and risk rating system should be selected.
- Geological mapping along the route corridor should be done.
- A geotechnical evaluation of the proposed corridor should be carried out.
- The best route based on the minimum likely slope failure should be selected.

ENGINEERING DESIGN

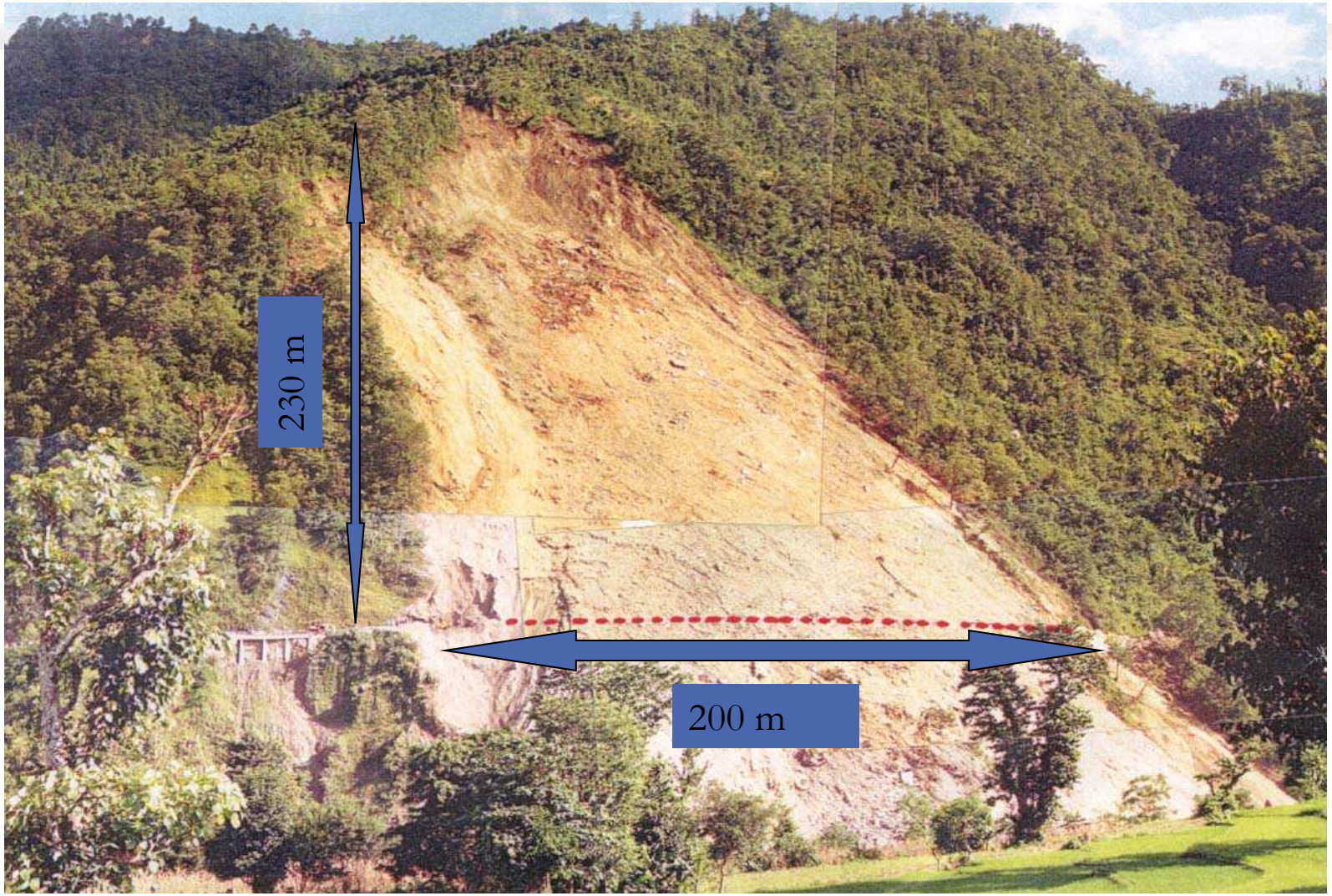
- Cut slope design and other road structures such as retaining walls, breast walls should be designed based on detailed geotechnical study of the site.
- Climate change effect should also be considered while modifying/ changing design standards and used appropriately.

PAST EXPERIENCE

PRIOR TO FAILURE OF AUG 11, 2000 :

Krishnavir

FAILURE EXTENT



CLEARING DEBRIS

AFTER SLOPE TRIMMING – JULY 2003

UNDER CONSTRUCTION OF GABION BOLSTERS –

JULY 2003

AFTER PLANTATION AUGUST, 2003

AUGUST, 2004

EAST SLOPE : 2003

EAST SLOPE AFTER CIVIL & BIO_ENGG : 2006

WEST GULLY BEFORE CONSTRUCTION OF CHECK DAMS 2003

WEST GULLY 2003

BEFORE CONSTRUCTION OF DOWNHILL CASCADE : 2004

AFTER CONST. OF DOWNHILL CASCADE BELOW WEST CULVERT : 2005

SLOPE AROUND EAST CASCADE 2004

SLOPE TRIMMING FOR BIO-ENGG. 2005

AFTER SLOPE PREPARATION 2005

2009

THANK YOU