Stream Restoration and Environmental River Mechanics

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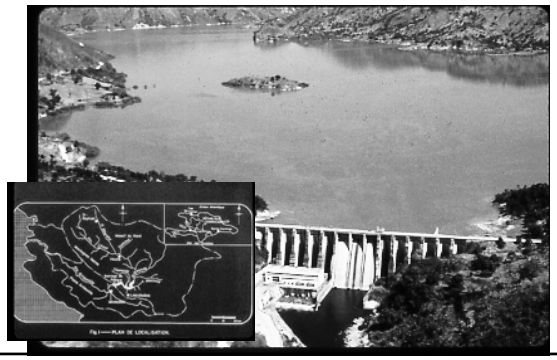
Objectives

Brief overview of environmental river mechanics and stream restoration:

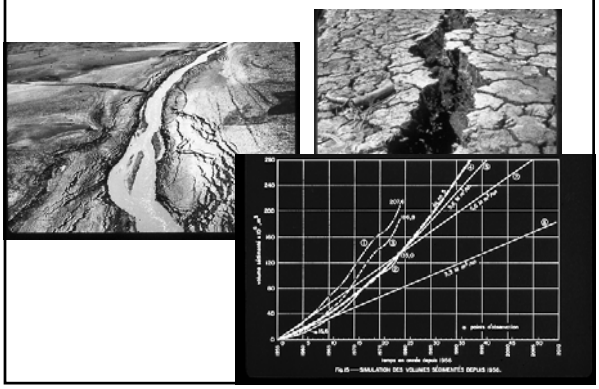
1. Typical problems in environmental river mechanics, bank protection, and bio-engineering;
2. Stream restoration example - Rio Grande
3. Provide Guidelines in Stream Restoration

1. Peligre Dam in Haiti (deforestation)



1. Peligre Dam (sedimentation)

1. Peligre Dam (reduced life expectancy)



2. Bank Protection

2. Lateral Channel Migration

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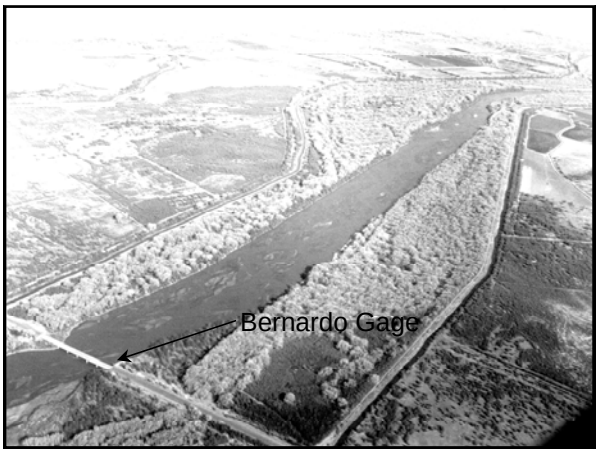
3. Vertical Degradation

Headcutting

3. Vertical Degradation

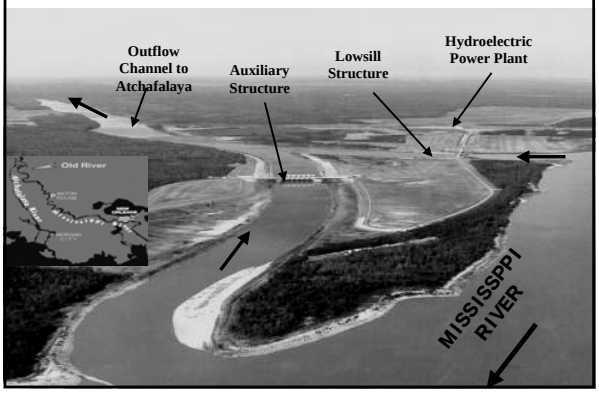
4. Jetty fields and vegetation of the Rio Grande

Jetty System (near Bernardo), USACE 1963



5. Woody Debris against Bridges

5. Woody Debris - Lower Mississippi River



5. Woody Debris - Lower Mississippi River

Three Laws of Stream Restoration

#1 There is no cookbook approach to stream restoration projects.

#2 Solutions normally require equilibrium conditions between sediment regime and stream ecology.

#3 Solutions need to be effective, environmentally acceptable and economical.

Restoration vs Rehabilitation

Restoration

•returning a resource to some former condition.

Rehabilitation

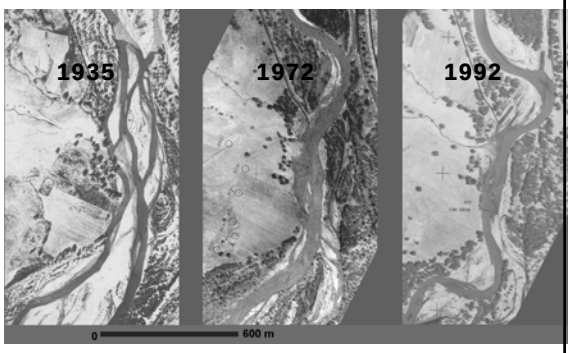
•maximize the potential beneficial uses of a resource to some reasonable and practical level.

6. Rio Grande Restoration– Santa Ana

Project Goals

- **Protect Levee**
- **Create a Functioning Floodplain**
- **Improve Wildlife Habitat**

6. Hydraulic geometry of the Rio Grande



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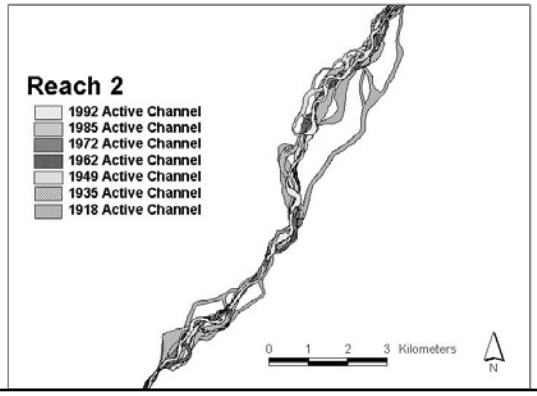

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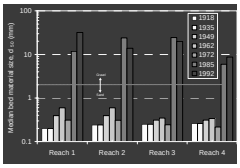
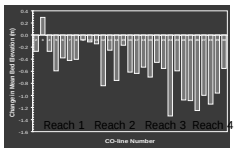
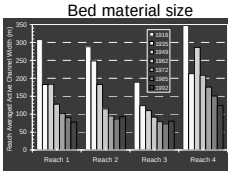


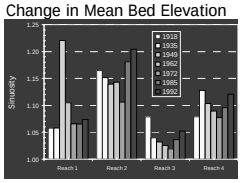
Bed material size



Change in Mean Bed Elevation



Active channel width



Sinuosity

6. Rio Grande Restoration– Floodplain restoration

Santa Ana Reach - Mid 80's

Santa Ana Reach – Mid 90's

6. Rio Grande Restoration– Endangered Species

- **Bimodal sand/gravel bed**
- **Deep water h ~ 1.20 m**
- **Water velocities 1.4 m/s**

Restoration

- **Create wider channels**

- **Sandy/silty substrate**
- **Shallow water h < 0.4 m**
- **Water velocities**
  0.1 m/s < V < 0.5 m/s

Gradient Restoration Facility

- Raise Riverbed with GRF

River Realignment

- Excavate Pilot Channel

River Realignment

- **Construct Bio-engineering Bankline**

Habitat Improvement

- **Sediment Storage Upstream from GRF**
- **Low Velocity Overbank Flows**
- **Planting and Natural Reseeding of Native Vegetation**

Floodplain Maintenance

- **Lower Terraces with Heavy Equipment**

Floodplain Restoration

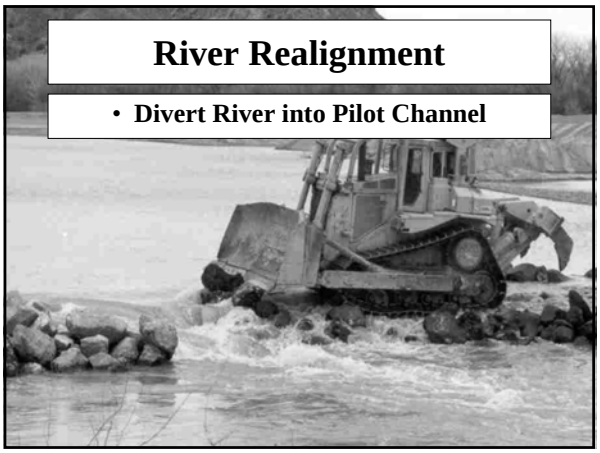
- **Excavated Sediment Placed near Pilot Channel**

Pilot Channel – Pre-Watering

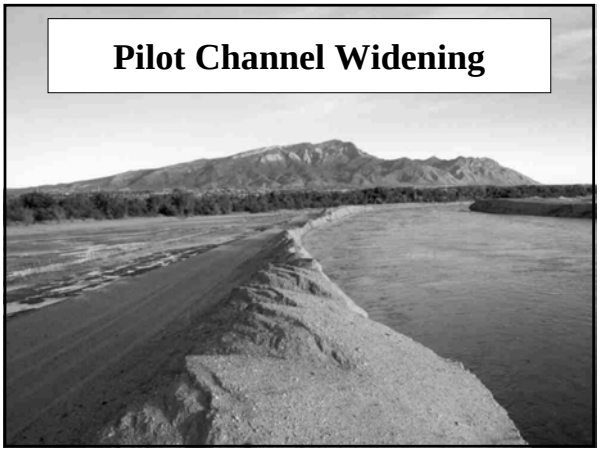
Opening Pilot Channel

River Realignment

- Divert River into Pilot Channel



Pilot Channel Widening

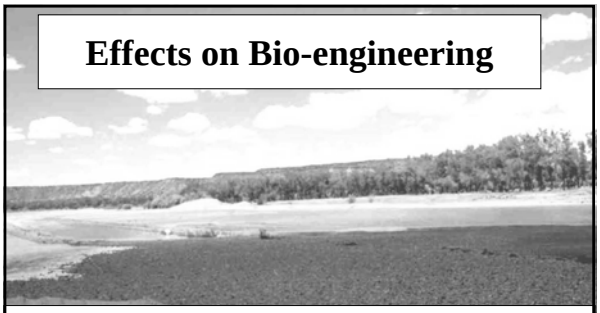


Spring Runoff - 2001

Post-Runoff Assessment

- More Gravel than Anticipated
- Mean Bed Elevation 2 ft Higher than Anticipated
- Pilot Channel 50-100 ft Narrower than Desired

Effects on Bio-engineering



- Most Willows in Fabric Encapsulated Soil (FES) Completely Submerged
- Sections of Bio-engineering Covered in Sediment

Rio Grande Conclusions

- Thoroughly study river mechanics and apply finding to the design process.
- Understand the evolution of the project and consider intermediate conditions.
- Be Flexible…Apply adaptive management techniques.

Stream Restoration Guidelines

1. **OBJECTIVES** - Clearly define the engineering and ecological objectives. Restoration vs rehabilitation.

2. **PAST, PRESENT and FUTURE –** Consider present conditions in the perspective of past events and examine future changes.

Stream Restoration Guidelines

3. **UPPER WATERSHED** – Look at the geology, deforestation, land use changes, urbanization, climate and extreme events. Examine water and sediment supply, flood frequency curves, sediment mass curves sediment concentrations, water quality, etc.

4. **DOWNSTREAM REACH** – Look at possible changes in the downstream reach that may affect current conditions – like reservoirs, base level changes, headcutting, etc.

Stream Restoration Guidelines

5. **CHANNEL GEOMETRY** – Determine equilibrium downstream hydraulic geometry in terms of width, depth, velocity, slope, discharge and morphology.

6. **AQUATIC HABITAT**– determine appropriate aquatic habitat conditions including low and high flow periods, pools, riffles, spawning grounds, shade, aeration, migration, etc.

Stream Restoration Guidelines

7. **EXAMINE ALTERNATIVES** – Identify several different stream rehabilitation schemes that would suit the engineering and environmental needs.

8. **DESIGN SELECTION –** examine the various alternatives and select the best possible alternative and proceed with the design. Solution must be effective, environmentally sound and economical.

Stream Restoration Guidelines

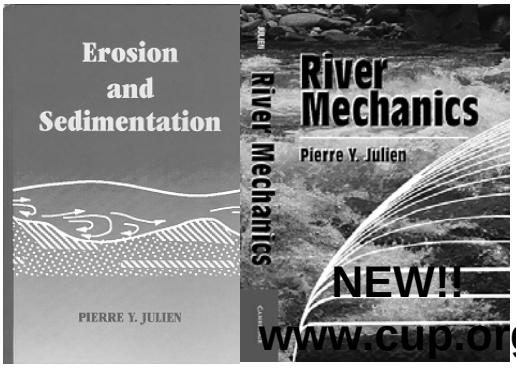
9. **CONSTRUCTION** – Carefully plan the construction and consider the possible impact of possible extreme events during the construction period.

10. **MONITORING** – Things may not work as planned. A post-construction analysis and monitoring should be carried out until the objectives have been met.

Conclusions

- Deforestation can result in significantly increased sediment yield and reduced life expectancy of reservoirs.
- Vegetation can stabilize river banks but woody debris can damage bridges and hydraulic structures.
- Stream restoration projects require expertise in river mechanics and stream ecology.

Erosion and River Mechanics Textbooks



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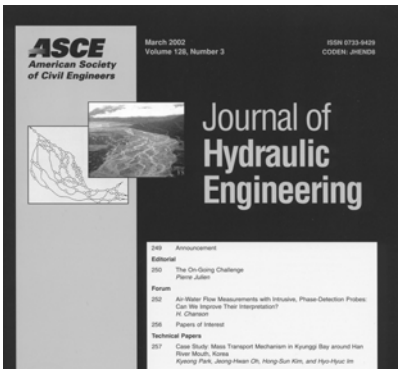

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THANK YOU for your Attention!