DAM REMOVAL
ENGINEERING ISSUES & OPTIONS

Presented by:

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CLEAR GOALS and OBJECTIVES

- Fish Passage
- Habitat Defragmentation
- Water Quality
- Dam Failure Hazards
- On-site Safety
- D/S Channel Degradation
- Hydrologic Modifications
- Sediment Transport Continuity
- Maintenance & Operational Costs
DAM REMOVAL ISSUES

SOCIOECONOMIC
- OWNERSHIP (Water Rights; Easements)
- CURRENT USES
- RECREATION
- PUBLIC SAFETY
- ECONOMIC ANALYSIS
- ARCHEOLOGICAL/HISTORICAL
- SENTIMENTAL VALUE
- AESTHETICS

HYDROLOGY
- WATERSHED HYDROLOGY
- FLOODWATER STORAGE
- IMPOUNDMENT DRAWDOWN
- DOWNSTREAM IMPACT
- WELL IMPACTS

FLUVIAL MORPHOLOGY
- Data Collection
- CHANNEL MORPHOLOGY/DESIGN (form, function, process, materials)
- CHANNEL EVOLUTION
- SITE RESTORATION

WATER QUALITY
- CHEMICAL PROPERTIES
- PHYSICAL PROPERTIES
  (i.e. temperature, turbidity)
- PUBLIC HEALTH

ENGINEERING
- DATA COLLECTION
- TYPE & CONDITION OF DAM
- SITE LIMITATIONS (Utilities, Topo)
- UPSTREAM & DOWNSTREAM ISSUES
  (bridges/structures, tributaries)
- PROJECT PERMITTING
- ALTERNATIVES ANALYSIS

ECOLOGY
- ANADROMOUS / RESIDENT FISH
- AQUATIC HABITAT
- HABITAT FRAGMENTATION
- ECOLOGICAL RECOVERY
- VEGETATION
- WILDLIFE
- SPECIES OF SPECIAL CONCERN

HYDRAULICS
- CHANNEL HYDRAULICS & SAFETY
- FLOODPLAIN HYDRAULICS
- SEDIMENT STABILITY/TRANSPORT
- FISH PASSAGE
- ICE JAMS

CONSTRUCTION
- SEASONAL CONSTRUCTION LIMITS
- CONSTRUCTION ACCESS
- CONSTRUCTION SEQUENCE
- SEDIMENT MANAGEMENT AND DISPOSAL
- WATER CONTROL
DAM REMOVAL FALLACIES

• All Dams Have A lot of Sediment
• All Impounded Sediments Will Erode
• Barren Mud Flats Last Forever
• River Dries Up
• All Upstream Channels Headcut
• All The Fish Die
• Dam Removal Allows Fish Passage
CONSTRUCTION BID DOCUMENTS

1. **Planning and Analysis**
   - Site Planning
   - Sediment Probes
   - Sediment Testing
   - Hydrology
   - Hydraulic Analysis
   - Schematic Alternates

2. **Preliminary Design**
   - Access
   - Water Control
   - Initial Breach
   - Sediment Management
   - Demolition Plan
   - Restoration Plan

3. **Final Design**
   - Cross Sections
   - Custom Details
   - Easements
   - Utilities

4. **Cost Estimates**

5. **Specifications**

6. **Permitting**
   - Local, State, Federal
STUDY PROCESS
DAM MANAGEMENT ALTERNATIVES

**BASE DATA**
- NID
- FEMA
- STATE AGENCIES
- DESIGN PLANS
- HISTORY
- OWNERSHIP
- AS-BUILT DATA
USE

**DATA COLLECTION**
- SITE DATA
  - TOPOGRAPHY
  - WETLANDS
  - RARE SPECIES
  - HYDROLOGY
  - GEOLOGY
  - HISTORIC VALUE
  - SEDIMENTS
  - WATER QUALITY

**DAM SAFETY**
- HAZARD CLASSIFICATION
- PHYSICAL INSPECTION
- SPILLWAY CAPACITY
- SIZE CLASSIFICATION
- OPERATIONAL HAZARDS
- STRUCTURAL / GEOTECH.

**PUBLIC & REGULATORY**
PARTICIPATION

**IDENTIFY ALTERNATIVES**
- YES
  - IS DAM SAFE?
- NO
  - EMERGENCY REPAIRS OR DRAWDOWN

**REPAIR OR REPLACE DAM**
- MARGINAL DAM

**LOWER CREST**
- FISH LADDER
- D/S RAMP
- U/S RAMP
- HIGH LEVEL BY-PASS CHANNEL

**LIMITED FEASIBILITY STUDY**
- SITE SPECIFIC TOPICS

**ELIMINATE DAM AND IMPOUNDMENT**
- NO ACTION
- FULL REMOVAL
- PARTIAL BREACH
- LOW LEVEL BY-PASS
- OTHER

**PUBLIC & REGULATORY**
PARTICIPATION, SELECT ALTERNATIVE

**COMPLETE REMOVAL**
- VERY SMALL OR LOW RISK DAM, SIMPLE DECOMMISSION

**DETAIL FEASIBILITY STUDY**
- HYDRAULIC ANALYSIS
- SEDIMENT TESTING
- SEDIMENT TRANSPORT
- CHANNEL MORPHOLOGY
- U/S AND D/S IMPACTS
- WETLAND IMPACTS
- LAND USE / AESTHETICS
- AQUATIC SPECIES
- RECREATION
- LAND RIGHTS
- WATER RIGHTS
- UTILITIES
- ACCESS
- FINANCIAL IMPACTS
- CONSTRUCTION METHODS
- SITE RESTORATION
- EROSION CONTROL

**IMPLEMENTATION**
- CONSTRUCTION PLANS
- SPECIFICATIONS
- COST ESTIMATES
- FUNDING
- EASEMENTS
- REGULATORY PERMITS
- CONSTRUCTION ADMINISTRATION
- SITE RESTORATION
- AS-BUILTS
- OPERATIONAL PLAN
- EMERGENCY RESPONSE PLAN

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**STUDY PROCESS**
DAM MANAGEMENT ALTERNATIVES

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FISH PASSAGE OPTIONS

FISH POWER
• Dam Removal, Thru Channel
• Full Flow By-Pass Channel
• Partial Flow By-Pass Cannel
• Downstream Ramp
• Upstream Ramp
• Structural Fish Ladder

MECHANICAL POWER
• Trap and Haul
• Elevators
**Impoundment Management**

**Channel Form**
- Natural Formed Channel
- Create Regime Channel
- Armored Channel
- Grade Controls
- Alignment Controls
- Combination

**Sediment**
- Natural Erosion
- Excavate Sediment
- Relocate Sediment
- Contain Sediment
- Combination
SEDIMENT DEPOSITS IN RESERVOIRS

Modified from Morris, 1998
SEDIMENT ISSUES

• Sediment Quality & Quantity
• Sediment Stability
• Sediment Transport
• Stabilize, Remove or Natural Erosion
• Sediment Disposal
• Downstream Sediment Impacts
• Ecological Recovery Time
DAM REMOVAL SEDIMENT ANALYSIS

Set Goals & Objectives
Contact Agencies
Estimate Scope

Collect Data
Profile Analysis

- Historic Search
- Watershed Search
- Site Investigation
- Geomorphic Observations
- Substrates
- Hand Borings
- Ex. Hydrology Data
- Ex. WS Profiles
- Sediment Quality
- Sediment Quantity
- Grain Size Analyses

Non-Alluvial Channels

Alluvial Channels

Hydraulic Geometry

Reference Reach
Regional Data
Regime Eq.

Classification (Optional)

Hydraulic Analysis

Complex Projects
Advanced Sediment Transport Modeling
1D Fixed Width
1D Variable Width
2 & 3D

Design Development

Planform Habitat Passage Aesthetics Banks Access Vegetation Sediment Management

Simple Projects

Moderate Projects
Threshold Stability and/or Sediment Transport Equations

Hydraulic Analysis

1D Fixed Width
1D Variable Width
2 & 3D

Modified from Mac Broom 2003
KEY CHANNEL EVOLUTION FACTORS

**Independent**
- Hydrology
- Sediment Yield
- Pre-Dam Substrate
- Valley Slope
- Valley Width
- Bank Vegetation

**Dependent**
- Sediment Gradation
- Cohesive Strength
- Pool Thalweg
- Pool Aspect Ratio
- Delta Position, Slope
- Breach Size & Depth
UPSTREAM CHANNEL PREDICTION

- Historic Data on Pre Dam Conditions
- Reference Reaches - NCD
- Regime Equations
- Hydraulic Geometry Equations
- Slope – Discharge, Stream Power
- Hydraulic & Sediment Transport Methods
- Extremal Hypothesis
SEDIMENT MANAGEMENT OPTIONS

• Do Nothing – Allow Erosion
• Create Stable Channel
• Stabilize Sediment, Re-vegetate
• Relocate Sediment Onsite
• Partial Dredge and Remove “Hot Spots”
• Isolate and Contain Fines, Contaminants
• Divert Channel Around Impoundment
• Full Dredge and Remove
• Combination
SEDIMENT ANALYSIS UNCERTAINTY

• Hydrology – Watershed and Climate Change?
• Sediment Supply Reach - Load and Gradation
• Flow Regime - Roughness, Velocity, Shear
• Bank Stability - Mass Failures or Slow Slumps?
• Cohesion - Rate of Erosion?
• Channel - Slope, Shape, and Size
• Transport Capacity - Compare with Supply and Erosion Rates
• Buried Subgrade - Armor or Bedrock Controls?
• Legacy Dams - Submerged in Pool?
• Choice of Algorithms
• Prediction Accuracy
DIFFICULT DAM REMOVALS

- Urban Dams
- Legacy Dams
- Wide Impoundments
- High River Flow Rates
- Sediment Sensitive Rivers
- Contaminated Sediments
- Undocumented Dams
- Infrastructure, Bridges, Utilities
- Weak or Unprofessional Management Teams
DESIGN DAMS FOR FUTURE REMOVAL

- Permanent Access Roads
- High Capacity Outlet Works
- Sediment Sluices or Bypasses
- Multiple Construction Joints
- Clear Downstream Hazard Areas
- Archive Design Plans
- Construction Photographs