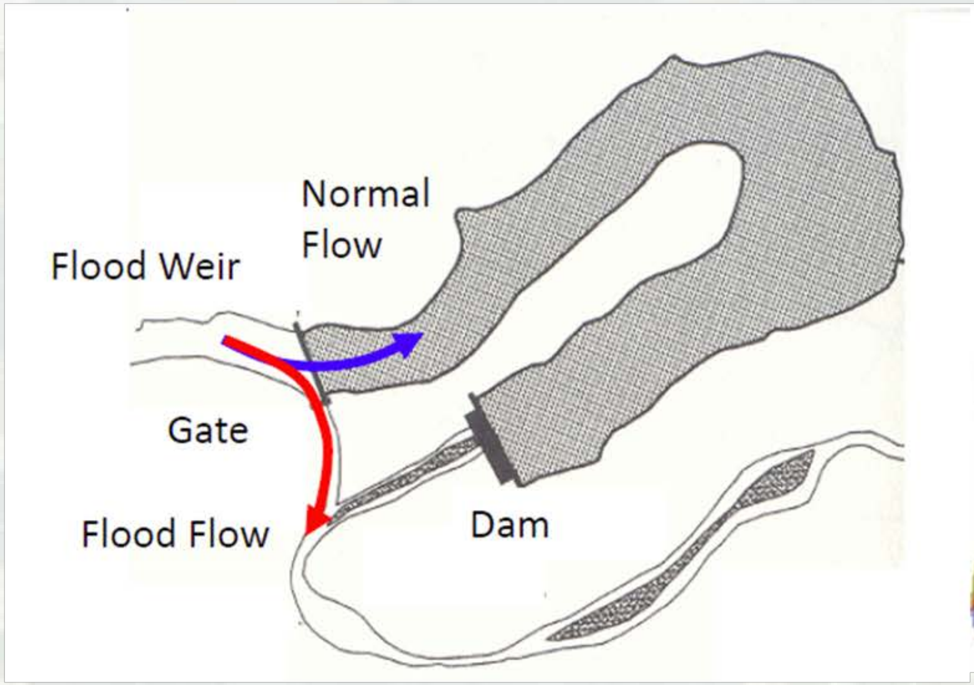
Reservoir Sediment Management & Analysis for Engineers

Sediment Bypass Channels and Tunnels

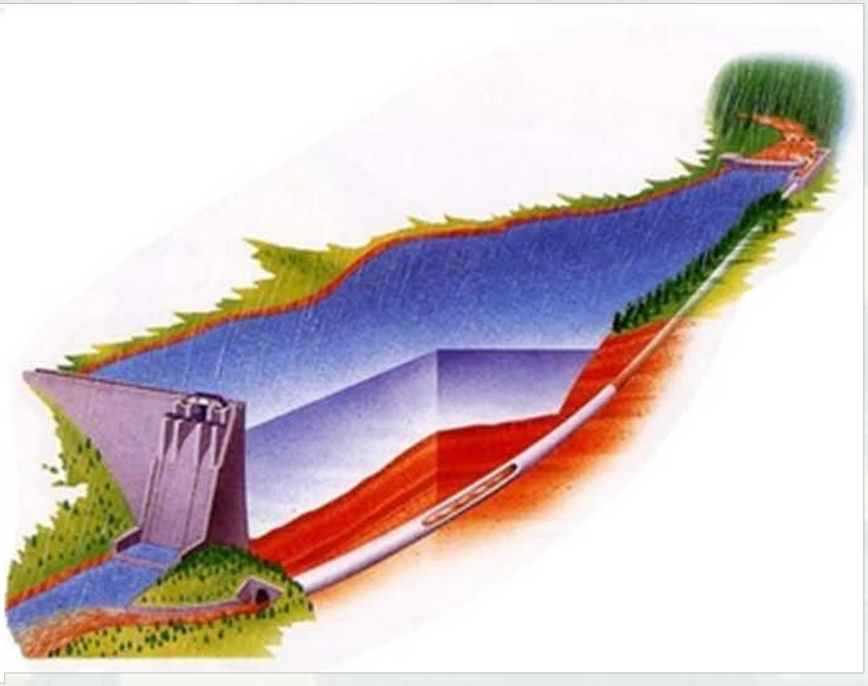
University of Kansas
LEEP2 Building – Room G415
June 11-15, 2018

ERDC
Engineer Research and Development Center

Sediment Bypass



Sediment bypass at Nagle Dam, South Africa
(Figure from Annandale 2013)



Sediment bypass tunnel at Miwa Dam, Japan
(Figure from Annandale 2011)

Sediment Bypass – Main Channel Storage

- Bypass high sediments flows around reservoir by constructing a large-capacity channel or tunnel
- Topographic conditions are favorable
- Intercept / divert flow upstream of the reservoir pool
- May eliminate the need, or reduce size, for a large-capacity spillway at the main dam since flood flow is diverted

Sediment Bypass Example

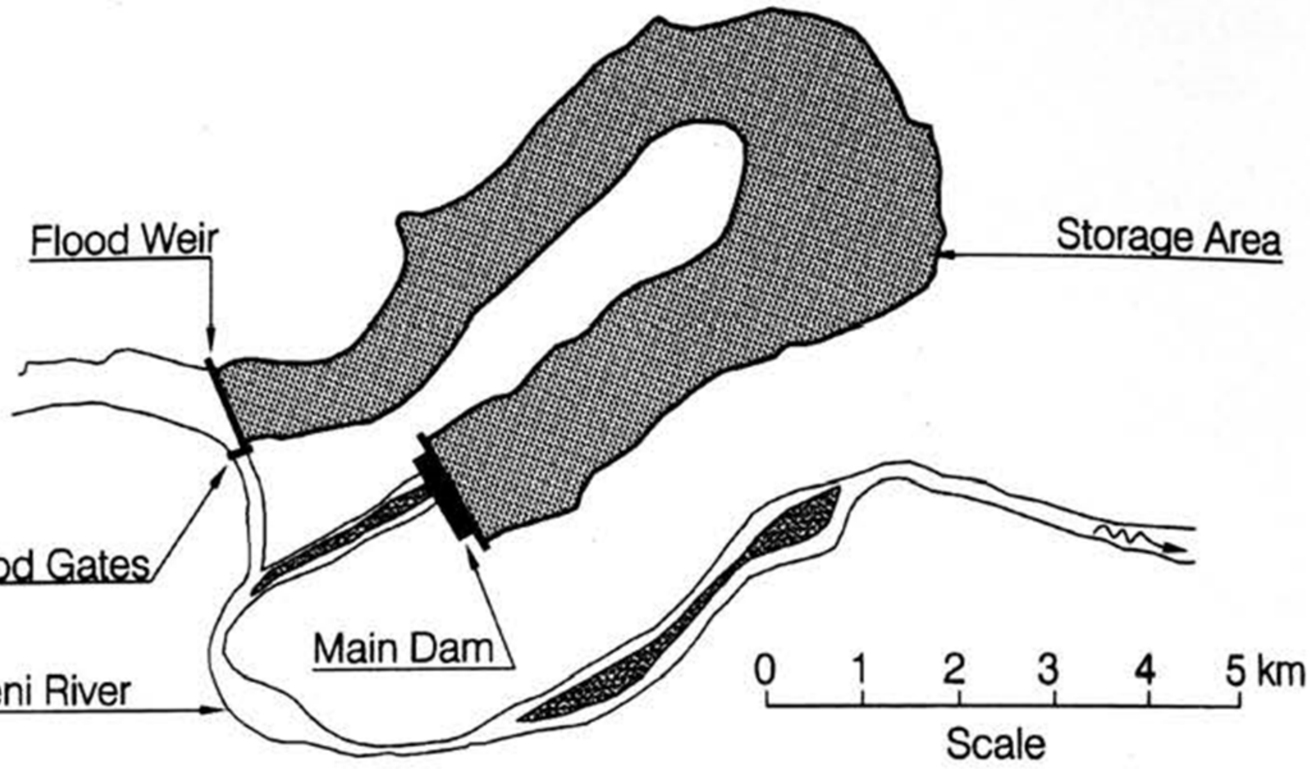


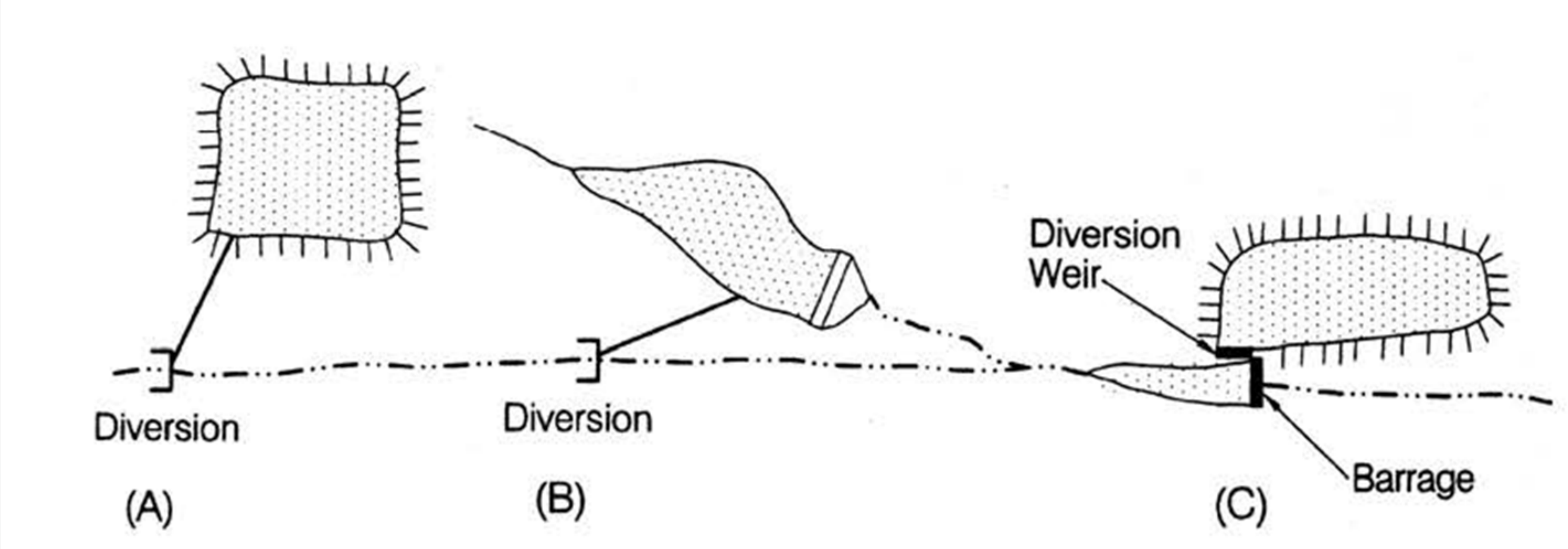
FIGURE 13.9 Sediment bypass configuration at Nagle Reservoir in South Africa (*after Annandale, 1987*)

From Morris and Fan, Reservoir Sedimentation Handbook

Sediment Bypass – Offstream Storage

- Constructed storage off the main river
- Most sediments continue with the main channel
- Fill with diverted water of low sediment concentration
- Sediment floodwaters can be partially excluded
- Intake designed to exclude coarse sediments
- Construct by dike impoundment in floodplain or small dam on tributary
- Flow into storage is limited by lesser of diversion capacity and stream flow at time of diversion

Sediment Bypass – Offstream Storage Examples

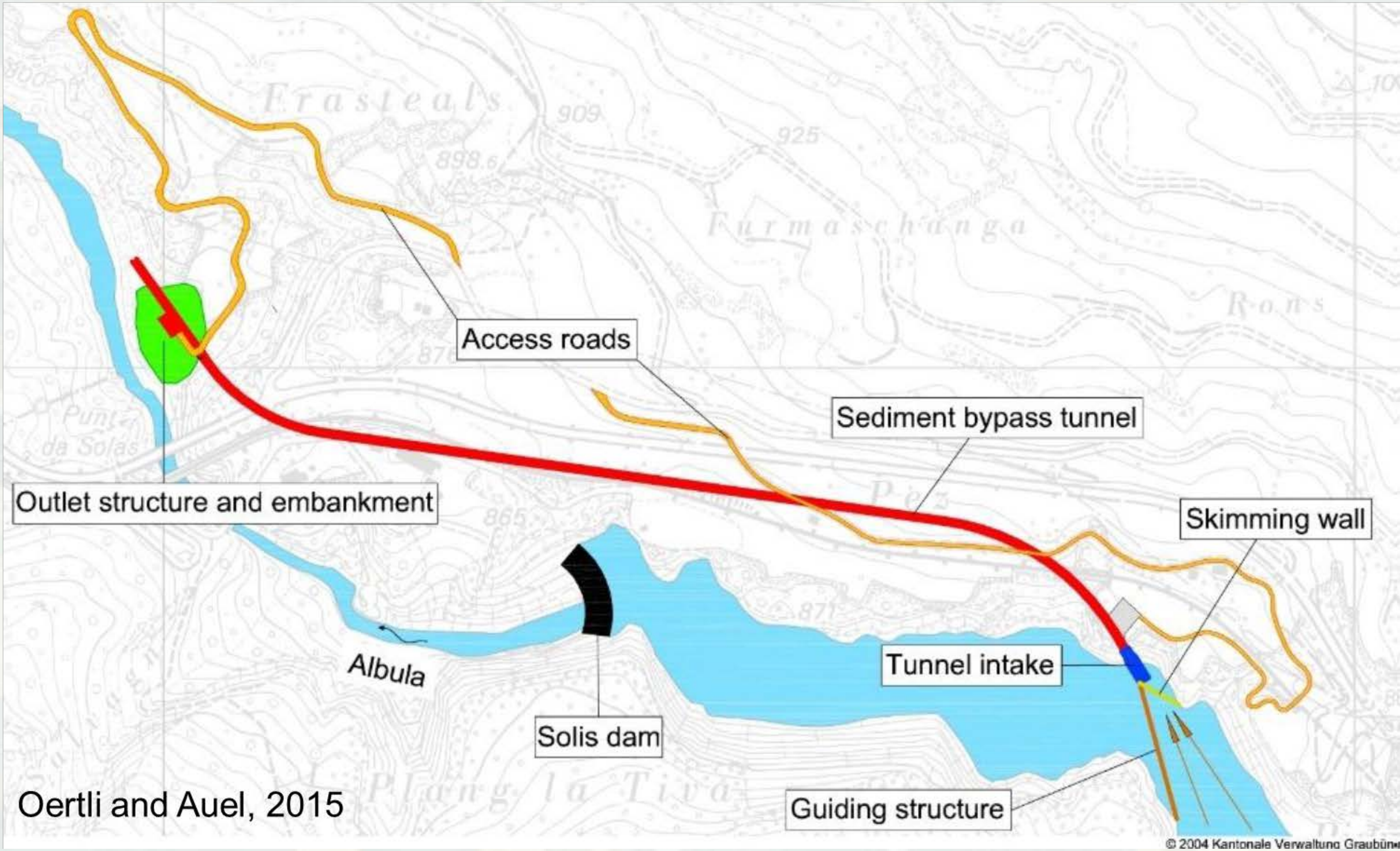


From Morris and Fan, Reservoir Sedimentation Handbook

Sediment Bypass

- PRO
  - Passes sediment during high flows (more natural) maintaining storage volume
- CON
  - Very expensive retrofit for existing facilities
  - Doesn’t pass 100% of sediment
  - Not effective in low head elevations & coarse material

Solis Reservoir, Switzerland



Oertli and Auel, 2015

Oertli and Auel, 2015

Downstream Discharge

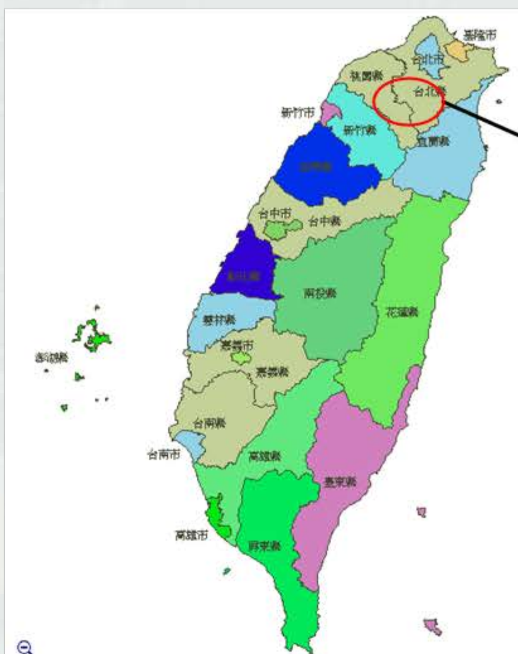
Oertli and Auel, 2015

Effectiveness

1987 Flood (No SBT)	2014 Flood (with SBT)
▪ 252 m^3/s	▪ 288 m^3/s
▪ 248,000 m^3 deposition	▪ 102,000 m^3 deposition

Shihmen Reservoir in Taiwan

- Location
  - Taoyuan County
  - DaHan River
  - Build in 1956-1964
- Functions
  - Municipal Use & Irrigation
  - Power Generation
  -



During Typhoon

Large amount of sediments enters reservoir during large storm

- Photo: during typhoon 海棠(July 2005)

Increased Sediment Supply

- 4 time more than the original estimate
- Impact of 921 Earthquake (in 1999; 2,415 death)
  - Steep Watershed Valley
  - Geological Weathering and Climate Change
  - Landslides and Soil Erosion

Typhoon Aere

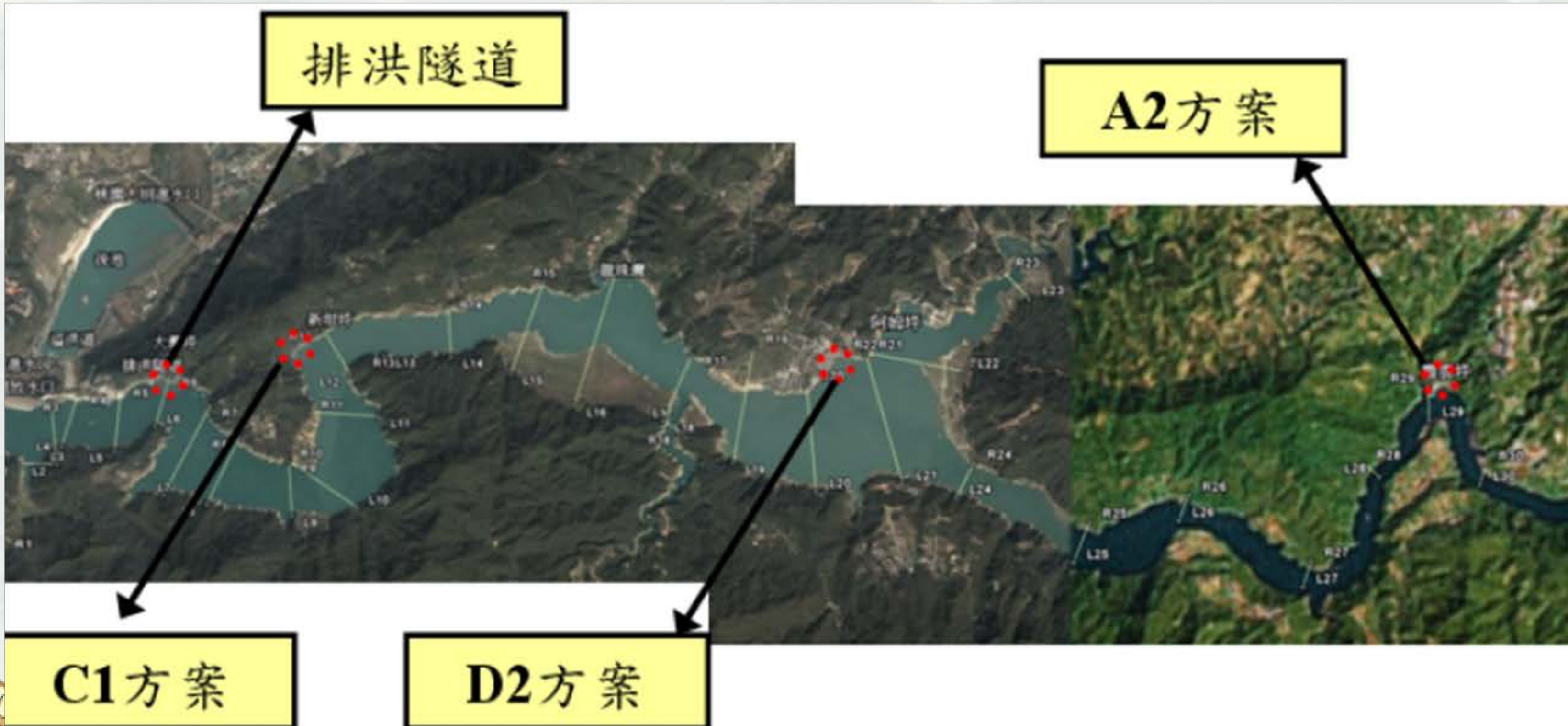
- Time: August 23-26, 2004 Rainfall: 973 mm
- Peak Discharge: 8,594 cms Deposit: 27.9 mill-m^3
- Reservoir Capacity Loss: 11%
- SSC > 100 g/L for 3 weeks
- Water supply stopped for 17 days

Government Mandates after Aere

- 25 billion NTD (~ 780 million USD)
- Water Supply Ensured (>1 million people)
- Reservoir Life Extended/Sustained

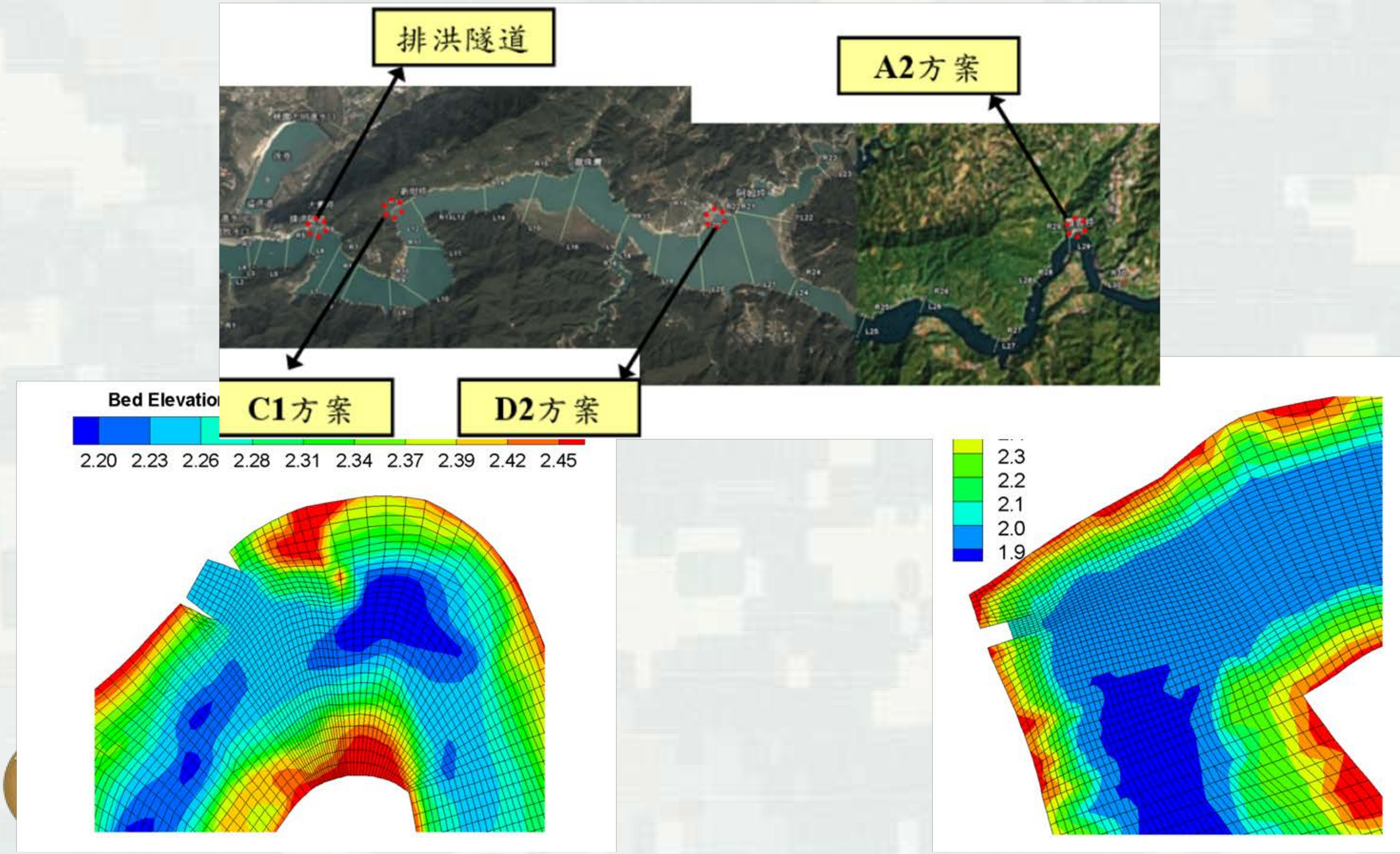
New Bypass Tunnels (Desilting)

- Plan A, B, C and D
- Typical Design: 12m diam; 1600 cms capacity



Bypass Tunnels

- Plan A (1,600 cms) and C: (1,200 cms)



Comparison of Plans

- Percentage of sediment passed through outlets during typhoon Aere

		Bypass Tunnel	Power House	Spillway & Flood Diversion	Perm. Channel	Shihmen Intake	Total Passed
Existing	Numerical	none	30.3%	22.6%	2.42%	0.52%	**55.9%**
	Physical		29.0%	13.2%	2.36%	0.54%	**45.1%**
C Tunnel Plan	Numerical	31.4%	25.3%	12.1%	2.10%	0.46%	**71.4%**
	Physical	31.6%	18.8%	14.7%	1.41%	0.38%	**67.0%**
A Tunnel Plan	Numerical	35.4%	22.9%	12.6%	1.83%	0.41%	**73.0%**
	Physical	31.4%	22.8%	13.0%	1.78%	0.38%	**69.4%**

Tseng-wen Sediment Sluicing Tunnel (or bypass or venting)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Questions?