Lessons Learned – Successes & Failures with Articulated Concrete Blocks in Stilling Basins

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Articulated Concrete Block (ACB) Stilling Basin Installations

- Nilan Reservoir North Dam
  - Lewis & Clark County, near Augusta Montana

- Deadman’s Basin Reservoir
  - Wheatland County, near Harlowton, Montana
Nilan Reservoir North Dam
Nilan Reservoir North Dam

- Off Channel Reservoir
- Designed in 1951
- Full-pool storage of 10,100 acre feet
- Outlet conduit: 48” diameter concrete pipe
  - Slope = 0.09%
  - Capacity 395 cfs
- Outlet canal system
  - Slope = 0.3%
  - Capacity = 180 cfs
Original Outlet Structure
Outlet Structure Replacement

- Replacement designed by DNRC in 2007
- PWD Basin – Size “F”
  - capacity of 120 to 280 cfs
  - ACB in place of riprap
DNRC Design
Articulated Concrete Blocks
Articulated Concrete Blocks

Open Cell Block

Close Cell Block

SIDE VIEW

END VIEW
Articulated Concrete Blocks

Typical Mat
Outlet Replacement Structure

- March 14, 2008
Nilan Outlet Replacement Structure

- March 14, 2008
Nilan Outlet Replacement Structure

- July 31, 2008 - 6.75 cfs
Nilan Outlet Replacement Structure

- July 31, 2008 - 6.75 cfs
Nilan Outlet Replacement Structure

- **Outlet flow rate**
  - Typically less than 20 cfs
  - DNRC estimated historic peak of 80 cfs

- **Hydraulic jump**
  - Located within conduit at low flow rate
  - Located at the outlet structure for flow rates > 50 cfs
Deadman’s Basin
Deadman’s Basin

- Off Channel Reservoir
- Constructed in 1941 and enlarged in 1958
- Full-pool storage of 72,218 acre feet
- 8’x8’ box culvert conduit
  - Slope = 0%
  - Capacity = 970 cfs
- Outlet canal system
  - Slope = 0.13%
  - Capacity = 560 cfs
  - Normal operating flow rate = 200 to 300 cfs
Original Outlet Structure
Outlet Replacement Structure

- Replacement designed in 2009
- Construction completed May, 2010
- Design flow rate = 560 cfs
- PWD Basin
  - Size “H” Basin: capacity of 450 to 640 cfs
  - ACB in place of riprap
Outlet Replacement Structure
Outlet Replacement Structure
2010 Outlet Flow Rates

- **May**: 40 cfs -> 175 cfs
  - Test at 300 cfs
- **June**: 10 cfs -> 20 cfs
- **July**: 15 cfs -> 225 cfs
- **August**: 200 cfs -> 140 cfs
- **September**: 140 cfs -> 25 cfs
  - 300 cfs for 2 hours to calibrate Sontek
Failure Analysis – October 2010
Failure Analysis – October 2010
Repair Alternatives

- **Riprap**
  - Large diameter, not readily available
  - Significant sandstone bedrock excavation

- **Grouted Riprap**
  - Large diameter, not readily available
  - Significant sandstone bedrock excavation
  - Requires relief for hydrostatic pressures

- **48” A-Jacks**
  - Tested at velocities up to 32 feet/sec
  - High energy dissipation
  - Minimum bedrock excavation
A-Jacks Installation
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A-Jacks Run-Up Test

- Initially scheduled for May 2011
- Delayed due to flooding

Photo from Havre Daily News

Photo from Billings Gazette
A-Jacks Run-Up Test

- Conducted on August 12, 2011
- Flow rates (cfs) tested: 100, 150, 200, 265, 345
A-Jacks Run-Up Test
A-Jacks Run-Up Test
Questions?