

# hydroAMP: Penstock Condition Assessment Guide -draft



**Sharon Demeaux, PE**

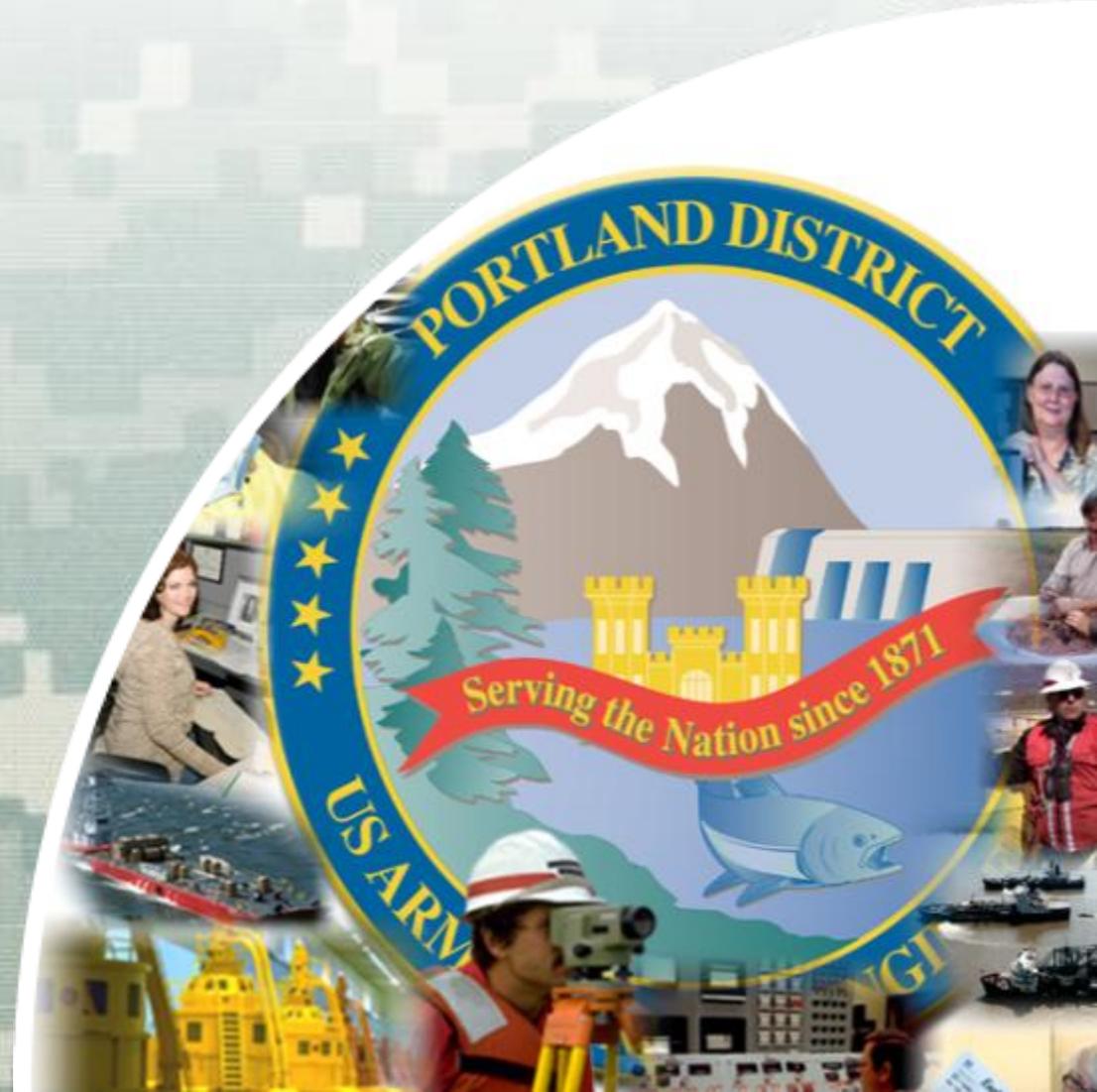
Lead Structural Engineer

Hydroelectric Design Center

September 25, 2012



US Army Corps of Engineers  
**BUILDING STRONG®**





# hydroAMP: Penstock Condition Assessment Guide -*draft*

- Agenda
  - ▶ A little about hydroAMP.
  - ▶ Penstock Condition Assessment Guide.
    - Penstock Assessment Guide
    - Tier I
    - Tier II
    - Status Update
  - ▶ Questions ?



# hydroAMP History

- The original program was developed by a partnership between USACE, USBR, BPA and Hydro Quebec
- Beginning in 2009 CEATI began program oversight and management



# A Very Brief Primer on Asset Management

- What is an asset management program?

Asset management is a program or a plan to take care of the things that you own or are responsible for

- What do you need to know before you can prepare an asset plan?
  - ▶ What you own – your assets
  - ▶ **The condition of your assets and some idea about their risk of failure**
    - If you have a lot of stuff spread out over a large area a consistent method is important
  - ▶ Cost of keeping your assets operational
  - ▶ How much you care if they fail



# hydroAMP Users

- Corps of Engineers
  - ▶ 75 power plants, 375 generators and associated power equipment
  - ▶ 133 database users
- Bureau of Reclamation
  - ▶ 59 powerhouses, 192 generators and associated power equipment
  - ▶ 102 database users
- Other that have used the hydroAMP framework include:  
Allegheny, Chelan PUD, Manitoba, Seattle City Light,  
Tacoma Power, Puget Sound Energy



# hydroAMP's Condition Assessment Principles

- Simplified process
- Developed from routine tests and inspections
- Technically sufficient (valid though not necessarily perfect)
- Objective results
- Easy interpretation
- Consistent and repeatable results
- Guided by multi-agency team effort
- Start small, expand with time
- Open to improvement



# hydroAMP Has Developed Equipment Condition Rating Guides for the Following Equipment

1. Circuit Breakers
2. Turbines
3. Transformers
4. Generators
  - ▶ Stator
  - ▶ Rotor
5. Governors
6. Exciters
7. Surge Arrestors
8. Cranes
9. Batteries
10. Compressed Air Systems
11. Emergency Closure Gates and Valves





# hydroAMP: Penstock Condition Assessment Guide -*draft*

- *Draft* HydroAMP Penstock Condition Assessment Guide is written and is in review.
  
- Authored by
  - ▶ Sharon Demeaux, USACE Hydroelectric Design Center
    - Lead Structural Engineer with HDC, began work at HDC in 2000
    - Expertise in the analysis and inspection of existing penstocks, review of new designs
  - ▶ Bill McStraw, USBR Hydroelectric Research & Technical Services Group
    - Author of FIST Manual “Inspection of Steel Penstocks and Pressure Conduits”
    - Leads Penstock Inspection Program for the USBR.
    - Has 33 years of experience with steel penstocks, the first 15 in design -the last in inspection.





# hydroAMP: Penstock Condition Assessment Guide *-draft*

- Why?
  - ▶ Penstock failure can result in powerhouse flooding, potential loss of life, potential loss of pool.
  - ▶ Significant economic impacts due to high cost of repairs and lost revenues during extended forced outage.
- What can be done?
  - ▶ Maintain penstock properly.
  - ▶ Operate penstock within design parameters.
  - ▶ Be aware of condition and design parameters.







# hydroAMP: Penstock Condition Assessment Guide *-draft*

- hydroAMP is a condition assessment tool.
  - ▶ It is used as input to an asset management program that prioritizes budget needs based on condition and risk of failure.
  - ▶ It is not a safety program, a FIST manual, or a design standard.
  - ▶ A good Condition Index Score  $\neq$  Assured Safety
    - Poor results from ANY inspection, test, or measurement may require that the penstock be taken out of service and the penstock dewatered.
    - Safety is independent of Penstock Condition Index Score.



# hydroAMP: Penstock Condition Assessment Guide -*draft*

- Penstock Assessment Guide

- ▶ Tier I

- Tier I is based on visual assessment made by project staff as part of routine activities.
    - Condition Indicators (what areas matter)
    - Weighting Factors (how much do they matter)

- ▶ Tier II

- Tier II requires a more detailed look by highly specialized staff.
    - Detailed NDE, Detailed DE, Surveys, Assessments, Analyses, Tests



# hydroAMP: Penstock Condition Assessment Guide *-draft*

- Tier I: Condition Indicators & Weighting Factors
  - ▶ Physical Condition: (50%)
  - ▶ Maintenance: (12%)
  - ▶ Operational Concerns: (29%)
  - ▶ Age: (10%)

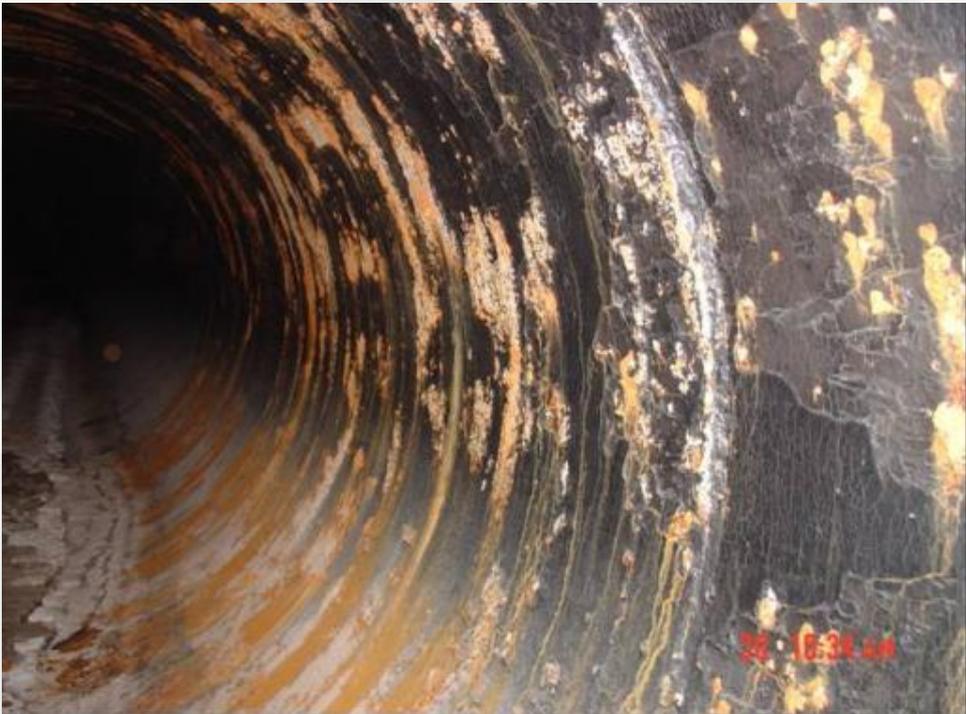


# hydroAMP: Penstock Condition Assessment Guide *-draft*

- Tier I: Physical Condition Indicator
  - ▶ Rates Four Separate Areas
    - Penstock Steel Shell and Joints/Connections
    - Linings and Coatings
    - Expansion Joints and Couplings
    - Penstock Supports
  - ▶ Visual Assessment only, no NDE







25 16:34 AM



# hydroAMP: Penstock Condition Assessment Guide *-draft*

- Tier I: Maintenance Indicator
  - ▶ Assesses maintenance required as either minimal, moderate, or extensive.
    - Includes maintaining linings and protective coatings, air valves, expansion joints and couplings, and cleaning bearing pads of the supports.
    - Does not address failure to perform maintenance .



# hydroAMP: Penstock Condition Assessment Guide *-draft*

- Tier I: Operational Concerns Indicator
  - ▶ Requires documented knowledge of penstock operational design parameters be on-file.
  - ▶ Addresses Four Separate Areas
    - Emergency Closure System
    - Water Hammer Analysis & Load Rejection Testing
    - Air Vent Analysis
    - Vibration







# hydroAMP: Penstock Condition Assessment Guide -draft

## ■ Tier I: Age Indicator

▶ Based on the oldest component in the penstock assembly.

### ▶ Scoring

Age	Score
• >25 yrs	high
• ≥25 and <50 yrs	↓
• ≥50 and <80 yrs	↓
• ≥80 yrs	low



# hydroAMP: Penstock Condition Assessment Guide *-draft*

- Tier II
  - ▶ Non-routine, outage required.
  - ▶ Specialized tools and expertise is required.
  - ▶ Triggered by low scores in Tier I.
  - ▶ Also triggered by safety programs, other concerns.
  - ▶ Tier I Penstock Condition Index is adjusted based on outcome of each Tier II activity.



# hydroAMP: Penstock Condition Assessment Guide *-draft*

- Tier II
  - ▶ Detailed NDE, Detailed DE
    - Detailed Non-Destructive Examination (NDE) of Penstock
    - Detailed Destructive Examination (DE) of Penstock
  - ▶ Surveys, Assessments
    - Ovality and Alignment of Penstock
    - Geotechnical Assessment of Penstock
  - ▶ Analyses, Tests
    - Hydraulic Transient Analysis, Load Rejection Test
    - Detailed Stress Analysis of Penstock
    - Vibration Testing and Fatigue Analysis of Penstock





# hydroAMP: Penstock Condition Assessment Guide *-draft*

- How is the Penstock Condition Index Score Used?
  - ▶ Penstock Condition Index is used as input to an asset management program to prioritize resources and establish a business case for maintenance and replacement/repair.
  - ▶ Scores between 3 and 7 suggest Tier II testing and re-evaluation of O&M practices. Continued operation.
  - ▶ Scores lower than 3 suggest immediate Tier II testing, consultation with experts, and adjustments to O&M practices as is prudent. Replacement or repair process is initiated.



# hydroAMP: Penstock Condition Assessment Guide -*draft*

## ■ Status Update

- ▶ *Draft* is in review by CEATI and HydroAMP users.
- ▶ Guide only covers steel penstocks.
- ▶ CEATI members will add entire section on geotech through an A/E.
- ▶ Some have used guide and provided comments.
- ▶ HydroAMP user group has concerns that the guide goes too far into safety issues.
- ▶ Next steps – review & comment, revision, hydroAMP validation & testing, add to hydroAMP tools.





# hydroAMP: Penstock Condition Assessment Guide -*draft*

- RE-CAP

- ▶ *Draft* HydroAMP Penstock Condition Assessment Guide is written and being reviewed.
- ▶ Tool helps prioritize budget needs based on condition and risk of failure.
- ▶ Goals:
  - Provide accurate condition information for asset management .
  - Improve penstock maintenance.
  - Operate penstock within design parameters.
  - Prevent penstock failures and lengthy forced outages.





- QUESTIONS?

