



USACE Dam Safety Program

Design of Spillway Upgrades

Sal Todaro, P.E. – Senior Hydraulic Structures Engineer
U.S. Army Corps of Engineers
Risk Management Center



Presentation Overview

1. USACE (RMC) approach to design of spillways
2. Isabella Arced Labyrinth Weir (An ongoing spillway design and optimization)
3. USACE need for passive spillways (such as PK Weirs) to reduce our need for spillway gates



Who is the US Army Corps of Engineers (USACE) ?

- Staff of more than 35,000
- Have built and operate more than 700 dams
- Many of our dams built from 1940s through 1970s
- We have a Major National Dam Safety (Evaluation and Upgrade) Program.
- Annual Dam Safety Construction Budget exceeding \$500,000,000



Role of the Risk Management Center in USACE Dam Safety Upgrades

- Nationally Prioritize USACE Dams Repair based upon *Probability of Failure and Risk to Loss of Life*
- Provide expert assistance and support to design teams
- Provide Project oversight from concept design through construction

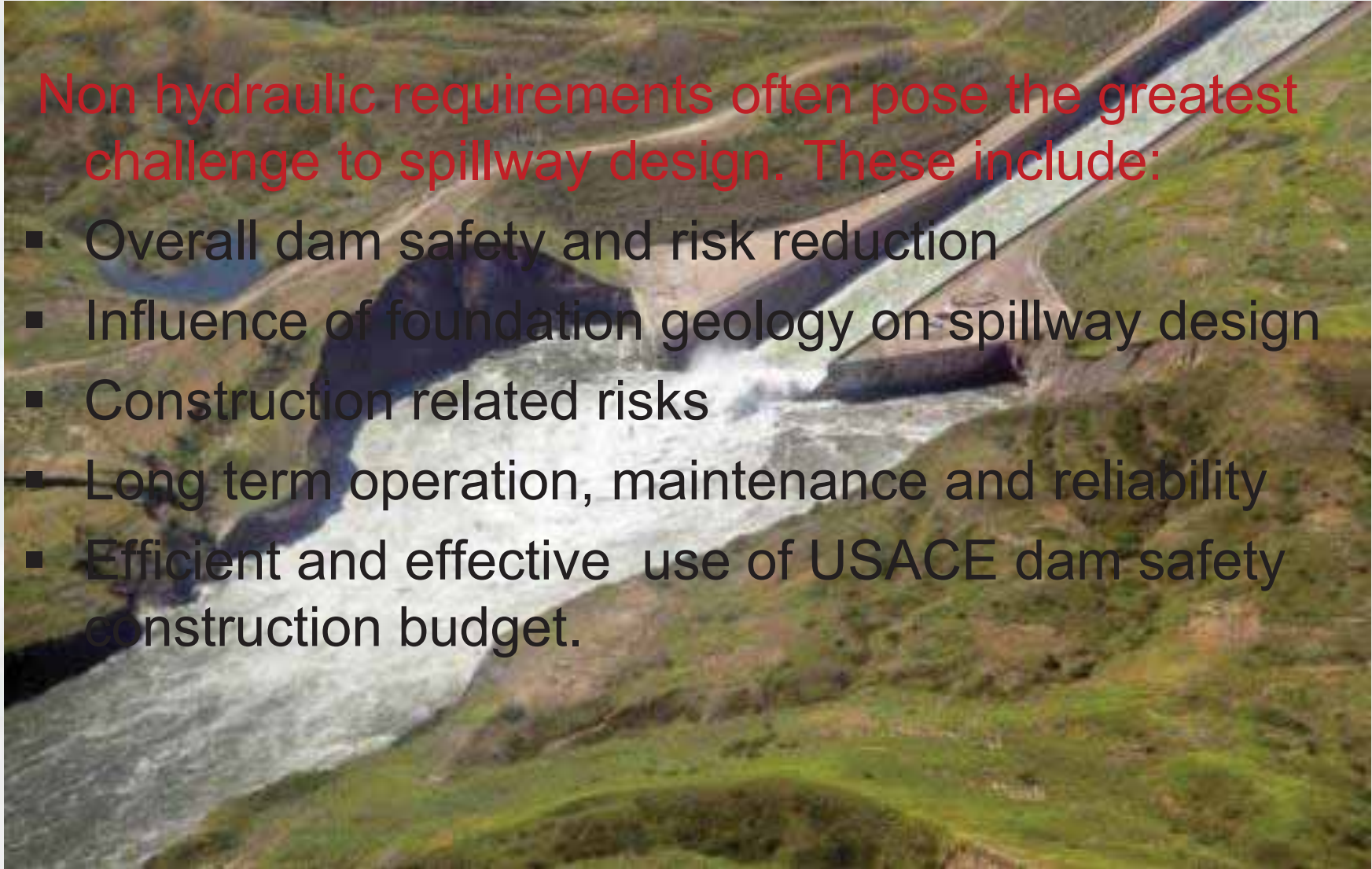


Our Approach to Spillway Design Includes:

- Emphasize the importance of conceptual design
- Early use of (world class experts) for design support
- Coordination of hydraulic design and modeling with other (design and construction) disciplines to meet overall project needs.
- Leverage site opportunities and manage site constraints.



Important Non- Hydraulic Requirements that Influence Spillway Design include:



Non hydraulic requirements often pose the greatest challenge to spillway design. These include:

- Overall dam safety and risk reduction
- Influence of foundation geology on spillway design
- Construction related risks
- Long term operation, maintenance and reliability
- Efficient and effective use of USACE dam safety construction budget.



ISABELLA LAKE DAM SAFETY MODIFICATION PROJECT APPROVED PLAN

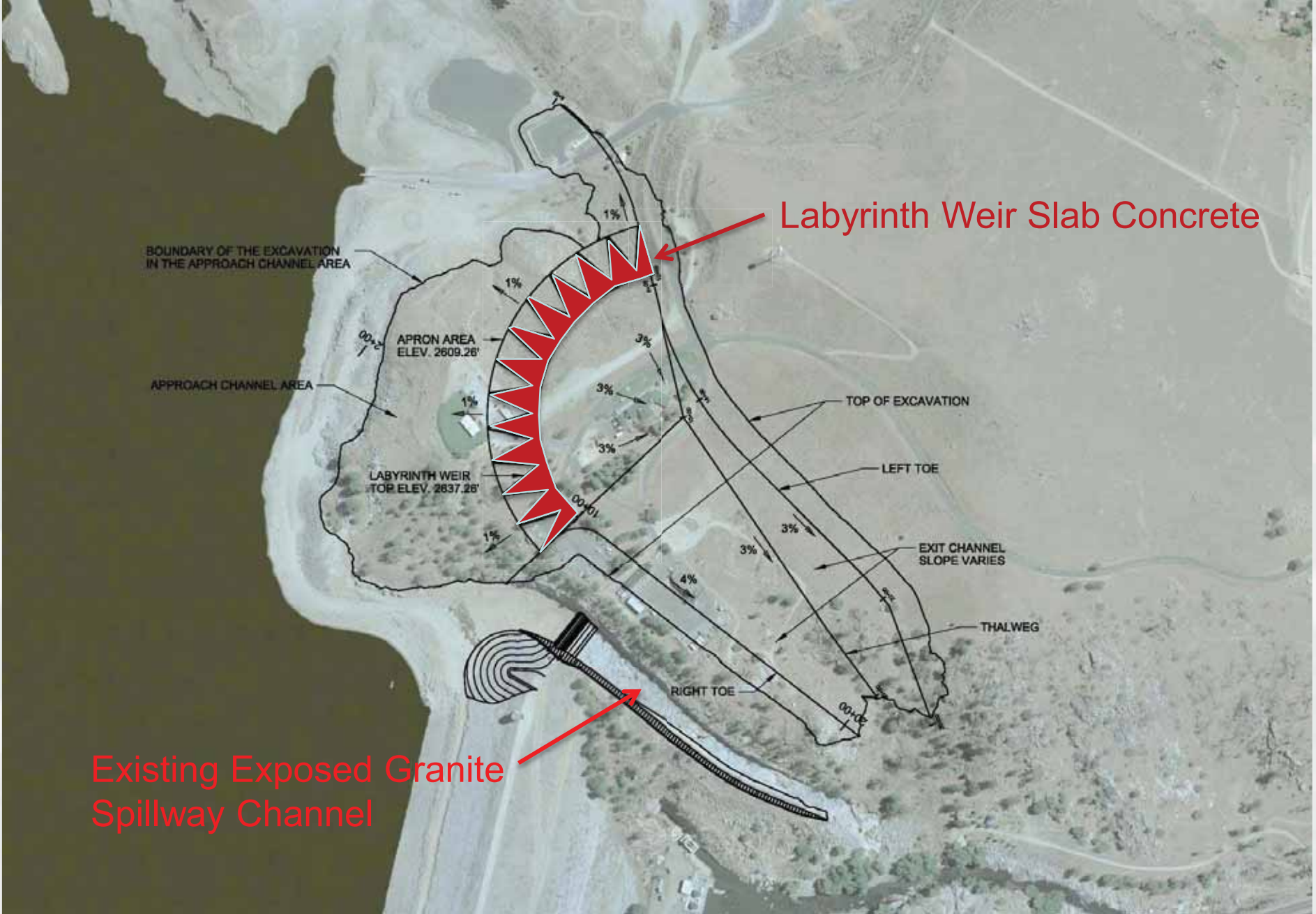


Dam Safety Deficiencies:

1. Dam overtopping and breach - inadequate spillway capacity
2. Major earthquake - fault through abutment in high seismic area

Dam is Located Upstream of Bakersfield California (very high potential for loss of life)





Labyrinth Weir Slab Concrete

Existing Exposed Granite
Spillway Channel

SPILLWAY PLAN



Comparison - Linear and Arced Labyrinth Weir Designs

Linear Labyrinth Weir

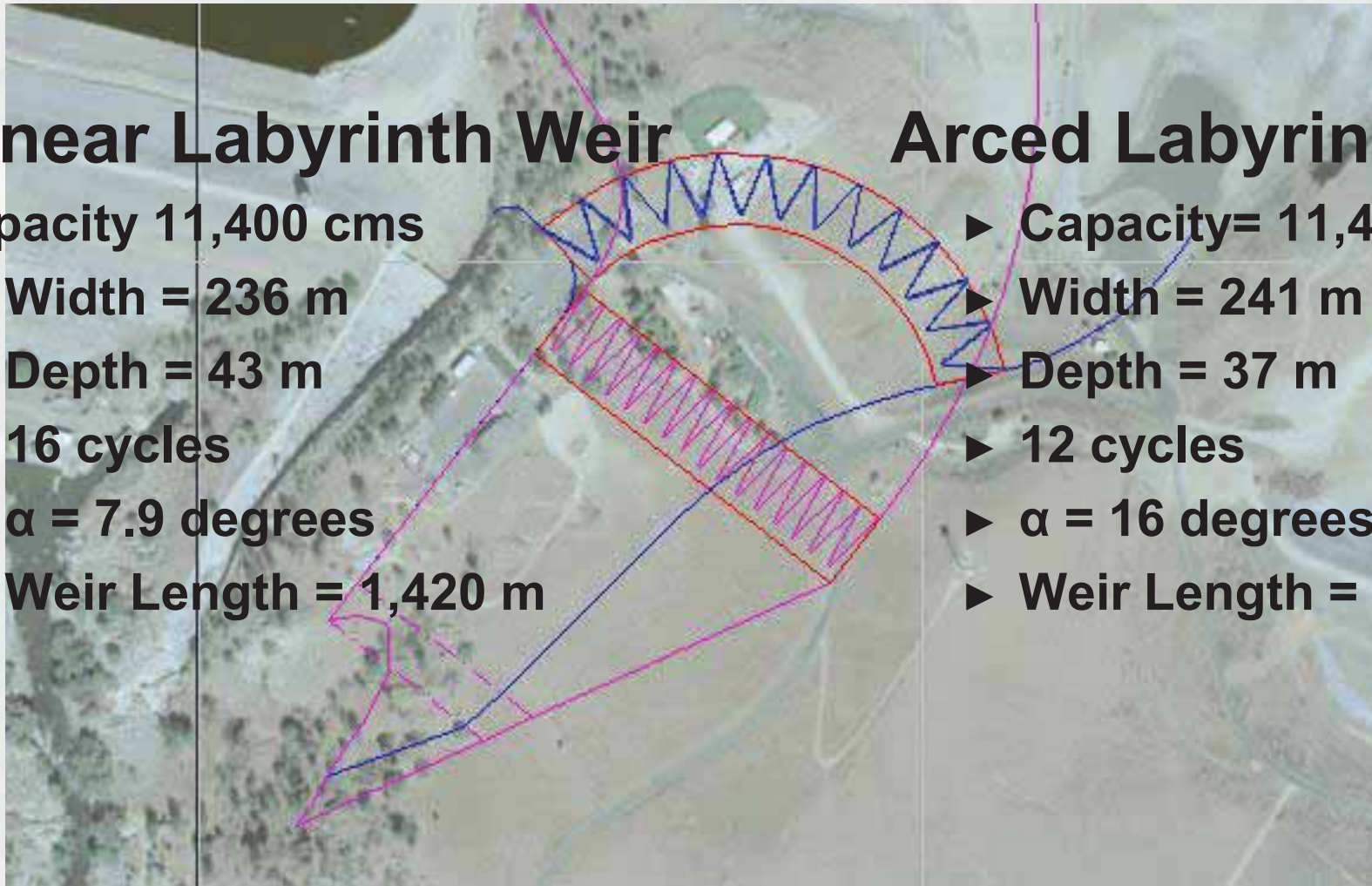
Capacity 11,400 cms

- ▶ Width = 236 m
- ▶ Depth = 43 m
- ▶ 16 cycles
- ▶ $\alpha = 7.9$ degrees
- ▶ Weir Length = 1,420 m

Arced Labyrinth Weir:

▶ Capacity= 11,400 cms

- ▶ Width = 241 m
- ▶ Depth = 37 m
- ▶ 12 cycles
- ▶ $\alpha = 16$ degrees
- ▶ Weir Length = 960 m



Critical Design Insights

(Based Upon the Initial Linear Labyrinth Weir)



- Goal - Reduce Spillway Cost
- Goal – Design the spillway for infrequent use.

Labyrinth Spillway begins to operate at 1/4500 year flood.

- Goal - Tailor spillway excavation to meet rock borrow requirements.

Initial straight design required 2.7M m³ rock excavation, but borrow required for dam modifications estimated to be 1.9M m³.

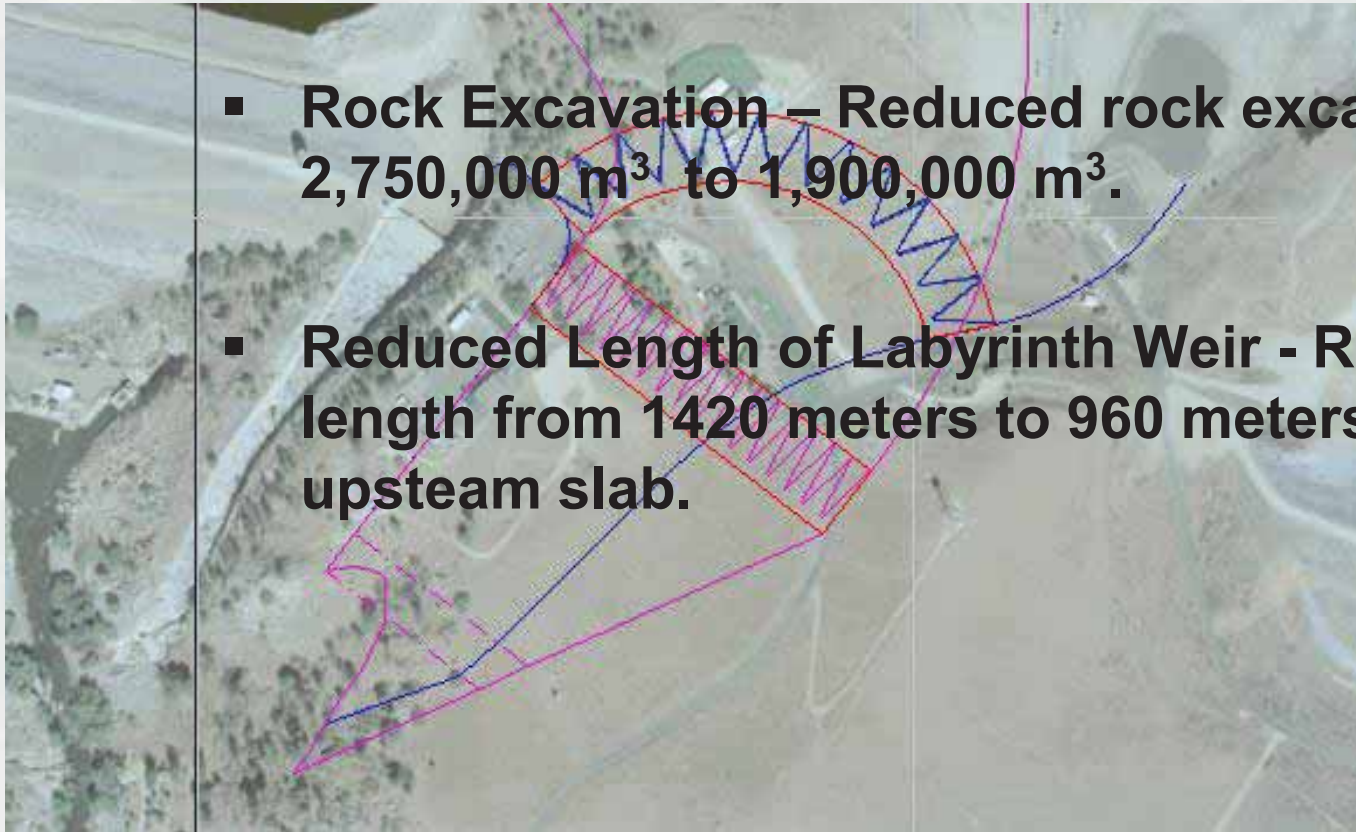
- Goal – Optimize hydraulic and structural design of labyrinth to reduce concrete volume and cost.



Critical Design Insights

Arced Labyrinth

Savings to date from spillway optimization:



- **Rock Excavation – Reduced rock excavation - from 2,750,000 m³ to 1,900,000 m³.**
- **Reduced Length of Labyrinth Weir - Reduced weir length from 1420 meters to 960 meters and reduced upstream slab.**



Conclusions

- A robust conceptual design is **CRITICAL** to successful hydraulic structure design
- Coordinate Hydraulic Design with other project requirements and design disciplines
- Use expert advisors to supplement design team
- Communication and coordination between disciplines is crucial!



BUILDING STRONG®

Ideas for increasing use of PK Weirs at USACE Dams

PK WEIRS TO INCREASE SPILLWAY CAPACITY

- **USACE prefers ungated spillways**, when increasing discharge capacity at existing dams.
- **The labyrinth weir is commonly considered** for upgrading spillways.
- **The PK Weir not often considered**, primarily because of the staff's unfamiliarity with this design.

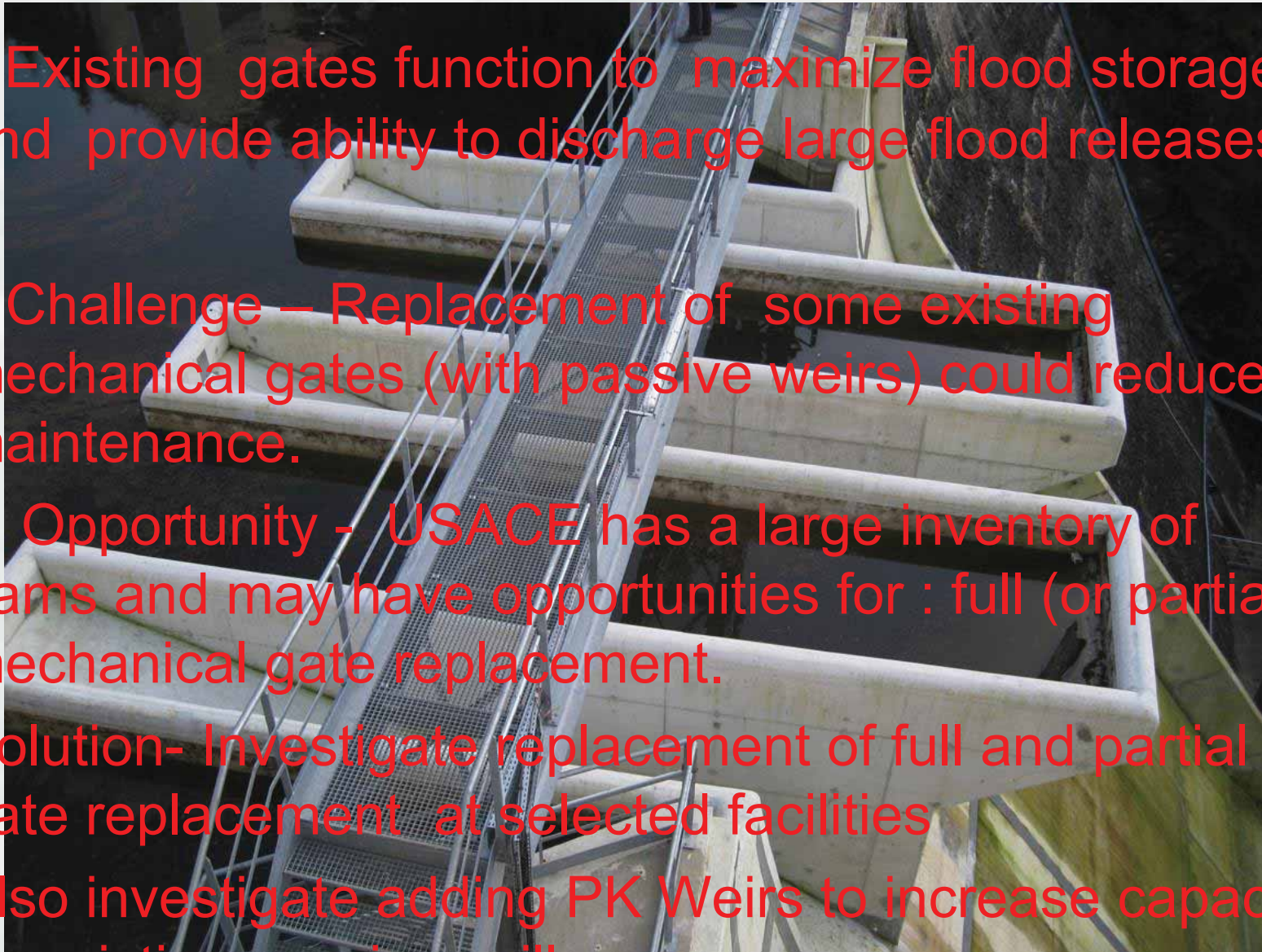
Increased USACE awareness of the PK weir's unique ability to increase passive discharge over concrete gravity dams could result in more frequent consideration.



Ideas for Replacing Aged Gates

Existing gates function to maximize flood storage and provide ability to discharge large flood releases

- Challenge – Replacement of some existing mechanical gates (with passive weirs) could reduce maintenance.
- Opportunity - USACE has a large inventory of dams and may have opportunities for : full (or partial) mechanical gate replacement.
- Solution- Investigate replacement of full and partial gate replacement at selected facilities
- Also investigate adding PK Weirs to increase capacity at existing passive spillways.



Ideas to Increase USACE Knowledge (and use) of PK Weirs:

- Continued active USACE attendance at PK Weir Workshops and Working Groups
- Conduct USACE Webinar on Design of PK Weirs
- Identify USACE Spillway Modification PK Weir Project as a stated goal.





Questions & Discussion

Sal Todaro, P.E. – Senior Hydraulic Structures Engineer
U.S. Army Corps of Engineers
Risk Management Center

