

FY21 RSM IPR: *Chirp Determination of Reservoir Storage: Year II*

USACE NWO: Paul Boyd; USACE-ERDC: Heidi Wadman, Jesse McNinch (ret.)



BLUF: Chirp sub-bottom imagery presents an opportunity to recreate missing reservoir pre-impoundment surveys, greatly improving estimates of reservoir lifespan.

Year II: Processing and interpretation of chirp sub-bottom profiles collected in FY20 at Cherry Creek Reservoir and Shadow Mountain Lake, CO

Challenge/Objectives

- Process sub-bottom data collected at FY21 sites and identify pre-impoundment reservoir base
- Estimate volume of post-dam sediment accumulation; compare where possible to modern estimates
- Compare chirp-derived reservoir pre-impoundment basin structure with existing as-build profiles.



FY21 RSM IPR: *Chirp Determination of Reservoir Storage: Year II*

USACE NWO: Paul Boyd; USACE-ERDC: Heidi Wadman, Jesse McNinch (ret.)

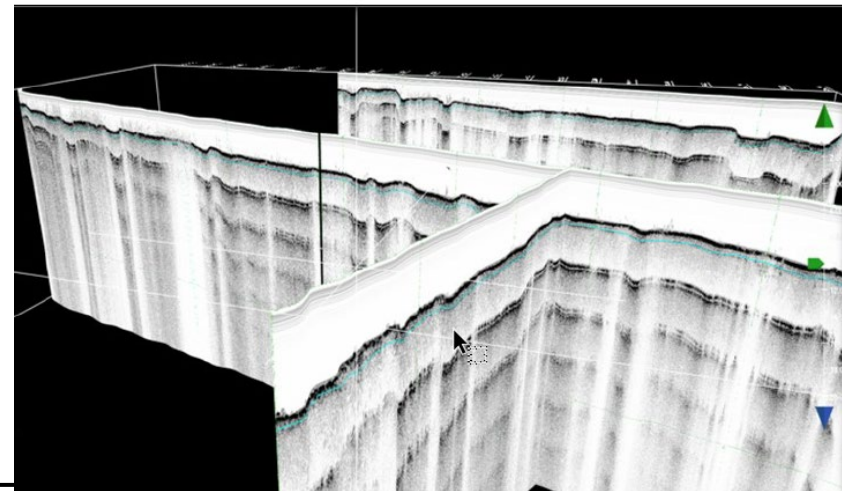


Approach – FY21 (recap)

- Collect sub-bottom profiles at Shadow Mountain Lake near Grand Lake, CO.
- Collect sub-bottom profiles along historical profiles at Cherry Creek Reservoir near Denver, CO

Approach – FY22

- Identify likely reservoir surface based on local geology (both sites).
- Digitize this surface and calculate the volume of sediment above it (both sites).
- Compare historical pre-impoundment profile shapes/depths with chirp-defined ones extracted at the same lat/lon (Cherry Creek).
- Compare chirp-estimated volume with modern volume estimates (Cherry Creek)
- Assess overall suitability of method for recreating lost pre-impoundment surveys.



FY21 RSM IPR: *Chirp Determination of Reservoir Storage: Year II*
USACE NWO: Paul Boyd; USACE-ERDC: Heidi Wadman, Jesse McNinch (ret.)



USACE and Other PDT Members

Paul Boyd, P.E. – NWO
Dan Pridal, P.E. – NWO
Dr. Heidi Wadman, ERDC-CHL
Dr. Jesse McNinch (ret.), ERDC-CHL
Joshua Friend, LRE
Dan Dombroski, Reclamation
Kent Collins, Reclamation

Leveraging/Collaborative Opportunities

US Bureau of Reclamation, Technical Service Center (vessel support)
Colorado Parks and Wildlife (Cherry Creek)
U.S. Forest Service (Shadow Mountain Lake)
LTC Alexandre P Albuquerque, FM (BRA)

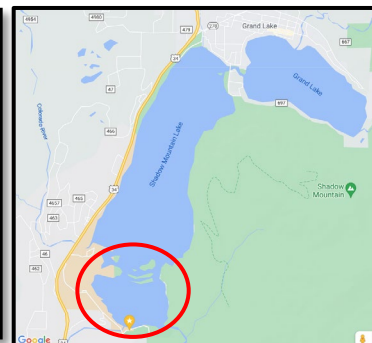
Stakeholders/Partners

US Bureau of Reclamation, Technical Service Center
Hydraulics and River Engineering Group, Lakewood, CO



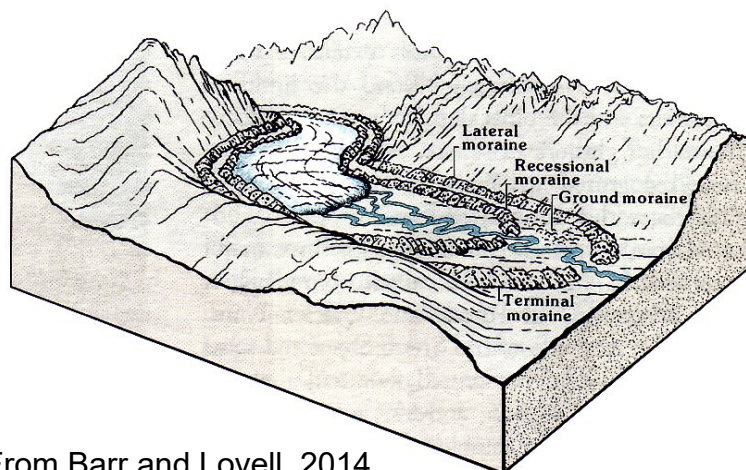


Accomplishments/Deliverables: Shadow Mountain Lake



Constructed between 1944-1946

- Earthen dam constructed on the original terminal moraine
- Flooded the flat alluvial plain & successional moraines upstream
- Holding reservoir for water pumped from Lake Grandy; serves populated regions of Colorado, including Denver, CO.



From Barr and Lovell, 2014



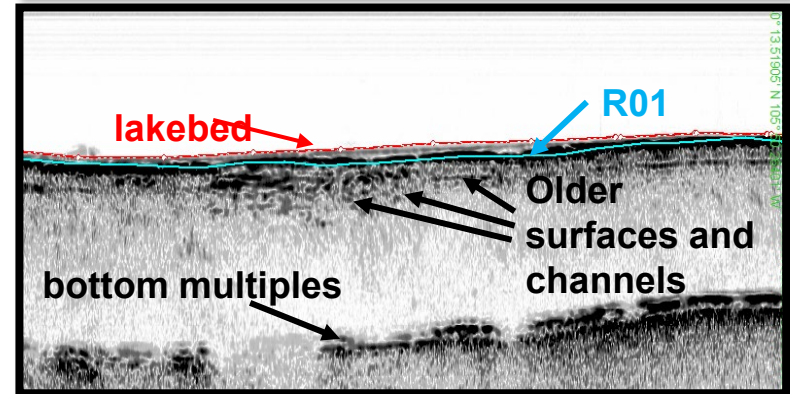
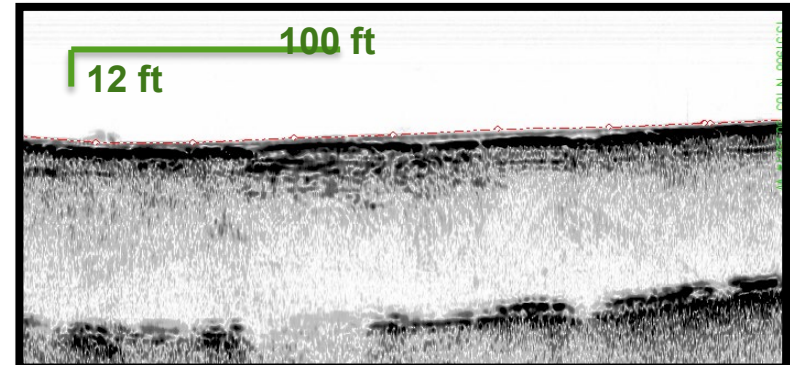
Accomplishments/Deliverables: Shadow Mountain Lake



Light color and low amplitudes of lakebed = less-dense material

Extensive, coherent reflection surface (R01) represents original, coarse-grained alluvial plain sediment flooded post-dam

Evidence of earlier surfaces from earlier warming & glacial melting periods

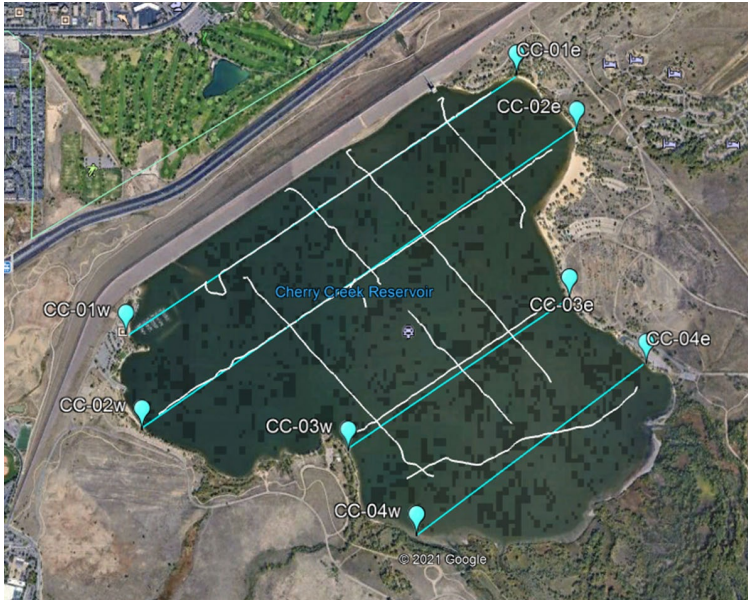


FY21 RSM IPR: *Chirp Determination of Reservoir Storage: Year II*

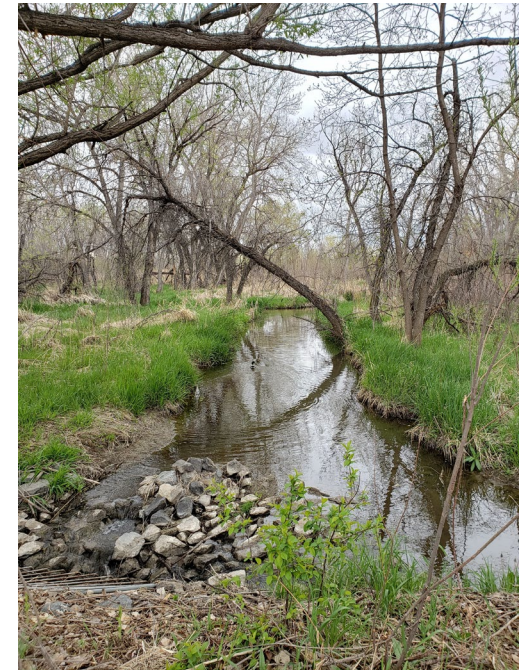
USACE NWO: Paul Boyd; USACE-ERDC: Heidi Wadman, Jesse McNinch (ret.)



Accomplishments/Deliverables: Cherry Creek Reservoir



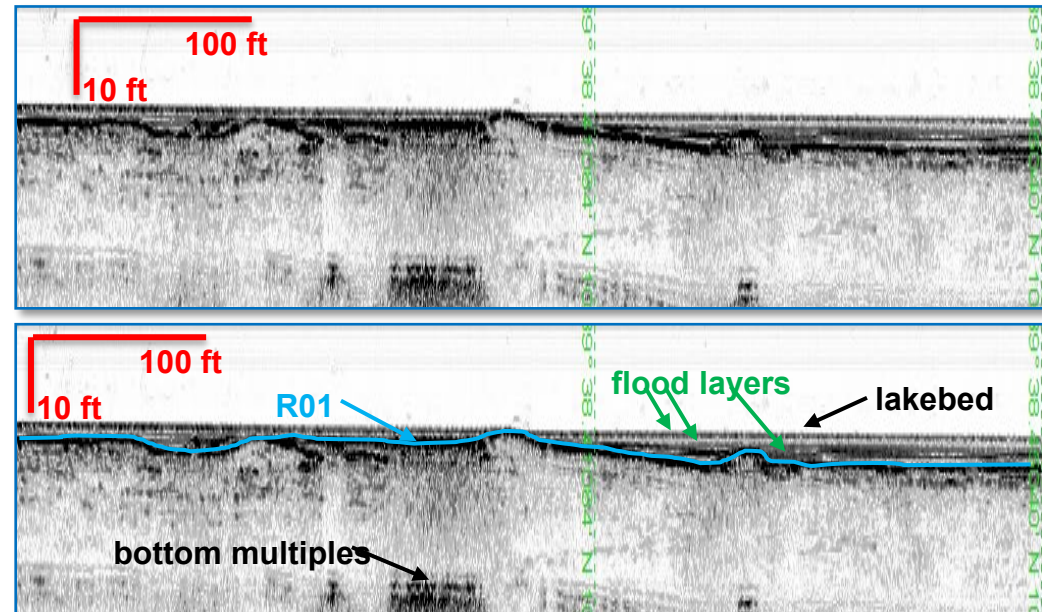
- Construction 1948-1950
- Part of the Denver Tri-Lakes system of flood mitigation
- Formed over rolling prairie and series of creeks
 - Cottonwood Creek
 - Cherry Creek



- Multiple topographic and bathymetric surveys since dam completion provide an “opportunity” to compare chirp-derived pre-impoundment topography with actual mapped topography



Accomplishments/Deliverables: Cherry Creek Reservoir



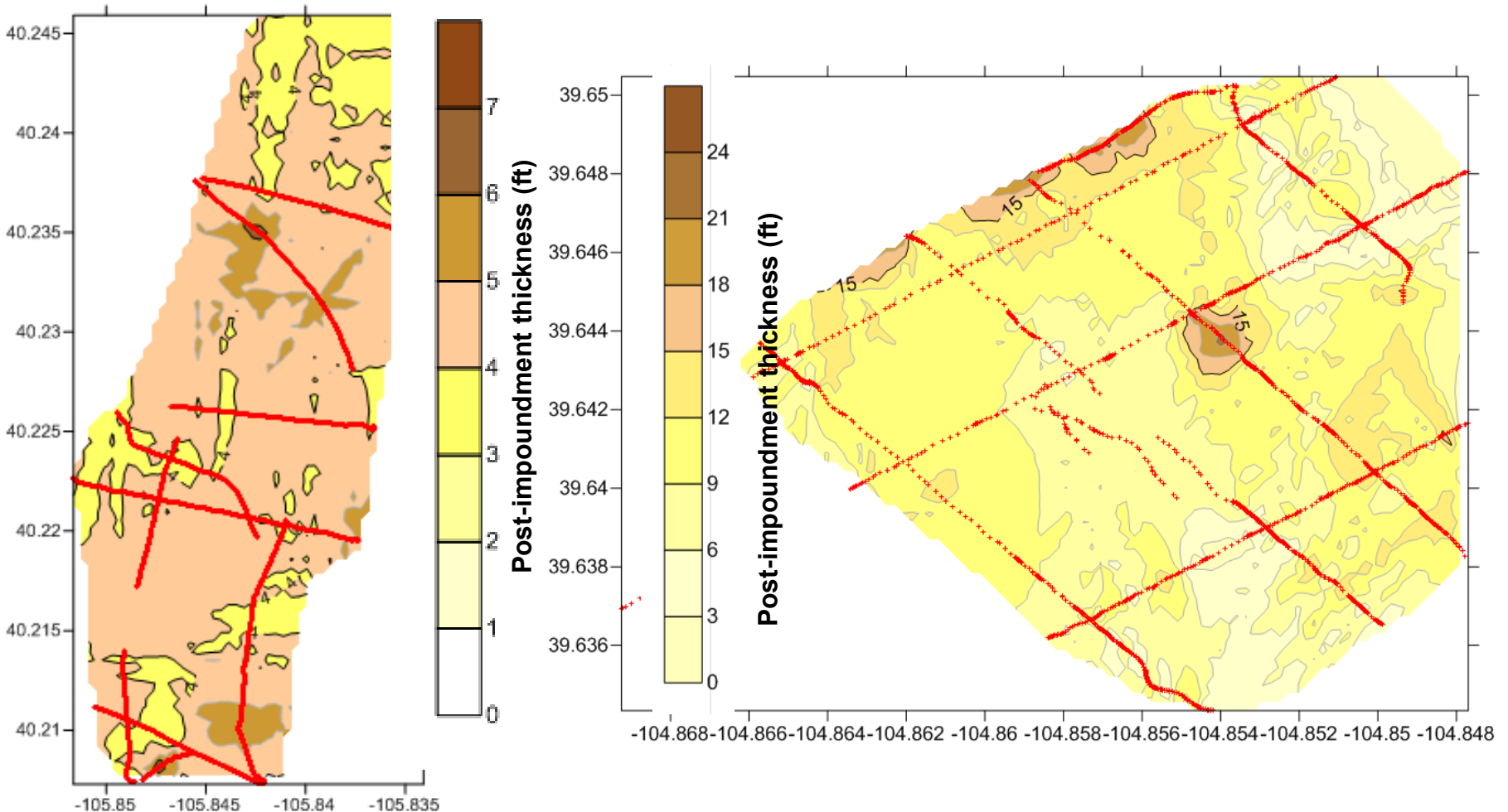
- Multiple preserved fluvial channels, infilled since dam construction.
- Abundant flood layers suggest flooding events are the dominant process influencing sediment accumulation and storage within the reservoir.

FY21 RSM IPR: *Chirp* Determination of Reservoir Storage: Year II

USACE NWO: Paul Boyd; USACE-ERDC: Heidi Wadman, Jesse McNinch (ret.)



Accomplishments/Deliverables: Calculating sediment volumes? Successful...

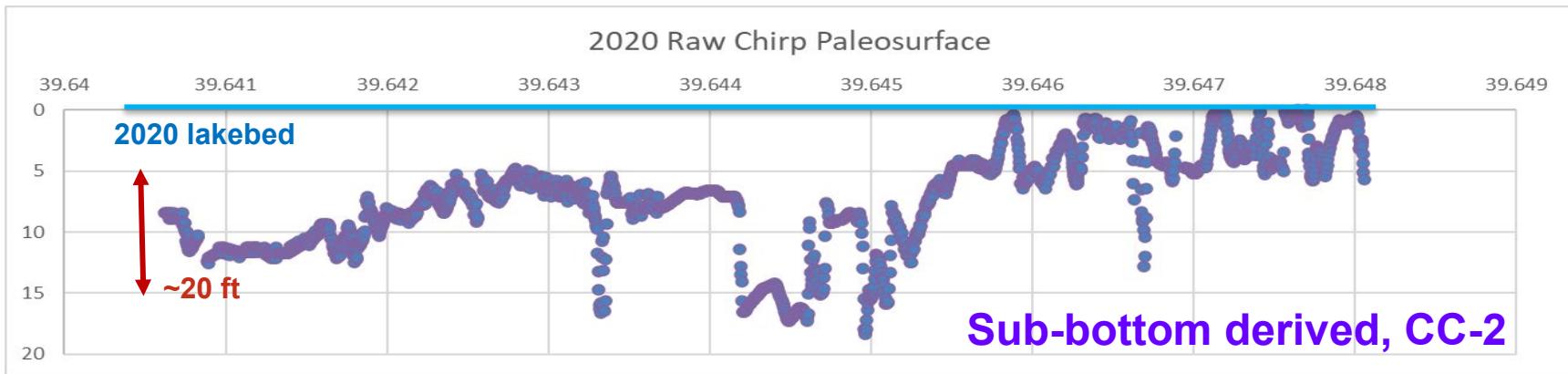
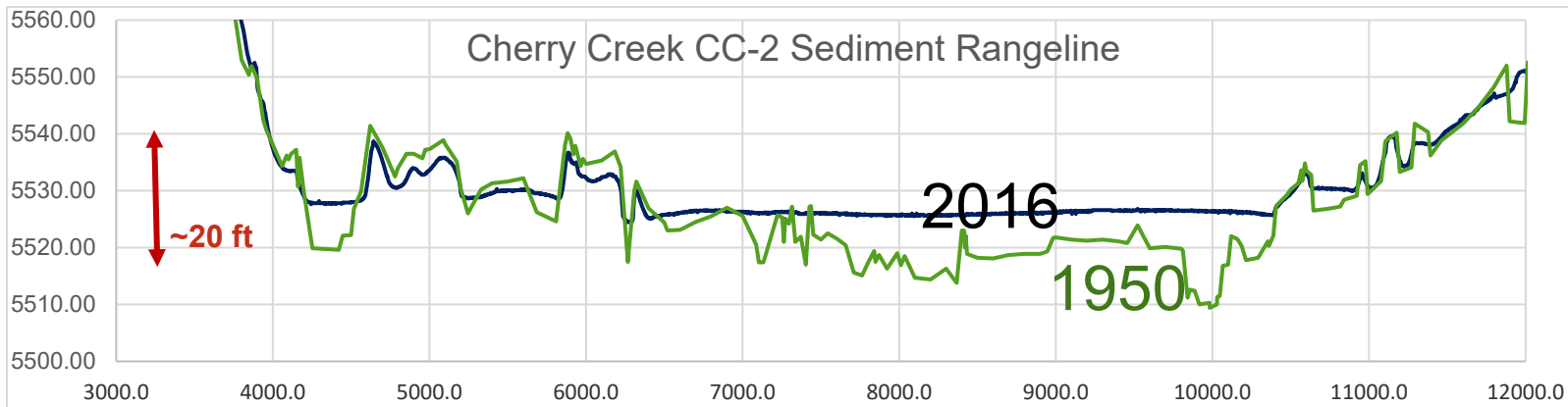


FY21 RSM IPR: Chirp Determination of Reservoir Storage: Year II

USACE NWO: Paul Boyd; USACE-ERDC: Heidi Wadman, Jesse McNinch (ret.)



Accomplishments/Deliverables: Profile comparisons are... challenging...



Published at peer-reviewed abstract, with presentation, at USSD 2021 (April, 2021)
Draft of MRB 40 report near-completion (TR for this based on that).

FY21 RSM IPR: *Chirp Determination of Reservoir Storage: Year II*

USACE NWO: Paul Boyd; USACE-ERDC: Heidi Wadman, Jesse McNinch (ret.)



Challenges & Lessons Learned

- Chirp sub-bottom imagery useful for recreating lost pre-impoundment surveys
 - More accurate volume measurements & dam lifecycle estimates
 - Provide insight into sedimentation processes
- Require unique sub-bottom equipment and specialized interpretation
 - Require high power & low frequency chirp technology that's portable – **SO NEED GOOD LOGISTICAL SUPPORT**
 - Clear understand of local geology for effective survey planning and post-collection interpretation
- Initial comparisons of 1950 data & 2020 survey are optimistic
 - Significant challenges with horizontal and vertical datums
 - Limited qualitative assessment indicates pre-impoundment surface successfully recreated at Cherry Creek
- Significant potential for dam safety applications
 - Geologic risk
 - Structural integrity of earthen and concrete structures



FY21 RSM IPR: *Chirp Determination of Reservoir Storage: Year II*

USACE NWO: Paul Boyd; USACE-ERDC: Heidi Wadman, Jesse McNinch (ret.)



How is this project benefiting the USACE and Nation?

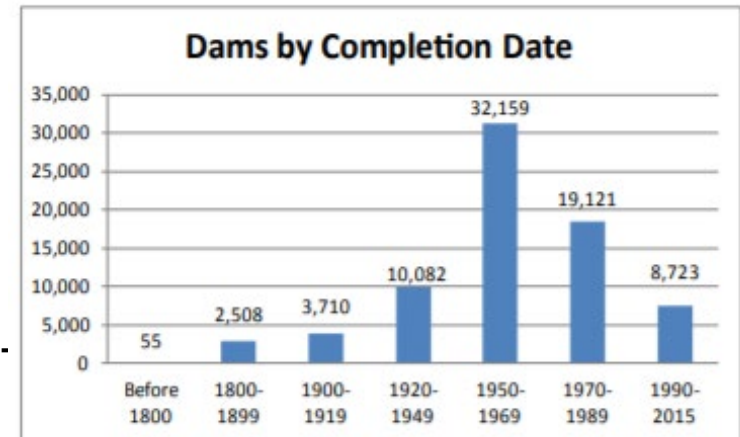
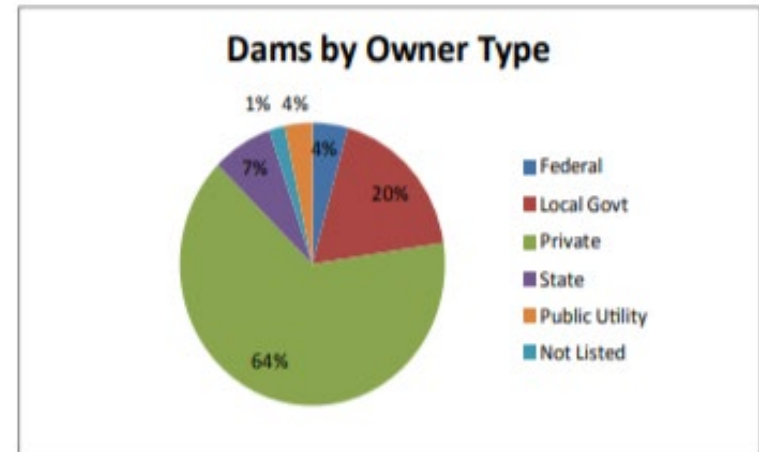
Over 90,000 dams in the U.S.

- ~70 % regulated by Dam Safety Offices
- ~64 % are privately owned.
- ~30-40% are considered to have “hazard potential”

Together, the U.S. Army Corps of Engineers (USACE) and the Bureau of Reclamation (Reclamation) manage nearly 800 water storage reservoirs

~ 10% USACE and ~60% of Reclamation dams lack pre-impoundment surveys & thus lack accurate historical sedimentation rates

- Limits ability to assess capacity-related hazards to flood risk reduction, water supply, irrigation, etc.
- Sustainable Sediment Management requires accurate assessment of loss of benefits
- Recent surveys are decadal snapshots at best; little-no info on original baseline, volume loss, structural integrity of the actual dam



FY21 RSM IPR: *Chirp Determination of Reservoir Storage: Year II*
USACE NWO: Paul Boyd; USACE-ERDC: Heidi Wadman, Jesse McNinch (ret.)



How is this project benefiting the USACE and Nation?

This effort suggests chirp sub-bottom profiles can rapidly and accurately assess the history of a reservoir, including changes in sedimentation over time.

Currently, the only practical ways to determine pre-impoundment elevations include:

- Deep coring through the deposited sediments
 - Expensive and time-consuming
 - Does not address spatial variability in sedimentation patterns
- Ground penetrating radar
 - Limited to the subaerial region



Chirp sub-bottom imagery:

- Is rapid and yet addresses complex spatial sedimentation patterns in the submarine portion of reservoirs
- Is affordable and greatly reduces the need for deep cores
- Can be used to assess the health of structures themselves under the water's surface
 - HUGE dam safety application