BUREAU OF RECLAMATION

Knowledge Stream

Research and Development Office

Innovation in Sustainable Reservoir Sediment Management

U.S. Department of the Interior

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Research and Development Office (R&D) Contacts

Program Manager
Ken Nowak
knowak@usbr.gov

Science and Technology Program Administrator
John Whitler
jwhitler@usbr.gov

Desalination and Water Purification Research Program Administrator & Water Treatment Research Coordinator
Vacant
@usbr.gov

Hydropower and Water Infrastructure Research Coordinator
Erin Foraker
eforaker@usbr.gov

Water Availability Research Coordinator
Vacant
@usbr.gov

Prize Competitions Program Administrator
Jennifer Beardsley
jbeardsley@usbr.gov

Open Water Data Coordinator
Allison Odell
aodell@usbr.gov

Programs Analyst
Vacant
@usbr.gov

Budget Analyst
Rosann Velnich
rvelnich@usbr.gov

Administrative Assistant
Laurie Edwards
ledwards@usbr.gov

GIS Program Analyst
Lisa Johnson
lisajohnson@usbr.gov

Data Resource Manager
James Nagode
jbnagode@usbr.gov

Message from R&D

Welcome to the Fall 2022 issue of the *Knowledge Stream*! In this issue, we highlight research and innovation activities related to sustainable reservoir sediment management. Reservoirs provide a

- Challenges and opportunities related to reservoir sedimentation
-
-
- Guardians of the Reservoir prize competition
-

About the *Knowledge Stream*

Knowledge Stream

-
- Desalination and Water Purification Research Program
- Prize Competitions Program
-
- Open Water Data Program
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Content Lead

Contact
Carolyn Gombert
cgombert@usbr.gov

More Information
usbr.gov/research

For more information on articles within this issue, please contact the listed author or Carolyn Gombert.

Will Recent Trends in Wildfires Cause Reservoir Sedimentation Issues?

pg. 18

Assessing Mercury Release from Contaminated Sediments During Dredging

pg. 21

Contents

Front Cover: Willow Creek Reservoir near Granby, CO in 2021 showing reservoir delta with recent sedimentation effects from the East Troublesome Creek fire being studied by researchers at Reclamation. (photo credit Luke Javernick, River Science).

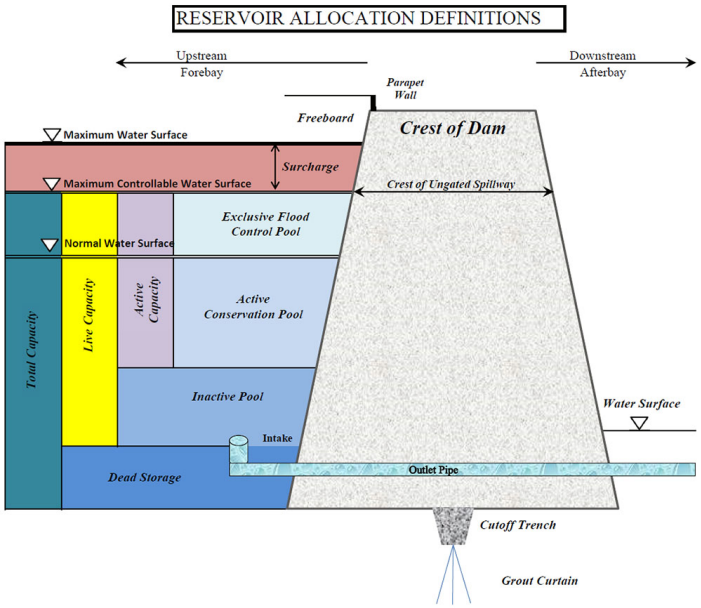
Back Cover: Aerial view of sediment delta formed in Elephant Butte Reservoir in New Mexico. (photo credit Nathan Holste, Bureau of Reclamation)

The information being offered herein represents the opinion of the author(s) and is not a statement of fact about Bureau of Reclamation findings or conclusions.

Community Needs

Recognizing Reservoirs as Assets

By Dan Staton & Jenn Bountry
dstaton@usbr.gov, jbountry@usbr.gov



requirements and processes for data stewardship,

and editor applications across the organization for

Reclamation reservoirs.

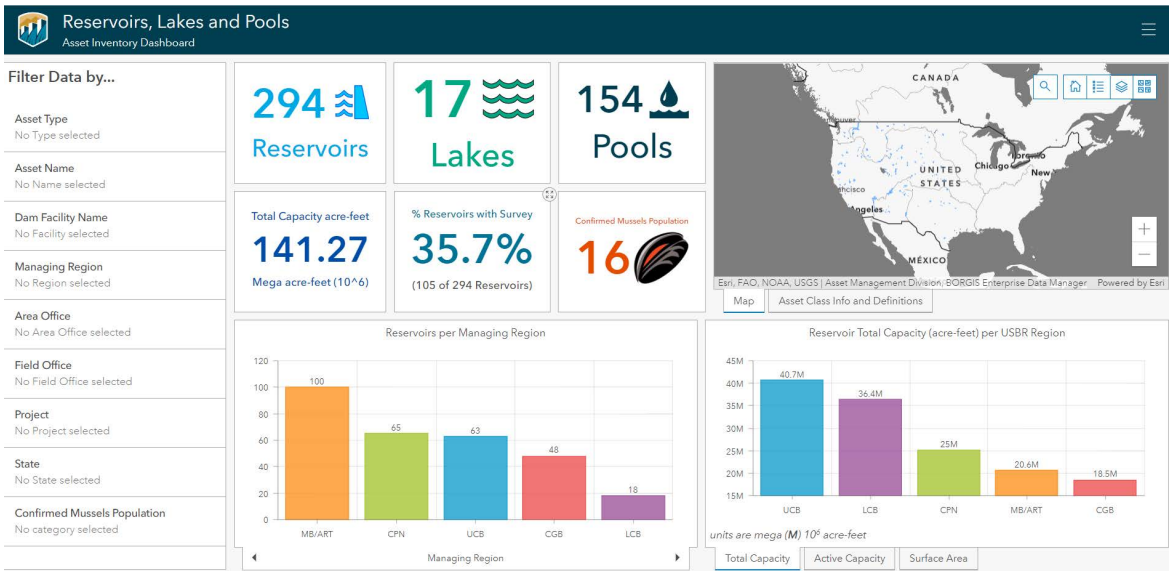
part of the asset class is recognizing
how storage levels in our reservoirs are categorized

in the active pool and result in release of sediment

encourages natural sediment transport processes

coastal areas, and riparian zones, but it must be

Research to help with sediment monitoring, removal, and management tools will help Reclamation in the coming decades to optimize multipurpose operations and continue to meet our mission of delivering water



The new reservoir asset class dashboard here provides a single source in geospatial environment for tracking information about the Bureau of Reclamation's reservoirs.

Building Survey Capacity for Monitoring Sedimentation

By Andrew Geister, Darion Mayhorn, & Jenn Bountry
ageister@usbr.gov, dmayorn@usbr.gov, jbountry@usbr.gov

Conducting a reservoir bathymetric survey on Palisades Reservoir in June 2022. Photo taken by Travis Hardee, June 30, 2022.

is being built to house all

tables in one unique place!

to contribute, please reach

usbr.gov

Reclamation reservoir assets

original construction, and

outdated, as the mean time

02-01, Operating Practices

Fall 2022 issue of the for more information about development

Collaboration on Reservoir Sedimentation: The Importance of Partnerships

By Tim Randle & Jenn Bountry; with partner, U.S. Geological Survey & U.S. Army Corps of Engineers

jbountry@usbr.gov,trandle@usbr.gov

Bureau of Reclamation and U.S. Army Corps of Engineers scientists working collaboratively on research to determine sediment thickness in reservoirs.

technical aspects of reservoir sedimentation.

recent Guardians of the Reservoir research prize

methods of numerical sediment transport models

training on reservoir sedimentation in Vietnam and Laos and invited international governments to send engineers and scientists to Denver, Colorado,

on sediment issues; and advances in information gathering, storing, and sharing; for decision

and collaboration among Federal agencies continues

n

processes, measurements of incoming sediment loads to reservoirs, characterization of sediment deposits in reservoirs, and released sediment loads

transfer and collaboration. Reclamation, the

Federal scientists, engineers, and managers from various natural resources disciplines. Proceedings

are available at _____. Papers include recent accomplishments and progress in research;

and biological aspects of sedimentation; and the development and use of computer models that

all Federal agencies concerned with water and sediment. Reclamation uses FISP research and development on sediment measurement methods

reservoirs and sediment released from dams.

Key Perspectives

Reservoir Sedimentation Challenges and Opportunities

By Carolyn Gombert, Jenn Bountry, & Tim Randle
cgombert@usbr.gov, jbountry@usbr.gov,trandle@usbr.gov

Water storage reservoirs in the arid Western United

rivers that transport water to our reservoirs also

this trend demands critical thought and intentional action. Coupling shifts in design and management

accumulate in the stagnant reservoir pool. Over time,

reservoir sedimentation.

achieving sustainable reservoir management requires

life. Designers planned for accumulation of

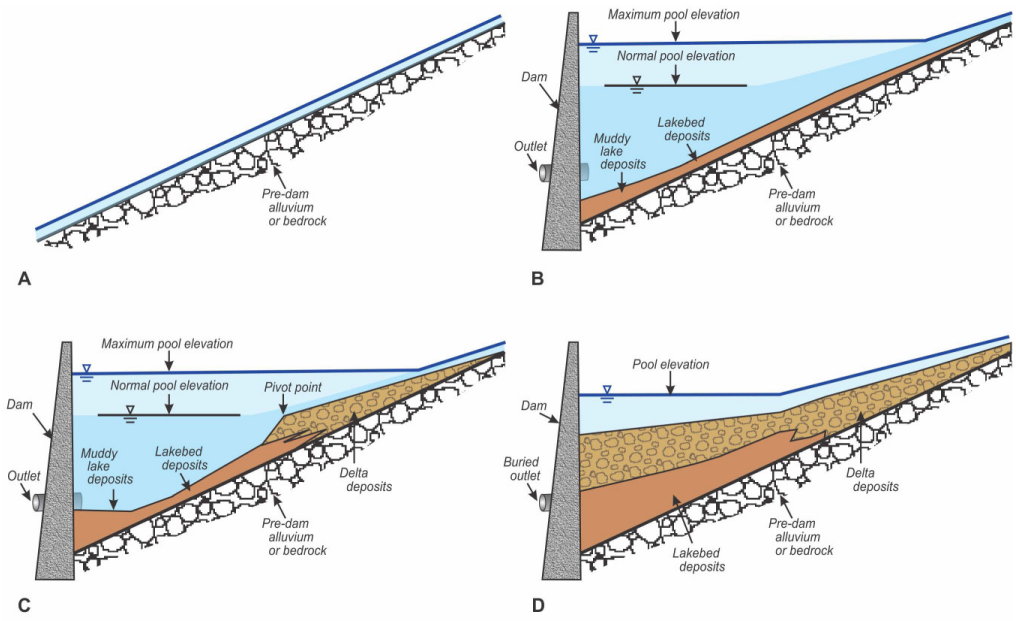
l

as the sediment-design life. Design plans then

storing, and regulating water, reservoirs provide water for agricultural, industrial, and municipal

outlet structure, above the estimated sediment level associated with the sediment-design life.

– continued



Process of reservoir sedimentation:
A) original riverbed,
B) new dam construction,
C) sedimentation that is near the "sediment-design life," and
D) dam outlet works burial.

Schematic of locating the outlet works intake to account for reservoir sedimentation at Sumner Dam near Fort Sumner, New Mexico. Photo captures the same outlet works, 65 years later, after sediment-design life has been reached.

– continued

the dam, over the sediment-design life, was used to storage in the United States has declined to storage

life. Sedimentation and debris can plug dam outlets, without dipping below the water surface to get the

ramps lead to sand instead of water. Sedimentation sedimentation will go undetected unless the sediment accumulation interferes with dam infrastructure

of sedimentation come with a fundamental shift in deposition in a reservoir, it is best to complete

the United States around 2000, but sedimentation than half of the reservoirs in the Western United

growth into account, the current per-capita reservoir

– continued

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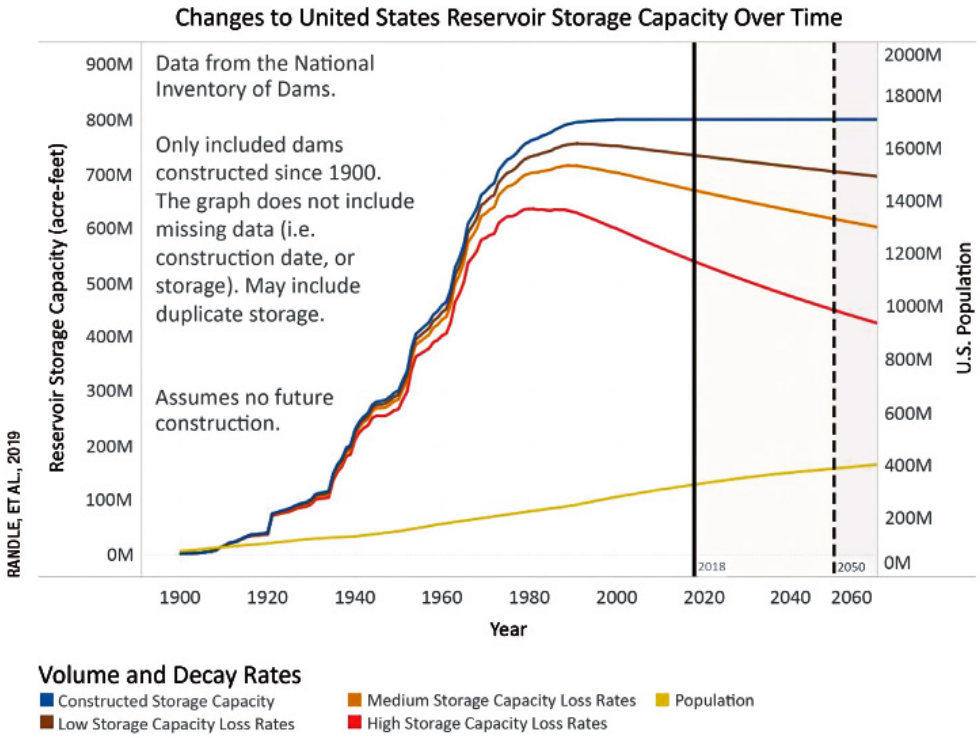
sediment-design life. Climate change is predicted to accelerate rates of reservoir sedimentation.

to a need for a shift in approach. Research reservoir sedimentation puzzle.



Changes to United States reservoir storage capacity over time due to dam construction and reservoir sedimentation. Randle, et al. 2019

Heavy sedimentation in Basin 3 of the All American Canal desilting works has required sediment removal with heavy equipment.

New Tools on the Block

Evaluation of Subbottom Profiling Technologies for Measuring Reservoir Sedimentation Stratigraphy

By Dan Dombroski; with partners, U.S. Geological Survey & U.S. Army Corps of Engineers
ddombroski@usbr.gov

EdgeTech CSS-200 subbottom profiling instrument in tow at Cherry Creek Reservoir in Colorado.

Reservoir sedimentation varies in space

monitoring to establish sediment management

deposited sediments and determining pre-

reservoir with well-studied geomorphic conditions.

frequencies to penetrate up to tens of meters into sediments for remote characterization of

to compositional nonuniformities cause unique

which can then be interpreted to generate maps

collected through traditional methods alone, such

characterizing deposited sediments at two

Grand View.

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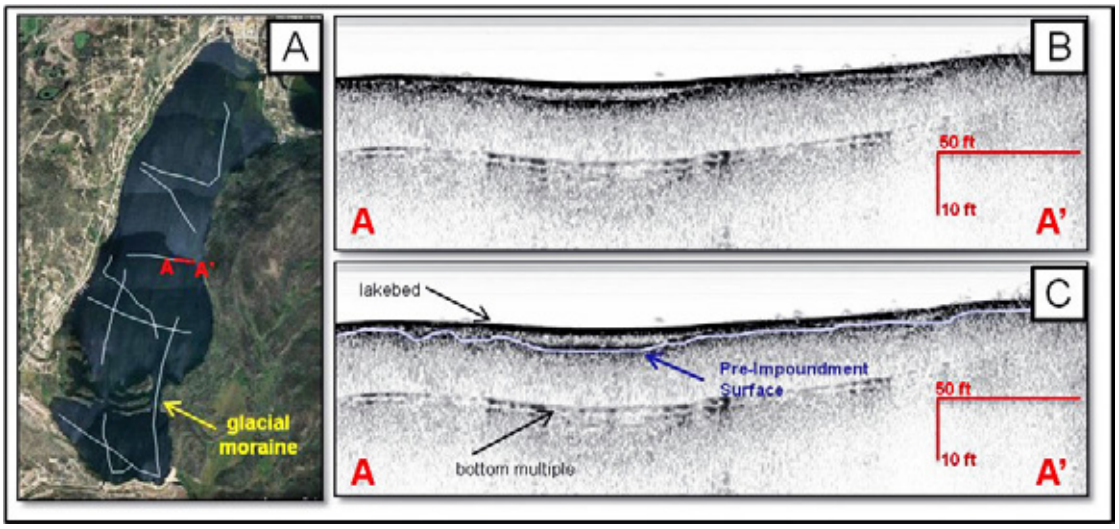


(A) Map view of Shadow Mountain Lake reservoir (Colorado), with subbottom track lines plotted in white. The location of the cross-sections in (B) and (C) are noted by the red A- A' line on plot (A). The glacial moraine is noted by the yellow arrow and text. (B) Example of uninterpreted and (C) interpreted subbottom profiles.

–continued

construction, and the data supported inferences

of the shallow acoustic technique in imaging pre-impoundment surfaces and assessing geomorphic conditions.

l agencies to further evaluate the capabilities and limitations

range of stratigraphic resolution and penetration

in shallow reservoirs or reservoirs with restricted

applications to reservoir sedimentation studies,

instrument characteristics on interpretation of results and develop guidelines concerning the selection

reservoir basin to allow for accurate and independent

Predicting Reservoir Drawdown Flushing to Improve Reservoir Sustainability

By Victor Huang
vhuang@usbr.gov

sediment in small gorge-shaped reservoirs and to

reservoir shapes using a two-dimensional

and reservoir shape, among others.

–continued

–continued

event. During model calibration, sediment concentration from the reservoir release will be used for comparison.

Paonia Outlet structure during emergency actions to maintain diversion, November 11, 2014.

For the seco

provides a proactive approach to

minimizing downstream impacts.

sedimentation will result in a loss

proposed research will provide a numerical algorithm to simulate scouring and resuspending sediment deposited in the reservoir and

research will help determine the

reservoir sedimentation impacts and will provide Reclamation and other Federal agencies with an application

planning approach to best manage reservoir sediment in a sustainable

guidance for reservoir sediment

the fundamental characteristics of

result in usage of it in the ill-suited

action, wasting of water, and adverse

Paonia Reservoir pool elevation and release sediment concentration during 2014 drawdown flushing.

Abrasivity of Slurry-Transported Sediment: Development of Laboratory Test Systems

By Evan Lindenbach, PE, PG; Richard Bearce, PhD, PE; Mikayla Oligney, & Zachary Hein
elindenbach@usbr.gov, rbearce@usbr.gov, moligney@usbr.gov, zhein@usbr.gov

and can cause damage to the reservoir pumping

sedimentation removal and future operations.

to optimize design and selection of materials of

Phase I comprises a series of comparative tests using standardized bench-scale instruments with reservoir sediment and common pipe materials to elucidate on

and have utilized materials from Imperial Dam and

stainless steel have been evaluated for their relative

Number test, the underwater concrete abrasion test,

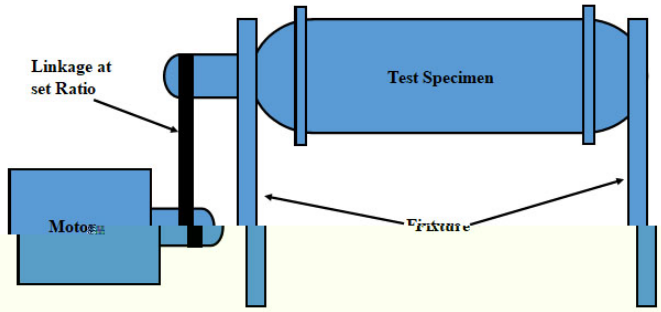
data collected during Phase I provide the underpinning

resistance of common pipe materials.

ed to evaluate the resistance of the common pipe materials using

constructed with commissioning occurring this fall,

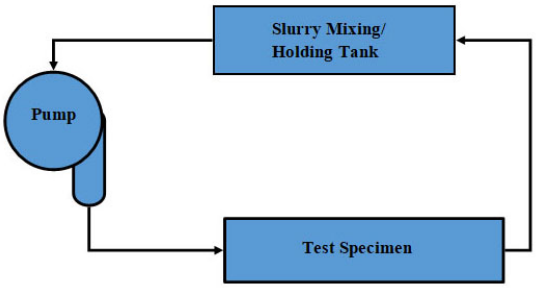
over time documented; this approach builds on one



Rotating pipe test conceptual layout.

Phase IIb is the design and construction of a large-scale

device design is complete, and construction will occur



"Dirty Pump" hydraulic circuit.

concepts, including how the data collected from the

more or less resistant to erosion, what operational

comments on considerations for future designs in which

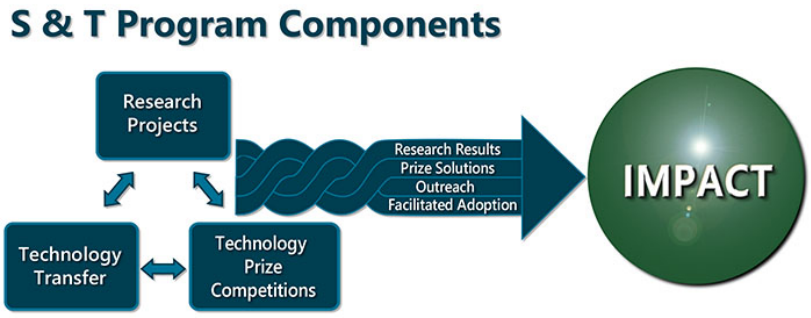
Moving Research to Application: New Facilitated Adoption

By Ken Nowak
knowak@usbr.gov

technologies to end users such that mission outcomes

gap for Reclamation in which promising information,

will use a competitive,



members of prize competition teams will be

Facilitat

potential research results and prize solutions from completed activities and support further evaluation and implementation at Reclamation through demonstrations

5 million for this program

Request.

Rocks, Rivers, and Reservoirs: Can Long-Term Erosion Rates be used to Inform Modern Rates of Sedimentation?

By Melissa Foster
mfoster@usbr.gov

Rivers transport sediment sourced from the upstream

reservoir is too short to capture how rare rare events

this sediment is trapped and accumulates through

the average rate at which the contributing drainage basin delivered or produced sediment on a decadal

reservoir.

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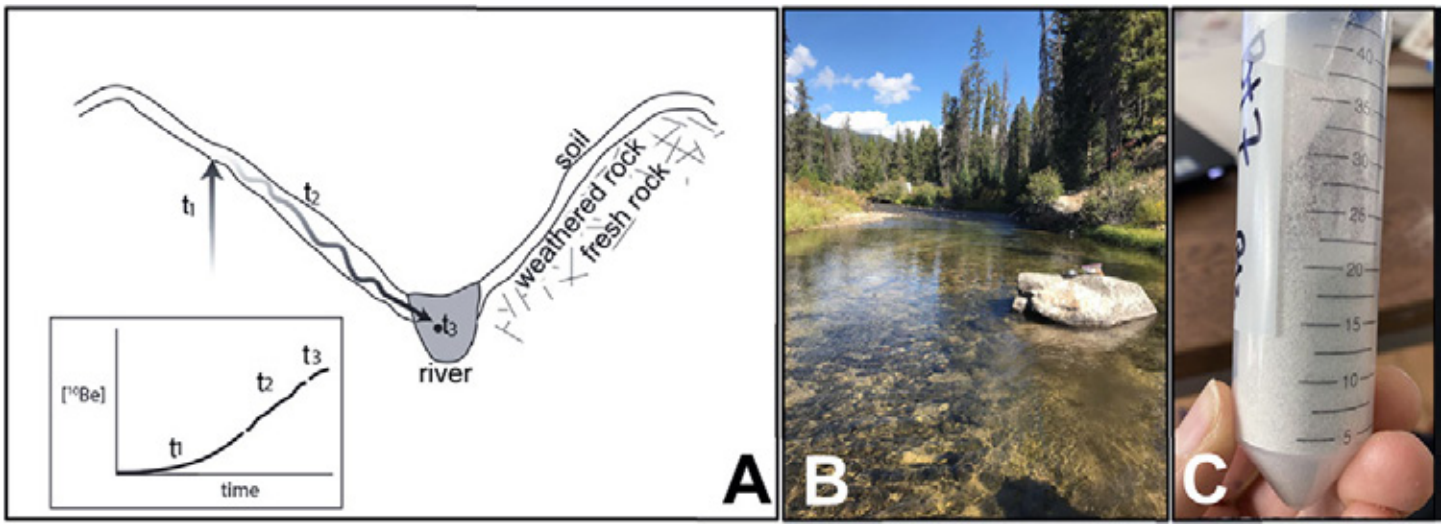


A. Conceptual model of how beryllium-10 accumulates during exhumation of rock, residence time on hillslopes, and residence time in a stream (adapted from Foster and Anderson [2016]). B. Example sample site on the Deadwood River where sands were recently deposited behind a larger boulder. C. Quartz, isolated from other minerals within sand.

–continued

voir sedimentation,

long-term basin erosion rates to inform modern rates of reservoir sedimentation. We use the concentration

assumes that quartz is well-distributed throughout

containing grains sourced throughout the watershed.

quartz-rich
also tried to avoid sites with large upstream dams.

and three reservoirs are located in the eastern

to infer the mass of sediment delivered from the

long-term basin erosion rates, we collected samples

the reservoirs, we sampled multiple rivers because

contributing drainage area.

show that there is good agreement between modern basin erosion rates

term erosion rates between subbasins at the four reservoirs where multiple rivers were sampled.

sampled subbasins, while the subbasin erosion rates

future sediment management plans at reservoirs,

input from subbasins with high erosion rates.

Sedimentation in Action

A Closer Look at the East Troublesome Fire and Willow Creek Reservoir

By Carolyn Gombert & Jenn Bountry
cgombert@usbr.gov, jbountry@usbr.gov

East Troublesome Fire in Grand County, burned 192,560 acres, the wildfire is the second largest in recorded Colorado history.

watershed has the

increase the rate of sedimentation,

its useful life and

water management and

With climate change,

events is increasing.

less predictable, water resources become less reliable. Reclamation needs to plan for increases in sediment loads

partner agencies, the new Reclamation Wildland Fire Program, and Reclamation facilities shared

sedimentation, and debris loading to reservoirs prompted numerous researchers to develop proposals, several of which focused on Willow

m and Reservoir are located on

that feeds the reservoir. It was the second largest

www.thedenverchannel.

growing more than 150,000 acres in a single

forested watershed. Read below for highlights from

Post-Wildfire Increases in Sediment Loading to Willow Creek and Willow Creek Reservoir

By Kent Collins
kcollins@usbr.gov

Sediment and debris deposited in Willow Creek upstream of the reservoir following the East Troublesome Fire. (photo courtesy of Nate Bradley)

used to measure the volume and distribution of

characterize sediment properties, describe the increase in sediment available for transport,

PONAR sampler used to collect surface sediment samples from the bottom of Willow Creek Reservoir. (photo courtesy of Rob Hilldale)

while Northern Water contractor River Science repeats November 2020 and fall 2021 and

surface of the reservoir bottom up to the dam crest elevation. Surface and core samples are also being

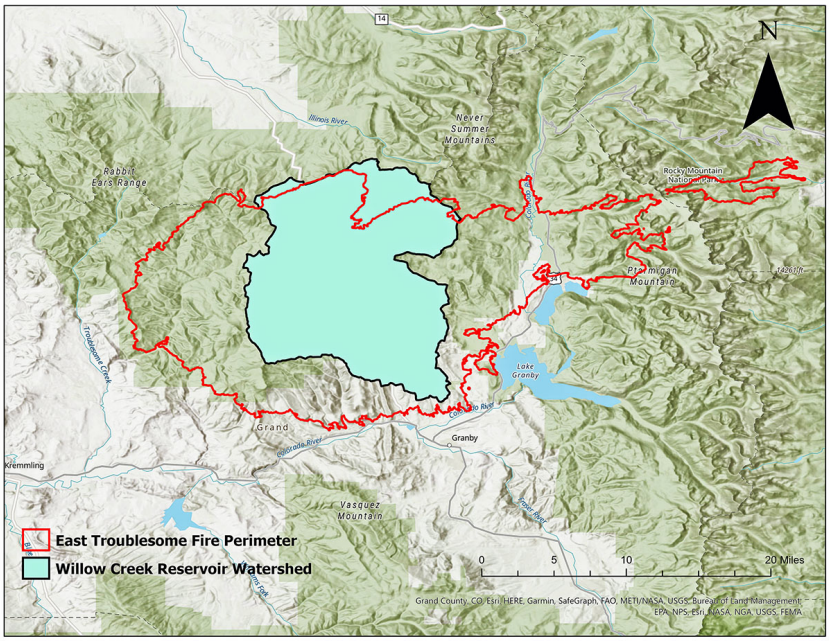
to the reservoir.

Will Recent Trends in Wildfires Cause Reservoir Sedimentation Issues?

By Ben Abban
babban@usbr.gov

increased hillslope and channel erosion. Increased consequence of reservoir sediment management can be hillslope scale up to the watershed scale at which models have been developed for large watersheds, which places a severe limitation on their predictive as well as soil erosion and channel sediment transport management actions.

ed for a model capable of hillslope soil erosion processes and in-channel loads to reservoirs and evaluating watershed management actions.



The East Troublesome Fire burned over 90% of Willow Creek Reservoir's watershed, raising the question of whether or not there will be increased sediment delivery to it over the next few years.

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improved model will be tested in the Willow

Potential Impacts of Phosphorous Loading from the East Troublesome Fire on Surface Water Quality

By Lindsay Bearup
lbearup@usbr.gov
S&T Project page:
www.usbr.gov/research/projects/detail.cfm?id=22019

Algal bloom in Willow Creek Reservoir the summer after the East Troublesome fire. (photo compliments of Rob Hilldale)

Willow Creek after the East Troublesome fire. (photo compliments of Alexis Navarre-Sitchler)

sampling water, soil, and sediment to determine where the nutrient is stored and its form, which will help improve our understanding of phosphorous behavior.

to address increased phosphorous loading and provide

Post-Wildfire Forecasting Improvements Using Non-Newtonian Flow Processes with a High-Resolution, Integrated Hydrologic Model

By Drew Loney
dloney@usbr.gov

due to the changed watershed properties and the

Kent Walker, a Hydraulic Engineer with Reclamation, is seen testing settlement and flow with sediment using one of the dam models.

representations and have a coarse

Reclamation to operate its facilities in

basin stabilizes and recovers.

Impacts of Sediment Removal on Water Quality

Assessing Mercury Release from Contaminated Sediments During Dredging

By Dan Deeds & Angela Paul
ddeeds@usbr.gov, appaul@usgs.govv

Long-term sedimentation in Lahontan

downstream communities and agriculture.

Dredging Lahontan Reservoir to restore

recreational and subsistence anglers.

In collaboration with the U.S. Geological

collected cores from sediments near Lahontan

U.S. Geological Survey staff collecting sediment cores from Lahontan Reservoir for dredging water quality impact simulations.

direct pertinence to reservoirs dependent on

Beyond Storage: A Look into the Reservoir Delta Story

Investigating the Physical Processes that Impact Reservoir Delta Fish Passage and Evaluating Potential Solutions

By Colin Byrne
cbyrne@usbr.gov
S&T Project page: www.usbr.gov/research/projects/detail.cfm?id=22065

depths and velocities. When a river meets the pool of a reservoir, velocities slow, and the sediment the river was

Aerial images of deltas on four different reservoirs in the Yakima River Basin.

change course due to erosion of new

due to sediment deposition. While the

natural process, deltas in reservoirs are

the deltas do not often have a deep, reliable channel connection between the upstream river and the downstream

Salvelinus confluentus

prevented or impaired from migrating between the reservoirs and upstream spawning habitat because of the delta

complete dewatering of the delta stream

channel cover, leading to increased

–continued

–continued

basin, but the present solutions are labor intensive and unsustainable.

geomorphic processes that contribute to reservoir

model to formulate and evaluate solutions that

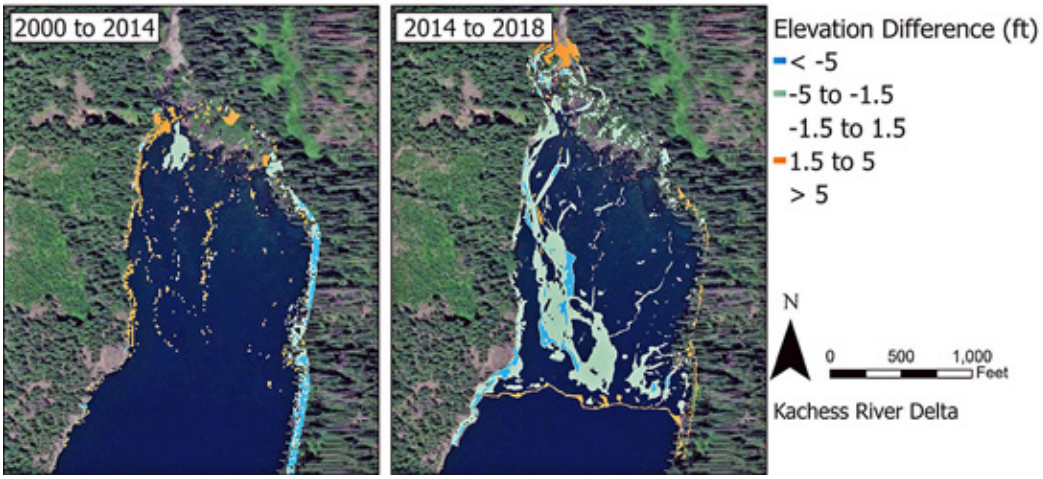
streams that enter the reservoir at the upstream

focused on site visits and data collection to better understand the sediment sizes and the longitudinal channel slopes of the delta surfaces. Initial comparison of elevation changes and inundation

shows that considerable channel changes occurred

but the surface was more stable over a longer

the delta surfaces and solution development.



Differences in elevation from 2000 to 2014 and 2014 to 2018 at the Kachess River delta at the upstream end of Kachess Lake, Washington.

Reservoir Delta Vegetation and Wetlands

By Nathan Holste
nholste@usbr.gov

hundreds of dams throughout the Western United

river channels and store water upstream; therefore,

documented and include lowering of the channel

reservoir pool elevation.

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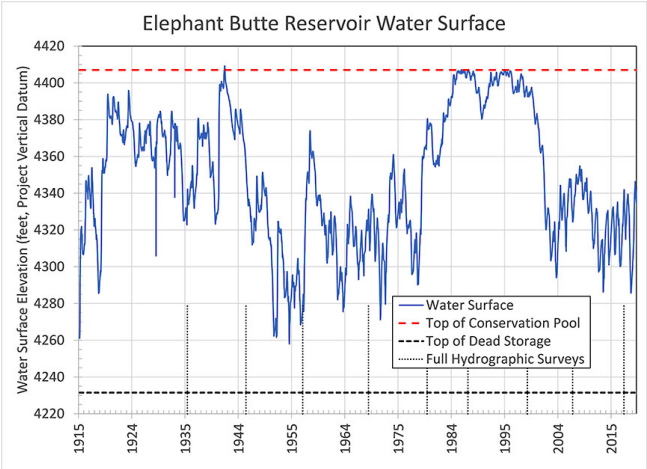
Matilija Dam in Ventura County, California (Surfrider Foundation/Paul Jenkin). Reservoir upstream of dam is transitioning to a wetland marsh and will eventually become riverine.

–continued

characteristics and age classes. Under static conditions, where there is little erosion or deposition, vegetation become established on fresh delta sediments.

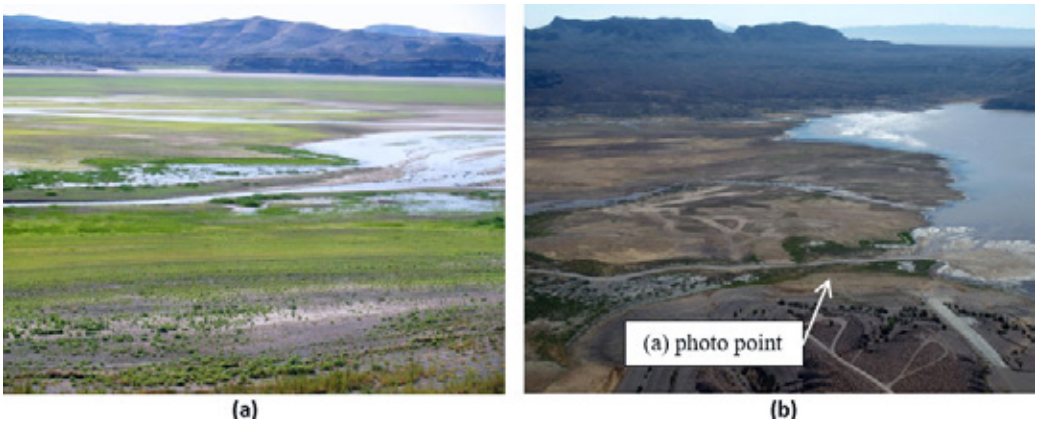


Fluctuations in Elephant Butte Reservoir water surface elevation since storage began in 1915 (Randle and Benoit 2020).

period, the pool elevation dropped about 100 feet between

Empidonax trailli extimus

Reservoir pool elevations have remained low while the former delta headwater area has become less suitable with a corresponding decline in elevation has caused a more static delta environment where little erosion, deposition, or emergence of new vegetation. Periodic reservoir pool sediment and vegetation habitat zone.



Downstream view of Elephant Butte Reservoir delta (a) from ground and (b) from airplane (Reclamation/ Nathan Holste). A recent decline in the pool elevation has exposed delta sediments that are being colonized by emergent riparian vegetation.

Groups and Resources to Know

Reservoir Sedimentation Information Resources

By Tim Randle
trandle@usbr.gov

lleagues through

groups and colleagues in the area of reservoir

resulted in numerous helpful guidelines, videos, and

sedimentation. Resources available on the topic of reservoir sedimentation include newsletters, videos, webinars, white papers, and

Dams supports a reservoir sedimentation technical committee through which,

Spring 2022 issue, highlighted an overview article on

Sedimentation and

comprised of engineers and scientists from multiple Federal and local agencies, universities, consultants,

- Introduct
- White paper
-
-

Develo
Sediment from Reservoirs

a technical committee at the Western Dredging

provides an overview of the dredging process as

respective capabilities, challenges, and engineering

the Guardians of the Reservoir prize competition.

nd

several technical guidelines related to reservoir

of Reclamation reservoirs.

management.

Science & Technology Prize Competitions Overview

Guardians of the Reservoir

By Jennifer Bountry & Tim Randle; with partners, U.S. Army Corps of Engineers
jbountry@usbr.gov, trandle@usbr.gov
www.usbr.gov/research/challenges/

competitions to spur new ideas and innovation in areas of

We have awarded more than

Guardians of the Reservoir Sediment Removal Competition

important challenge to spur

through reservoirs, with

of the competition was to

to improve reservoir sediment management.

implemented to help us maintain water storage and reservoir function into the future. In some

compete in Phase 2, each receiving

demonstrations between December 2020 to

demonstrate their technologies at increasing scales

scale demonstration, with the top performing team winning $100,000.

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Video from Research & Development Office Prize Competitions website "Sediment Removal Techniques for Reservoir Sustainability" www.usbr.gov/research/challenges/sediment-removal.html or watch on YouTube.

- of

  "A Cure for Ailing Reservoirs"

- ***"Air Bubble Suction Pipe with Water Recirculation"***

- ***"Sediment Continuity and Restoration":***

  Prometheus Innovations, LLC, and

  Service, Louisiana, ***"3 D DREDGER™: Complete Sediment Management"***

  larger debris using three dredging attachments.

  environment, without impacting operation or recreation.

- ***"High Volume Deep Dredging for Low Water De-silting:"***

  and power consumption and reducing abrasion in pumps and pipelines.

with important partnerships. Reclamation teamed

Federal partner to help improve reservoir sediment management solutions. We also had amazing support

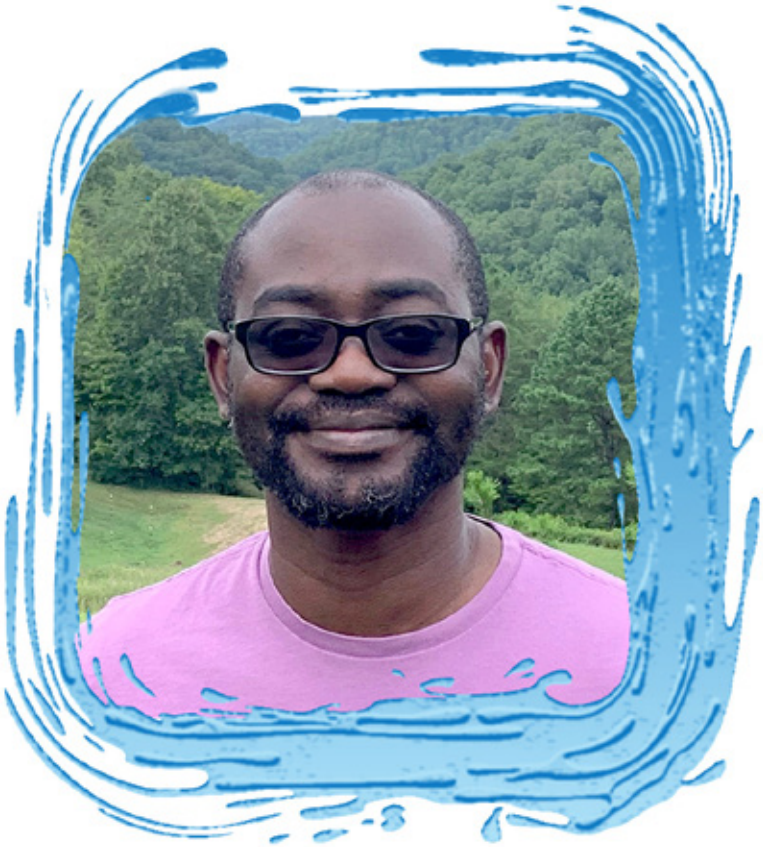
facilitated the prize competition design, solver team

Competition, we brought in a new partner, Fed

and business plans to improve potential for future implementation. We also appreciate our collaboration with the World Organization of Dredging

who helped advertise the Competition and provided

Featured Faces



Ben Abban

babban@usbr.gov

modeling, including watershed model development.

returning to graduate school.

an appropriate scale unit for the prediction of water

landscapes," captures his contributions on estimating both sediment sources as well as their associated

Featured Faces *–continued*

Colin Byrne
cbyrne@usbr.gov

Reclamation, Colin was a postdoc at the

Research Letters.

and sediment transport modeling of rivers. While at Reclamation, Colin has completed modeling

of a numerical, sediment transport model to predict similar transport and depositional patterns

River in Washington.

Featured Faces *–continued*

Dan Deeds
ddeeds@usbr.gov

California Water Science Center in San Diego

speciation, and the development of novel methods to detect ultra-trace concentrations

in assessing how changes in watershed health

*

* Chem

*

* Favor

Featured Faces *–continued*

Melissa Foster
mfoster@usbr.gov

couple modeling and remote sensing to constrain

developed and now maintains the new Reservoir

Colorado to pursue her Ph.D. in geological