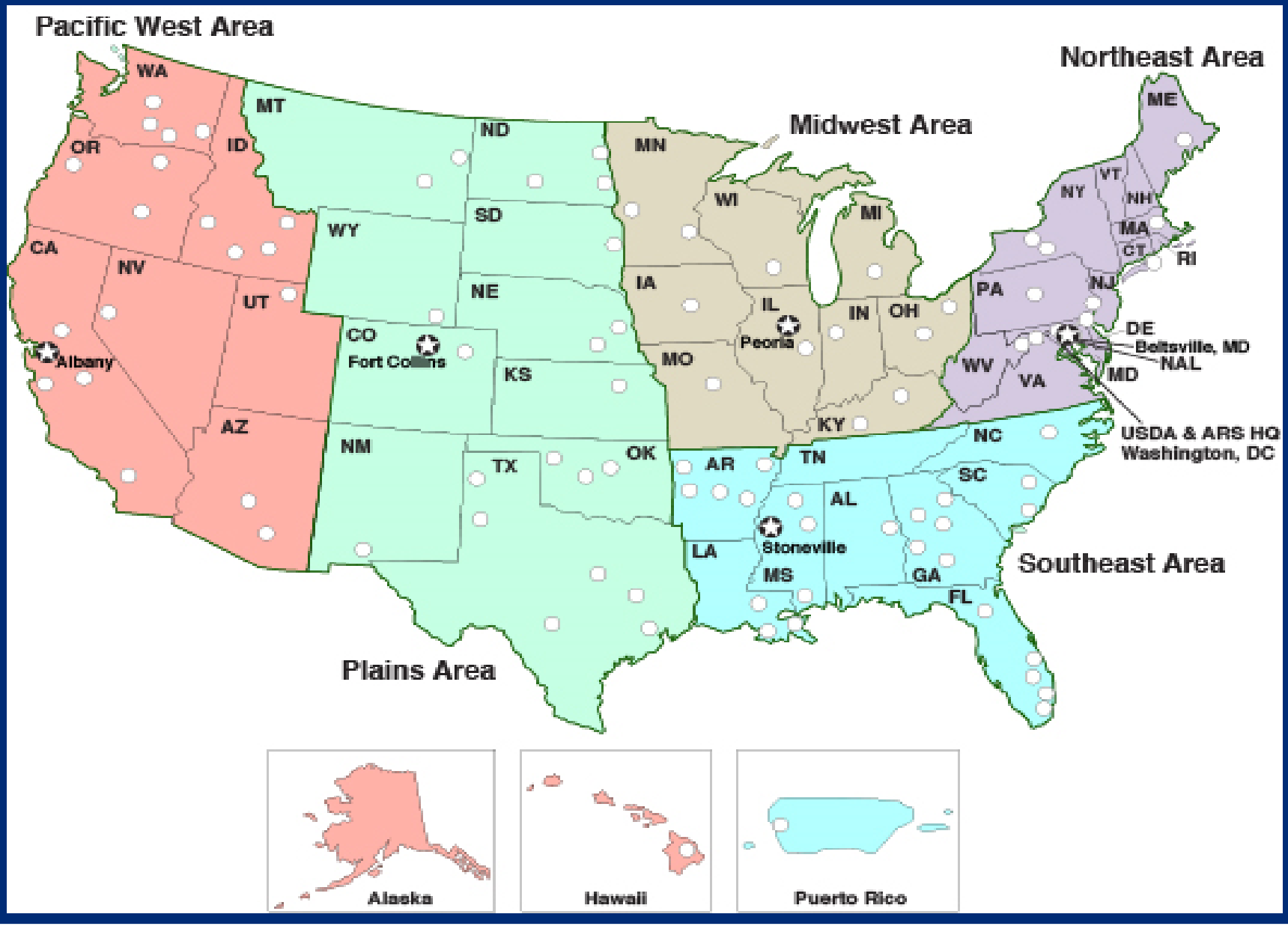
United States Department of Agriculture

USDA-ARS Hydraulic Engineering Research Unit
Stillwater, OK

Innovations in Hydraulic Engineering since *1940*.


Pacific West Area
Northeast Area
Midwest Area
Plains Area
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MD
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Fort Collins
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Stoneville
Beltsville, MD
NAL
USDA & ARS HQ
Washington, DC
Alaska
Hawaii
Puerto Rico

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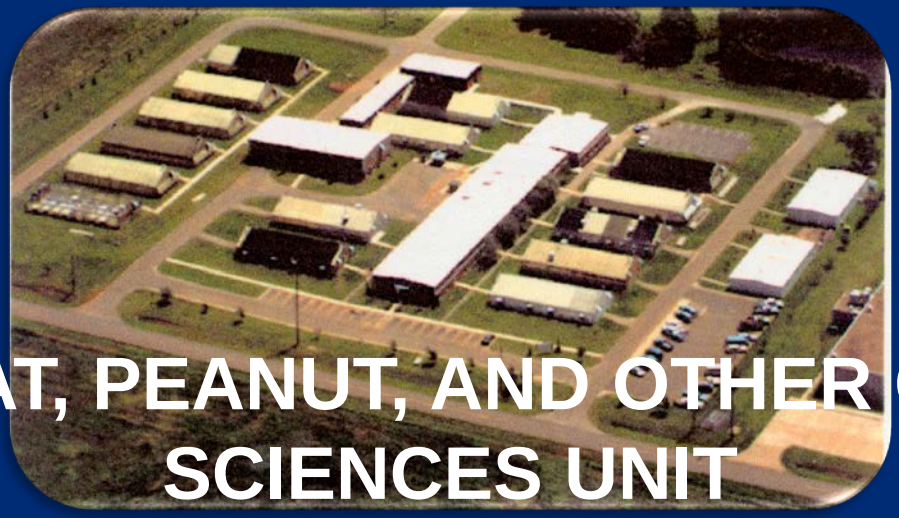

WHEAT, PEANUT, AND OTHER CROP SCIENCES UNIT

HYDRAULIC ENGINEERING RESEARCH UNIT

United States Department of Agriculture

Hydraulic Engineering Research Unit Staff

Dr. Sherry Hunt, *Research Leader*

Vacant, Research Civil Engineer

Kem Kadavy, *Agricultural Engineer*

Ron Tejral, *Agricultural Engineer*

Bob Sappington, *Engineering Technician*

Tyler Selvey, *Engineering Technician*

Dr. Abdelfatah Ali, *ORISE Post-doc*

United States Department of Agriculture

Spartanburg, South Carolina
Outdoor Hydraulic Laboratory

MISSION: Determine the hydraulic characteristics of vegetations used for waterway lining.

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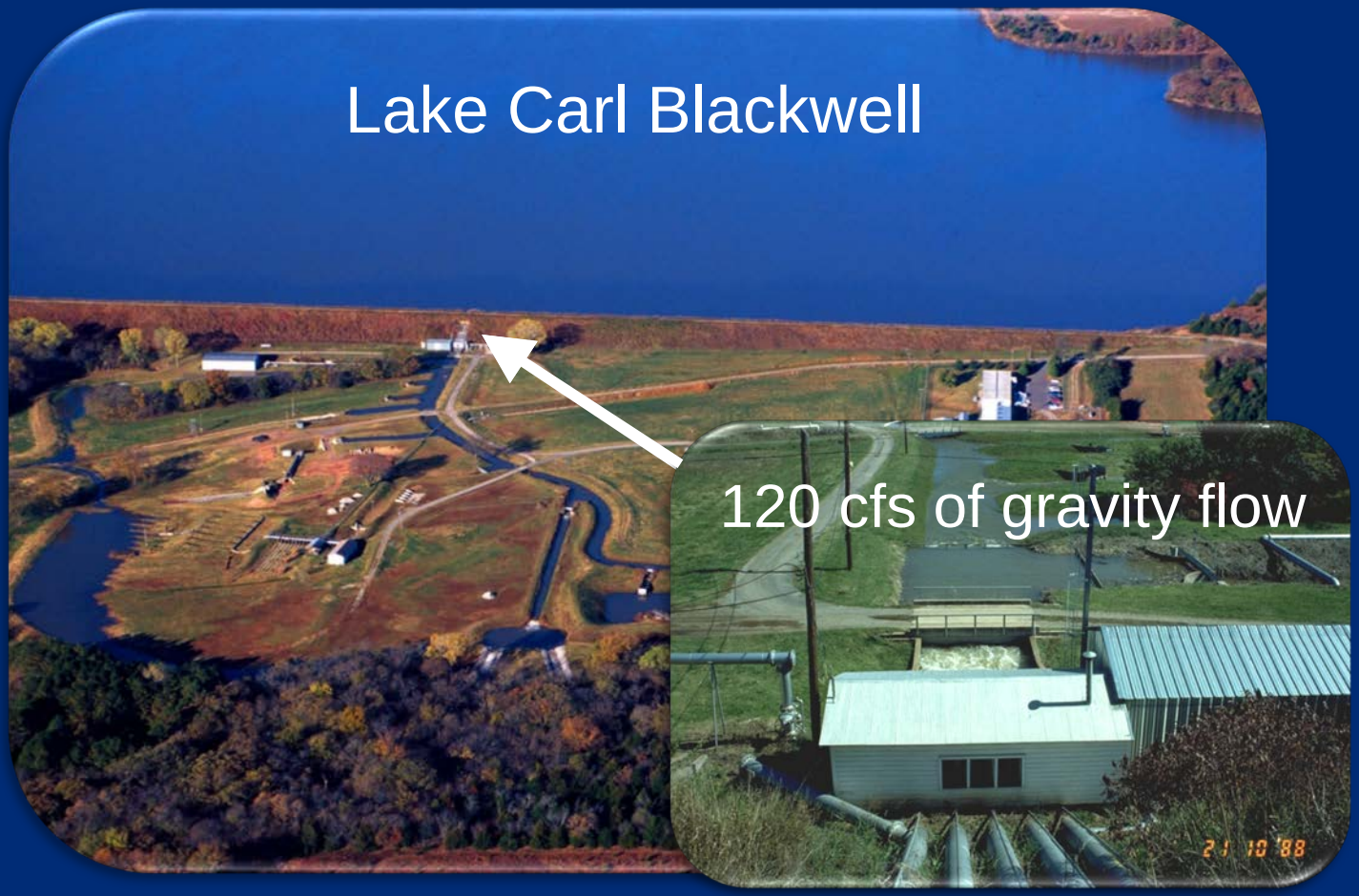
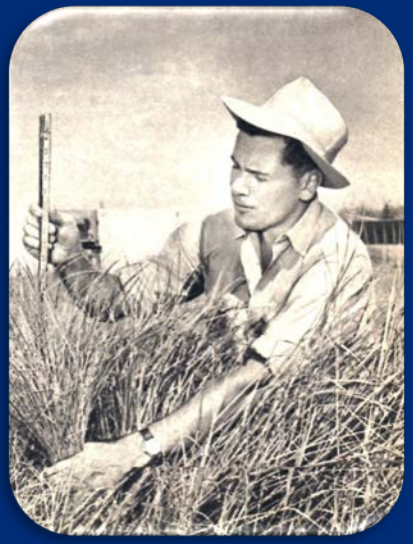
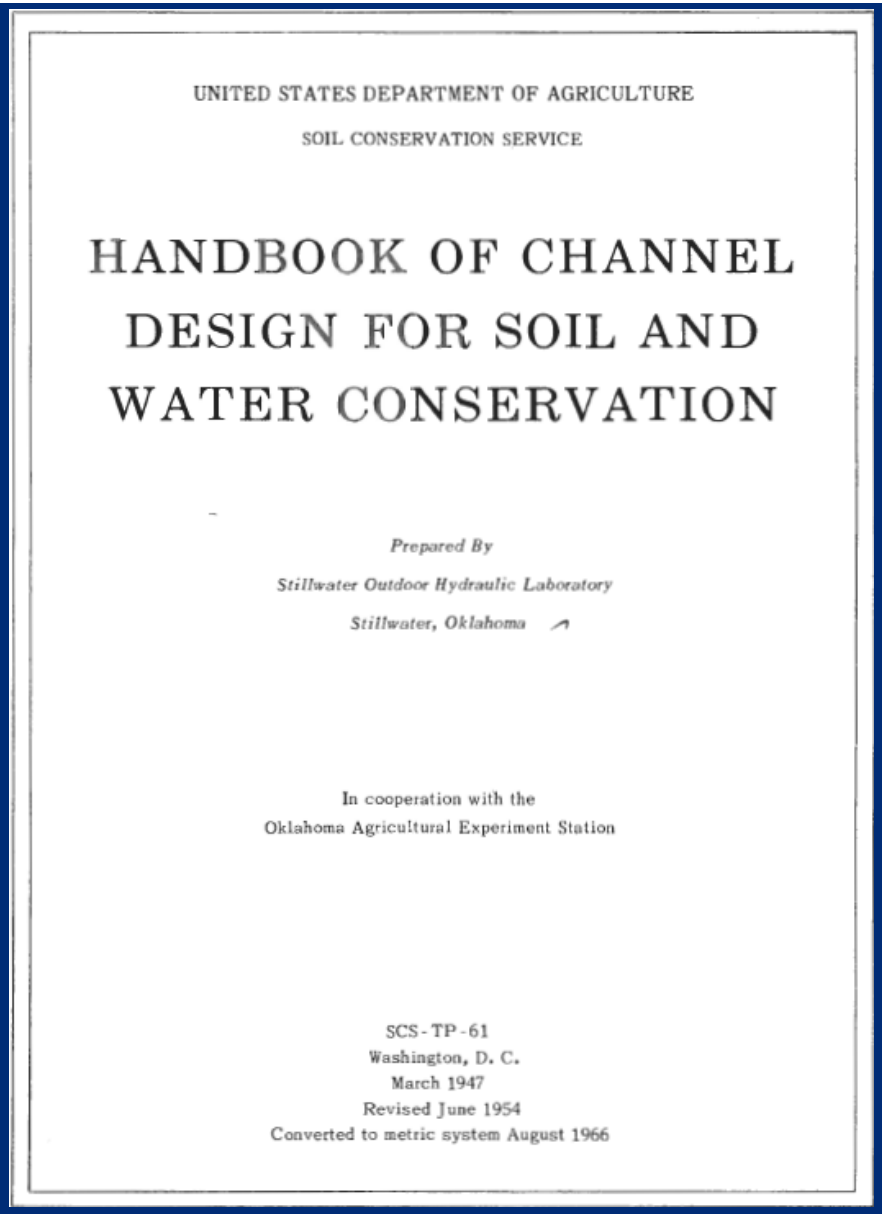
Agricultural Research Service
HERU
Hydraulic Engineering Research Unit



United States Department of Agriculture



MISSION: Determine the hydraulic characteristics of vegetations used for waterway lining.



UNITED STATES DEPARTMENT OF AGRICULTURE

SOIL CONSERVATION SERVICE

HANDBOOK OF CHANNEL DESIGN FOR SOIL AND WATER CONSERVATION

Prepared By

Stillwater Outdoor Hydraulic Laboratory

Stillwater, Oklahoma

In cooperation with the
Oklahoma Agricultural Experiment Station

SCS-TP-61
Washington, D. C.
March 1947
Revised June 1954
Converted to metric system August 1966

- ✓ SCS TP-61 Handbook of Channel Design

- ✓ SCS TP-61 Handbook of Channel Design
- ✓ ARS AH-667 Stability Design of Grass-Lined Open Channels

- ✓ SCS TP-61 Handbook of Channel Design
- ✓ ARS AH-667 Stability Design of Grass-Lined Open Channels
- ✓ NRCS NEH, Part 650, EFH Ch 7 Grassed Waterways.
- ✓ NRCS NEH, Part 654, SRD Ch 8 Threshold Channel Des.
- ✓ NRCS EFT v 1.1.2 Waterway Development Tool v 2.0.0.3 released
- ✓ NRCS-ARS – SITES Model v 2005.1.3
- ✓ U.S. Army Corps of Engineers SITES SSEA

- ✓ ASABE EP464.1 Grassed Waterway for Runoff Control
- ✓ASABE EP492.1 Diversions
- ✓NRCS Conservation Practice Standards
  - 412 Grassed Waterway
  - 468 Lined Waterway or Outlet
  - 600 Terrace
  - 378 Pond
  - 402 Dams

- ✓ SCS TP-61 Handbook of Channel Design
- ✓ ARS AH-667 Stability Design of Grass-Lined Open Channels
- ✓ NRCS NEH, Part 650, EFH Ch 7 Grassed Waterways.
- ✓ NRCS NEH, Part 654, SRD Ch 8 Threshold Channel Des.
- ✓ NRCS EFT v 1.1.2 Waterway Development Tool v 2.0.0.3 released
- ✓ NRCS-ARS – SITES Model v 2005.1.3
- ✓ U.S. Army Corps of Engineers SITES SSEA
- ✓ NRCS-ARS – WINDAM Breach Model (Beta Test Version)

MISSION: Develop criteria for the analysis and design of conservation structures and channels for the conveyance, storage, and measurement of runoff waters.

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MISSION: Expanded to include Hydraulic Structures.

- ✓ NRCS NEH, Part 654, SRD TS Part 14 Stone Sizing Criteria

MISSION: Expanded to include Hydraulic Structures.

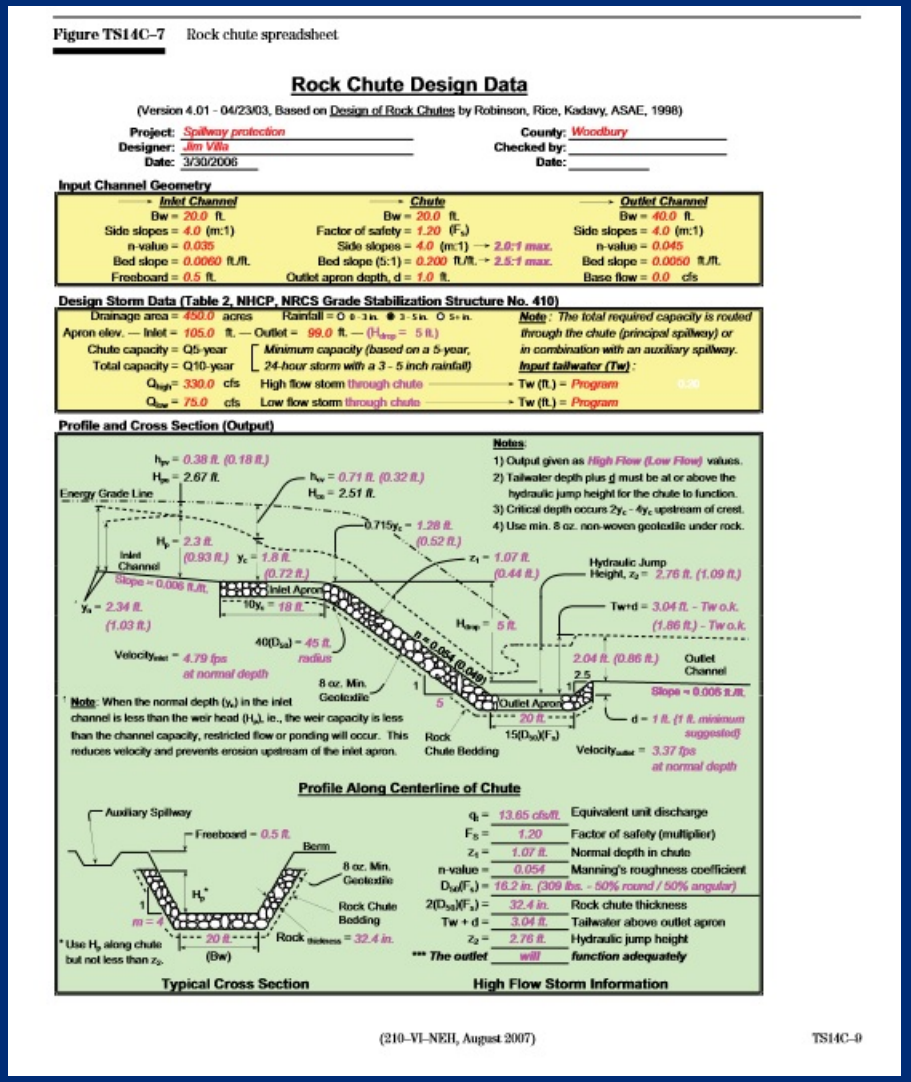

Figure TS14C–7 Rock chute spreadsheet

Rock Chute Design Data

(Version 4.01 - 04/23/03, Based on Design of Rock Chutes by Robinson, Rice, Kadavy, ASAE, 1998)

Project: Spillway protection — County: Woodbury
Designer: Jim Villa — Checked by:
Date: 3/30/2006 — Date:

Input Channel Geometry

Inlet Channel	Chute	Outlet Channel
Bw = 20.0 ft.	Bw = 20.0 ft.	Bw = 40.0 ft.
Side slopes = 4.0 (m:1)	Factor of safety = 1.20 (F_s)	Side slopes = 4.0 (m:1)
n-value = 0.035	Side slopes = 4.0 (m:1) → 2.0:1 max.	n-value = 0.045
Bed slope = 0.0060 ft./ft.	Bed slope (5:1) = 0.200 ft./ft. → 2.5:1 max.	Bed slope = 0.0050 ft./ft.
Freeboard = 0.5 ft.	Outlet apron depth, d = 1.0 ft.	Base flow = 0.0 cfs

Design Storm Data (Table 2, NHCP, NRCS Grade Stabilization Structure No. 410)

Drainage area = 450.0 acres — Rainfall = ○ 0-3 in. ● 3-5 in. ○ 5+ in.
Apron elev. — Inlet = 105.0 ft. — Outlet = 99.0 ft. — (H_{drop} = 5 ft.)
Chute capacity = Q5-year
Total capacity = Q10-year
Minimum capacity (based on a 5-year, 24-hour storm with a 3 - 5 inch rainfall)
Q_{high} = 330.0 cfs — High flow storm through chute → Tw (ft.) = Program
Q_{low} = 75.0 cfs — Low flow storm through chute → Tw (ft.) = Program

Note: The total required capacity is routed through the chute (principal spillway) or in combination with an auxiliary spillway.
Input tailwater (Tw):

Profile and Cross Section (Output)

Profile Along Centerline of Chute

q_t =	13.65 cfs/ft.	Equivalent unit discharge
F_s =	1.20	Factor of safety (multiplier)
z_1 =	1.07 ft.	Normal depth in chute
n-value =	0.054	Manning's roughness coefficient
$D_{50}(F_s)$ =	16.2 in. (309 lbs. - 50% round / 50% angular)	
$2(D_{50})(F_s)$ =	32.4 in.	Rock chute thickness
Tw + d =	3.04 ft.	Tailwater above outlet apron
z_2 =	2.76 ft.	Hydraulic jump height
*** The outlet	will	*function adequately*

Typical Cross Section — High Flow Storm Information

- ✓ NRCS NEH, Part 654, SRD TS Part 14 Stone Sizing Criteria
- ✓ NRCS NEH, Part 654, SRD TS Part 14 Grade Stabilization Tech.
- ✓ Supplemental Technology to TR-59 Hydraulic Design of Rip-Rap Gradient Control Structures

MISSION: Expanded to include Hydraulic Structures.

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- ✓ NRCS NEH, Part 654, SRD TS Part 14 Stone Sizing Criteria
- ✓ NRCS NEH, Part 654, SRD TS Part 14 Grade Stabilization Tech.
- ✓ Supplemental Technology to TR-59 Hydraulic Design of Rip-Rap Gradient Control Structures
- ✓ ARS Specific Model Study – NRCS Riffle Pool Rock Chute Application Sugar Creek, OK
- ✓ NRCS-ARS – WINDAM Breach Model (Beta Test Version)

✓NRCS Conservation Practice Standards

410 Grade Stabilization Structure

MISSION: Expanded to include Hydraulic Structures.

THE CLINTON DAILY NEWS

New Flood Warning - Torrent Racing Down Washita, Is Report

15 DEAD AND 6 MISSING IN FLOOD

Five Men, Numb With Exposure, Rescued From Tree Tops

RESCUE BOATS BATTLE WATER TO REACH MEN

All Five, Suffering From Cold, Said To Be Recovering

MOST POPULAR STUDENTS

CLINTON STUDENTS TO TAKE PART IN FINE ARTS MEET

700 Contestants From 14 Towns To Enter Musgrave Contest

In U. S. for Visit

River Bottom Is Hunted for Flood Victims

BULLETIN

MANY COUNTY OIL LEASES RECORDED

Boger Echoes Still Strong Here

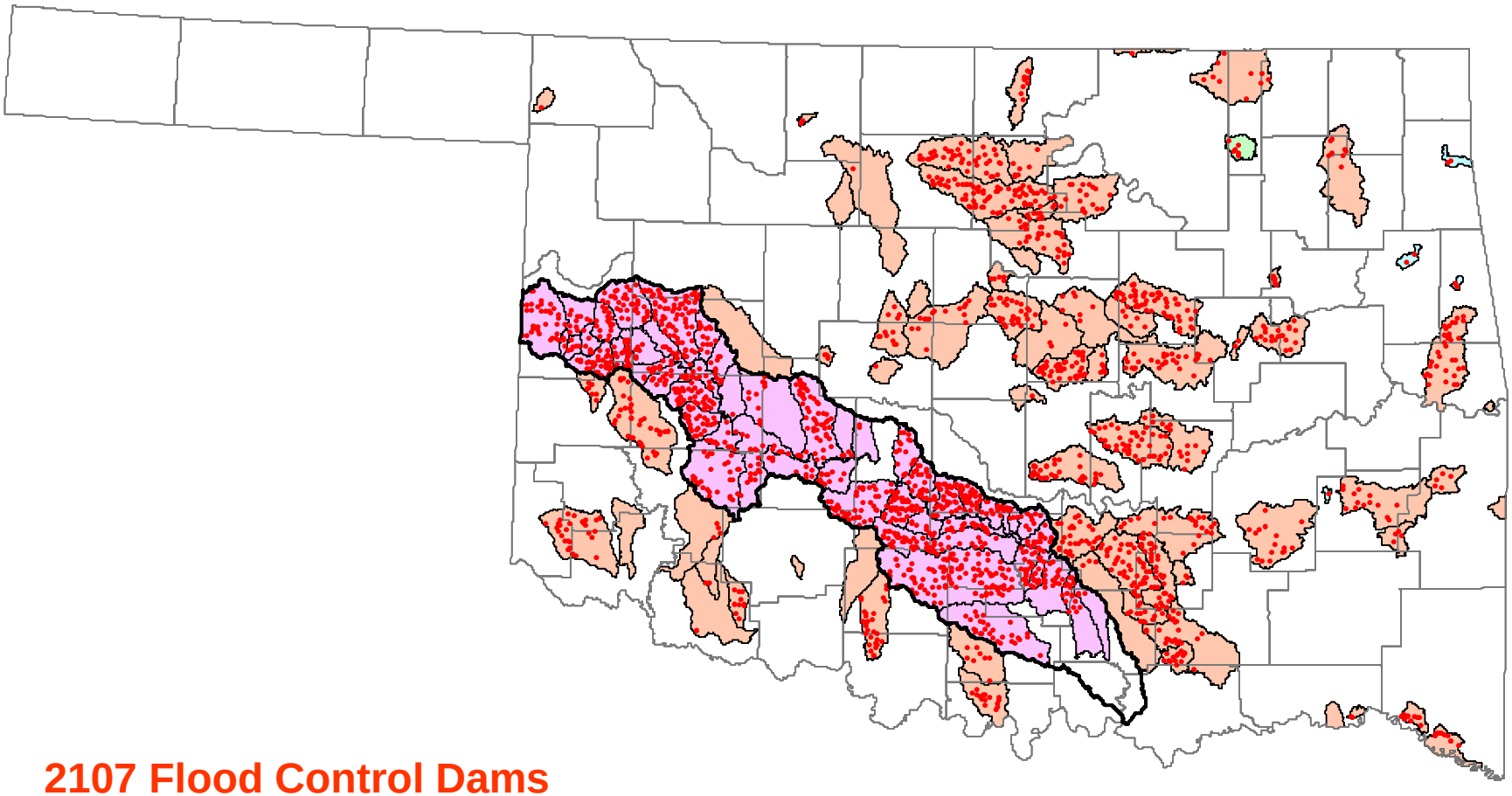
COUNTY CORN-HOG GROUP ORGANIZES

Lonnie Dean Elected President

APPEAL FOR OLD CLOTHES ISSUED

Flooding across the Midwest

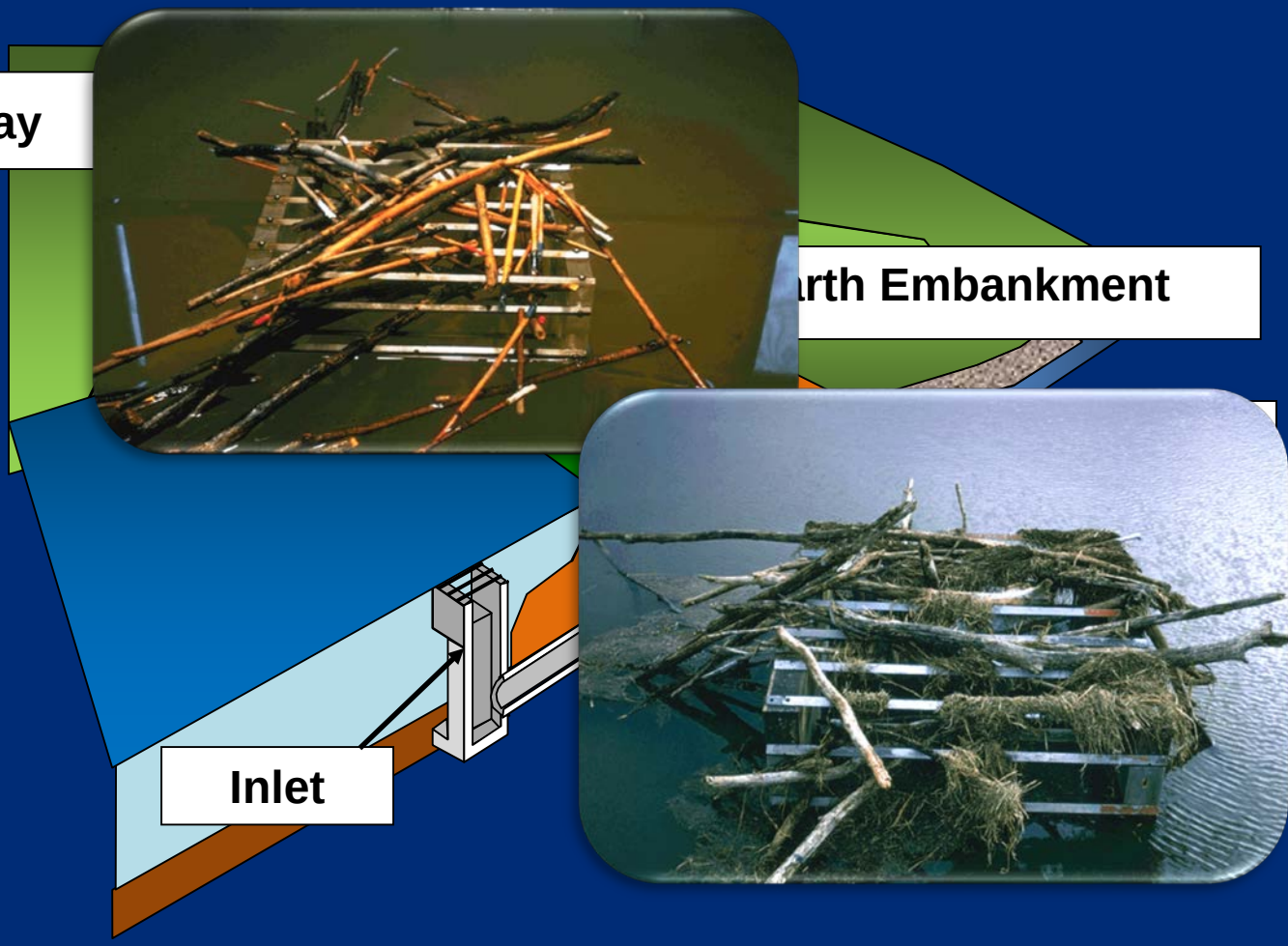
United States Department of Agriculture



2107 Flood Control Dams

USDA Small Watershed Program

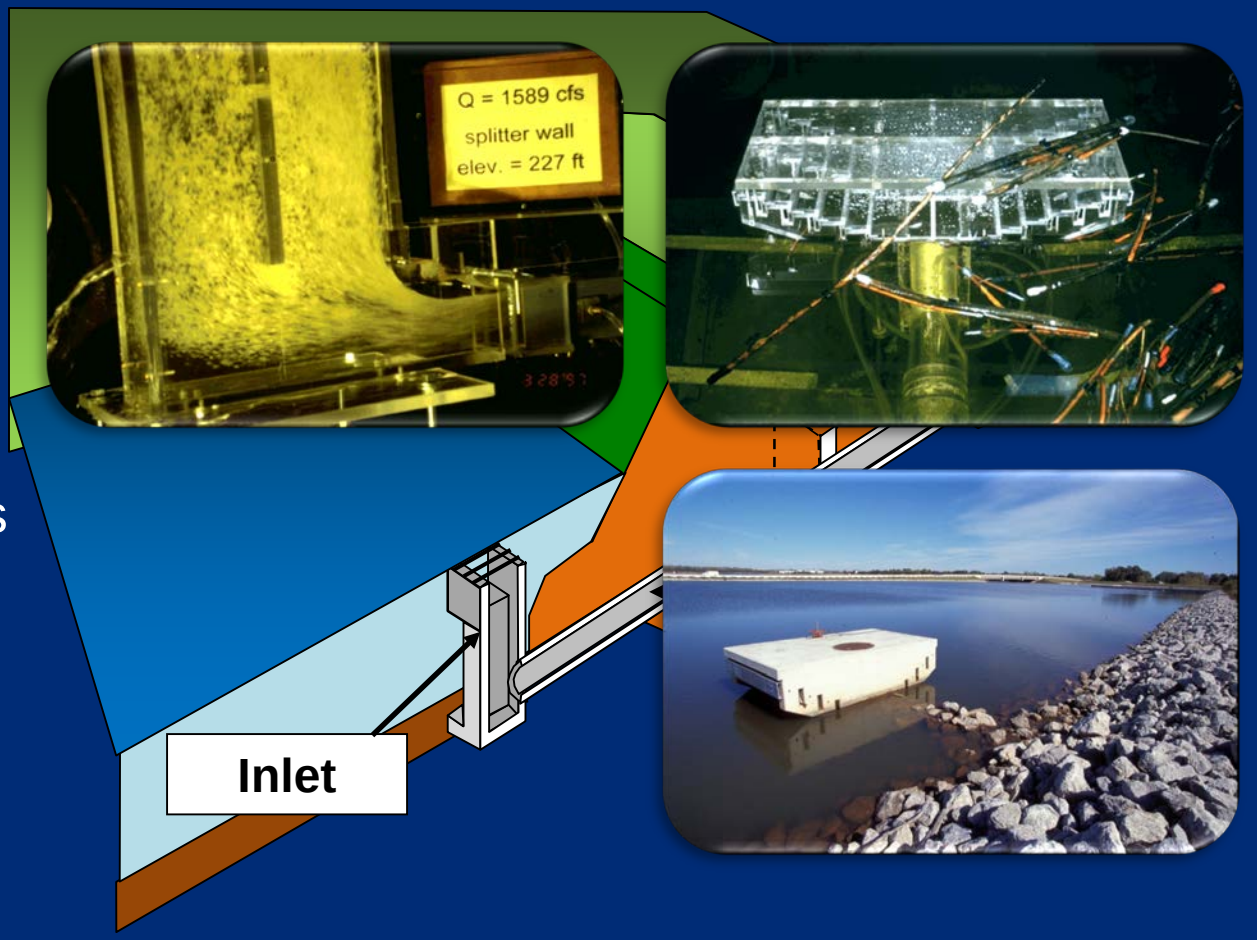
United States Department of Agriculture



- ✓ TR-03 Hood Inlets for culvert spillways

USDA Small Watershed Program

- ✓ TR-70 Hydraulic proportioning of two-way covered baffle inlet riser.
- ✓ TR-29 Hydraulics of two-way covered risers.



USDA Small Watershed Program

United States Department of Agriculture

Outlet

- ✓ Design Note 6 Riprap-lined plunge pool for cantilever outlet.
- ✓ ARS AH-76 Scour at cantilevered pipe outlets.

USDA Small Watershed Program

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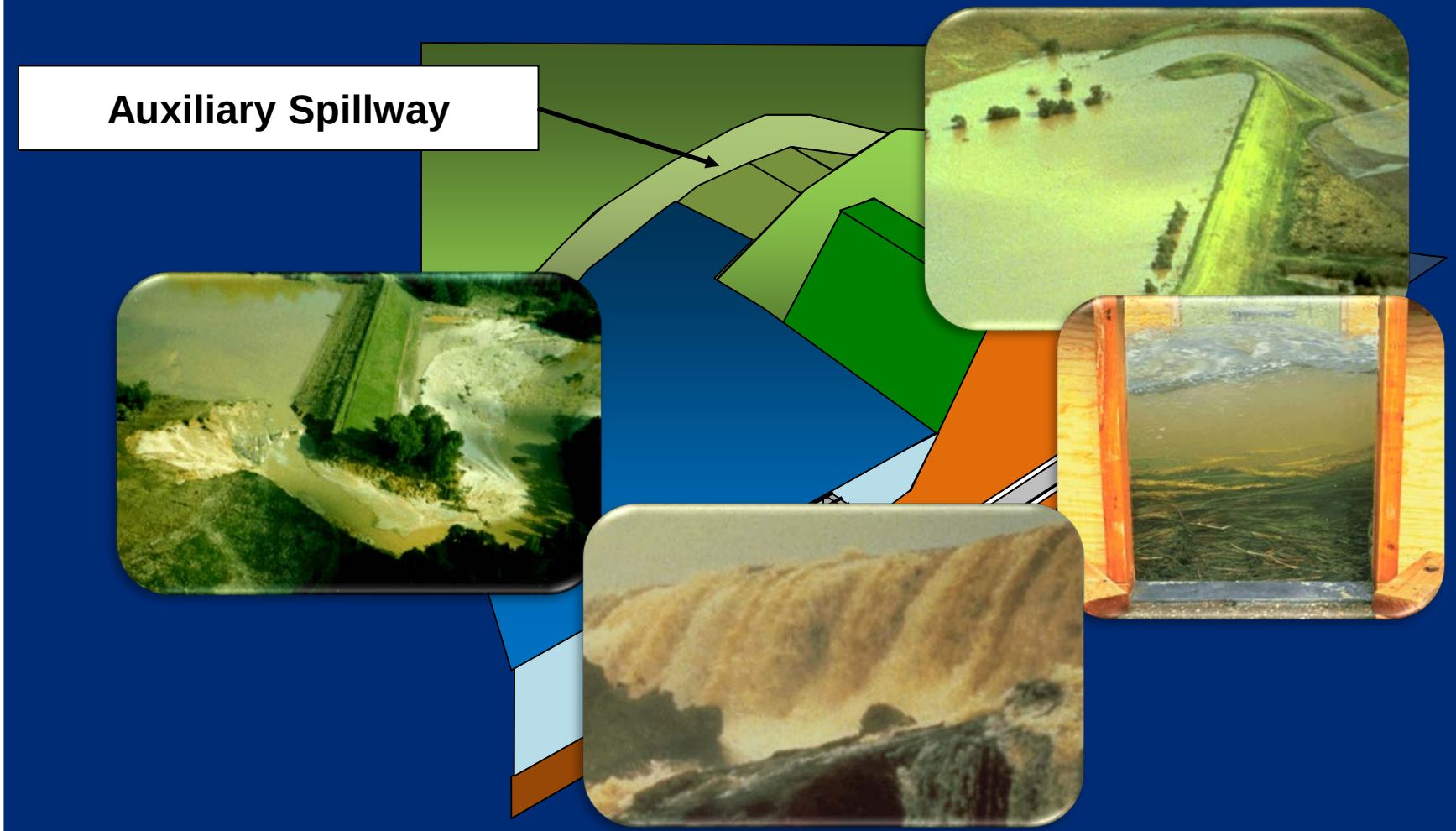
✓ Site-specific Structural Spillways – Boomer Lake, Stillwater, OK.

USDA Small Watershed Program

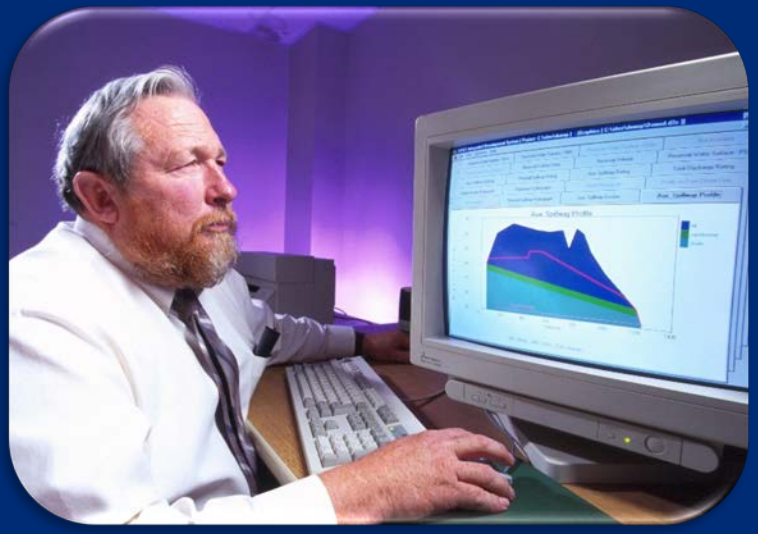
United States Department of Agriculture



USDA Small Watershed Program

- ✓ NEH – Part 628 , Ch 50 Earth Spillway Design
- ✓ NEH – Part 628 , Ch 51 Earth Spillway Erosion Model

- ✓ NEH – Part 628 , Ch 50 Earth Spillway Design
- ✓ NEH – Part 628 , Ch 51 Earth Spillway Erosion Model
- ✓ NEH – Part 628 , Ch 52 Field Procedures Guide for the Headcut Erodibility Index



- ✓ NEH – Part 628 , Ch 50 Earth Spillway Design
- ✓ NEH – Part 628 , Ch 51 Earth Spillway Erosion Model
- ✓ NEH – Part 628 , Ch 52 Field Procedures Guide for the Headcut Erodibility Index
- ✓ TR-60 Earth Dams & Reservoirs
- ✓ NRCS-ARS – SITES Model v 2005.1.3
- ✓ U.S. Army Corps of Engineers SITES SSEA

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JET Erodibility Device and Methodology

- ✓ ASTM Standard Field and Laboratory Erodibility Measurement Method
- ✓ NRCS-ARS – SITES Model v 2005.1.3
- ✓ NRCS-ARS – WINDAM Breach Model (Beta Test Version)
- ✓ ARS – Bank Stability and Toe Erosion Model (BSTEM)

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Users of the JET Device and Methodology

- ✓ U.S. Bureau of Reclamation
- ✓ U.S. Army Corp of Engineers
- ✓ Other ARS Scientists
- ✓ Academic Institutions
- ✓ Private Consultants
- ✓ International Scientific Community

JET Erodibility Device

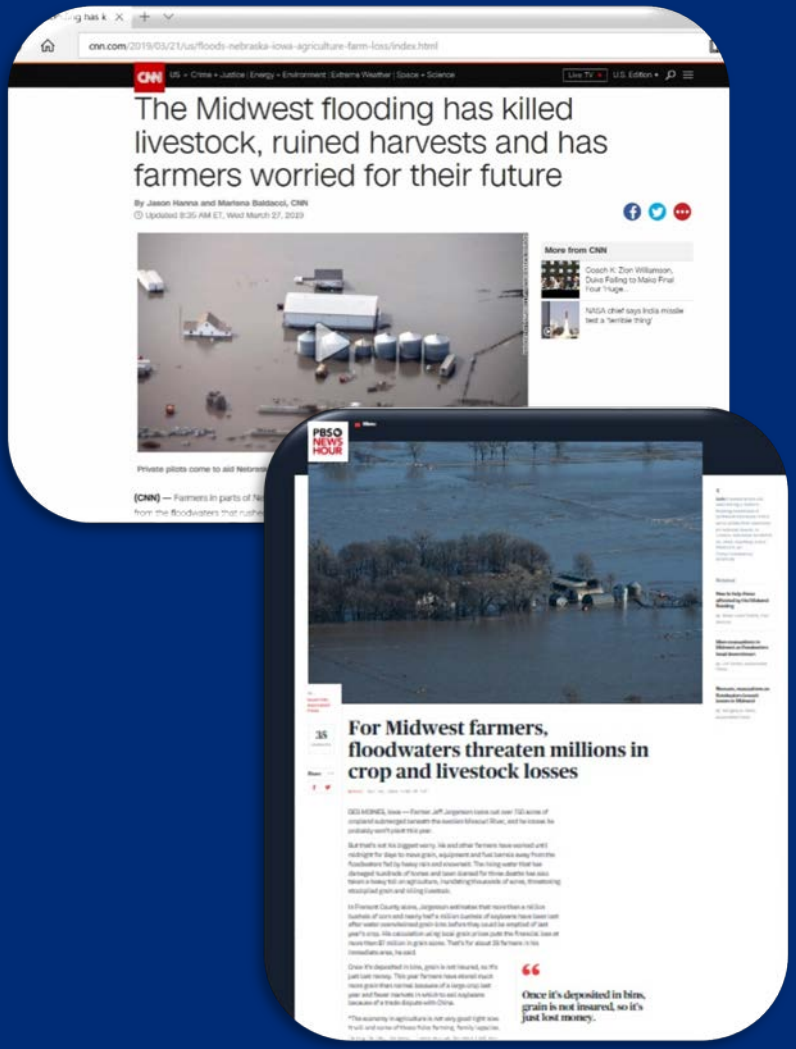
United States Department of Agriculture

The USDA Small Watershed Program Historic Landmark of Agricultural Engineering Dedicated by American Society of Agricultural and Biological Engineers in 2011

Challenges:

- Competition for food, fiber and water
- Urbanization
- Climate Change
- Aging infrastructure with structural deterioration and/or sedimentation

Challenges: Extremes Weather Events Become More Extreme



2019 Headline News Examples

- Flood Impact on Cattle – Nebraska Cow/Calf Produce Losses – Progressive Farmer
- Midwest Flooding Threatens Water Safety in 1 Million Wells – CNN News
- Nebraska Faces $1.3 Billion in Flood Losses – NPR
- Flooding Breaches Dam in Nebraska – The Weather Channel

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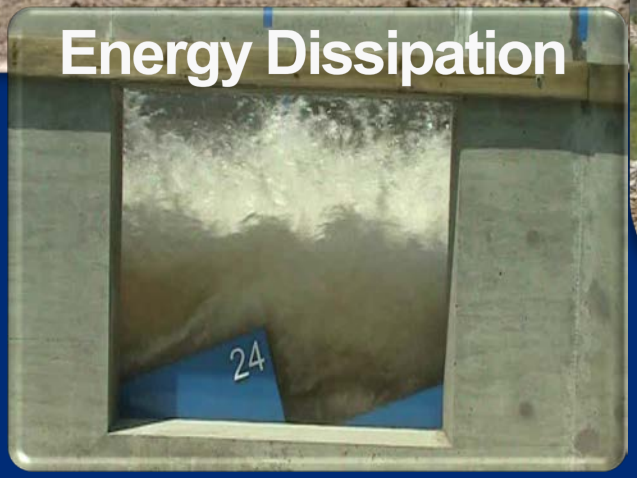
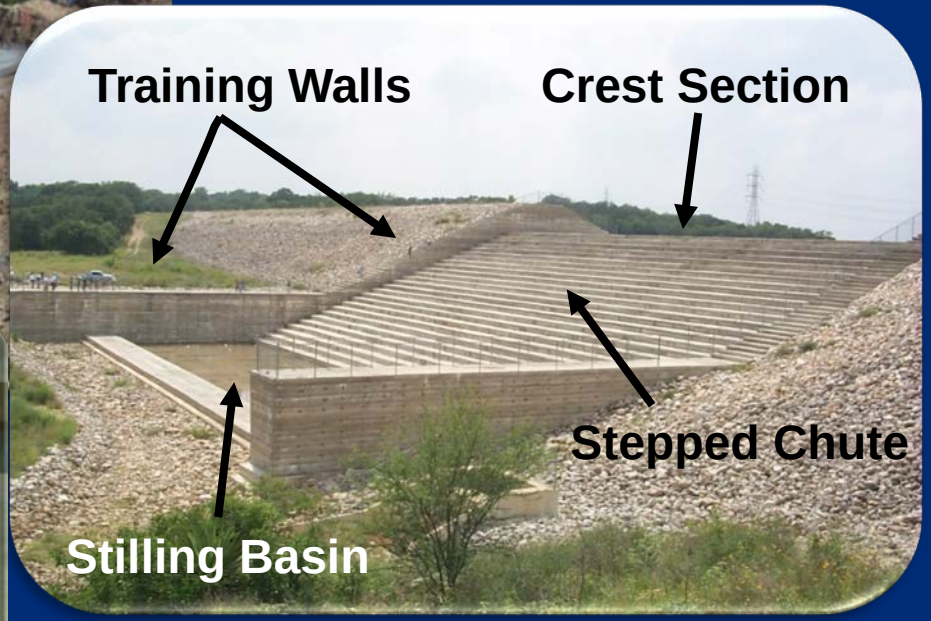
Alternative Spillway Designs and Overtopping Protection Systems

United States Department of Agriculture





Typical RCC Stepped Spillway

RCC Stepped Spillway Research

- ✓ Site-specific Stepped Chute Studies
  - ✓ Texas
  - ✓ Virginia
  - ✓ North Carolina
  - ✓ Georgia
  - ✓ North Dakota

RCC Stepped Spillway Research

United States Department of Agriculture

RCC Stepped Spillway Research

United States Department of Agriculture

Impact of Site-specific Stepped Chute Studies:

✓NRCS

✓Private Engineering

✓Forest Service

RCC Stepped Spillway Research

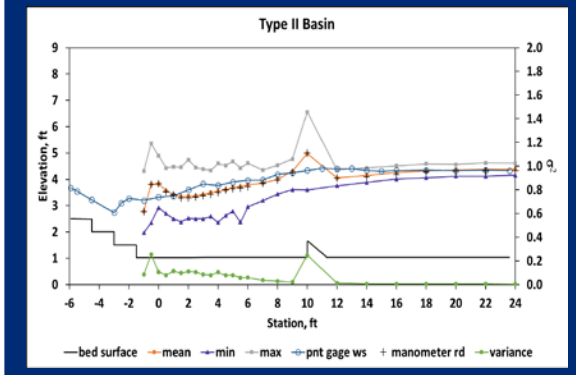
- ✓ NRCS NEH Chapter in development
- ✓ U.S. Corps of Engineers – EM 1110-2-1603 Hydraulic Design of Spillways (*in press*)

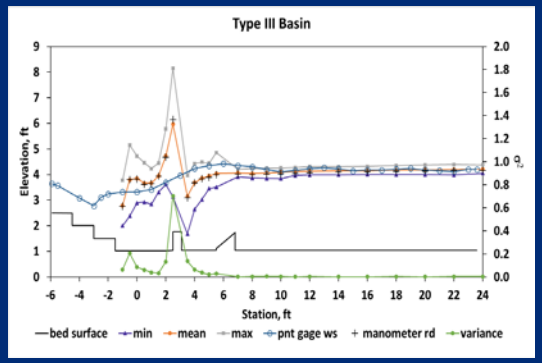
Generalized RCC Stepped Spillway Research

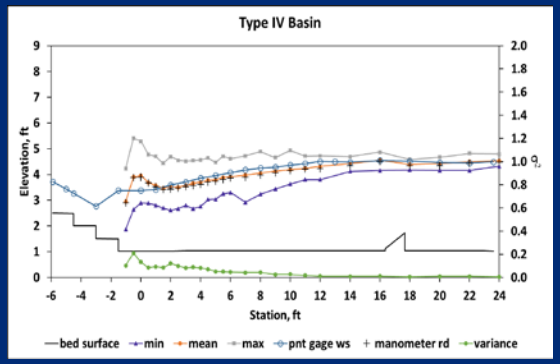
United States Department of Agriculture

- ✓ NRCS NEH Chapter in development
- ✓ U.S. Corps of Engineers – EM 1110-2-1603 Hydraulic Design of Spillways (*in press*)
- ✓ U.S. Corps of Engineers – EM 1110-2-1602 Hydraulic Design of Reservoir Outlet Works (*updating*)

Generalized RCC Stepped Spillway Research







- ✓ NRCS NEH Chapter in development
- ✓ U.S. Corps of Engineers – EM 1110-2-1603 Hydraulic Design of Spillways (*in press*)
- ✓ U.S. Corps of Engineers – EM 1110-2-1602 Hydraulic Design of Reservoir Outlet Works (*updating*)

Generalized RCC Stepped Spillway Research

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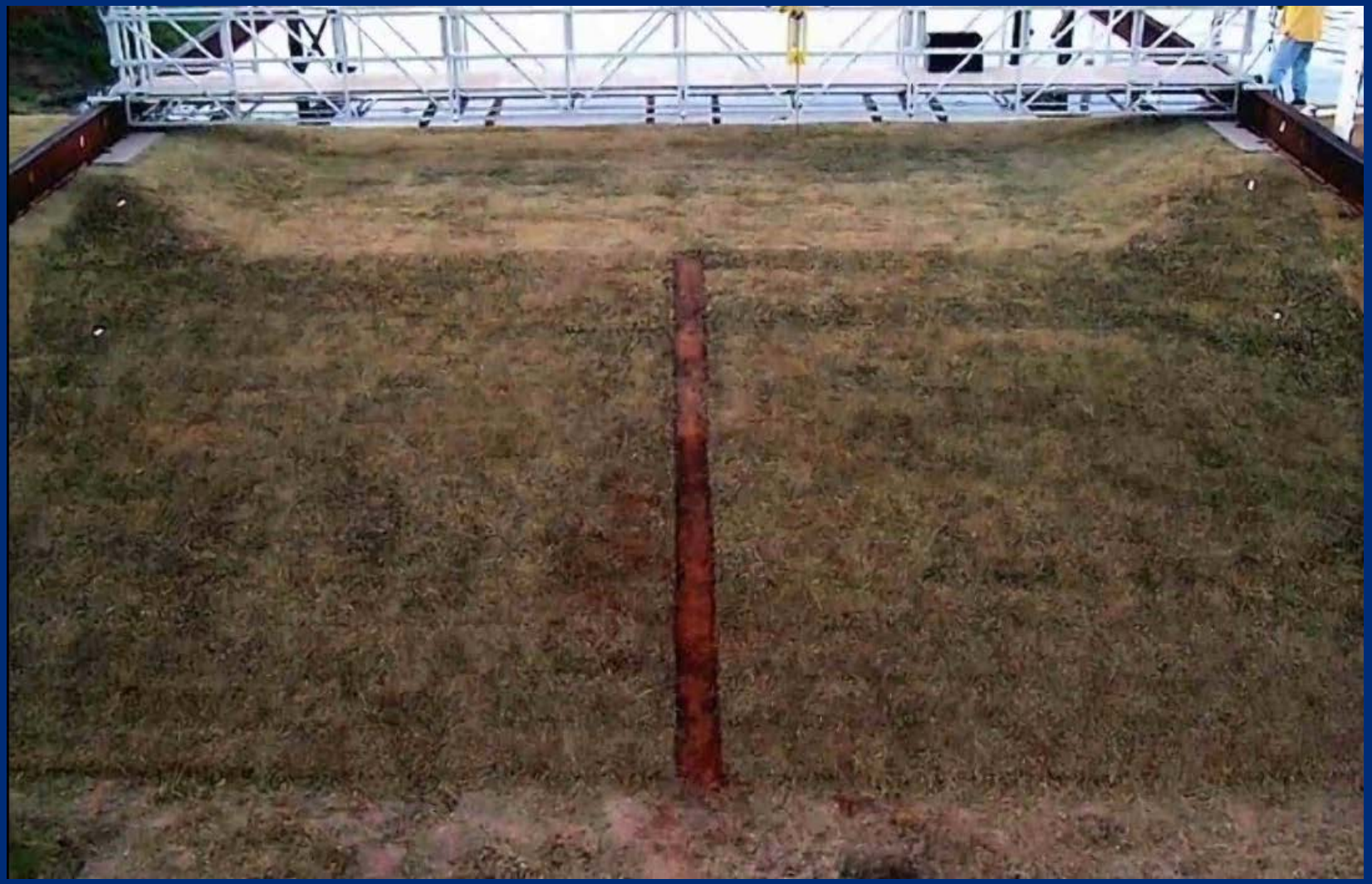
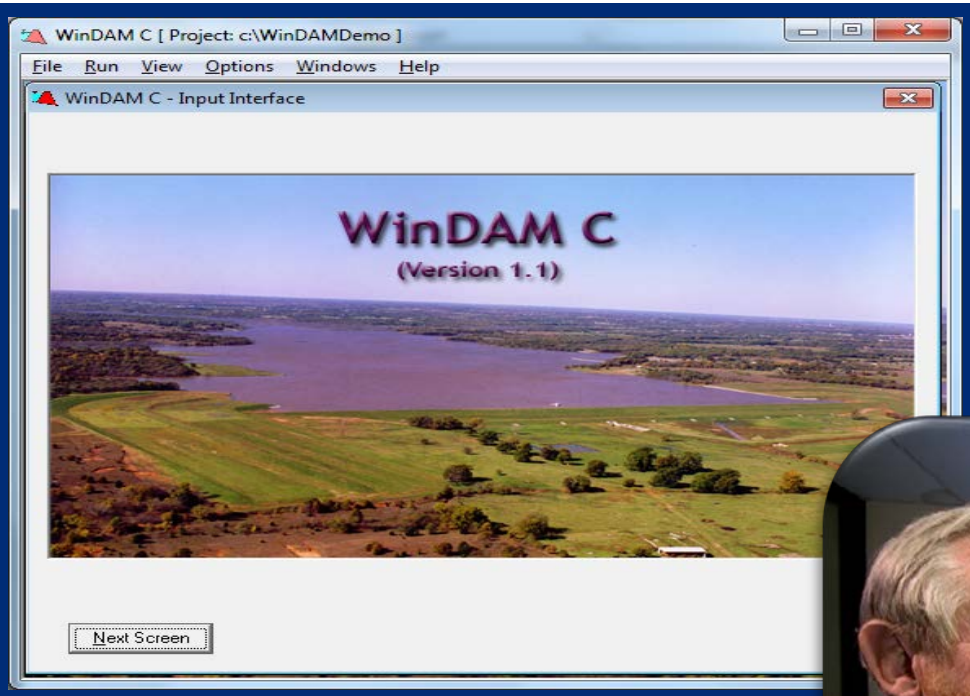
Embankment Breach Research

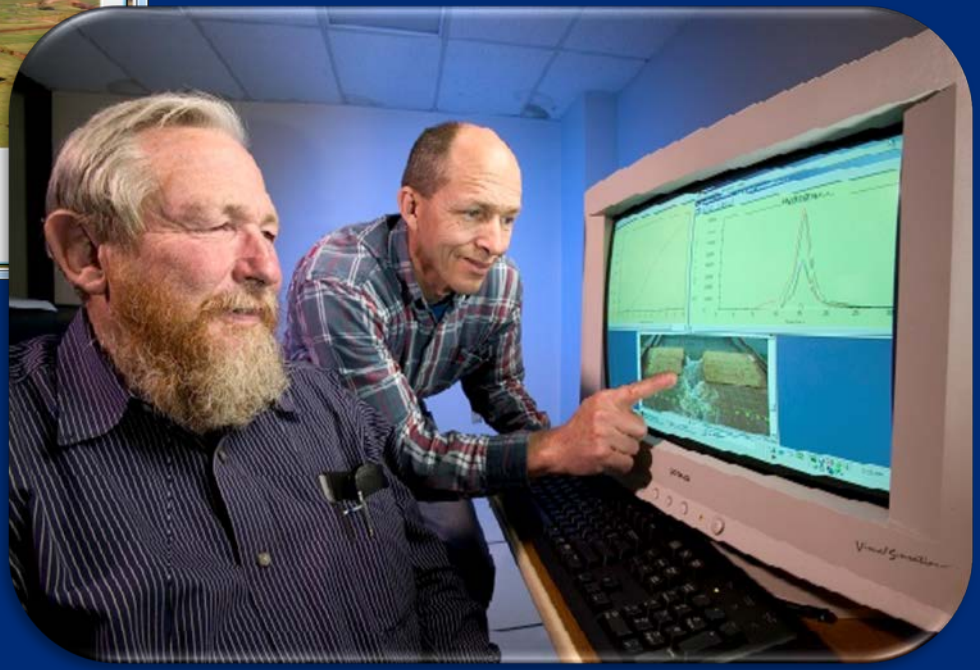


Embankment Breach Research

Embankment Breach Research

United States Department of Agriculture





Embankment Breach Research

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Embankment Breach Research

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Embankment Breach Research

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Embankment Breach Research

Impact

- Prioritization of Rehabilitation
- Improvement of Flood Warning Systems
- Development of Emergency Action Plans
- Zoning Regulations


$2.3 BILLION
IN ANNUAL BENEFITS

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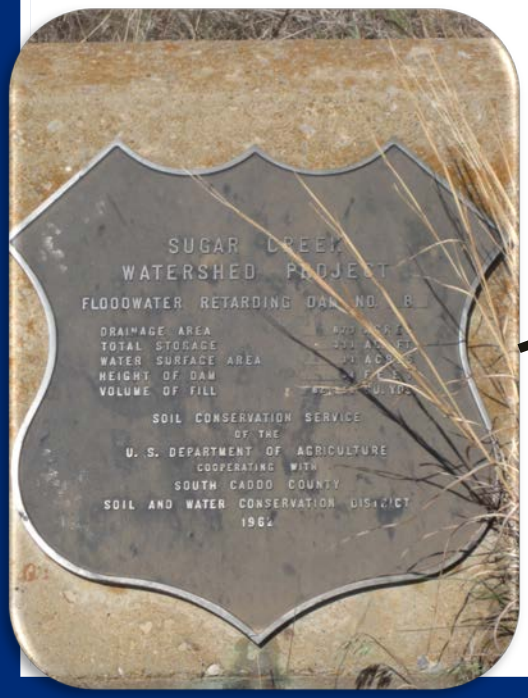

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Continuing the benefits

for generations to come.

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Leading America towards a better future through agricultural research and information.

USDA is an equal opportunity provider and employer.