Flood Control District of Maricopa County
Dam Safety Program

Presented by:
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Powerline FRS
Background

Flood Control District Dams

– District Operates and Maintains 22 Flood Control Dams
– 16 Dams Built by Natural Resources Conservation Service (NRCS - Formerly SCS)
– 5 Dams Built by Corps of Engineers
– 1 Designed and Built by District
– Dams Total 64 Miles in Length
– District was local Sponsor for NRCS and Corps Dams
– Arizona Department of Water Resources is the Jurisdictional Agency
Background

16 NRCS Dams
- Built From 1954 to 1991
- 100-Year Flood Protection for Agricultural Areas
- Flood Storage: Average 3,000 Acre-Feet Maximum 11,000
- Most Single Zone Earthen Dams, Average Length 3.2 miles

4 Corps of Engineers Dams, District as Local Sponsor
- Built From 1974 to 1985
- SPF Flood Protection for Urbanized Areas
- Flood Storage: 300, 18,000, 43,000 47,000 Acre-Feet
- Zoned Earthen Dams, Average Length 0.8 miles

McMicken Dam – USACOE, 1956
Casandro Wash Dam –District, 1996
Dam Safety Program Activities

Recurrent Dam Safety Activities

Structures Assessments and Repairs

Dam Rehabilitation

CENTENNIAL NARROWS DAM
1997 DAM FAILURE
Dam Safety Program Goals

Risk Reduction and Risk Management

- Stay ahead of issues to assure no imminent threats to public safety
- Reduce dam safety risk through dam rehabilitation and modifications
- Maintain or improve current level of flood protection provided by 22 dams for the long-term
- Manage risk through; inspections, monitoring, surveys, maintenance, repairs, EAPs
Common Dam Safety Issues

• Dam Safety
  – Embankments: Cracking
  – Foundations: Erosive Soils, Collapsible Soils
  – Emergency Spillways: Capacity, Erosive Soils
  – Subsidence, Earth Fissures
  – Outlets: CMP Outlets, Potential for Piping
  – Utilities

• Urbanization

• Changing design standards and regulations
Failure Modes and Effects Analysis (FMEA)

FMEA Utilized By District For:

- Initial Overall Assessment of Dams
- Dam Rehab Alternatives Analysis and Selection
- Dam Rehab Final Design
- Site-Specific Issue: Assessment and Repair
- Special Studies: Development of Utility Penetration Guidelines for District Dams
How is FMEA Different?

Requires a focused and concerted effort by a qualified team to “investigate” all background material for potential failure modes and failure scenario clues.

Goes beyond the traditional means for assessing the safety of a dam by intentionally and systematically seeking input on “non-standard” potential failure modes from a diverse team of individuals.
Recurrent Dam Safety
Dam Safety Inspections

Inspection Types:
• Quarterly Inspections
• Semi-Annual Inspections
• Annual Inspections
• Formal Inspections
• Inspections During and Post Significant Storm Events
Pre-Inspection Records Review

- Previous Inspection Reports & Crack Logs
- Survey Data
- As Built
- Old Construction Reports
- Instrumentation Data
- Developments occurring after previous annual inspections such as ROW activities, storms, maintenance activities, investigations, etc.
- Aerial Maps
Inspection Coverage

- Crest
- Upstream Slope/Toe
- Downstream Slope/Toe
- Appurtenant Structures - dikes, outlet works, drains, and emergency spillway

New River Dam
**FLOOD CONTROL DISTRICT OF ANDROPAWA COUNTY - DAM SAFETY EMBANKMENT DAM INSPECTION CHECKLIST (REPORT)**

Each item of the checklist should be completed. Repair is required when obvious problems are observed. Monitoring is recommended if there is a potential for a problem to occur in the future. Investigation is necessary if the reason for the observed problem is uncertain.

A brief description should be made of any noted condition, needed maintenance, or problems. Abbreviations and short descriptions are recommended. Additional details may be provided on Other and Additional comments.

| ADVANCED NO. | CRITICAL | MONITOR | MAINTENANCE | REPAIR | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---------------|----------|---------|-------------|--------|---|---|---|---|---|---|---|---|----|
| 8100          | 2405     |         |             |        | 130 | | | | | | | | | |
| HILLWAY DESIGN CREST ELEVATION: 168.9 ft | HILLWAY DESIGN WIDTH: 56 ft | ADWRA DAM HEIGHT: 14 ft | |
| BIVALVE DESIGN FLOOD: 32 ft | BIVALVE DESIGN WIDTH: 156 ft | ADWRA DAM WIDTH: 14 ft | |
| CURRENT STORE LEVEL: 130.3 ft | TOTAL DESIGN DETROIT: 86 ft | PHOTOS: YES | |

1. **DESIGN**
   - Total design height = 25 ft. Lengths = 11,678 ft. (Ex. 25 ft 2.3% / 25 ft 2.4%)
   - Safety factor design = 3.02. Maximum storage capacity = 7234.4 ft3 (7234.4 ft3)
   - Dam related costs in 1980 included the installation of a new filter, a new dam license, and new survey costs.
   - 1. Settlement, soils, depressions, erosion
      - 1. Settlement
      - 2. Soils
      - 3. Depressions
      - 4. Erosion
      | 5. Inspection

2. **UPSTREAM SLOPE**
   - 1. Erosion
   - 2. Inundation erosion
      | 3. Erosion
      | 4. Inundation erosion
      | 5. Erosion
      | 6. Inundation erosion
      | 7. Erosion
      | 8. Erosion
      | 9. Erosion
      | 10. Erosion

3. **DOWNSTREAM SLOPE**
   - 1. Erosion
   - 2. Inundation erosion
   - 3. Erosion
   - 4. Erosion
   - 5. Erosion
   - 6. Erosion
Recurrent Dam Safety
Video Inspection of Outlets
Recurrent Dam Safety
Dam Surveys
Recurrent Dam Safety Activities

Earth Fissure and Land Subsidence Monitoring

- McMicken Dam
- White Tanks FRS#3
- Powerline FRS
Recurrent Dam Safety

Emergency Action Plans

- Significant Flood Events and Related Emergency Conditions
- Define Agency Responsibilities
- Inundation Mapping
- EAP Updates
McMicken Dam Breach Inundation
Emergency Action Plans

Emergency Spillway Discharge Inundation Mapping

SIGNAL BUTTE FRS Inundation Area with Emergency Spillway at 1/3 Capacity Approx. 3,700 cfs
Notification
Flow Chart

Maricopa County Department of Emergency Management

Continue monitoring conditions

Pool at 50% (10.0 ft)?
Yes
No
Yes, notify the above agencies

Another emergency or adverse conditions?
Yes
No

Other emergency or adverse conditions?
Yes
No

Activate EOC
First Priority Notify: Goodyear, MCMWCD, RID, BWCD, Perryville Prison, NWS, MCDOT, MCSO, DPS, Rural Metro, ADOT, ADWR, UPRR, & Schools

Pool at 90% (14.7 ft)?
Yes
No
Yes, notify the above agencies

Second Priority Notify: NRCS, Red Cross, and ADEM

Pool at 100% (15.7 ft)?
Yes
No

See Flow Chart 2 – Gated Principal Spillway Discharges

Storm subsides and threat has ended?
Yes
No

Contact information is found in the MCDEM RED Book.

See Also:
Flow Chart 2 – Gated Principal Spillway Discharges
Flow Chart 3 – Emergency Spillway Discharge Inundation
Flow Chart 4 – Dam Failure Inundation

Examples: HazMat spill upstream of reservoir; blocked principal or emergency spillway, equipment failure, boggy areas, rapid increase or cloudiness of seepage.
Dam Rehabilitation/Modification Projects Completed and Ongoing

- Spook Hill FRS Rehab – Completed 2008
- White Tanks FRS No.3 Rehab – Completed 2011
- Buckeye FRS No.1 Rehab
- White Tanks FRS No.4 Rehab
- Vineyard Road FRS Rehab
- Powerline FRS – Replace Dam with Channel
- McMicken Dam Rehab
- Cave Buttes Dam Modifications
McMicken Dam
Project Background

Dam Safety Issues

- Land Subsidence
- Earth Fissures
- Embankment Cracking
- Foundation
- Outlets
- Emergency Spillway
Earth fissures originally identified in 1982 were found to be threatening the dam in 2002.
Structures Assessment and Repairs
McMicken Dam Earth Fissures Investigations
Earth Fissure

- Are tension cracks that result from land subsidence commonly caused by ground water withdrawal.
CRACK RELATED FAILURE MODE

HYDRAULICS OF FLOW: ASSUMPTION A&B:

- Erosion of Holocene soils by downward seepage into fissure creating gully extending beneath upstream slope
- Cracking and large deformations of upstream slope
- Lateral seepage erosion of embankment - Holocene soil interface to downstream toe

Random Earthfill

Geomembrane

Drain Rock
K = 3-30 cns

Geotextile Filter

Erosion gully created by seepage into fissure

Migration of erosion gully beneath dam

Trench Backfill, Native Soils

Strongly Cemented Late Pleistocene Alluvium

1356' Emergency spillway crest elevation

[Diagram details]
Picacho Dam Failure - Jan. 1955
Hazard Risk Zoning

**High Hazard (Sta. 56+00 to 75+00)** - Distinct possibility that earth fissures are present in the alluvial foundation soils under the dam in this zone.

**Moderate Hazard (Sta. 75+00 to 105+00)** - Probability of an open fissure present in close proximity to the base of the embankment is low, but continued strain could produce future fissuring to the surface along photo-lineaments.
Structures Assessment and Repairs
McMicken Dam Earth Fissure Risk Zone Remediation Project

South End of McMicken Dam
PVR Dams: Earth Fissure At Powerline FRS
Structures Assessments and Repairs

Earth Fissure Investigations – Powerline FRS
Powerline Earth Fissure
Powerline FRS  Fissure Risk Zone Mitigation Project
Earth Fissure Risk Zones
Powerline FRS IDSM
Construction Completed 2014
White Tanks FRS No. 3 Remediation Project

- Earthfill flood control dam
- Constructed by SCS (NRCS) 1954, modified in 1981
- NRCS Federal Project Sponsor
- Operated/Maintained by District – Local Sponsor
- ADWR is jurisdictional agency
- Crest length is 7,700 Feet
- Structural height is 29’
- Dam Safety Issues
White Tanks FRS No. 3 FRS Remediation Project

Dam Safety Issues

- Subsidence
- Earth fissure risk zone
- Foundation
- Embankment cracking
- Outlets
- Emergency spillway

White Tanks FRS No.3  2004
Two Construction Phases

Phase 1 Construction
- Plug and Abandon Existing CMP Outlets
- New Principal Outlet Structures to Replace CMP’s
- Soil Cement Embankment Section and Cutoff Walls in South Fissure Risk Zone

Phase 2 Construction
- New Emergency Spillway Structure
- Non-fissure Risk Zone Embankment
White Tanks FRS No. 3 Phase I Construction

Soil Cement Embankment  Cutoff Walls
White Tanks FRS No. 3 Phase II

Embankment

Emergency Spillway
Construction
Completed White Tanks FRS#3 Rehab Project
Spook Hill FRS

- Earthfill Flood Retarding Structure (FRS)
- Provides 100-year Flood Protection
- Controls PMF
- 4.1 Miles Long
- 23 Feet High
- 11.4 Square Mile Drainage Area
- High Hazard
Spook Hill FRS

Embankment Cracking

**Category I Failure Mode:**  
Potential dam failure due to internal erosion along a transverse crack through the embankment or through hydraulically connected cracks.

**Category II Failure Mode:**  
Potential dam failure due to piping along base of the dam.
Spook Hill FRS

Principal Spillway Outlet

Category II Failure Mode:
Potential Dam Failure Due To Seepage Erosion Around Principal Spillway Outlet
Spook Hill FRS
New Principal Outlet Construction
Spook Hill FRS
Central Filter Construction
Dam Rehabilitation

Spook Hill FRS Rehabilitation & Loop 202L Red Mountain Freeway
White Tanks FRS No. 4 Rehabilitation Project

Background

Earthfill Flood Retarding Structure (FRS)

Constructed by SCS (NRCS) 1954 and Modified in 1982

Operated & Maintained by FCDMC

ADWR is Regulatory Agency

Crest Length is 1.3 miles

Height is 20 ft.
WHITE TANKS FRS NO.4
Dam Rehabilitation

New Central Filter
Raise Dam to Accommodate Inflow Design Flood
Modify Emergency Spillway for Increased Flow Capacity and Erosion Protection
New Principal Outlet System
Earthwork in Impoundment Area
Include Opportunities for Multi-Use
Phase I
Remove and Replace Central Filter
Buckeye FRS No.1 Rehabilitation Project

**Background**

- Earthfill Flood Retarding Structure (FRS)
- Constructed by SCS (NRCS) 1974 and Modified in 1980
- Operated & Maintained by FCDMC
- ADWR is Regulatory Agency
- Crest Length is 7.1 miles
- Height is 26 ft.
Buckeye FRS No.1 Rehab Project
Buckeye FRS No.1  New Central Filter
Area Protected by PVR Structures
Powerline FRS, Vineyard Road FRS, Rittenhouse FRS

Dam Safety Issues:
• Embankments: Cracking
• Foundations: Erosive Soils, Collapsible Soils
• Emergency Spillways: Capacity, Erosive Soils
• Subsidence, Earth Fissures
• Outlets: Potential for seepage

Projects:
• Replace Powerline FRS with Channel
• Rehabilitate Vineyard FRS
• Rehabilitate Rittenhouse FRS
McMicken Dam
Project Background

- Constructed by Corps in 1955
- Original function was to protect Luke AFB & agricultural lands
- Provides 100-year flood protection
- Crest length is 10 miles
- Central filter added in 1985
- Total watershed area 250 square miles
- Operated and maintained by District
- ADWR is jurisdictional agency
McMicken Dam
Project Background

Dam Safety Issues
Land Subsidence
Earth Fissures
Embankment Cracking
Foundation
Outlets
Emergency Spillway
Area Protected by McMicken Dam
Luke Air Force Base and Goodyear
August 1951 (7.3”-24hr., 13.6” total storm)
McMicken Dam Rehabilitation Project

Embankment with Moderate Risk of Earth Fissures

Embankment with Little to No Risk of Earth Fissures
Cuve Buttes Dam Project, 19 May, 2010

Photo 1-26-10 Cave Buttes and Cave Creek Dams
CAVE BUTTES DAM Modifications

Background

Earthfill dam 2275 ft long at crest with 3 dikes (FRS)

Maximum Height is 110 ft

Constructed by USACE in 1980

Storage Capacity is approximately 86,000 ac-ft.

Operated & Maintained by FCDMC

ADWR is Regulatory Agency

Cave Buttes Dam and Dikes 1 and 2.
Wildlife at FCDMC Dams
O&Ms Snake Safety Plan
Questions?

Deer at McMicken Dam