Fern Ridge Lake Hydrologic Aspects of Operation during Failure

Presented by Bruce J Duffe, PE

CENWP-EC-HY

03 August 2005
St Louis, MO

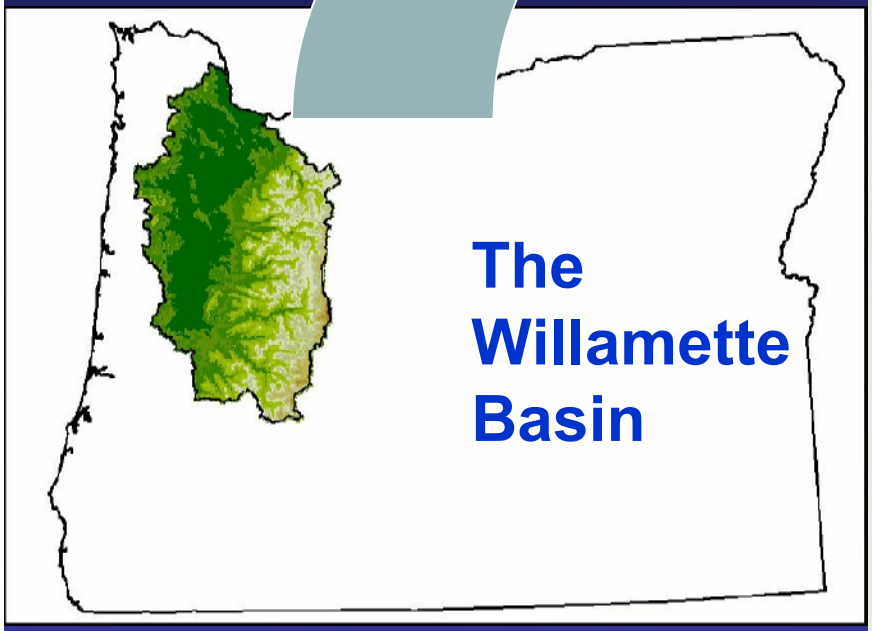
Fern Ridge Lake

- Oldest Corps Dam in the Willamette Basin
  - Completed in 1942
  - Raised in 1965
- Multipurpose Project; uses shared storage
- Current Authorized Uses:
  - Flood Control, Irrigation, Low Flow Regulation
- Regular Periodic Inspections – drainage problems noted
- Standard maintenance requirements (old)

Fern Ridge Lake

- Dam Safety General Issues
  - Seismic Deficiency
  - Hydrologic Deficiency
  - Embankment Drain Failure
- Follow the Time Line of the Failure
  - July 2002 to Present
- General information; hitting high points

Fern Ridge Lake



Fern Ridge Lake

- **Watershed (square miles)** 275
- **Crest Elevation (ft)** 381.5
- **Crest Length (ft)** 6,610
- **Reservoir Pool (acre-ft)**
  - Max FC Pool Storage, EL 375.1 111,400
  - Max Conservation Storage, EL 373.5 97,300
  - Inactive Storage, EL 353.0 2,800
- **Spillway**
  - Six 34’ wide x 18’ high Tainter Gates EL 358.5
  - Maximum Discharge (ft^3/s) 47,200
- **Outlet**
  - Four 6.75’ x 9.75’ Sliding Gates
  - One 3’ x 3’ Sluice Gate
  - Design Discharge at Max FC Pool (ft^3/s) 8,440

Fern Ridge Dam and Reservoir

Outlet Works

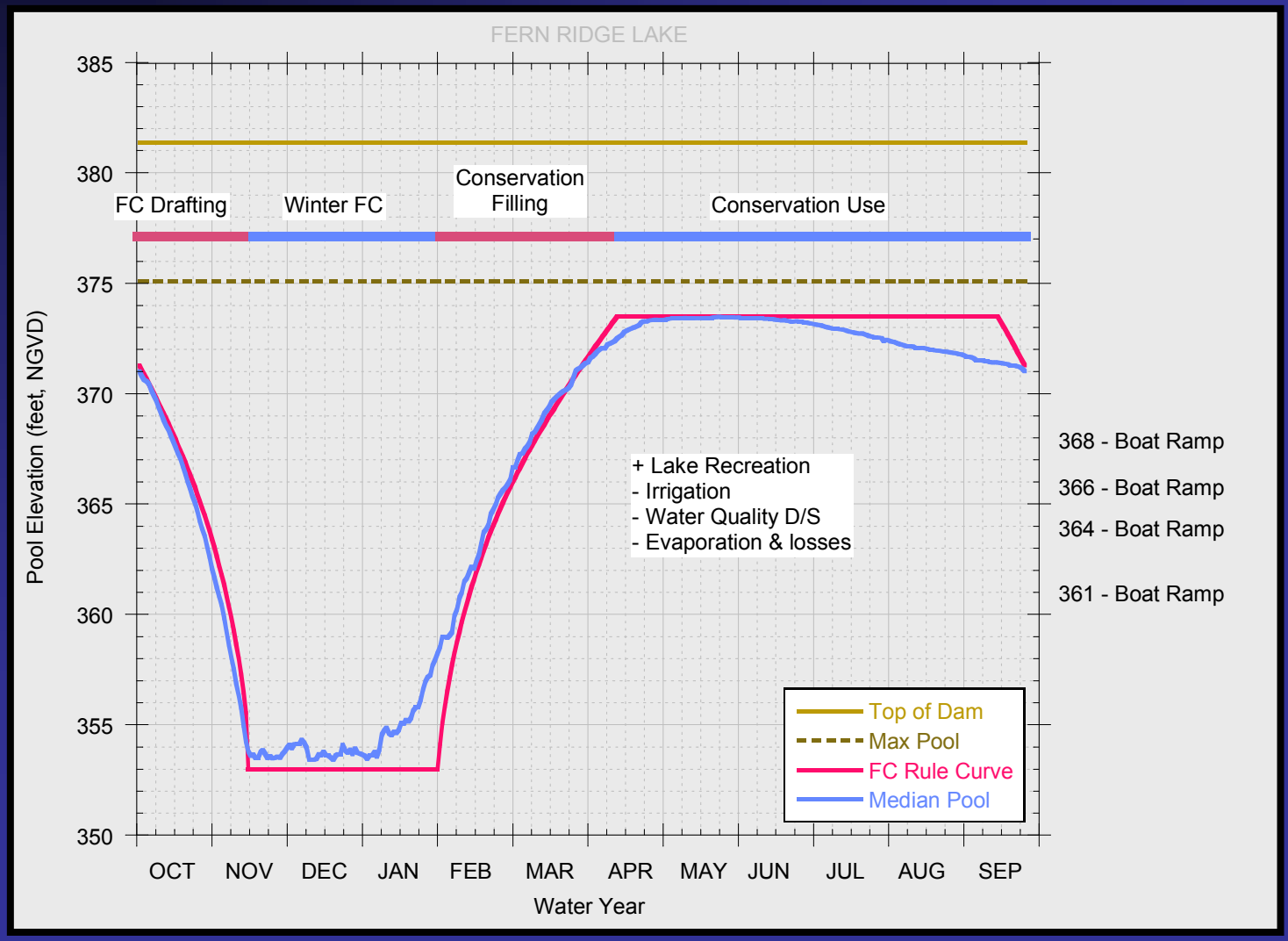
Project Overview

Looking east along upstream face of spillway towards right wing wall

Project Overview

Tailrace from right bridge abutment (230 cfs)

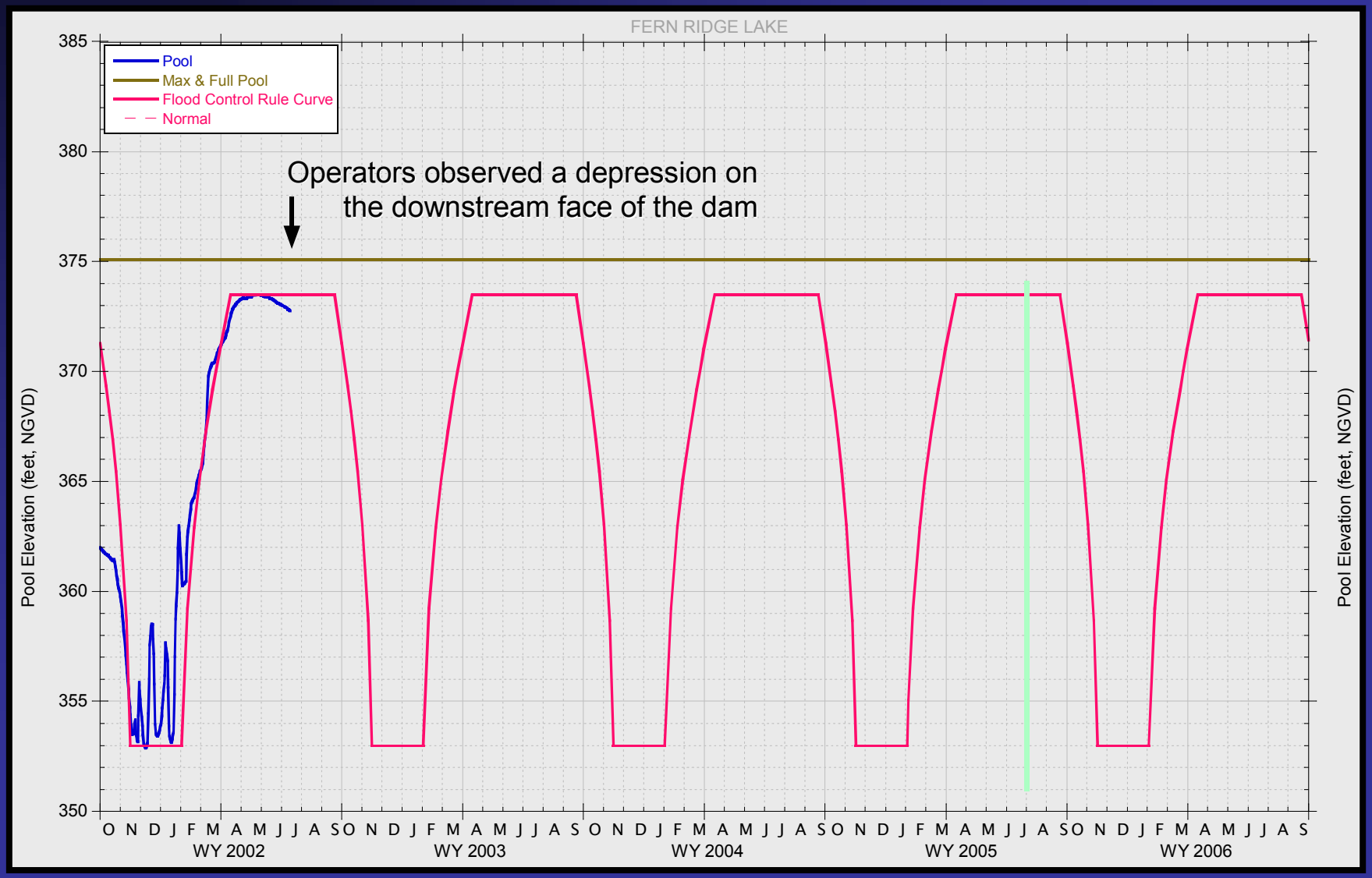
Typical Operation



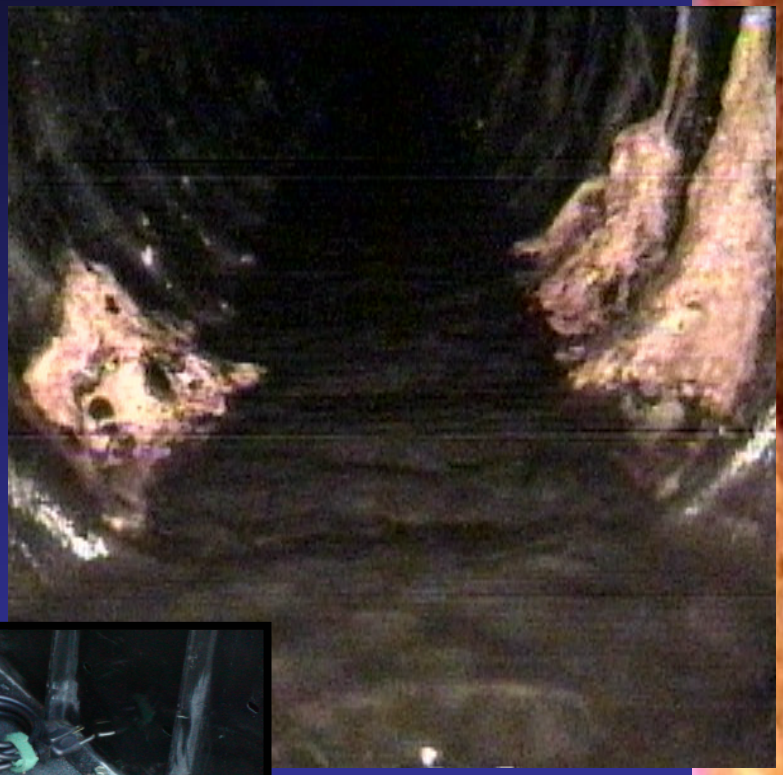
July 2002 – The Start

- All had been well…
- Embankment Depression
  - Spotted by Maintenance Crew
  - First real indication
- No recent abnormal flows or operations

July 2002

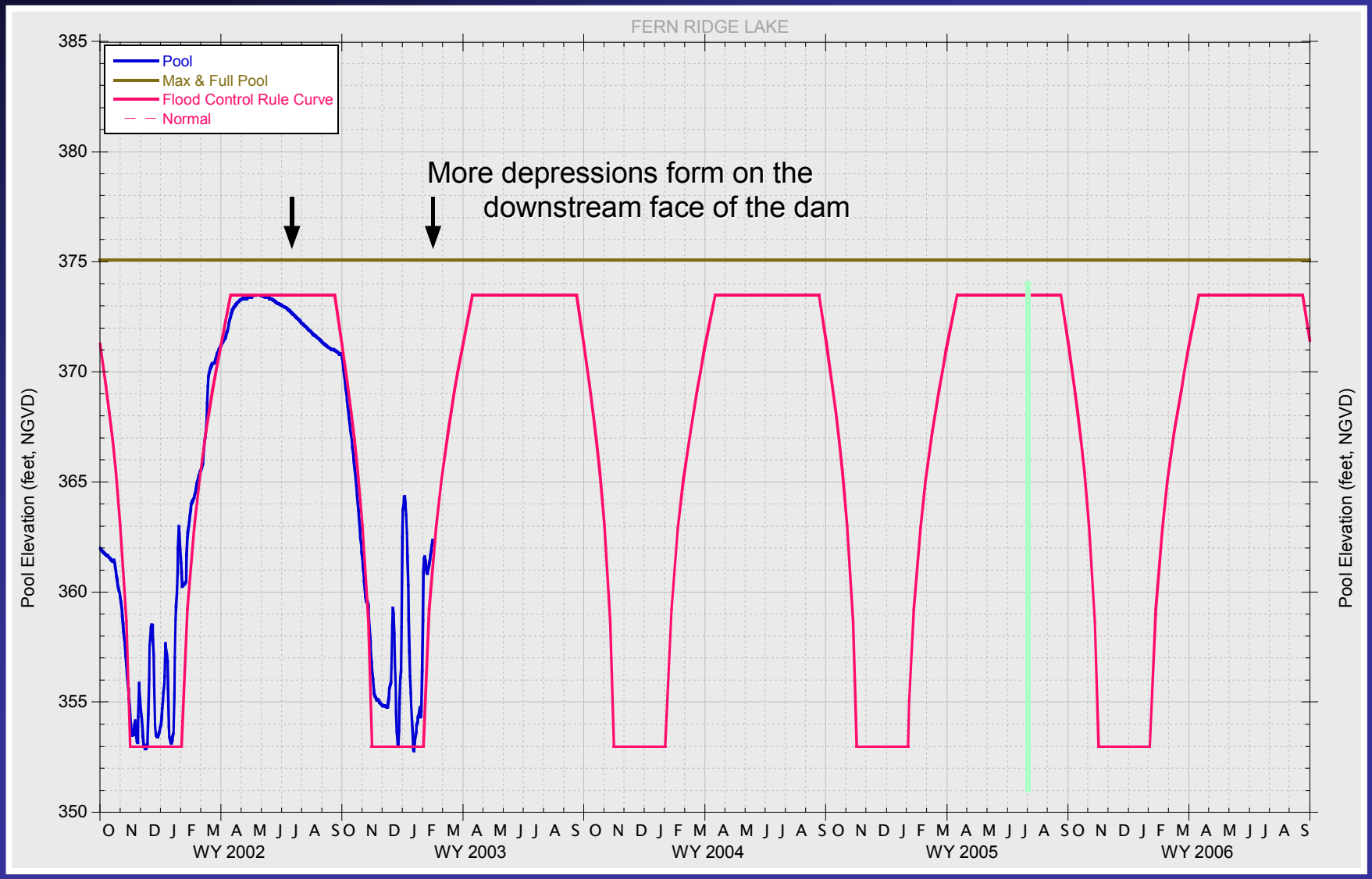

FERN RIDGE LAKE
Pool
Max & Full Pool
Flood Control Rule Curve
Normal
Operators observed a depression on the downstream face of the dam
Pool Elevation (feet, NGVD)
385
380
375
370
365
360
355
350
O N D J F M A M J J A SO N D J F M A M J J A S O N D J F M A M J J A SO N D J F M A M J J A SO N D J F M A M J J A S
WY 2002
WY 2003
WY 2004
WY 2005
WY 2006

Calcification Inside Drain

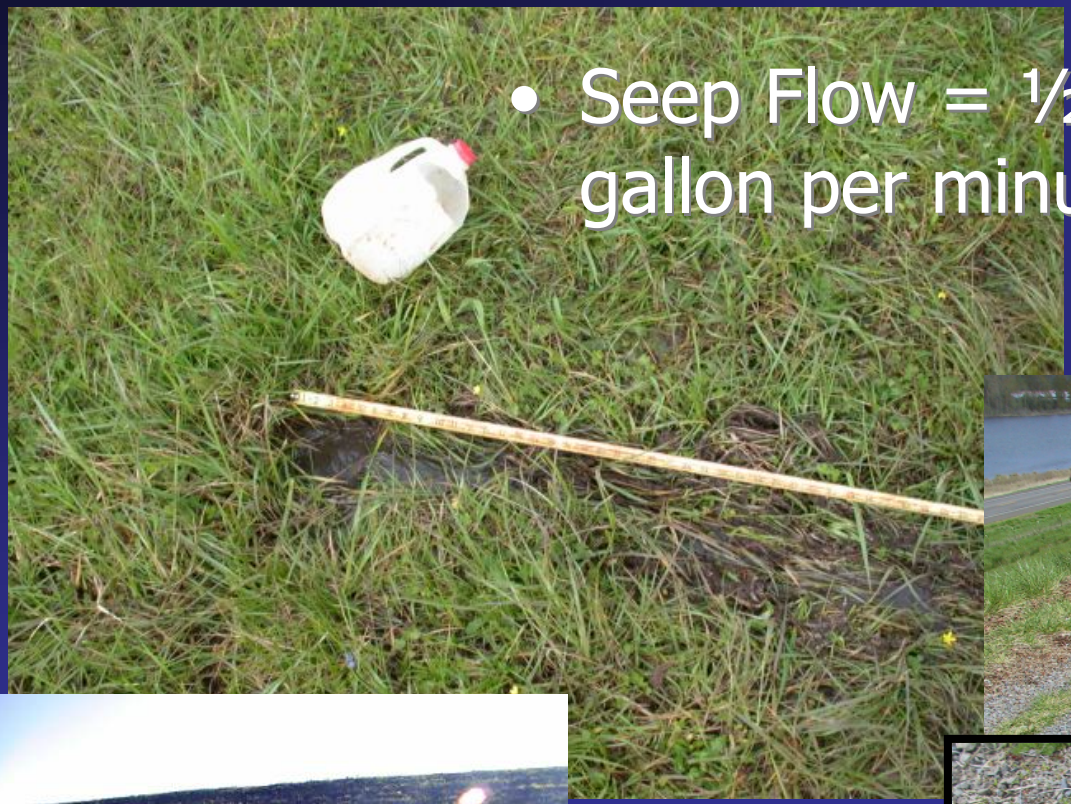


- Video Inspection Rover

February 2003 - Conundrum



Seeps & Sinks

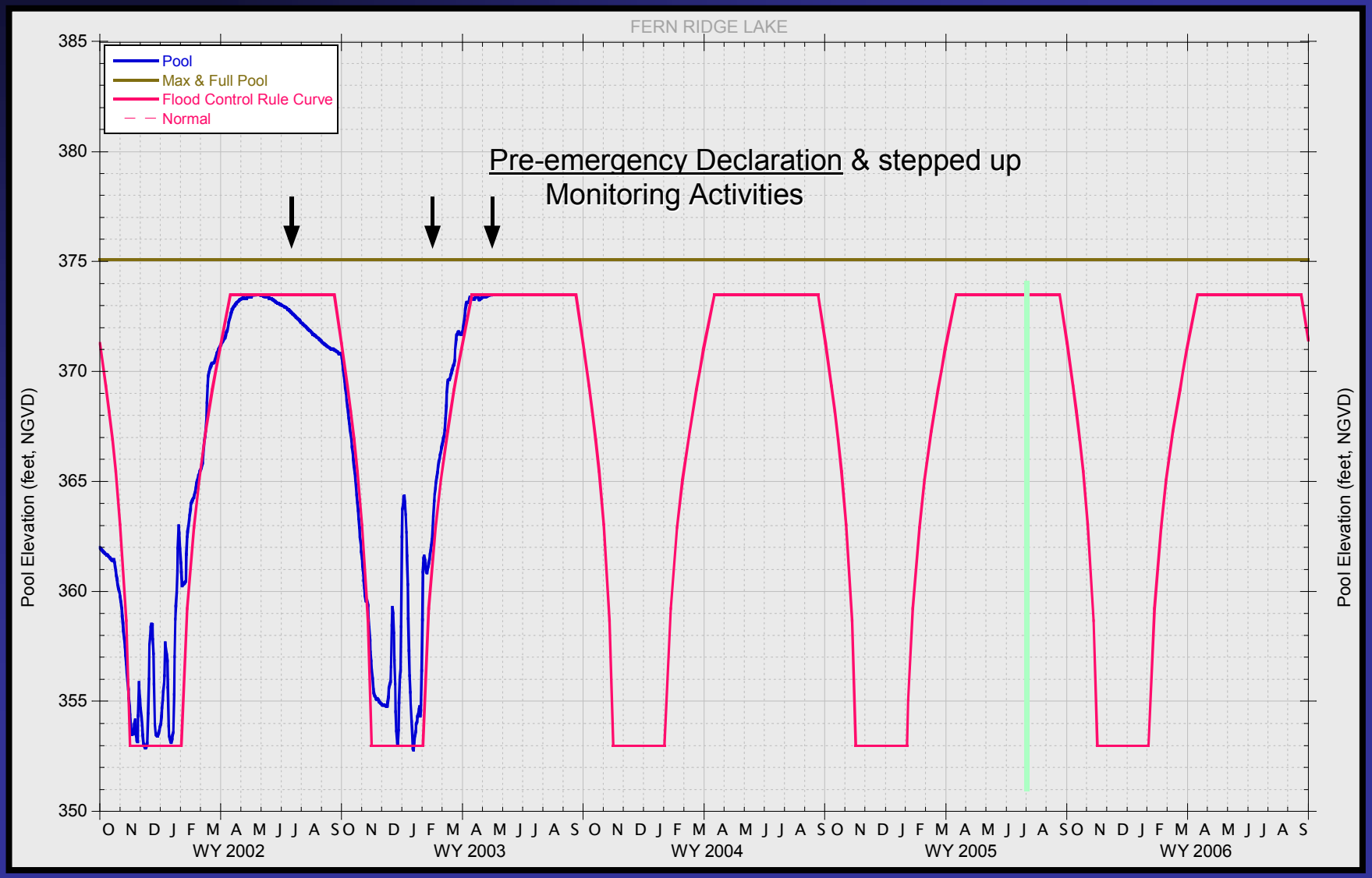


- Seep Flow = ½ gallon per minute

February 2003

Drain System

May 2003


FERN RIDGE LAKE
Pool
Max & Full Pool
Flood Control Rule Curve
Normal
Pre-emergency Declaration & stepped up
Monitoring Activities
Pool Elevation (feet, NGVD)
385
380
375
370
365
360
355
350
O N D J F M A M J J A SO N D J F M A M J J A S O N D J F M A M J J A SO N D J F M A M J J A SO N D J F M A M J J A S
WY 2002
WY 2003
WY 2004
WY 2005
WY 2006

Monitoring

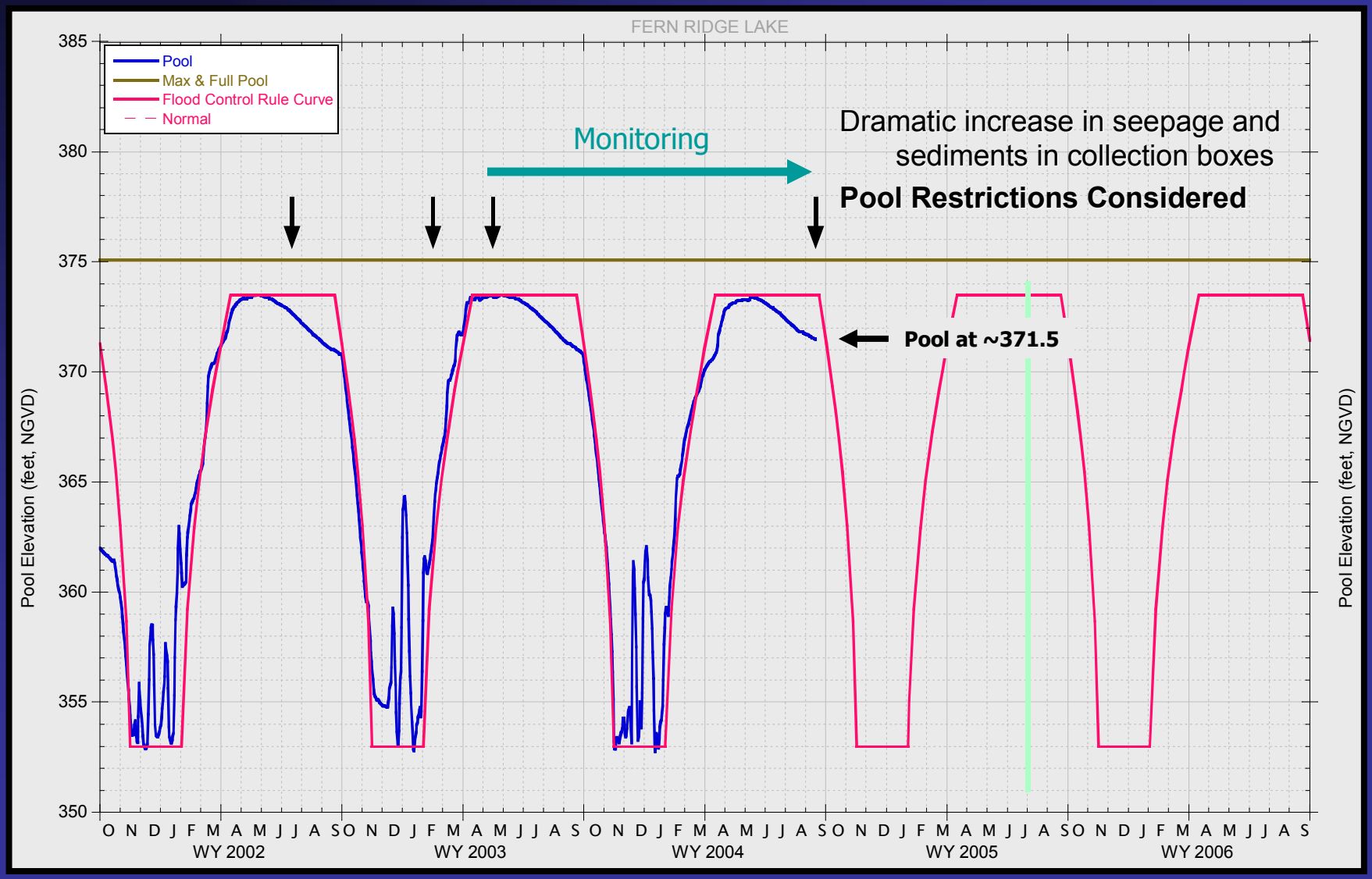
- June 2003 – August 2004
  - Started gathering operational and hydrologic information
  - Field investigation (drilling, sampling, lab work); redoubled monitoring; sediment sampling; automation of equipment completed sprinkler test, test pits; etc.
  - Looked for funding methods/support
- No big changes until August
  - Dramatic increases in drainage discharge & sediment accumulation in weir boxes

August 2004

Debris collected from Station 22+00

Sediment accumulated in Station 45+00 weir box

Monitoring - May 03…Aug 04

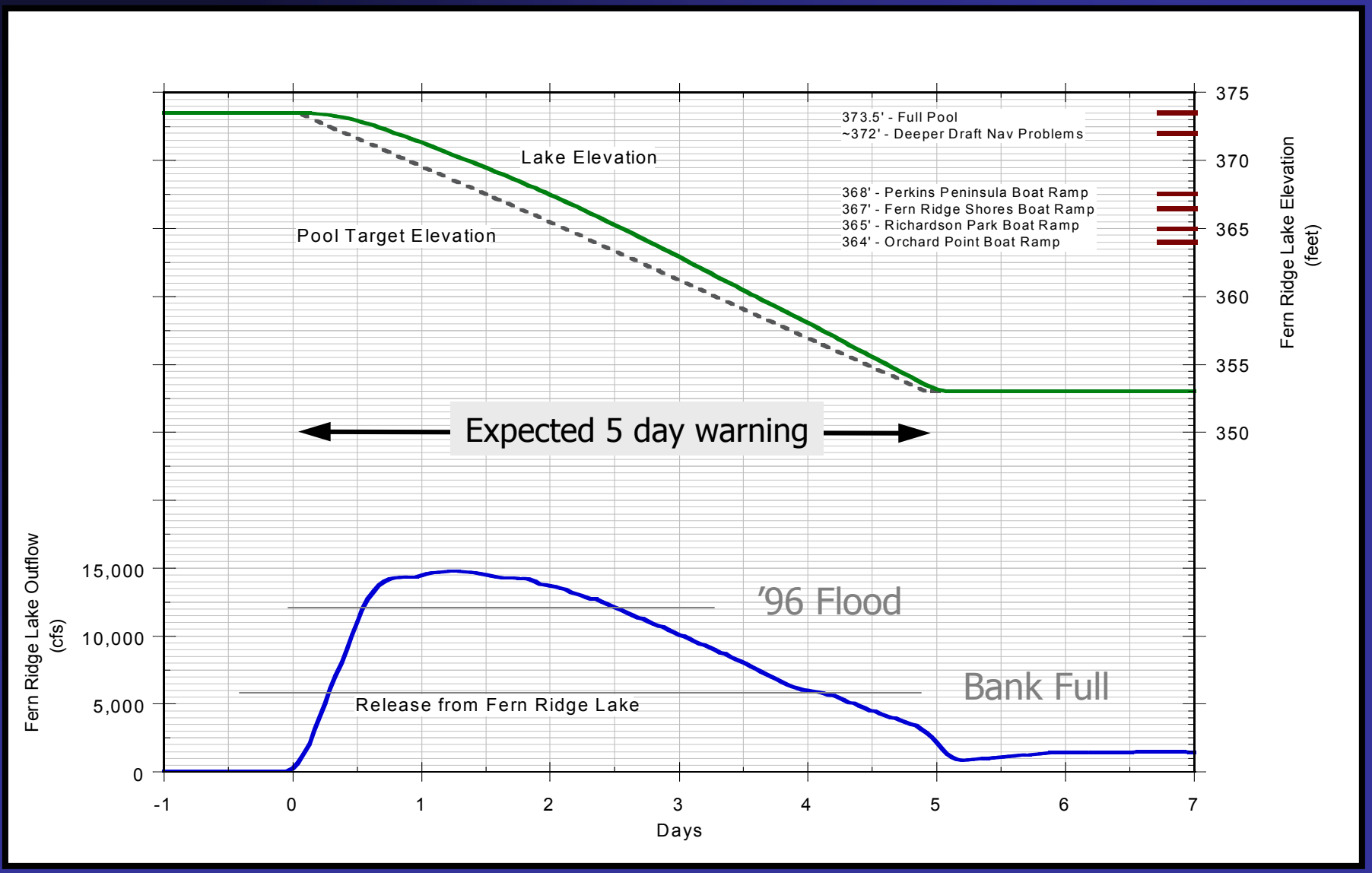


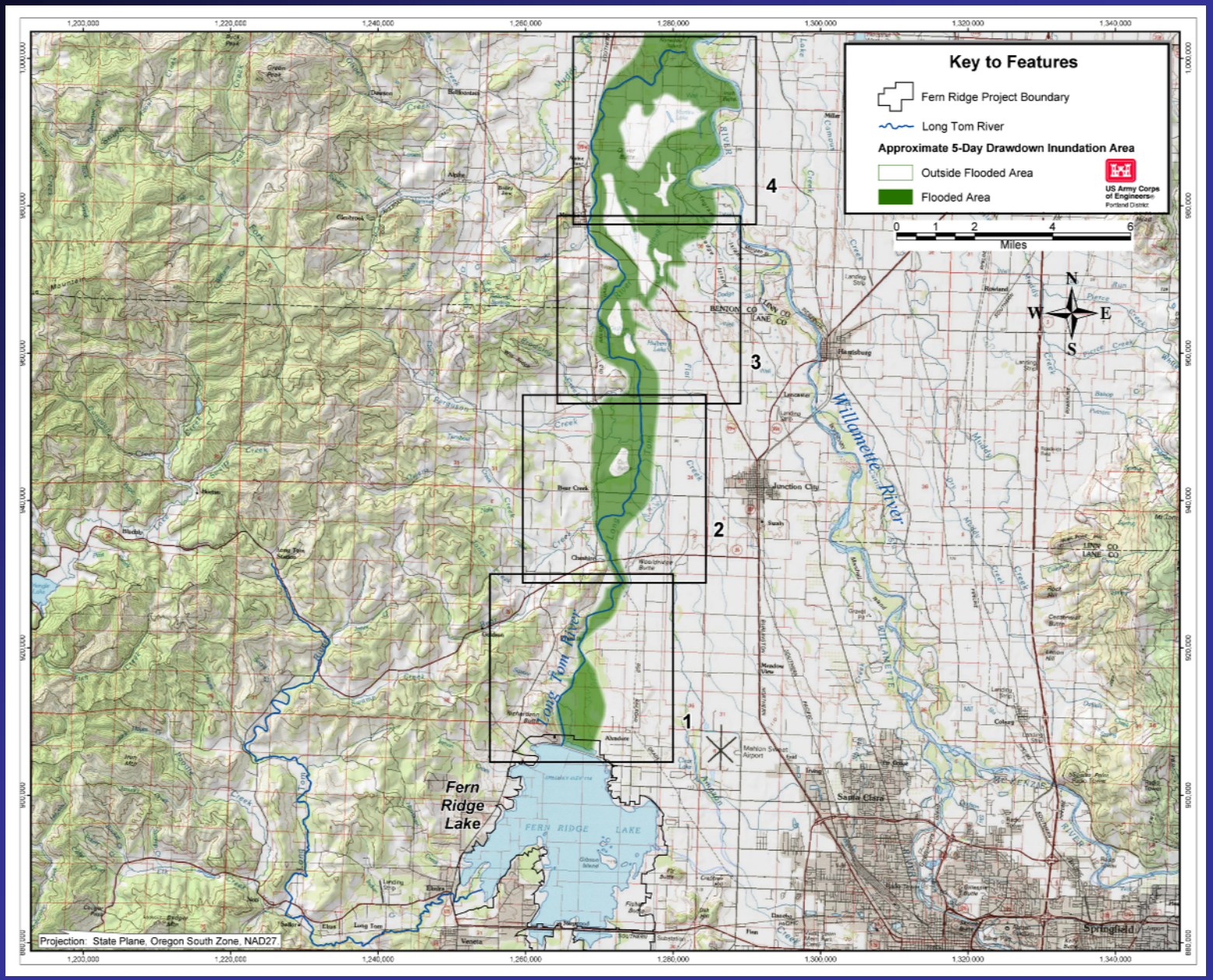
NWP Proposed Restriction

- In effect from 1 October to 1 May
- Maximum pool to be 371 ft
- Does Not Eliminate Possible Need for a Rapid Drawdown of the Reservoir

- Small Risk of Additional Flooding (<5%)
- Impacts to Deep Draft Recreational Users (a shorter season)
- Numerous scenarios evaluated

Emergency Drawdown?




Key to Features
Fern Ridge Project Boundary
Long Tom River
Approximate 5-Day Drawdown Inundation Area
Outside Flooded Area
Flooded Area
US Army Corps of Engineers
Portland District
0 1 2 4 6
Miles
N
W
E
S
4
3
2
1
Fern Ridge Lake
Long Tom River
Willamette River
Harrisburg
Junction City
Santa Clara
Springfield
Projection: State Plane, Oregon South Zone, NAD27

Direction

- September/October 2004
  - NWP / NWD / HQ
  - Dam Safety Assurance Study/Funding
  - Hydrologic and Seismic Design Deficiency and Embankment Drain Repair
  - **3 to 5 years to complete**
- Advised a second opinion on conclusions
  - Senior Review Board
  - December 2004

Senior Review Board

- Review Board
  - Francke Walberg (USACE Retired)
  - Keith Ferguson (National Water Resources Program Director, Kleinfelder)
  - James Talbot (Independent)
- Tasks
  - Assess Condition of Structure
  - Recommendations for continued operations
  - Methods for Temporary and Permanent Repairs

December 2004 - Review Board

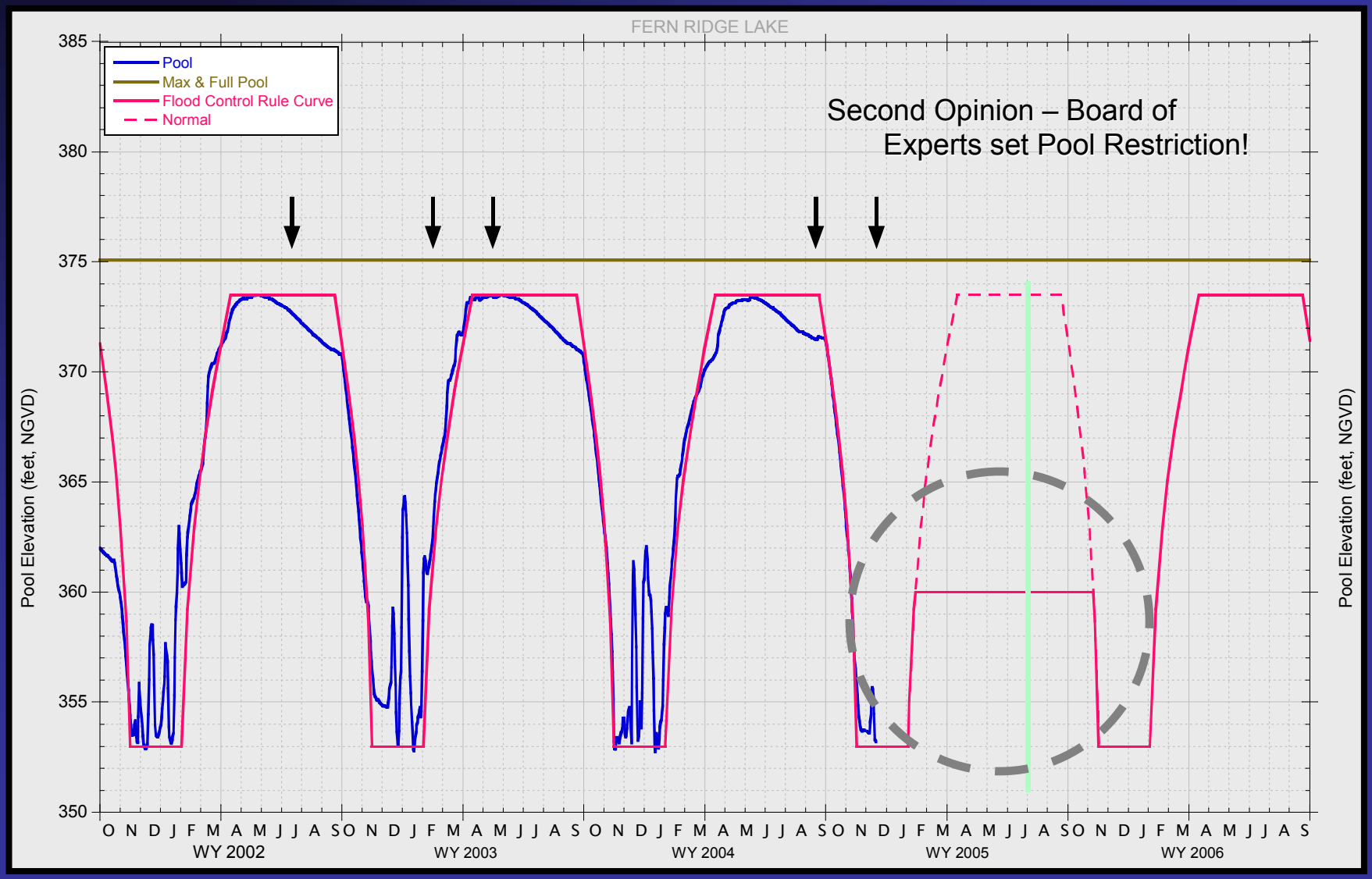
- "Active state of failure by piping and/or internal erosion"
- 20-30% Chance of failure during the next 5 years
- Dam will steadily worsen without a repair even with operational restrictions in place
- And…

Review Board

- Operation restrictions are required
  - Maximum pool height should be reduced by 13.5 feet to elevation 360 feet

- "District's focus should be immediately shifted from investigations and evaluation to development and implementation of corrective actions."

December 2004



Operation under Restriction

- Flood control storage reduced by ~9/10
- Conservation storage reduced by over 4/5
  - Irrigation – unknown
  - Flow augmentation – unknown
- Lake depths – most recreational use eliminated
- $$$ Cost? How many seasons?

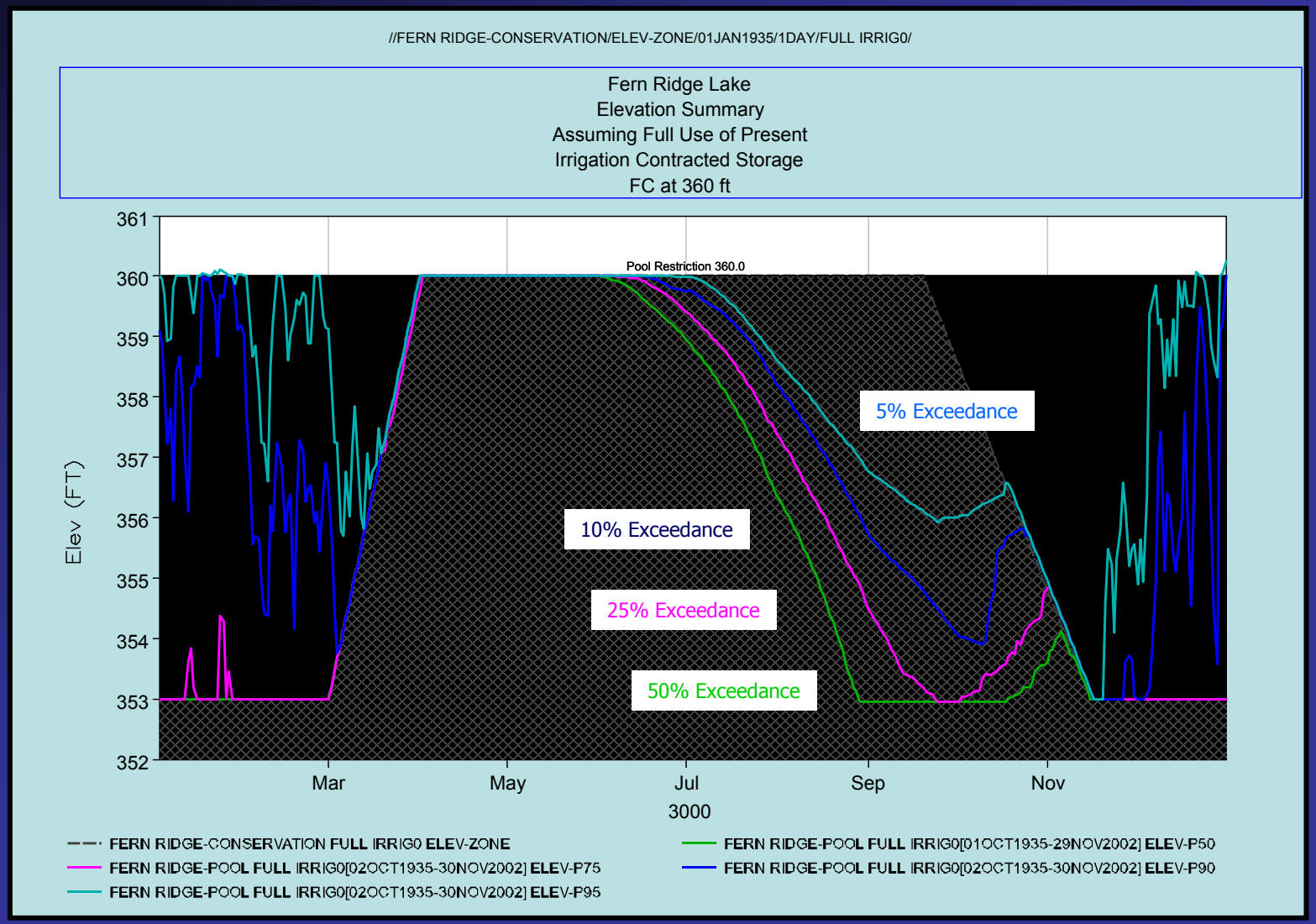
January 2005 - Evaluations

- Jan 2005
- Evaluated Numerous Project Options
  - Impacts to project benefits
- Flood Control
  - New flood control constraints
  - Risk Calculations
- Irrigation
  - Period of Record Irrigation Evaluations
  - Negotiated possible voluntary restraints
- Public Input

Project Benefits

- Flood Control Annual Benefit
  - $400M in damages prevented over life of project
  - $80M in 1996 & Over $40M each in 1997 and 1999
- Irrigation Annual Benefit
  - $1.5M to $2.9M for Agricultural Products
- Recreation Annual Benefit:
  - 600,000 Visitors per year
  - $5M in local benefits and $3.5M in indirect benefits

Irrigation

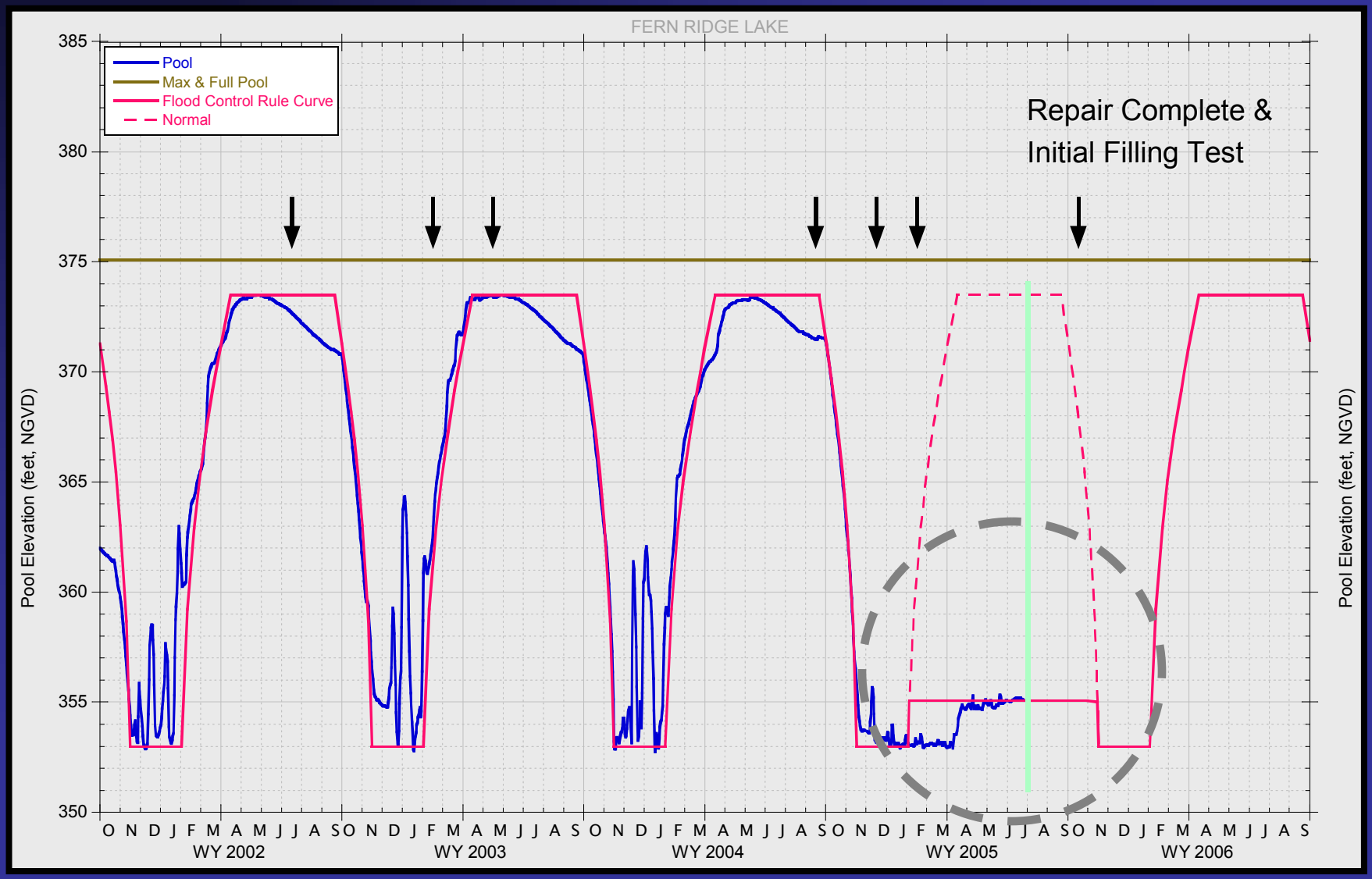

//FERN RIDGE-CONSERVATION/ELEV-ZONE/01JAN1935/1DAY/FULL IRRIG0/
Fern Ridge Lake
Elevation Summary
Assuming Full Use of Present
Irrigation Contracted Storage
FC at 360 ft
Pool Restriction 360.0
5% Exceedance
10% Exceedance
25% Exceedance
50% Exceedance
Elev (FT)
361
360
359
358
357
356
355
354
353
352
Mar
May
Jul
Sep
Nov
3000
FERN RIDGE-CONSERVATION FULL IRRIG0 ELEV-ZONE
FERN RIDGE-POOL FULL IRRIG0[02OCT1935-30NOV2002] ELEV-P75
FERN RIDGE-POOL FULL IRRIG0[02OCT1935-30NOV2002] ELEV-P95
FERN RIDGE-POOL FULL IRRIG0[01OCT1935-29NOV2002] ELEV-P50
FERN RIDGE-POOL FULL IRRIG0[02OCT1935-30NOV2002] ELEV-P90

February 2005 - The Decision

- Vertical Team
  - NWP; NWD; HQ
  - Unanimous decision to proceed with embankment repair

- Design and Award done – May 2005
- Repair complete – October 2005

October 2005

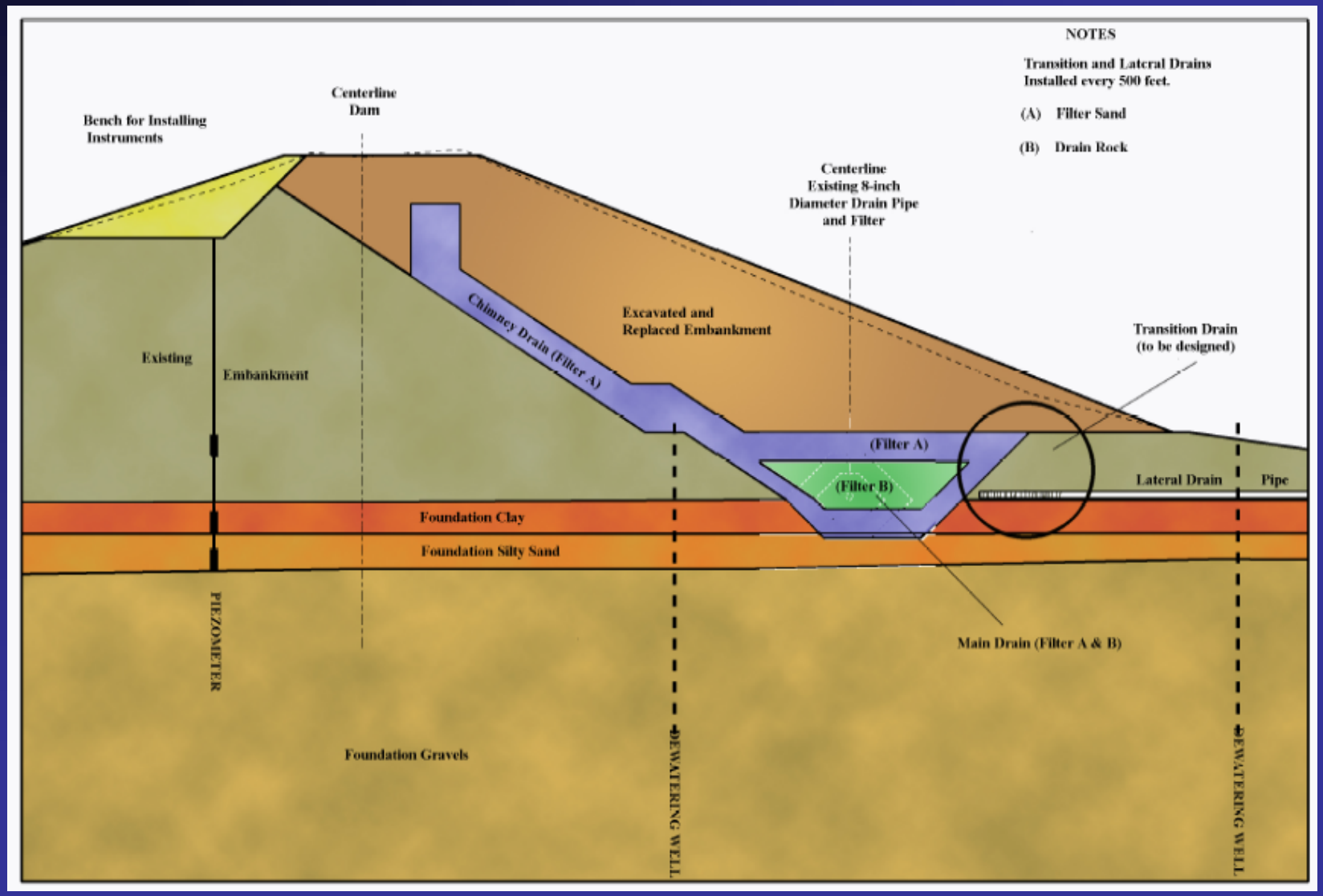


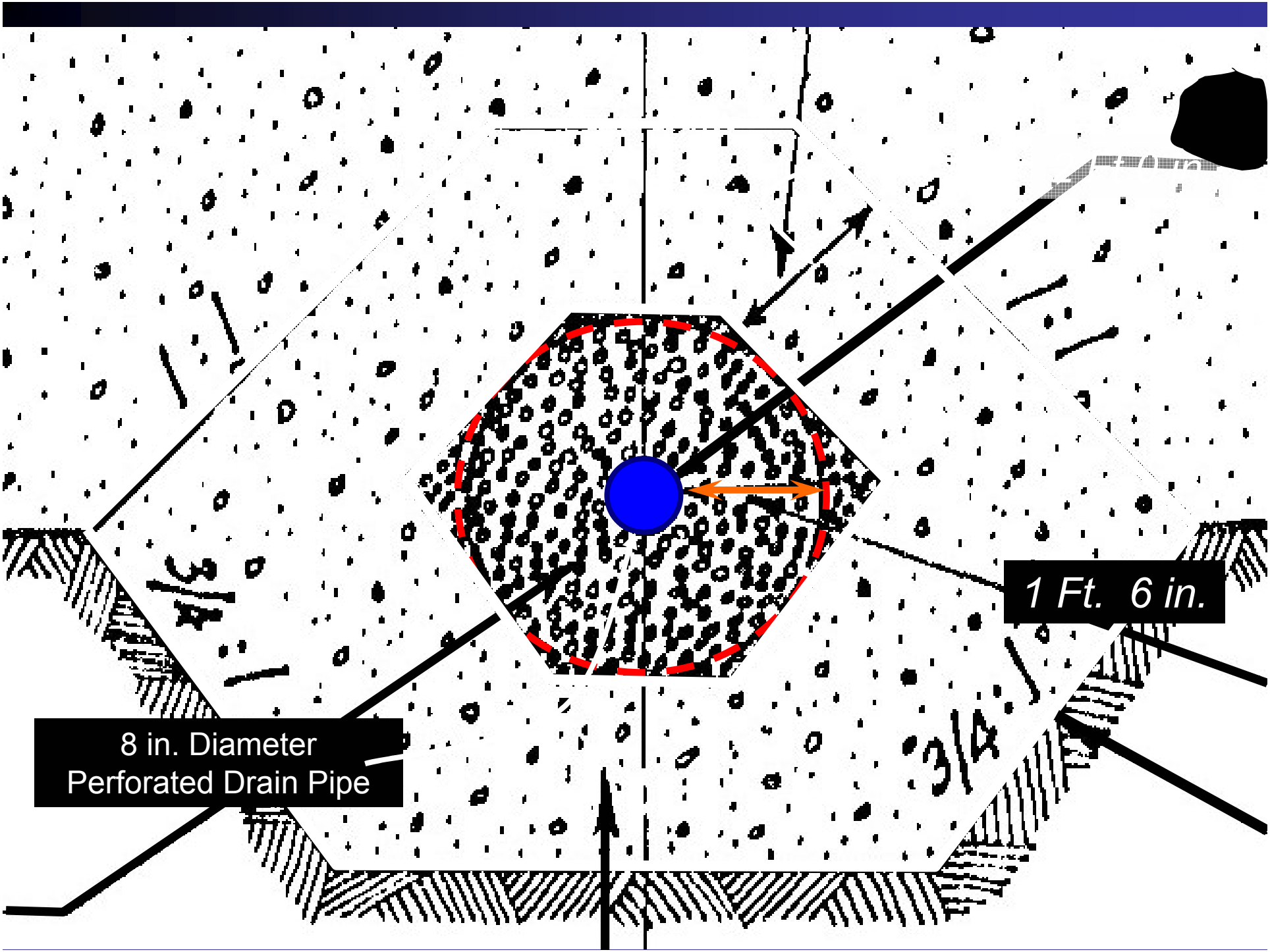
Ongoing Efforts

Ongoing Efforts

Ongoing Efforts

Questions?


NOTES
Transition and Lateral Drains Installed every 500 feet.
(A) Filter Sand
(B) Drain Rock
Centerline Dam
Bench for Installing Instruments
Centerline Existing 8-inch Diameter Drain Pipe and Filter
Chimney Drain (Filter A)
Excavated and Replaced Embankment
Transition Drain (to be designed)
Existing
Embankment
(Filter A)
(Filter B)
Lateral Drain
Pipe
Foundation Clay
Foundation Silty Sand
PIEZOMETER
Main Drain (Filter A & B)
Foundation Gravels
DEWATERING WELL
DEWATERING WELL


1 Ft. 6 in.
8 in. Diameter
Perforated Drain Pipe