# SPILLWAY ADEQUACY ANALYSIS

# OF

# ROUGH RIVER LAKE

# LOUISVILLE DISTRICT

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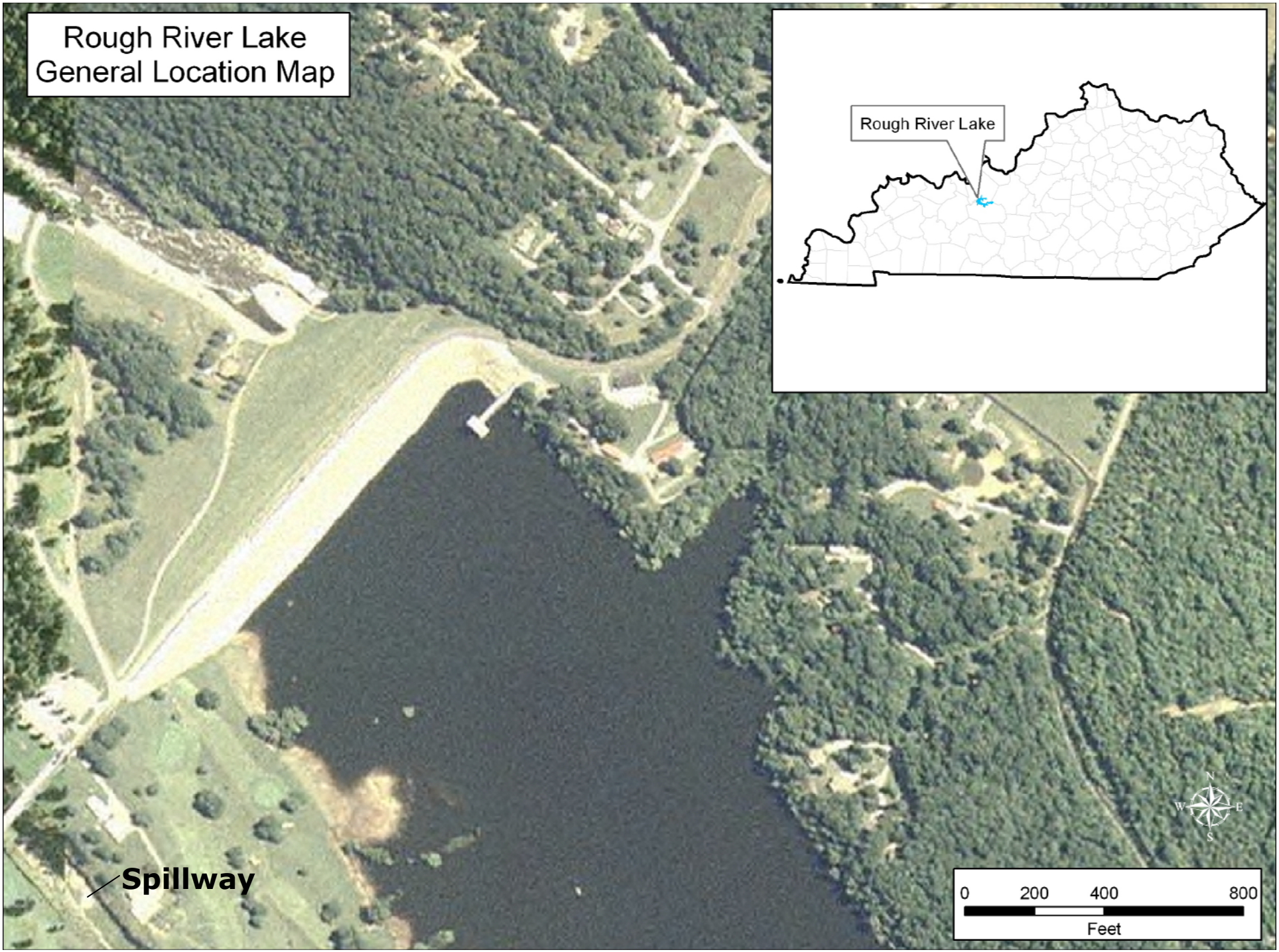

Rough River Lake
General Location Map
Rough River Lake
Spillway
N
W
E
S
0
200
400
800
Feet

# ROUGH RIVER LAKE
# PERTINENT DATA

| | |
|---|---|
| Construction Completed | Sept 1959 |
| Spillway Crest | 524 ft msl |
| Probable Maximum Flood<br>Total Precip in 48 hrs | 27.6 inches |
| Elevation of Pool at Start of flood<br>(routing of 1937 flood) | 503 ft msl |
| Maximum Water Surface Elevation | 549.1 ft msl |
| Top of Dam | 554.0 ft msl |

# Engineering Regulation 1110-8-2(FR)

Inflow Design Floods for Dams and Reservoirs

For Ohio River Basin – Antecedent Flood

30% of PMF w/ 3 Dry Days
or
39% of PMF w/ 5 Dry Days

# Engineering Regulation 1110-2-1155

## Dam Safety Assurance Program

Policy:

Dam Safety Modifications related to Hydrologic Deficiencies should be recommended to meet or exceed the Base Safety Condition (BSC).

The BSC is met when Dam failure will result in no significant increase in loss of life or economic damages compared to without Dam failure.

# GUIDELINES

# for

# EVALUATING MODIFICATIONS OF EXISTING DAMS RELATED TO HYDROLOGIC DEFICIENCIES

OFFICE OF THE CHIEF OF ENGINEERS

U.S. Army Engineer
Institute for Water Resources
IWR Report 86-R-7

September 1986

# EVALUATING MODIFICATIONS OF EXISTING DAMS RELATED TO HYDROLOGIC DEFICIENCIES

SEVENTEEN STEP PHASE

Steps 1-11

- Determine if the existing Dam is Hydrologically deficient based upon the latest IWR guidelines

Steps 12-17

- If these Dams are Hydrologically deficient, focus on the evaluation of alternative measures which can provide the required level of Dam safety.

# Step 1 - Describe the Physical Project Characteristics

a) Summarize and display the physical features of the project

b) Describe the physical features of the project

c) Describe the operations and use of the project

d) Describe the economic development upstream and downstream of the Dam

# Step 2 - Determination of the Existing Threshold Flood

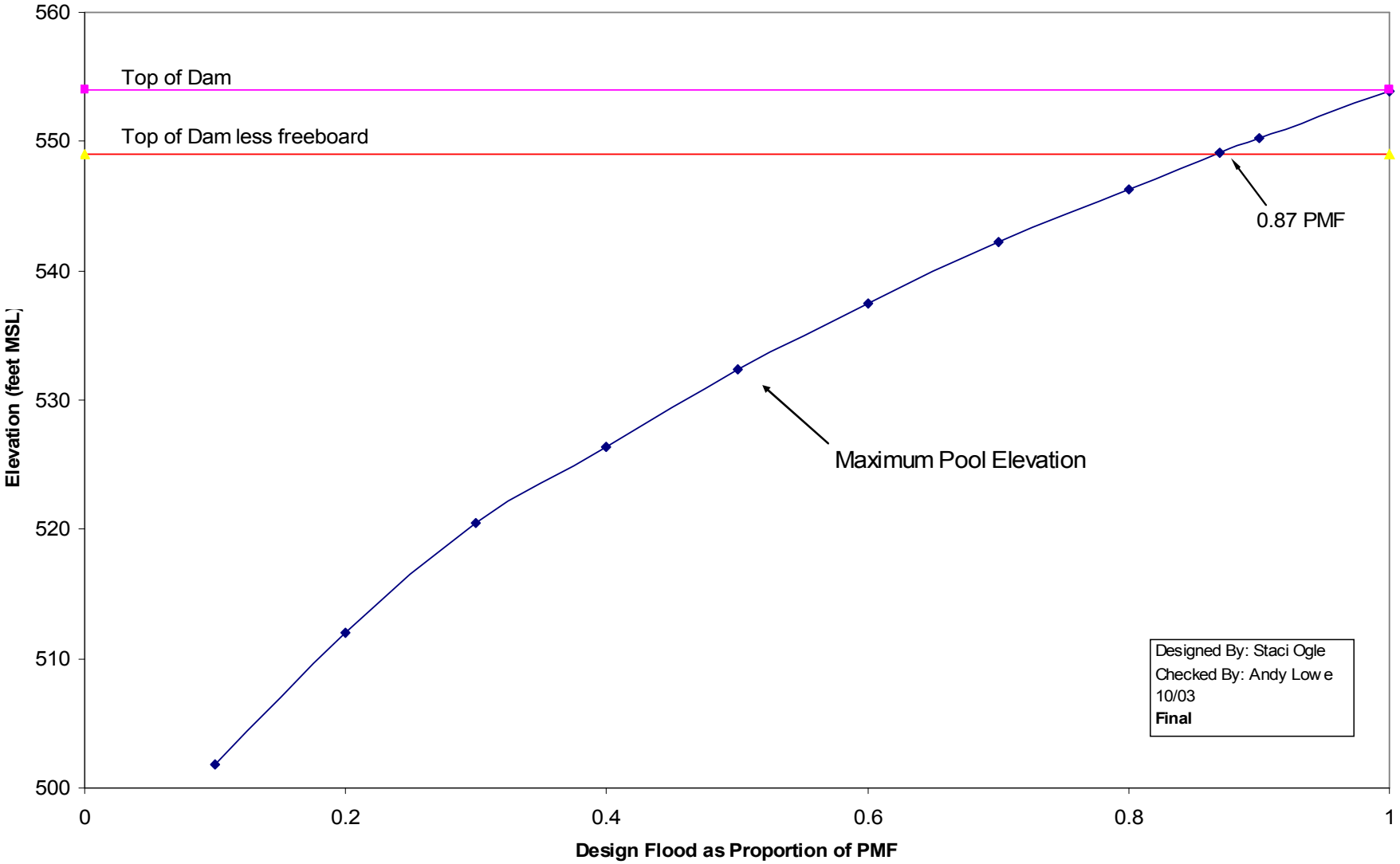
1) The Threshold flood is that flood that results in a peak lake water surface elevation equal to the top of Dam less appropriate freeboard. Expressed as % of the PMF.

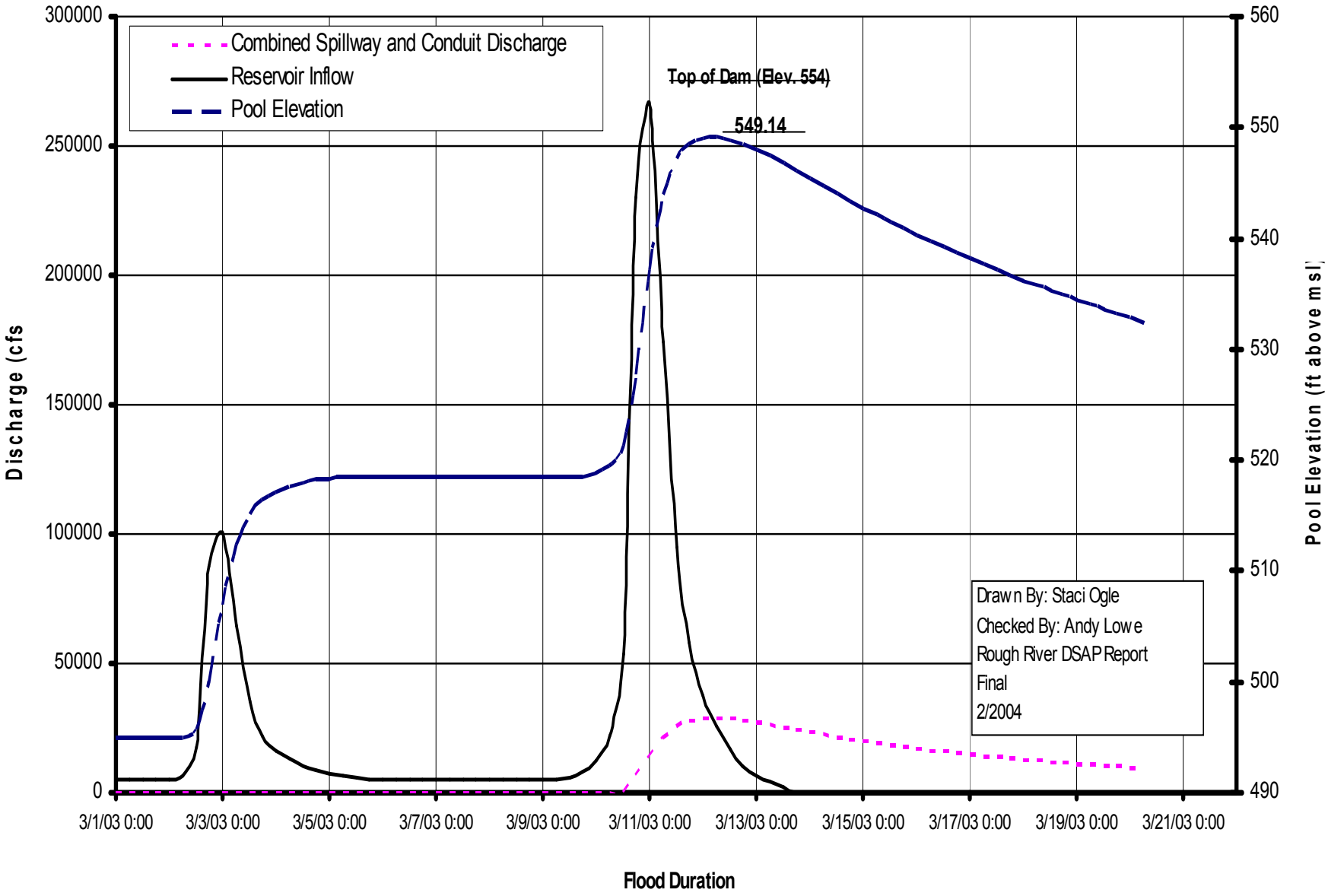
2) Assume an antecedent flood begins 5 days prior to the onset of the Threshold flood and is 50% of the following Threshold flood.

or

Assume antecedent flood is 30% of the Threshold flood with 3 days dry period or 39% of Threshold flood with 5 days dry period for Ohio River Basin.

# Determination of Threshold Flood
# (as calculated by HEC-HMS)




Combined Spillway and Conduit Discharge
Reservoir Inflow
Pool Elevation
Top of Dam (Elev. 554)
549.14
Drawn By: Staci Ogle
Checked By: Andy Lowe
Rough River DSAP Report
Final
2/2004
Discharge (cfs
Pool Elevation (ft above msl)
Flood Duration
300000
250000
200000
150000
100000
50000
0
560
550
540
530
520
510
500
490
3/1/03 0:00
3/3/03 0:00
3/5/03 0:00
3/7/03 0:00
3/9/03 0:00
3/11/03 0:00
3/13/03 0:00
3/15/03 0:00
3/17/03 0:00
3/19/03 0:00
3/21/03 0:00

# Step 3 - Determine total flows and downstream inundation elevations from the Threshold Flood "with and without" dam failure and from lesser floods.

The results of this step will be used to produce inundation maps for the evaluation of potential fatalities and economic losses.

DAM BREACH MODELS:

1. HEC-RAS
2. NWS DAMBRK
3. FLDWAV
4. HEC-1; HEC-HMS
5. BREACH

TRAINING:

October 25-27, 2005 Salt Lake City, Utah
FEMA/ Association of State Dam Safety Officials
Susan Sorrell (859) 257-5146

# Dam Break Model Parameters

| | |
|---|---|
| Initial Reservoir Water Surface Elevation | 495 (Summer Pool) |
| Water Surface Elevation at Time of Breach | 554 (Top of Dam) |
| Breach Side Slope | 1:1 |
| Stream Bed Elevation | 424 |
| Final Breach Bottom Elevation | 424 |
| Breach Base Width | 300 feet |
| Time of Breach Formation | 6 hours |

# Step 4 – Compute the hypothetical maximum Dam failure flows and downstream inundation elevations.

Purpose – To determine the maximum lateral boundaries for the collection of data on economic and life losses for the succeeding steps.

# Step 5 – Prepare inundation maps and collect data on damageable property and populations for the hypothetical maximum flooding determined in Step 4.

PURPOSE – Requires the collection of data for use in estimating economic flood losses and life losses.

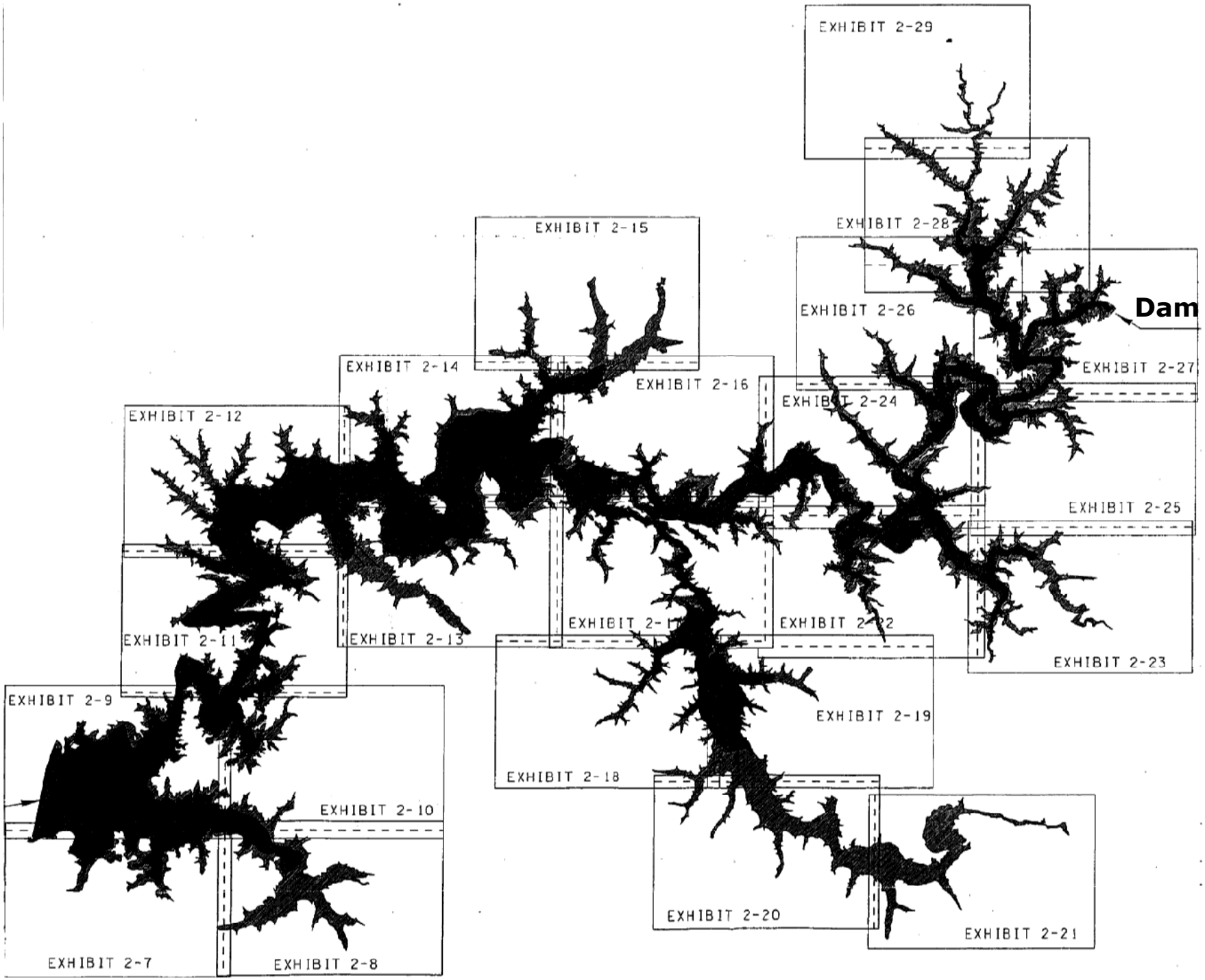


EXHIBIT 2-29
EXHIBIT 2-28
EXHIBIT 2-15
EXHIBIT 2-26
Dam
EXHIBIT 2-14
EXHIBIT 2-16
EXHIBIT 2-27
EXHIBIT 2-24
EXHIBIT 2-12
EXHIBIT 2-25
EXHIBIT 2-11
EXHIBIT 2-13
EXHIBIT 2-17
EXHIBIT 2-22
EXHIBIT 2-23
EXHIBIT 2-9
EXHIBIT 2-19
EXHIBIT 2-18
EXHIBIT 2-10
EXHIBIT 2-20
EXHIBIT 2-21
EXHIBIT 2-7
EXHIBIT 2-8

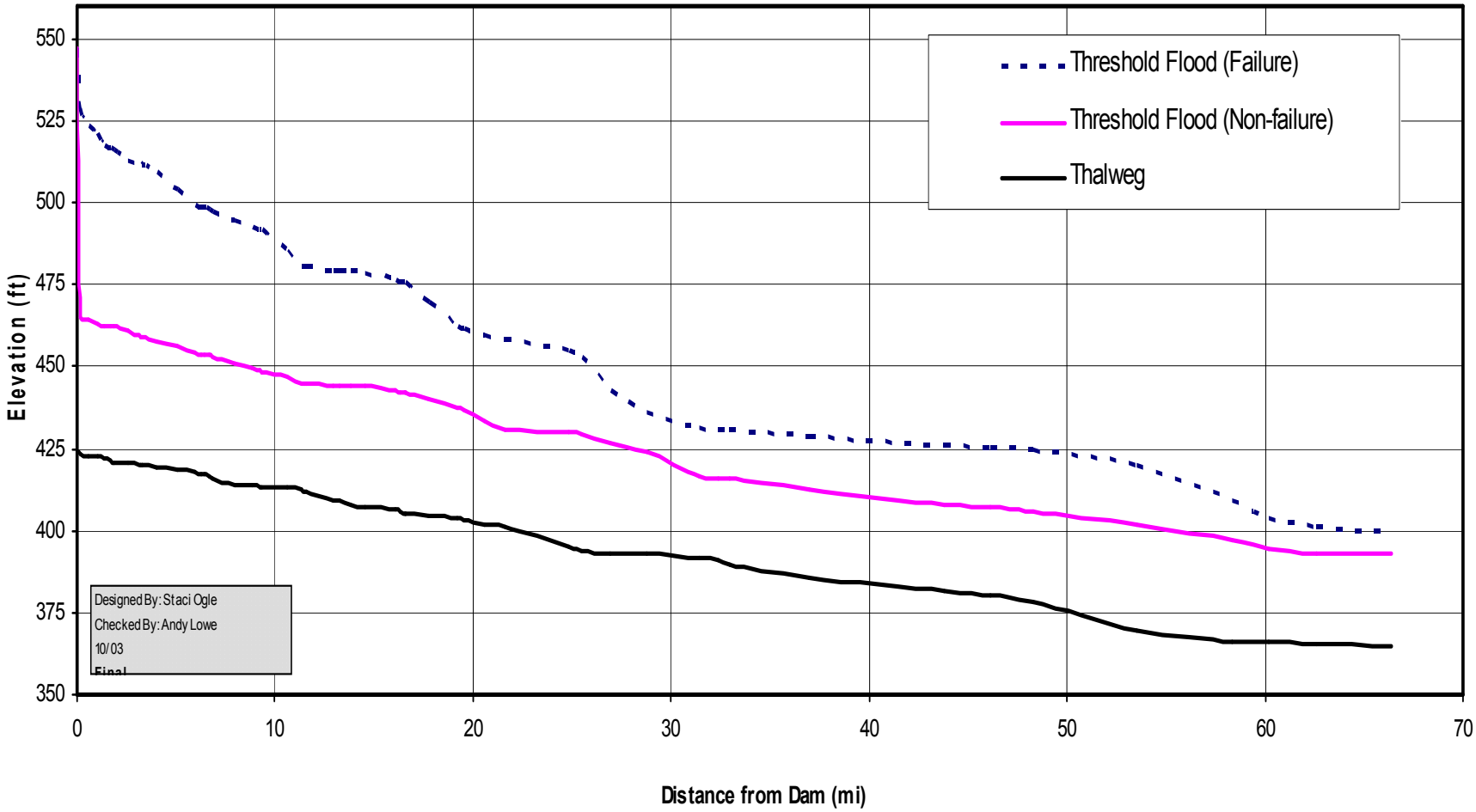
Study: Rough River
Description: Rough River Dam Safety Study
Pathname: C:\Documents and Settings\h2pmpklm\My Documents\HEC\FDA\Rough River
Plan: Without
Year: 2003

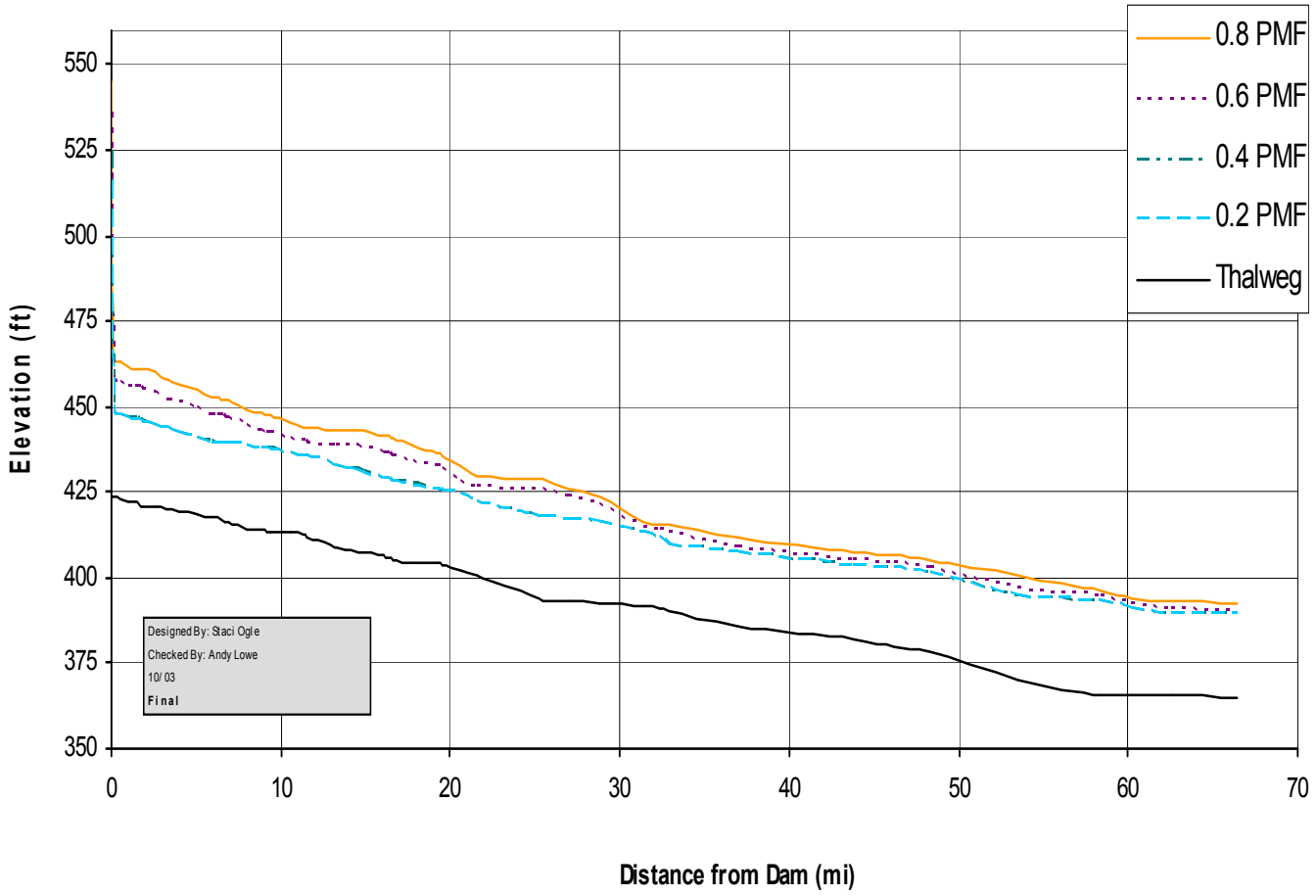
| Struc_Name | Stream_Name | | Station | Bank | Year | Cat_Name | Occ_Name |
|---|---|---|---|---|---|---|---|
| Structure Name | Stream Name | Reach Name | Station | Bank | Year In Service | Damage Category | Occupancy |
| 1 | Rough River | Gray-Co | 0.16 | Left | -901 | PUBLIC | PUBL |
| 2 | Rough River | Gray-Co | 0.16 | Left | -901 | PUBLIC | PUBL |
| 3 | Rough River | Gray-Co | 0.2 | Left | -901 | PUBLIC | PUBL |
| 4 | Rough River | Gray-Co | 5.2 | Left | -901 | Residential | 7 |
| 5 | Rough River | Gray-Co | 5.2 | Left | -901 | Residential | 2 |
| 6 | Rough River | Gray-Co | 5.2 | Left | -901 | Residential | 5 |
| 7 | Rough River | Gray-Co | 5.2 | Left | -901 | COMM | WARE |
| 8 | Rough River | Gray-Co | 5.2 | Left | -901 | Residential | 2 |
| 9 | Rough River | Gray-Co | 5.3 | Left | -901 | Residential | 1 |
| 10 | Rough River | Gray-Co | 5.4 | Left | -901 | Residential | 7 |
| 11 | Rough River | Gray-Co | 5.4 | Left | -901 | Residential | 7 |

# Step 6 – Prepare inundation maps for the Threshold flood with & without Dam failure.

This information will be used to determine economic flood losses and the population threatened by failure and non-failure floods.

**Existing Condition Inundation Elevation for the Threshold Flood**
**Dam Failure and Dam Non-failure**
**(as calculated by Boss DamBrk Program)**




0.8 PMF
0.6 PMF
0.4 PMF
0.2 PMF
Thalweg
Elevation (ft)
550
525
500
475
450
425
400
375
350
0
10
20
30
40
50
60
70
Distance from Dam (mi)
Designed By: Staci Ogle
Checked By: Andy Lowe
10/ 03
Final

# Step 7 – Determine population at risk (PAR) from the Threshold flood and lesser events.

Population at Risk defined as all persons that would be exposed to flood waters if they took no measures to evacuate.

PAR will be used to estimate the Threatened Population (TP) and Loss of Life (LOL).

PAR varies for time of day (daily transients).
PAR varies for time of year (seasonal transients).

# ROUGH RIVER LAKE

Average daily traffic counts were obtained in the study area for both low-severity zones and medium-severity zones to estimate transient motorist population at risk.

# Step 8 – Determine economic losses from Threshold flood and specified lesser floods.

If economic losses are significantly greater with Dam failure than losses without failure, an investment to improve the safety of the Dam may be warranted.

TYPES OF LOSSES:

a) Residential structure & contents
b) Commercial and industrial structure & contents
c) Agricultural losses
d) Income losses
e) Damage to utilities, transportation & communication systems
f) Vehicles
g) Flood emergency costs
h) Project benefits lost with failure
i) Culture & environmental assets
j) Physical & psychological injuries

| | Dam Non-failure | Dam Failure |
|---|---|---|
| Total PAR | 139 | 1,367 |
| Total Econ. Losses | $1,867,000 | $17,833,000 |

# Step 9 – Determination of Dam failure warning time.

The estimated warning time will be used to estimate the threatened population in step 10 as well as the loss of life.

Threatened Population – all those likely to be exposed to floodwaters assuming that warnings have been issued.

# ROUGH RIVER LAKE ANALYSIS

The minimum warning time for a potential Dam failure is greater than 60 minutes.

# Step 10 – Estimate the baseline probable PAR, probable TP, and probable LOL from the Threshold flood and specified lesser floods.

At the time of this IWR report, it is stated "There is no generally accepted method of estimating the effectiveness of warning to calculate the probable TP and probable LOL."

| Flood Severity | Warning Time (min) | Flood Severity Understanding* | Fatality Rate (Fraction of People at Risk Expected to Die) | |
|---|---|---|---|---|
| | | | Suggested | Suggested Range |
| High | No Warning | N/A | 0.75 | 0.30 to 1.00 |
| | 15 to 60 | Vague | Use the values shown above and apply to the number of people who remain in the dam failure floodplain after warnings are issued. No guidance is provided on how many people will remain in the floodplain. | |
| | More than 60 | Precise | | |
| | | Vague | | |
| | | Precise | | |
| Medium | No Warning | N/A | 0.15 | 0.03 to 0.35 |
| | 15 to 60 | Vague | 0.04 | 0.01 to 0.08 |
| | More than 60 | Precise | 0.02 | 0.005 to 0.04 |
| | | Vague | 0.03 | 0.005 to 0.06 |
| | | Precise | 0.01 | 0.002 to 0.02 |
| Low | No Warning | N/A | 0.01 | 0.0 to 0.02 |
| | 15 to 60 | Vague | 0.007 | 0.0 to 0.015 |
| | More than 60 | Precise | 0.002 | 0.0 to 0.004 |
| | | Vague | 0.0003 | 0.0 to 0.0006 |
| | | Precise | 0.0002 | 0.0 to 0.0004 |

Bureau of Reclamations

*It was assumed that half the PAR would have a vague understanding of the resulting flood severity and the other half would have a precise understanding.

# Step 11 – Display existing condition results and propose additional action.

If there is a significant increment in economic losses or probable LOL due to Dam failure, additional study of alternatives to reduce the extent of the Dam safety hazard is warranted.

| | Dam Non-failure | Dam Failure |
|---|---|---|
| Total PAR | 139 | 1,367 |
| Total Econ. Losses | $1,867,000 | $17,833,000 |

# Step 12 – Identify alternatives to reduce the Dam safety hazard to people and property.

Alternatives should be based on percentages of the PMF, such as .80, .90 and 1.00 PMF.

ALTERNATIVES COULD INCLUDE:

a) Raising the top of Dam
b) Lowering/widening the Spillway
c) Reallocation of Reservoir storage
d) Permanent relocation of downstream population
e) Additional reservoirs
f) Additional Spillway capacity
g) FWEEPS

# LIST OF ROUGH RIVER LAKE ALTERNATIVES

- Widen spillway
- Raise Dam in combination with wall
- Use Fusegates to lower spillway
- Combination of fusegates and wall

# Step 13 – Evaluate the costs of BSC modification alternatives.

| | Total Cost |
|---|---|
| Widen spillway by 85 feet | $5,109,500 |
| Raise dam by 2 feet; construct 3-foot parapet wall across upstream crest | $1,433,000 |
| Deepen spillway by 20 feet; install Fusegates | $3,896,500 |
| Deepen spillway by 10 feet; install Fusegates construct 3-foot parapet wall | $3,147,700 |

# Step 14 – Evaluate alternatives in terms of their effectiveness in reducing the hazard.

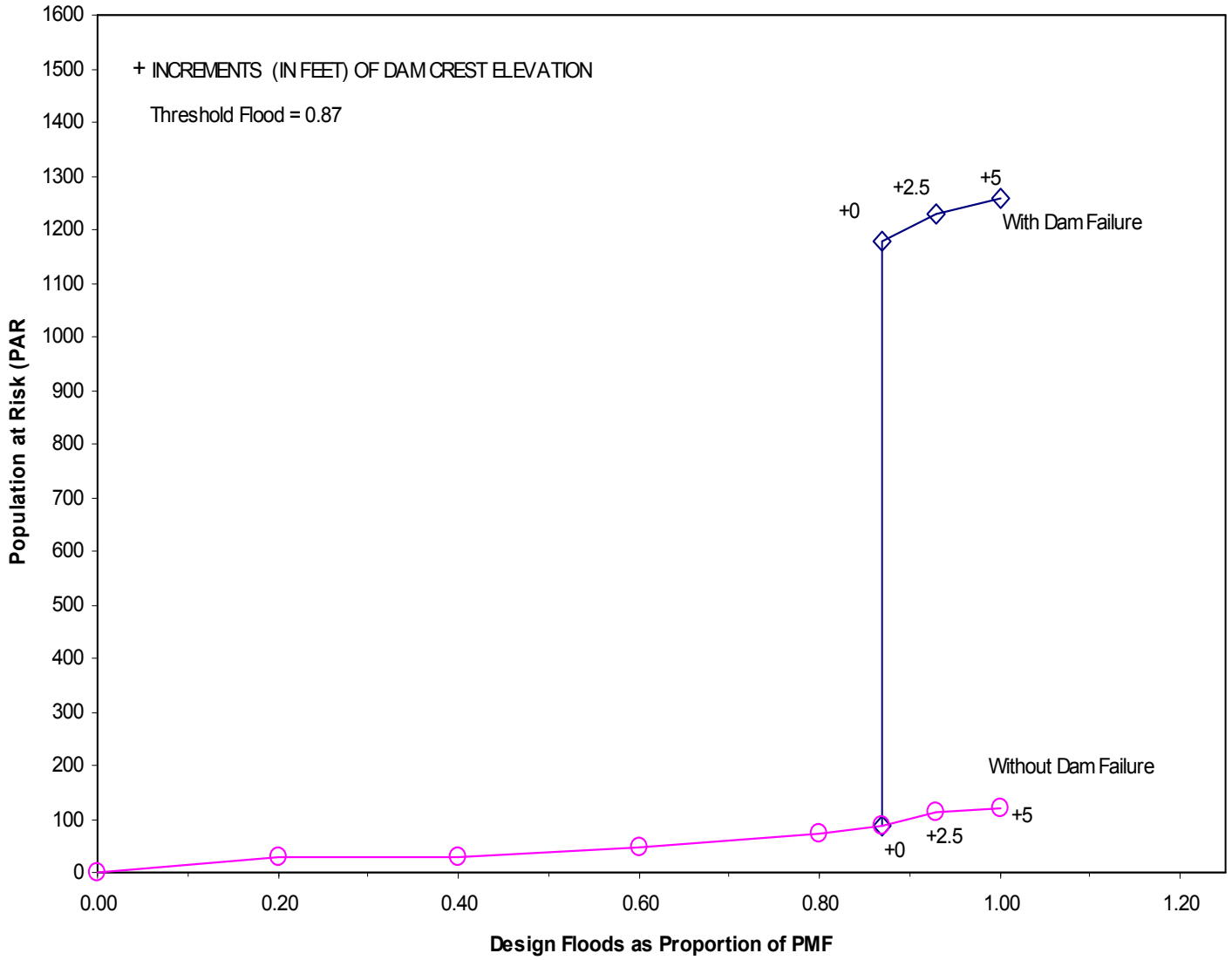
The method used for evaluating the alternatives follows the same steps as existing conditions as listed in steps 3-11.

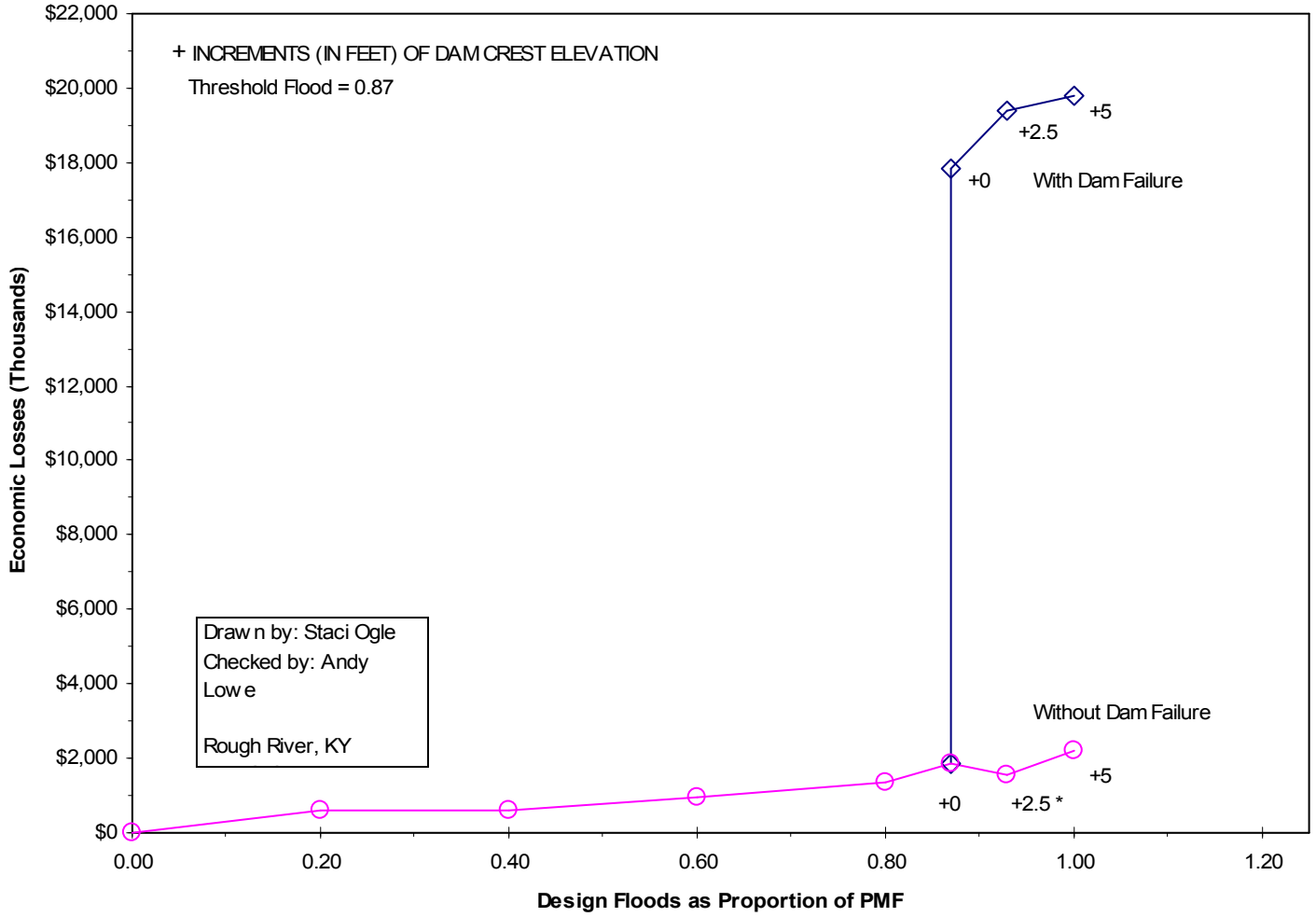
Their effectiveness is measured in PAR and economic losses.

# Step 15 – Determination of the Base Safety Condition (BSC).

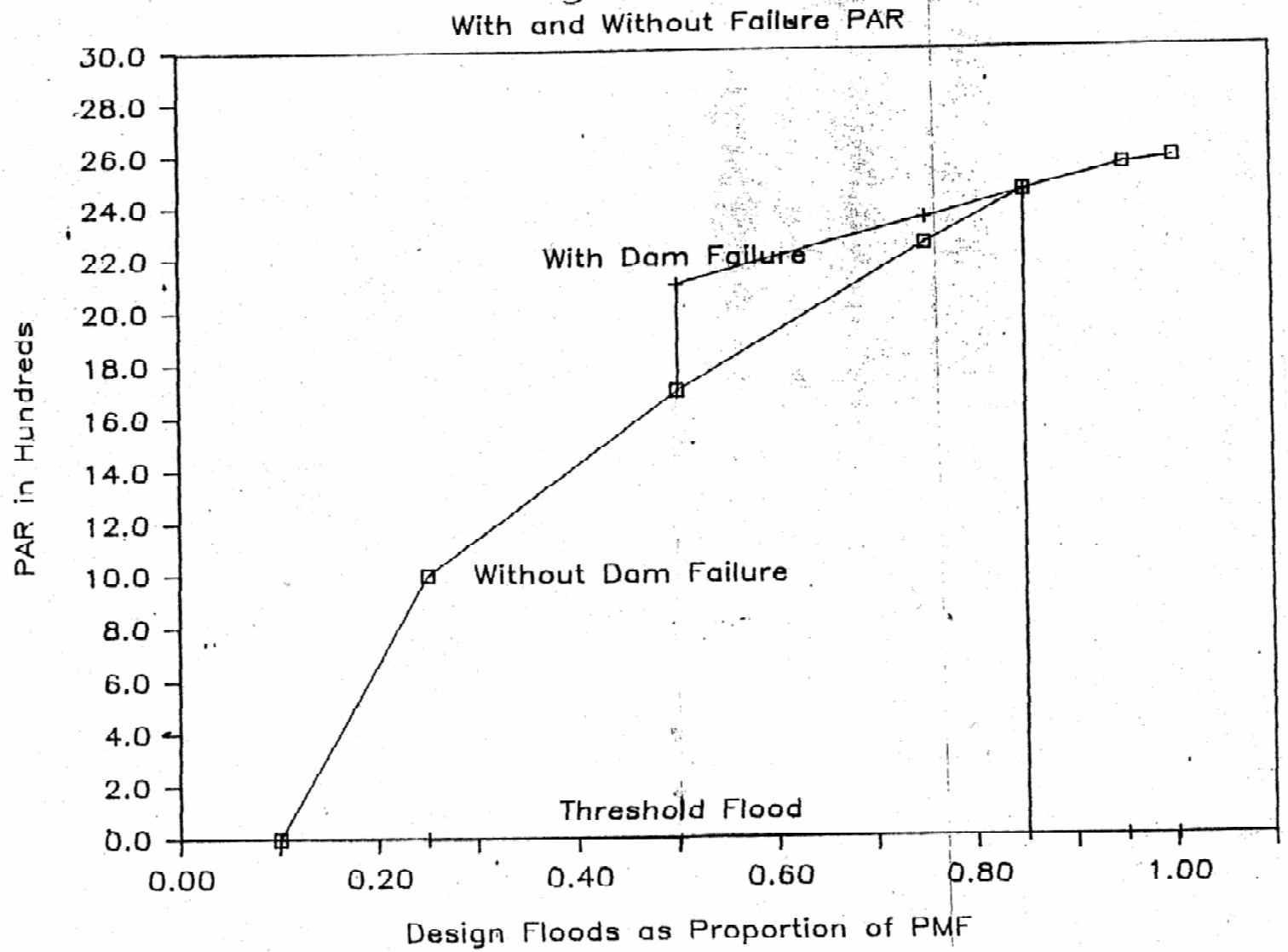
If there is a significant increment in economic & probable LOL losses at the Threshold Flood, The Dam must be designed to safely pass a larger flood that meets a Base Safety Condition (BSC).

BSC-Flood event where there is no significant increase in loss of life or economic losses from Dam failure compared to without Dam failure.


+ INCREMENTS (IN FEET) OF DAM CREST ELEVATION
Threshold Flood = 0.87
+0
+2.5
+5
With Dam Failure
Without Dam Failure
+0
+2.5
+5
Population at Risk (PAR
Design Floods as Proportion of PMF
0
100
200
300
400
500
600
700
800
900
1000
1100
1200
1300
1400
1500
1600
0.00
0.20
0.40
0.60
0.80
1.00
1.20


+ INCREMENTS (IN FEET) OF DAM CREST ELEVATION
Threshold Flood = 0.87
$22,000
$20,000
$18,000
$16,000
$14,000
$12,000
$10,000
$8,000
$6,000
$4,000
$2,000
$0
Economic Losses (Thousands)
0.00
0.20
0.40
0.60
0.80
1.00
1.20
Design Floods as Proportion of PMF
+5
+2.5
+0
With Dam Failure
Without Dam Failure
+5
+0
+2.5 *
Drawn by: Staci Ogle
Checked by: Andy Lowe
Rough River, KY

# Figure III–9

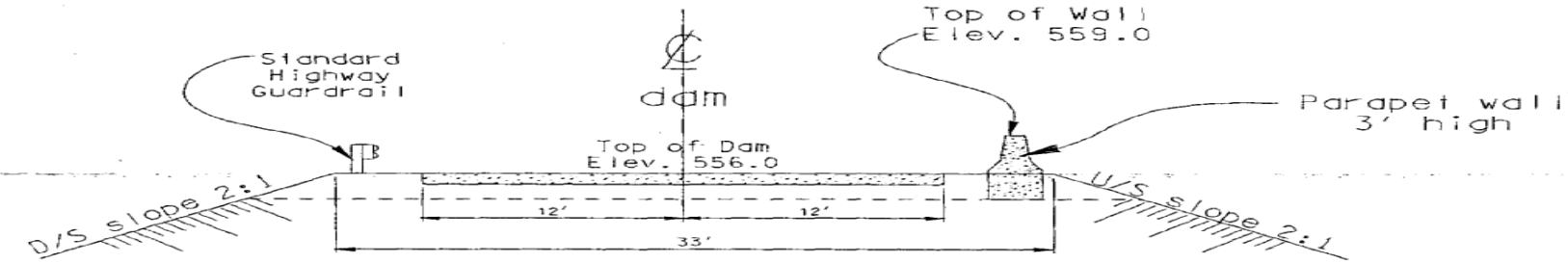

With and Without Failure PAR
30.0
28.0
26.0
24.0
22.0
20.0
18.0
16.0
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0
PAR in Hundreds
With Dam Failure
Without Dam Failure
Threshold Flood
0.00
0.20
0.40
0.60
0.80
1.00
Design Floods as Proportion of PMF

# Step 16 – Recommend Choice of alternatives to meet BSC.

In general, the lowest-cost alternative meeting the BSC should be recommended for implementation. The BSC, by definition, is never greater than the PMF.

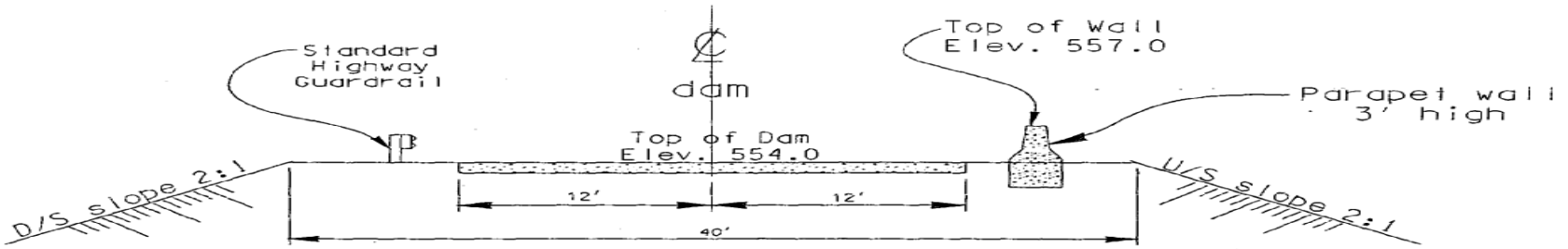
Provide a summary of the documentation of the evaluation process and to recommend a Dam safety modification for implementation.

WITH RAISING TOP OF DAM/ROAD




DETAIL SECTION OF TOP OF DAM

WITHOUT RAISING TOP OF DAM/ROAD




DETAIL SECTION OF TOP OF DAM

# Step 17 – Determination of whether breaching the Dam should be evaluated as an alternative.

If the benefits of continued operation of the lake project do not exceed the costs for modification, consideration should be given to breaching the Dam.

# ROUGH RIVER LAKE RECOMMENDED MODIFICATION

Cost = $1,433,000

Benefit to Cost Ratio = 76 to 1