



# Odell Dam Safety Analysis

## Final Presentation

By:

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# Overview

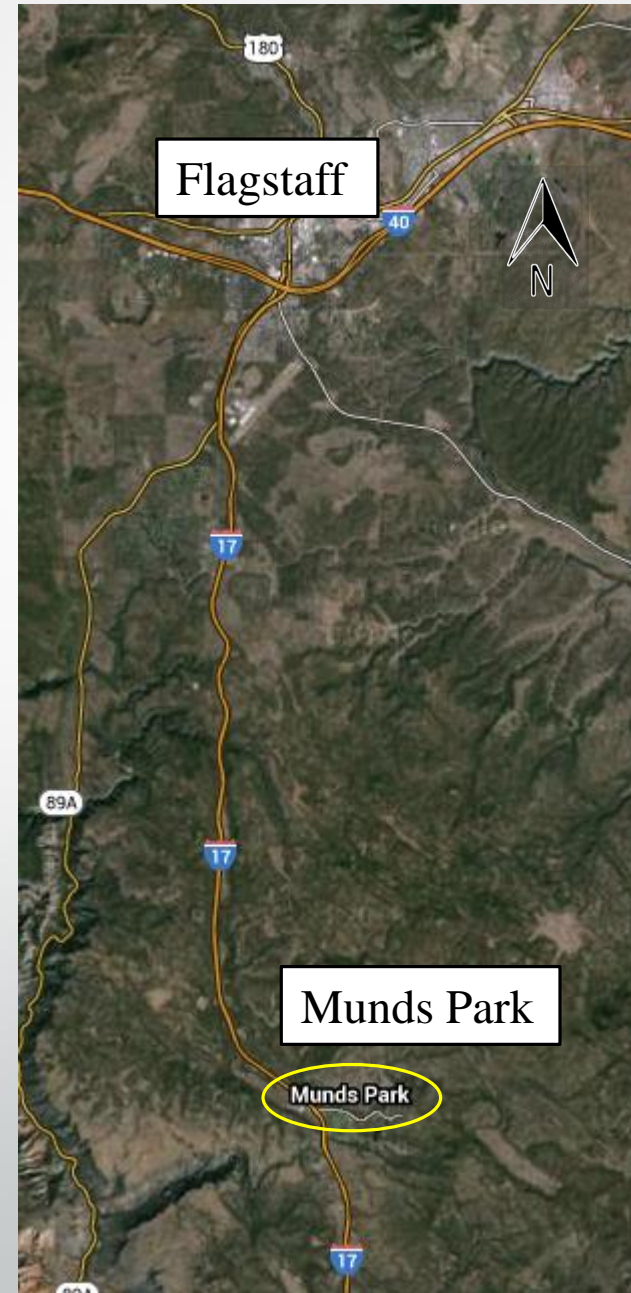
- Project Description
- Project Background
- Project Location
- Technical Analysis
- Summary of Results
- Cost
- Final Recommendations

# Project Description

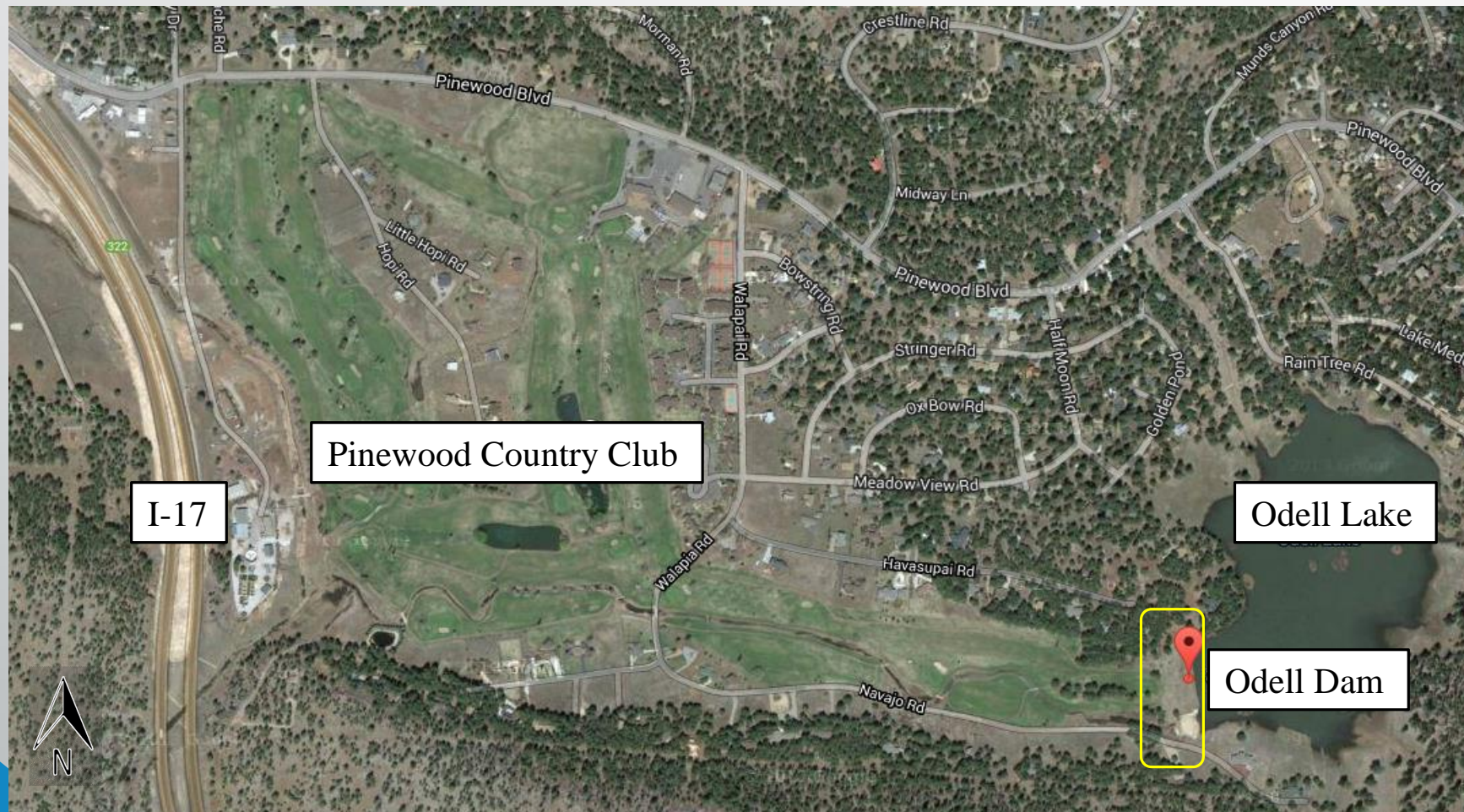
- Dam Safety Analysis
- The team has been asked by the client to provide qualitative answers for the following:
  - What storm event will contribute to a dam failure?
  - Determine the adequacy of the spillway capacity and side slope stability.
  - Discuss the effects of post-fire flooding.

# Project Location

- Munds Park
- 20 miles south of Flagstaff
- Pinewood Country Club



# Project Location



# Project Background

- Client:  
Pinewood Country Club
- Technical Advisor:  
Dr. Charles Schlinger
- ADWR Dam Status:  
Safe with deficiencies



Photo taken by: Braedan Hinojosa

# Technical Analysis

- Watershed Delineation
- Rainfall Intensities
- Storage Indication Curve
- Curve Numbers
- Time of Concentrations
- PondPack Modeling
- RocScience Modeling

# Watershed Delineation



Mormon Lake

Total Watershed Area is 19.8 mi<sup>2</sup>



# Rainfall Intensities

AMS-based precipitation frequency estimates with 90% confidence intervals (in inches/hour) <sup>1</sup>									
Duration	Annual exceedance probability (1/years)								
	1/2	1/5	1/10	1/25	1/50	1/100	1/200	1/500	1/1000
5-min	3.73 (3.19-4.36)	5.42 (4.63-6.30)	6.64 (5.65-7.72)	8.29 (7.00-9.60)	9.61 (8.06-11.1)	11.1 (9.18-12.8)	12.6 (10.3-14.6)	14.7 (11.9-17.2)	16.6 (13.2-19.6)
10-min	2.84 (2.43-3.31)	4.13 (3.52-4.80)	5.05 (4.30-5.87)	6.31 (5.33-7.30)	7.31 (6.14-8.46)	8.41 (6.98-9.74)	9.55 (7.84-11.1)	11.2 (9.03-13.1)	12.6 (10.0-14.9)
15-min	2.34 (2.01-2.74)	3.41 (2.91-3.96)	4.18 (3.55-4.86)	5.22 (4.40-6.04)	6.04 (5.07-6.99)	6.95 (5.77-8.05)	7.90 (6.48-9.16)	9.26 (7.46-10.8)	10.4 (8.27-12.3)
30-min	1.58 (1.35-1.84)	2.30 (1.96-2.67)	2.81 (2.39-3.27)	3.51 (2.97-4.06)	4.07 (3.41-4.71)	4.68 (3.89-5.42)	5.32 (4.36-6.17)	6.24 (5.03-7.29)	7.02 (5.57-8.29)
60-min	0.978 (0.837-1.14)	1.42 (1.21-1.65)	1.74 (1.48-2.02)	2.17 (1.84-2.52)	2.52 (2.11-2.91)	2.90 (2.41-3.36)	3.29 (2.70-3.82)	3.86 (3.11-4.51)	4.35 (3.45-5.13)
2-hr	0.554 (0.486-0.638)	0.789 (0.690-0.906)	0.961 (0.834-1.10)	1.20 (1.03-1.37)	1.39 (1.19-1.59)	1.60 (1.36-1.84)	1.83 (1.53-2.09)	2.15 (1.76-2.47)	2.43 (1.95-2.80)
3-hr	0.404 (0.359-0.460)	0.558 (0.494-0.634)	0.673 (0.592-0.763)	0.830 (0.725-0.940)	0.957 (0.829-1.08)	1.10 (0.942-1.25)	1.25 (1.06-1.42)	1.47 (1.22-1.68)	1.65 (1.35-1.90)
6-hr	0.254 (0.230-0.283)	0.339 (0.305-0.377)	0.401 (0.360-0.446)	0.487 (0.434-0.541)	0.555 (0.491-0.616)	0.631 (0.553-0.701)	0.708 (0.612-0.789)	0.816 (0.694-0.915)	0.905 (0.757-1.02)

- NOAA Atlas 14 Volume 1 Version 5.
- Sedona, Arizona, US. Latitude: N 39.9334° Longitude: W 111.6335 °
- Precipitation Intensity, Annual Maximum, Project area: Southwest

# Curve Numbers

- Based on the area's hydrologic soil group, land use, treatment and hydrologic condition.
- Pre-Burn: Oak Creek Flood Warning Study 1990 <sup>[1]</sup>
  - Determined to be 66
- Post-Burn: USDA Forest Service <sup>[2]</sup>
  - Determined to be 85

[1] National Engineering Handbook, Section 4, Hydrology, U.S. Department of Agriculture, Soil Conservation Service, 1972.

[2] U.S. Forest Service Coronado National Forest. 2003. Aspen Fire, Coronado National Forest, BAER hydrology report. Tucson, AZ: U.S. Department of Agriculture, Forest Service, Southwestern Region, Coronado National Forest.

# Time of Concentration

- SCS Lag Method

Scenario	Length (feet)	Slope (%)	CN	Tc (hours)
Pre-Burn	63212	13.18	66	.819
80% Post-Burn	63212	13.18	85	.563

$$t_c = \frac{1.67 * L^{0.8} \left( \frac{1000}{CN} - 10 \right)^{0.7}}{1900 * S^{0.5}}$$

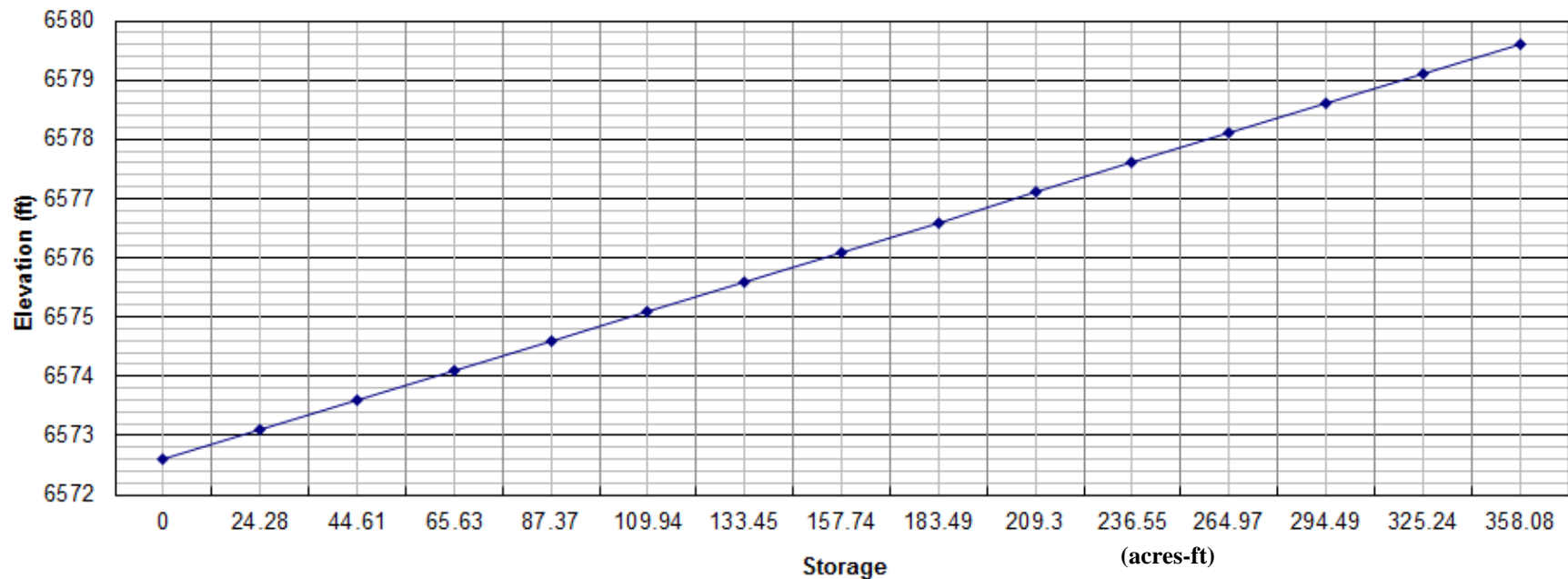
- Watershed: 1269 acres
- CN = SCS runoff curve number
- S = average watershed slope
- L = Longest flow path

# PondPack Hydrologic Modeling

- Parameters
  - Watershed Delineation
    - Area: 19.84 sq. miles
  - Time of Concentrations
    - Pre-burn: 49.14 minutes
    - Post-burn: 33.78 minutes
  - Curve Numbers
    - Pre-burn: 66
    - Post-burn: 85
  - Analyzed as a full reservoir

# Storage Indication Curve

Elevation-Storage Graph for Odell Dam

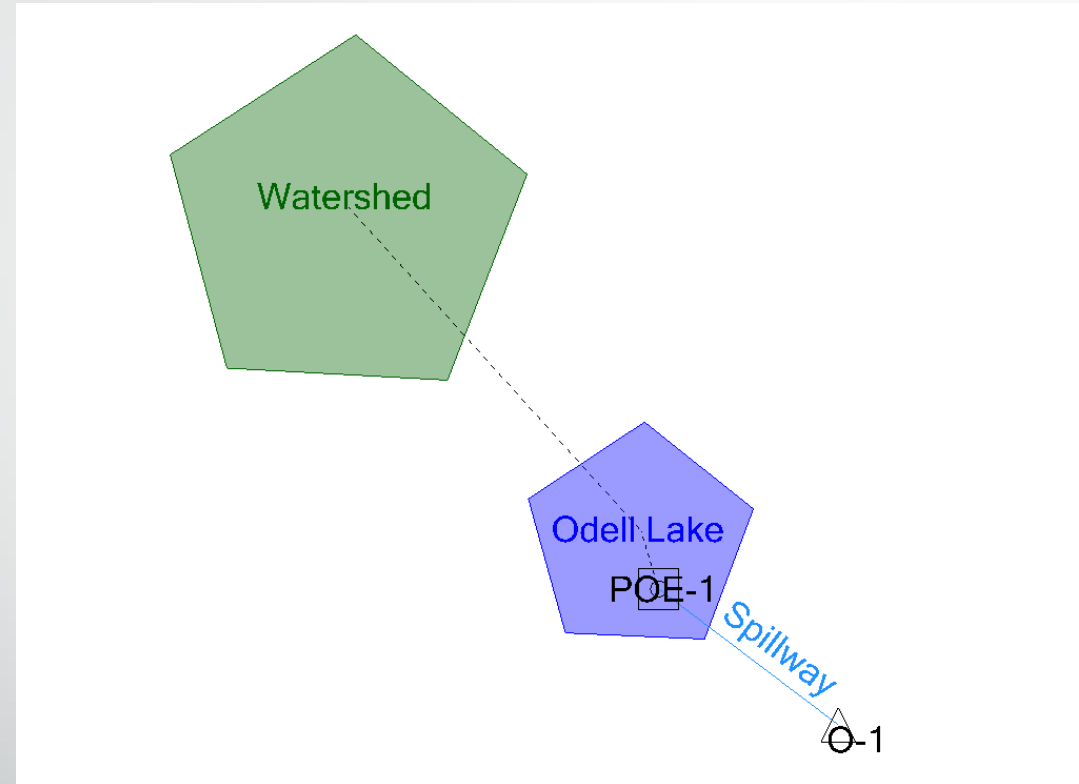


ADWR Multiple Sources. "Correspondence June 86 – March 07." Arizona Department of Water Resources. N.d.

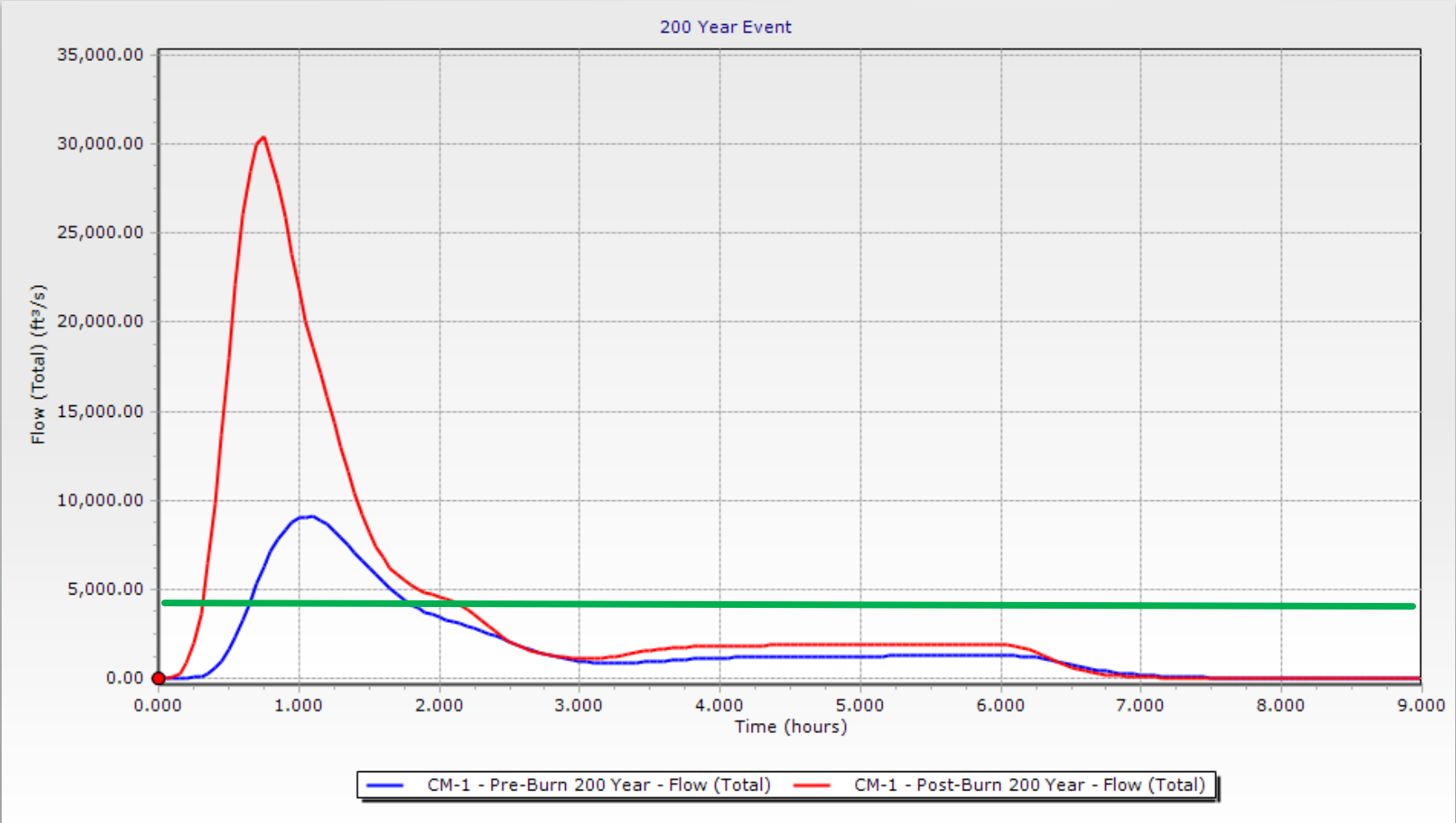
- Storage from crest of spillway to top of dam.

- Spillway Dimensions
  - Length: 80 ft
  - Height: 7 ft
- Spillway Capacity
  - ~ 4500 cfs

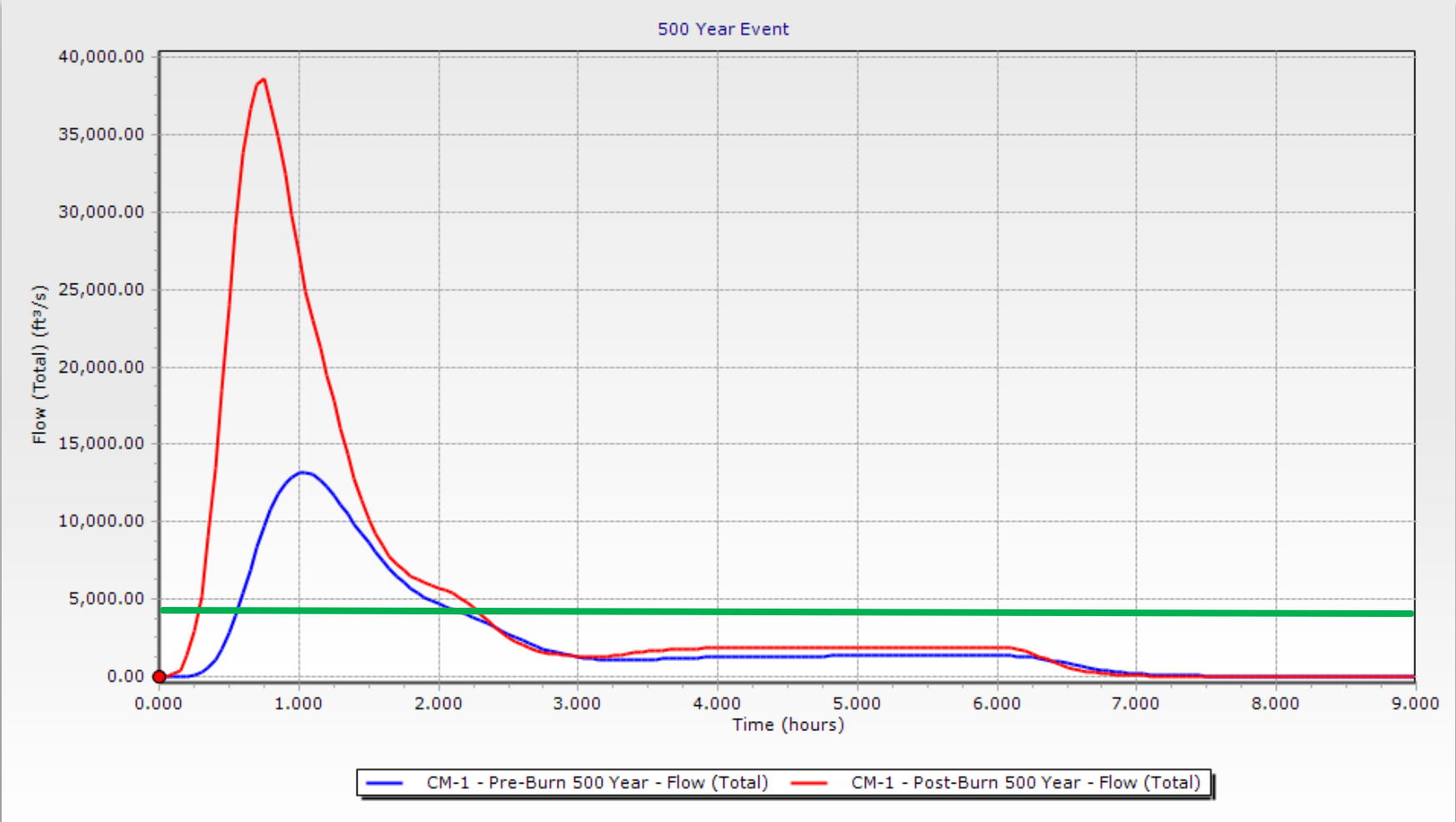
# PondPack Hydrologic Modeling



# 200 Year Hydrograph

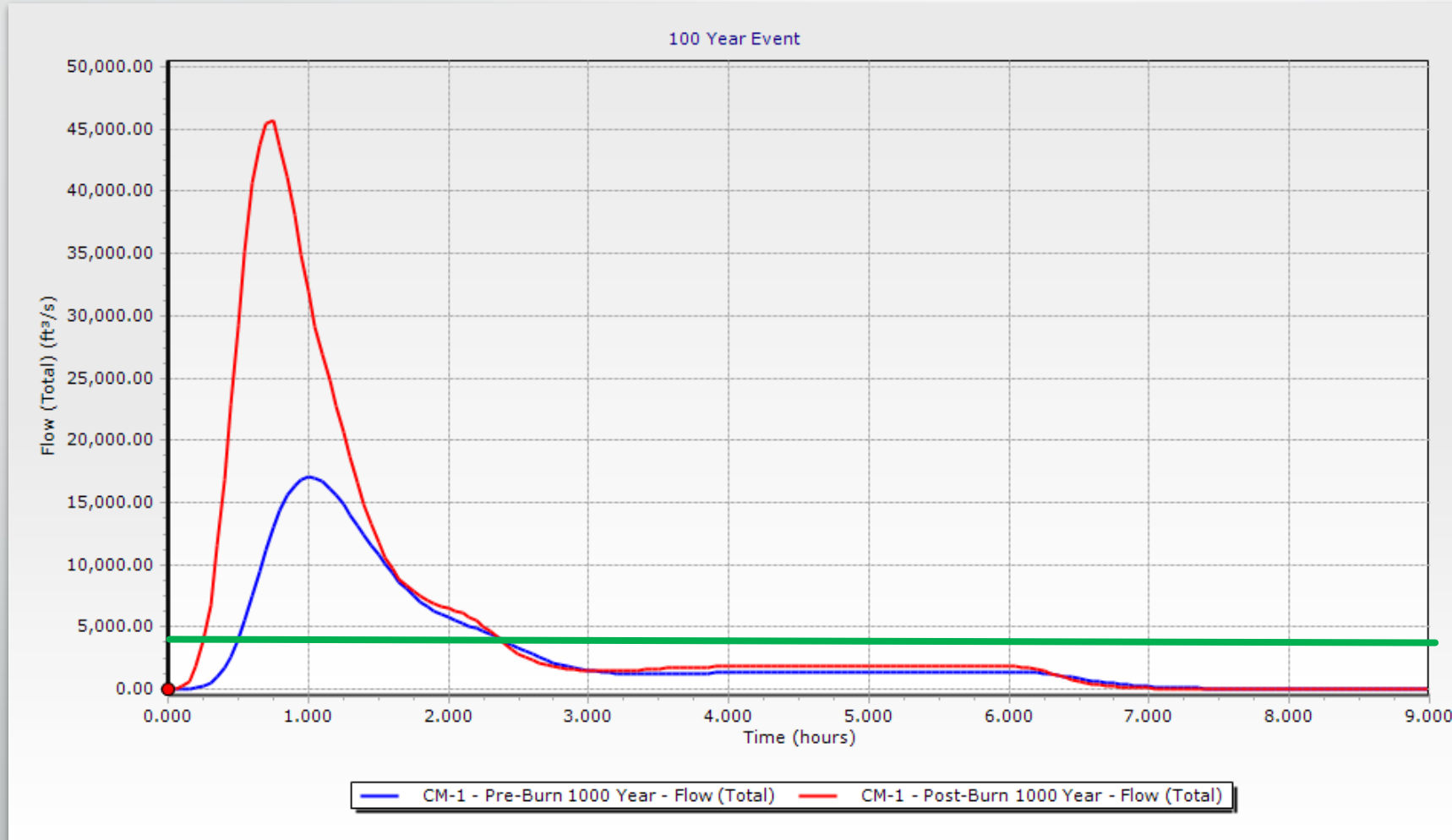


# 500 Year Hydrograph





# 1000 Year Hydrograph



# Inflow vs. Outflow

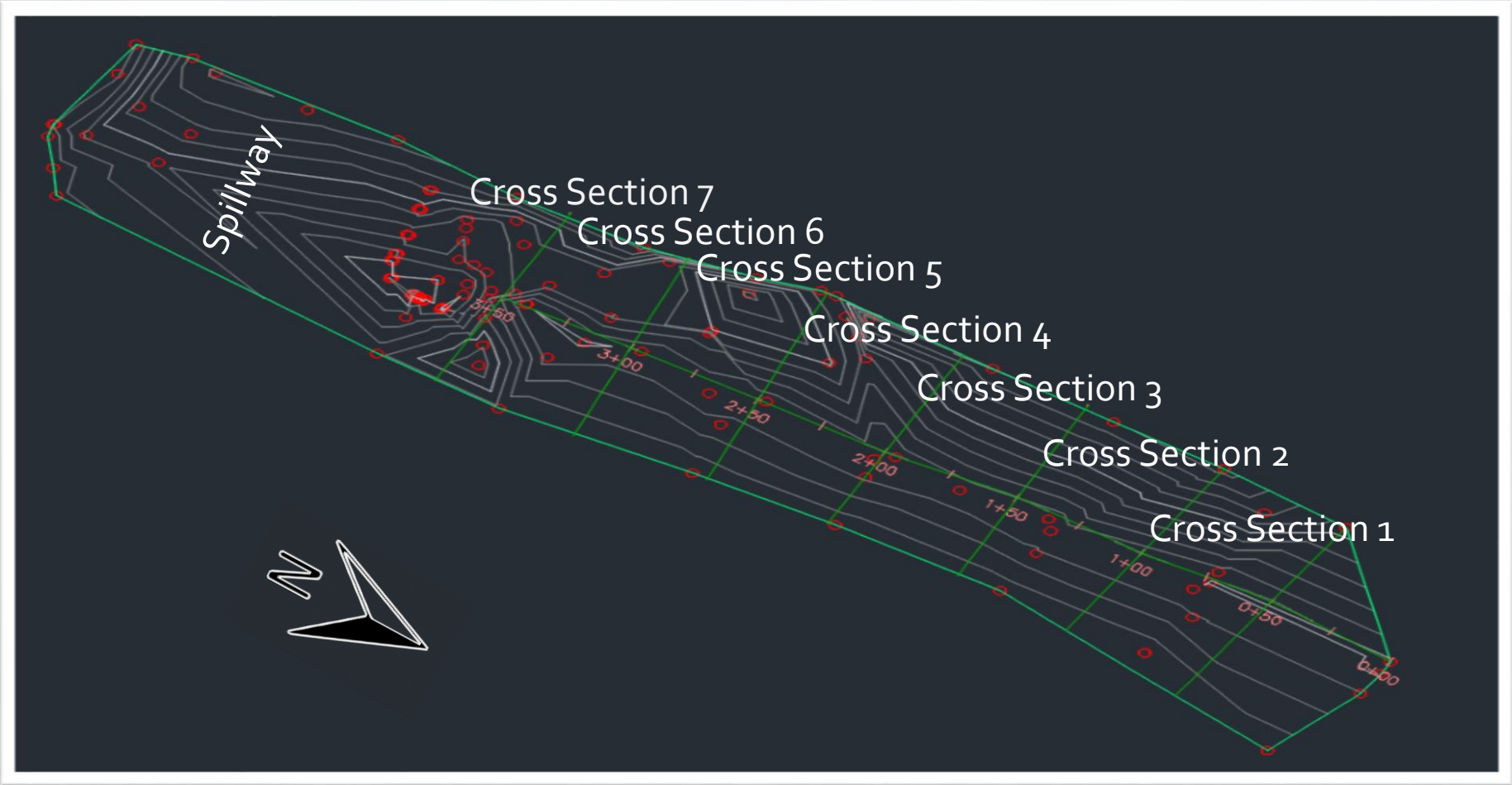
Storm Events	Pre-burn Conditions			Post-burn Conditions		
	Peak Inflow (cfs)	Peak Outflow (cfs)	Spillway Adequate?	Peak Inflow (cfs)	Peak Outflow (cfs)	Spillway Adequate?
2 Year	281.07	204.73	Yes	3443.26	1519.19	Yes
5 Year	538.79	411.23	Yes	6900.47	3167.07	Yes
25 Year	2914.50	1457.56	Yes	15484.56	N/A*	No
50 Year	4530.26	2401.13	Yes	19860.76	N/A*	No
100 Year	6617.25	3614.45	Yes	24891.91	N/A*	No
200 Year	9073.63	N/A*	No	30404.36	N/A*	No
500 Year	13164.09	N/A*	No	38575.88	N/A*	No
1000 Year	17056.60	N/A*	No	45669.15	N/A*	No

\*Spillway Overtops

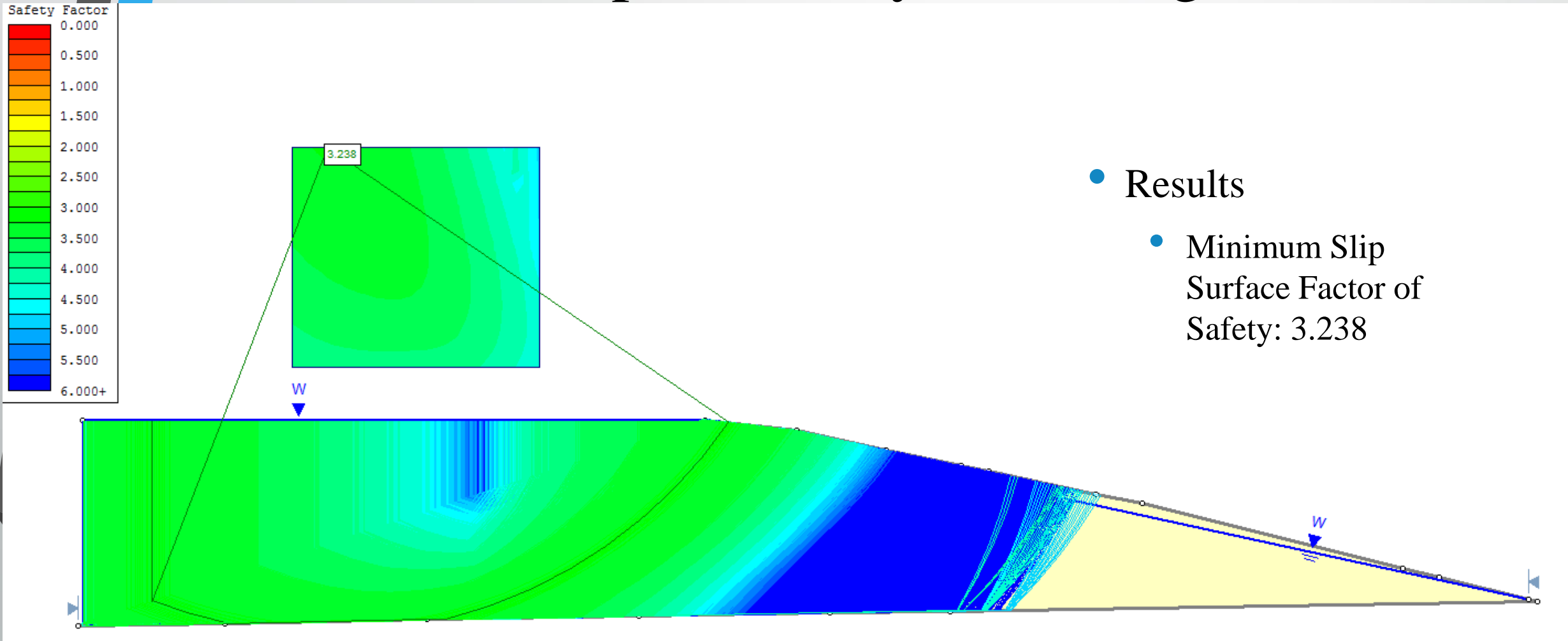
# RocScience Slope Stability Modeling

- Program is used to determine side slope stability of the dam.
- Parameters for Analysis
  - Dam Cross Section
  - Cohesion: 130.0 psf
  - Friction Angle: 25.1 Degrees
  - Saturated Weight of Soil: 120.0 pcf
  - Unsaturated Weight of Soil: 106.1 pcf
  - Side slope Factor of Safety  $\geq 1.5$
  - Analyzed with water level at top of dam

# Dam Geometry

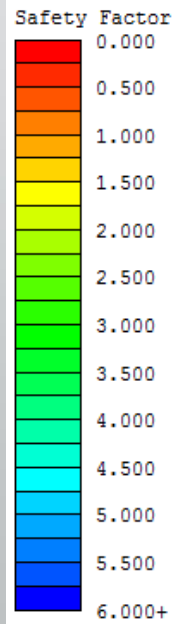


# RocScience Slope Stability Modeling

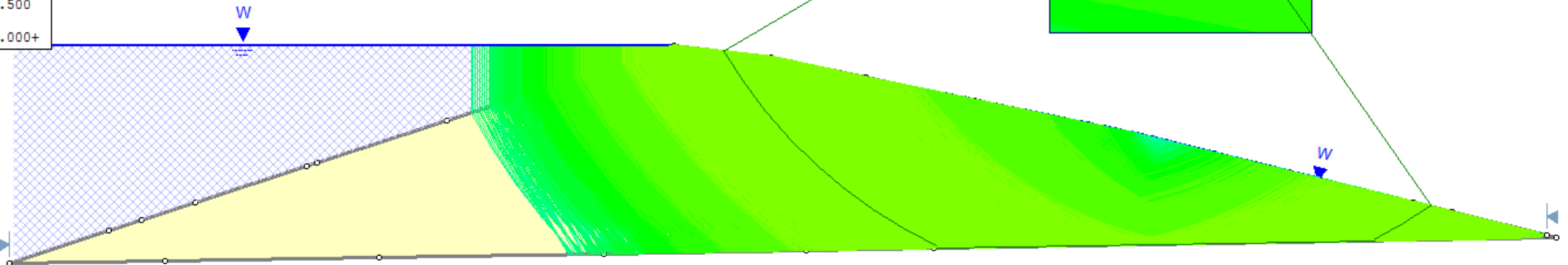


Heel (Right) to Toe (Left)

# RocScience Slope Stability Modeling



- Results
  - Minimum Slip Surface Factor of Safety: 2.382



Toe to Heel

# What storm event will contribute to a dam failure?

- Spillway Overtopping

Scenario	Storm Event	Peak Inflow (cfs)
Pre-Burn	100 to 200	6617 to 9073
80% Post-Burn	5 to 25	6900 to 15484

# Determine the adequacy of the spillway capacity and side slope stability.

- Side Slope Stability – Stable

Stability Model	Min. Factor of Safety	Stable?
Heel to Toe	3.238	Yes
Toe to Heel	2.382	Yes

- Spillway Capacity

- Max Outflow ~ 4500 cfs

Scenario	Storm Event	Outflow (cfs)
Pre-Burn	100 Year	3614.45
80% Post-Burn	5 Year	3167.07



# Discuss the effects of post-fire flooding.

- Time of Concentration decreased
  - Exponential increase in water runoff generated
- Debris from watershed accumulates
  - Decreases reservoir storage capacity
  - Raises stresses on the dam
  - Potential to block spillway

# Cost

Task Hours	Task								
Team Member	Management	Lit. Review	Surveying	Geotech.	Hydrologic	RocScience	PondPack	Reporting	Total
Braedan	25	15	10	8	20	0	20	32	130
Chandler	13	15	10	6	6	0	40	30	120
Sharlot	17	32	5	6	0	0	0	20	80
Ibrahim	13	12	5	20	0	30	0	20	100
Yaowan	13	12	5	20	0	10	0	20	80
<b>Cost – Billable Rate - \$75/hr</b>									
Total Hours	81	86	35	60	26	40	60	122	510
Total Cost (\$)	6075	6450	2625	4500	1950	3000	4500	9150	38250

# Final Recommendations

- We encourage our client, Pinewood Country Club, to look into previous ADWR recommendations to fix the minor deficiencies of the dam.
- ADWR Status: Safe w/ Deficiencies
  - Deficiencies are rodent holes, retaining wall and spillway cracks, and site management.
- Proper burn control to prevent severe burn conditions.

# Questions?

- Thank you.



Photo taken by: Braedan Hinojosa