Comprehensive Review of the Fill Lake Mead First Initiative

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ECL 290
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Lake Powell

- Commissioned in 1966, full pool 1980
- 2nd largest man-made reservoir in United States (24.3 MAF)
- Important for water storage and power generation for the Western United States

USBR (2015)

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Impacts of Lake Powell and Glen Canyon Dam

Fish

Mollie & Aviva: Showed the dam almost eliminated sediment flows, decreased river temp. and allowed for a more hospitable environment for non-native fish. ***Vanessa:*** Discussed how dams contributed the extirpation of native fish.

Water Rights

Jesse & Jennifer: Native American's access to water rights in the upper and lower basin, (Navajo water rights are in the Lake Powell watershed).

Sediment

Jeff: Sediment regime of the lower basin has been completely altered by impoundment of Lake Powell. ***Sarah:*** How dams contributed to changes to riparian ecosystems. ***Jasmin:*** Using high flow experiments to redistribute sediment and create beaches

Dam Operation

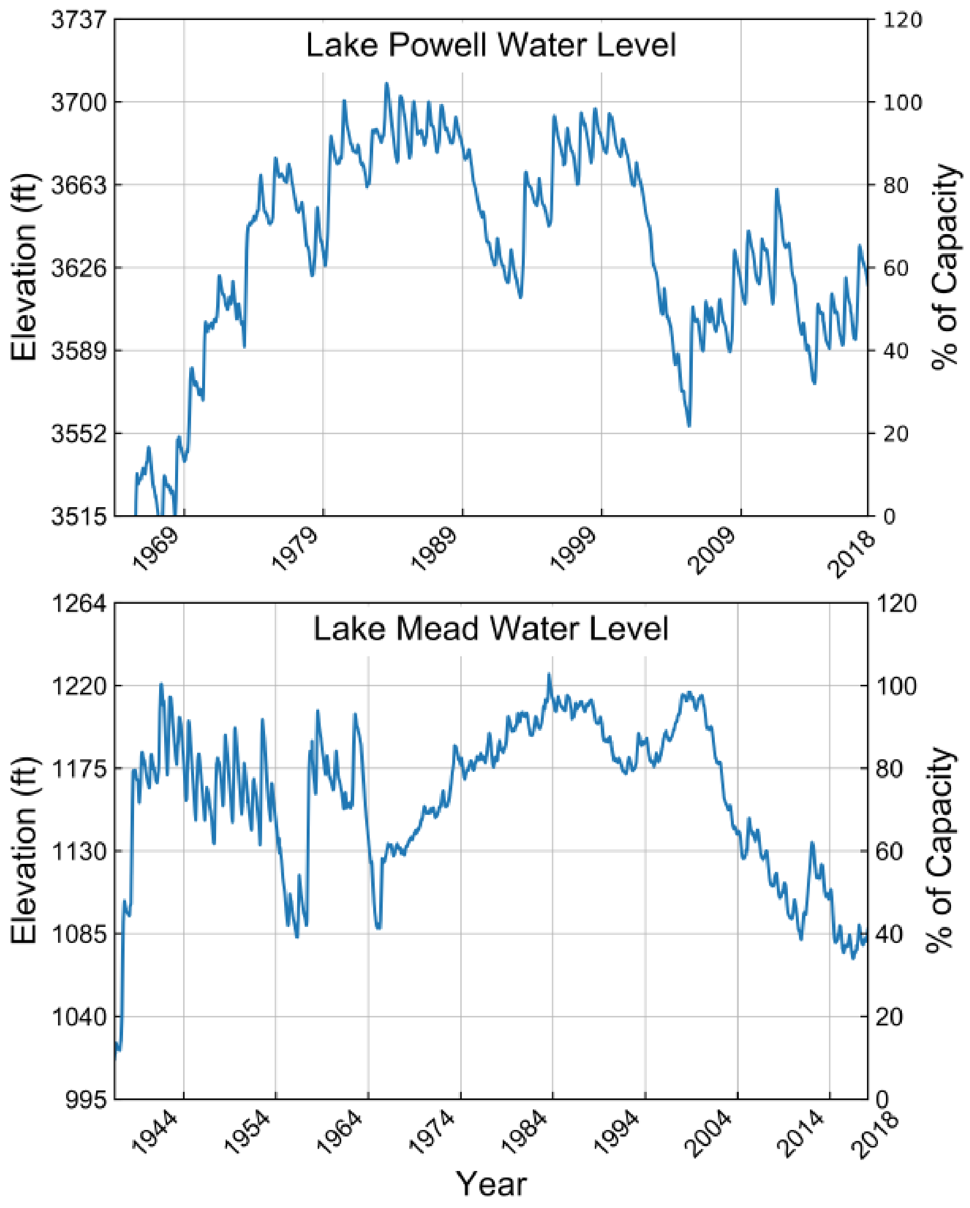
Marisa: Citizen science program looking at tidal effects caused by the dam

Other

Ann: Habitat destruction of the Kanab Ambersnail from high flows

Fill Lake Mead First Initiative

- Reservoir levels of both Lake Mead & Powell have been hovering around 50% full
  - Recent studies Barnett and Pierce (2008) and Kirk et al. (2017) showed reservoir levels will continue to decline, and hot drier conditions will be more common
- Drain water from Lake Powell to fill Lake Mead
- Glen Canyon dam would become a run of the river dam, with additional flood control capacity if needed



Data courtesy of water-data.com

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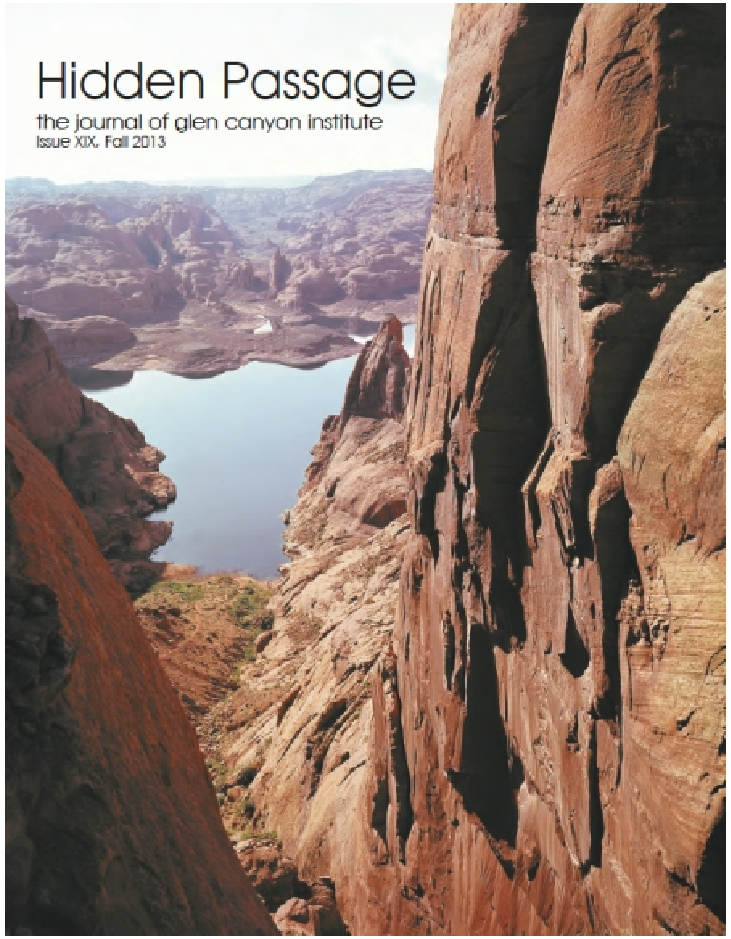
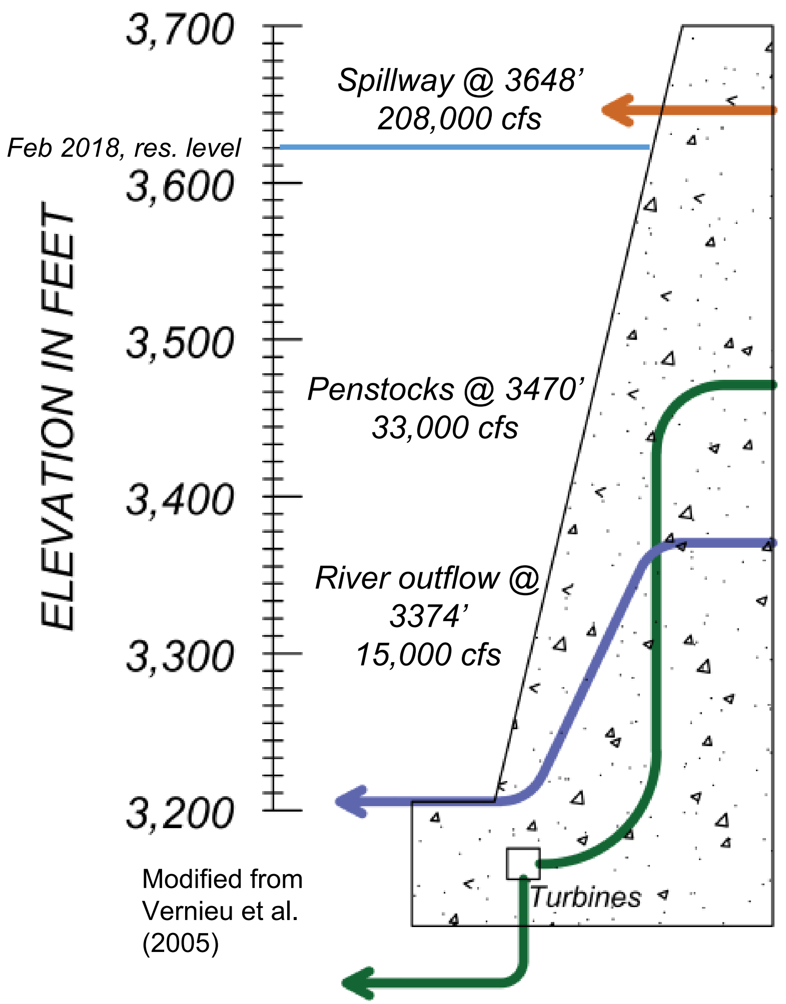
Goals of FLMF



Kellett (2013)

- First proposed by Glen Canyon Institute in 2013
- Identified 3 goals of the initiative:
  1. Save water by consolidating to one reservoir (300,000-600,000 AF/yr)
     - *Water losses associated with seepage and evaporation*
  2. Glen Canyon Recovery
     - *How does accumulated sediment affect Glen Canyon recovery*
  3. Colorado River restoration to pre-dam flows
     - *Is it possible to restore the Colorado river to pre-dam flows, and sediment regime*

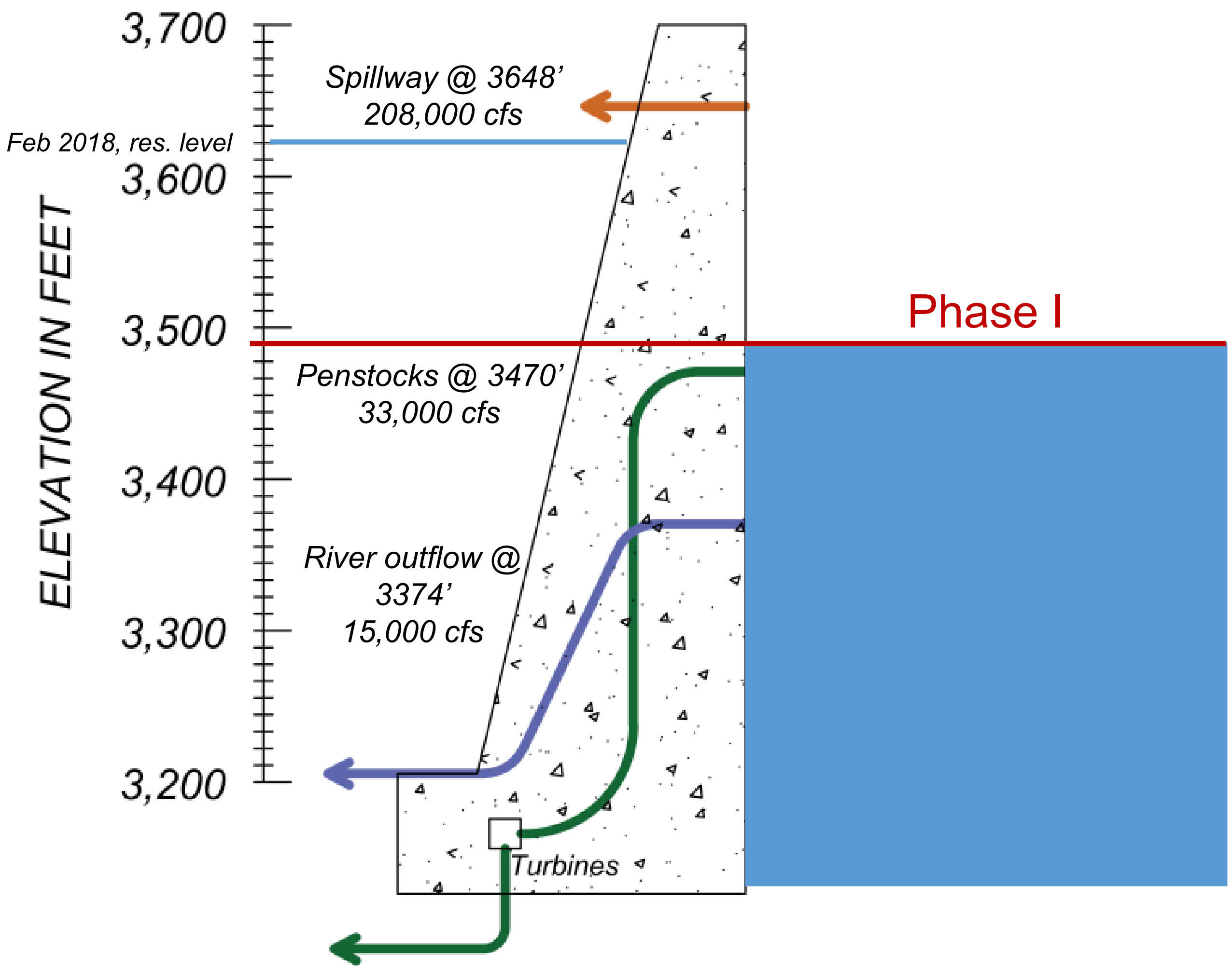
FLMF Implementation Details



Modified from Vernieu et al. (2005)

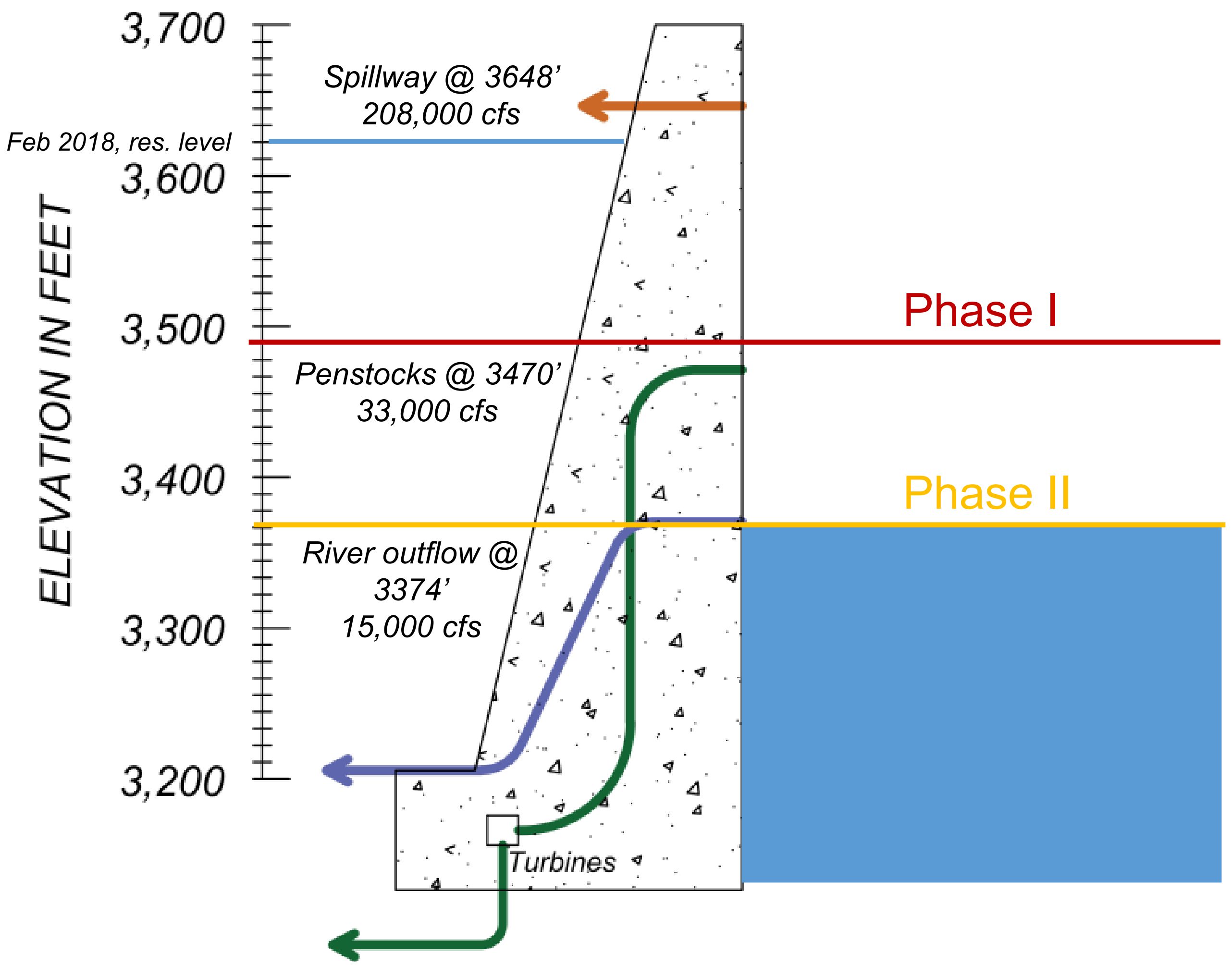
- Schmidt et al. (2016) summarizes the three stages of the FLMF
- Goal was to determine if the proposed plan would restore the Colorado river to a pre-dam flow regime

FLMF Implementation Details



- Phase I:
  - Water is lowered to Elevation, 3490’
  - Minimum power pool elevation
    - Only can release 45,000 cfs
    - Cannot release expected inflows in high flow (normal?) years

FLMF Implementation Details



- Phase II:
  - Water is lowered to Elevation, 3370'
  - Dead pool elevation
    - Only can release 15,000 cfs
    - Almost impossible to control reservoir elevation, and ***does not*** restore flows to pre-dam conditions

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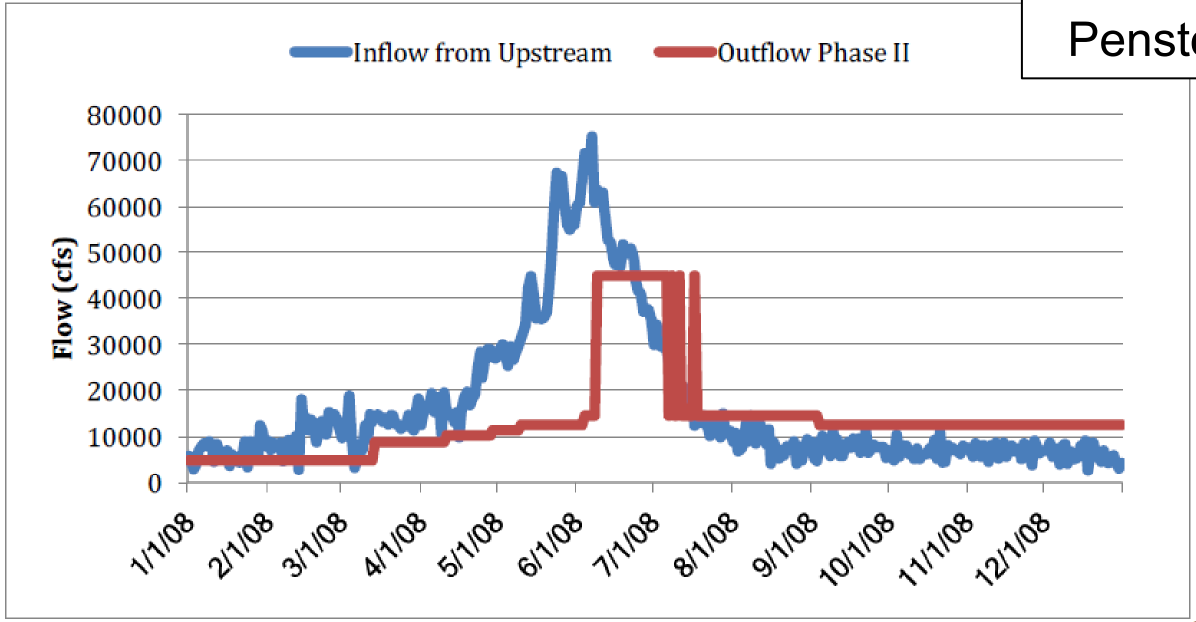
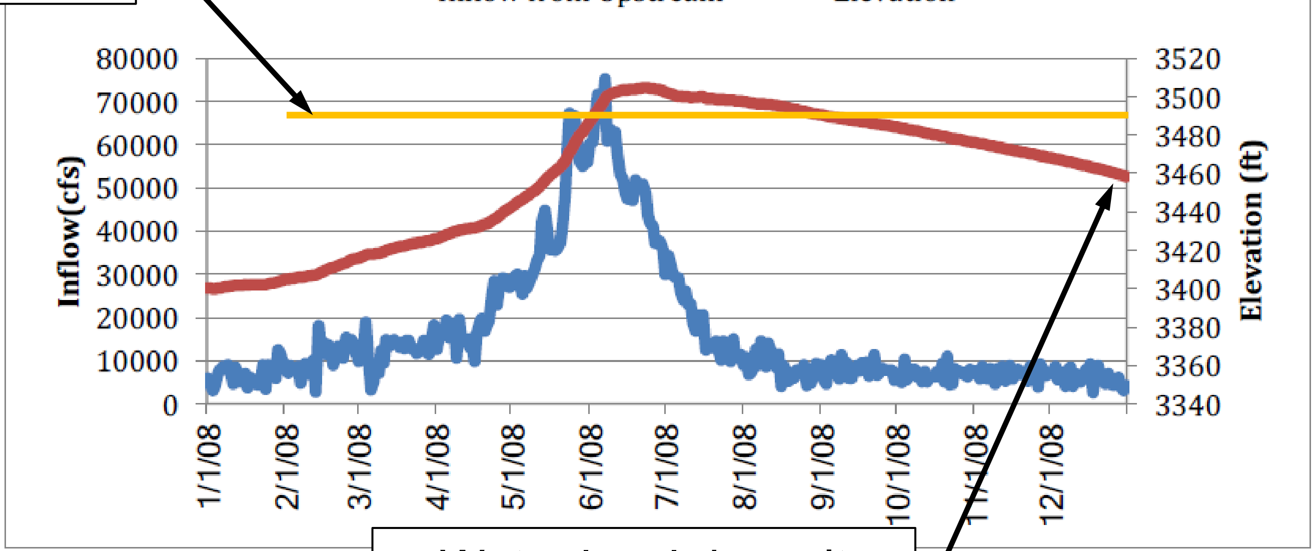
FLMF, Phase II

Capacity of will outflow will be quickly exceeded



Reservoir elevation will rise significantly

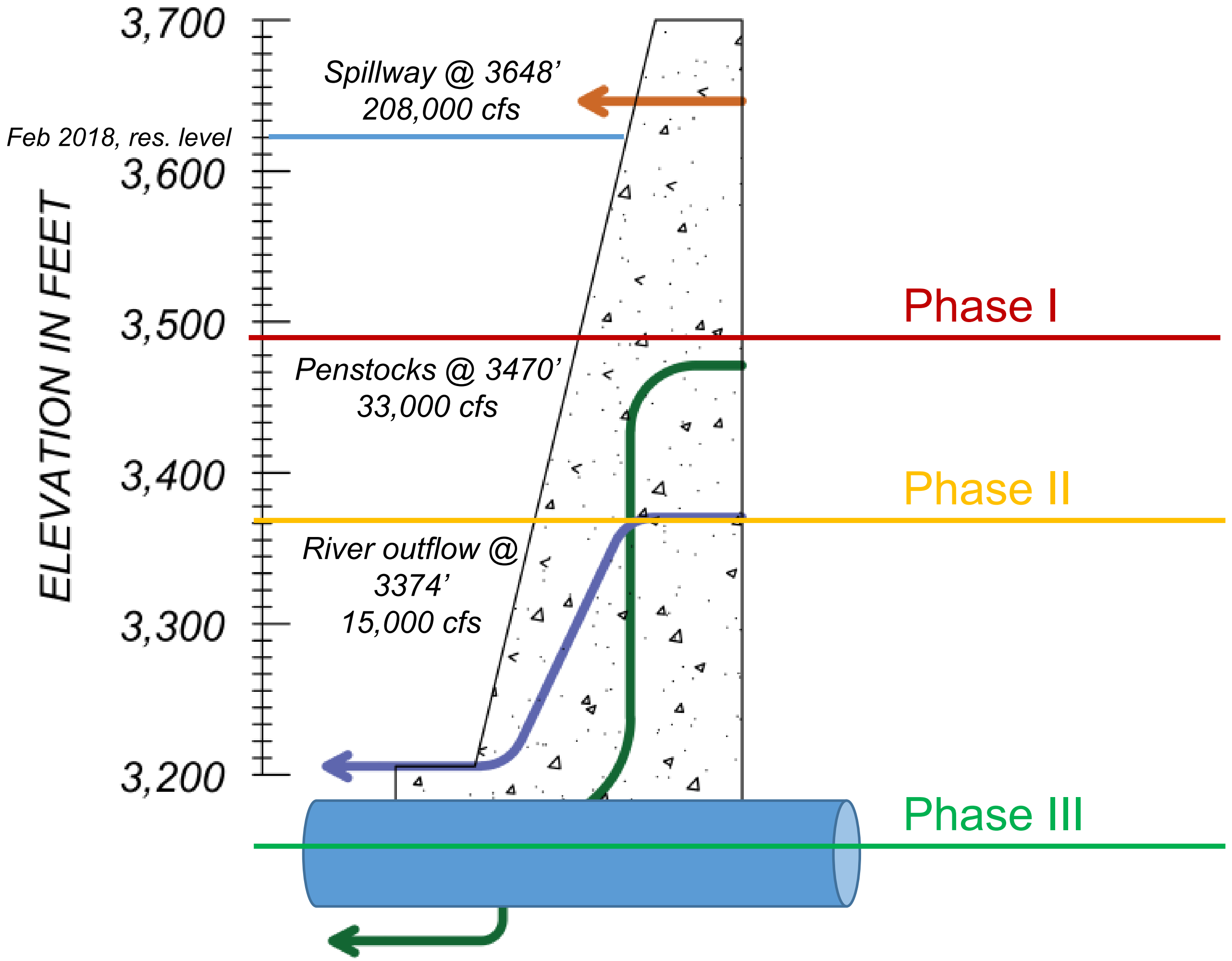
Water level reaches Penstocks



Water level doesn't reach starting elevation at year end

Schmidt et al. (2016)

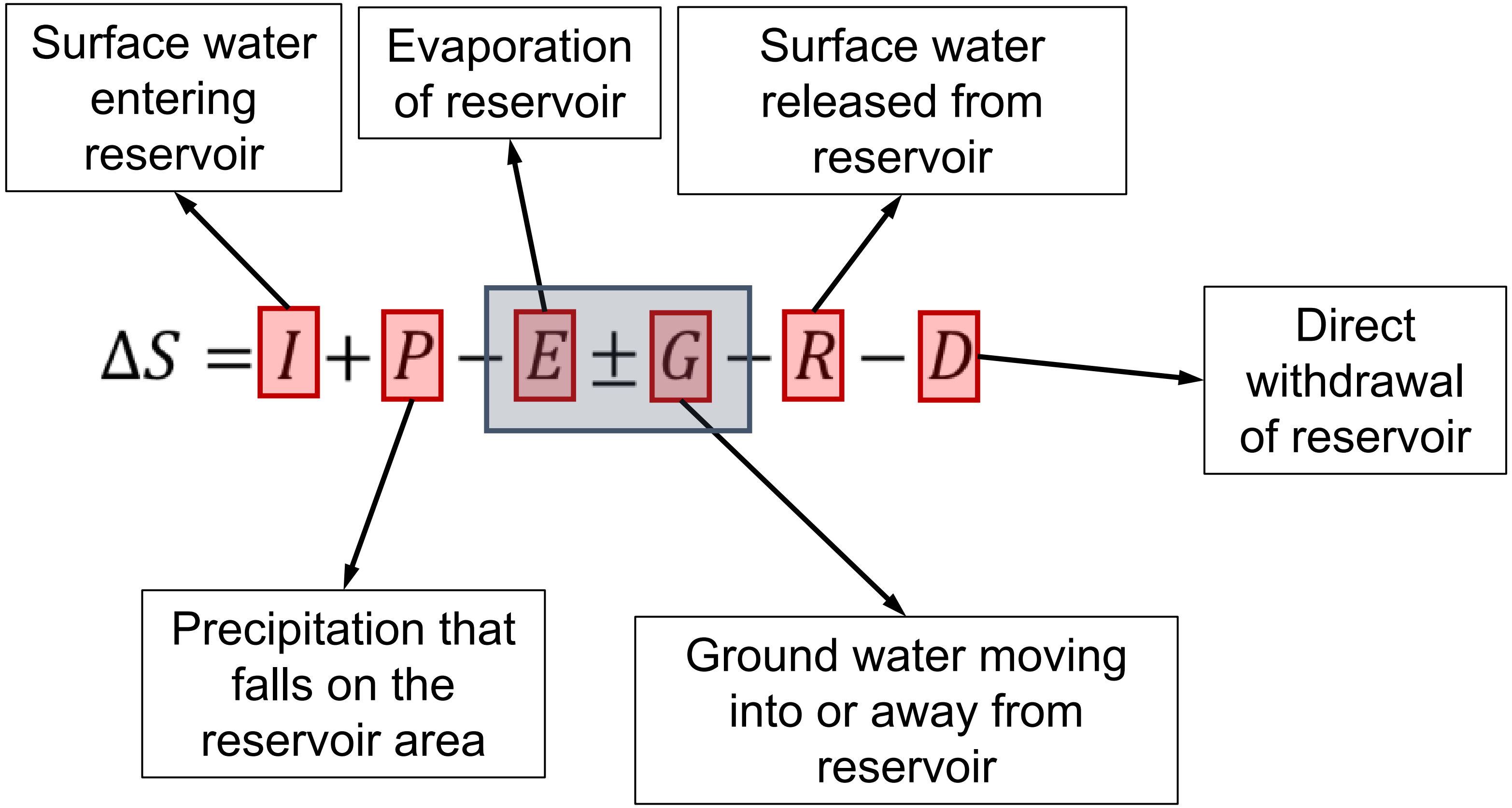
FLMF Implementation Details



- Phase III:
  - Diversion tunnels drilled, bypassing GCD
  - Pass expected peak flows
    - >25,000, 30,000, 50,000 cfs?
  - A 1978 USBR report concluded new tunnels would be costly

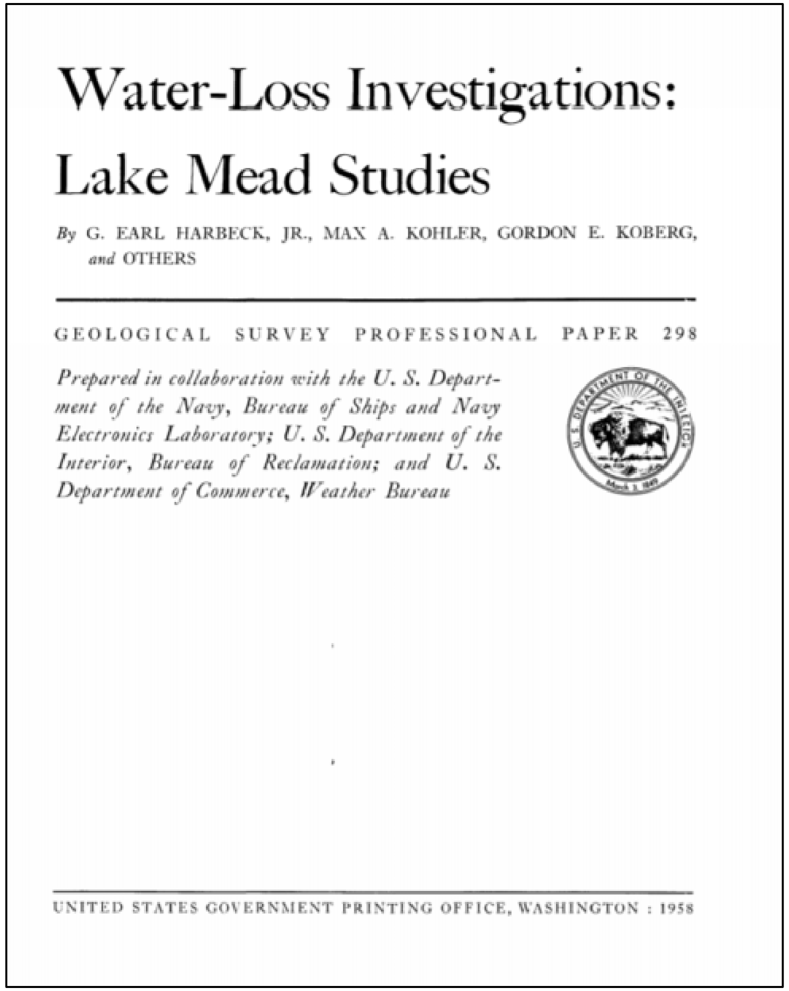
Water Loss of Lake Powell and Mead

- Change in reservoir storage (ΔS) can be expressed with a water budget



GCI: Estimated 300,000-600,000 AF/yr water saving

Water Loss: Evaporation



Water-Loss Investigations:

Lake Mead Studies

By G. EARL HARBECK, JR., MAX A. KOHLER, GORDON E. KOBERG, *and* OTHERS

GEOLOGICAL SURVEY PROFESSIONAL PAPER 298

Prepared in collaboration with the U. S. Department of the Navy, Bureau of Ships and Navy Electronics Laboratory; U. S. Department of the Interior, Bureau of Reclamation; and U. S. Department of Commerce, Weather Bureau

UNITED STATES GOVERNMENT PRINTING OFFICE, WASHINGTON : 1958

- Background:
  - Difficult to measure
  - Significant year-to-year variation

- Evaporation=(Surface Area)(Evaporation Rate)

- Multi-year studies have been conducted to determine the evaporation rates of both reservoirs

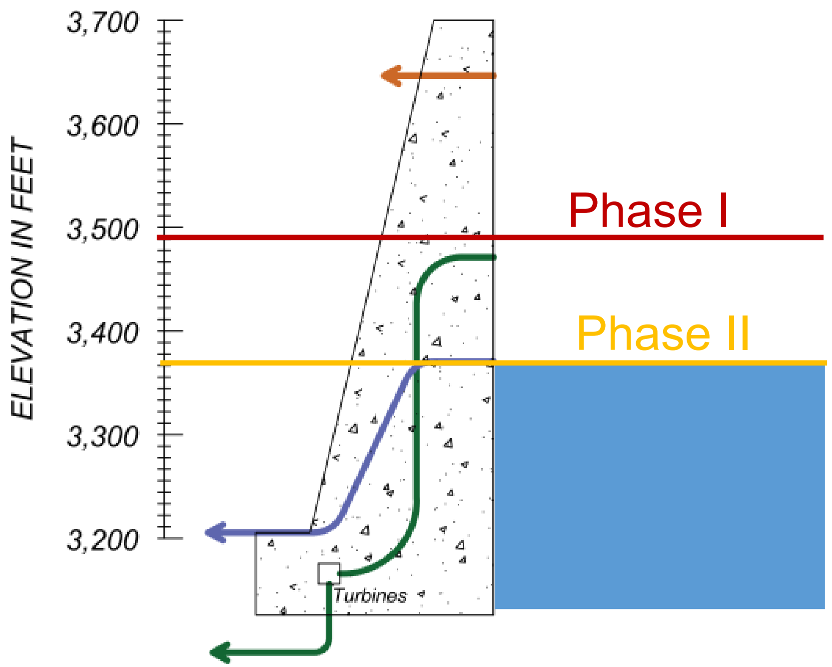
Water Loss: Evaporation

- Evaporation Rate Studies
- Lake Mead:
  - Anderson and Prichard (1951) = 5.3 ft/yr
  - Harbeck et al. (1958) = 7.1 ft/yr (in 1953)
  - Harbeck et al. (1958) = 7.0 ft/yr (1941-1953)
  - Westenberg et al. (2006) = 6.7 ft/yr (1953-1973)
  - Westenberg et al. (2006) = 7.5 ft/yr (1997-1999)
  - Lake Mead (2010-2015) most probable average annual rate = 6.2 ft/yr
- Lake Powell:
  - Jacoby et al. (1977) = 5.8 ft/yr (1962- 1975)
  - Reclamation (1986) = (using Jacoby et al. data) 5.7 ft/yr
  - Lake Powell (1965-1979) average annual rate = 5.7 ft/yr

Water Loss: Evaporation

- Schmidt et al. (2016) incorporating the uncertainty of measurements provided estimates of evaporation

Evaporation	Current	Phase I	Phase II
Lake Powell (AF)	570,000 (±80,000)	280,000 (±40,000)	120,000 (±15,000)
Lake Mead (AF)	560,000 (±40,000)	820,000 (±60,000)	870,000 (±70,000)
Total (AF)	1,100,000 (+200,000) (-100,000)	1,100,000 (±100,000)	1,000,000 (+100,000) (-200,000)



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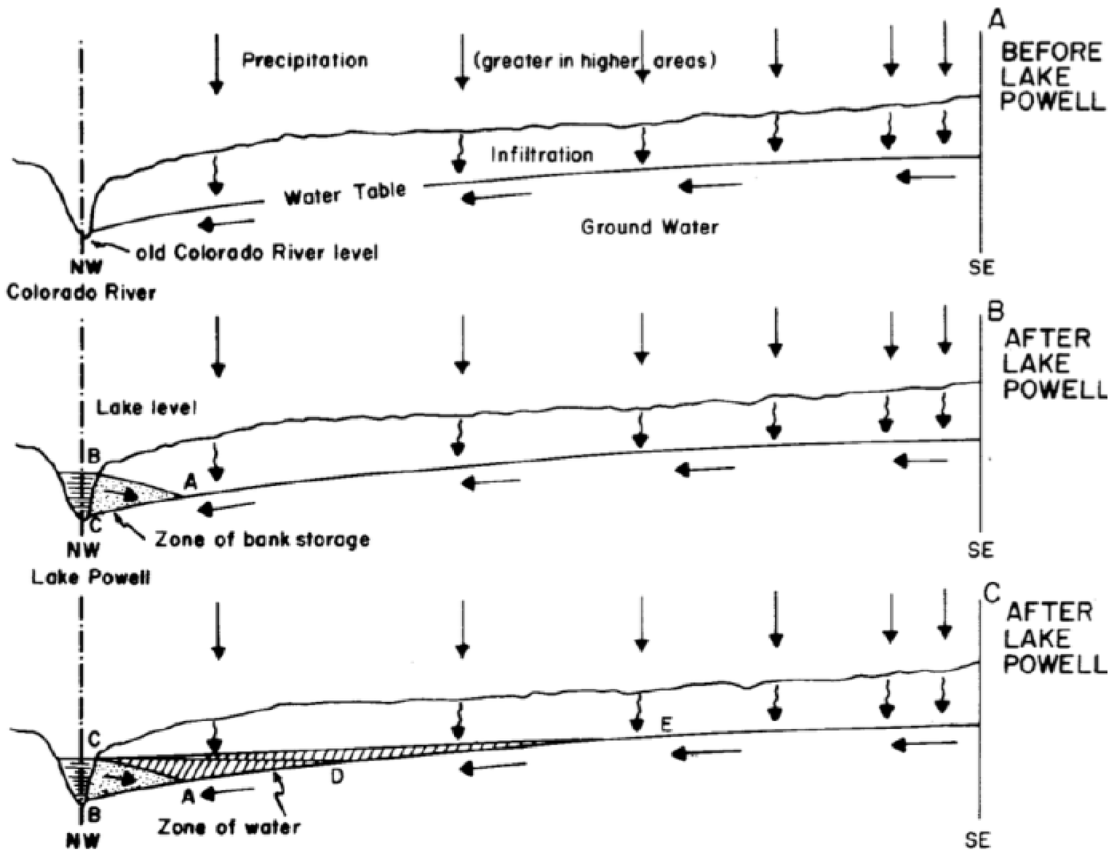
Water Loss: Seepage

- Background:
  - Porous (Navajo) sandstone beneath Lake Powell
  - Beneath Lake Mead is volcanic rock
- Lake Powell GW Studies:
  - Jacoby et al. (1977)
    - 0.85 MAF (1963-1966)
    - 0.69 MAF (1968-1971)
    - 0.68 MAF (1971-1976)
  - Thomas (1986)
    - 0.37 MAF (1963-1983)
    - 0.05 MAF (1983-2033)
    - 0.032 MAF (2033-2083)



Jacoby et al. (1977)

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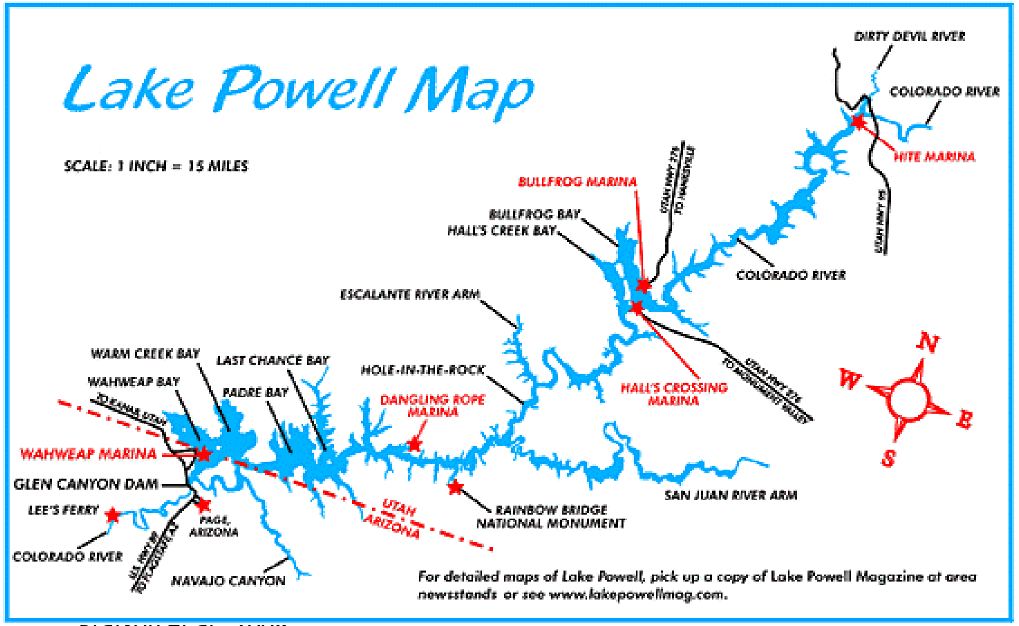
Water Savings of FLMF

- Best Estimate:
  - Evaporation (100,000 AF)+ Seepage (50,000 AF)= **150,000 AF**
  - It should be known that the best estimate contai[n]s uncertainty

- Glen Canyon Institute estimated a potential water savings of about 300,000-500,000 AF per year
  - Assumes similar evaporation rates
  - Estimates much larger seepage losses in Lake Powell

Damage to spillway following 1983 (USBR)

Glen Canyon Recovery: Sediment Remobilization



- No estimate of the amount of sediment flowing into Lake Powell
  - Topping et al. (2000) estimated that 54–60 million mt/yr was transported through Glen Canyon to Lees Ferry (1949-1962)
- Concern with Phase I and II is sediment will be remobilized closer to the dam, into Glen Canyon

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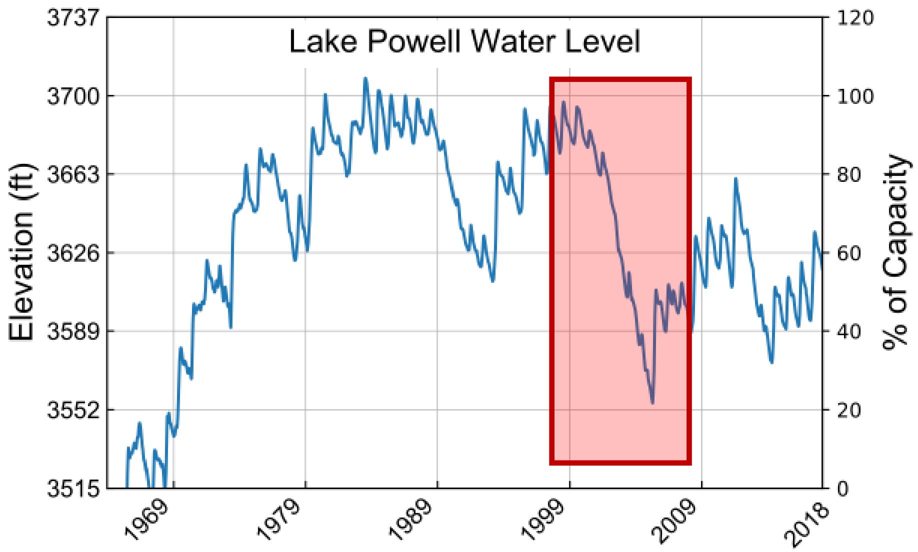
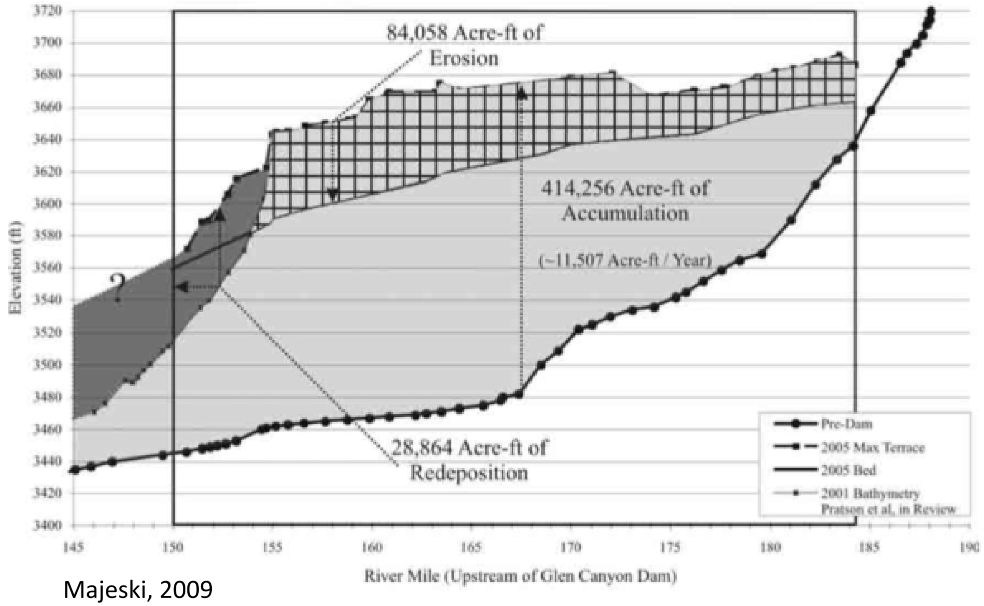
Sediment Remobilization

- Between 1999-2005 Lake Powell was lowered 55 m
- 84,000 AF sediment in the Colorado delta eroded.
  - 35% directly at the down of the delta, the rest much closer to the dam
- Similar conditions can be expected during drawdown of FLMF





Majeski, 2009

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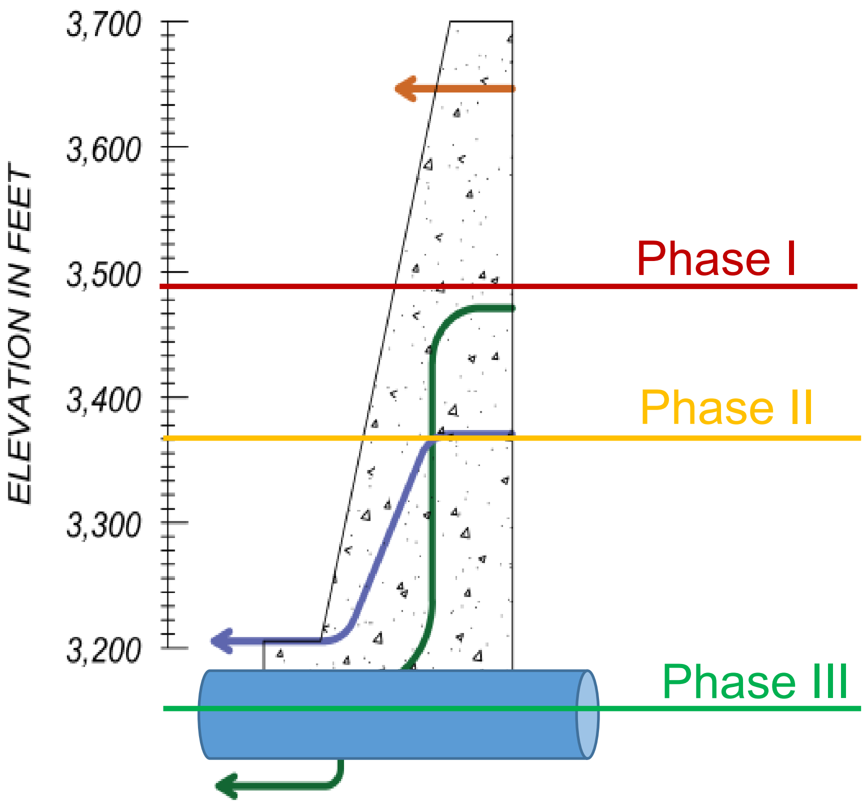
Ecological Concerns

- Only after Phase III is implemented would the river return to a natural flow regime
- The river would remain sediment deficient during Phase I and II
  - Under Phase III sediment will fill the Grand Canyon
- The river temperature would return to natural conditions in Phase II and III
- No known benefit or harm of native and non-native fish in the upper basin



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Conclusion and Policy Discussion

- FLMF would save approximately 150,000 AF
  - Seepage into the surrounding at Lake Powell will only decrease with time.
  - More data is always better
  - Does the 150,000 AF saving warrant an overhaul ~100 years of policy?

- Unless Phase III is implemented, the river, and sediment regime will not be restored to pre-dam conditions

- Sediment will remobilize into Glen Canyon under Phase I & II. Under Phase III it could take decades to clear all sediment

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Required Energy for Pumping

- 9.81 J to lift 1 liter of water 1 m
- Details:
  - Elevation difference between Hoover and Glen Canyon Dam, **775 m**
  - A 2012 USBR report estimated the **upper basin used 3.7 MAF** in 2010
- Total energy can be estimated:

$$\left[\frac{1000\ liters}{1\ m^3}\right]\left[\frac{9.81\ J}{1\ liter}\right][775\ m][3.7\ MAF]\left[\frac{1233\ m^3}{1\ AF}\right] = \mathbf{3.5 \times 10^{16}\ J}$$

$$[3.5\ \times 10^{16} J]\left[\frac{1\ kwh}{3.6\ \times\ 10^6 J}\right] = \mathbf{9.7\ Billion\ kwh > 9\ Billion\ kwh\ produced\ by\ the\ basin}$$