Glen Canyon Dam
Temperature Control Device

Engineering

Economics

Environment

Science

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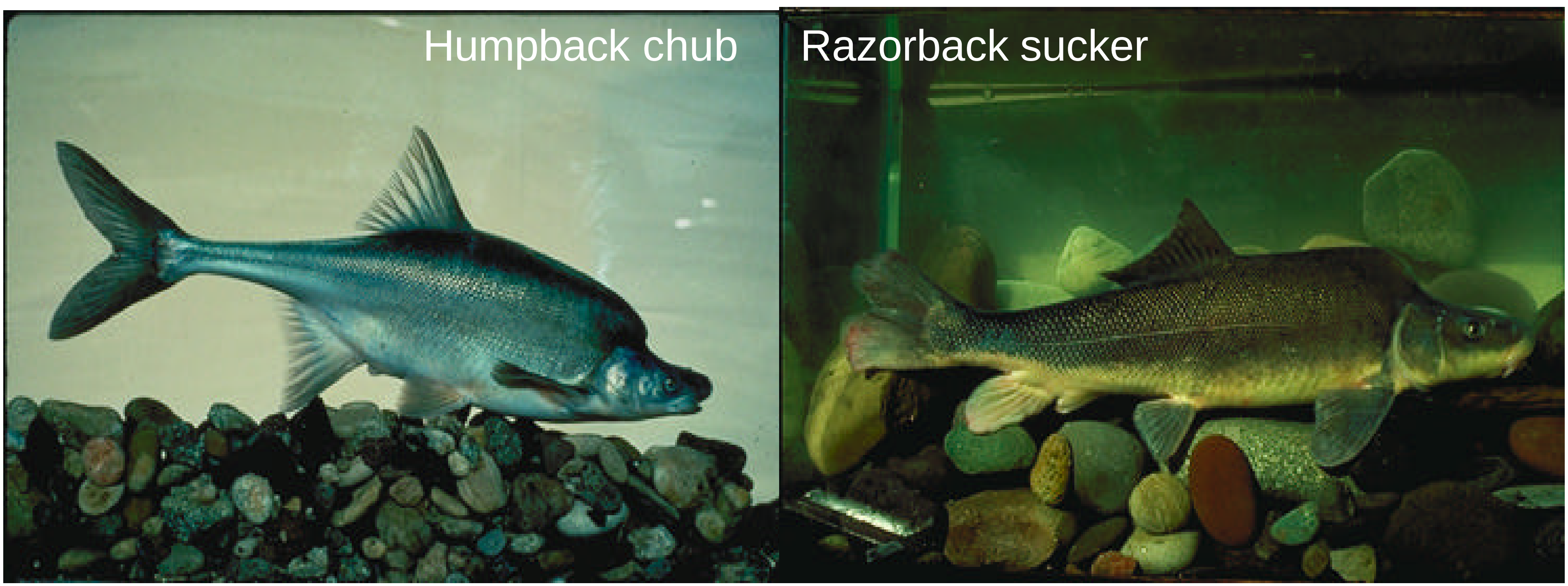
What do we Desire?

- To provide environmental conditions suitable for successful reproduction and recruitment of humpback chub in the Colorado River
- To do no harm to other important resources in the system

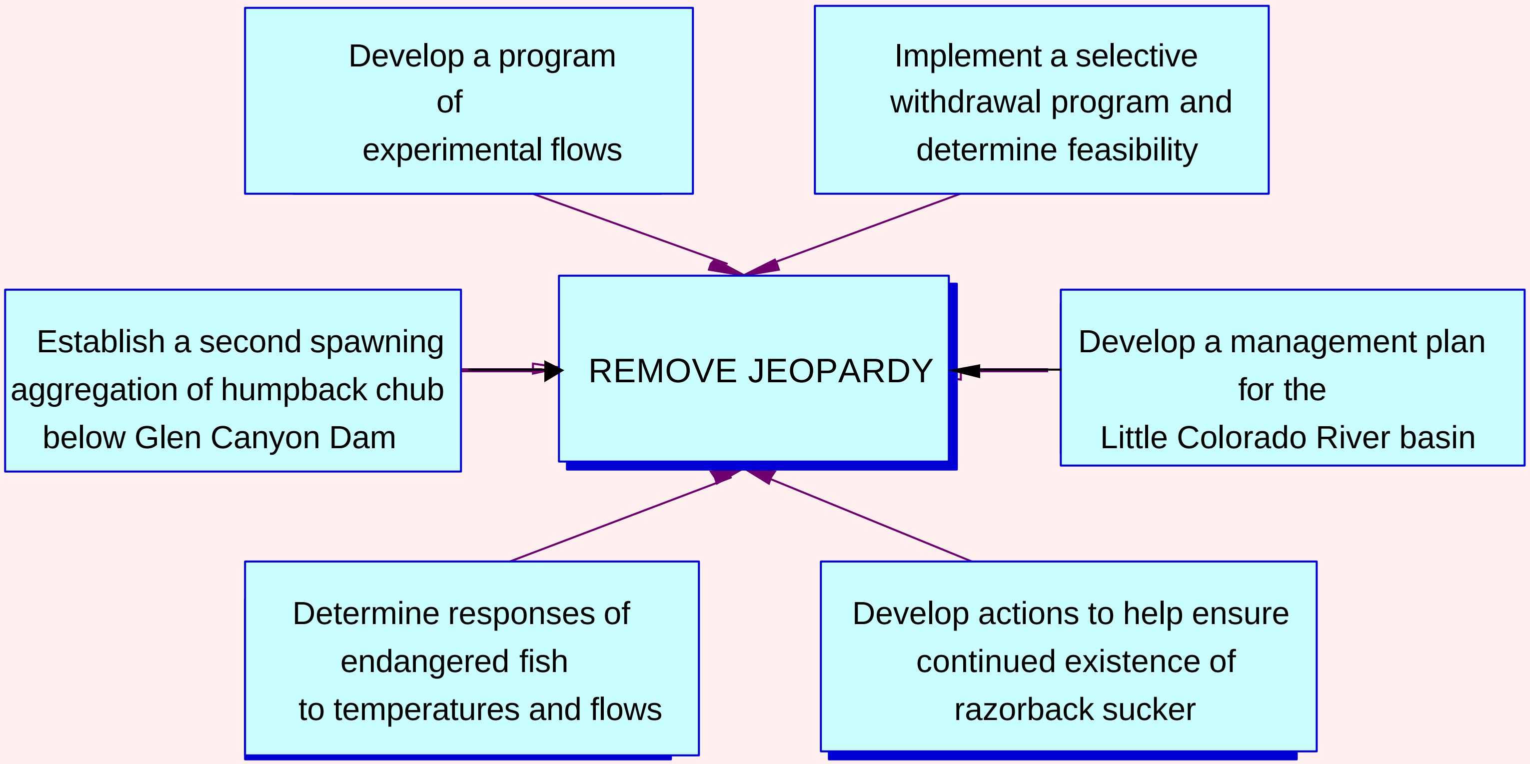
Biological Opinion on the Operation of Glen Canyon Dam

Fish and Wildlife Service

1995



Elements of the Reasonable and Prudent Alternative



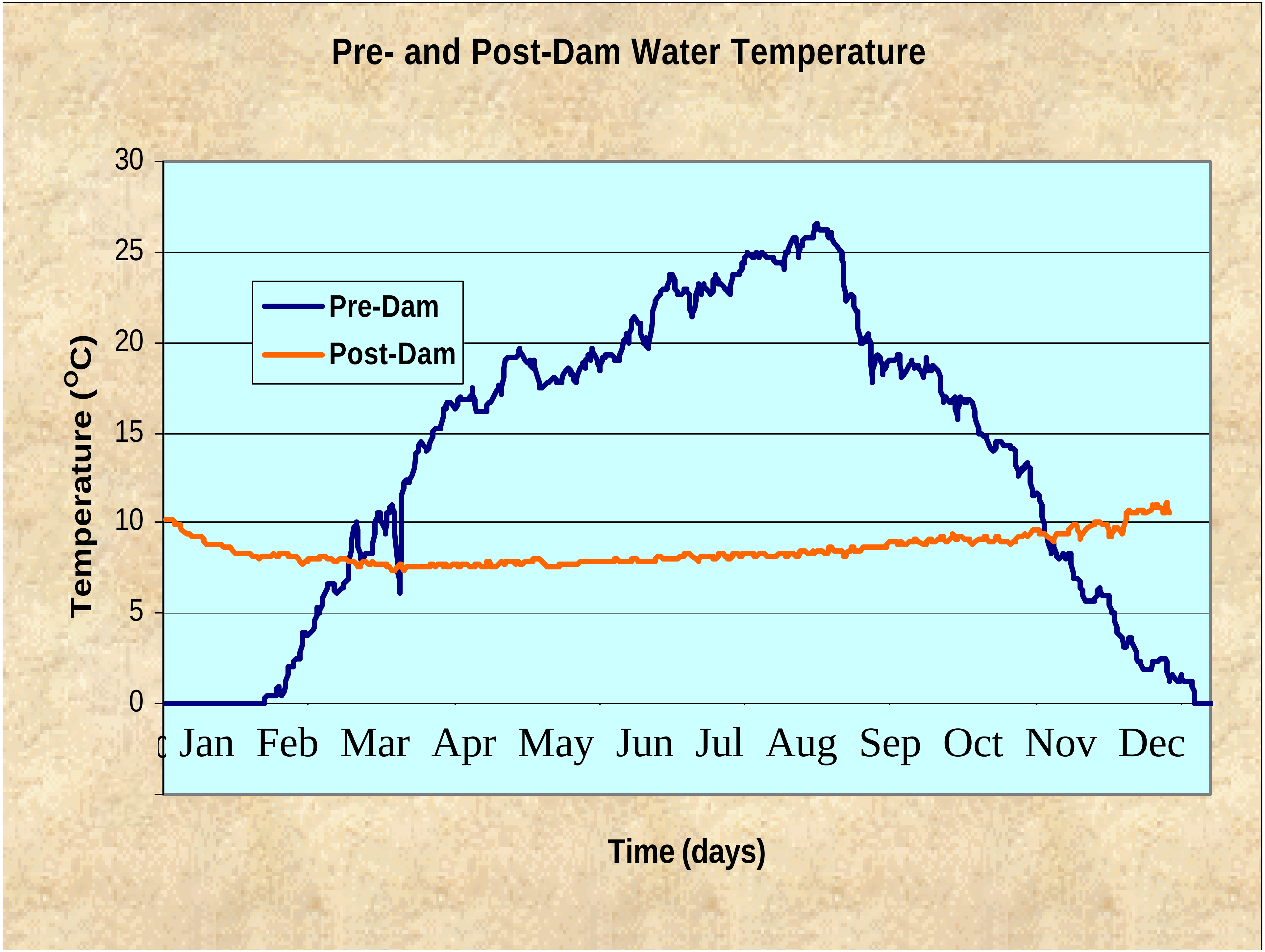
Other Threats to Endangered Fish in Grand Canyon

Existing exotic fish, parasites, and disease organisms

New invading exotic fish, parasites, and disease organisms

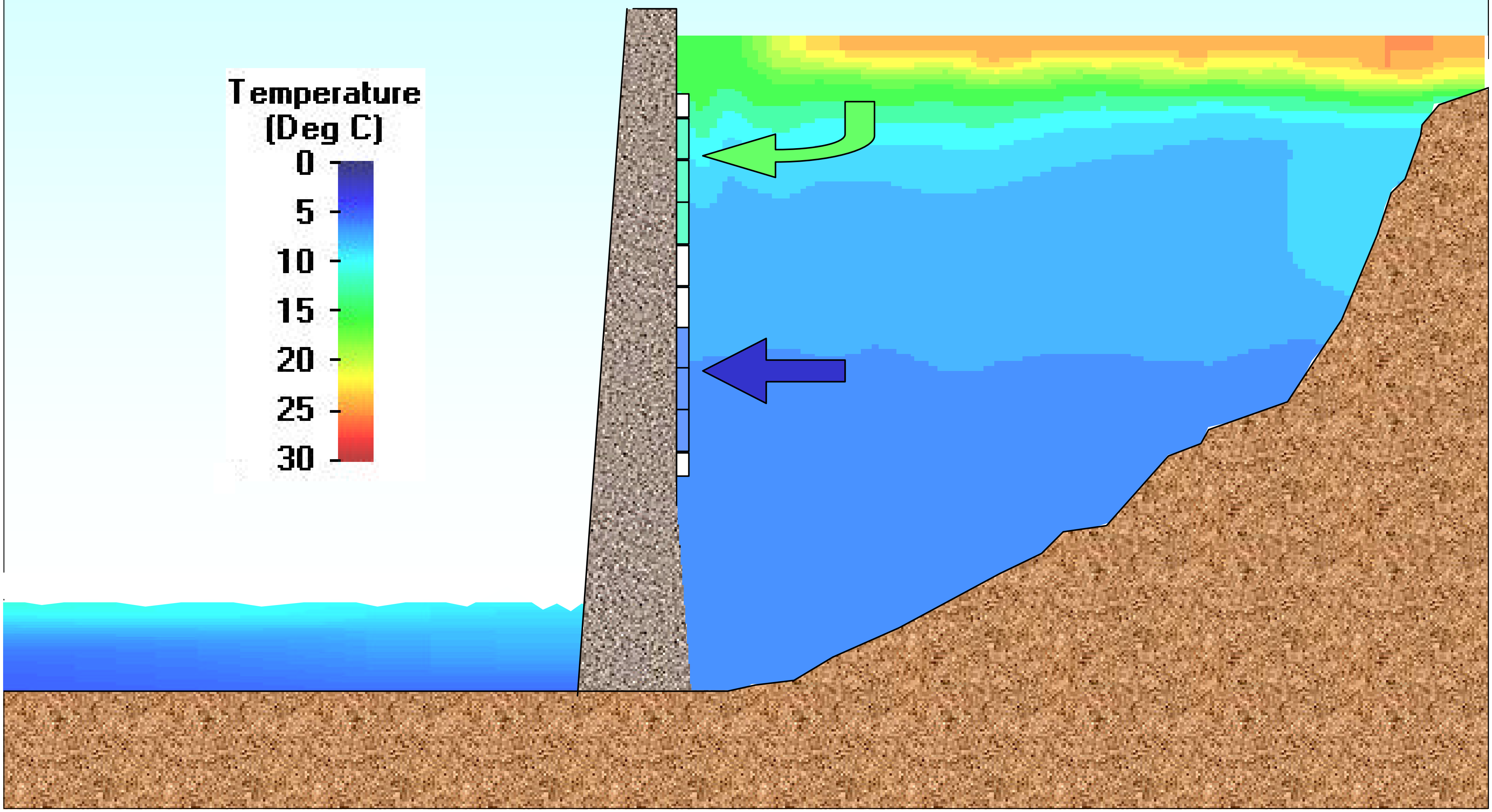
Surface water and groundwater diversions and depletions

Catastrophic events such as toxic spills

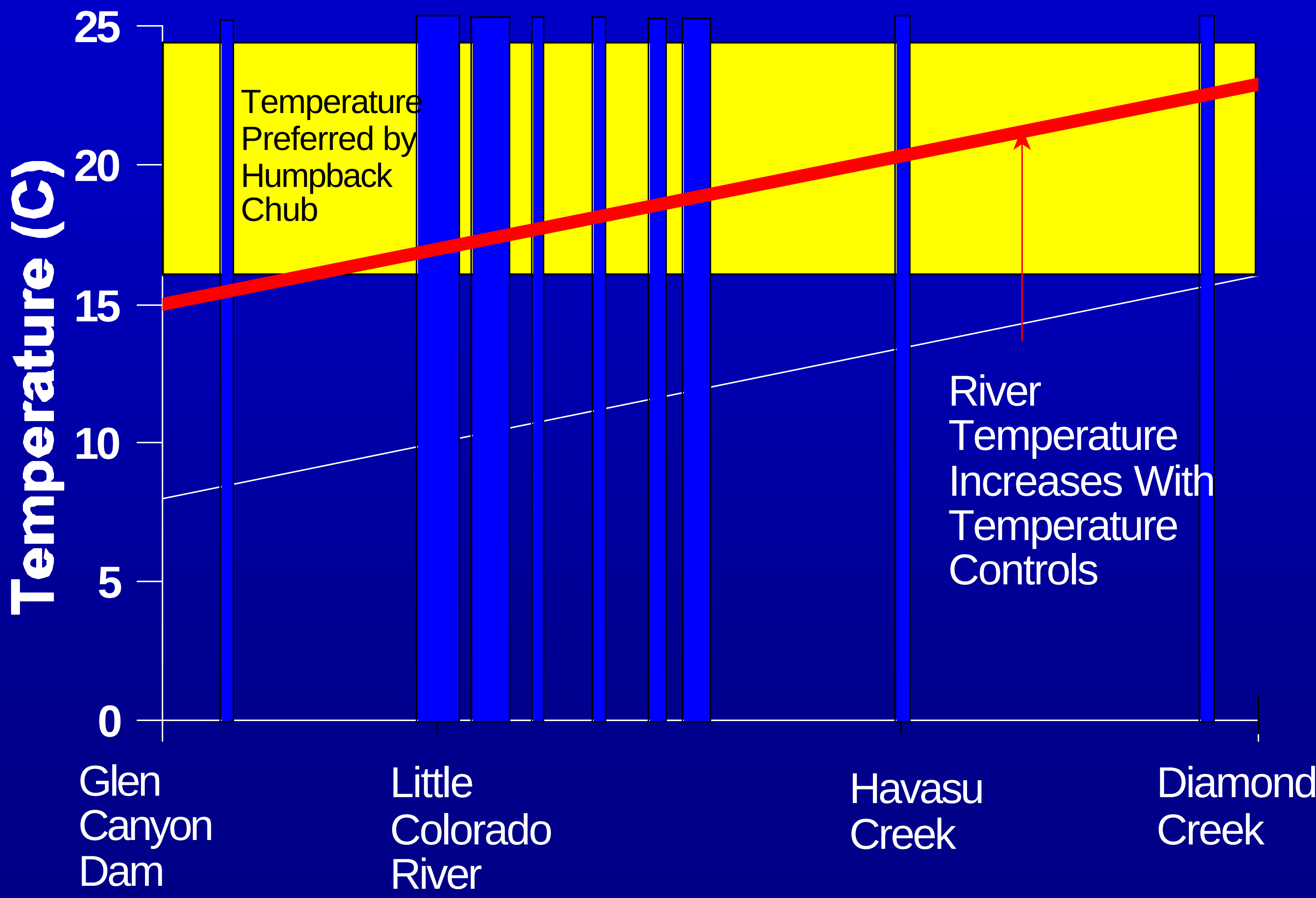


Pre- and Post-Dam Water Temperature
Pre-Dam
Post-Dam
Temperature (°C)
30
25
20
15
10
5
0
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Time (days)

Thermal Profiles in Lake Powell



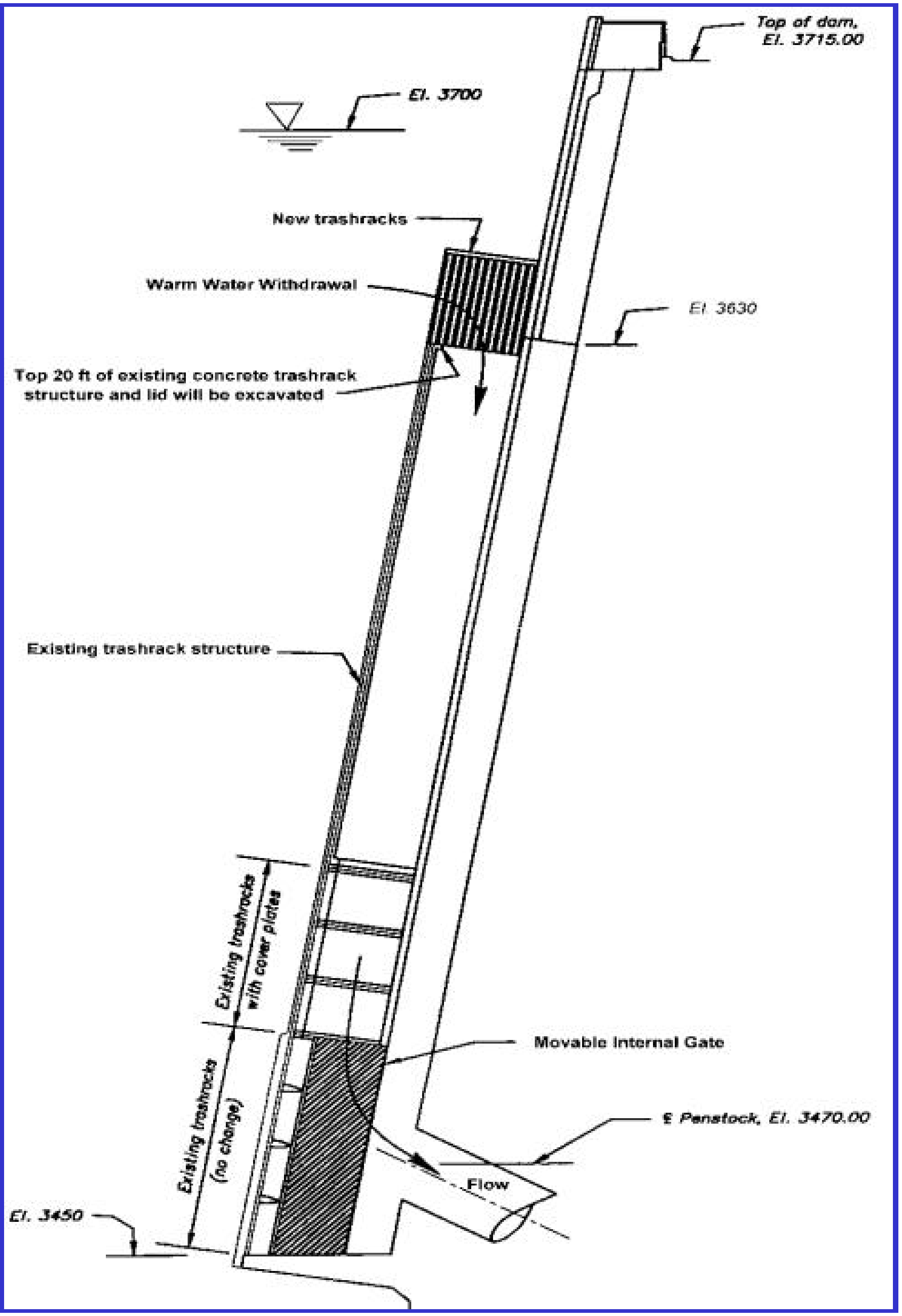
Conditions below Glen Canyon Dam with Controls

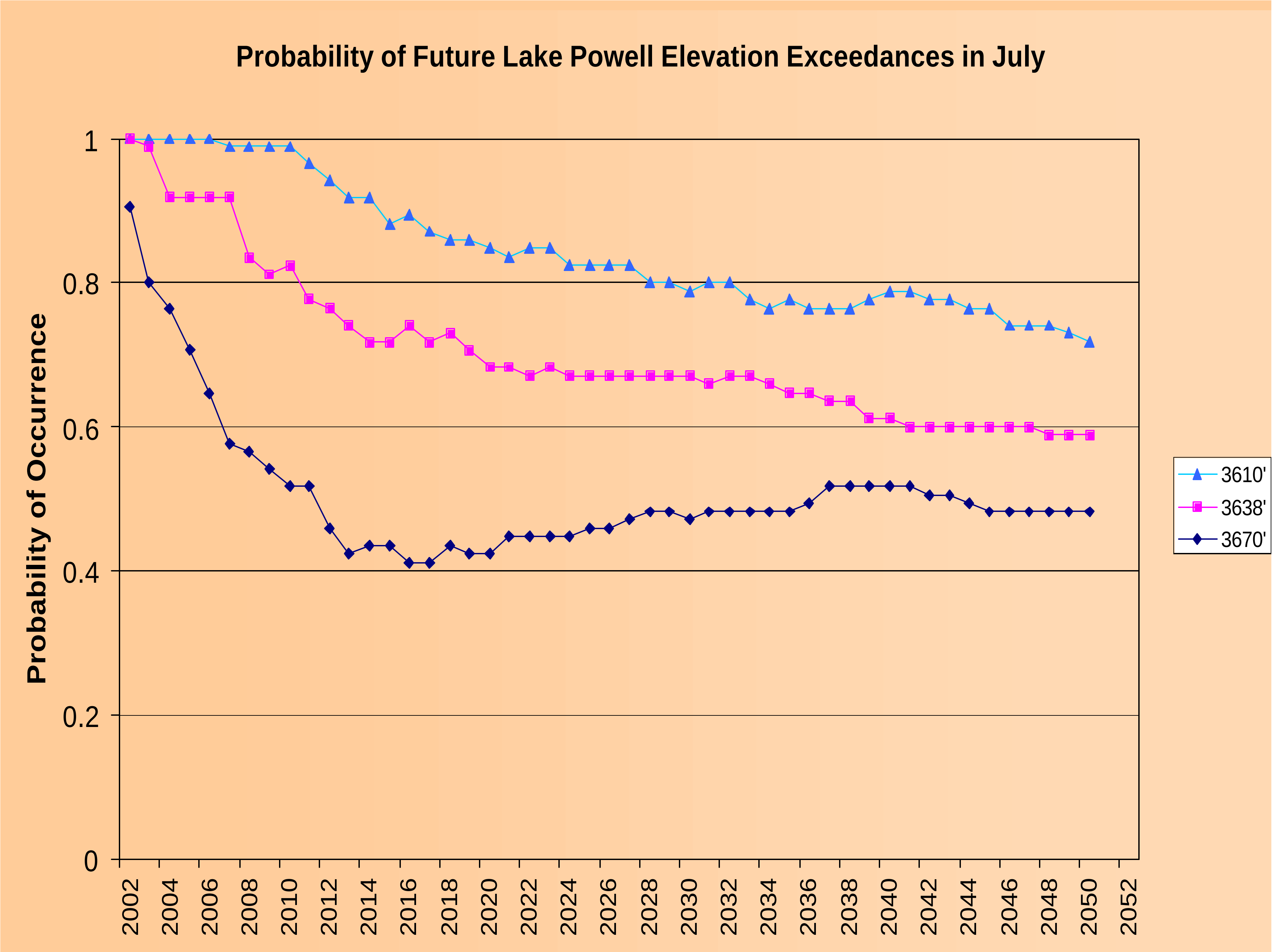


Uncontrolled Overdraw-Fixed Inlet

Overview

Operating Range/Minimum Reservoir Elevation: 30’/3670’



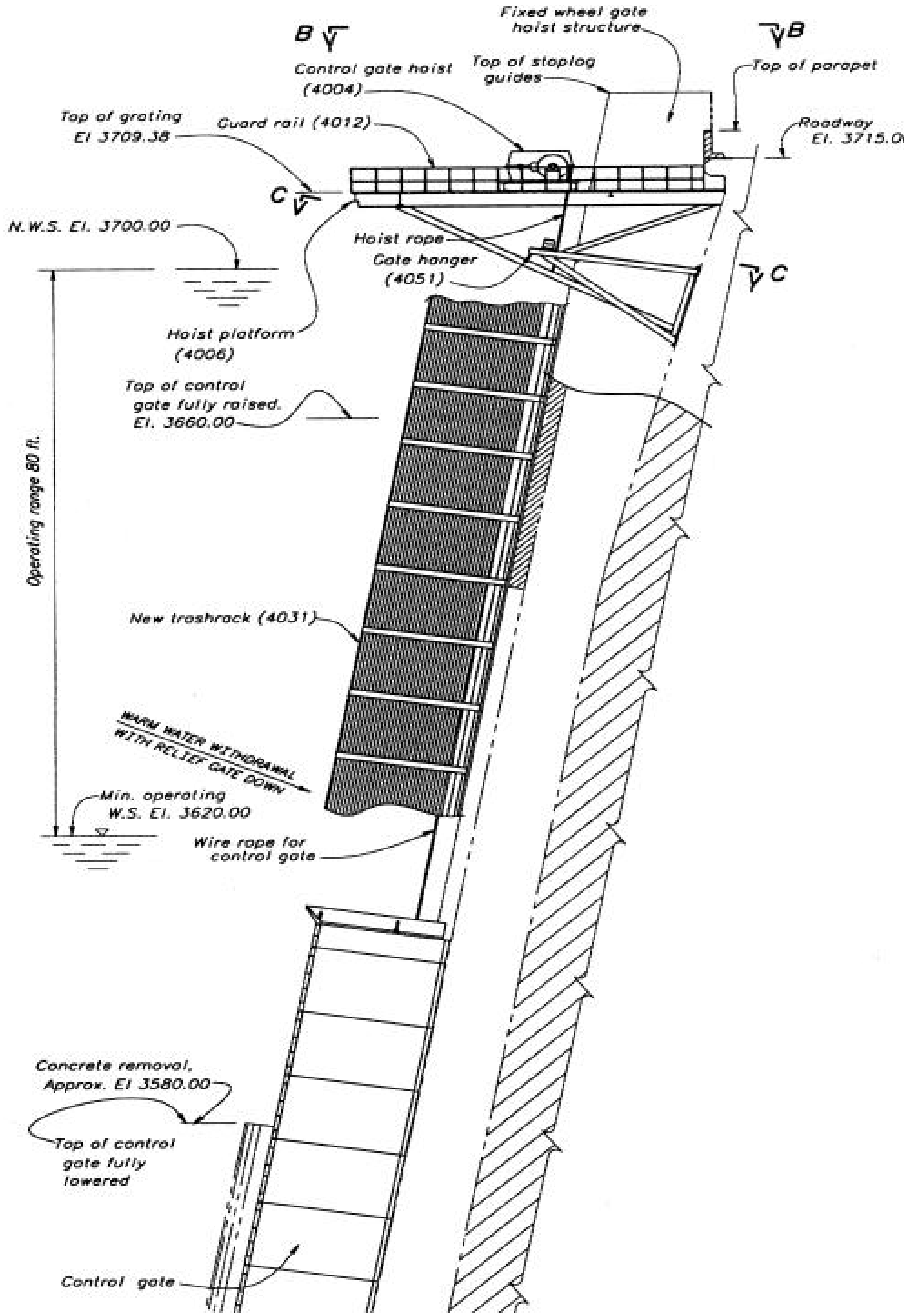


Probability of Future Lake Powell Elevation Exceedances in July
Probability of Occurrence
1
0.8
0.6
0.4
0.2
0
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
2024
2026
2028
2030
2032
2034
2036
2038
2040
2042
2044
2046
2048
2050
2052
3610'
3638'
3670'

Controlled Overdraw

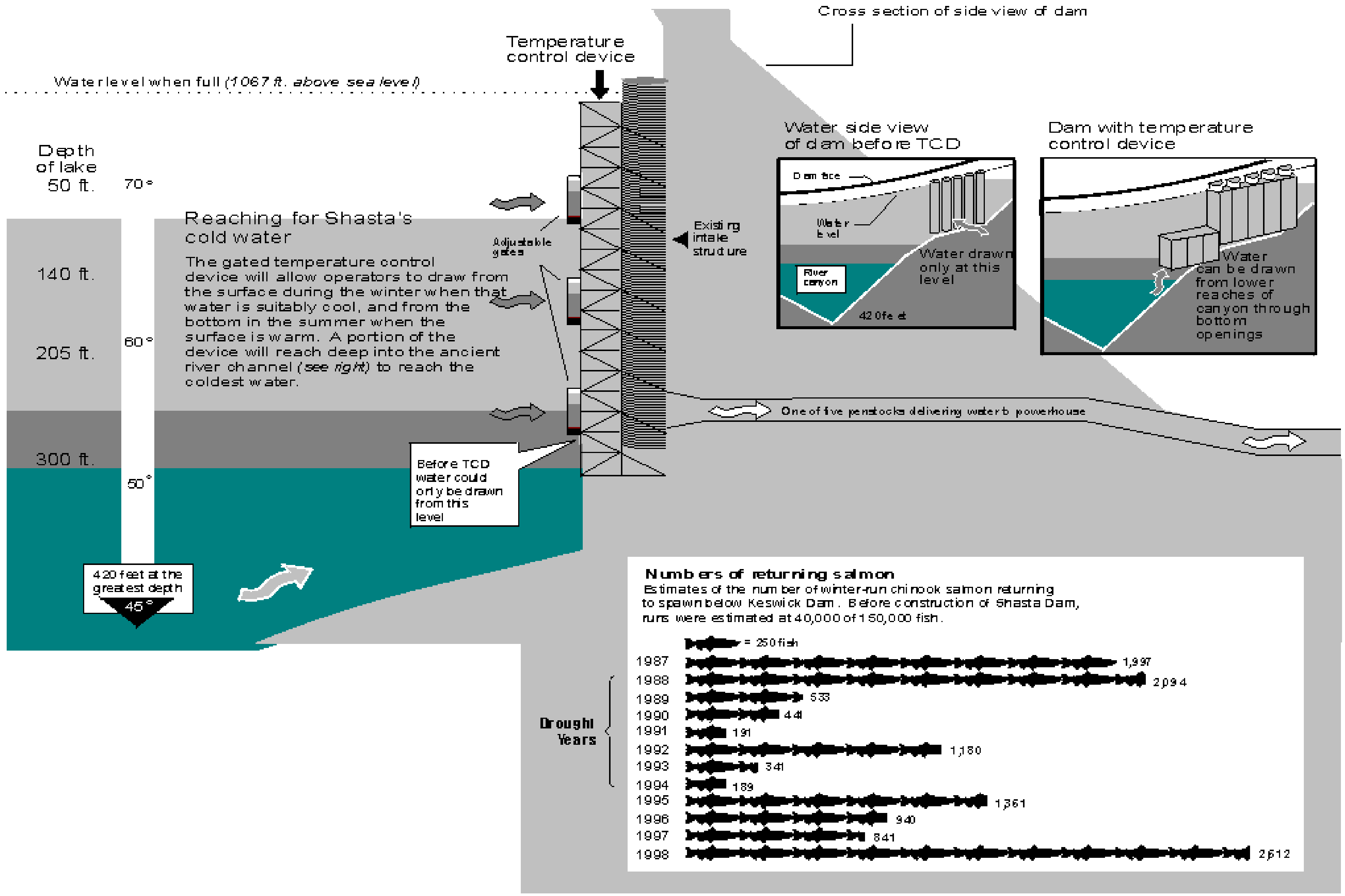
Overview

Operating Range/Minimum Reservoir Elevation: 100’/3600’



The Shasta Temperature Control Device (TCD)

allows water at selected temperatures to go through powerplant



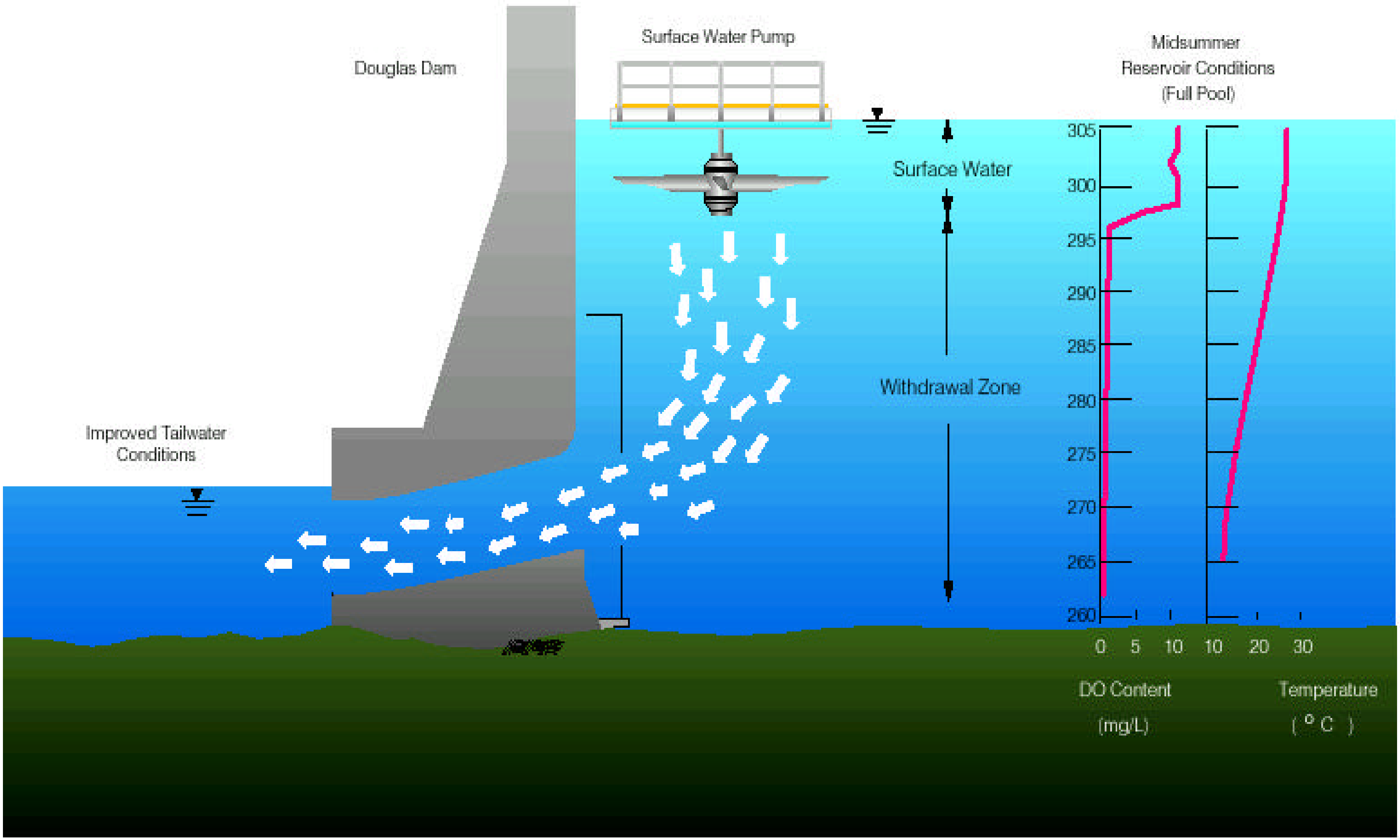


Figure 1. Schematic of Surface Water Pump Concept

Surface Water Pumps

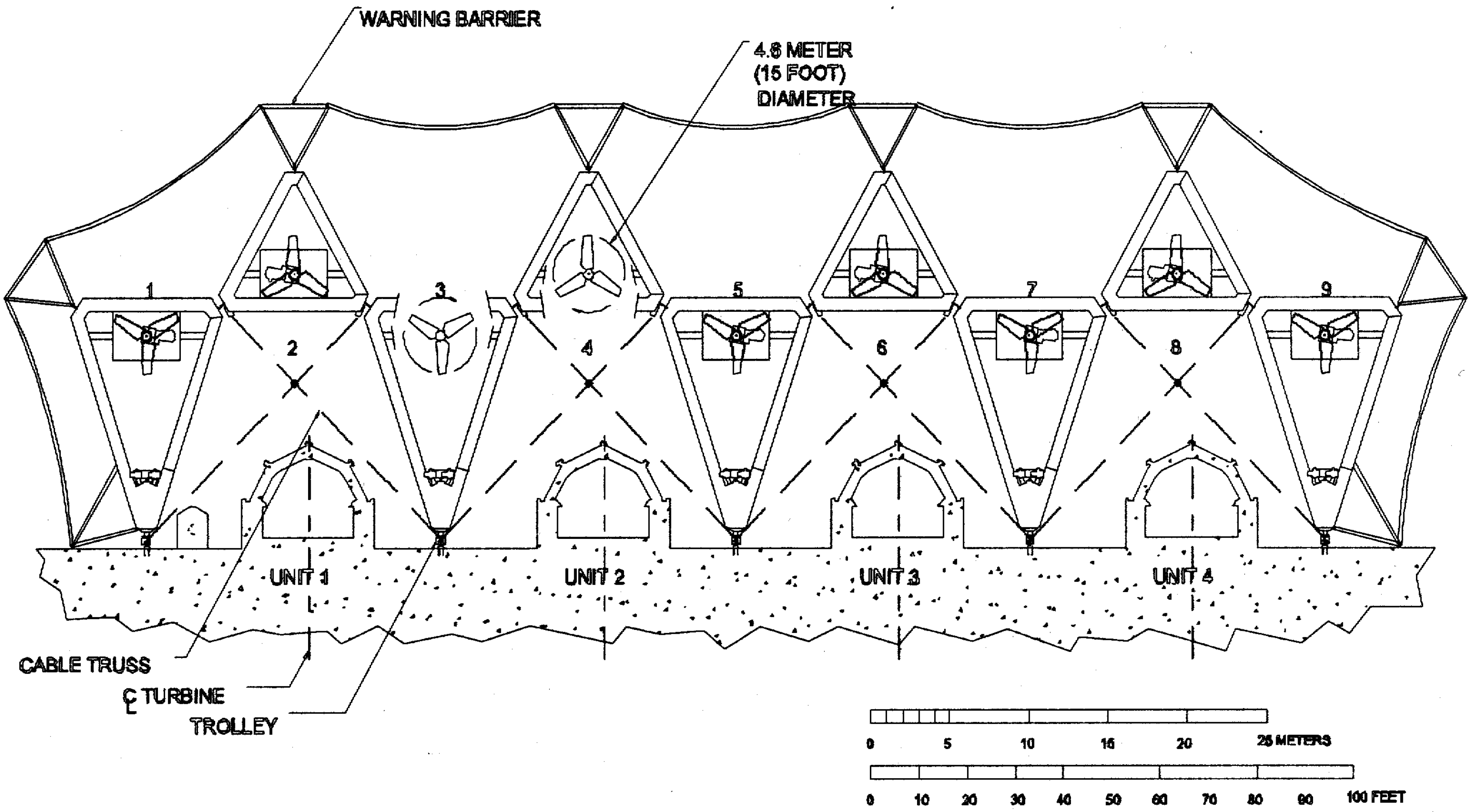
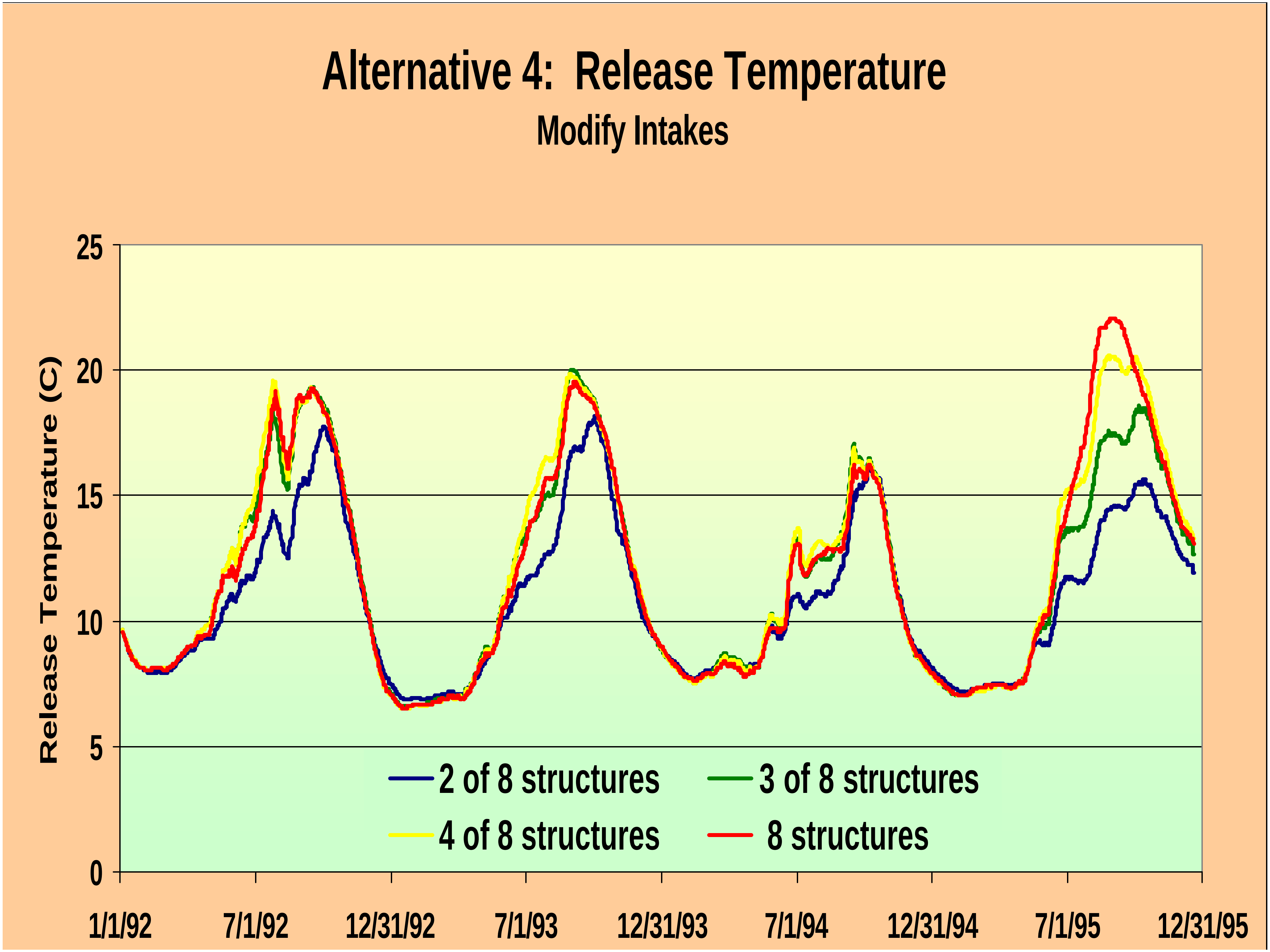


Figure 3. General Arrangement of Surface Water Pumps at Douglas Dam

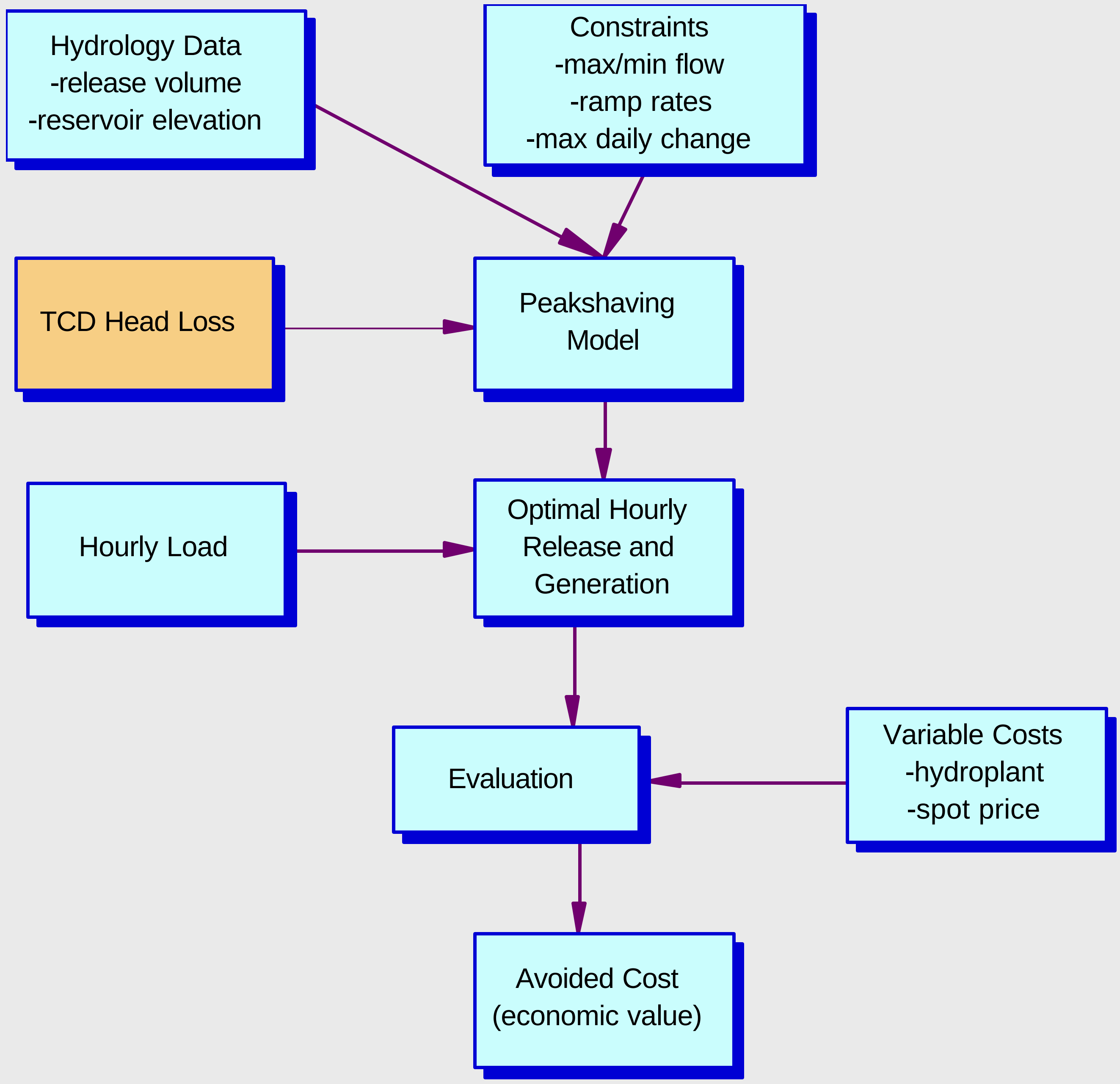

Alternative 4: Release Temperature
Modify Intakes
Release Temperature (C)
25
20
15
10
5
0
1/1/92
7/1/92
12/31/92
7/1/93
12/31/93
7/1/94
12/31/94
7/1/95
12/31/95
2 of 8 structures
3 of 8 structures
4 of 8 structures
8 structures

Alternative Temperature Control Device Options & Estimated Costs

Design option	Operating range (Min. op. W.S.***)	Construction cost	Add'l design time*	Construction time
Option 1 - Fixed inlet design (baseline)	30 feet (El.3670)	$13.5 M	2 months	24 months
Option 2- Controlled overdraw	80 feet (El. 3600)	$43.0 M (6/8 = $32 M)	15 months	33-35 months
Option 3 – External frame	100 feet (El. 3580)	$65.0 M (6/8 = $49 M)	18 months	24 months
Option 4 - Surface water pumps	150 feet	$9.9 M	10 months	12 Months

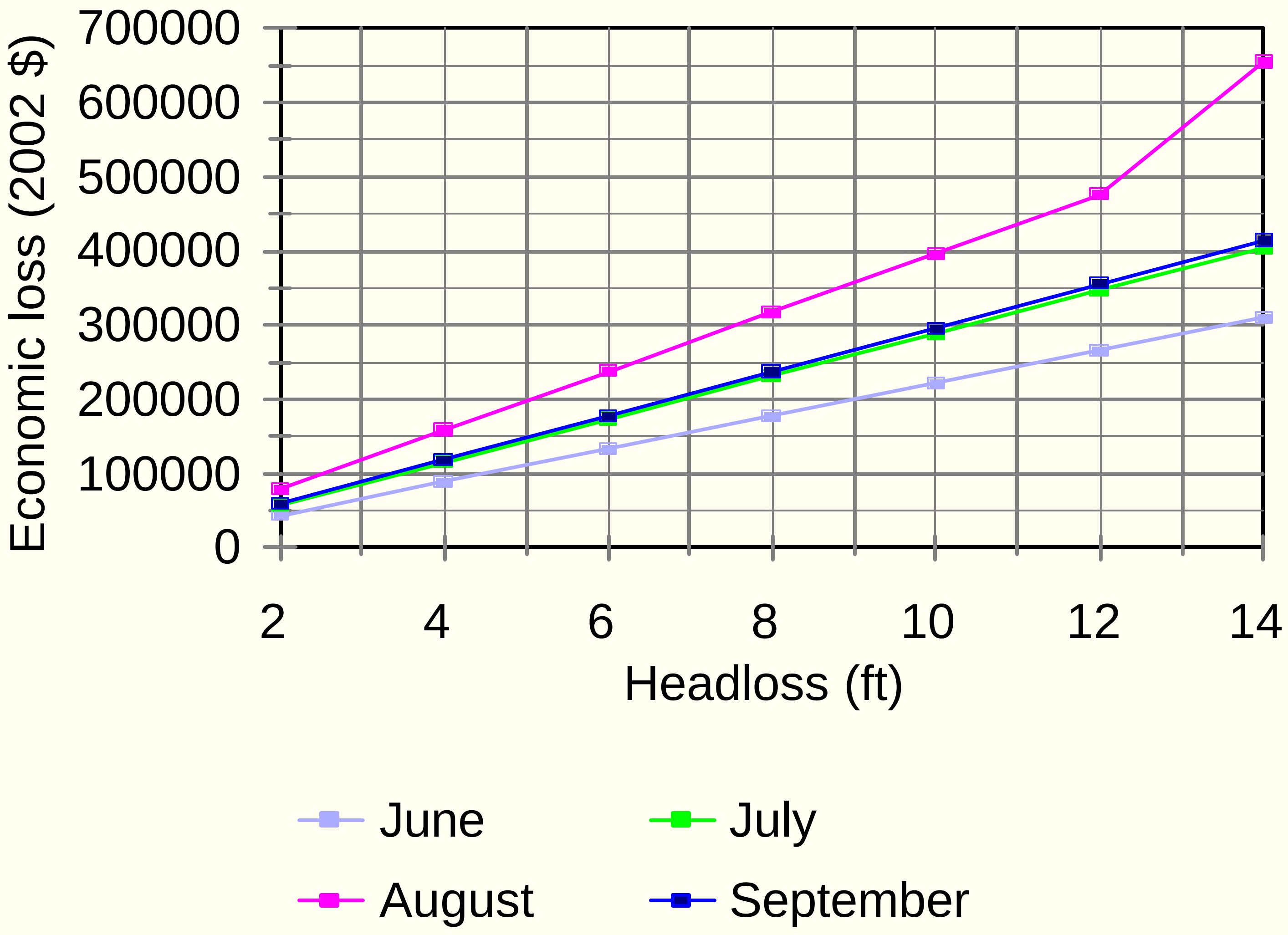
Operation and Maintenance Costs for Temperature Controls

Fiscal Year	Monitoring	O&M	Total
2000	$200,000	$100,000	$302,000
2001	$1,100,000	$100,000	$1,202,001
2002	$1,600,000	$100,000	$1,702,002
2003	$1,600,000	$100,000	$1,702,003
2004	$1,300,000	$100,000	$1,402,004
2005	$550,000	$100,000	$652,005



Source: Harpman, D.A. 1999. Land Economics 75(3):390-401.

Economic Loss vs Headloss

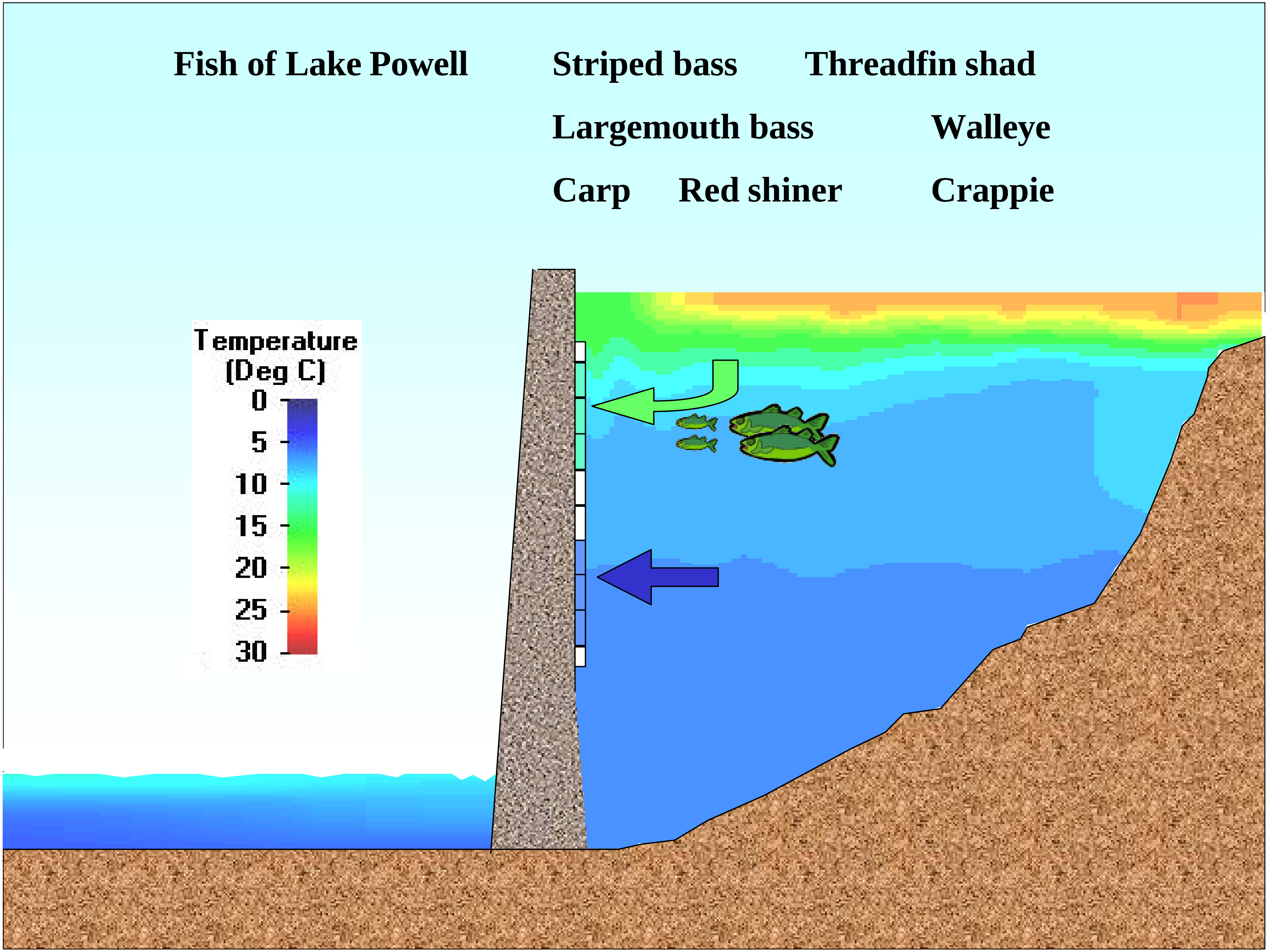


What Do We Know?

- Cold water temperatures restrict successful reproduction of humpback chub
- Cold water temperatures cause mortality of young humpback chub by thermal shock
- In the post-dam period, some non-native fish have been reduced, others have increased
- Primary productivity has increased dramatically in the tailwater

What Could go Wrong?

- We may entrain undesirable fish from higher levels in the reservoir and deliver them to the tailwater. Some will survive.

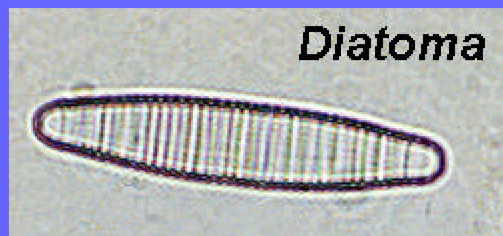

Fish of Lake Powell
Striped bass
Threadfin shad
Largemouth bass
Walleye
Carp
Red shiner
Crappie
Temperature (Deg C)
0
5
10
15
20
25
30

What Could go Wrong?

- Benthic algae and invertebrates that form the fish food base are adapted to constant, cold water temperatures. They may not be able to withstand cycling between warm and cold temperatures.

Aquatic Vegetation Colorado River

Cocconeis



Potamogeton

Oscillatoria

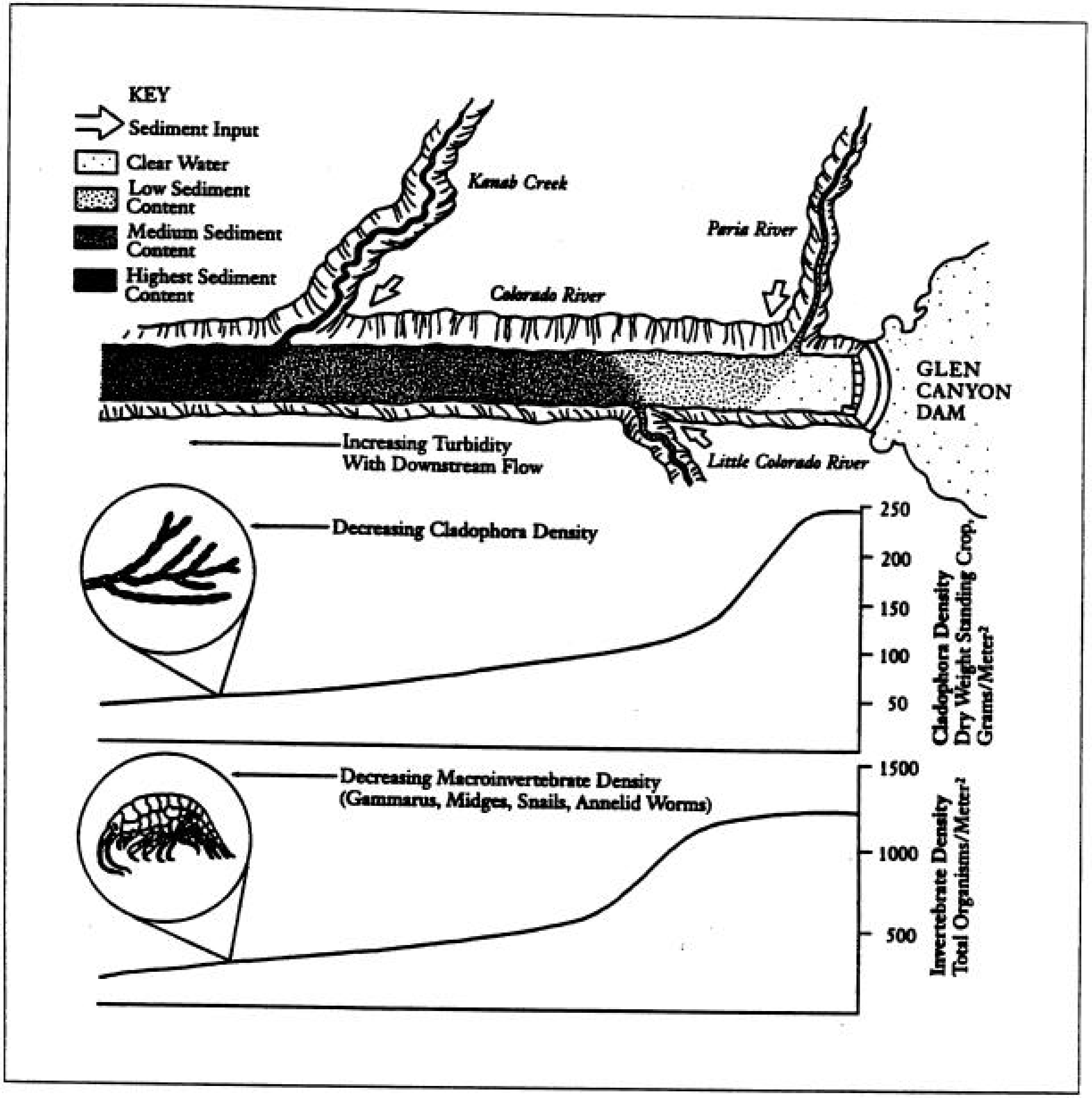


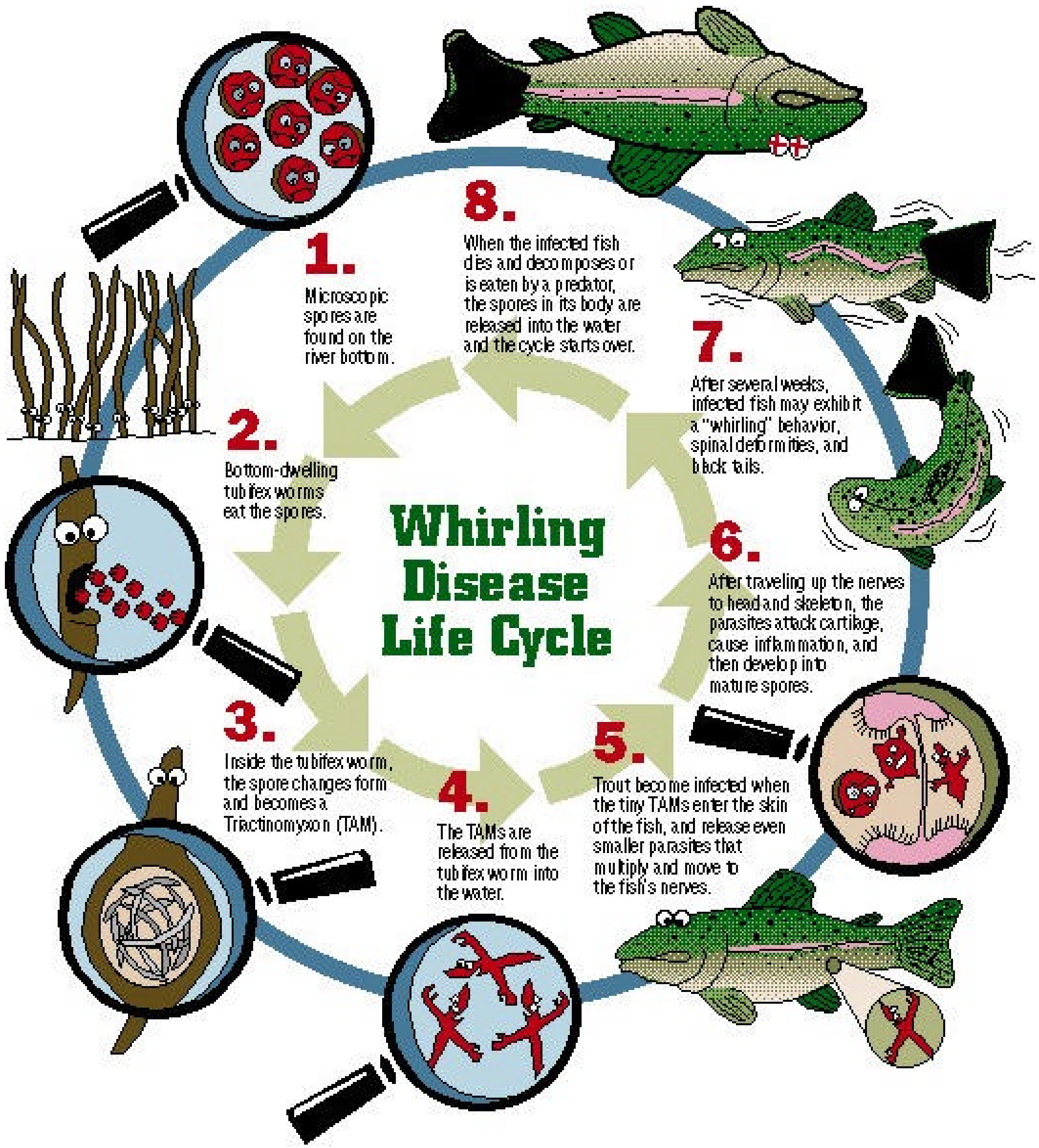
Figure 14. Longitudinal sediment concentration and biomass of *Cladophora* and macroinvertebrates in the Colorado River from Glen Canyon Dam to Diamond Creek (Source: Carothers and Brown 1991).

What Could go Wrong?

- Cold water temperatures suppress important diseases, parasites, competitors, and predators of the native fish
- Therefore, warming the water could result in negative impacts to native fish, including the endangered humpback chub

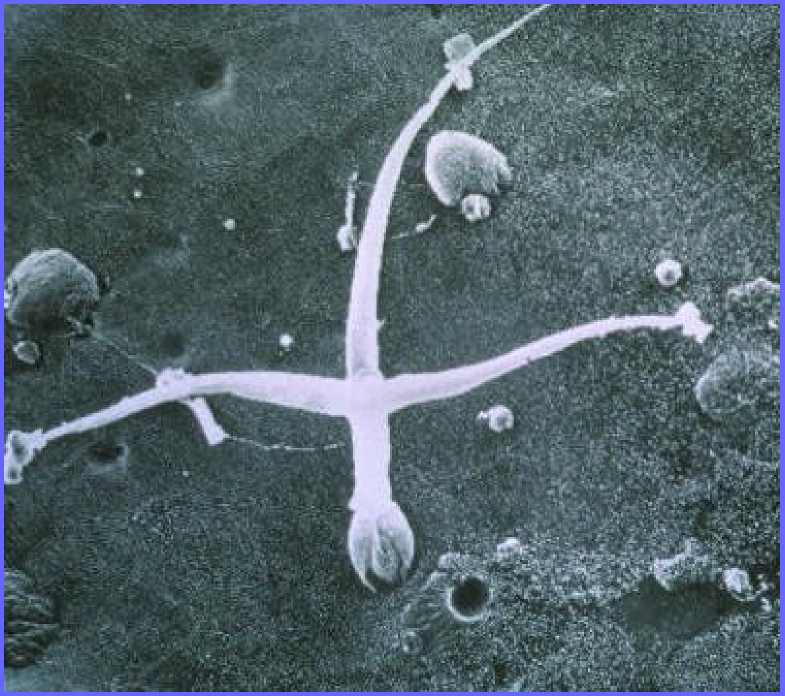
Life Cycle of Whirling Disease

Whirling Disease poses a serious threat to New Mexico's trout population. To prevent the spread of this disease it is helpful to understand its life cycle.



Intermediate Host & Infective Stage
Whirling Disease

Tubifex



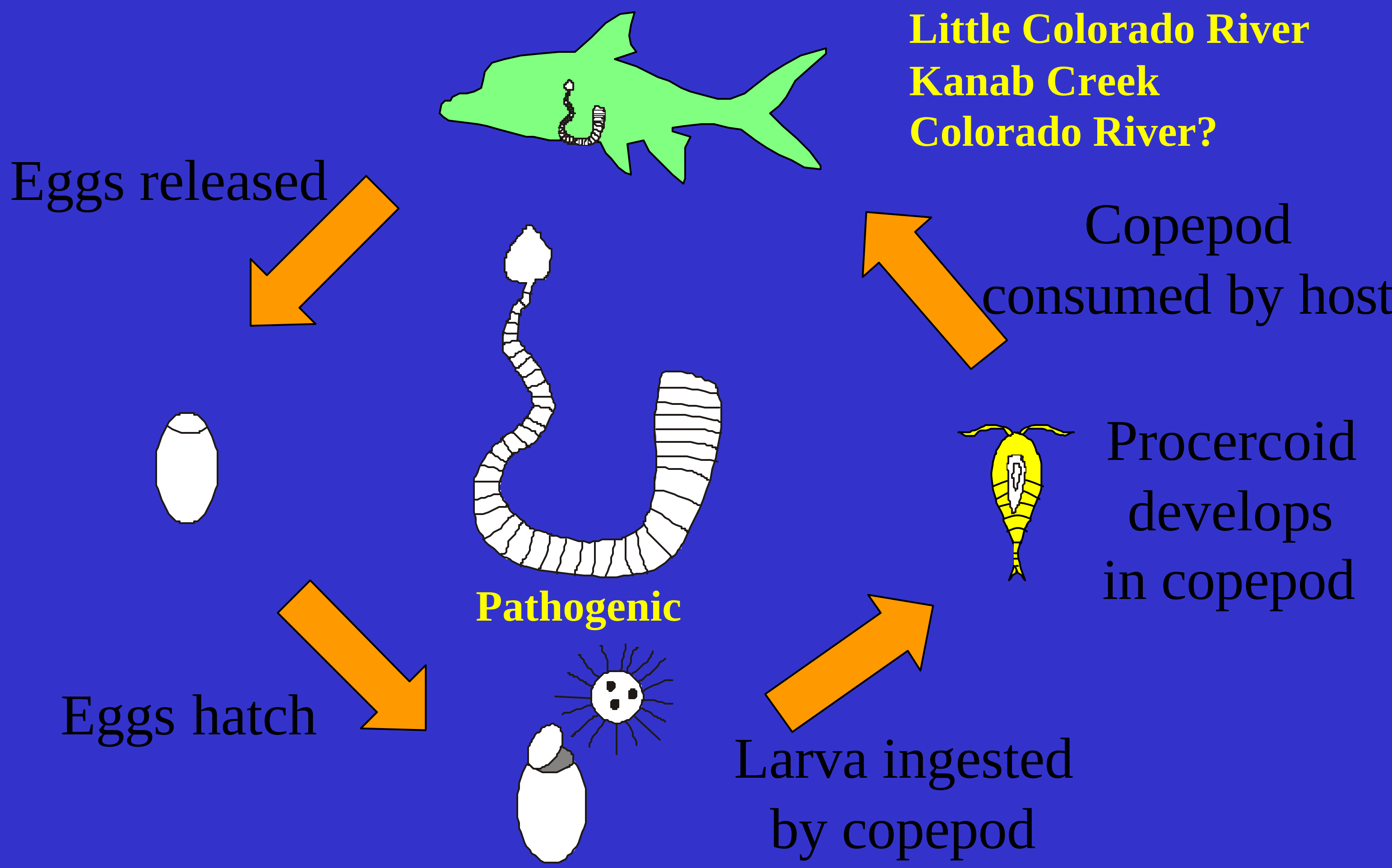
Myxobolus
'tam' stage

Number of Parasites Infecting Each Fish Species

	Host Species								
Parasite Species	BHS	FMS	HBC	SPD	CCF	CRP	FHM	PKF	RBT
Myxosporea									
Henneguya sp.					X				
Cestoda									
Bothriocephalus acheilognathi	X		X	X	X		X	X	
Corallobothrium fimbriatum					X				
Megathylacoides giganteum					X				
Trematoda									
Ornithodiplostomum sp.	X		X	X	X		X		
Nematoda									
Rhabdochona sp.			X	X					
Truttaedacnitis truttae									X
Eustrongylides sp.					X				
Contracaecum sp.					X				
Hirudinea									
Myzobdella lugubris					X				
Copepoda									
Lernaea cyprinacea			X						
Acari				X					
Total	2	0	4	4	8	0	2	1	1

AGFD 1999

Life Cycle of *Bothriocephalus acheilognathi*



Source: AGFD 1999

Suspected and Known Interactions between Native and Non-native Fish of the Colorado River in Glen Canyon and Grand Canyon

Non-native species	Humpback chub	Razorback sucker	Flannelmouth sucker	Bluehead sucker	Speckled dace
Common carp	P,D	P	P,D	P,D	P,D,H
Brown trout	P	P	P	P	
Black bullhead	P		P	P	P
Channel catfish	P		P?	P	P?
Rainbow trout	P		P?	P?	P?
Fathead minnow	P?,C?	P?	P?,C?	P?,C?	P?,C?
Red shiner	P?	P	P?	P?	P?
Green sunfish	P?	P?	P?	P?	P?
Bluegill	P?	P?	P?	P?	P?
Largemouth bass	P?	P?	P?	P?	P?
Black crappie	P?	P?	P?	P?	P?
Walleye	P?	P?	P?	P?	P?
Plains killifish	C?	C?	C?	C?	C?
Mosquitofish	C?	C?	C?	C?	C?
Striped bass	P?		P?	P?	P?
Golden shiner					
Threadfin shad					

P = Predation; D = Disease and Parasites; C = Competition; H = Habitat Alteration

Expert Panel Workshop

- Bring together modeling and empirical data gathering efforts
- Purpose to develop a sound framework for the TCD science plan
- Integrate into NEPA effort as an accompanying document to the environmental assessment

TCD Workshop Results

- Concern: Ability to Detect Change has not been Determined for many Resources
- Concern: Hydrology and Water Temperature Effects need to be Considered Jointly in Planning
- Concern: Scientists Need Better Communication with Water Managers in Planning Research and Monitoring

TCD Science Plan and AMP Monitoring

- 4 Primary Issues Associated with TCD.
- Adaptive Management Program Funded Monitoring Program Timeline.
- Role of PEP in Reviewing the TCD Science Plan.
- What supplemental scientific activities might be needed to address TCD issues.

Primary Biological Issues with TCD

- Entrainment of Fish from Reservoir/Reservoir dynamics.
- Changes in productivity in Lees Ferry and downstream (increase/decline or just change?)
- Increased predation on native fish by introduced species (warm water fish species as well as trout (browns & rainbows)).
- Increased risk of exposure to disease and parasites for all fish and rainbow trout exposure to whirling disease.

Time Line for Monitoring

Fish Monitoring Anticipate 3 years from 2002 to see trends in populations.	PEP – May Report – July RFP - September	Age2+ abundance & trends (stock synthesis & assessment) Distribution
Aquatic foodbase Anticipate 3 years from 2002 to evaluate utility of monitoring approach and to see trends.	PEP – May Report – July RFP - September	Uncertain- anticipating change in approach/scope. Biomass? Productivity? Composition?
Lees Ferry Trout Anticipate 3 years from 2001 to see trends	PEP – completed RFP - Funded	Age 2+ abundance & trends, condition, & PSD.

Additional considerations associated with the TCD

Time scales related to different research questions:

•Risk analysis associated with the level of effort and causal relationship needs.

•Short vs. long-term response: Larval fish info can be costly and may not indicate long-term success. But will answer mainstem spawning question sooner.

•Monthly productivity measures vs. quarterly or some other scale.—Provides different levels of information. One can approach potential mechanisms, while the other may not provide such refinement.

Additional work/considerations associated with the TCD

- Predator control either by physical means or with operations (fluctuations or other methods) and the effect of this in the short term.
- Relationships between increased metabolism and predation rates?
- Within reservoir community dynamics and downstream inputs.

Additional work/considerations associated with the TCD

Food quality shifts in foodbase and effectively measuring this.

Further development of CE Qual Model for Reservoir (more inputs and calibration/validation).

Set-up of radio-telemetered profiling stations to see short-term response and to determine if target temperatures are met.

Capability of TCD to accommodate blocked design or continuous operation vs. single year test.

Downstream thermal stratification and associated implications.