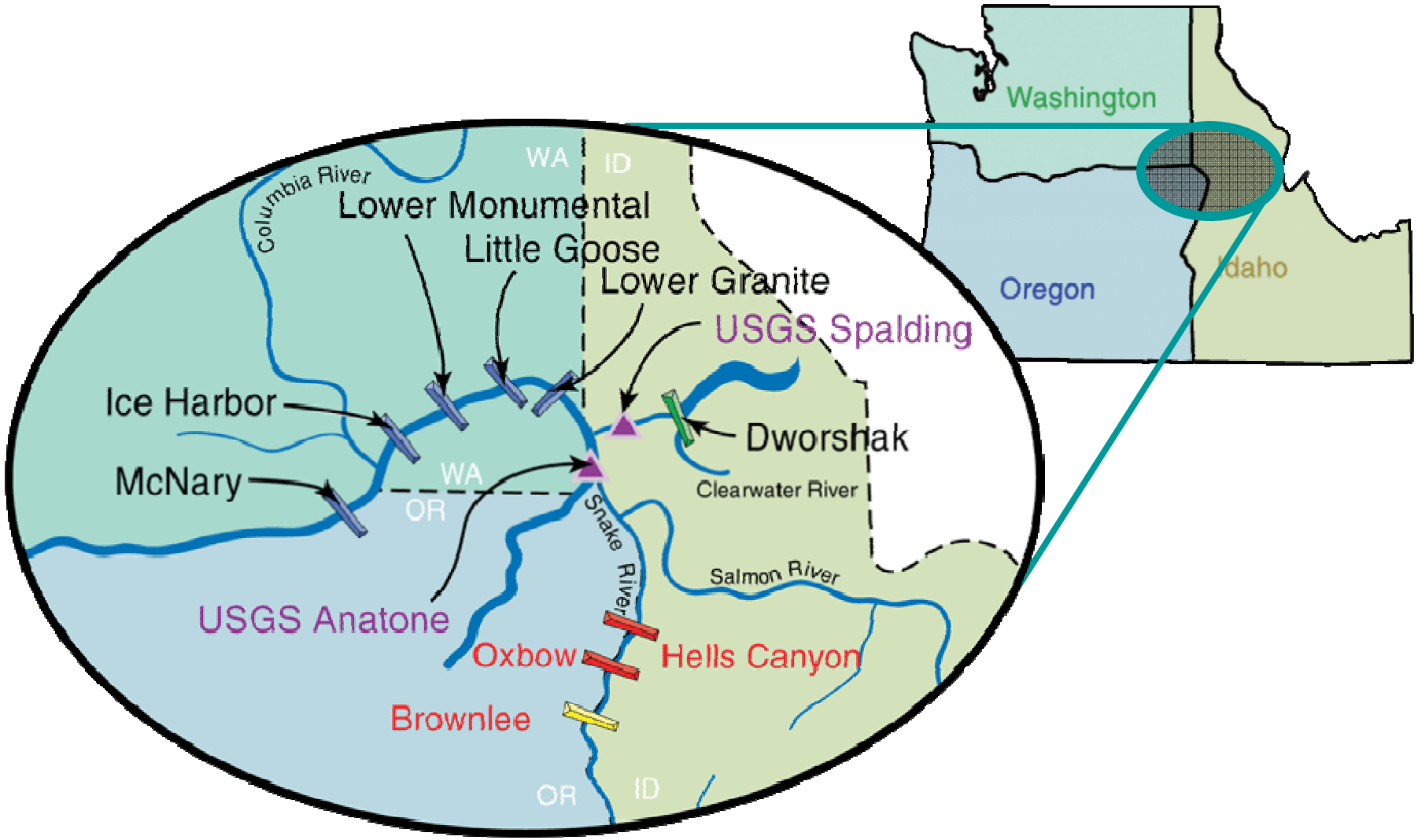
Lower Snake River Temperature Management

Dworshak Reservoir, Lower Snake River, and Hells Canyon Complex



Not to Scale

Lower Snake River Temperature Management 2006

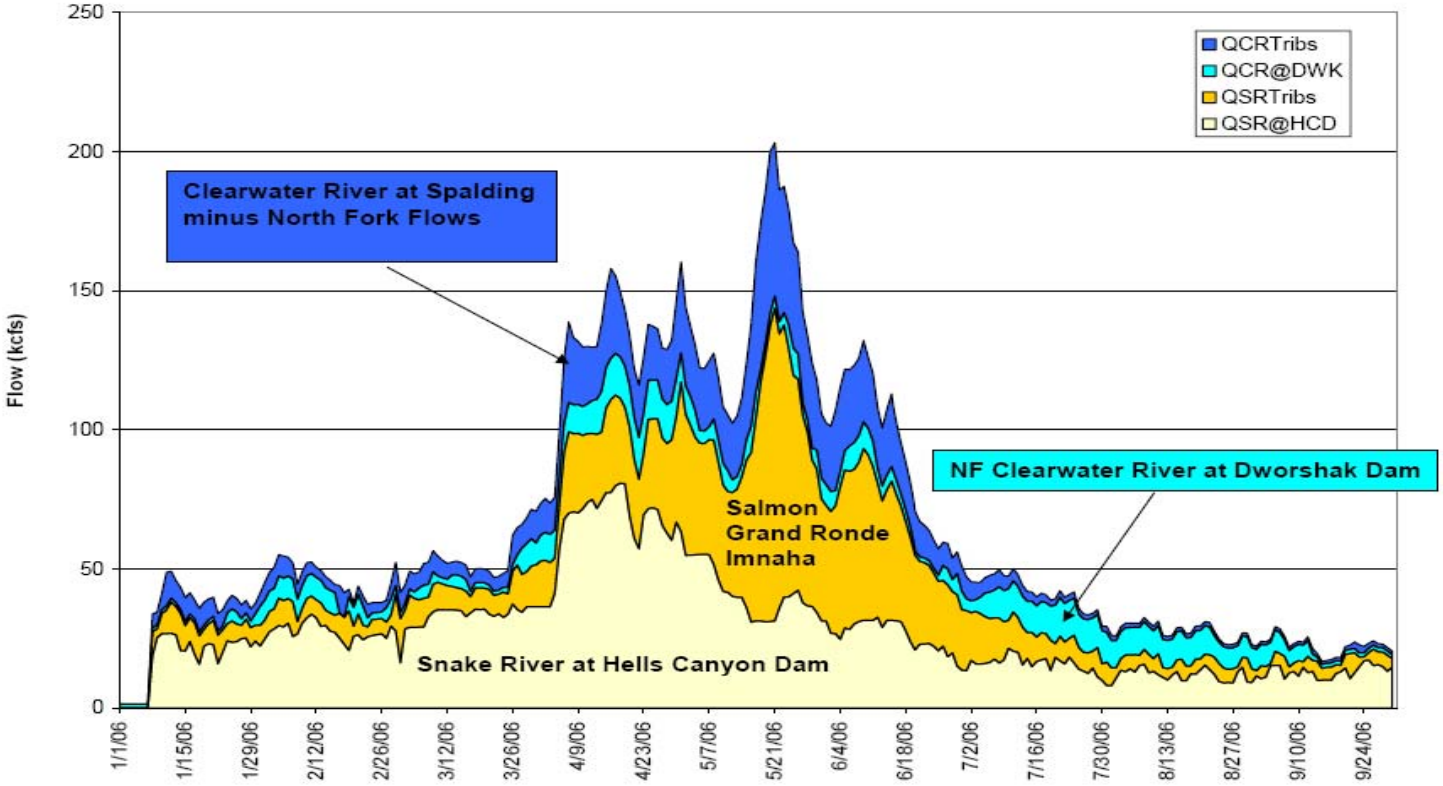
- Water Temperature released from Lower Granite Dam were generally less than 20 C during July and August of 2006
  - July Average of 19.8
  - August Average of 18.8
  - Warmer than 20 C during the first week in July
    - Very Hot conditions
    - Decision to begin draft after the 4th July Holiday
  - Several other short excursions above 20 C
    - Very Hot Weather
    - Above average flows from upstream (Salmon, Hells Canyon Projects)
  - Dworshak Operations
    - Undershot operations throughout
    - Stepped reduction in discharge
    - Spill of up to 4 kcfs to boost releases to 14 kcfs
    - Reached 1535 prior to August 31 (NP supported using more water)

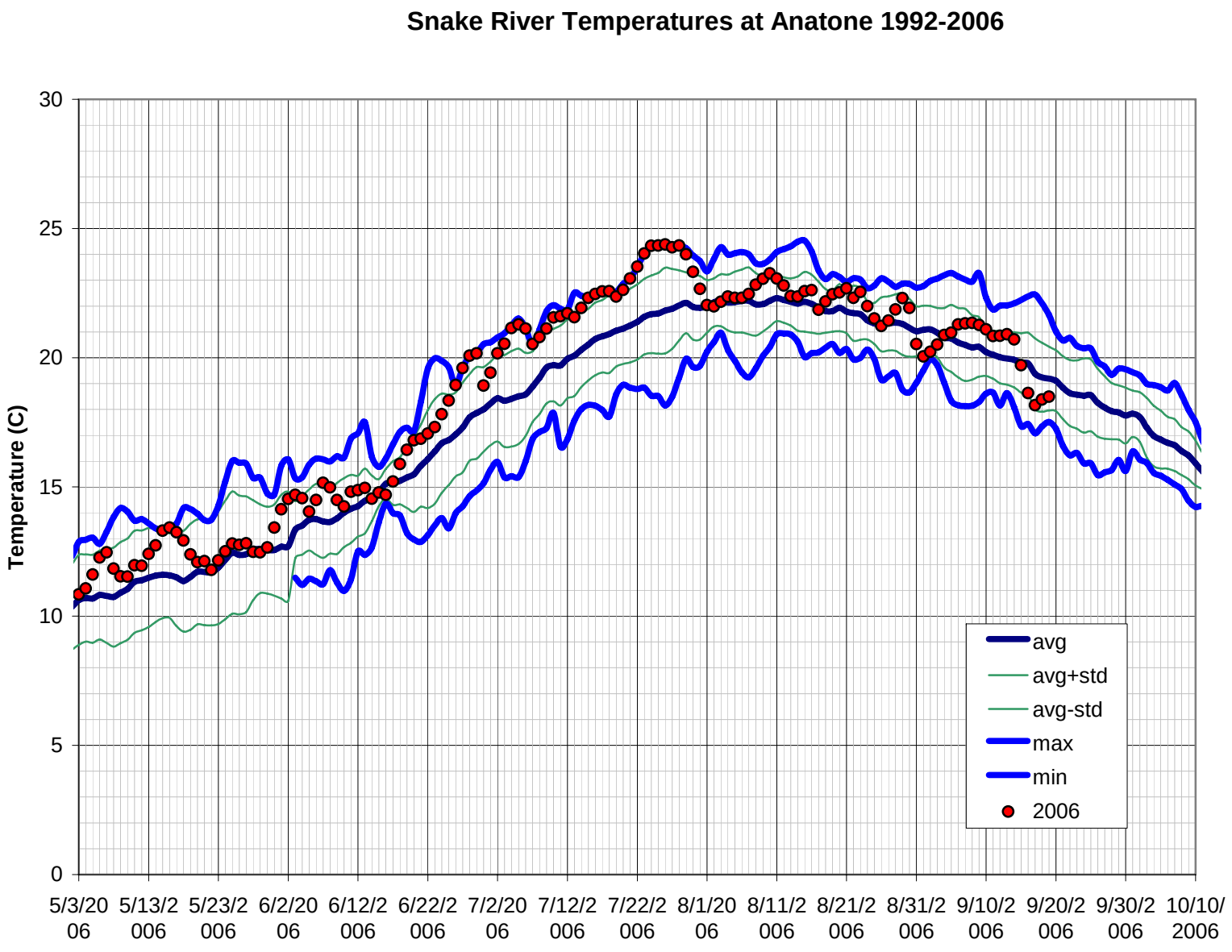
Lower Snake River Temperature Management 2006

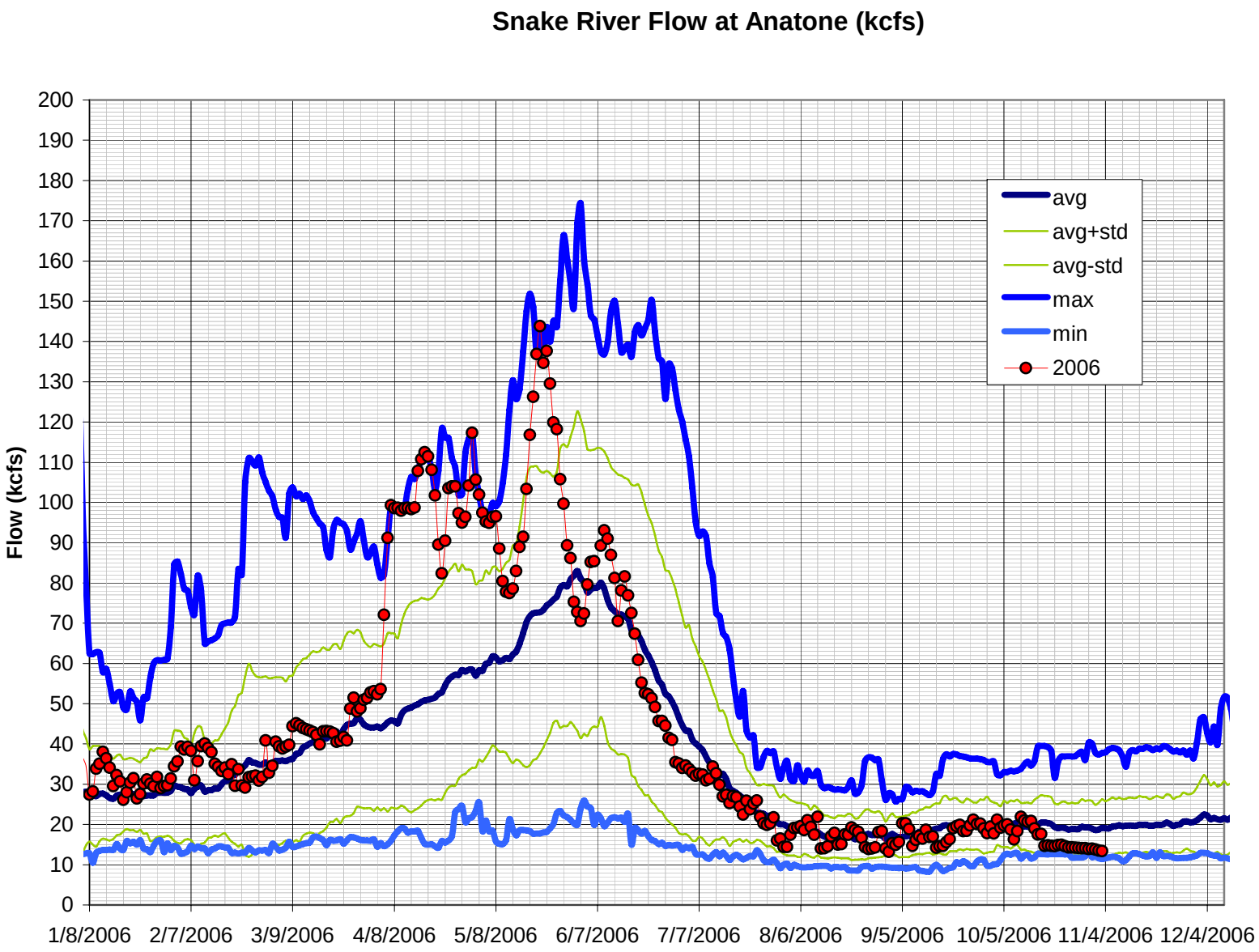
- Total Dissolved Gas Levels in the Clearwater River were generally held below 110%
  - Maximum amount of spill was 4.4 kcfs
  - Thermally induced variation in TDG saturation in Clearwater River
  - TDG production during small generation releases
  - Idaho WQ standards 110%
- Snake River at Ice Harbor > 20 C for over 2 months
  - Washington State Numeric Criteria 20 C or Natural Conditions
  - 2-3 Degree warming from LWG to IHR
- Snake River at Anatone was warmer than Ice Harbor
  - Peak temperature 25 C
  - Strong Diurnal component
  - Almost 3 months of 20+ Temperatures
  - Demonstrated cooling down to the confluence with Columbia River
- TMT Coordination
  - Weekly model simulations conducted to assess alternative operations
- Hells Canyon Peaking Operations
  - Introduces Heat Load cycling into Lower Granite Pool

Flow Contribution to the Lower Snake River - 2006

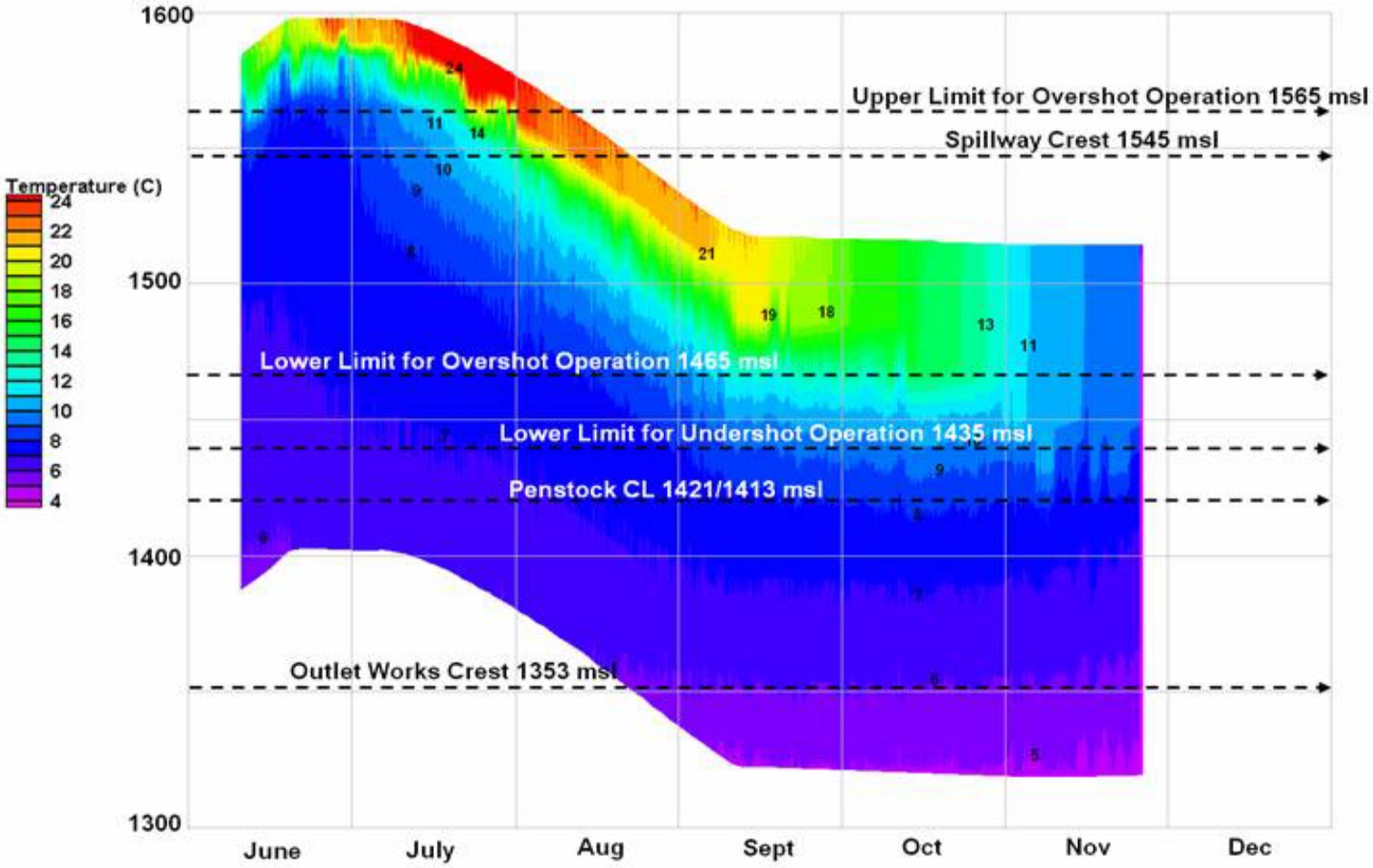
(Snake R. – Yellow, Clearwater R. – Light Blue)

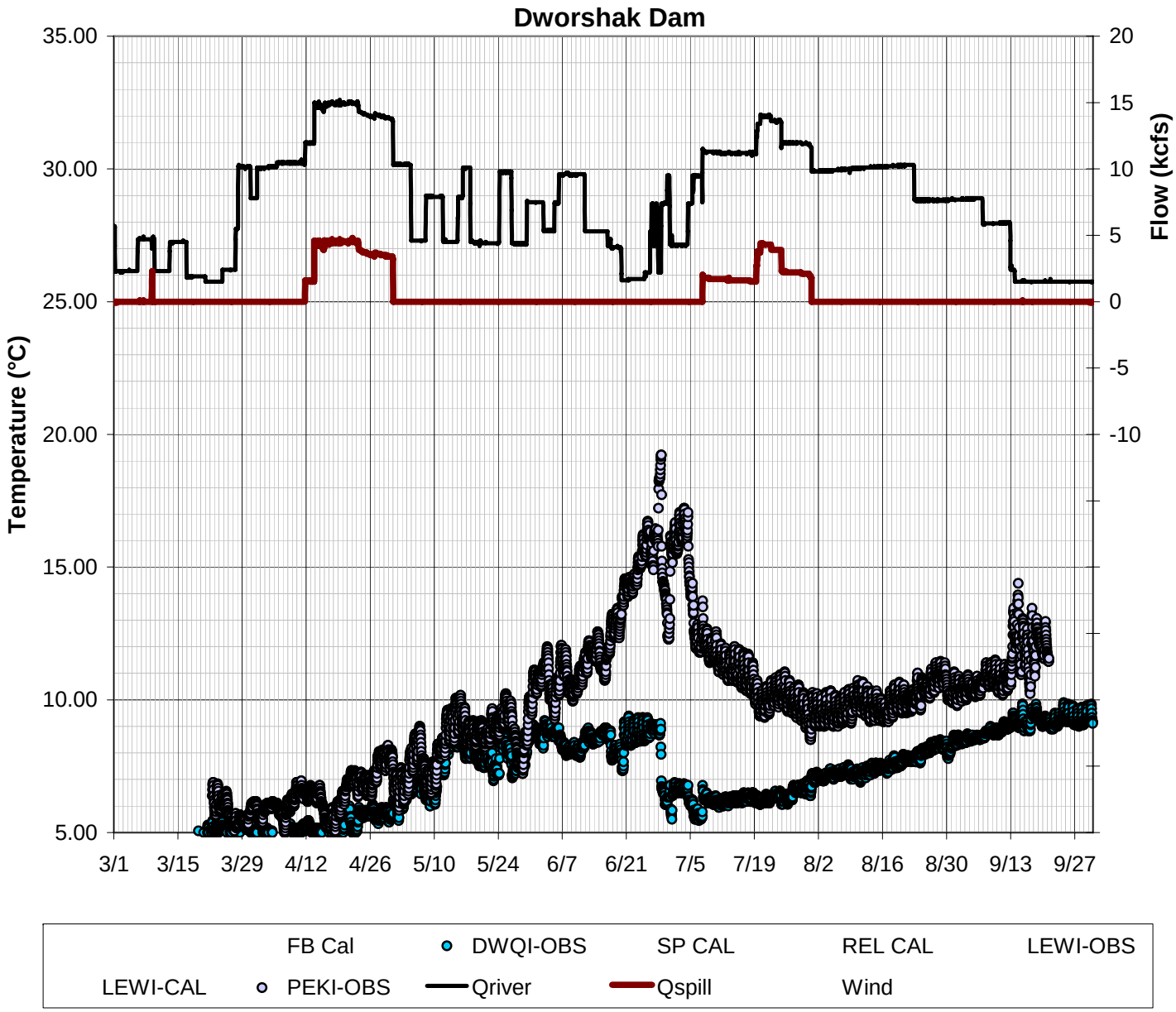


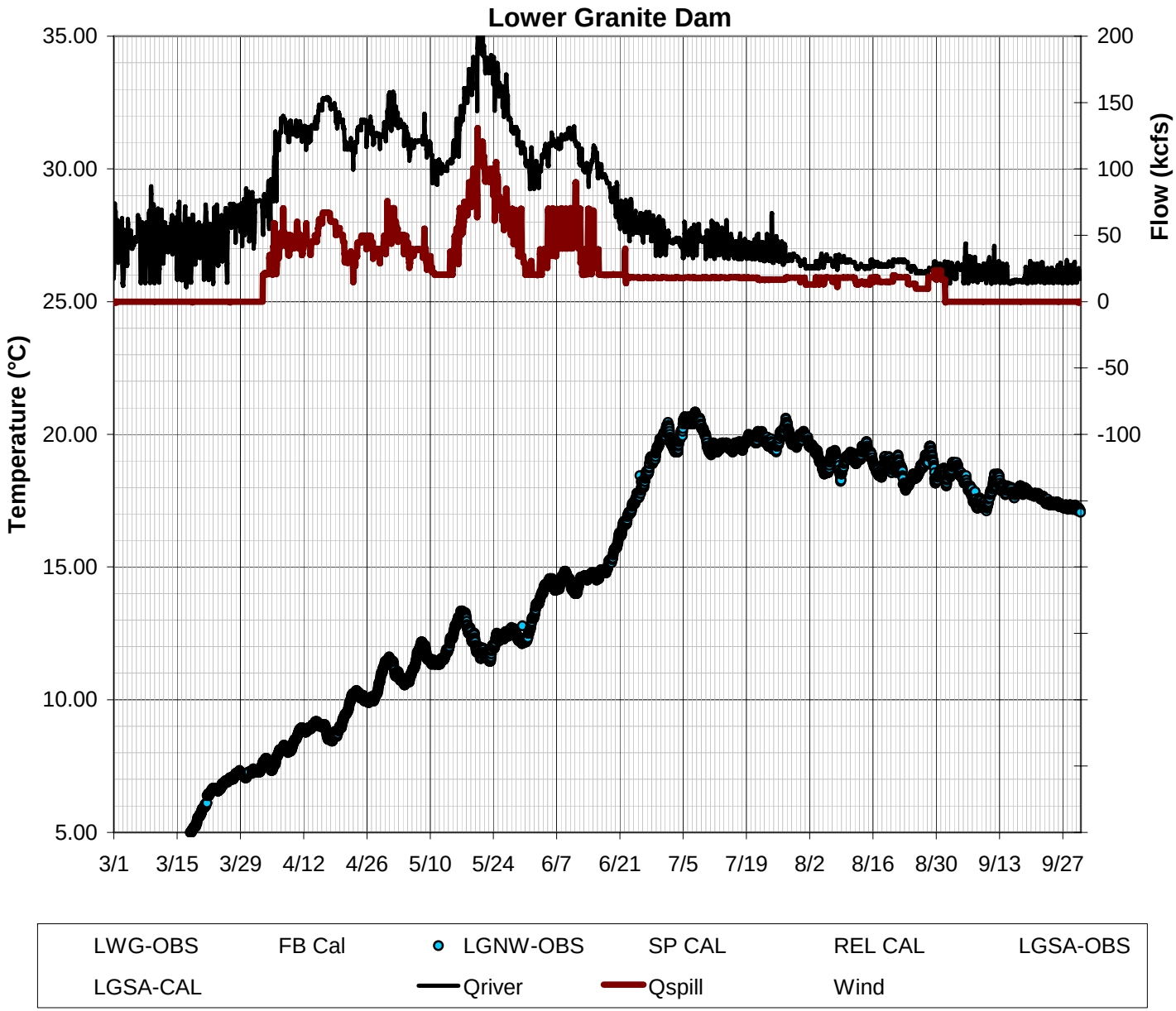

Snake River Temperatures at Anatone 1992-2006
Temperature (C)
30
25
20
15
10
5
0
5/3/2006
5/13/2006
5/23/2006
6/2/2006
6/12/2006
6/22/2006
7/2/2006
7/12/2006
7/22/2006
8/1/2006
8/11/2006
8/21/2006
8/31/2006
9/10/2006
9/20/2006
9/30/2006
10/10/2006
avg
avg+std
avg-std
max
min
2006

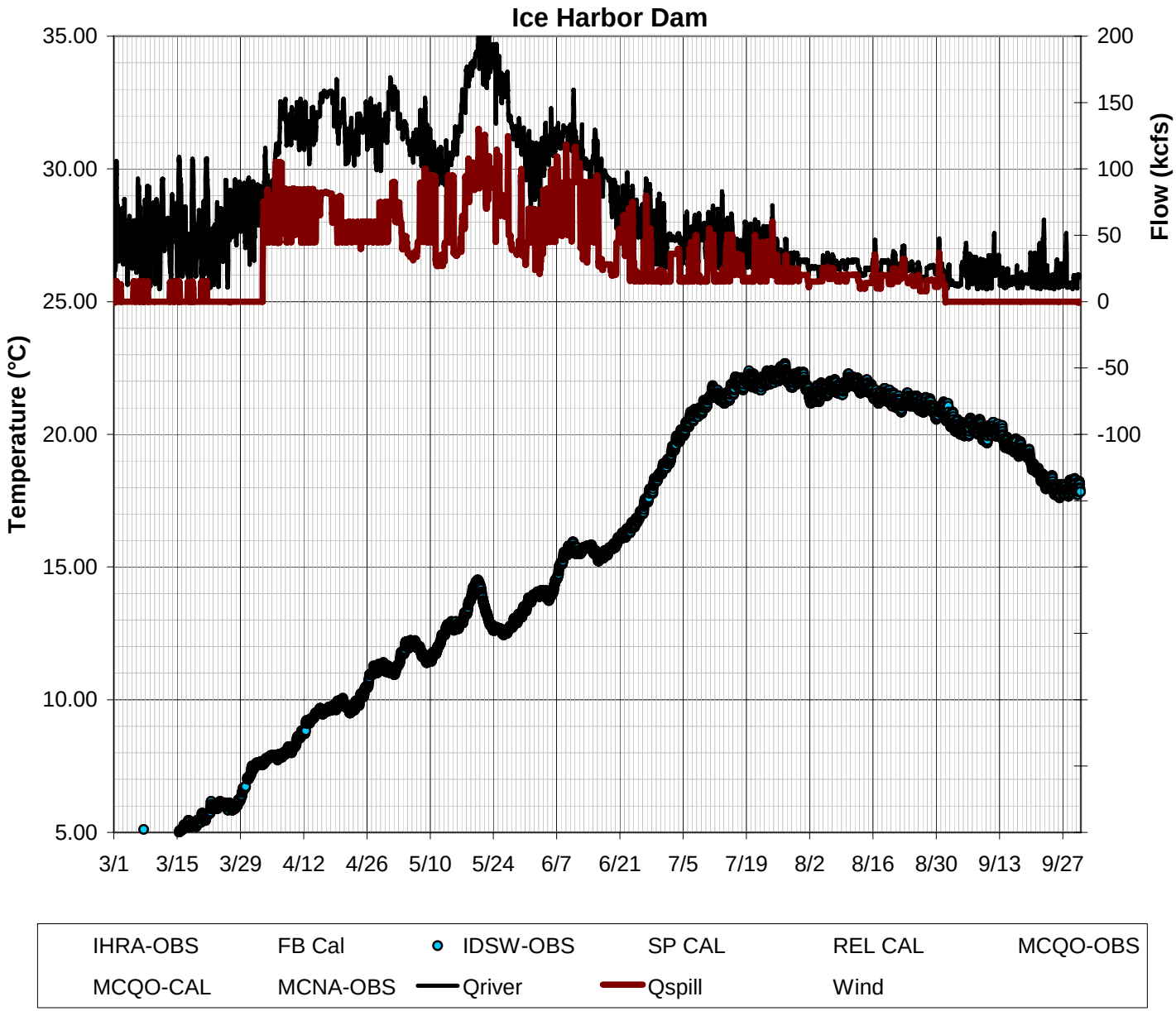

Snake River Flow at Anatone (kcfs)
Flow (kcfs)
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
1/8/2006
2/7/2006
3/9/2006
4/8/2006
5/8/2006
6/7/2006
7/7/2006
8/6/2006
9/5/2006
10/5/2006
11/4/2006
12/4/2006
avg
avg+std
avg-std
max
min
2006

Dworshak Forebay Cross Section




Dworshak Dam
Temperature (°C)
Flow (kcfs)
35.00
30.00
25.00
20.00
15.00
10.00
5.00
20
15
10
5
0
-5
-10
3/1
3/15
3/29
4/12
4/26
5/10
5/24
6/7
6/21
7/5
7/19
8/2
8/16
8/30
9/13
9/27
FB Cal
DWQI-OBS
SP CAL
REL CAL
LEWI-OBS
LEWI-CAL
PEKI-OBS
Qriver
Qspill
Wind


Lower Granite Dam
Temperature (°C)
Flow (kcfs)
35.00
30.00
25.00
20.00
15.00
10.00
5.00
200
150
100
50
0
-50
-100
3/1
3/15
3/29
4/12
4/26
5/10
5/24
6/7
6/21
7/5
7/19
8/2
8/16
8/30
9/13
9/27
LWG-OBS
FB Cal
LGNW-OBS
SP CAL
REL CAL
LGSA-OBS
LGSA-CAL
Qriver
Qspill
Wind

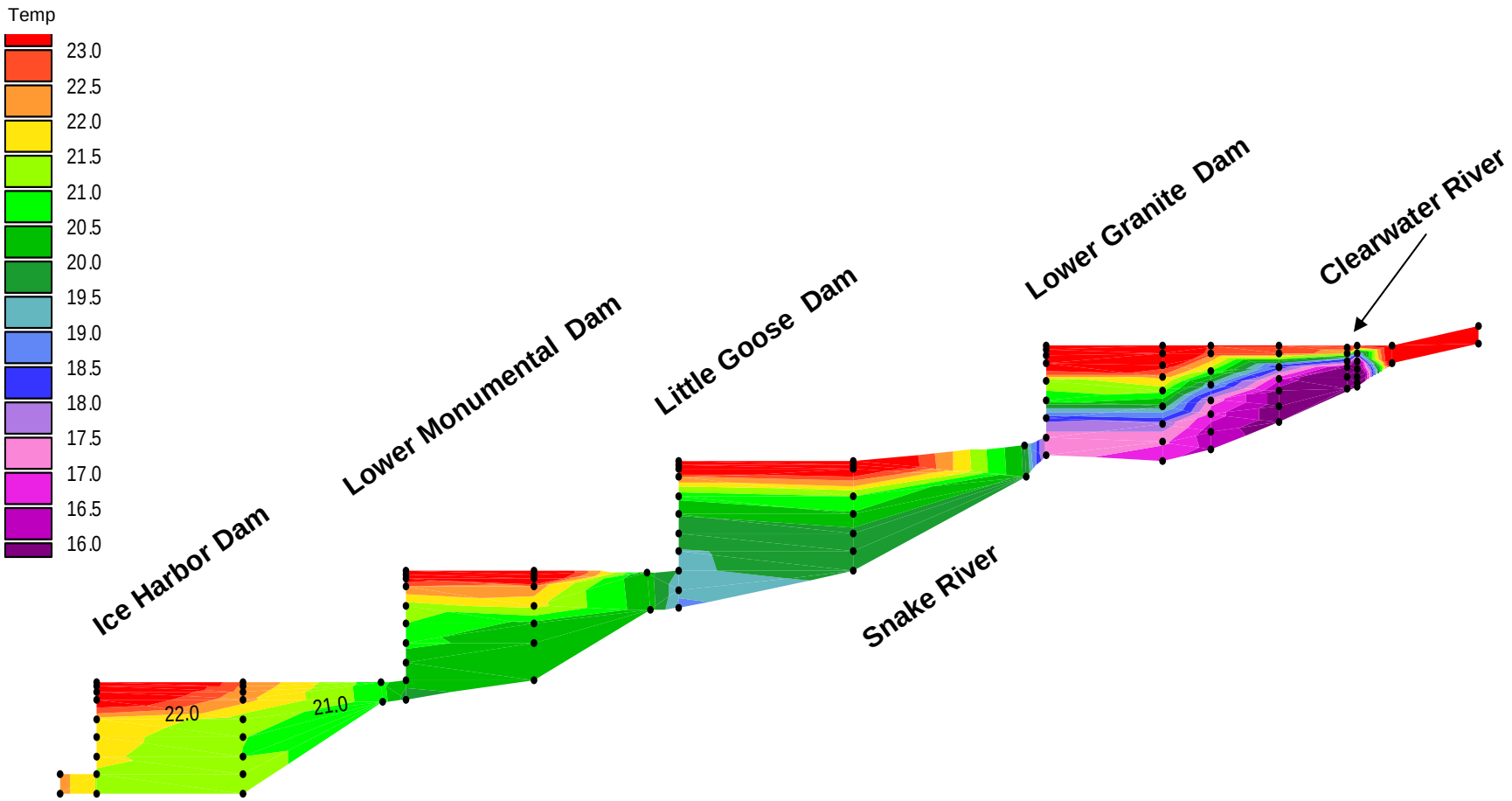

Ice Harbor Dam
Temperature (°C)
Flow (kcfs)
35.00
30.00
25.00
20.00
15.00
10.00
5.00
200
150
100
50
0
-50
-100
3/1
3/15
3/29
4/12
4/26
5/10
5/24
6/7
6/21
7/5
7/19
8/2
8/16
8/30
9/13
9/27
IHRA-OBS
FB Cal
IDSW-OBS
SP CAL
REL CAL
MCQO-OBS
MCQO-CAL
MCNA-OBS
Qriver
Qspill
Wind

Bi-Op Measure 143

Water Temperature Modeling and Data Collection Plan For Lower Snake River Basin

"The Action Agencies shall develop and coordinate with NOAA Fisheries and EPA on a plan to model the water temperature effects of alternative Snake River operations. The modeling plan shall include a temperature data collection strategy developed in consultation with EPA, NOAA Fisheries and state and tribal water-quality agencies. The data collection strategy shall be sufficient to develop and operate the model and to document the effects of project operations."

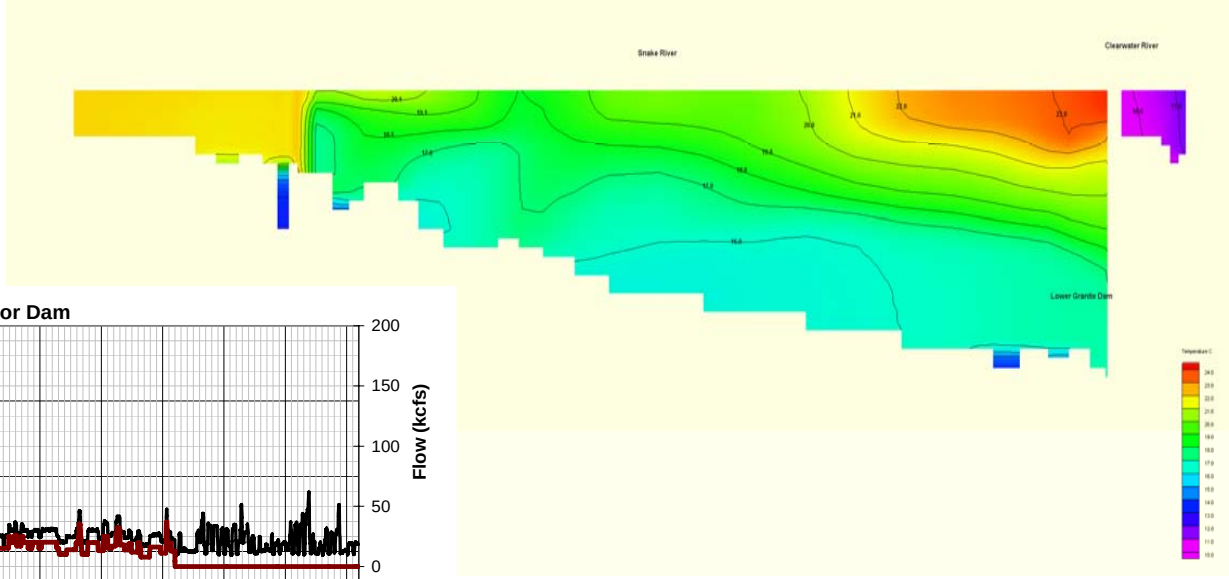
Lower Snake River Reservoir Temperature Profiles

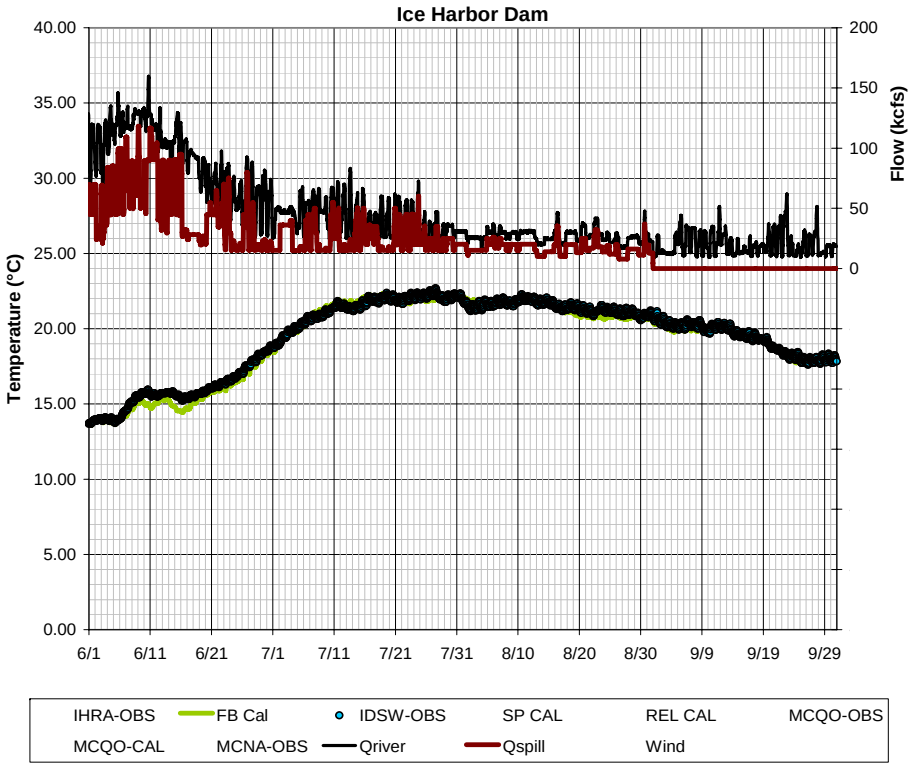


Data Collection and Analysis

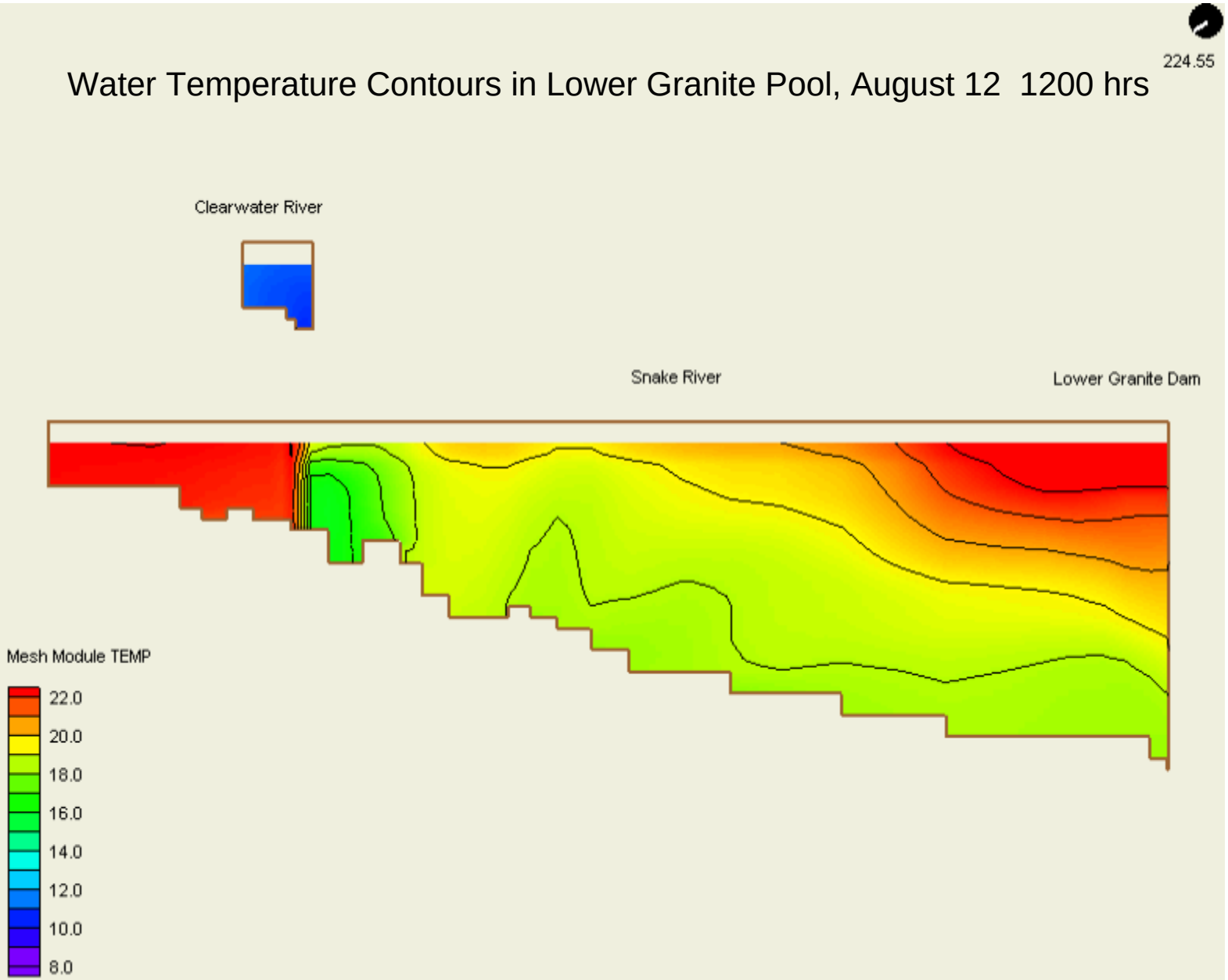
- Characterized thermal patterns in the Lower Snake River System during the 2002-6 summer and fall period
- Provided information to evaluate existing water quality monitors in representativeness for both spatial and temporal patterns in temperature and provide guidance of future sampling requirements
- Provided information that helped to decide on the required model resolution and model.
- Provided calibration and verification data for selected model

2006 CE-QUAL Simulation

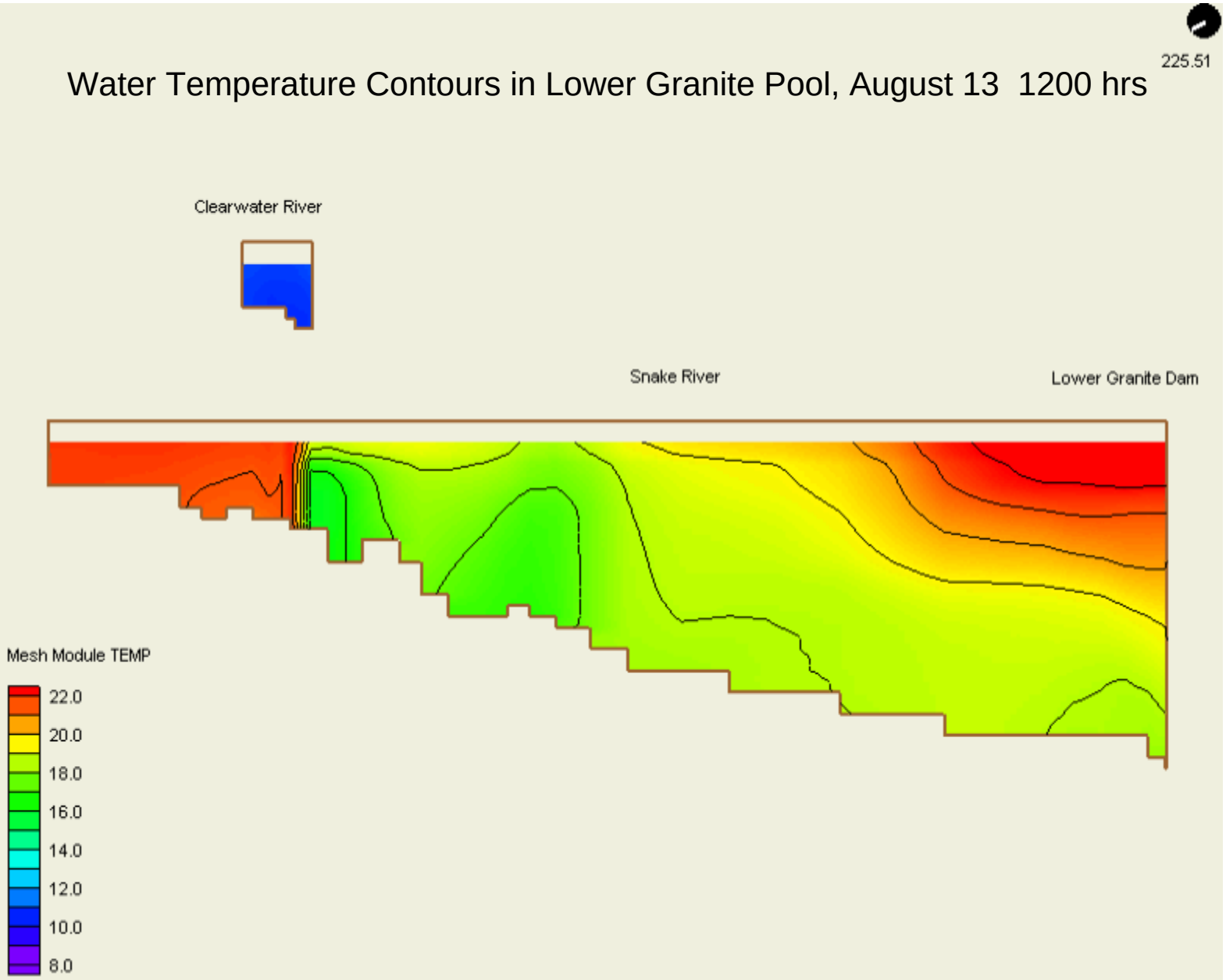




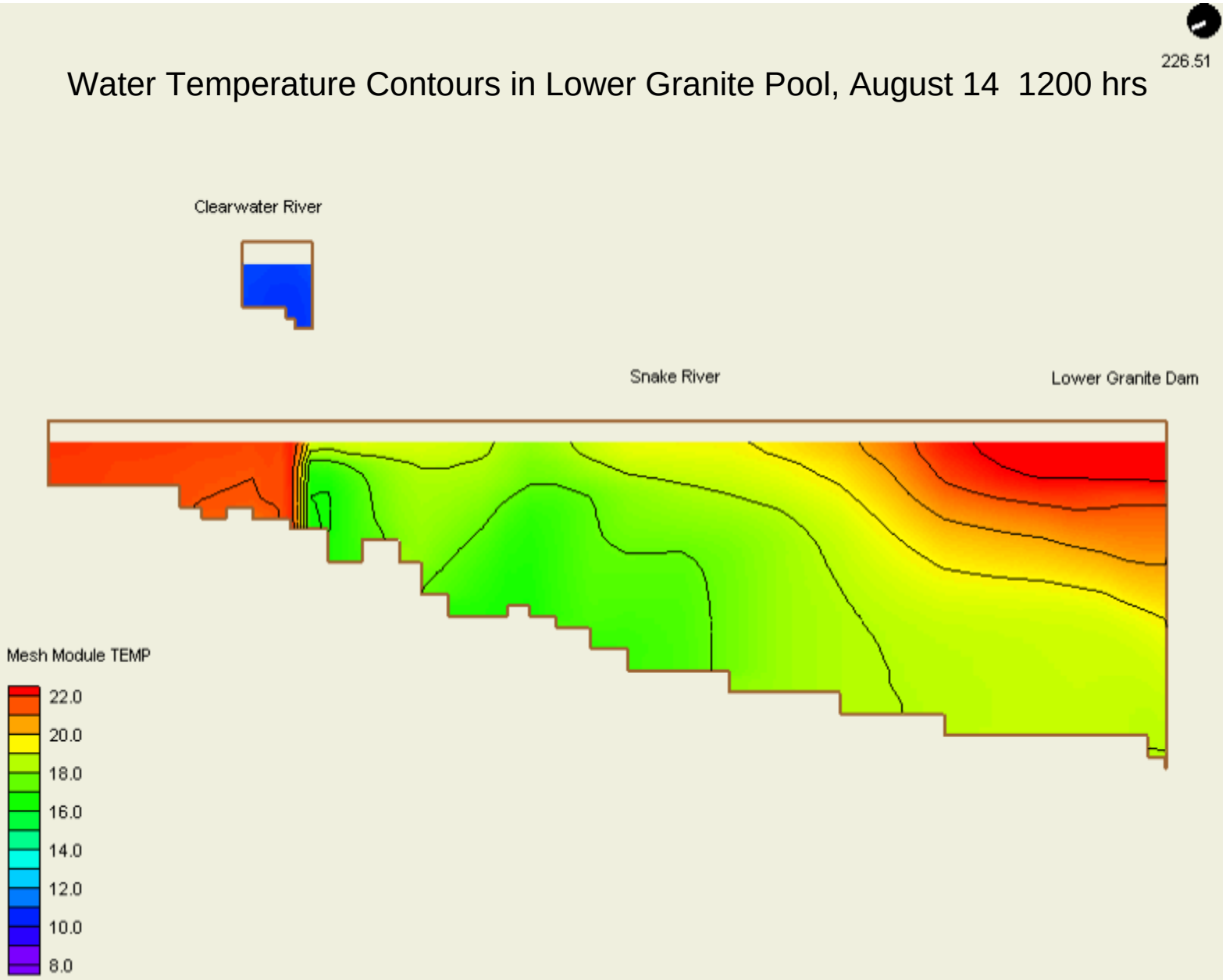
Water Temperature Contours in Lower Granite Pool, August 12 1200 hrs



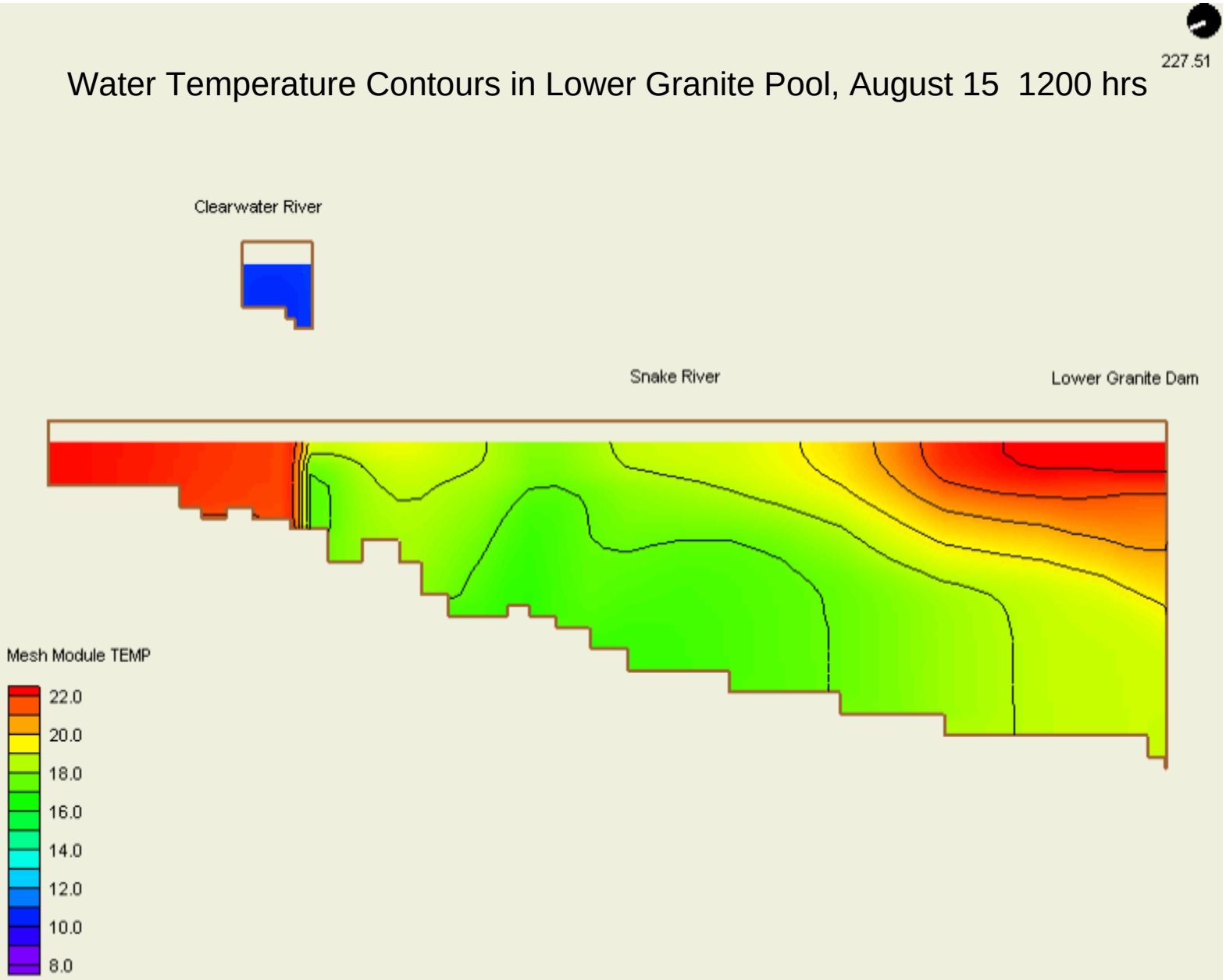
Water Temperature Contours in Lower Granite Pool, August 13 1200 hrs



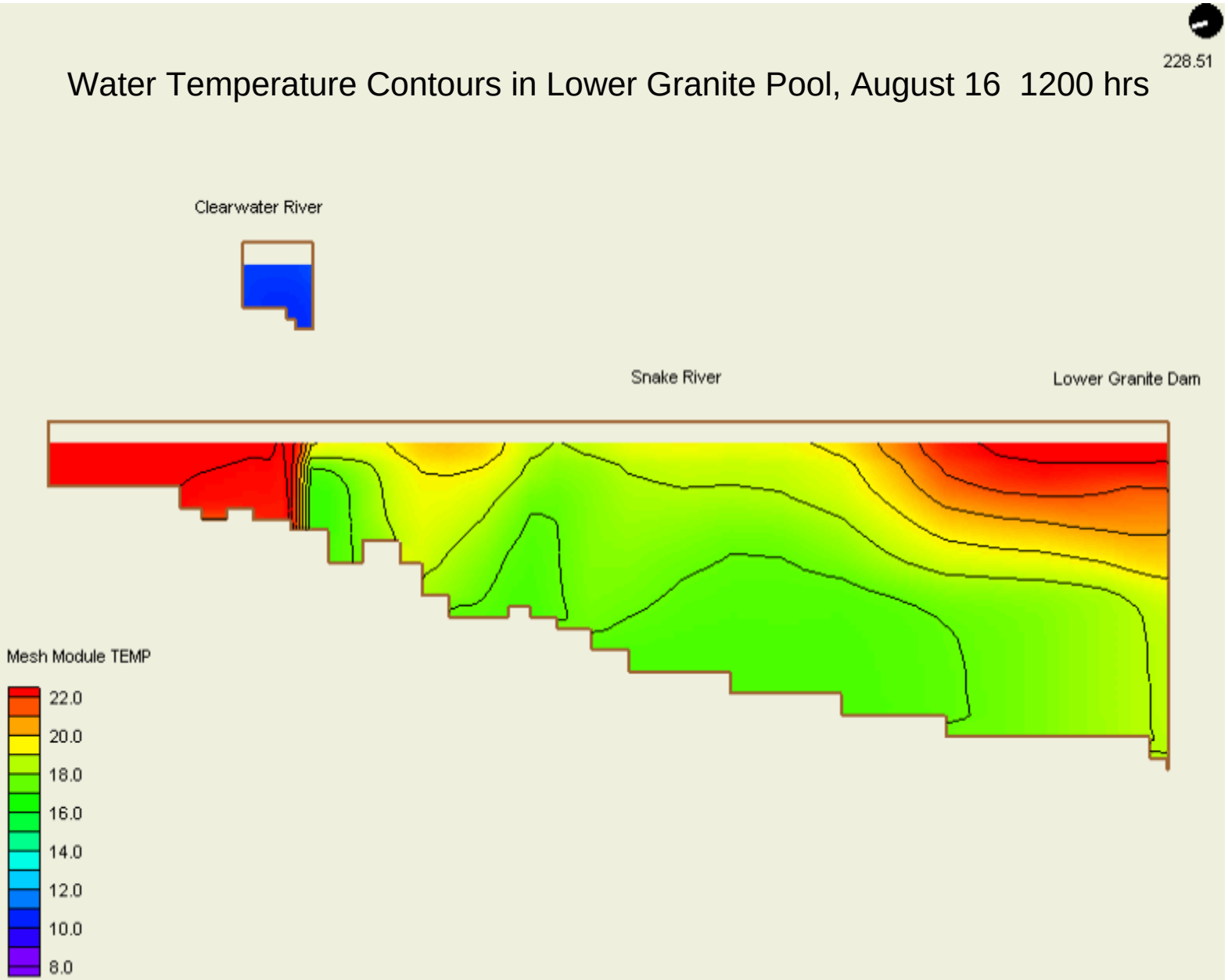
Water Temperature Contours in Lower Granite Pool, August 14 1200 hrs



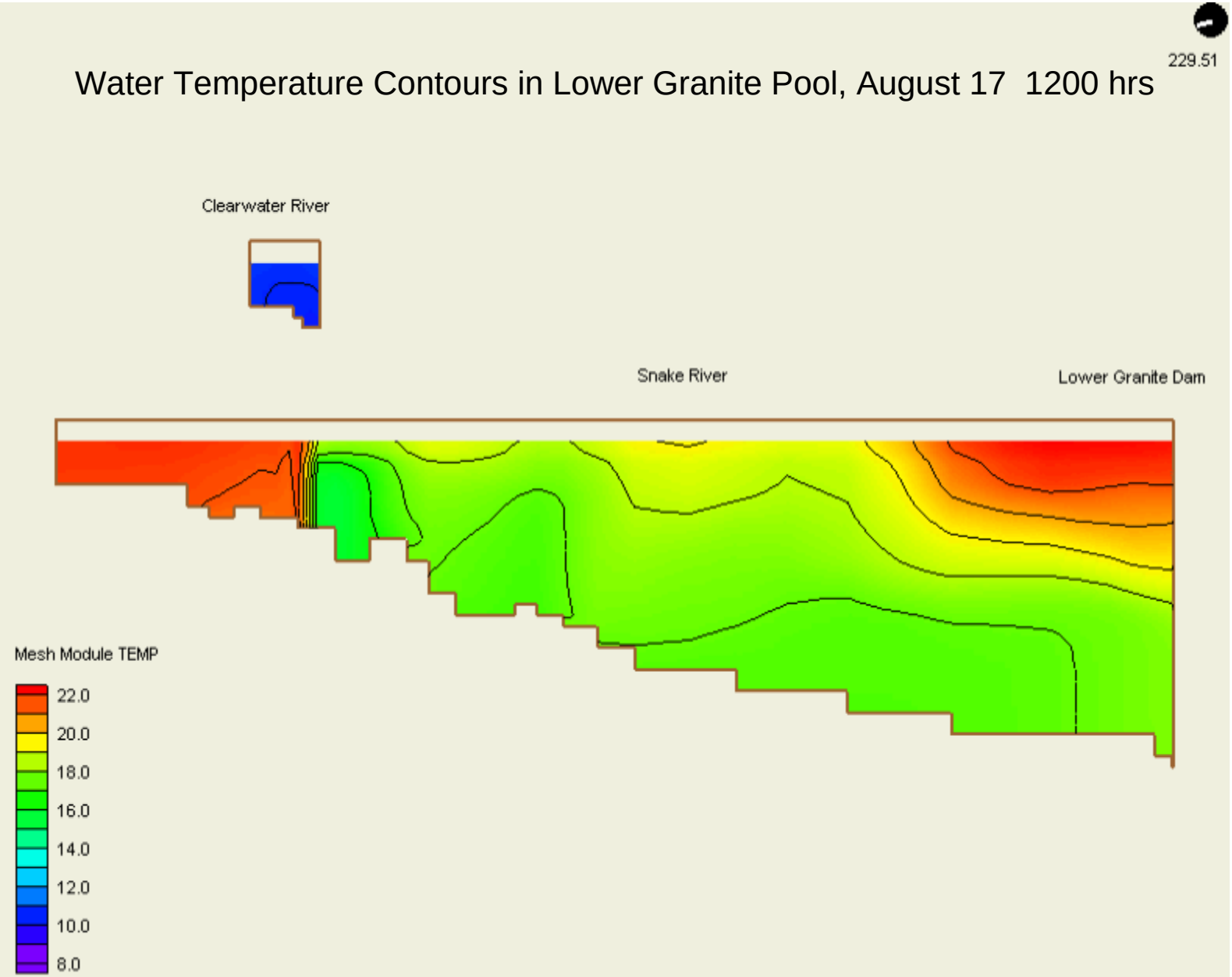
Water Temperature Contours in Lower Granite Pool, August 15 1200 hrs



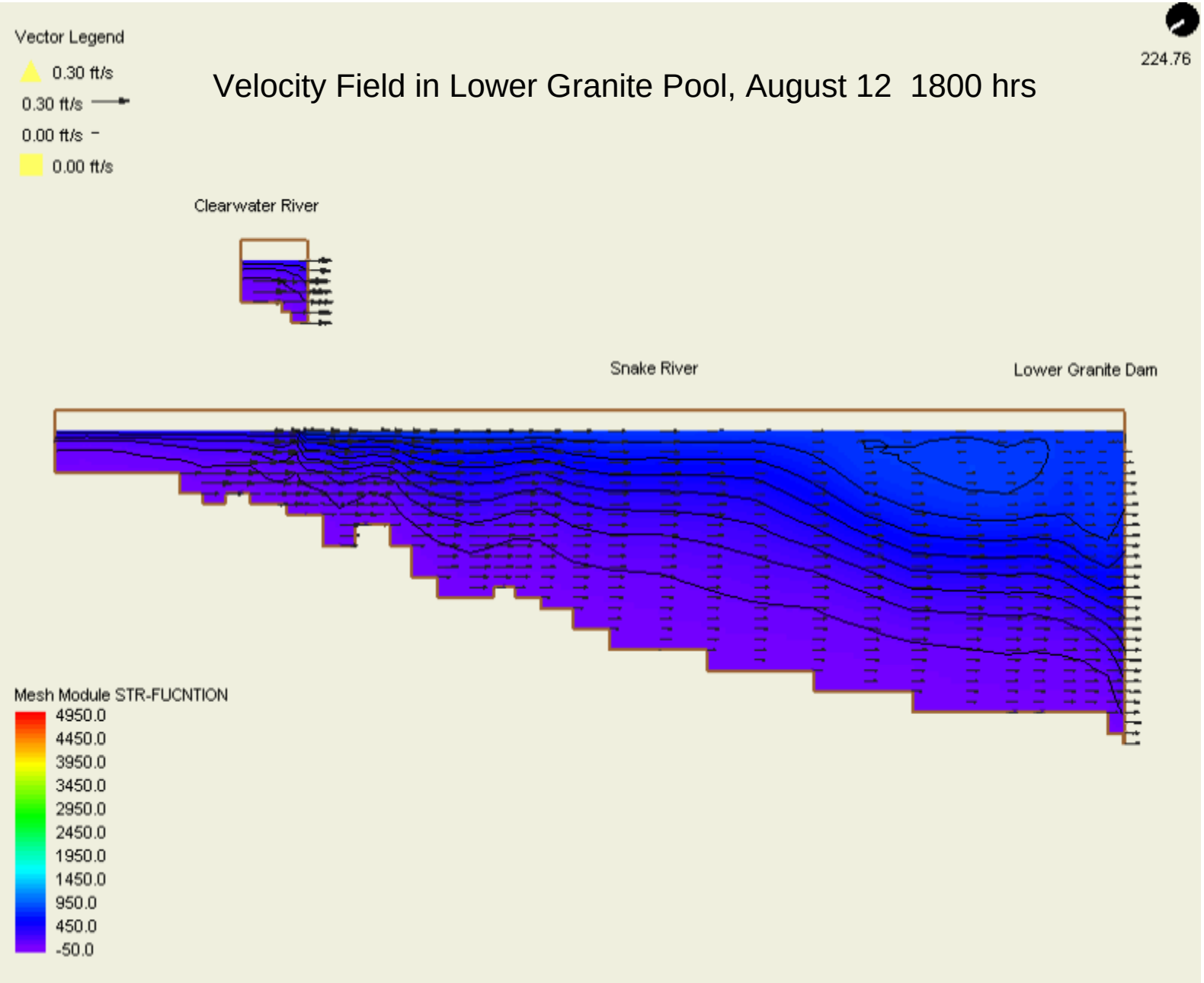
Water Temperature Contours in Lower Granite Pool, August 16 1200 hrs



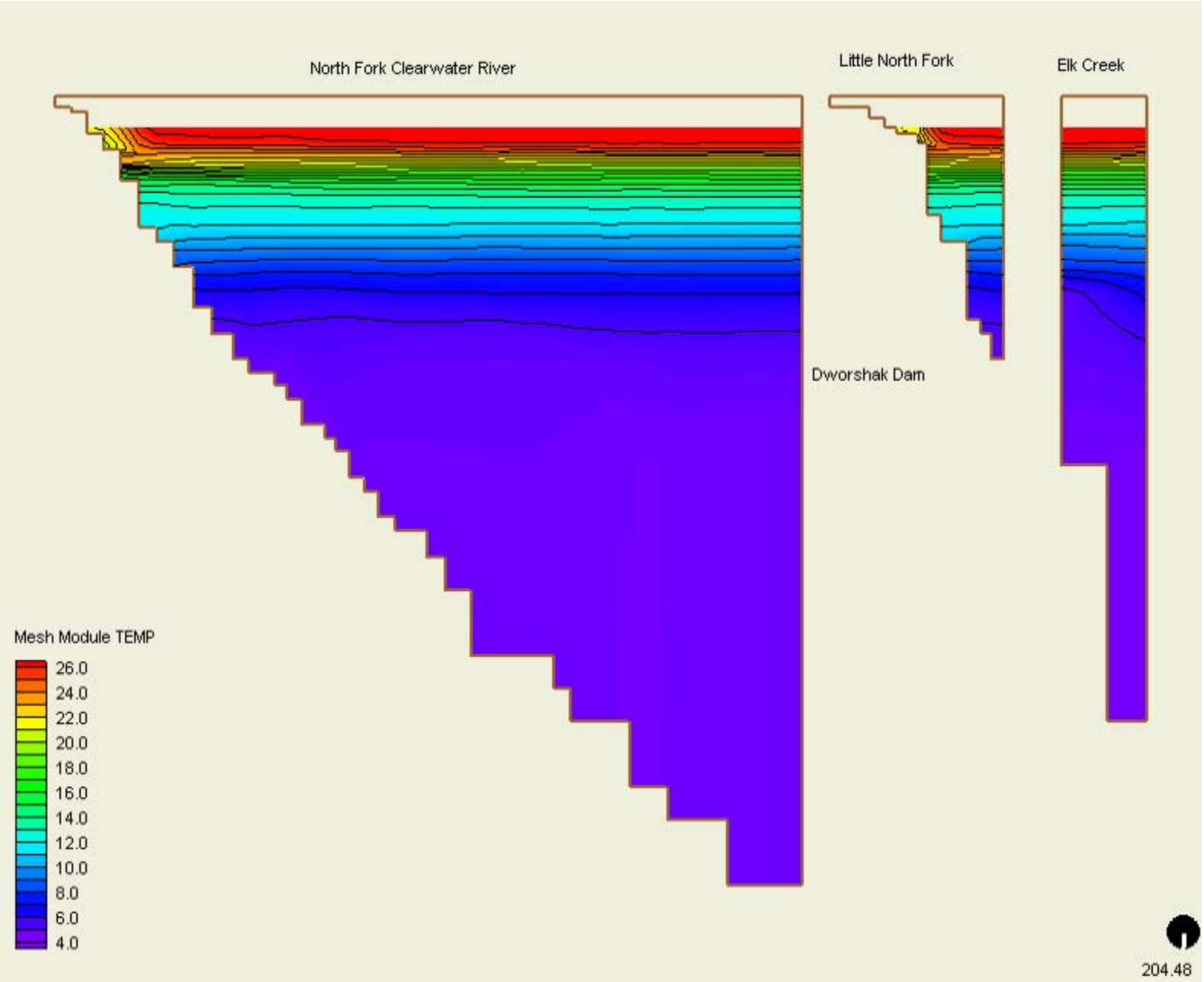
Water Temperature Contours in Lower Granite Pool, August 17 1200 hrs



Velocity Field in Lower Granite Pool, August 12 1800 hrs



Temperature Field in Dworshak Pool, July 23 1100 hrs



CE-QUAL-W2 Model Implementation 2006

- Objective
  - Temperature Management for Habitat Improvement in the Lower Snake River Basin
- Approach
  - Development of Numerical Model and Data input
    - CEQUAL-W2
      - 2D Laterally Averaged Hydrodynamic-Water Quality Model
    - Short and Long Term Forecasts of Hydrologic and Meteorologic Conditions for real-time management
    - Alternative Structural/Operation Conditions

Lower Snake Temperature Management Real-time Forecasting

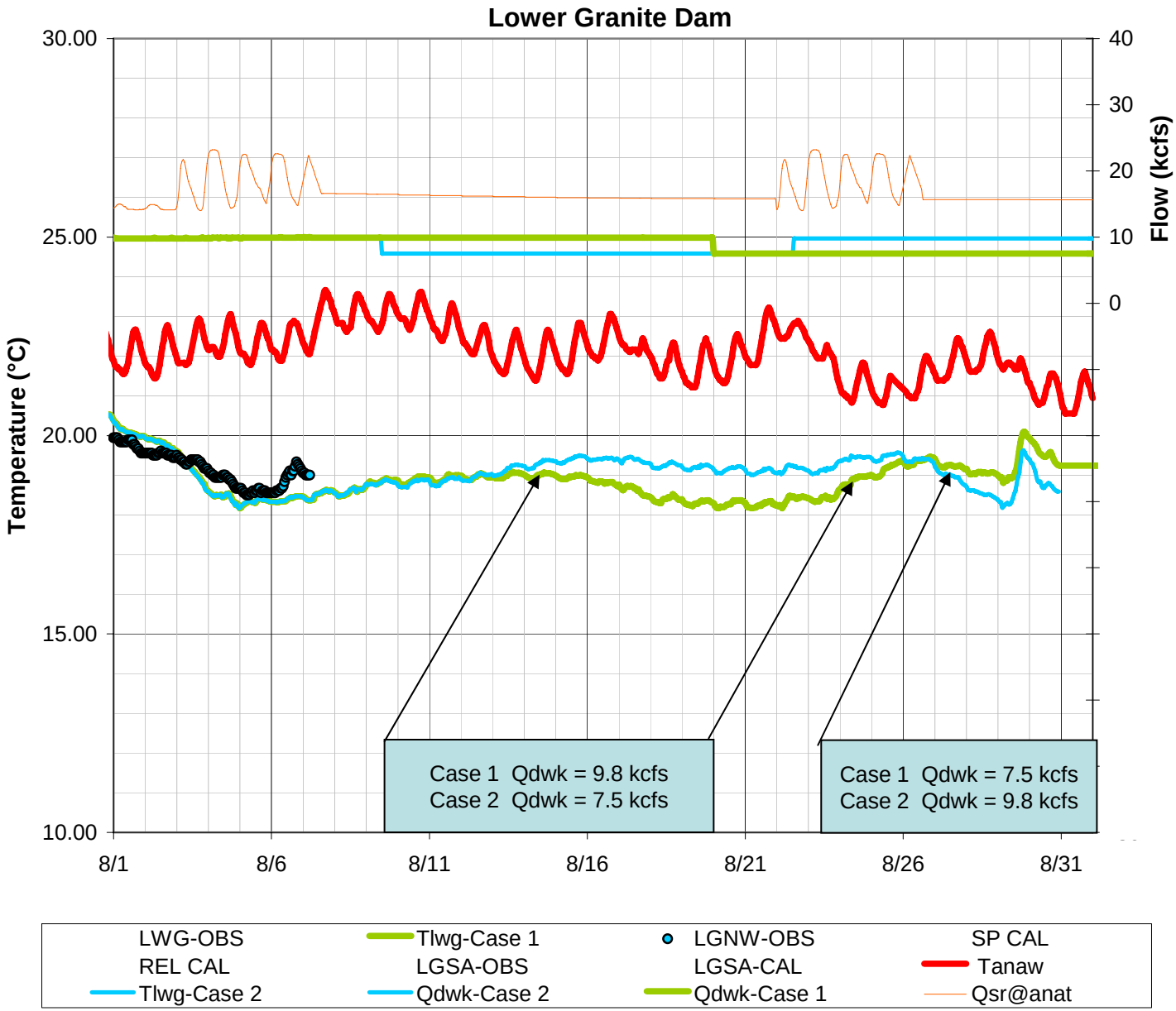
- Flows and Temperatures were simulated in the Snake River and Clearwater River Basins for the Month of July-August 2006.
  - Snake RM 107-167
  - Clearwater RM 0-42
- Meteorologic Conditions
  - NOAA 7 Day Forecast
  - Weather data 2005 Silcott Island/Dent Acres
- Boundary Conditions
  - Flows (STP)
  - Temperatures (2005 observed)
- Dworshak Operations (example)
  - Case 1 Aug 8-19 @ 9.8 kcsf, Aug 20-31 @ 7.5 kcfs
  - Case 2 Aug 8 @ 9.8 kcfs, Aug 9-22 @ 7.5 kcfs, Aug 22-31 @ 9.8 kcfs

Lower Snake Temperature Management

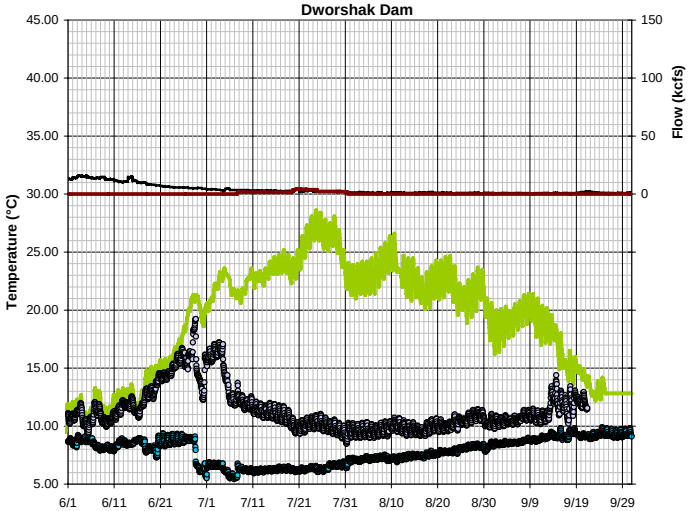
- Results
  - Shaping the releases (+/- 2.3 kcfs) from Dworshak can result in a ~1 C impact (increase or decrease) in releases from Lower Granite Dam
    - Case 1 – continued capacity releases from Dworshak will result in 19 C release temperatures from Lower Granite Dam this week
    - Case 1 - If releases from HC Dam are reduced to 10-11 kcfs daily average the release temperatures from Lower Granite Dam will fall below 19 C next week
    - Case 1 – operating schedule forces 2 turbine operation at 7.5 kcfs during the end of August to attain 1535 ft in Dworshak pool on Aug 31. This policy is less able to moderate a pulse of warm water from the SR during this time frame (second half of August).
    - Case 2 – Two turbine releases at 7.5 kcfs from Dworshak Dam are initiated on Aug 9 to conserve water for the second half of August with release temperatures at high as 19.5 C at Lower Granite Dam over the next week.
      - If HC Dam discharge remain higher than projected, temperature could approach 20 C.
    - Case 2 – The conservation of water in Dworshak pool afforded by this policy allows the moderation of water temperatures at the end of August during a pulse of warm water

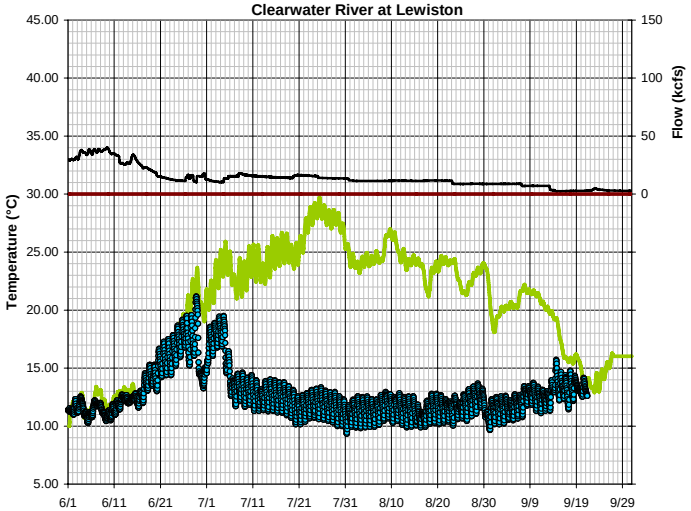
Lower Snake Temperature Management

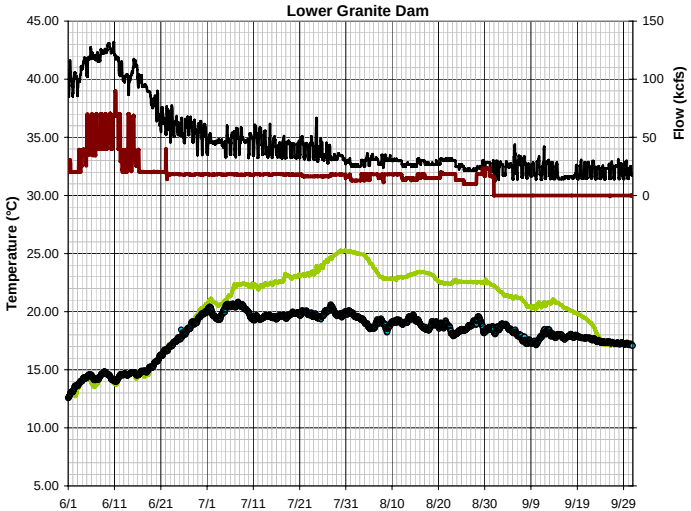
- Results
  - Recommended temperature management policy is to time capacity releases from Dworshak Dam with high thermal loading on the Snake River above the confluence with the Clearwater River
    - Metric of operational decision making should involve the average temperature of Clearwater River at Lewistion and Snake River at Anatone
    - When the average temperature from these sources is above 19 C it will generally result in 20+C at Lower Granite Dam
    - This location will allow for operational changes at DWK to be paired with thermal loading changes on the Snake River.
  - Lagged response between Dworshak operational change and thermal response at Lower Granite Dam
    - About a 5-6 day lag forecasted August conditions
  - Cooling influence of Dworshak releases go further in the second half of August due to lower forecasted flows on the Snake River.
  - Variability of forecasted water temperature are a function of model inputs (flows, temperatures, weather conditions)
    - Hells Canyon Dam Releases (Q & Temp)?
    - Reaccurance of “hellishly” warm weather conditions or rain

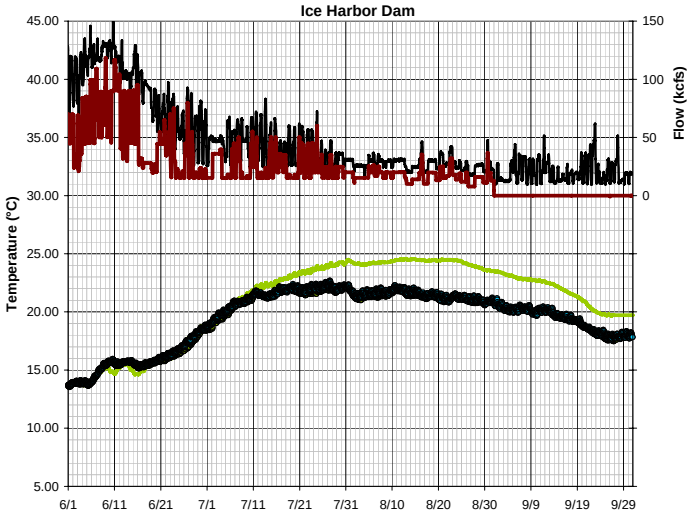

Lower Granite Dam
30.00
25.00
20.00
15.00
10.00
Temperature (°C)
40
30
20
10
0
Flow (kcfs)
8/1
8/6
8/11
8/16
8/21
8/26
8/31
Case 1 Qdwk = 9.8 kcfs
Case 2 Qdwk = 7.5 kcfs
Case 1 Qdwk = 7.5 kcfs
Case 2 Qdwk = 9.8 kcfs
LWG-OBS
Tlwg-Case 1
LGNW-OBS
SP CAL
REL CAL
LGSA-OBS
LGSA-CAL
Tanaw
Tlwg-Case 2
Qdwk-Case 2
Qdwk-Case 1
Qsr@anat

2006 Simulation Without Dworshak







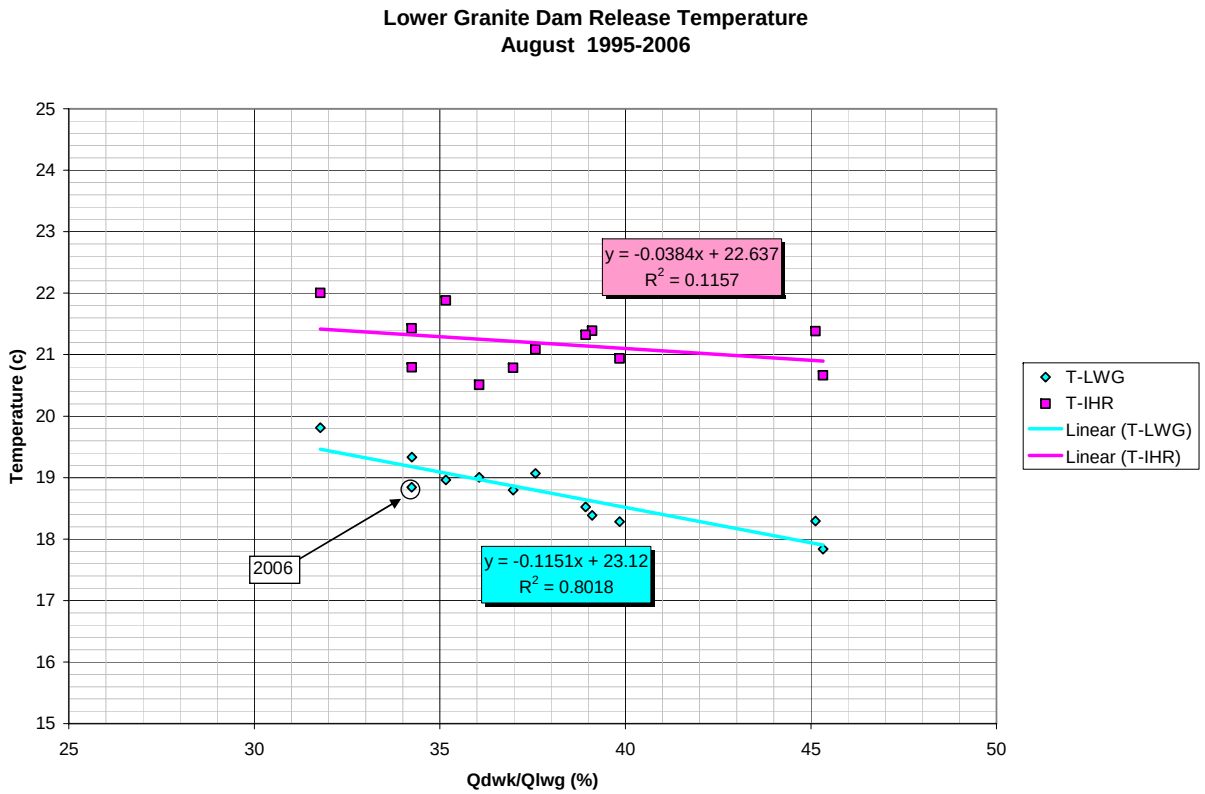


Snake River Temperature Management 2006

- Lessons learned
  - General
    - Managing Snake River Temperatures by Targeting Lower Granite Release Temperatures of 20 C or less should involve consideration of the thermal loading to the LWG Pool and the heat exchange during transit to the dam
      - Develop operation guidance for Dworshak releases involving thermal loading to LWG pool, time of travel, and atmospheric heating
    - Recommend consideration of alternative exposure metrics involving time of travel and suitable thermal habitat
    - First half of July will continue to be the most challenging period for maintaining temperature criteria

Snake River Temperature Management

- Q_{dwk}/Q_{lwg} and T_{lngw} are Strongly Correlated for the month of August
- August Average Temperatures all less than 20 C
- Weak relationship between Q_{dwk}/Q_{lwg} and T_{IHR}
- Temperature increase between Lower Granite and Ice Harbor Dam ranges from 2-3 degrees



Snake River Temperature Management 2006

- Lessons learned continued
  - General
    - Variability and Uncertainty of Temperature Forecasts should be a component of presenting management alternatives
      - Uncontrolled inputs of Thermal Loading
        - » Flows and Temperatures
        - » Atmospheric Heat Exchange
    - Worst Case Conditions in Lower Snake River
      - High flows from warm water sources
      - Hot weather conditions
      - Turbine outage at Dworshak
    - Flexibility in Scheduling Dworshak releases will lead to greater control of temperatures in the Lower Snake River
      - Optimal allocation of cold water

Snake River Temperature Management 2006

- Lessons learned continued
  - General
    - Washington State DEQ Water Quality Standards Updated
    - Site Specific Temperature Criteria for Lower Snake River
    - Temp Criteria
      - 1Dmax of 20°C or natural conditions+small allowance
        - » Temp>20°C Allowance=0.3 ^{o}C
        - » “At any time” Allowance = 34/(t+9)
    - Potential conflict between CWA-ESA for development of temperature management policy for Lower Snake River

Snake River Temperature Management 2006

- Lessons learned continued
  - Dworshak Dam and Pool
    - Water Budget Considerations Sensitive to
      - Lake storage volume properties
      - Estimated inflow volumes
    - Effective elevation of withdrawal is several meters above the controlling gate elevation in overshot mode
    - Early implementation of undershot withdrawals will lead to warmer releases as the season progresses
    - Initial conditions should be derived from averaged in-lake thermal conditions
      - transient temperatures

Snake River Temperature Management 2006

- Lessons learned continued
  - Clearwater River
    - Contains wide temperature range
      - North Fork 6-10 C
      - Clearwater River at Orofino 28 C
    - Travel Time to confluence less than one day
      - Typically 16 hours
    - Largest rate of warming (time rate of change)
      - Average warming rate 2-3 C in July and August

Snake River Temperature Management 2006

- Lessons learned continued
  - Lower Granite Pool
    - Dynamic conditions at the confluence
    - Development of density stratified flow
      - Vertical temperature gradients persist throughout the pool
    - Propagation of thermal fronts
      - Weather system induced
      - Flow ratio induced
    - Wide range in time of travel through pool (several days to weeks)
    - Release temperatures correspond closely with integrated temperatures in forebay
    - Temperature increase through pool 1-1.5 C

Snake River Temperature Management 2006

- Lessons learned continued
  - Lower Snake River Pools
    - Continual warming of average temperature
    - Weaker vertical gradients
      - Weather dependent
    - About 0.5-1.0 C warming per pool
    - Average Temperatures above 20 C (July, Aug)

– SR @ ANAW	22.4	22.2
– CR @ LEWI	13.1	11.0
– Lower Granite	19.8	18.8
– Little Goose	20.5	20.1
– Lower Monumental	20.7	20.7
– Ice Harbor	21.4	21.4

Snake River Temperature Management 2006

- Lessons learned continued
  - Modeling Issues
    - What is the influence of RSW operations on release temperatures and management issues?
    - How can uncertainties in system inputs best be captured in forecasted flow and temperature conditions?
    - Where should the upstream Snake River boundary be located?