CE-QUAL-W2 Model Applications to Examine the Effects of Operations on Fish Habitat in Lake Murray

Meeting to Report on Preliminary Results

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Relicensing Issues Identified by the Water Quality Technical Working Committee

- The causes of striped bass fish kills reported in previous years, especially factors related to Saluda Hydro operations
- The effects of Unit 5 operations on entrainment of blue-back herring
- Determination of operational changes that might increase habitat for striped bass and blue-back herring
- Track any impacts that could occur to the tailwater cold-water fishery due to potential operational changes

Factors Considered in Addressing Relicensing Issues

- Annual flow regimes
- Pool level management
- Unit 5 operations
- In-lake and release water quality
- Habitat for striped bass and blue-back herring
- Water quality, meteorological, and operations data over the period 1990-2005
- Emphasis will be placed on section of reservoir from Blacks Bridge to Saluda Dam

Plan for Using CE-QUAL-W2 to Address the Water Quality TWC Relicensing Issues

1. Analyze water quality, meteorological, flow, and operations data for the period of study

2. Set up CE-QUAL-W2 for the years when major striped bass fish kills occurred as well as other years

3. Run models to identify the causes that apparently contributed to the fish kills

4. Use the models to explore ways to avoid such fish kills in the future, with emphasis on project operations

Preliminary Findings

- High flow, especially during March-August, is the primary cause for fish kills

- Higher flows cause the bottom of the lake to warm which in turn increases the rate of DO depletion

- Meteorological conditions can affect striper habitat

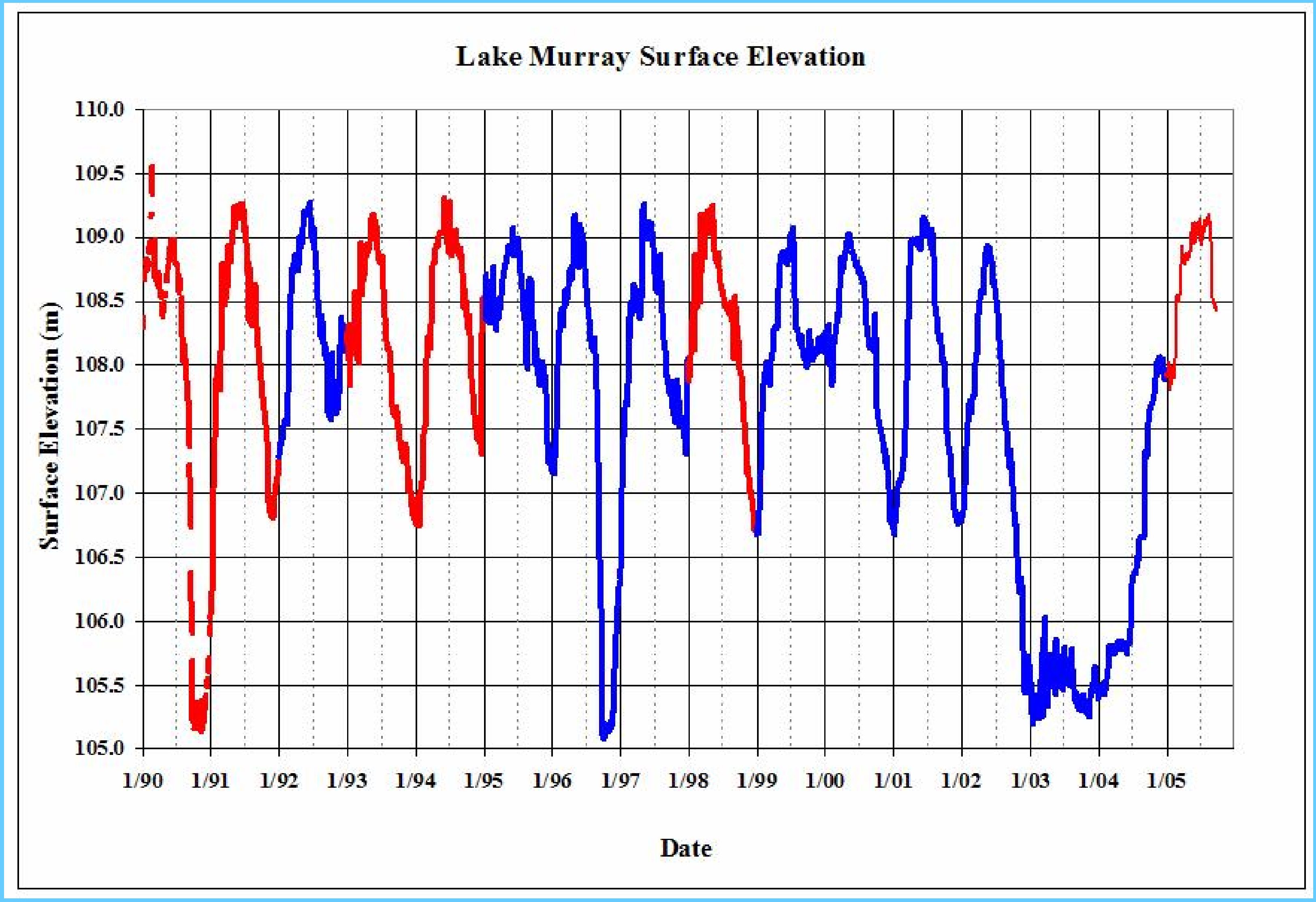
- Model results indicate that the temperature and DO range of tolerable striper habitat in Lake Murray is approximately:

  $T < 27^{o}C$ and $DO > 2.5$ mg/l

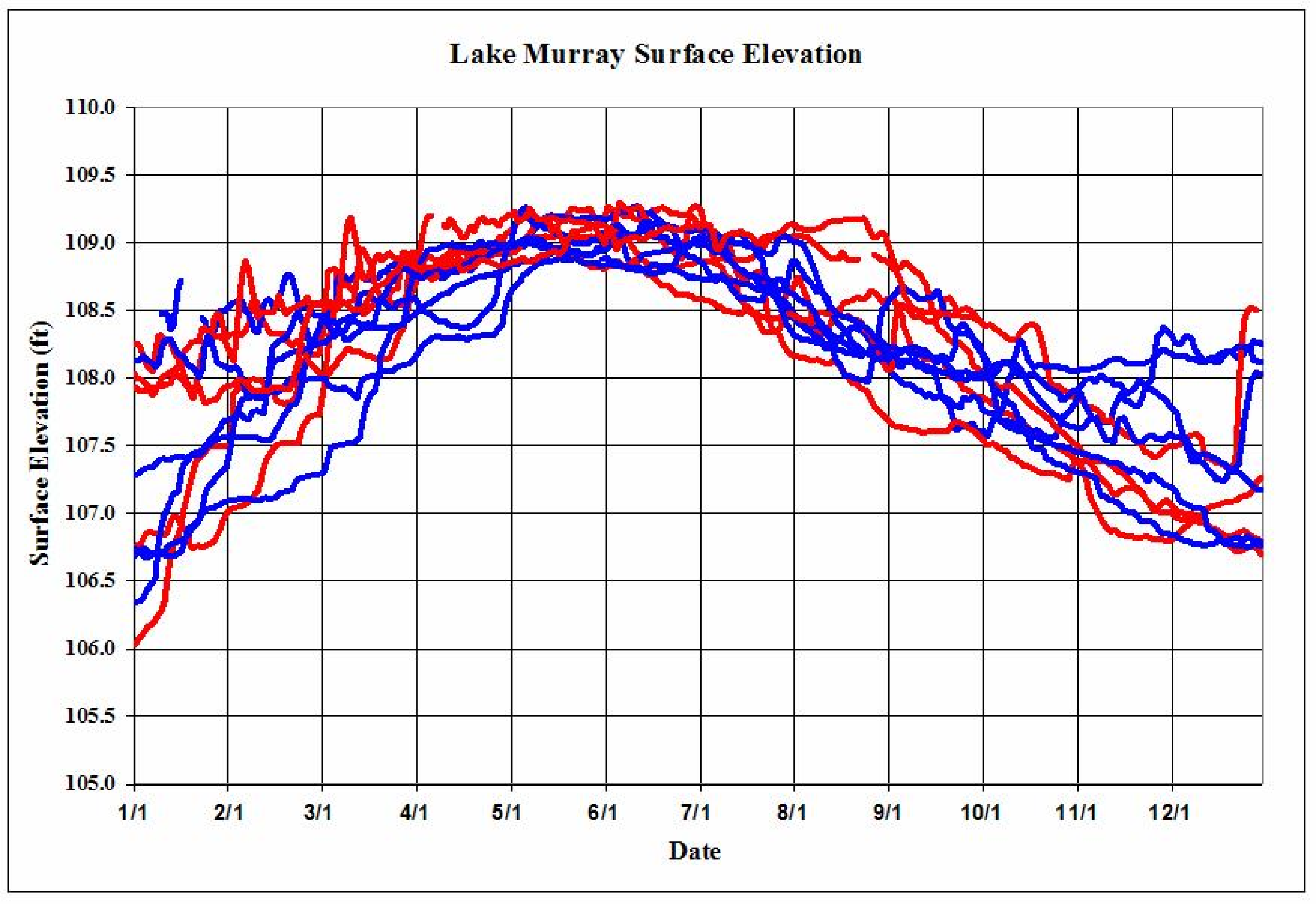
- Preferential use of Unit 5 helps preserve colder bottom water and was predicted to improve DO and increase striper habitat

Lake Murray Surface Elevation 1990-2005

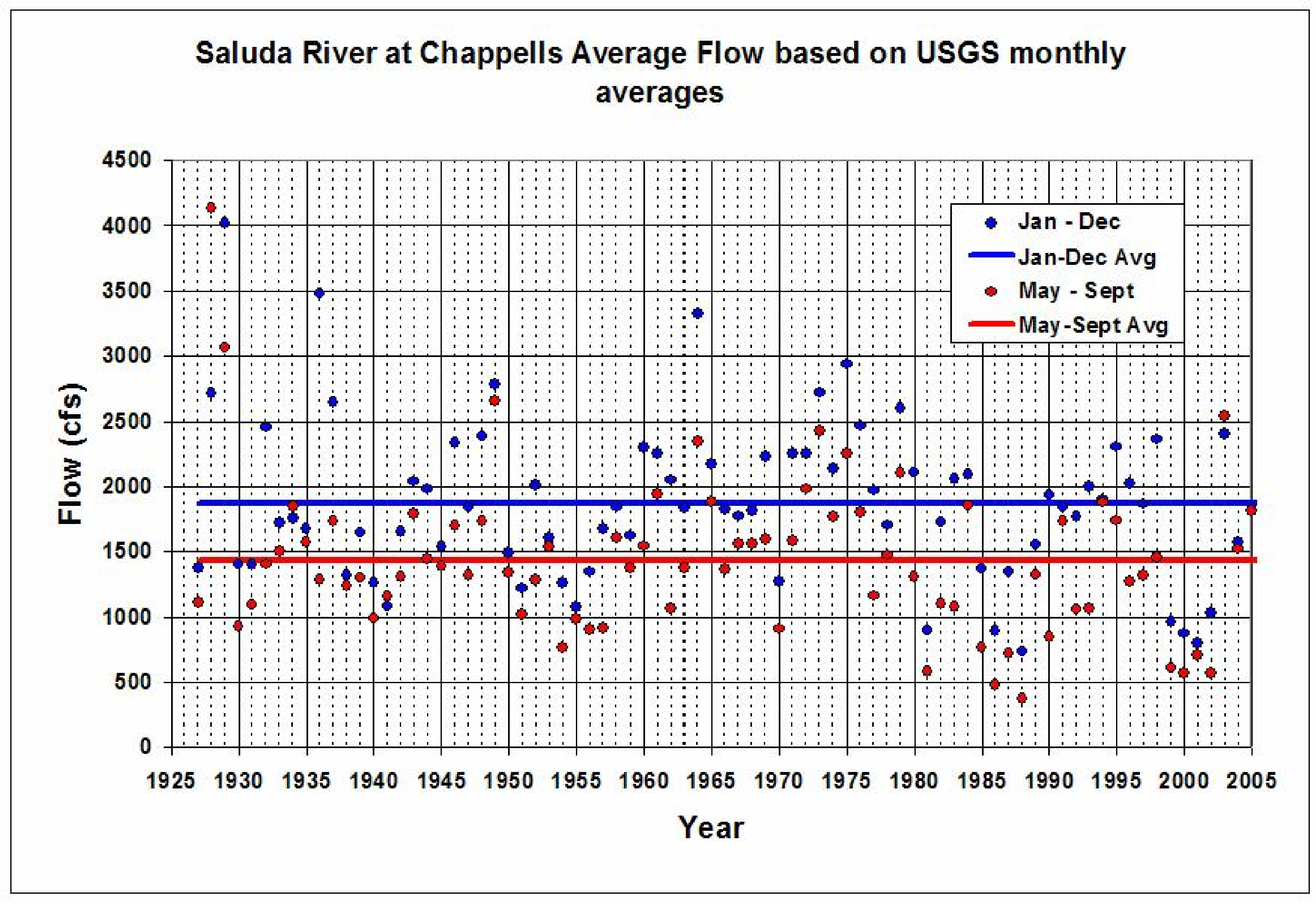
Years with documented striped bass kills are red



Lake Murray Surface Elevation 1990-2005
Typical Years Only (no special drawdowns)
Years with documented striped bass kills are red

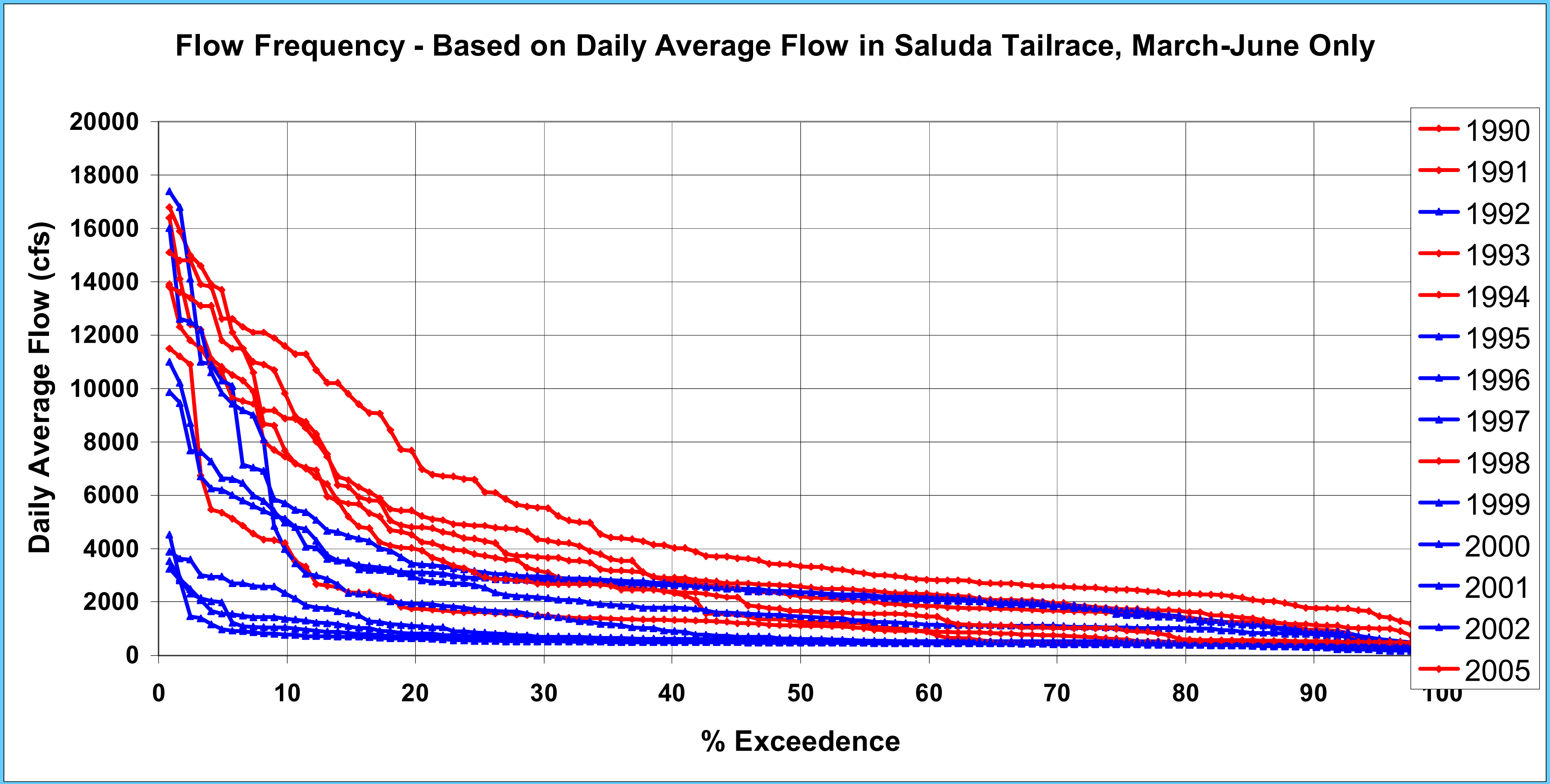


Average Annual Flow – Saluda River at Chappells



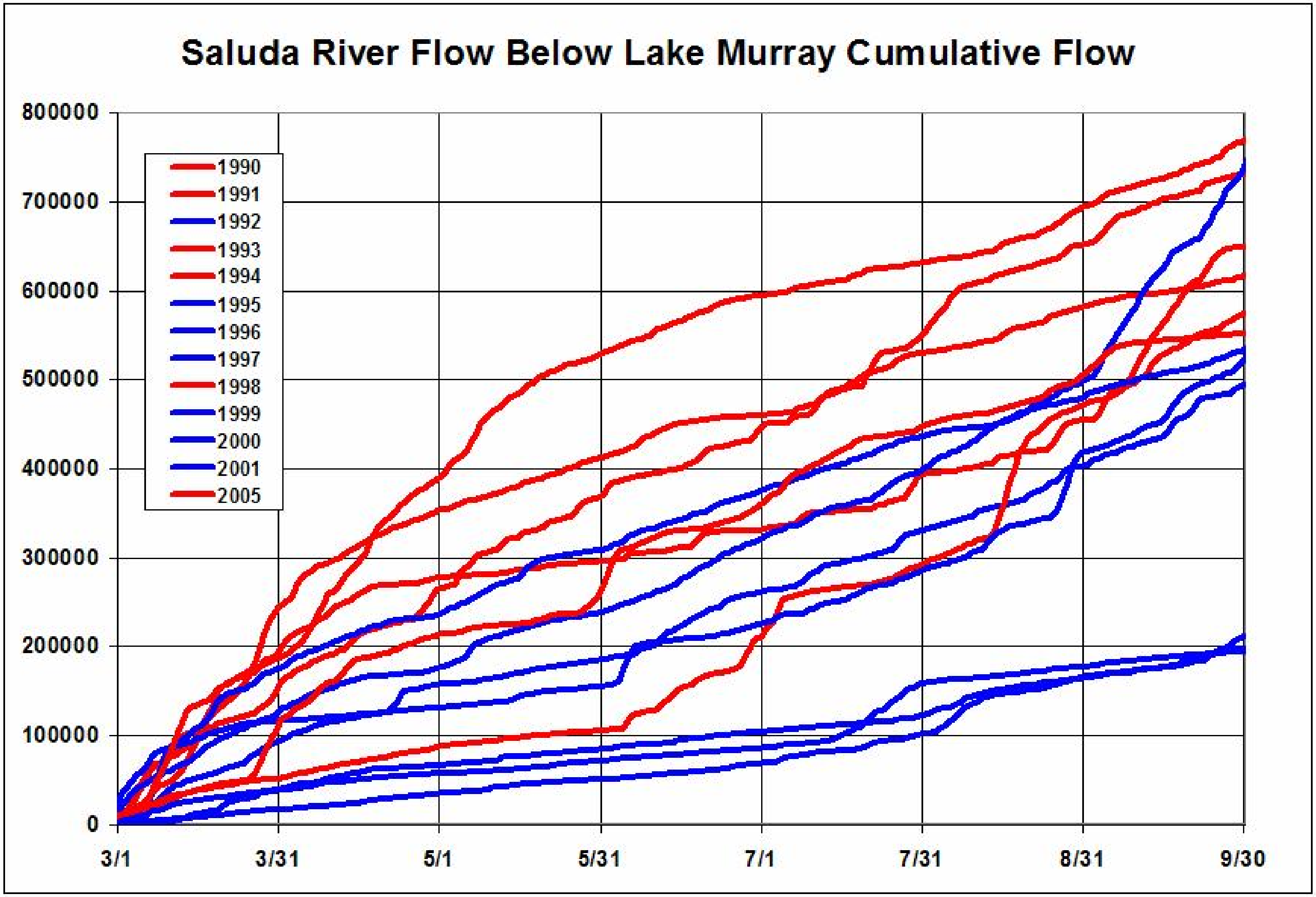
Excel Table with Monthly Average Flow Below Saluda

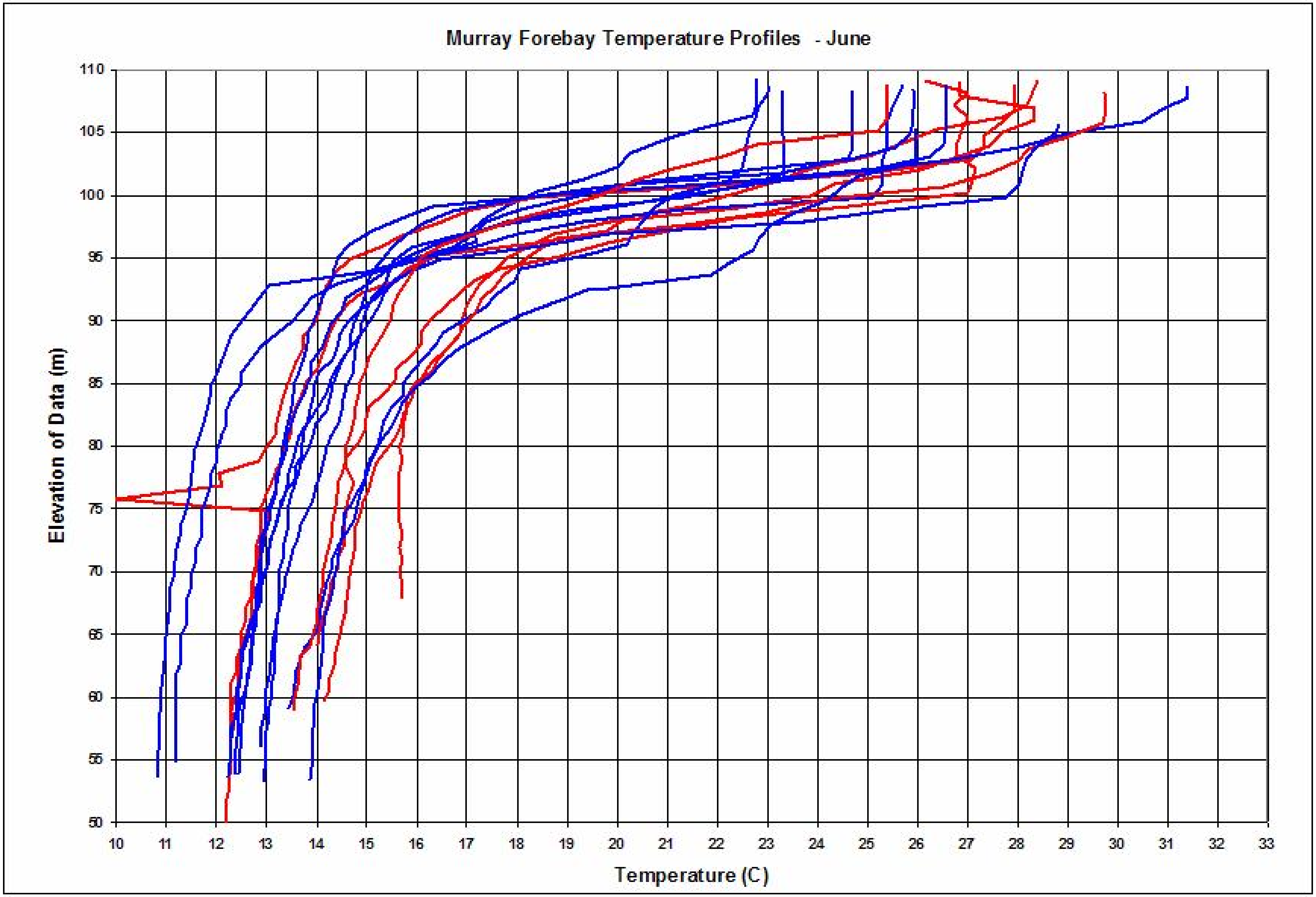
Flow Frequency – Saluda River Below Lake Murray



Cumulative Outflow – March-December

Years with documented striped bass kills are red





Murray Forebay Temperature Profiles - June
Elevation of Data (m)
Temperature (C)
110
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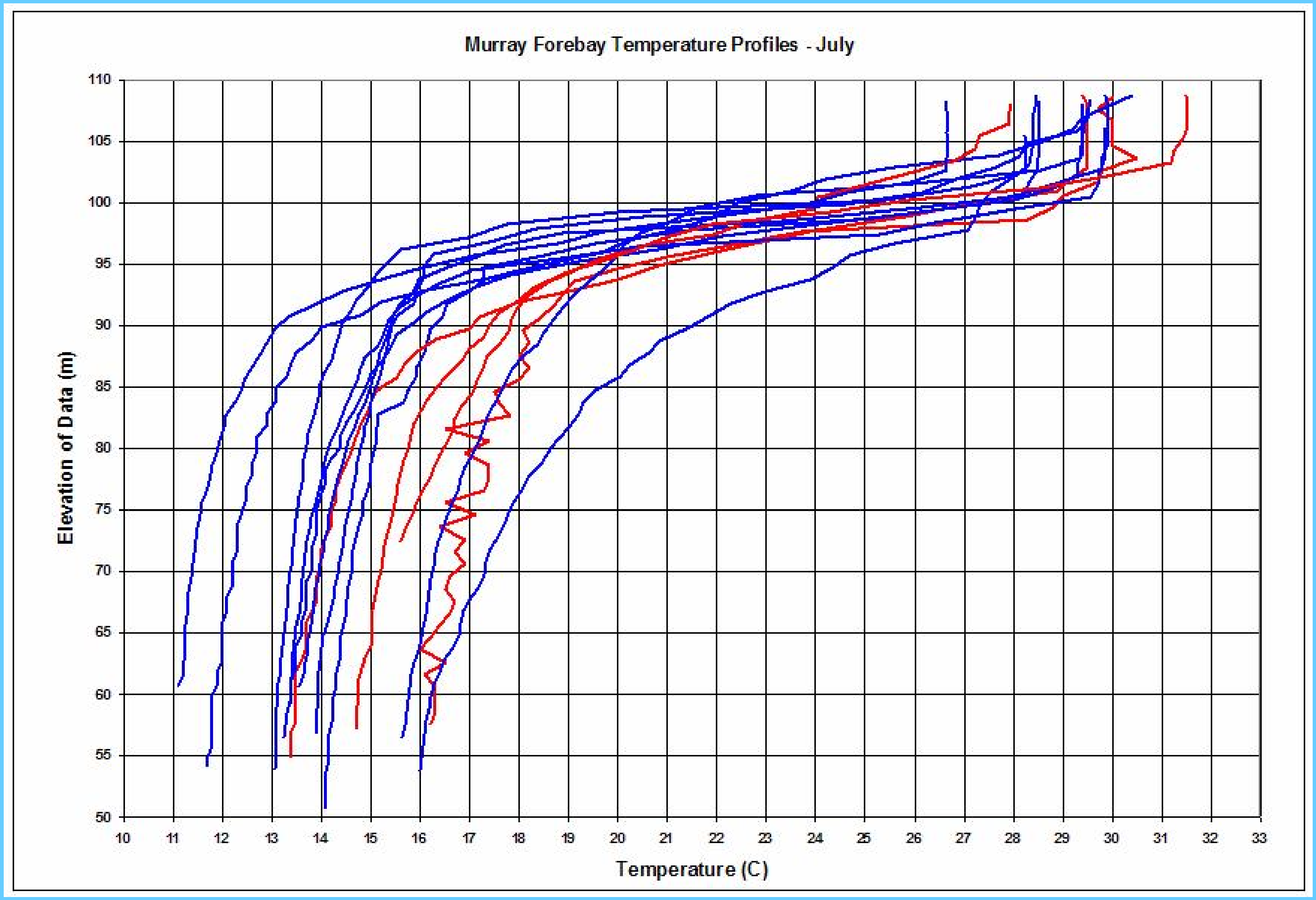

Murray Forebay Temperature Profiles - July
Elevation of Data (m)
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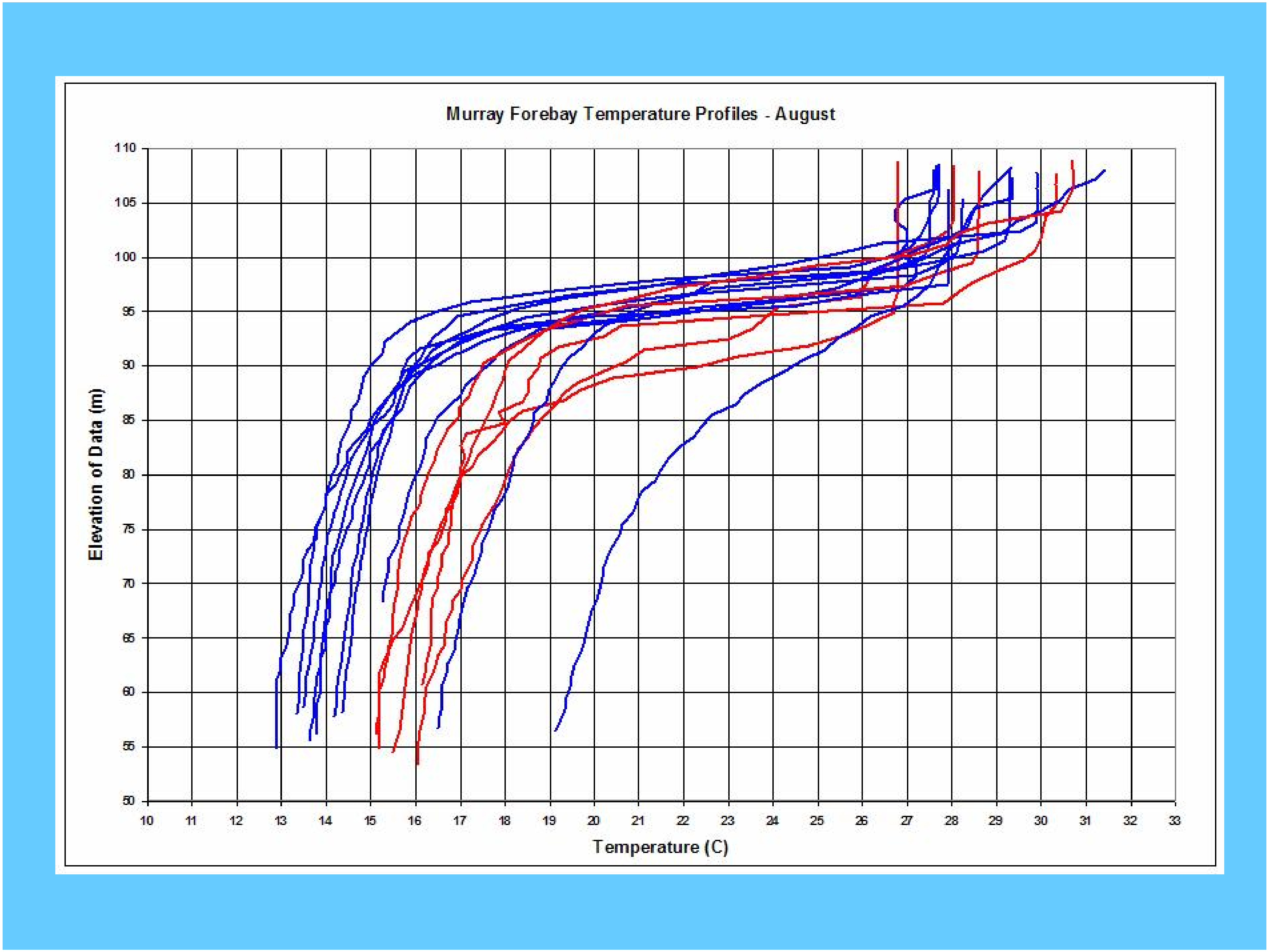
Temperature (C)


Murray Forebay Temperature Profiles - August
Elevation of Data (m)
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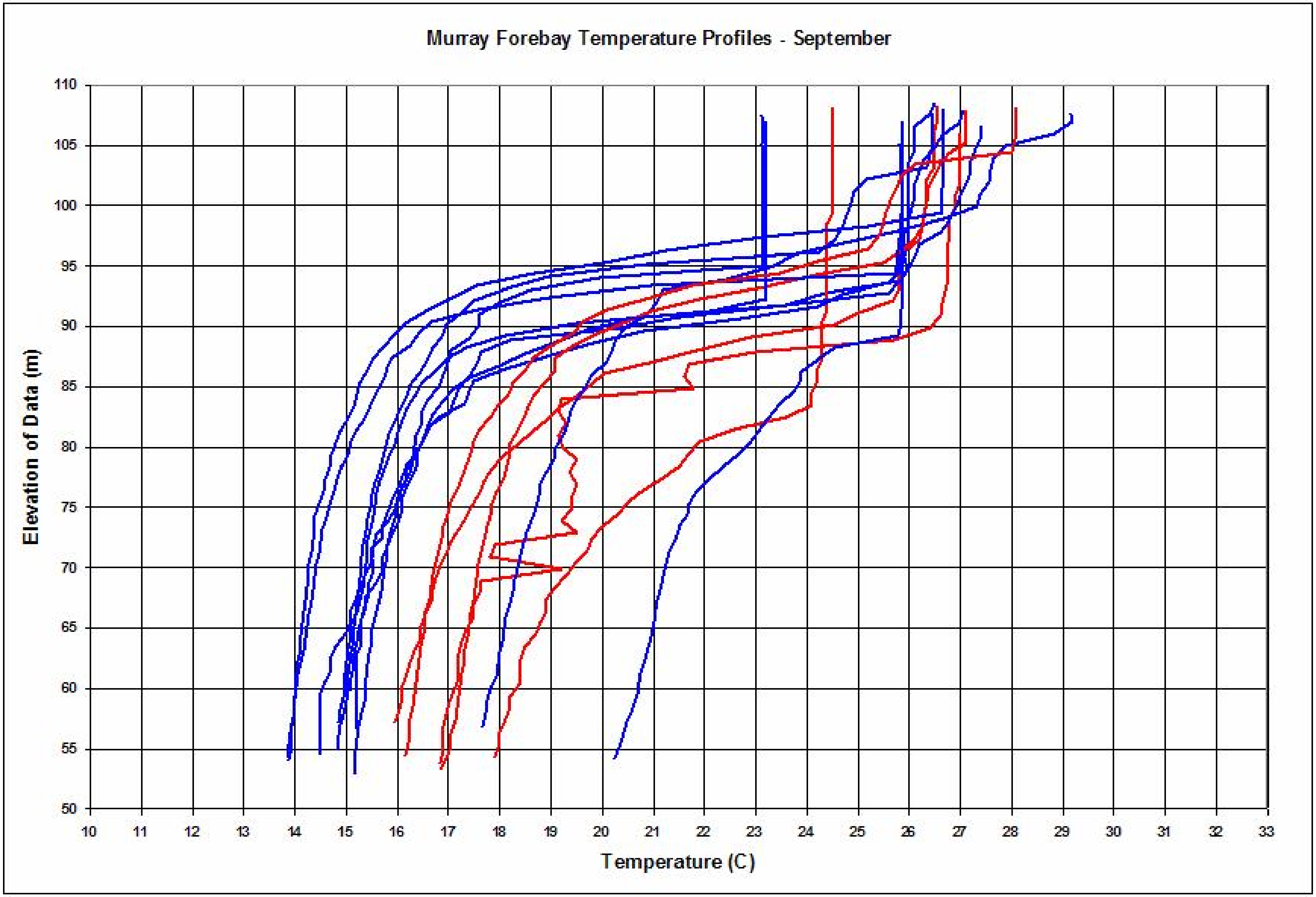
Temperature (C)


Murray Forebay Temperature Profiles - September
Elevation of Data (m)
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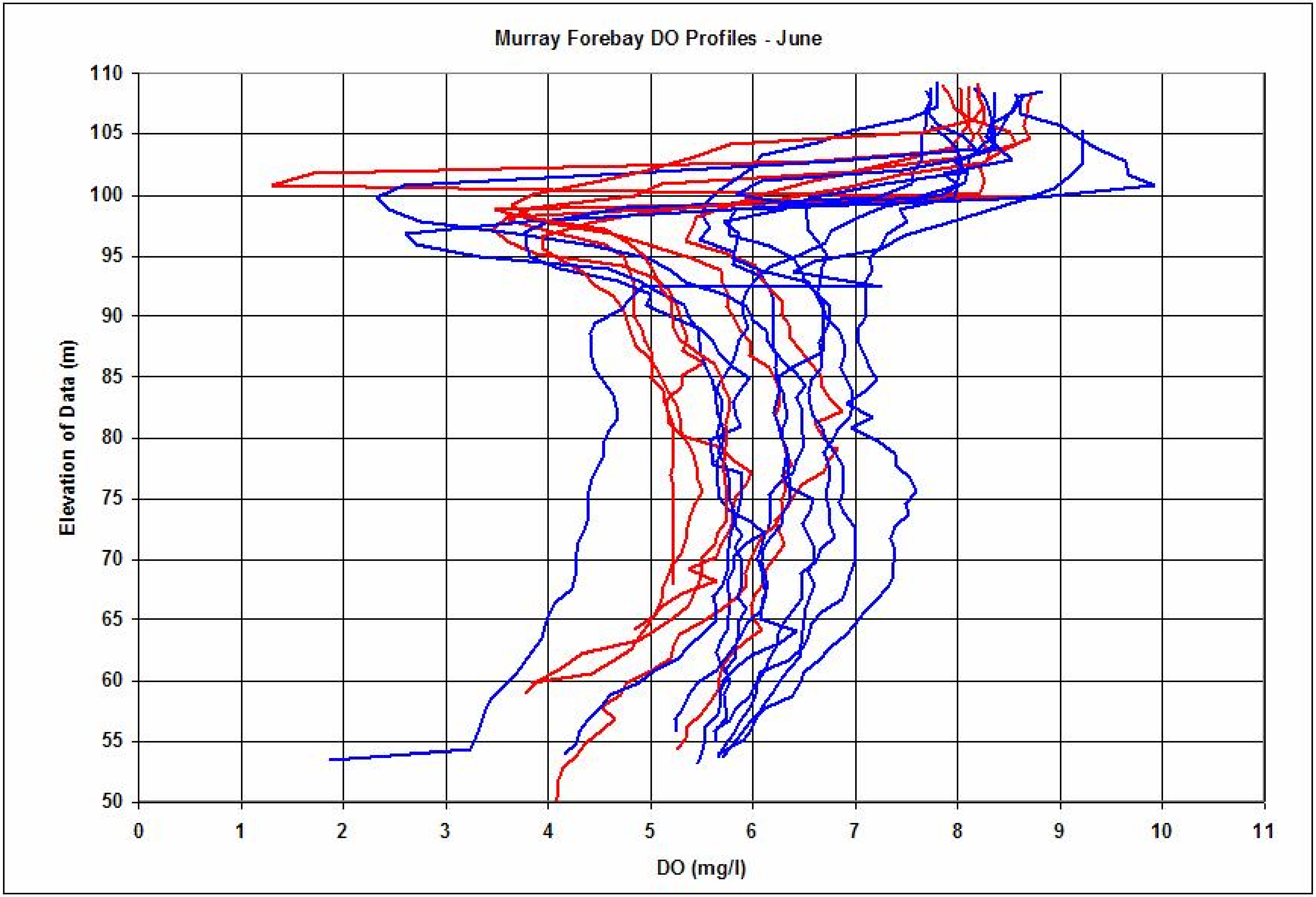
Temperature (C)


Murray Forebay DO Profiles - June
Elevation of Data (m)
DO (mg/l)
110
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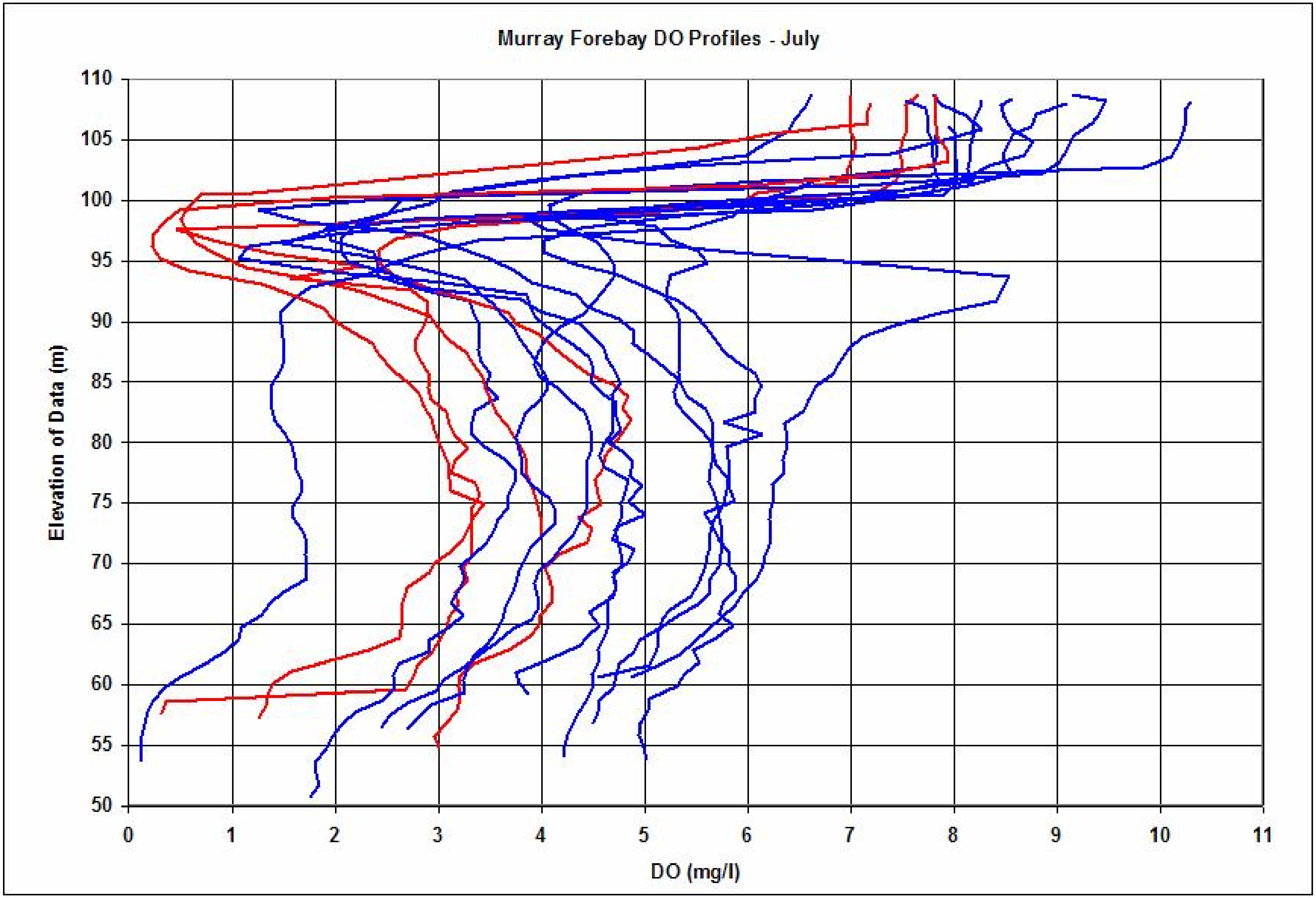
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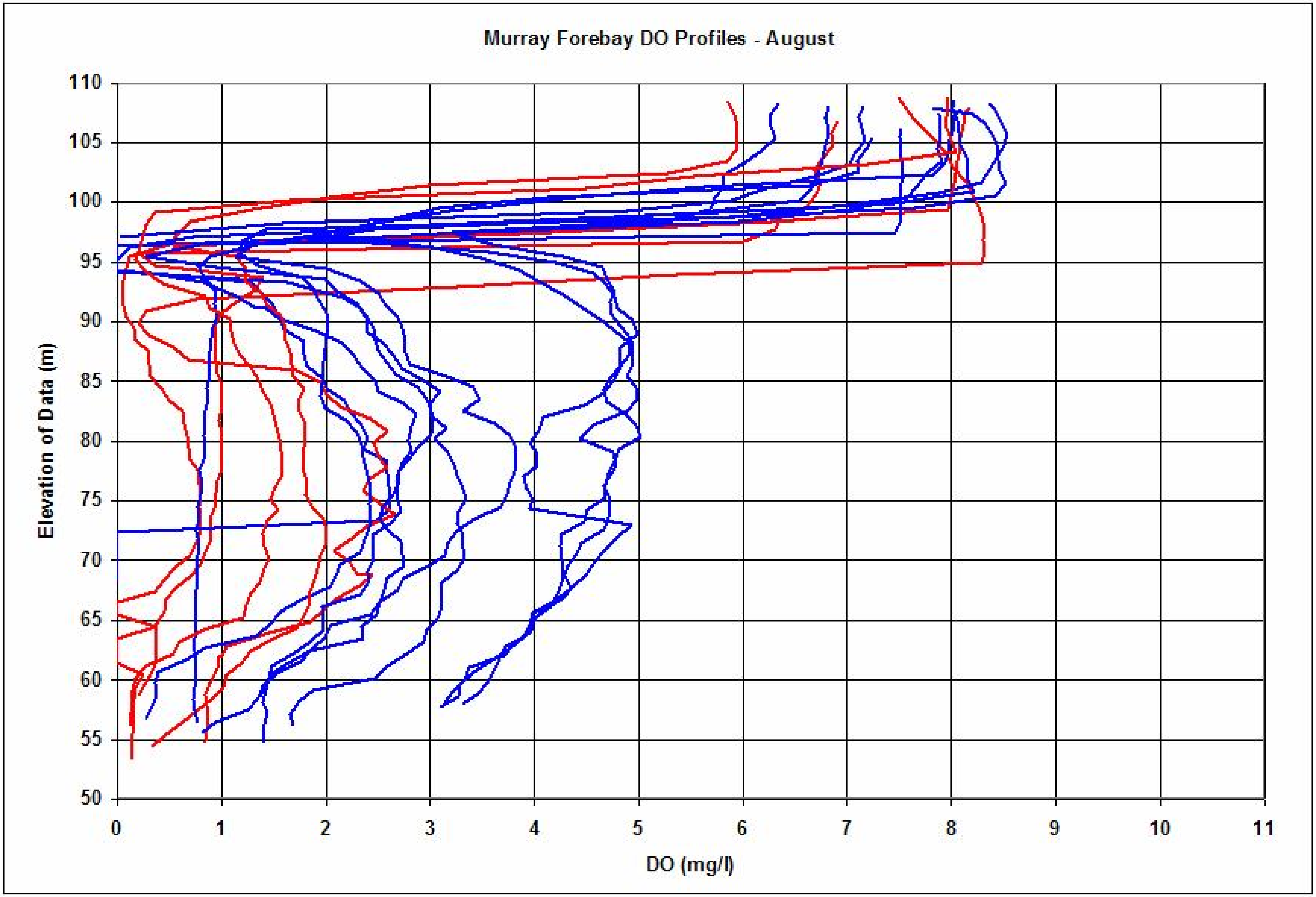

Murray Forebay DO Profiles - August
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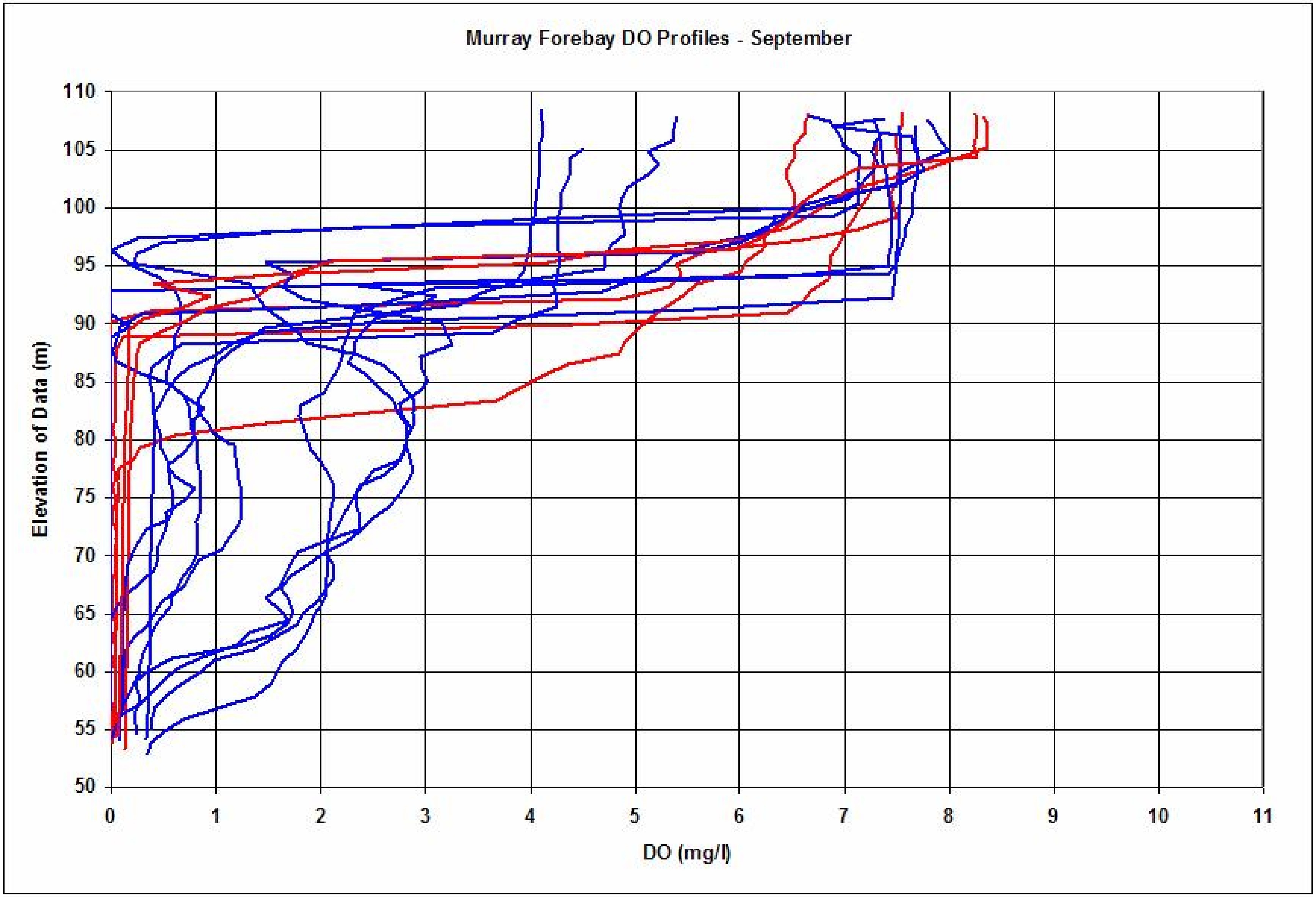
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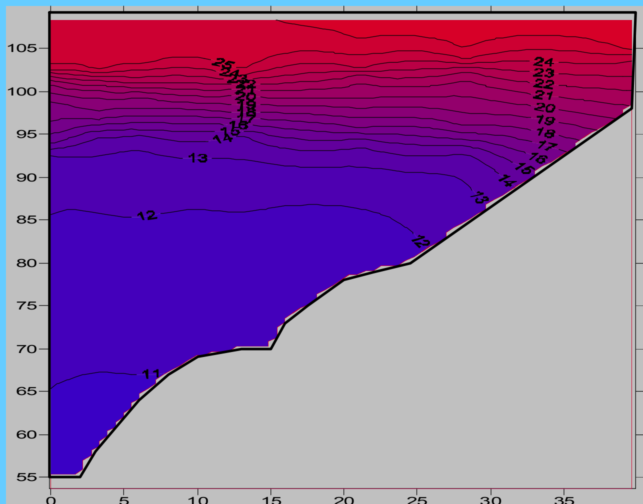
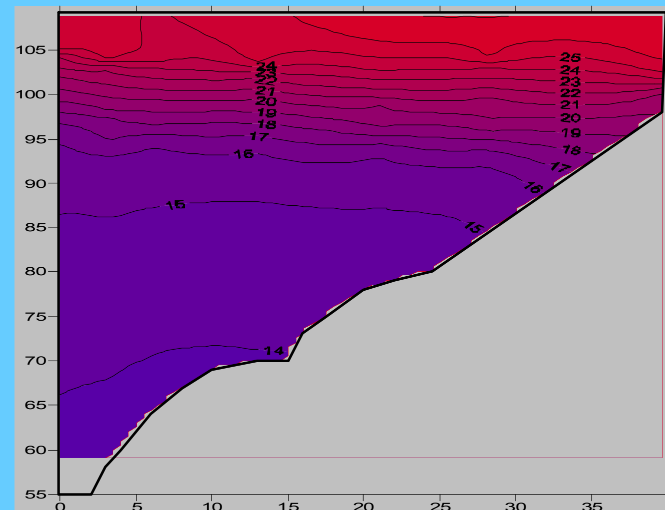
DO (mg/l)

Lake Murray Contour Plots

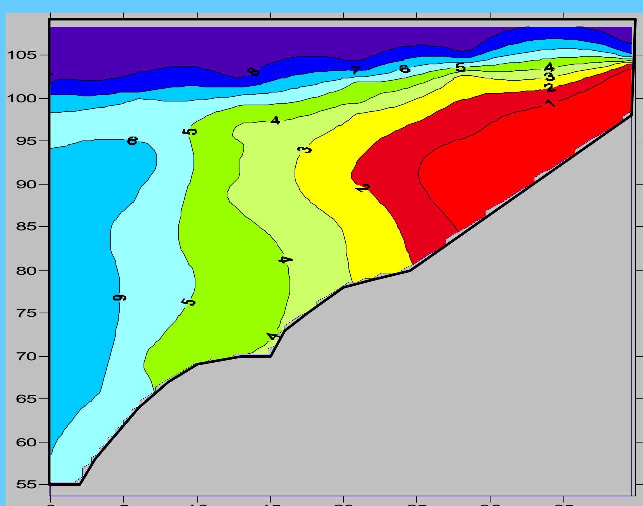
June 2002 Temperature



June 2005 Temperature



June 2002 DO



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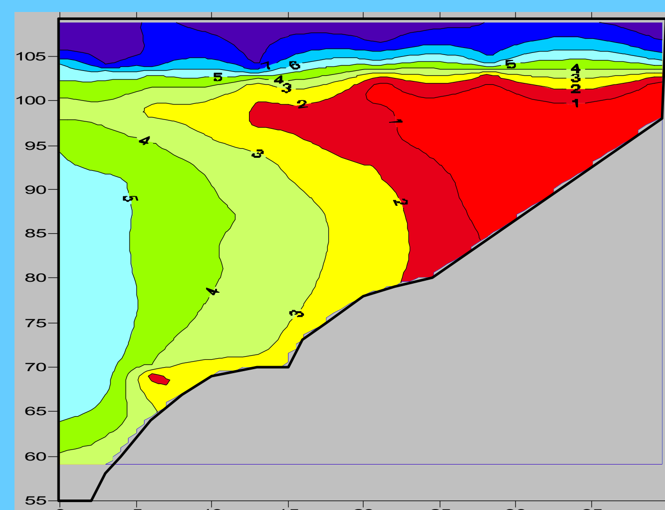
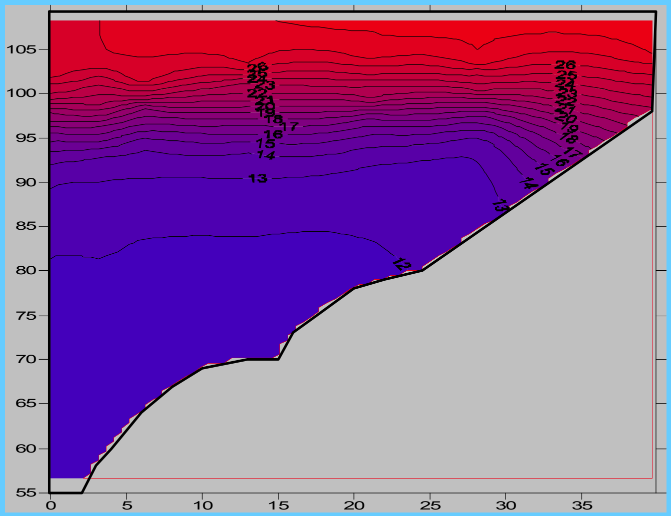
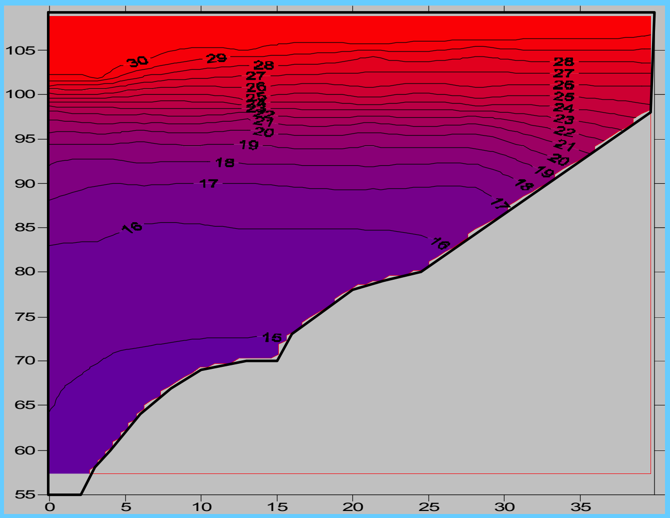


Lake Murray Contour Plots

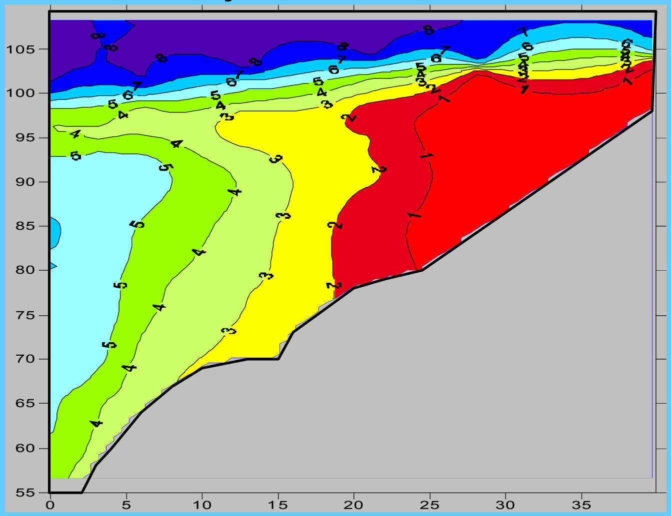
July 2002 Temperature



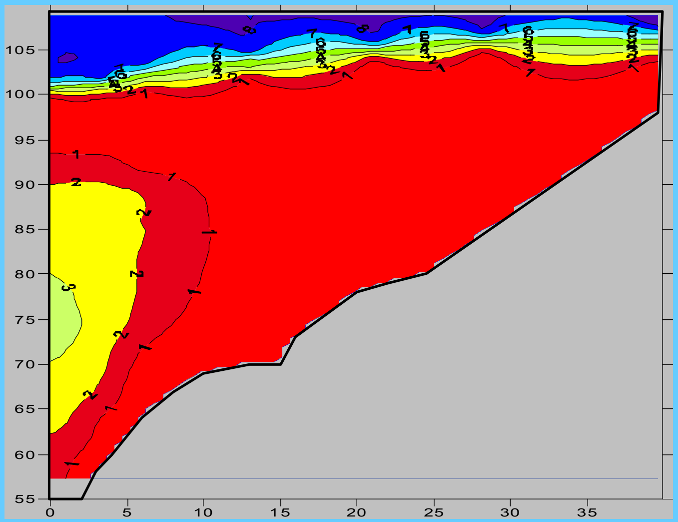
July 2005 Temperature



July 2002 DO

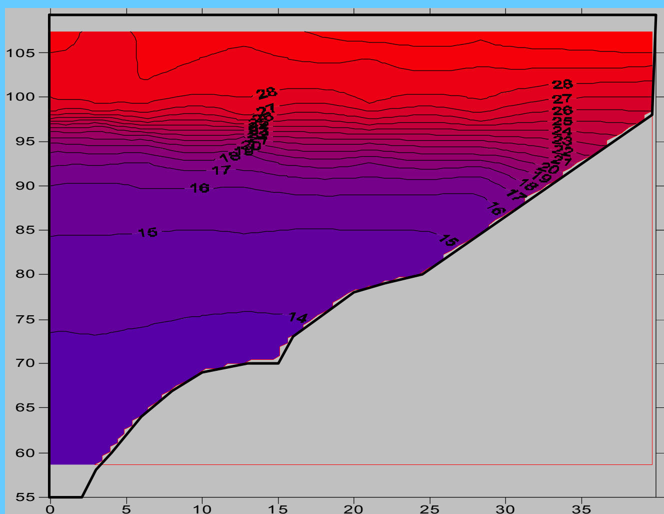


July 2005 DO

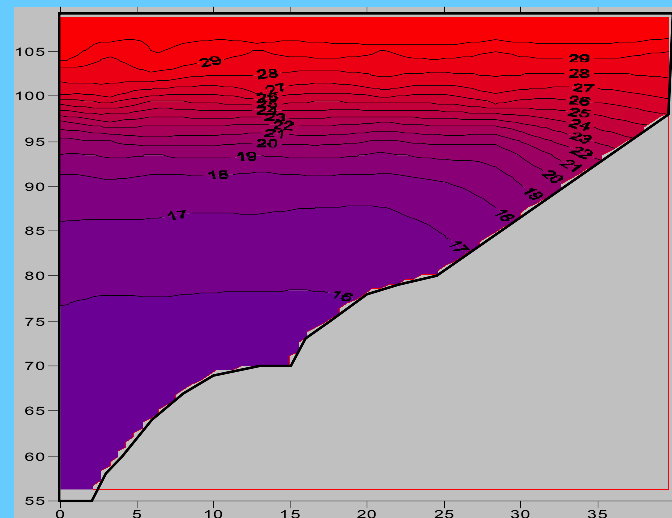


Lake Murray Contour Plots

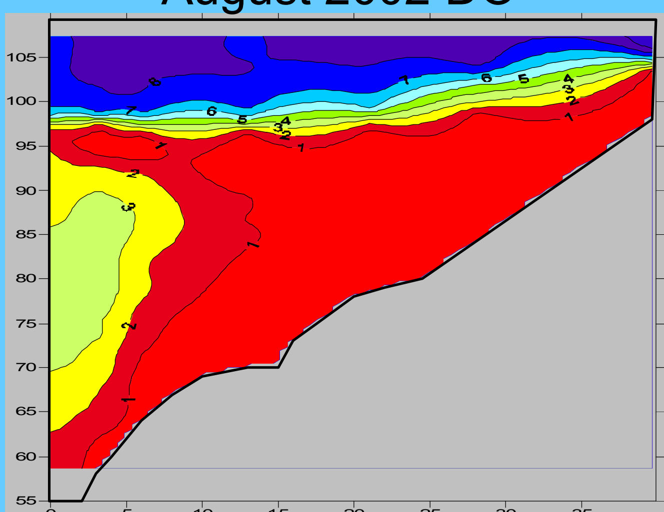
August 2002 Temperature



August 2005 Temperature



August 2002 DO



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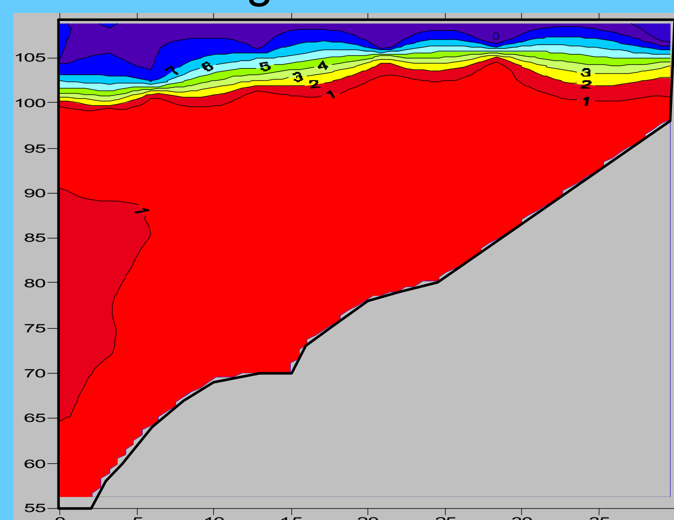
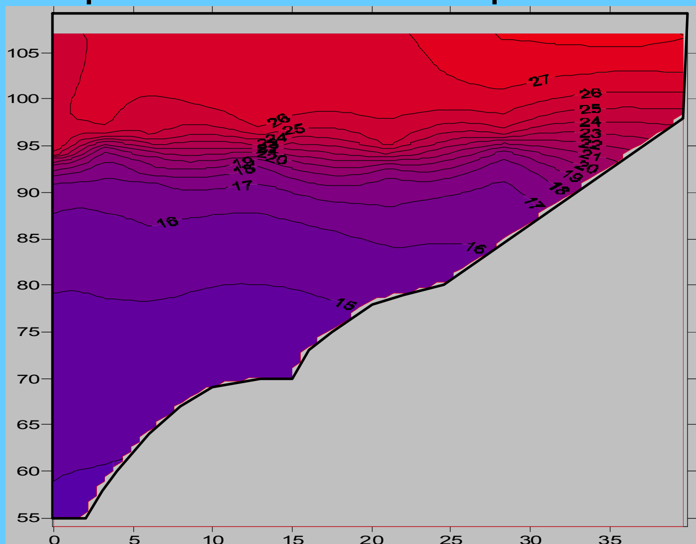
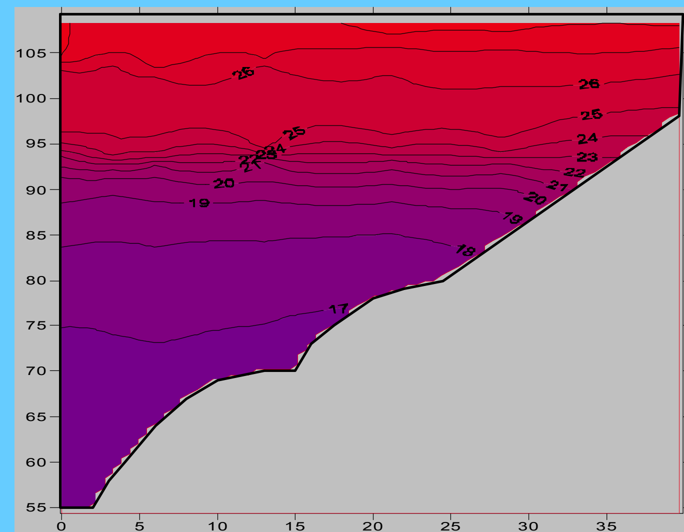


Lake Murray Contour Plots

September 2002 Temperature



September 2005 Temperature



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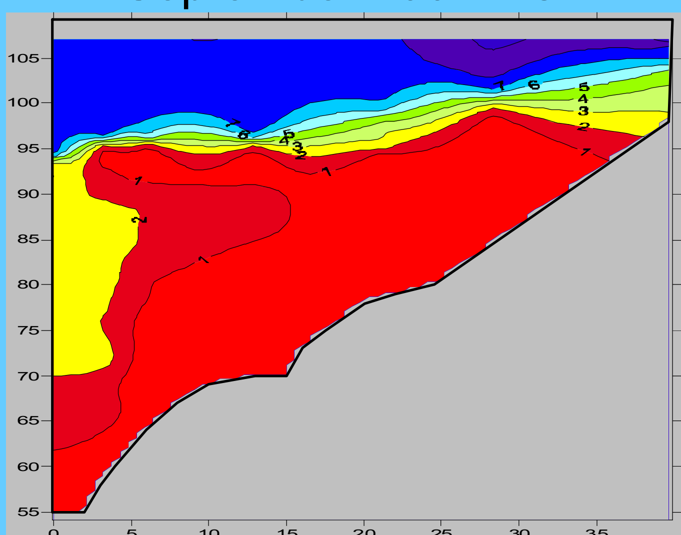

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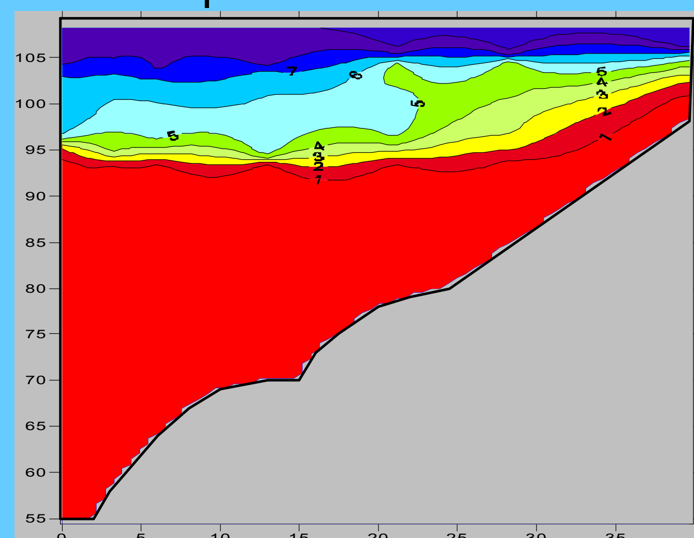
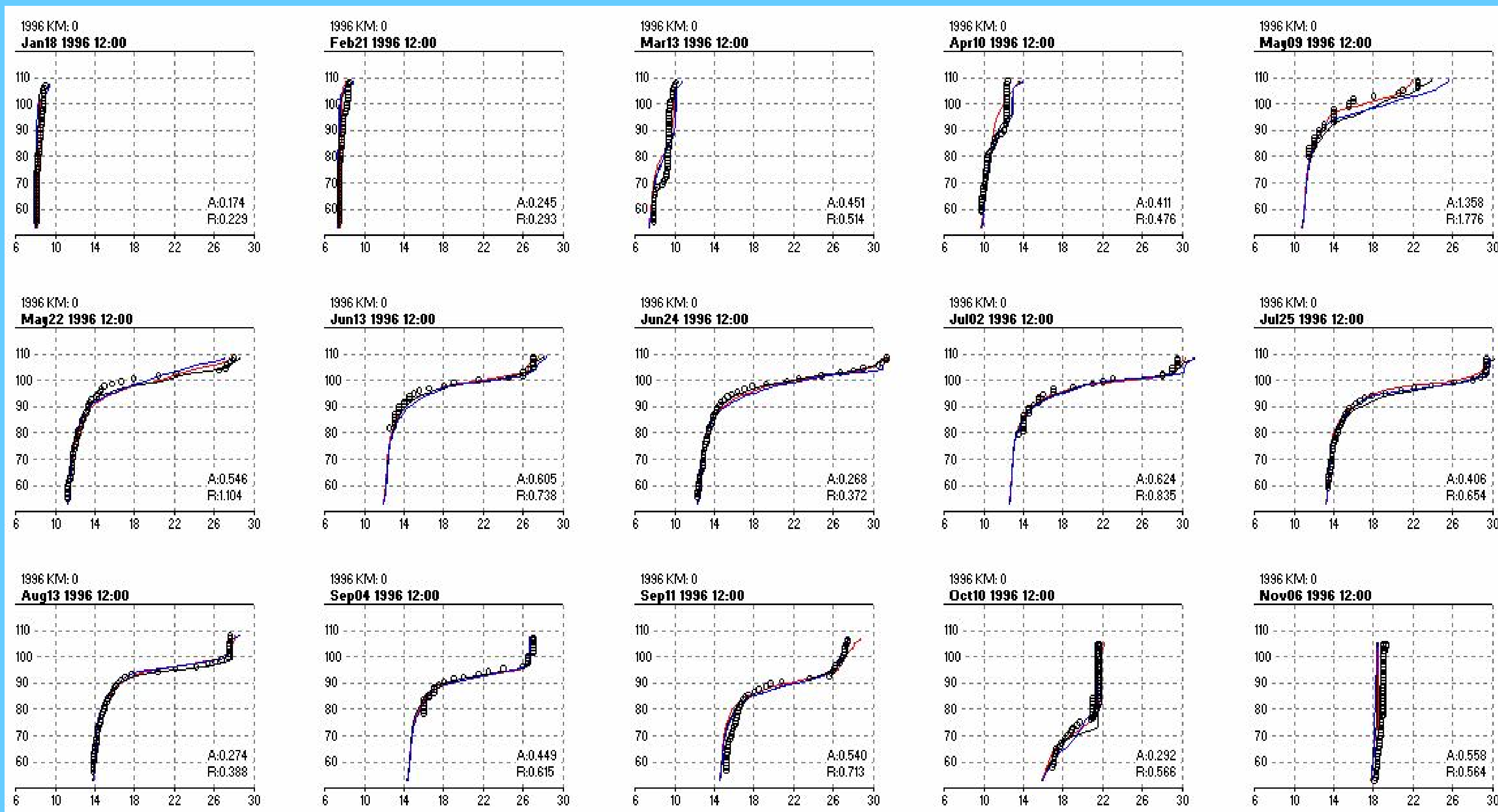


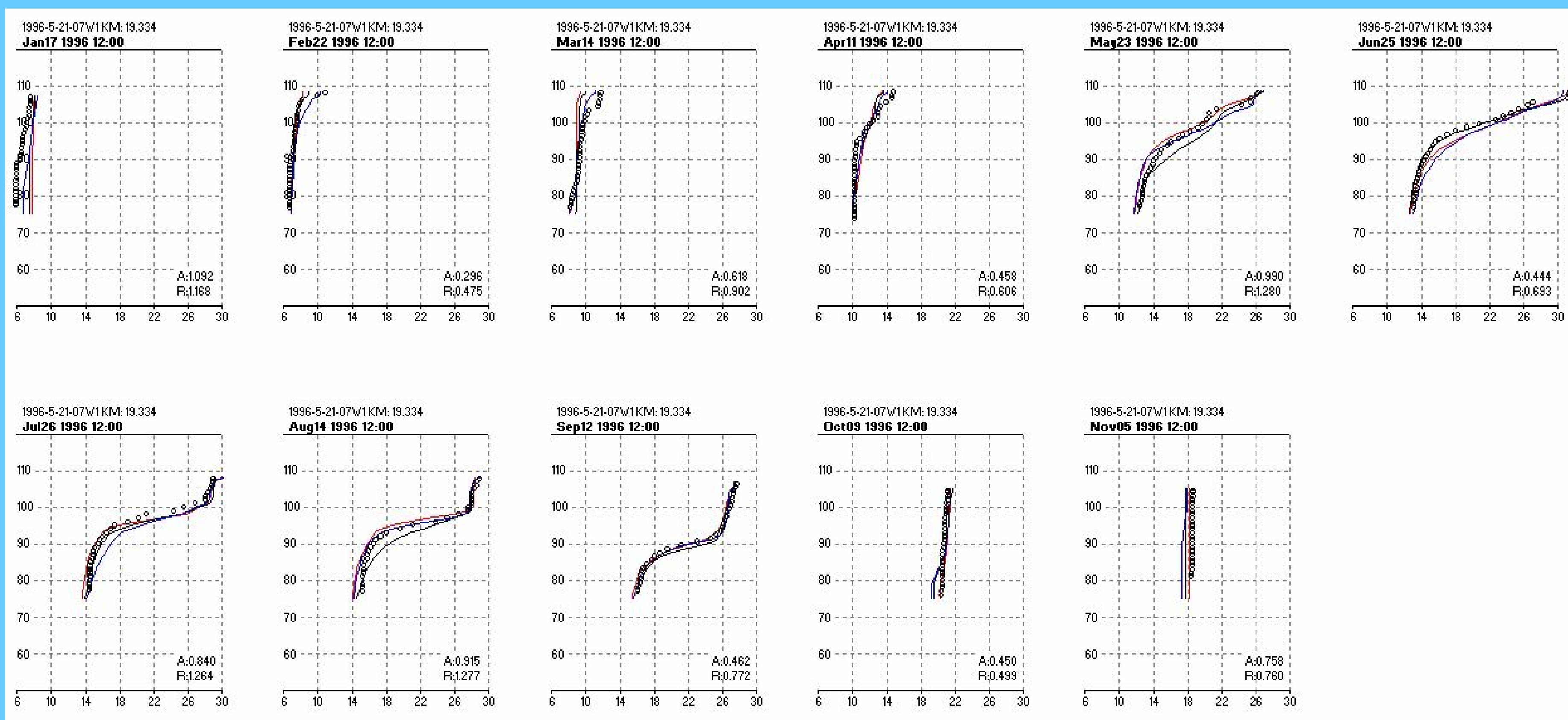
Model Calibration

- Model was originally calibrated to 3 years: 1992, 1996 and 1997
- Model SOD was adjusted in each of the 3 years to improve DO calibration

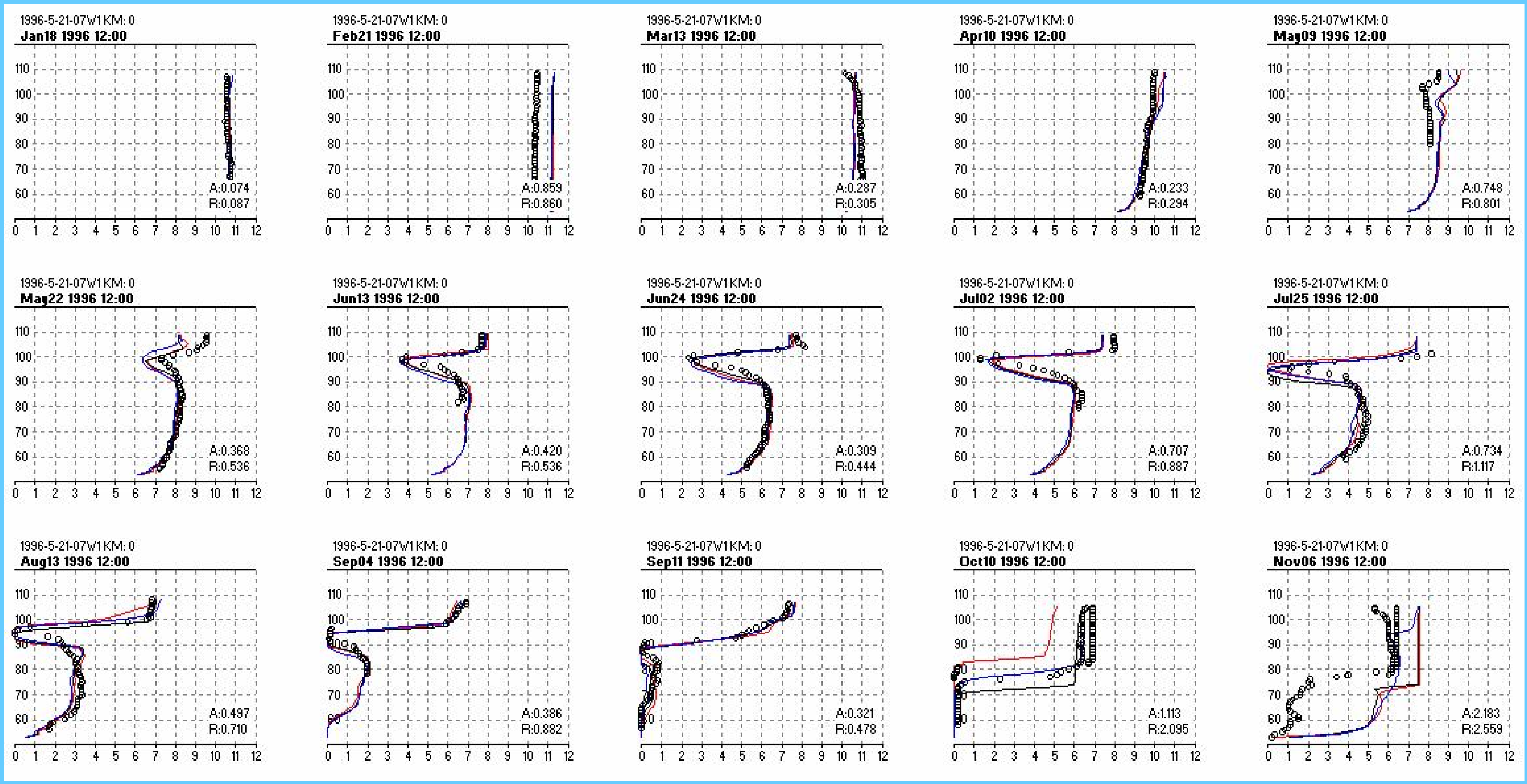
1996 Lake Murray Temperature Profiles
Forebay
Model vs. Data



1996 Lake Murray Temperature Profiles
19 Kilometers Upstream of Dam
Model vs. Data



1996 Lake Murray DO Profiles
Forebay
Model vs. Data



1996 Lake Murray DO Profiles
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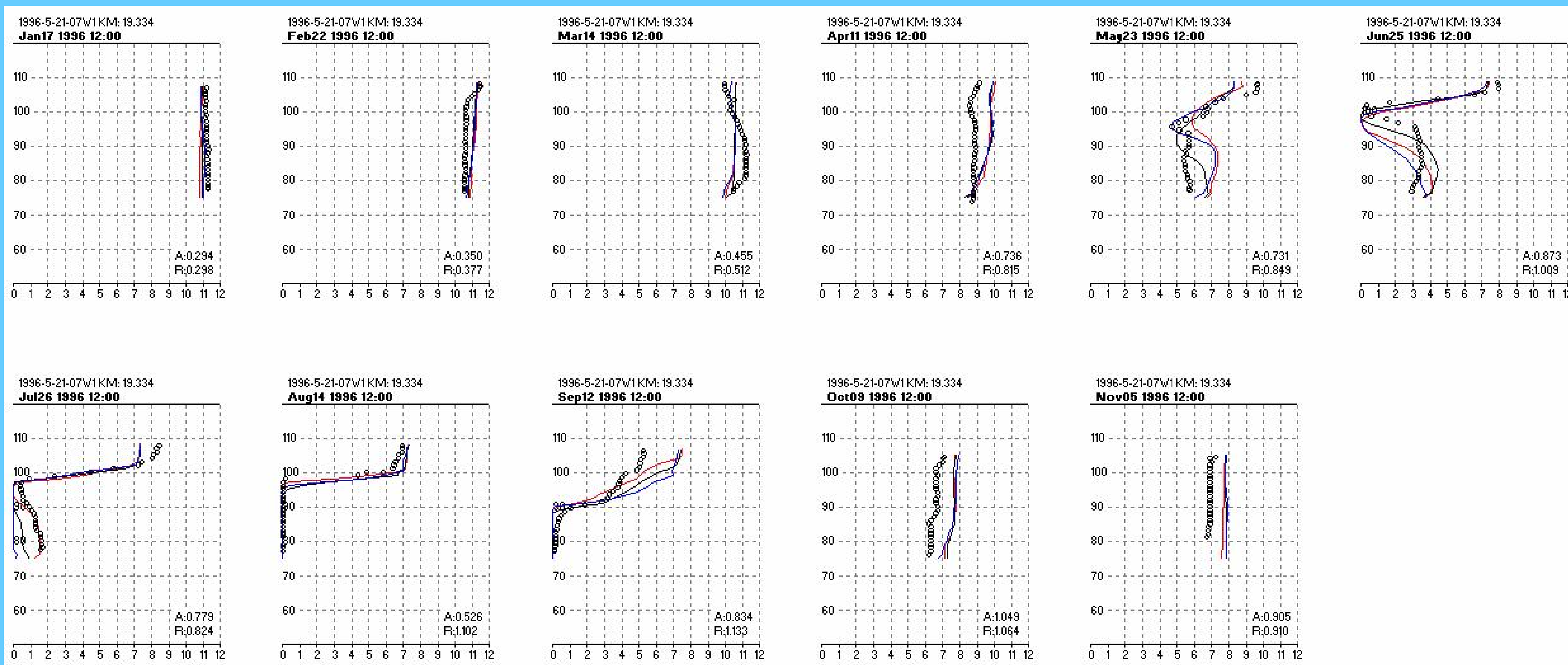
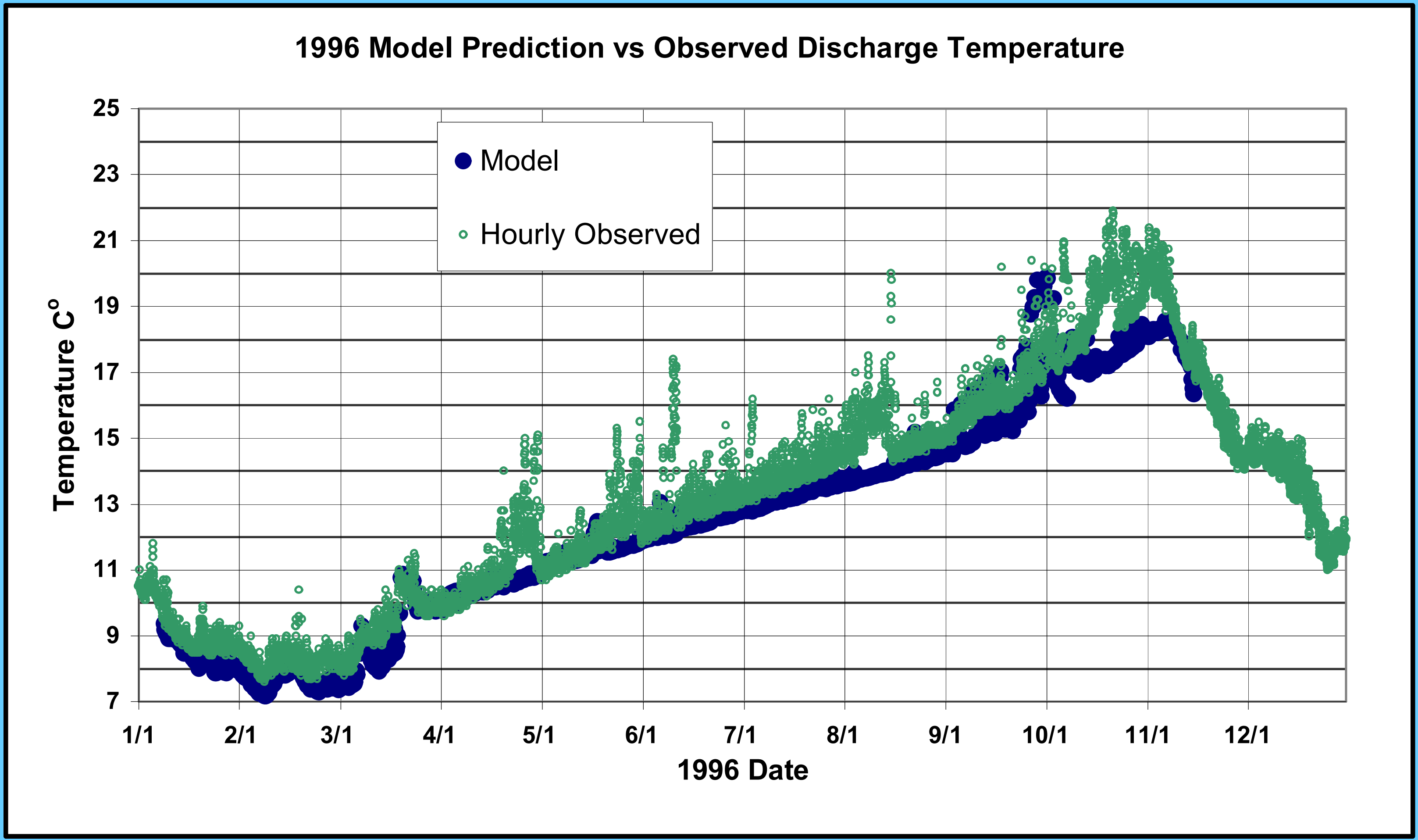
Model vs. Data



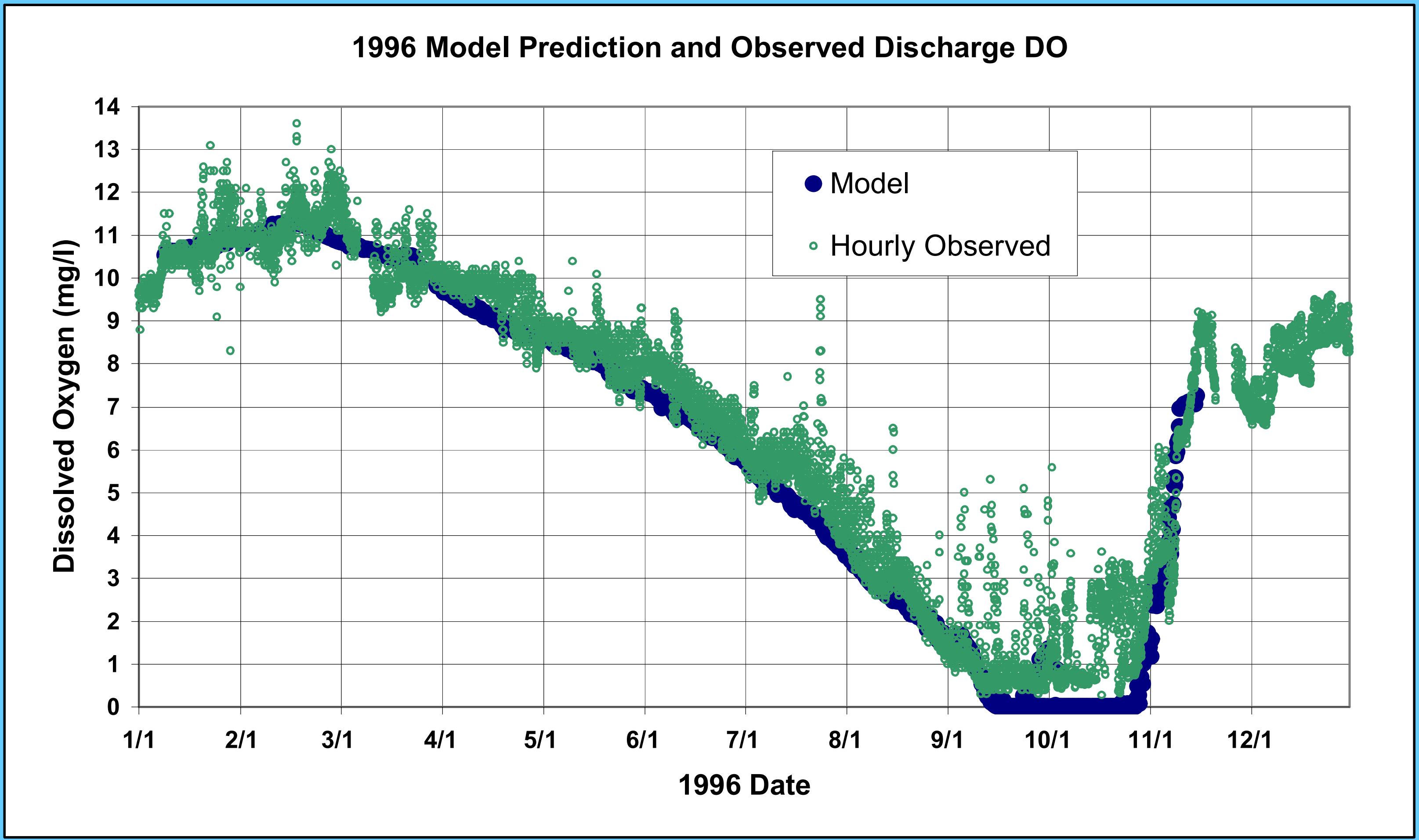
Release Temperature

Model vs. Data



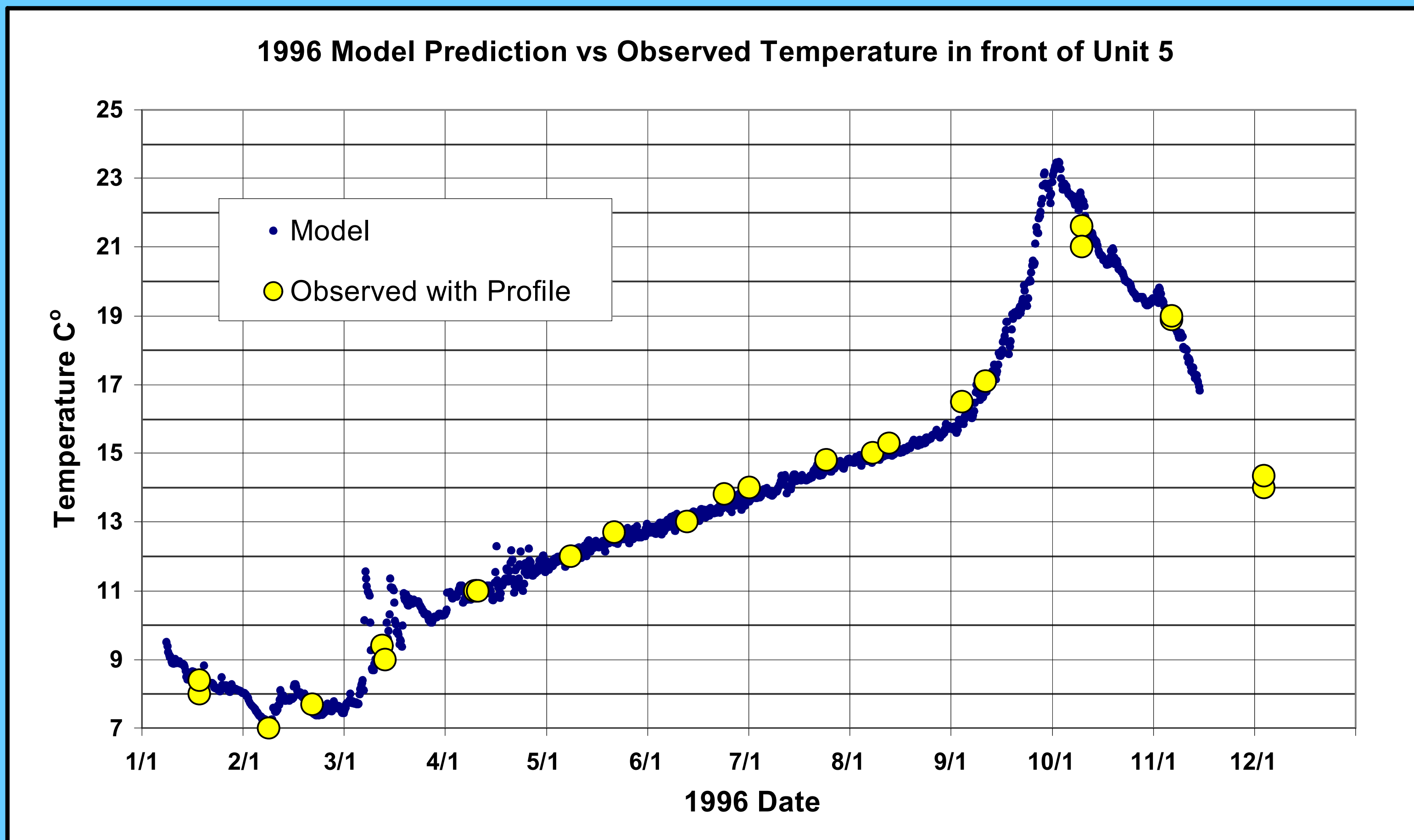
Release DO

Model vs. Data



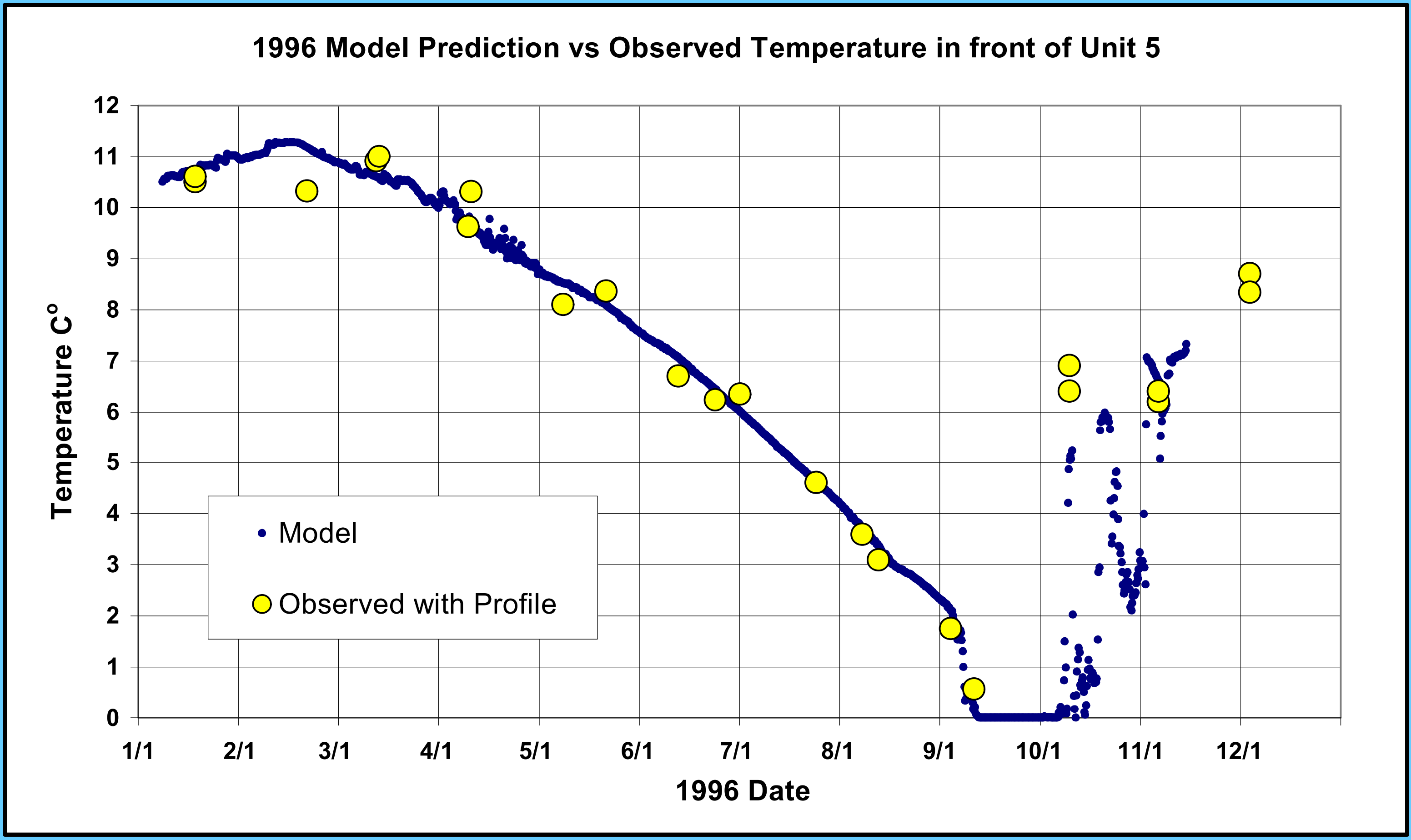
Temperature in Front of Unit 5

Model vs. Data

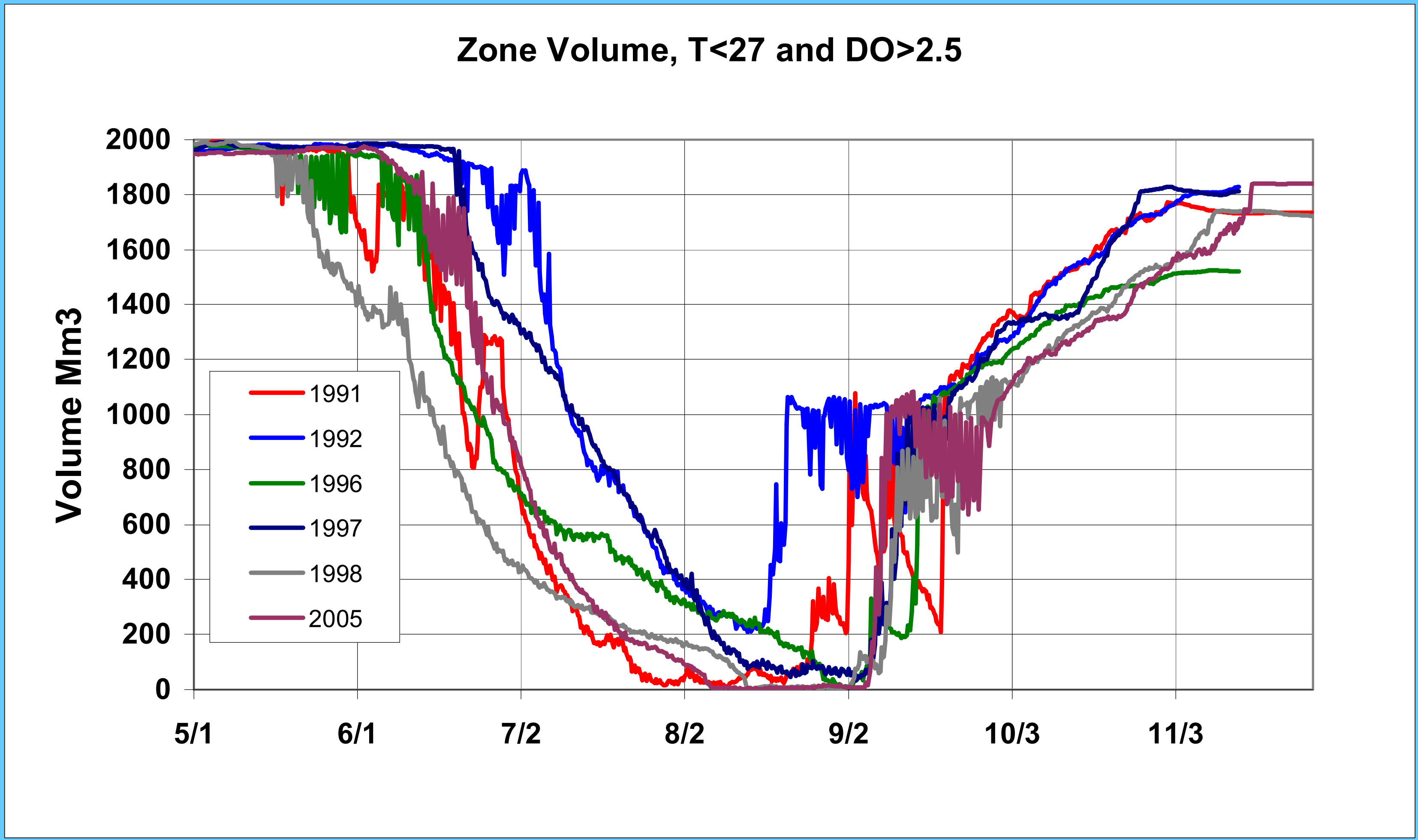


DO
in Front of Unit 5

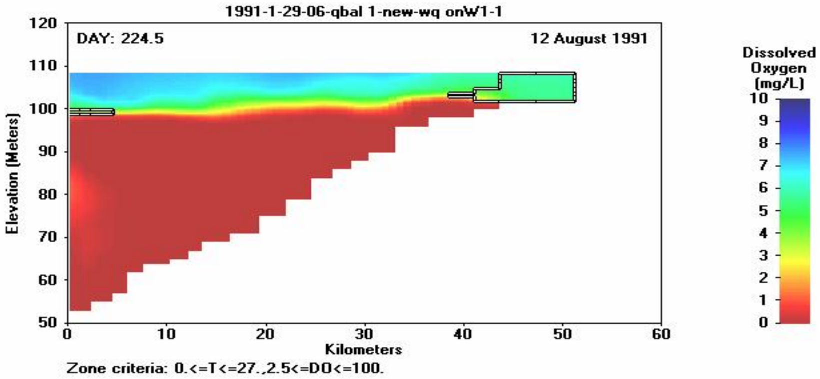
Model vs. Data

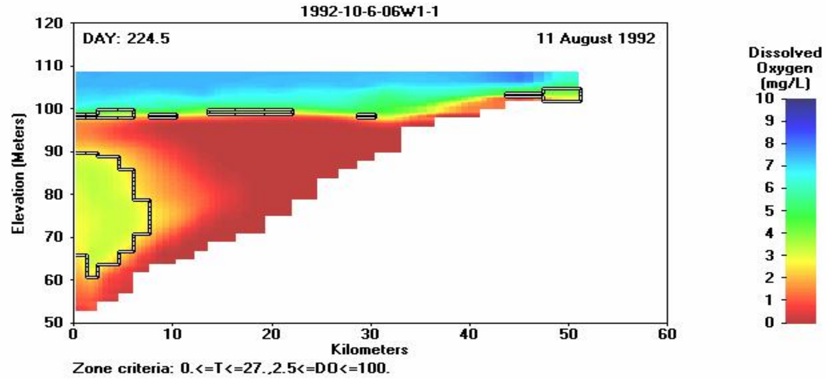


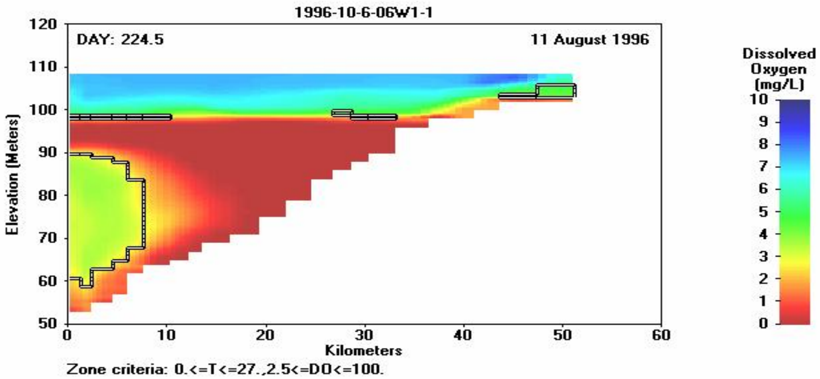
Striped Bass Habitat in Lake Murray

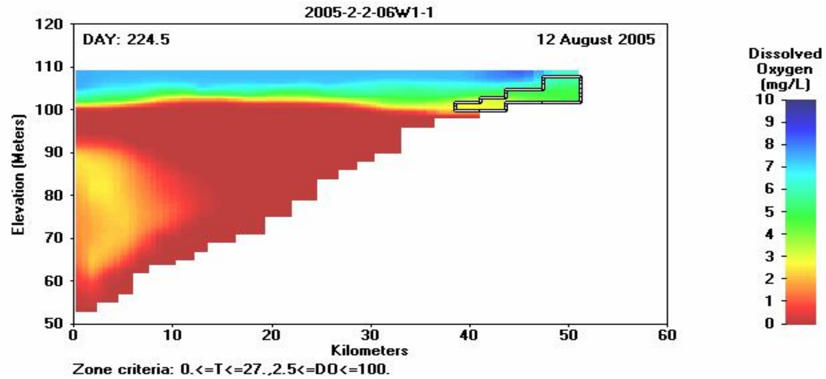


DO Animation with Striped Bass Habitat Highlighted









Sensitivity to Operations

- Original outflow assumption for all modeled years:

  Units 1, 2 and 4 – Q < 9,600 cfs

  Unit 5 – 9,600 < Q < 15,600 cfs

  Unit 3 – Q > 15,600 cfs

- When Unit 5 is operated first (Q < 6,000 cfs), cooler bottom water is conserved and availability of striper habitat improves

Evaluation of Raised Pool Levels

Scenarios Considered:

- 354(Jan1) to 358(May1⇨Sept1) to 354(Dec 31)
- 350(Jan1) to 358(May1⇨Sept1) to 350(Dec 31)

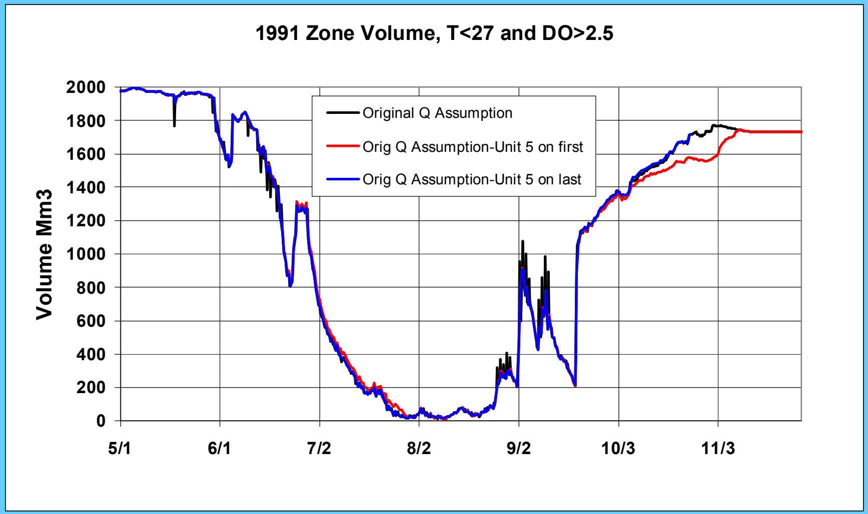
Assumptions:

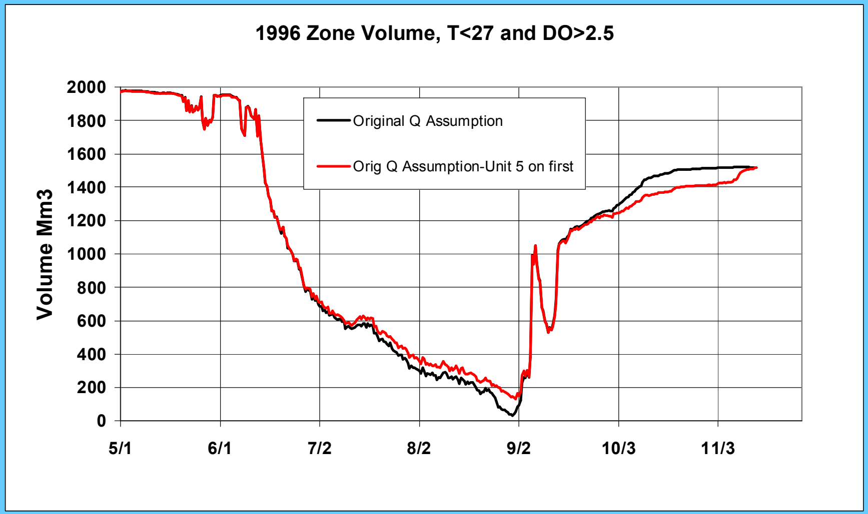
- Assumed 500 cfs for minimum release
- Assumed reserve generation averaged 3hr every two weeks at 18,000 cfs
- Balance of releases were assumed to be used to supplement system demand

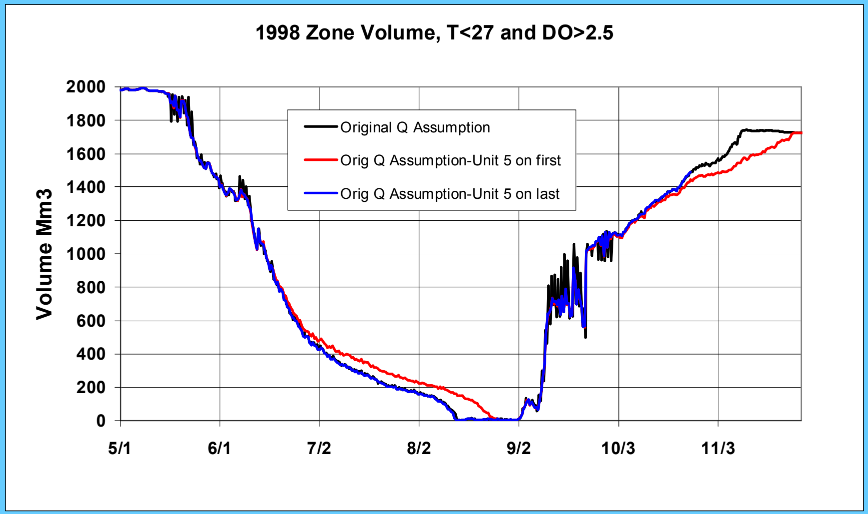
Approach:

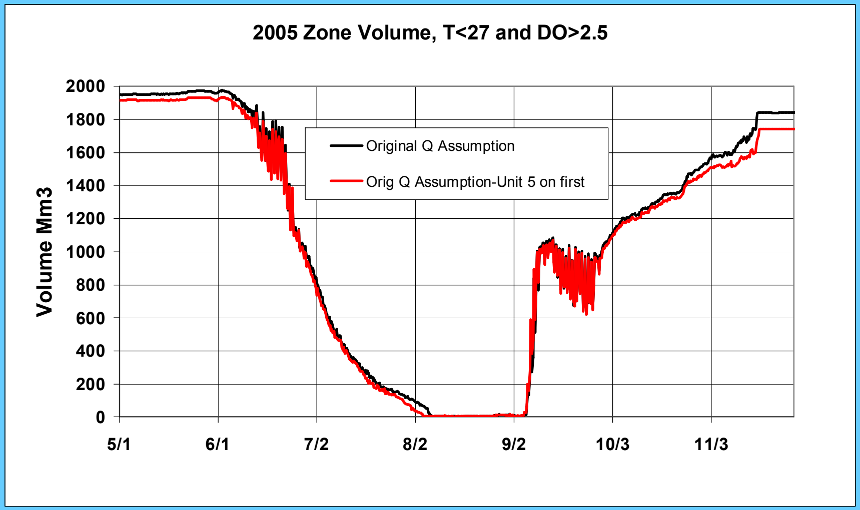
- The above scenarios were developed by KA using daily average flows using HEC-ResSim
- CE-QUAL-W2 was run using daily average flows and release flows were adjusted so that target pool levels were attained
- Using the daily average flows that were adjusted using the CE-QUAL-W2 model the hourly flows for each day were developed using the assumptions above

Comparison of Original Flow Assumption and Alternative Unit 5 Operation Scenarios



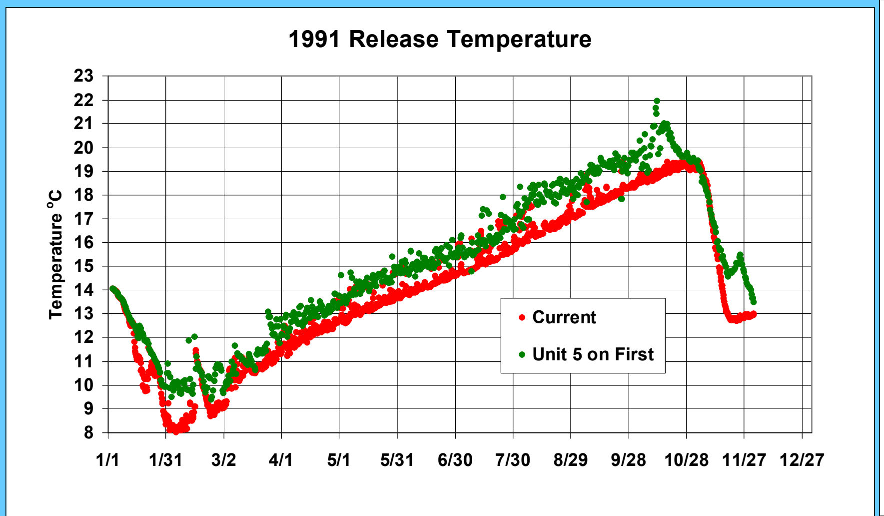


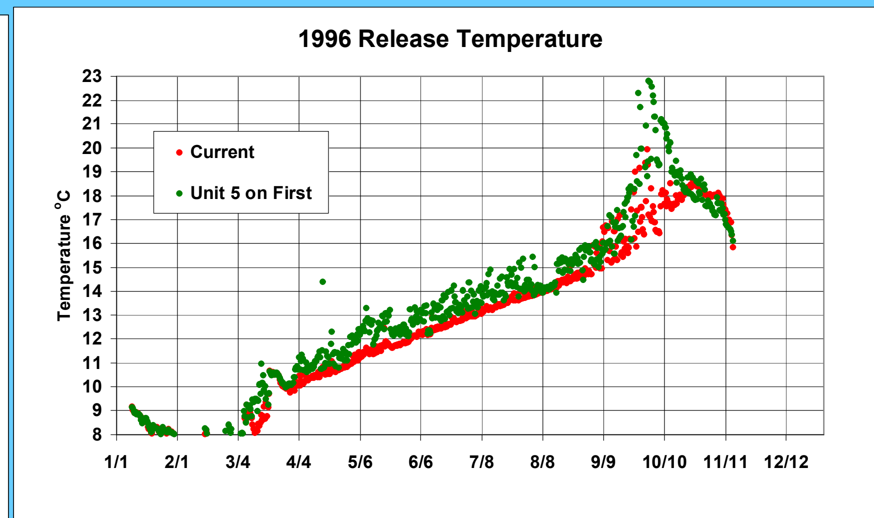


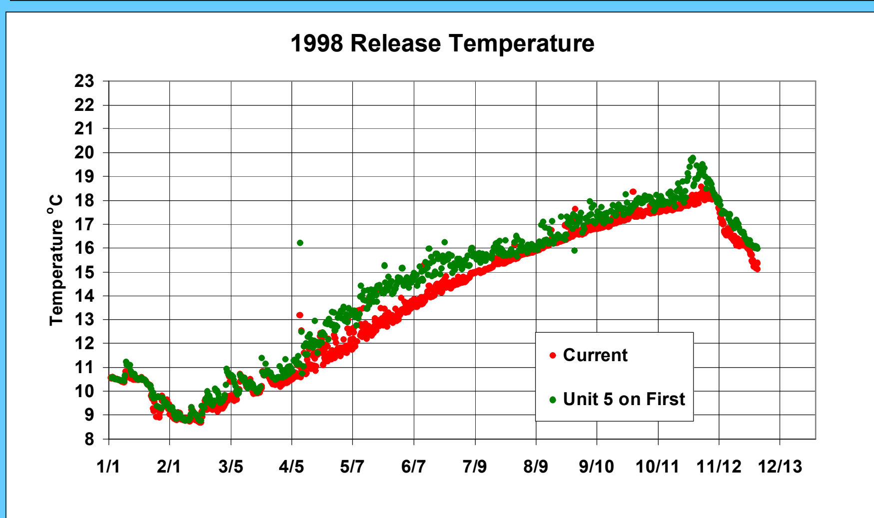


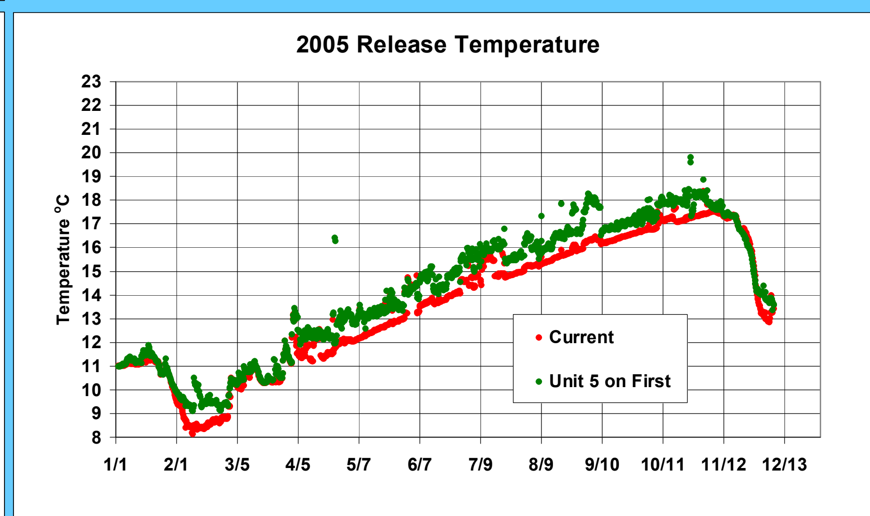
1998 Animation Comparison of Original Flow Assumption and Unit 5 on First Scenario

Tailrace Temperature - Comparison of Original Flow Assumption and Unit 5 on First Scenario

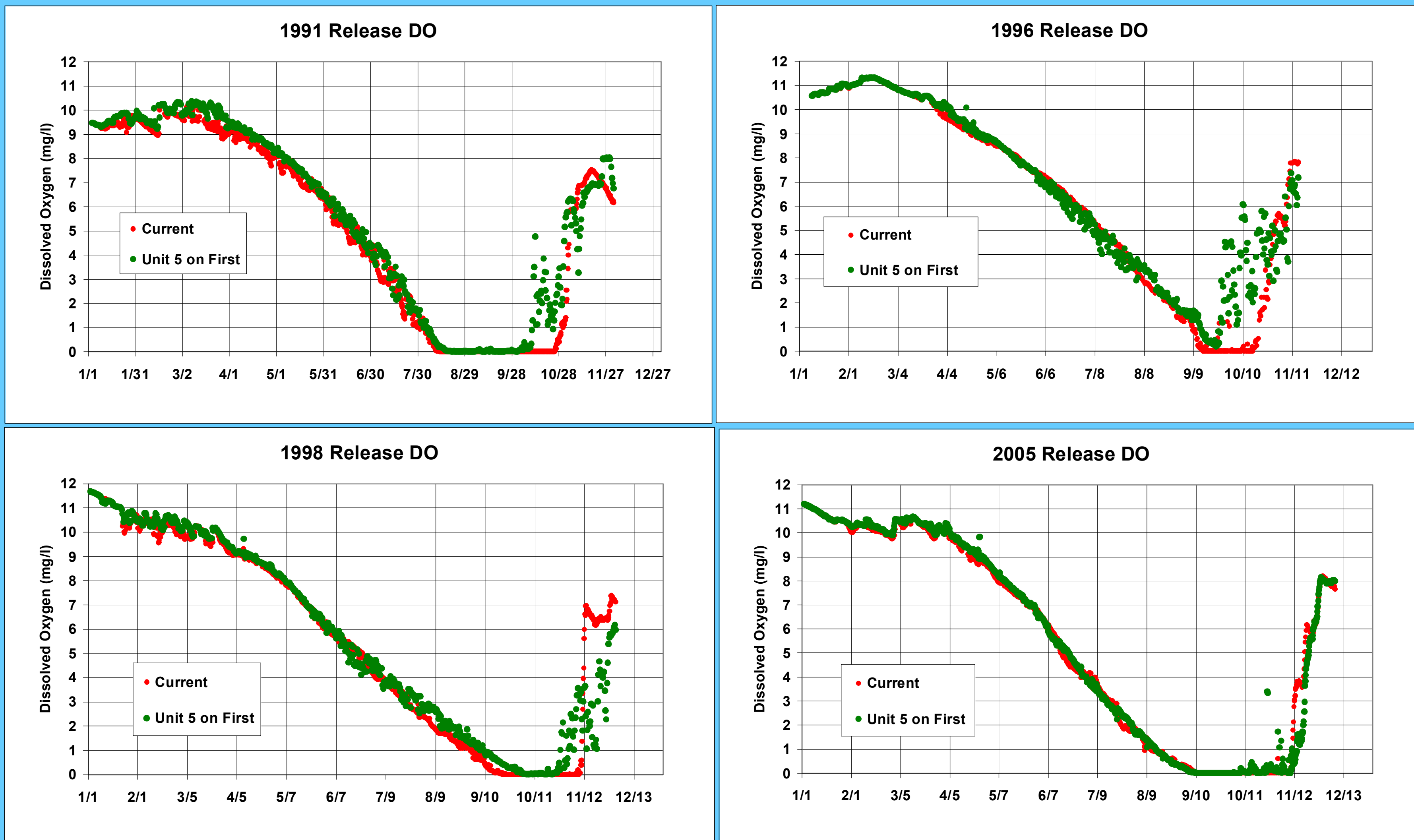




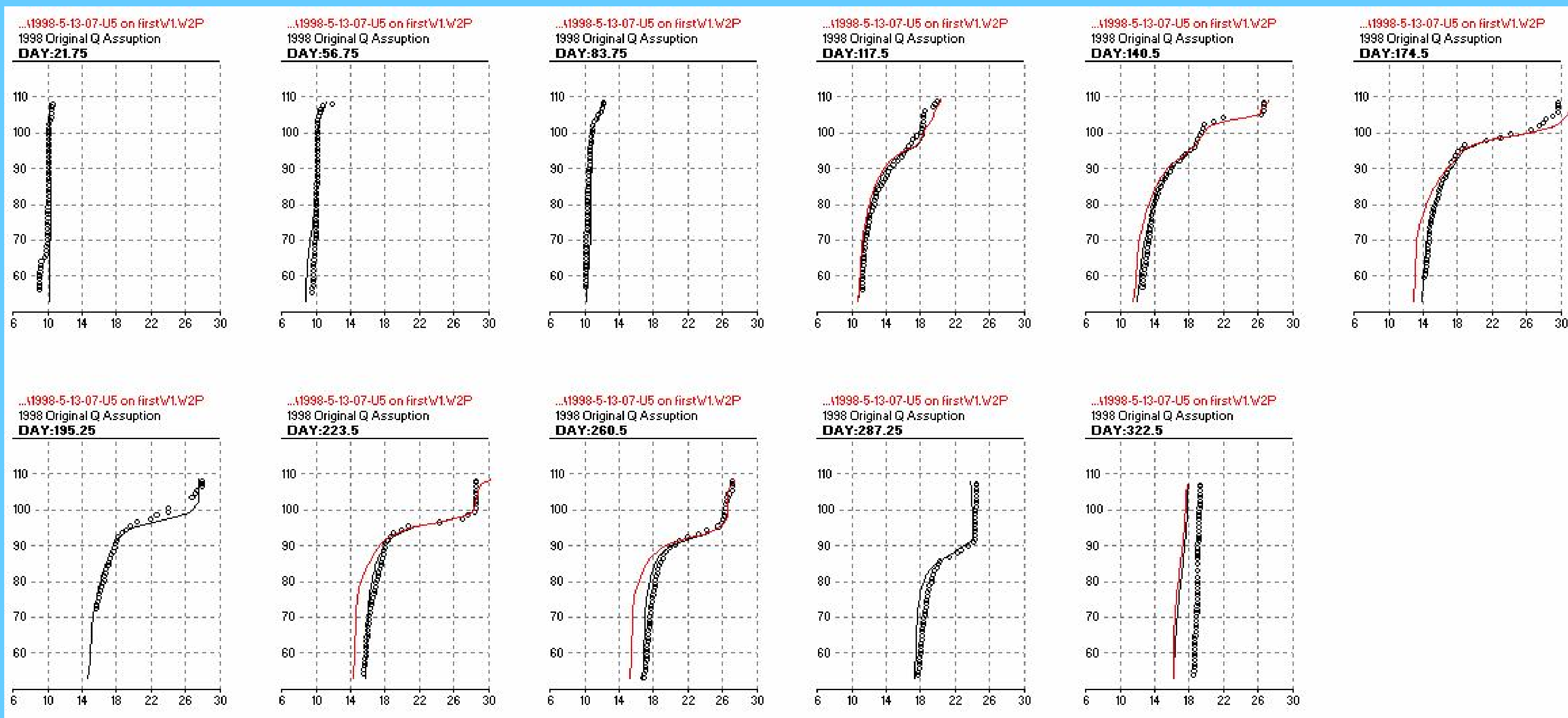




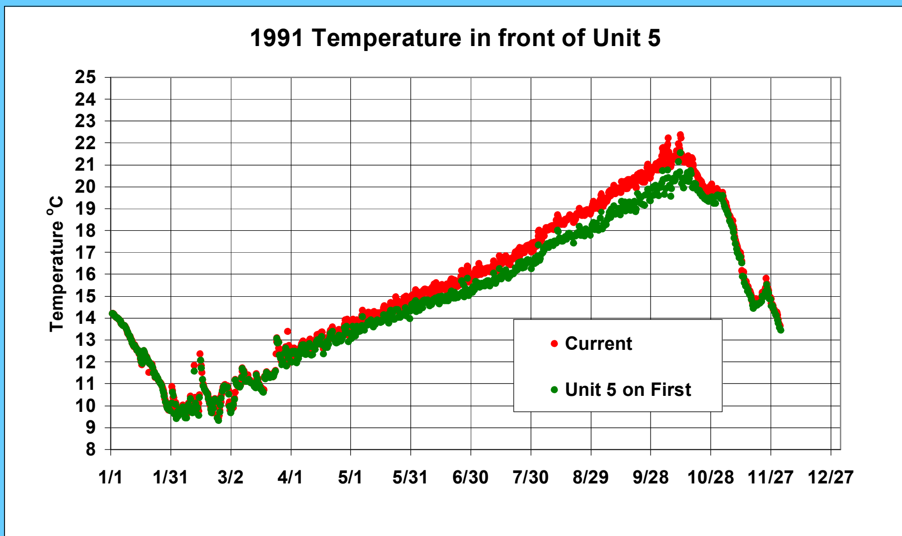
Tailrace DO - Comparison of Original Flow Assumption and Unit 5 on First Scenario

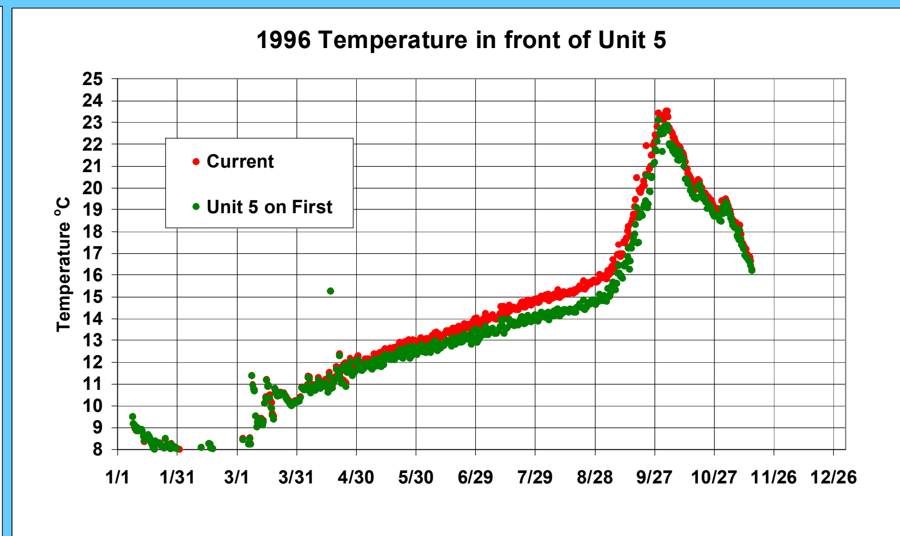


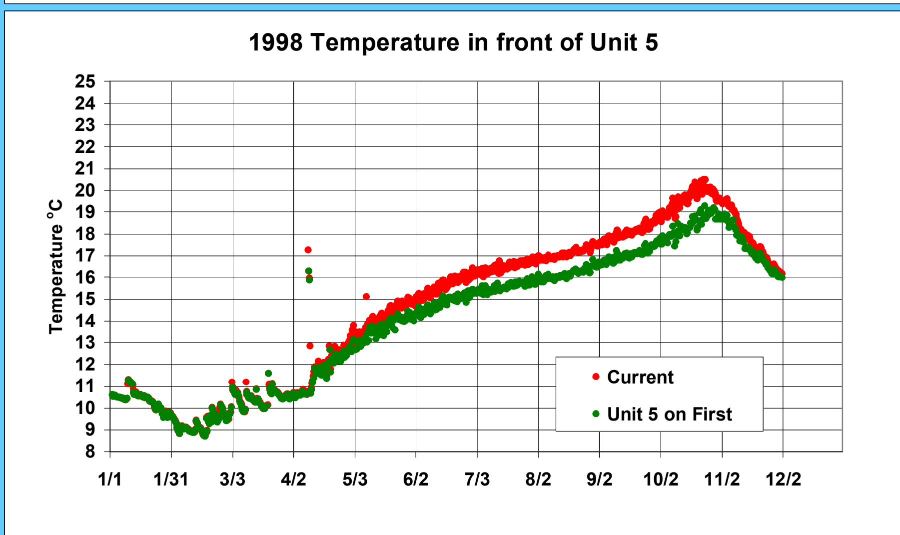
Forebay Temperature Profiles – Comparison of Original Flow Assumption and Unit 5 on First Scenario

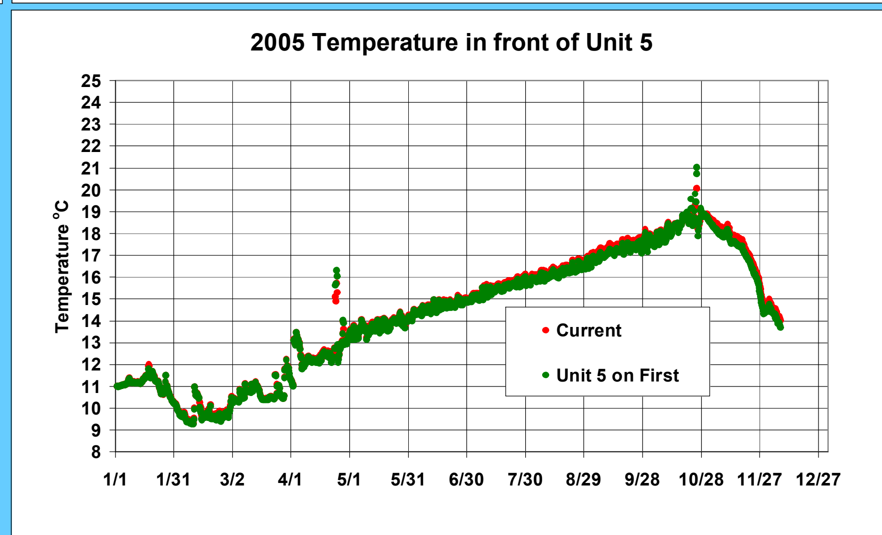


Temperature at the Intake to Unit 5
Comparison of Original Flow Assumption and Unit 5 on First Scenario

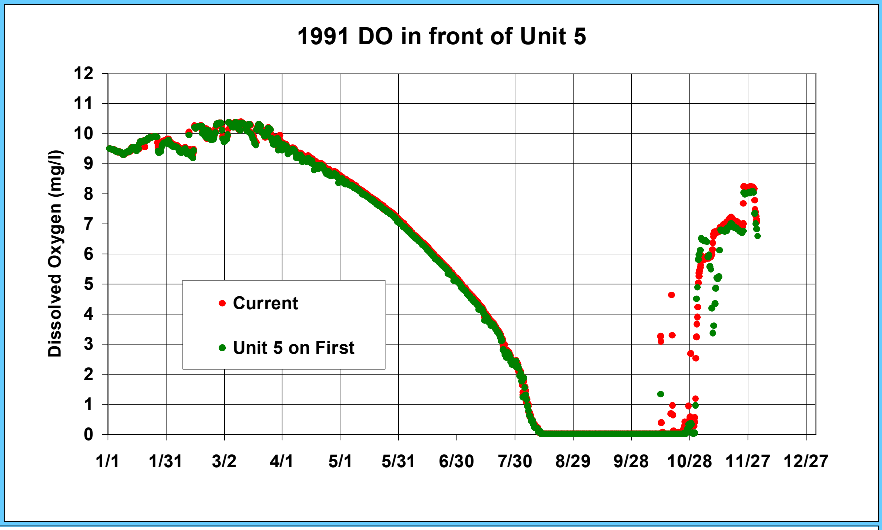


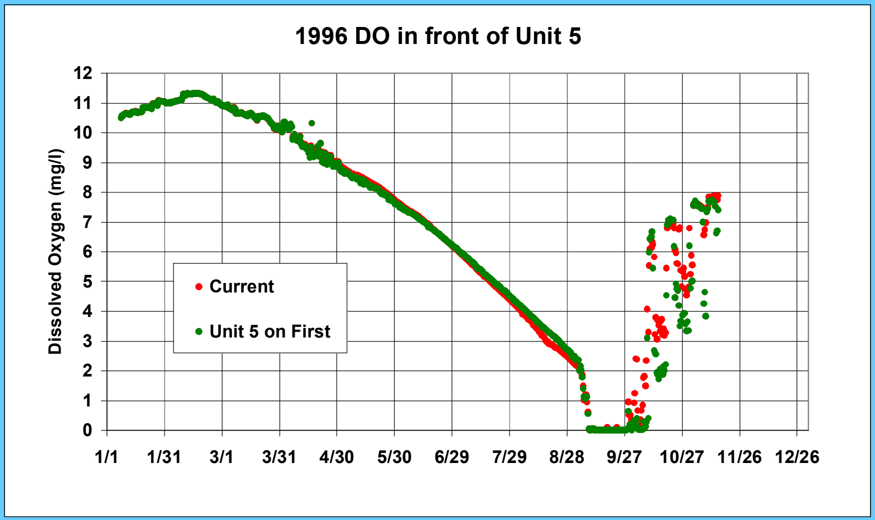


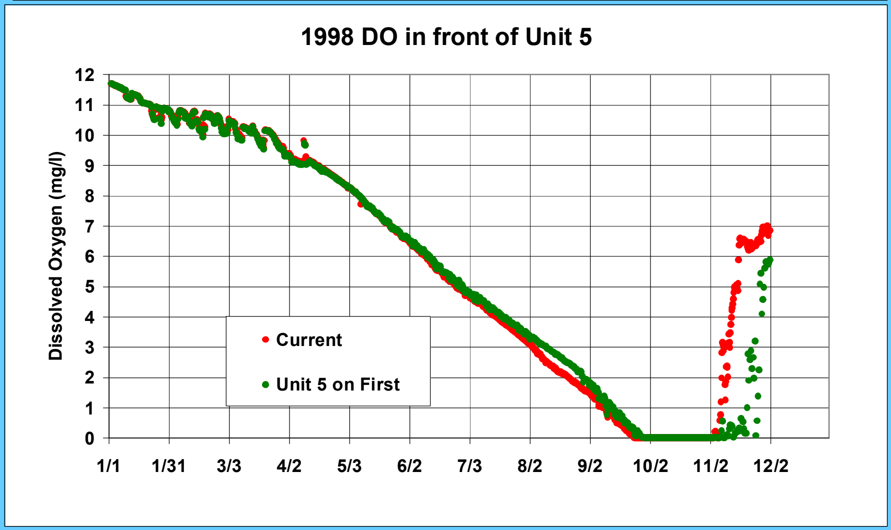


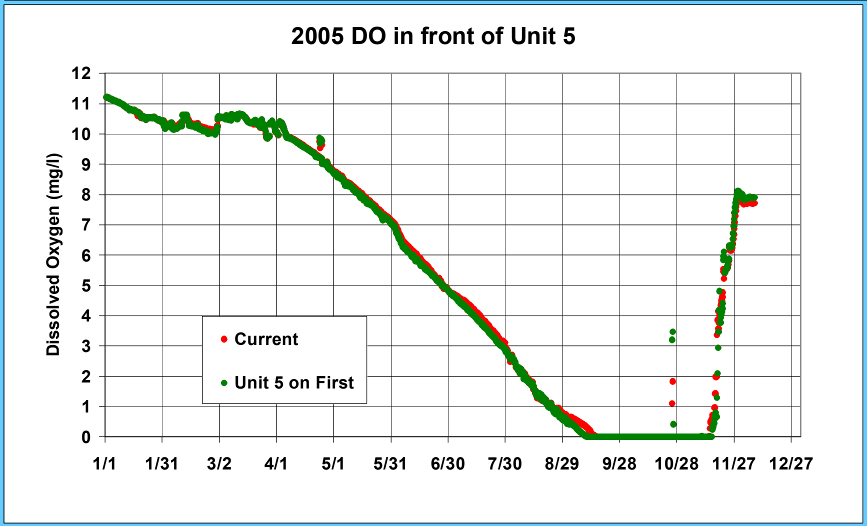


DO at the Intake to Unit 5
Comparison of Original Flow Assumption and Unit 5 on First Scenario

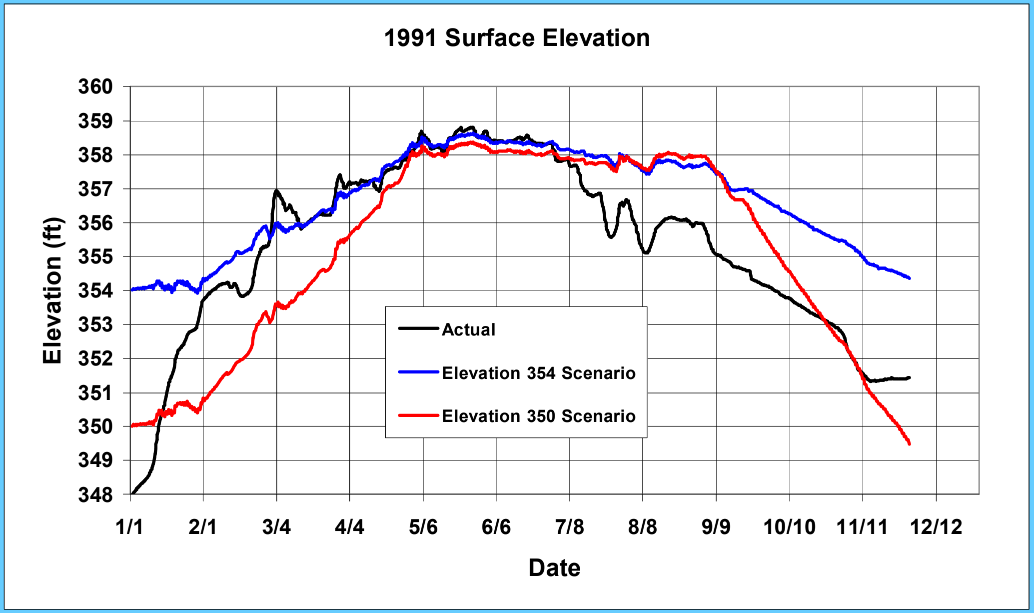


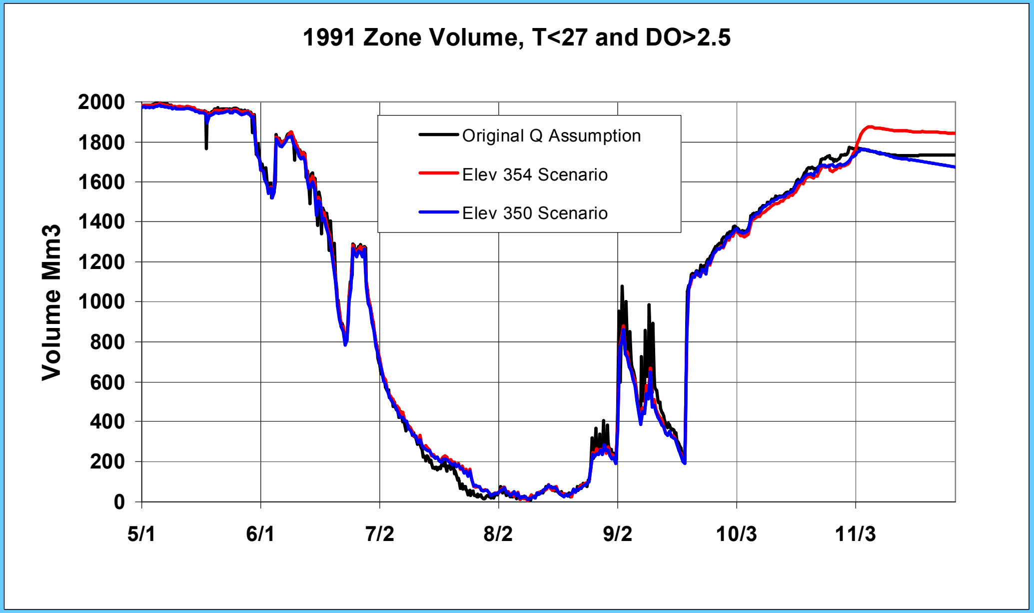




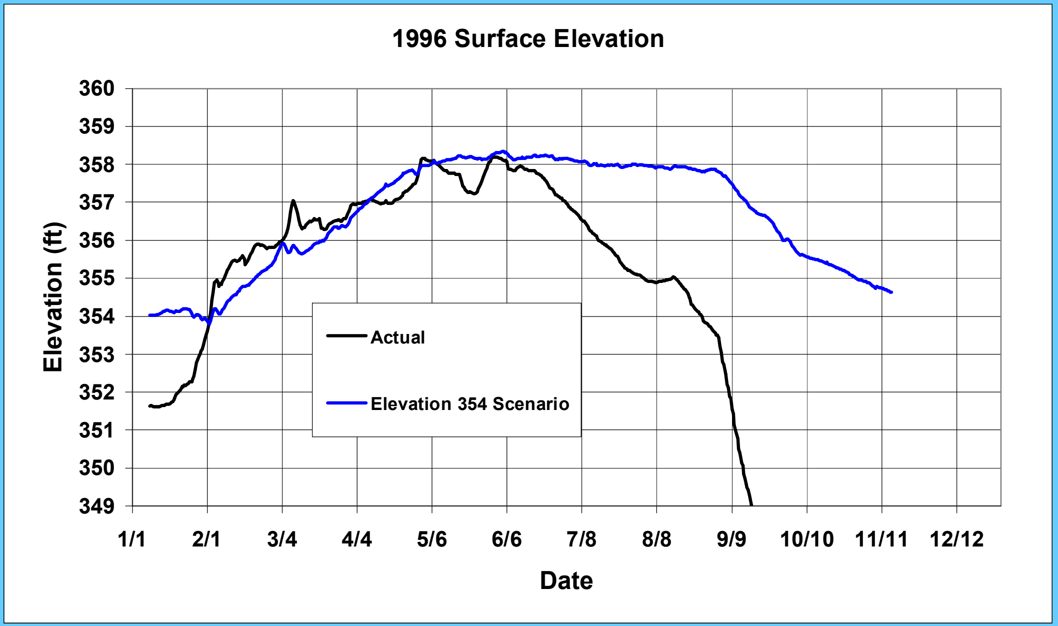


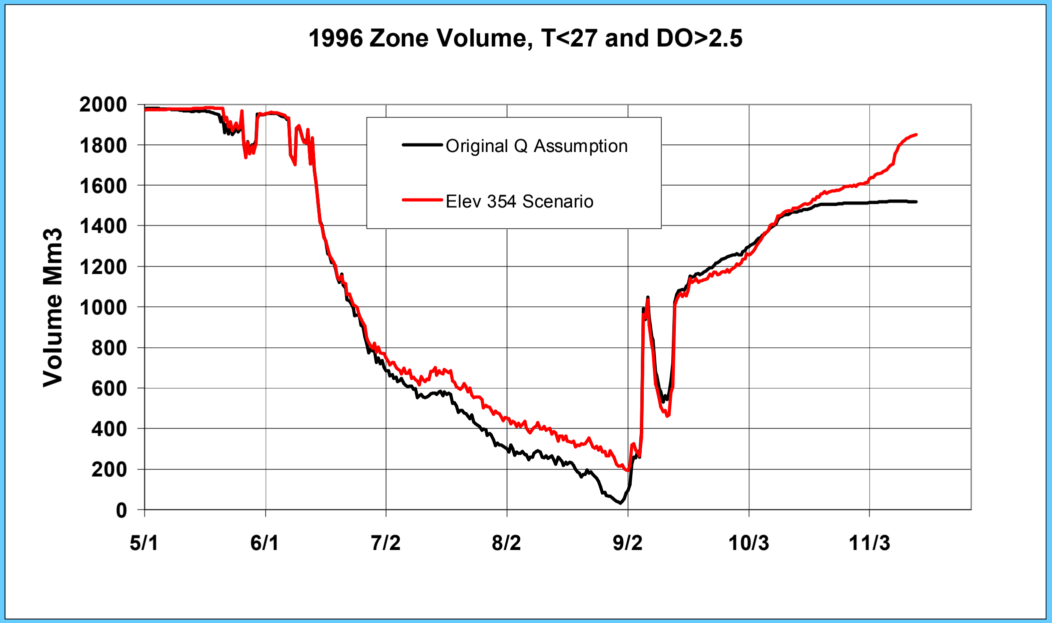
1991 Pool Level Management



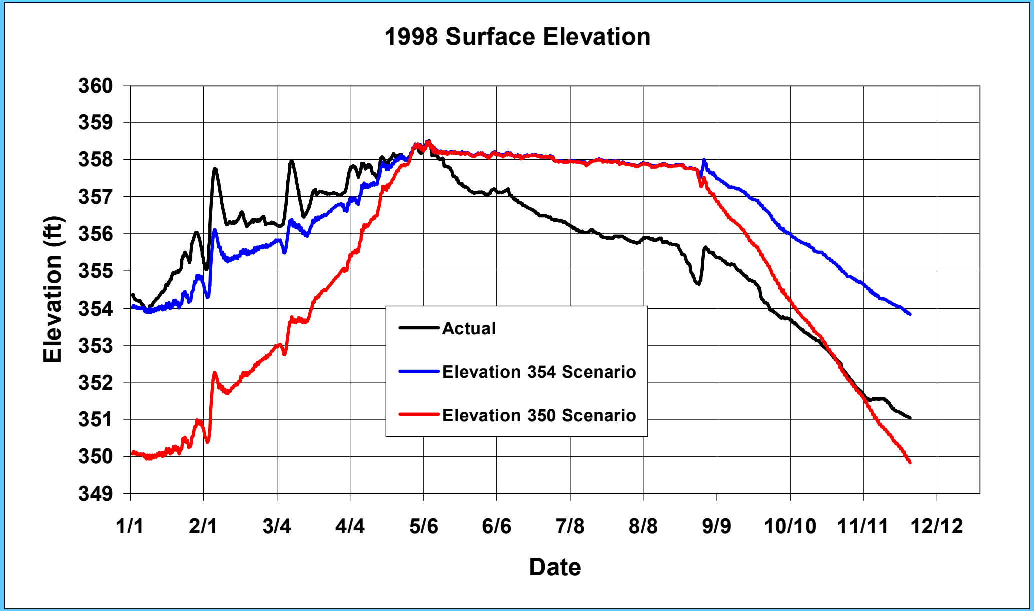


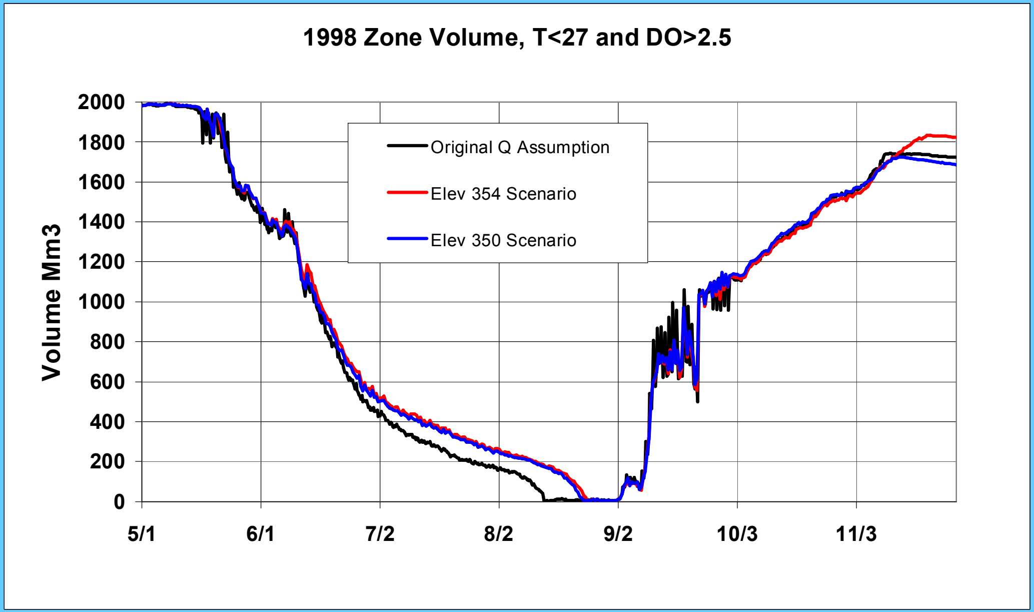
1996 Pool Level Management



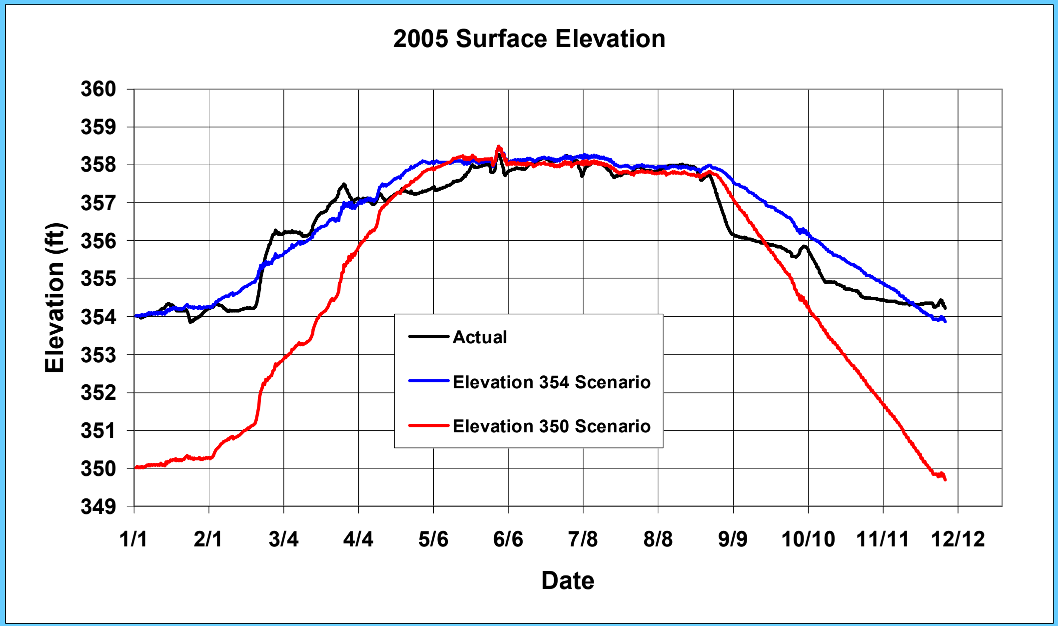


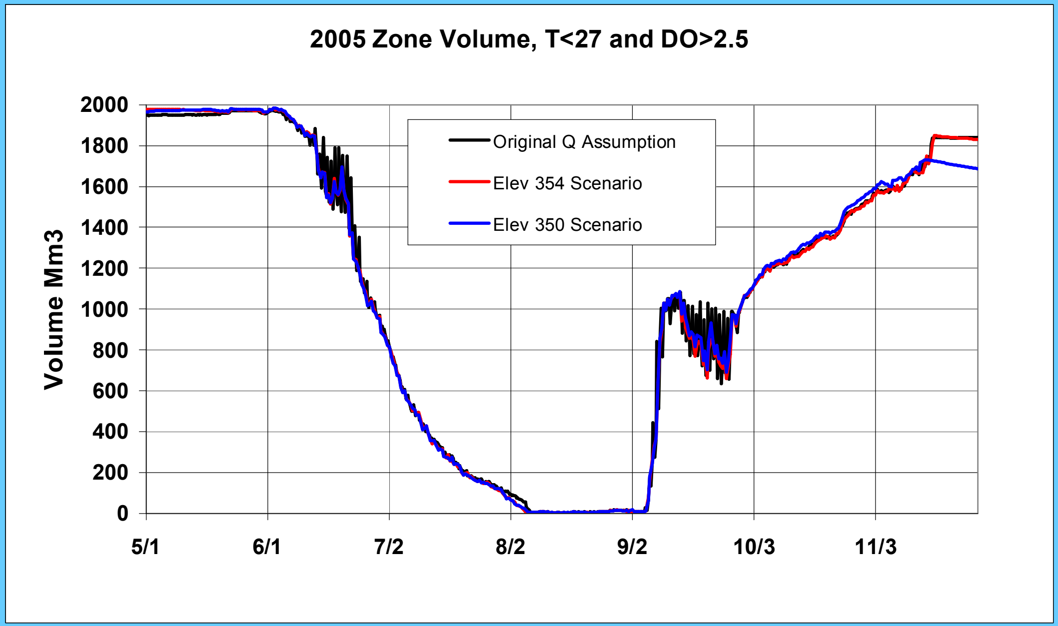
1998 Pool Level Management





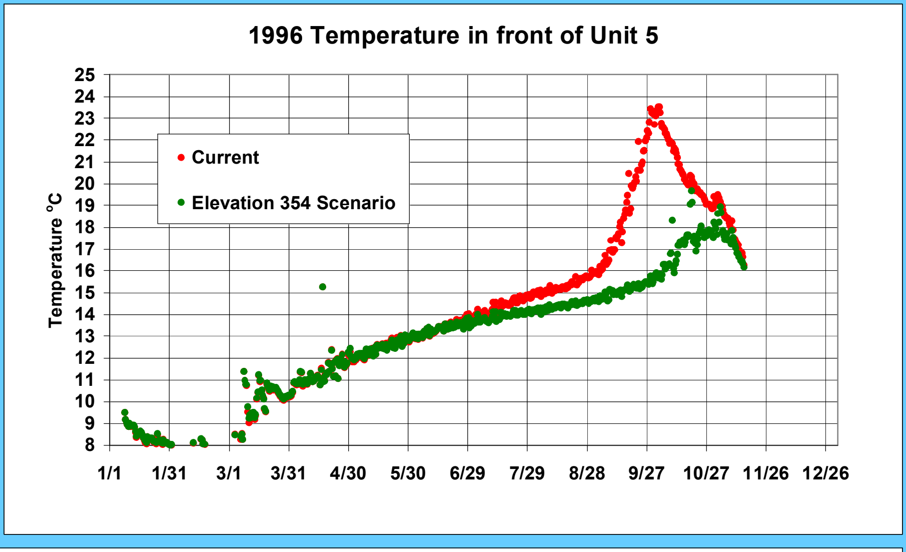
2005 Pool Level Management

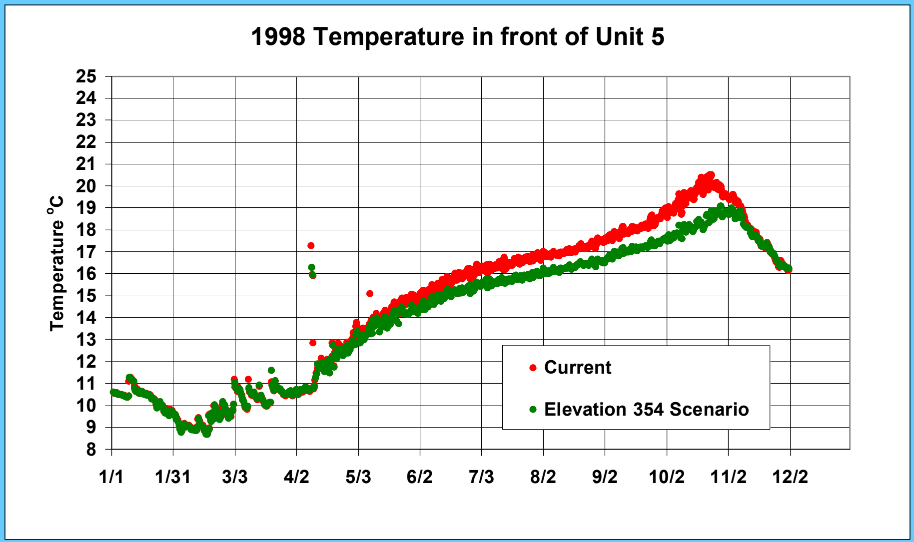


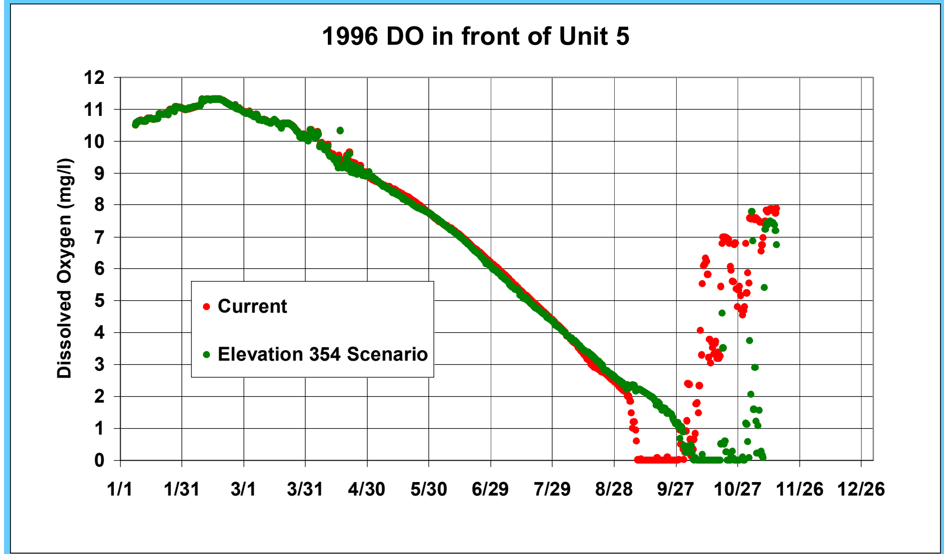


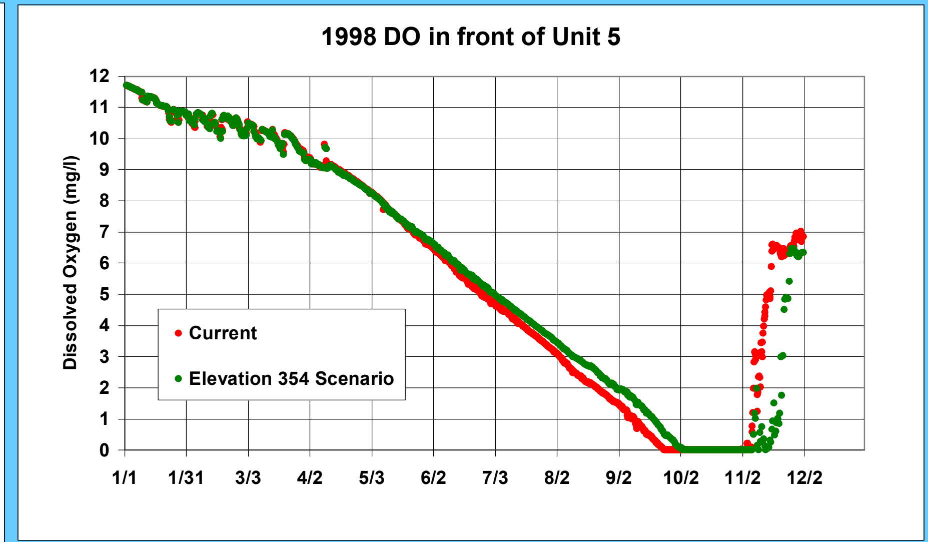
Excel Plots

Temperature and DO at the Intake to Unit 5 with Pool Level Management

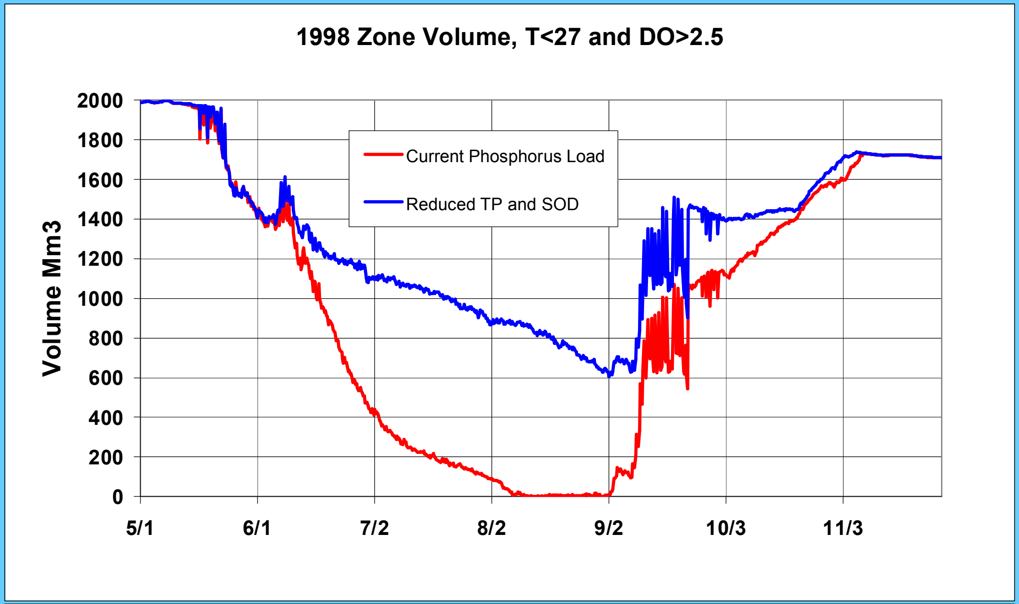


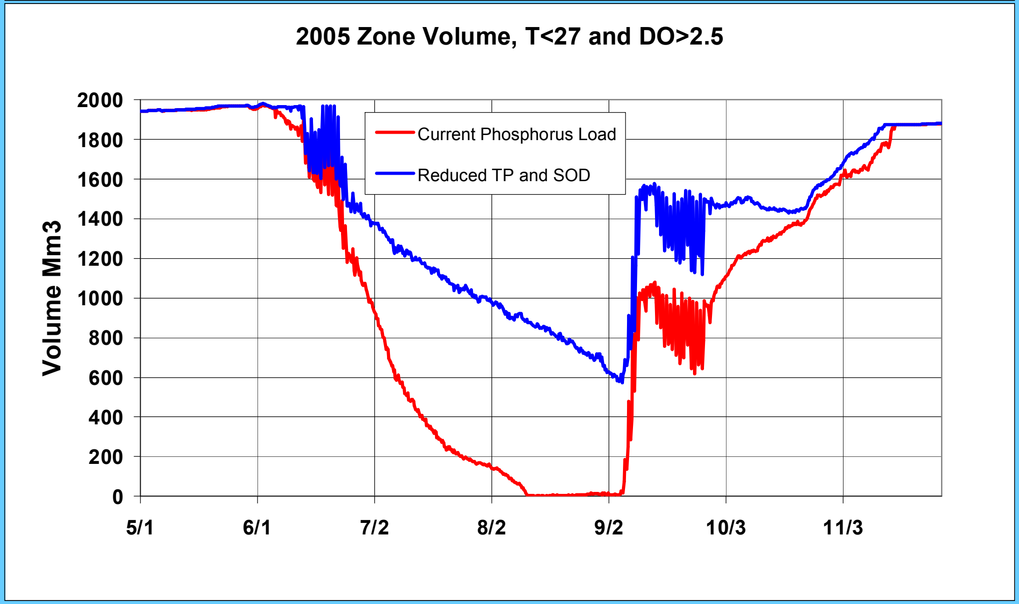






Comparison of Current Phosphorus Load and Reduced Phosphorus Scenario





Preliminary Conclusions

- Nutrients are the single dominant factor that can enhance striped bass habitat
- Flow is a dominant factor, but cannot be controlled to avoid fish kills
- Met conditions can be a periodic factor that alleviates otherwise dominant factors like flow
- Striped bass habitat conditions can be improved in some years by maintaining high summer pool levels (~ elev. 358 ft)
- Unit 5 preferential operations can improve striped bass habitat in some years

Next Steps

1. For selected years, finalize assessment (i.e., assess changes in releases) of operating guide for U5 preference for “first on, last off” operation using the hourly releases

2. For selected years, finalize assessment of maintaining summer pool levels at 358

3. For selected years, finalize assessment of the combination of maintaining summer pool levels at 358 with U5 preference for “first on, last off” operation using the hourly releases

4. Analyze additional years, especially a low flow year

5. Assess effects of minimum winter pool level, including effects on Little Saluda embayment, increased SOD, internal nutrient cycling, aquatic plants, sedimentation in coves,