State of Oklahoma

OWRB

WATER RESOURCES BOARD

the water agency

ADAPTIVE MANAGEMENT FOR LOW DISSOLVED OXYGEN IN THE GRAND AND HUDSON LAKE TAILRACES

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Oklahoma Water Resources Board (OWRB)

Project Overview

- Started monitoring in Summer 2006
- Requirement of Grand River Dam Authority's (GRDA) Federal Energy Regulatory Commission (FERC) license
- 3 Primary Goals of Monitoring
  - Long-term record of condition (particularly, dissolved oxygen)
  - Development of successful adaptive management strategies through empirical testing and modeling
  - Public awareness

Project Overview

- Monitoring at all GRDA Projects
  - Pensacola Dam (Grand Lake)
  - Kerr Dam (Lake Hudson)
  - Salina pump back (Lake WR Holway)
- Data measured, recorded, and telemetered through various data collection platforms
  - 6 tailrace buoys
  - 3 in-lake automated vertical profilers
  - 4 bridge mounted WQ sondes
  - Use YSI sondes for WQ measurements


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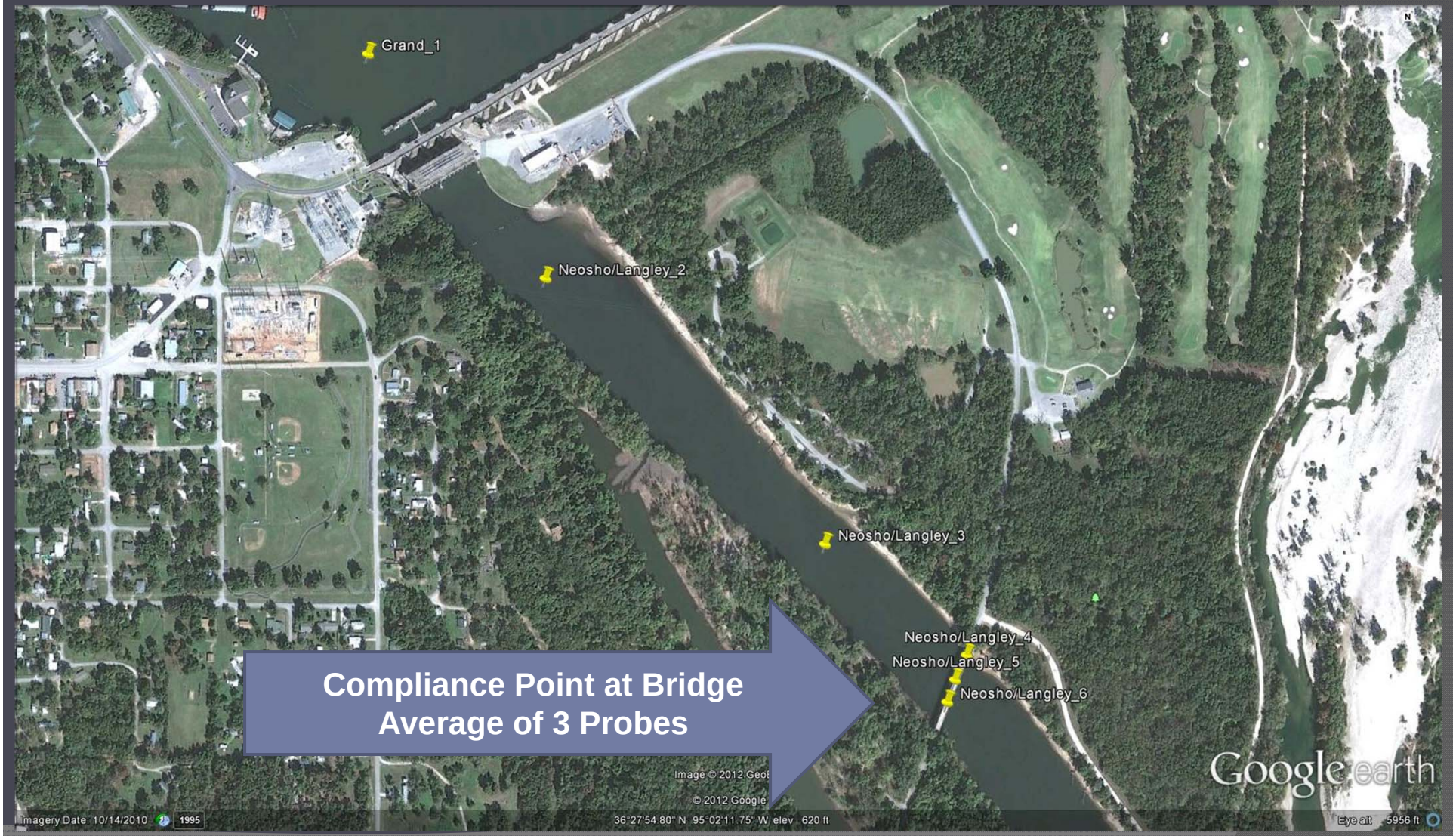
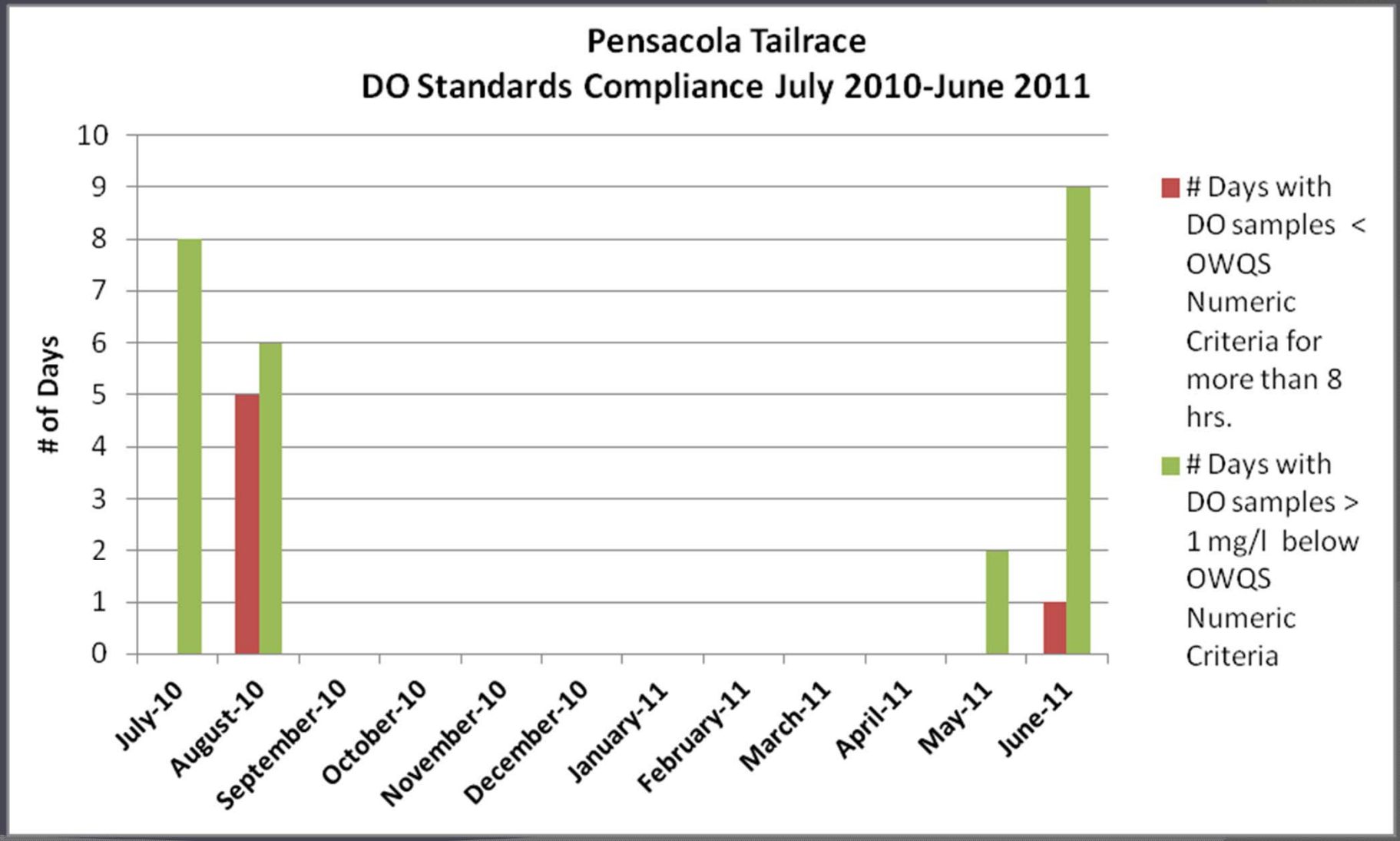
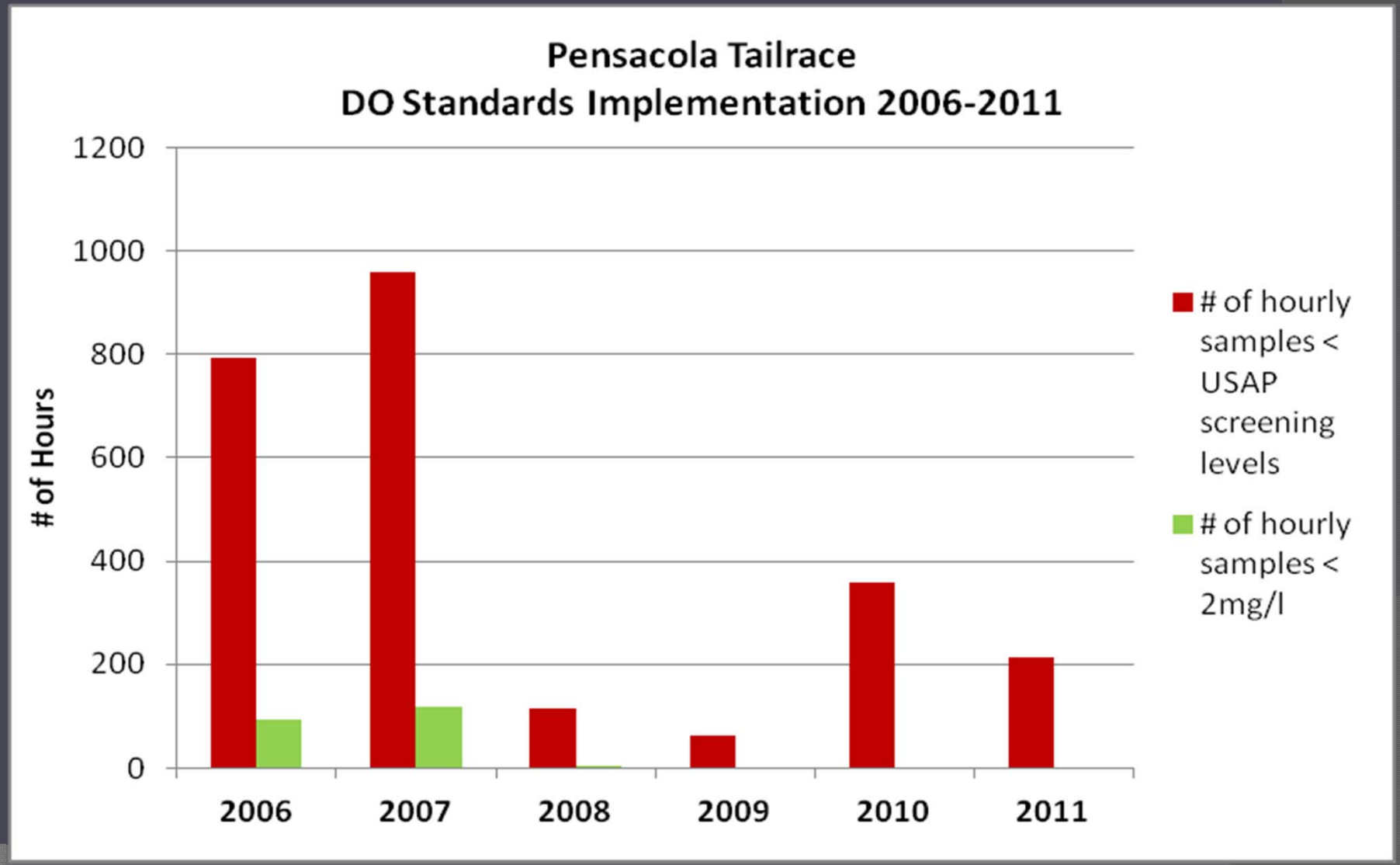
Pensacola Dam



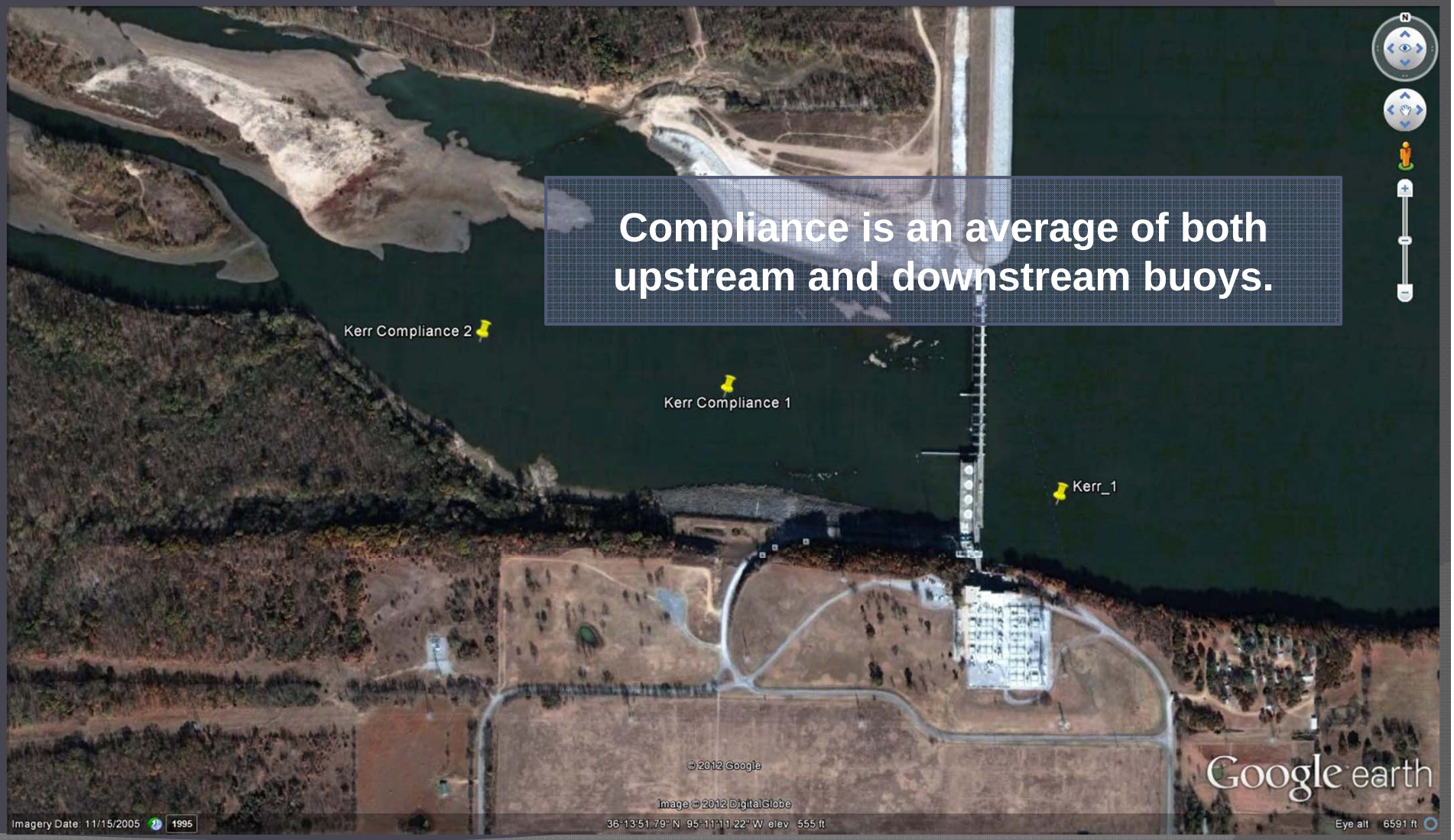
Pensacola Tailrace Standards Compliance



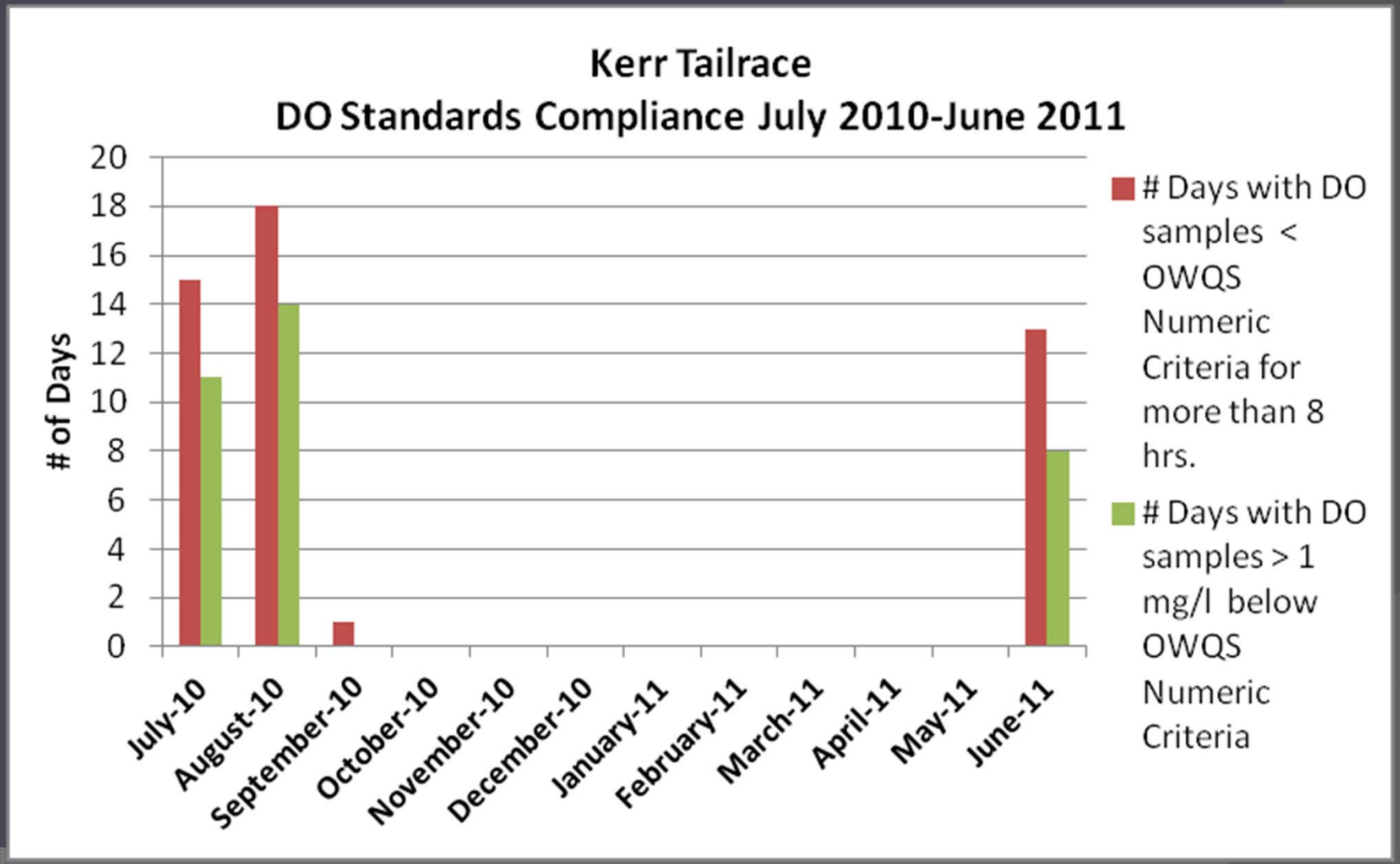
Pensacola Tailrace Standards Implementation



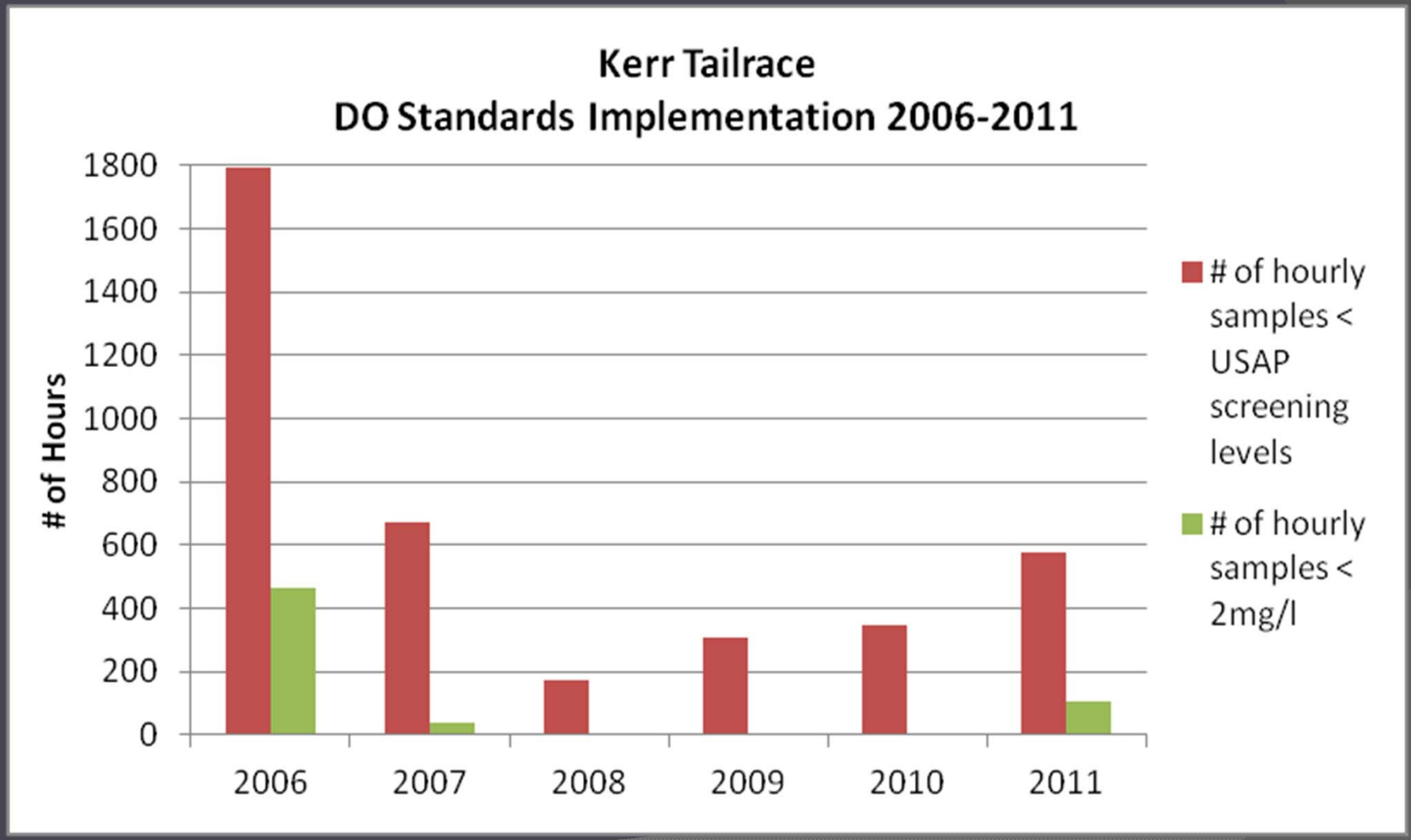
Kerr Dam


Compliance is an average of both upstream and downstream buoys.
Kerr Compliance 2
Kerr Compliance 1
Kerr_1
© 2012 Google
Image © 2012 DigitalGlobe
Google earth
Imagery Date: 11/15/2005
1995
36°13'51.79" N 95°11'11.22" W elev 555 ft
Eye alt 6591 ft

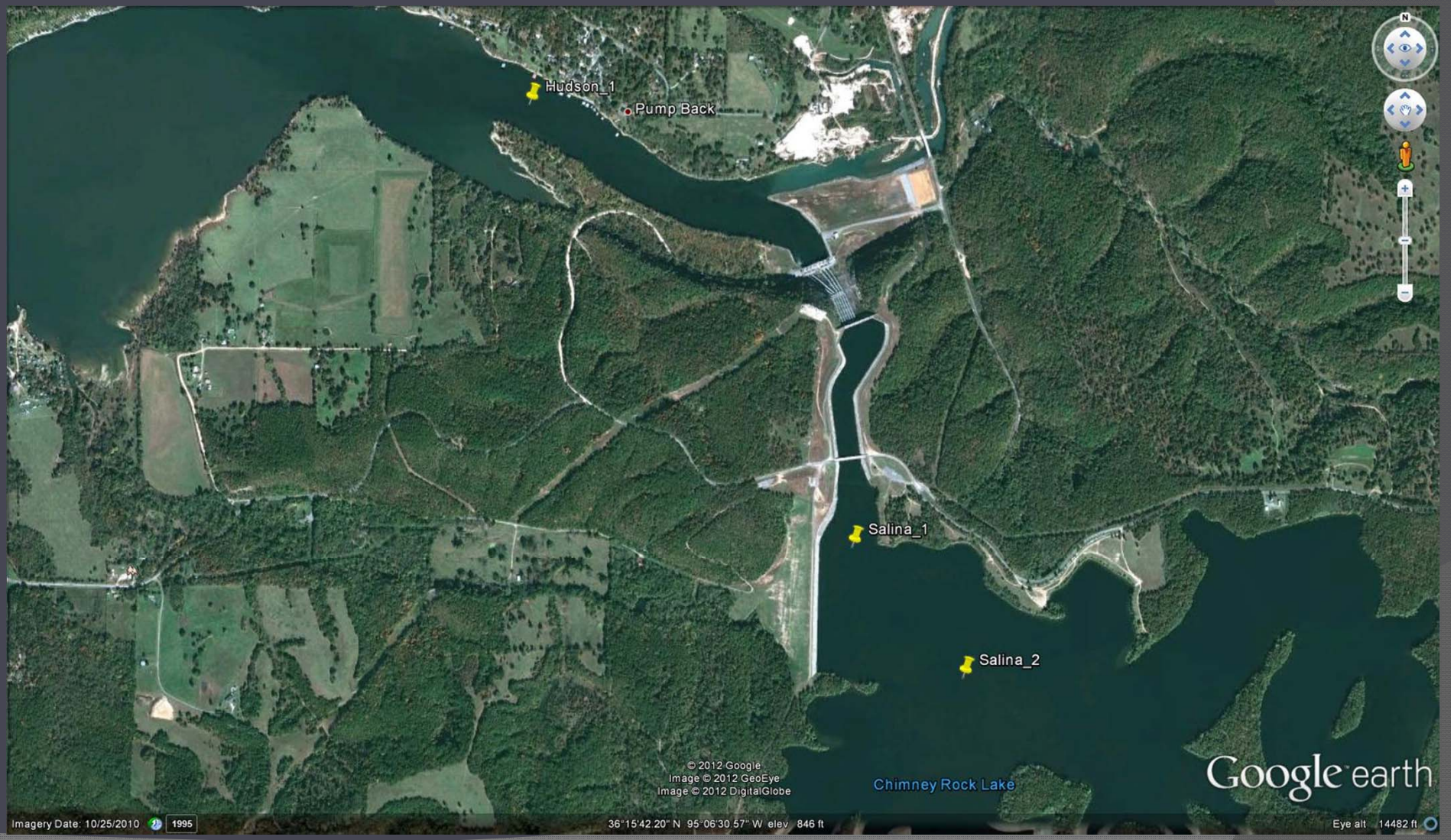
Kerr Tailrace Standards Compliance



Kerr Tailrace Standards Implementation



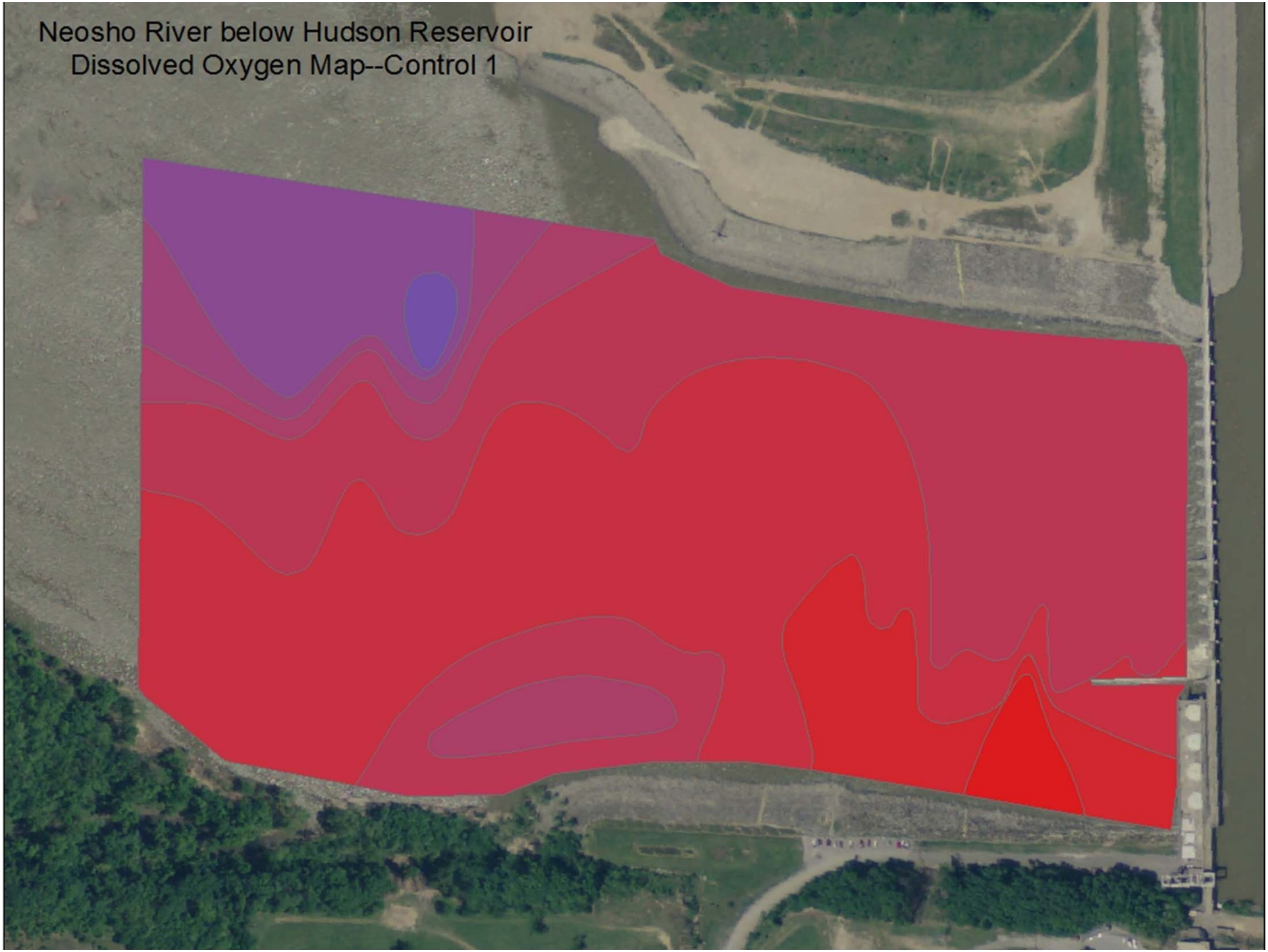
Salina Project

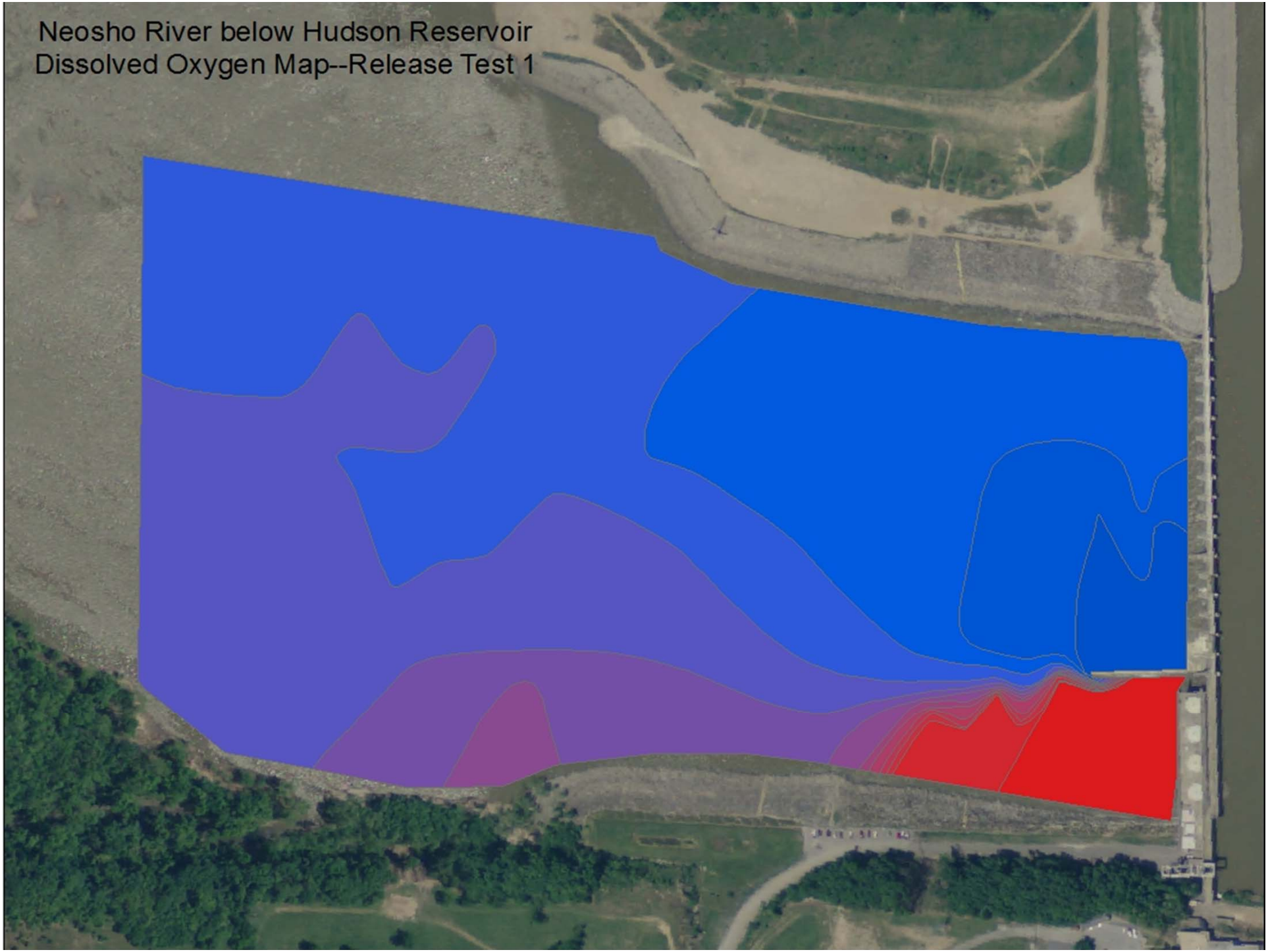


Mitigation Testing for Low DO

- Pulse releases from Pensacola Dam
  - Tested various release scenarios 2009-2011
    - Release Volume/Wicket gate position
    - Release Duration
    - No Release Duration
- Flood gate releases from Kerr Dam
  - Summer 2010 tested 24 hr. and 48 hr. releases at 1 chain link opening
  - Summer 2011 test 72 hr. releases
    - Used DO mapping to determine the extent of DO enhancement
  - After Mid-July gate was left open due to extremely low DO conditions to prevent fish mortalities

DO Mapping


Neosho River below Hudson Reservoir
Dissolved Oxygen Map--Control 1

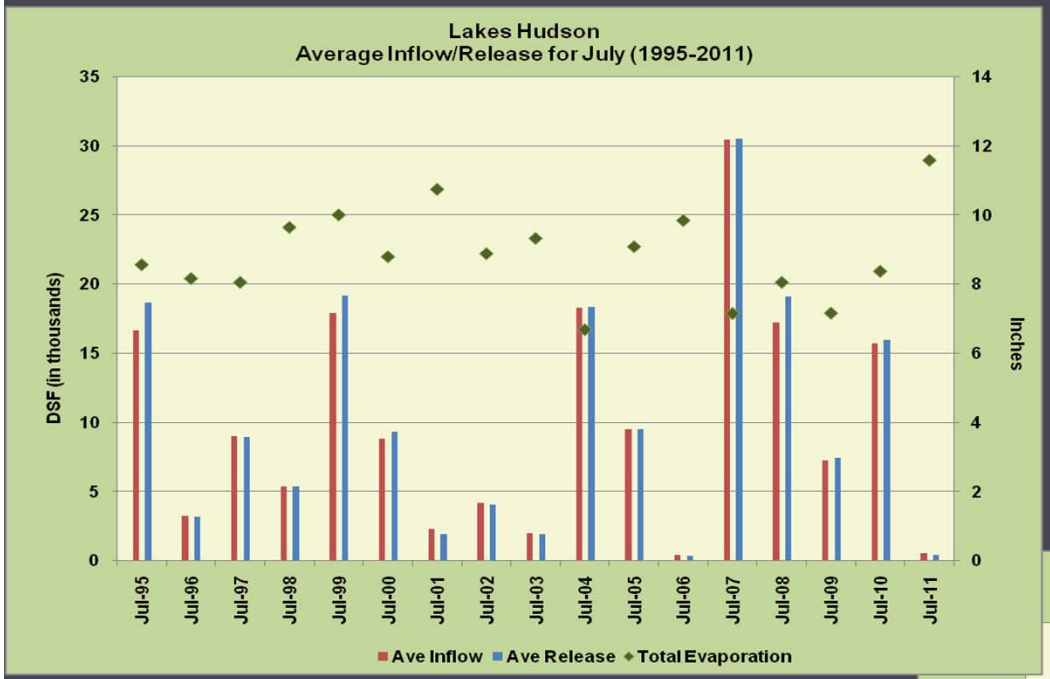

Neosho River below Hudson Reservoir
Dissolved Oxygen Map--Release Test 1

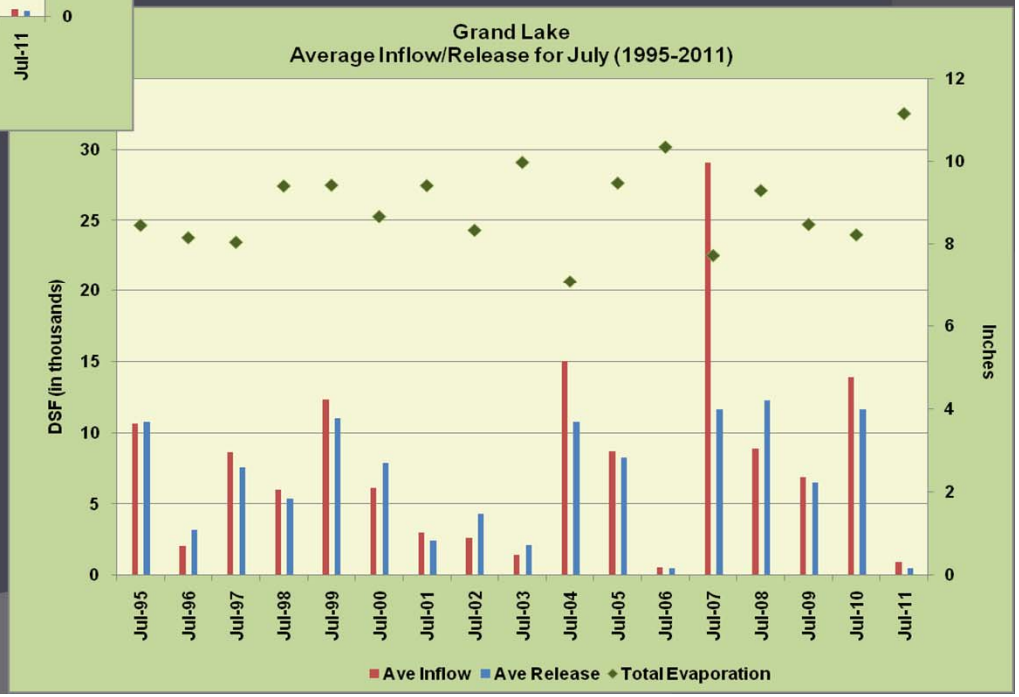
Adaptive Management

DO Mitigation

Sample Year 2011 Conditions

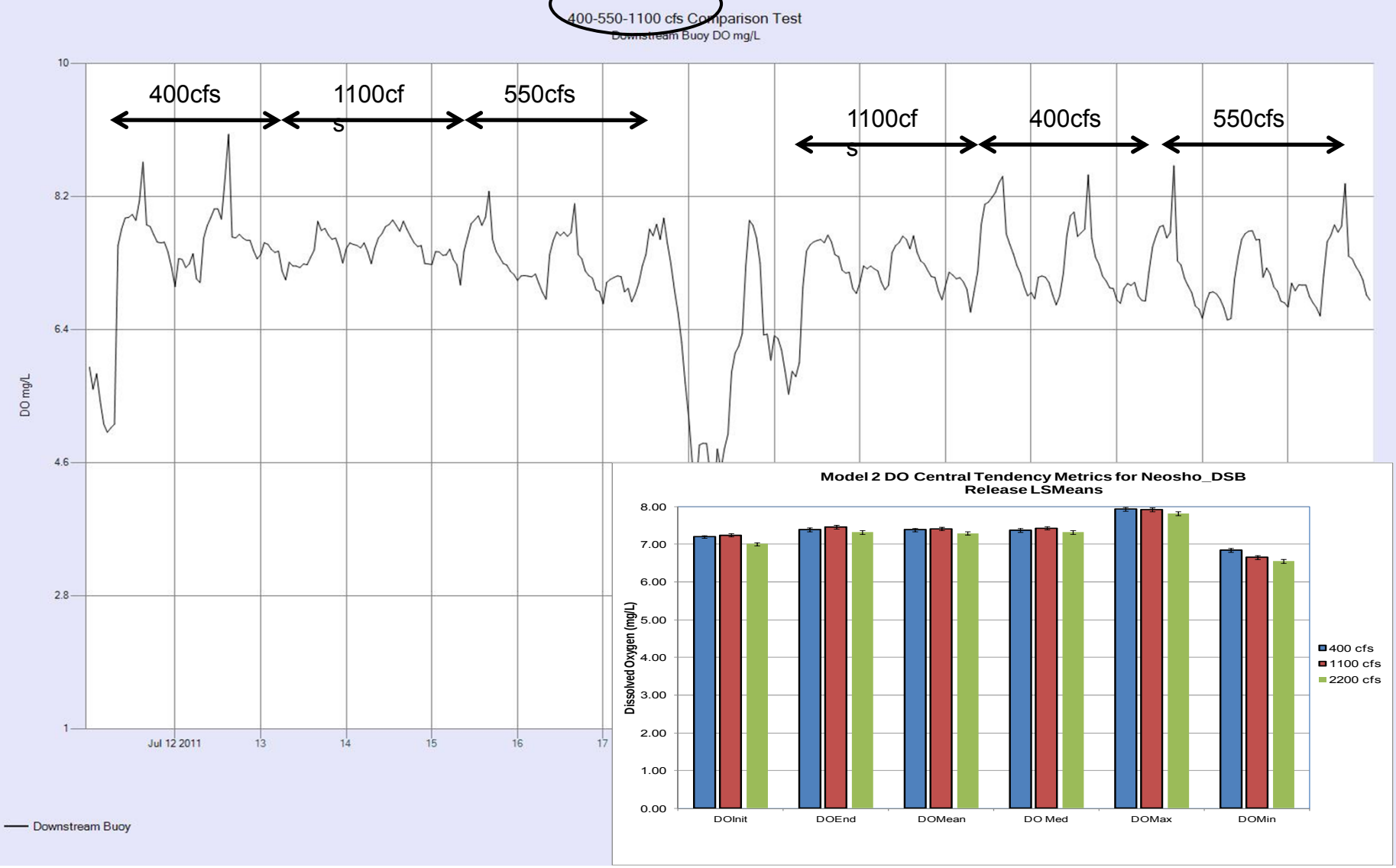
Extreme conditions.





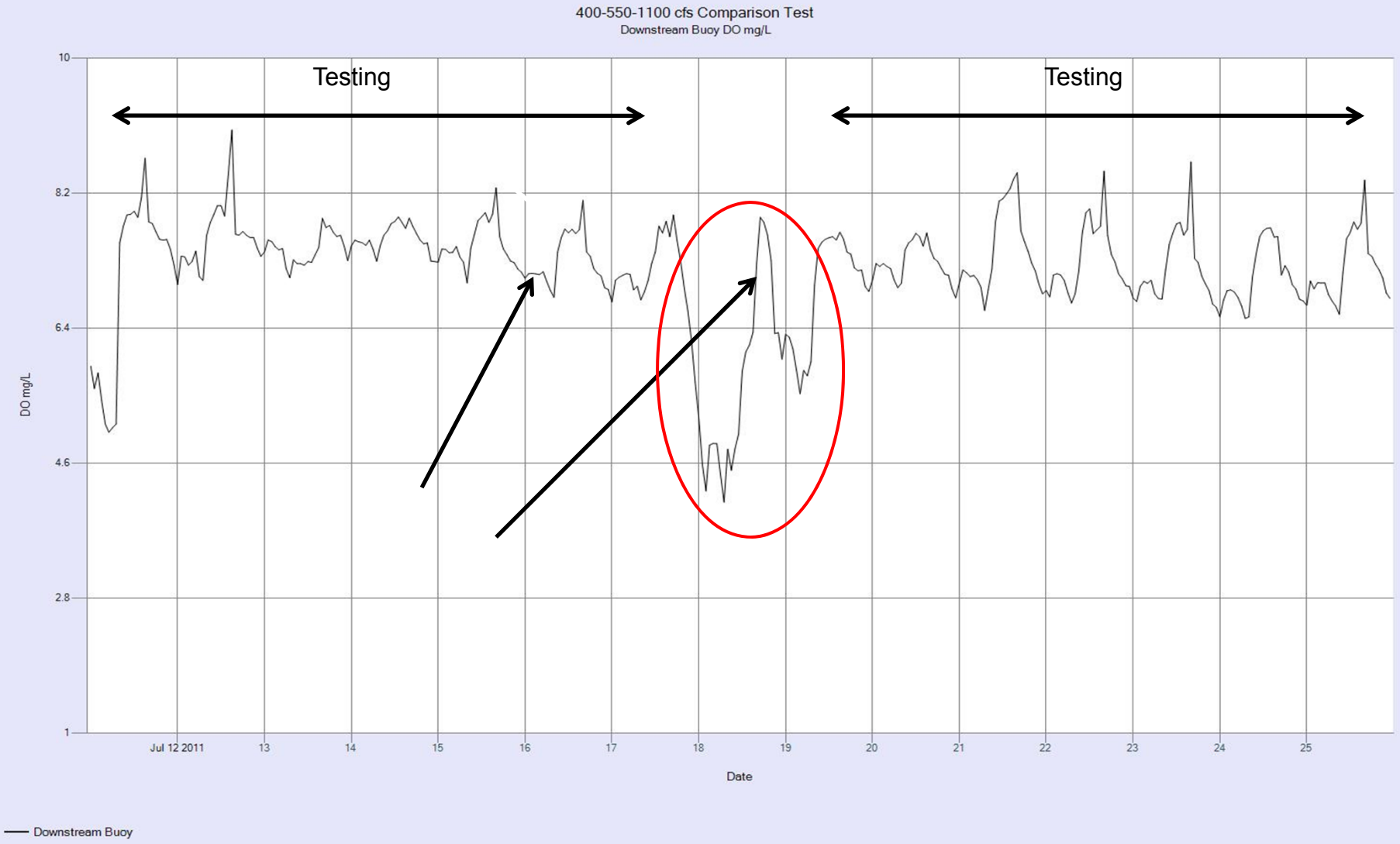
Pensacola General Conclusions

Release volume is relatively unimportant.



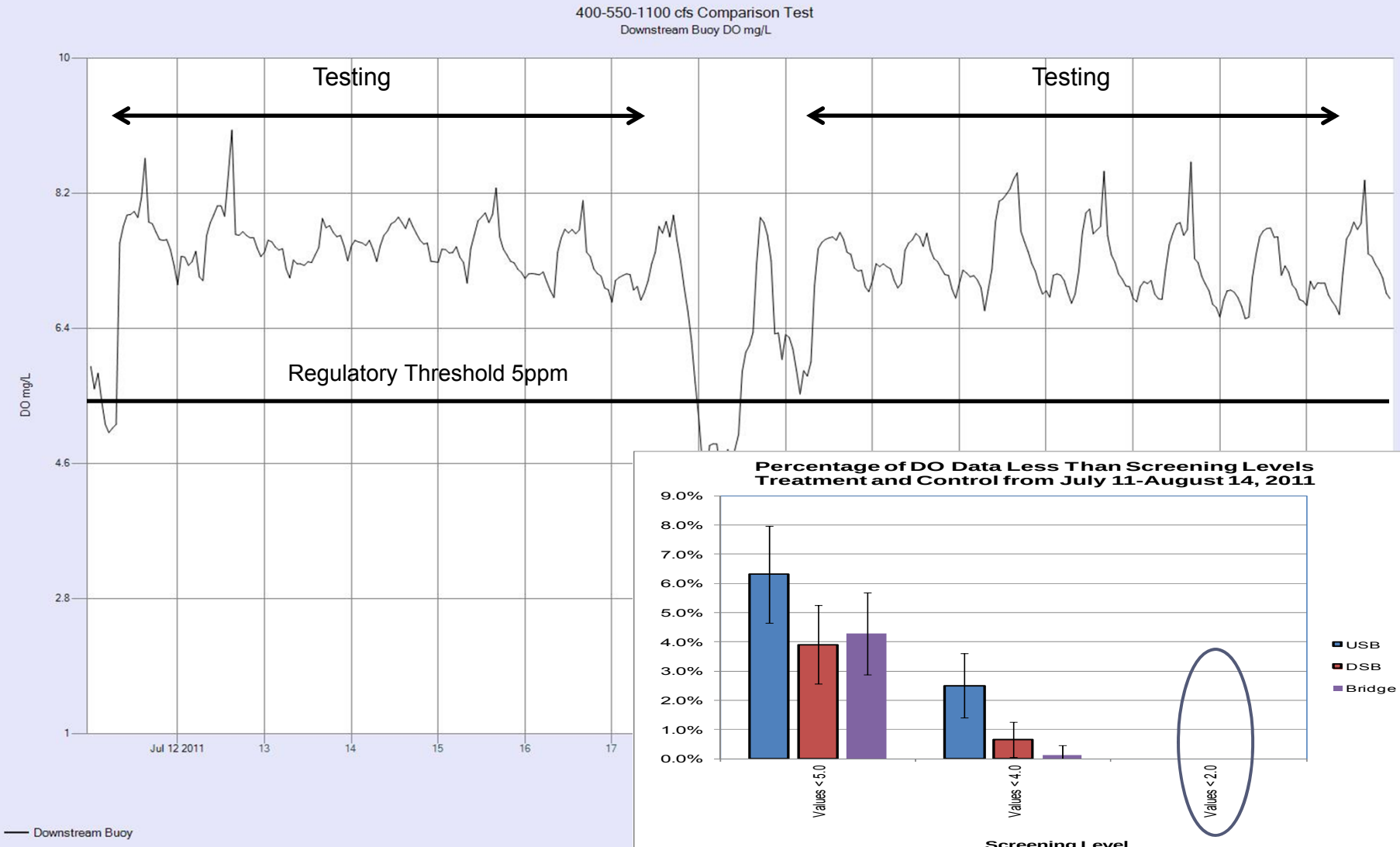
Pensacola General Conclusions

Natural diurnal effect important to outcomes.



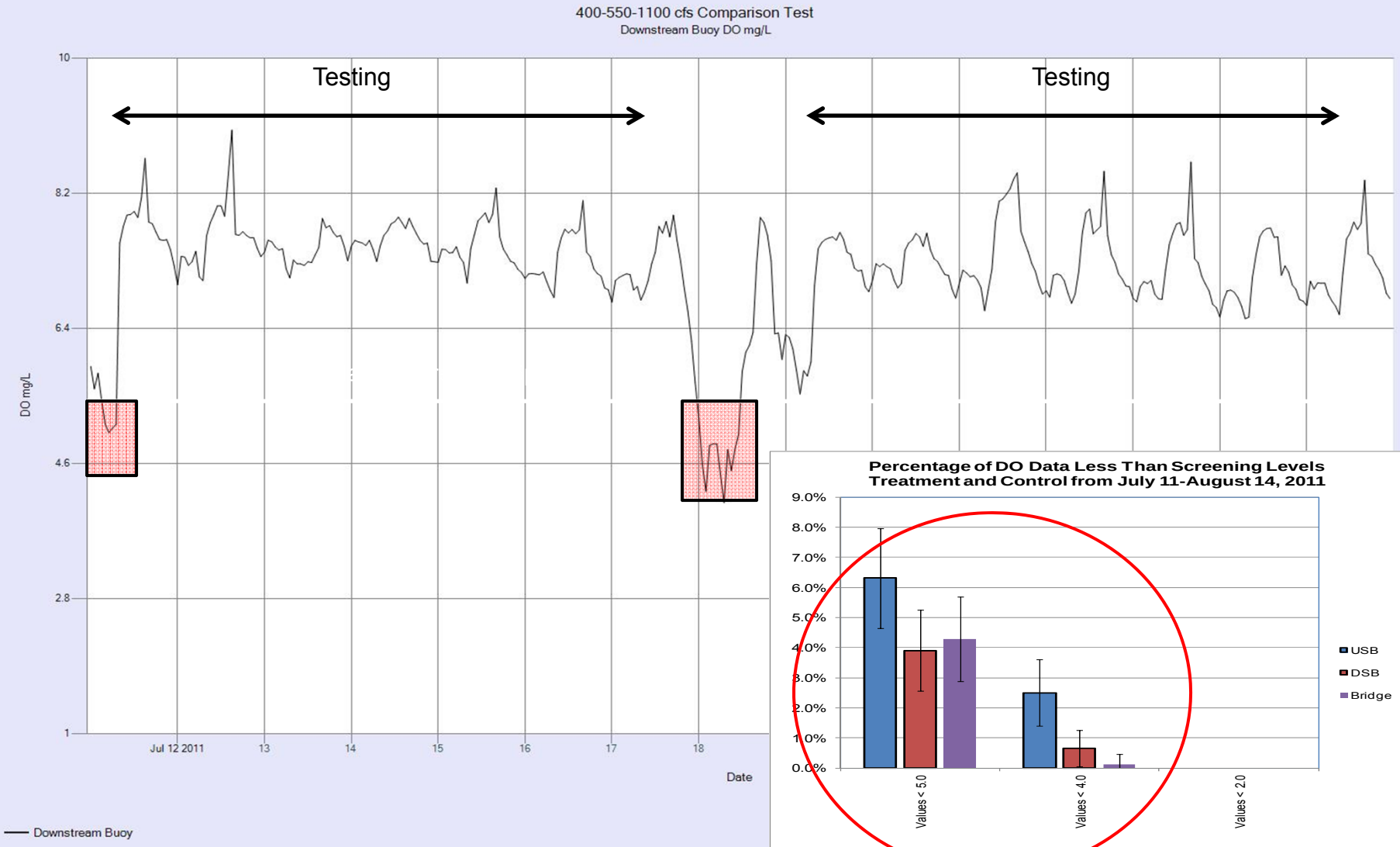
Pensacola General Conclusions

Mitigation activities have an overall positive impact on both regulatory and ecological endpoints.



Pensacola General Conclusions

Without releases have potential for regulatory impacts.



Pensacola Adaptive Management Scenario

In an effort to meet the OWQS DO criterion and mitigate for potentially harmful effects to aquatic life, the following plan is recommend to be **implemented, beginning June 1, 2012**. Compliance will be measured at the three probes along the Langley Bridge. Any individual probe on the bridge will activate a mitigation response.

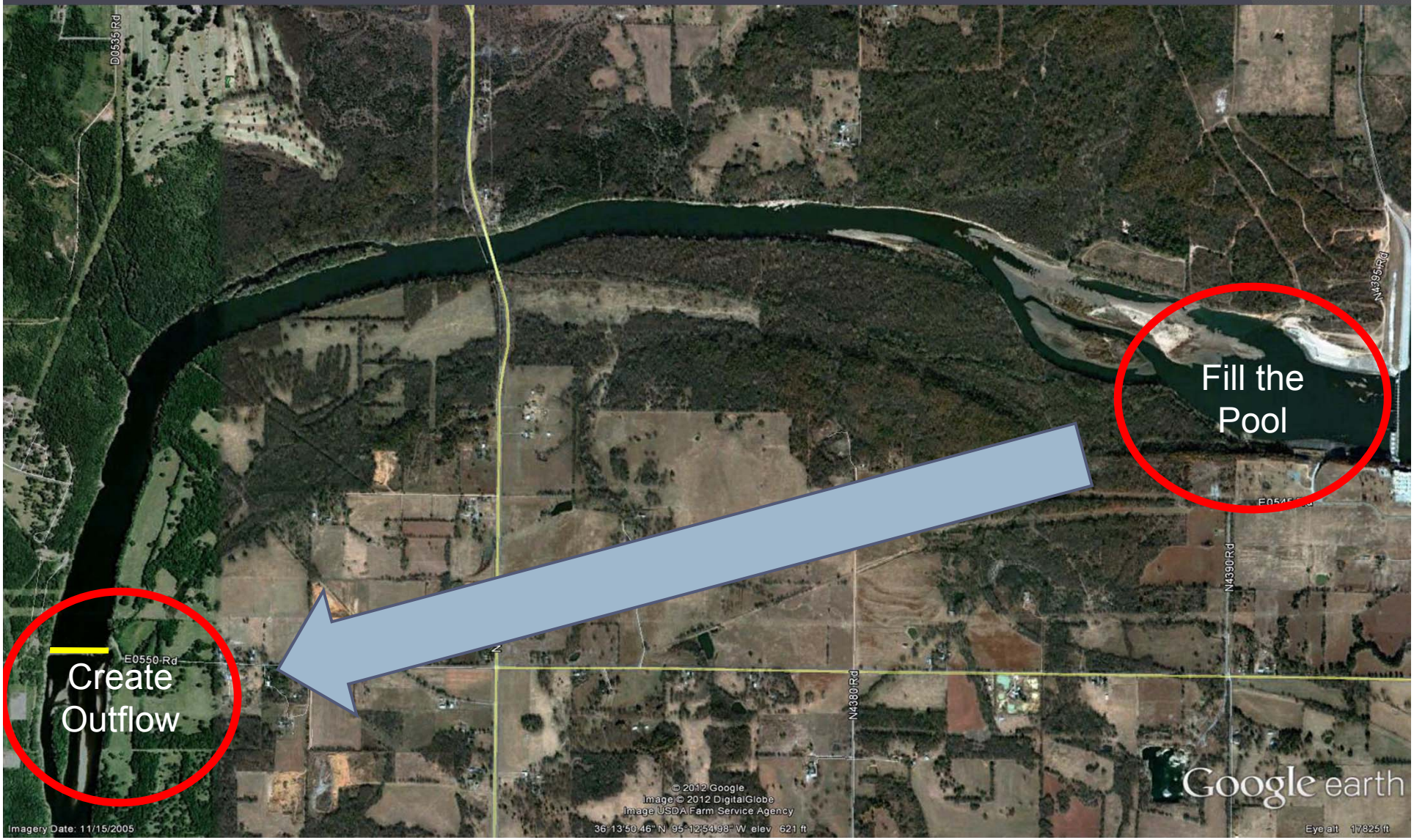
"**The action limit will be set at the OWQS criterion of 6mg/l from 10/16 though 6/15 and at 5 ppm from 6/16 through 10/15. Once the action limit is reached, according to an average of the Langley Bridge DO probes, one Turbine will begin running at 20% wicket gate (~ 320 cfs) with full aeration. Once a release is started, it will continue until the average DO value exceeds the criterion, but will continue for a minimum 6 hours. A second action limit will be set at 4.0 ppm. If the second action limit is reached, the first turbine will be upped to 25% wicket gate (~ 430 cfs) and will continue for a minimum of 2 hours. This operational plan will run year round and should ultimately be implemented as an automated process**."

In an effort to facilitate the response process, an **e-mail alert system** will be set up to notify both operators and interested parties. When any individual compliance probe indicates a DO mg/L reading below any of the action limits, the NexSens iChart 6.0 software housed at the OWRB offices will send out an alert email to all necessary personnel at GRDA, FERC, ODWC, USFWS, and the OWRB. This email will indicate the most recently measured DO concentration and will state the appropriate response according to the mitigation plan. The program will reset the alert email as soon as measurements rise above the action limit.

This mitigation plan may be adjusted under several circumstances. Primarily, in the event that mitigation flows do not enhance DO concentrations, the OWRB will consult with all interested parties within 48 hours to determine the appropriate course of action. If enhancement does not work and concentrations reach acute DO levels (i.e., < 2 ppm), the OWRB will work unilaterally with the GRDA in an attempt to **develop an ad hoc mitigation scenario to avert a fish mortality incident**. All other technical committee members and FERC will be notified within 48 hours of any ad hoc mitigation scenarios. Second, if allowances to the regulatory rule curve are not eventually allowed, mitigation flows will likely cease if rule curve elevations are met.

Kerr General Conclusions

Must create movement by raising the pool level.



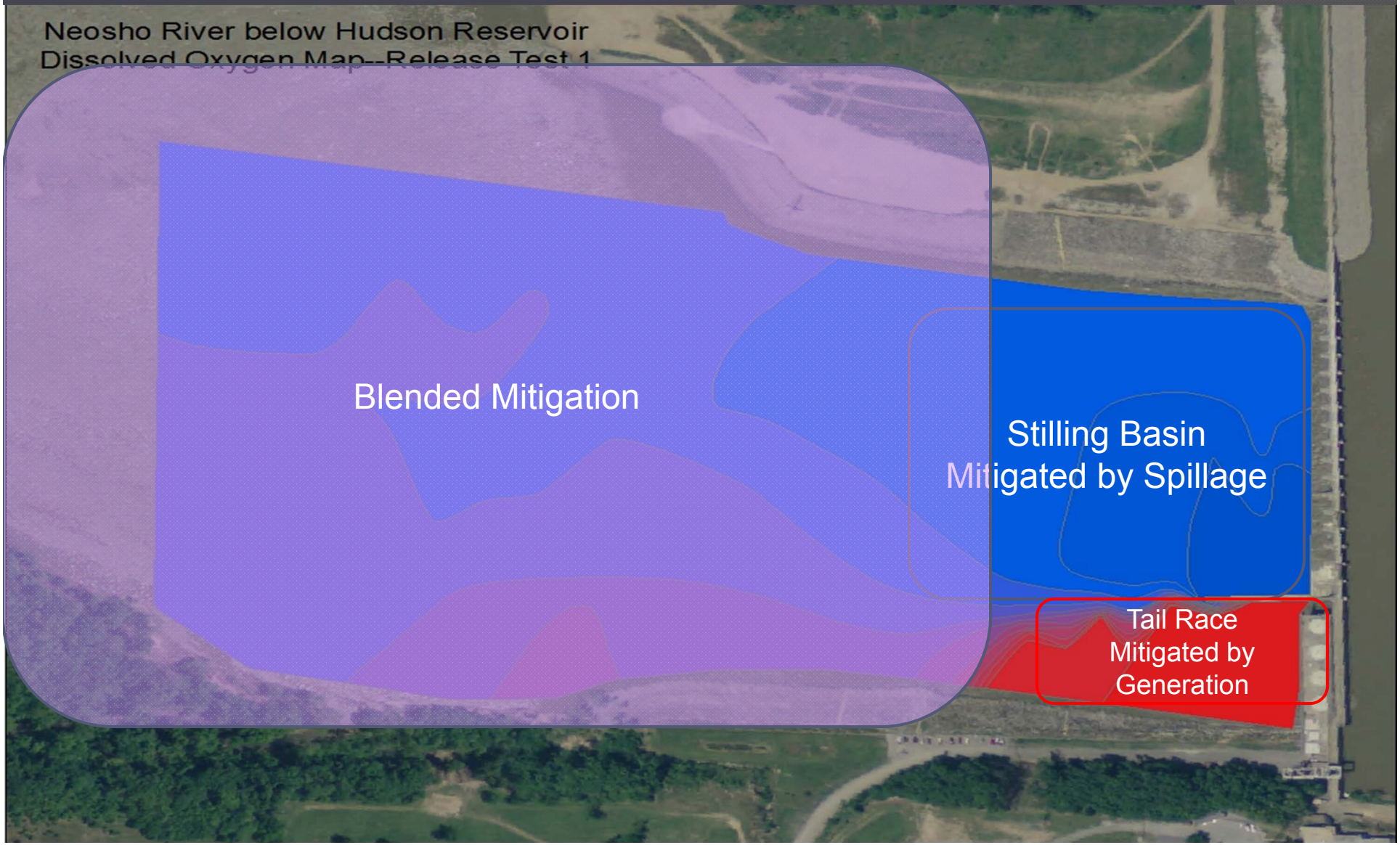
Kerr General Conclusions

Distinct Management areas

- large stilling basin
- small tail race.

Kerr General Conclusions

Requires multi-faceted mitigation.



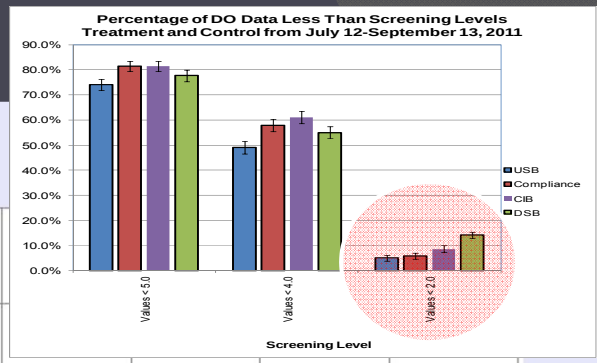
Kerr General Conclusions

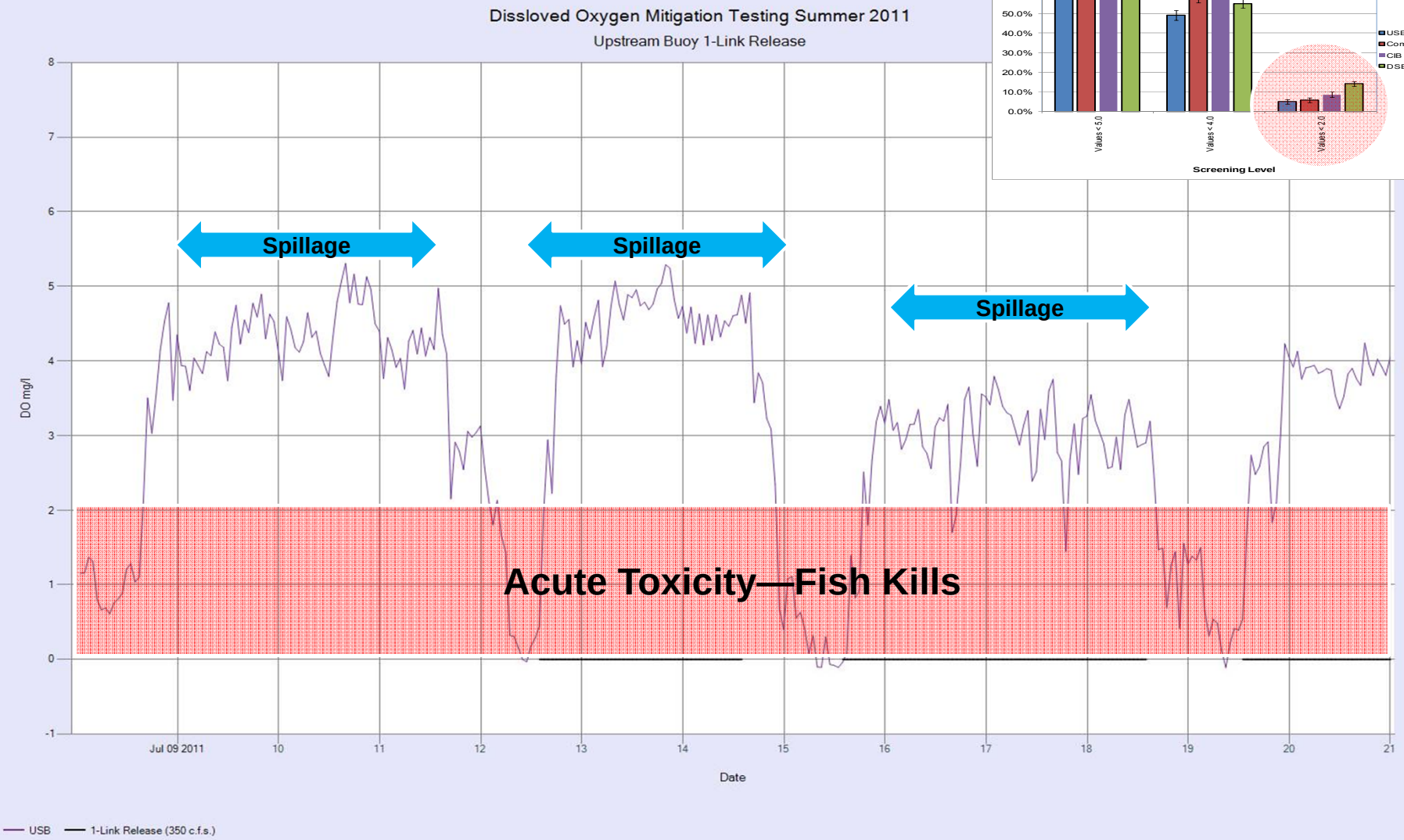
Difficult to mitigate consistently in immediate tail race.

Kerr General Conclusions

Two water quality management scenarios

1. Acute DO toxicity





Kerr General Conclusions

Two water quality management scenarios

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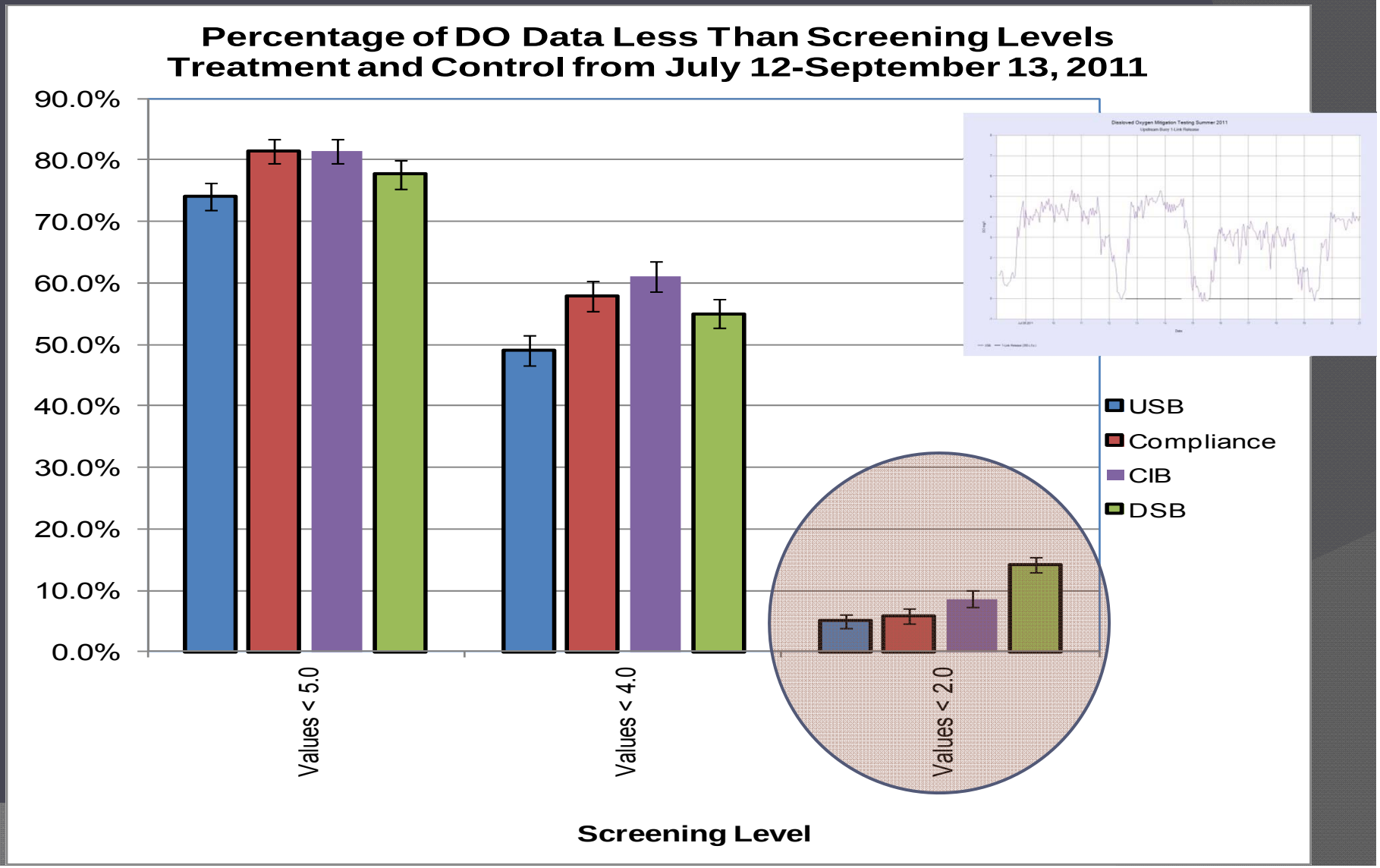
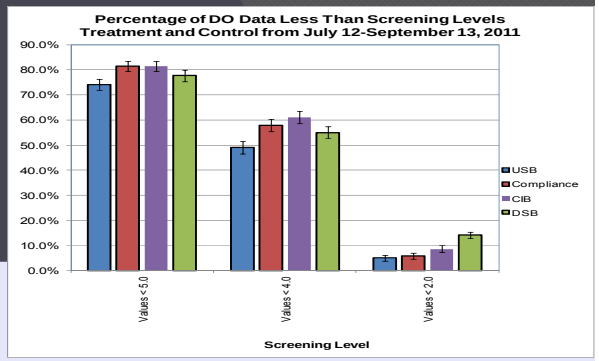
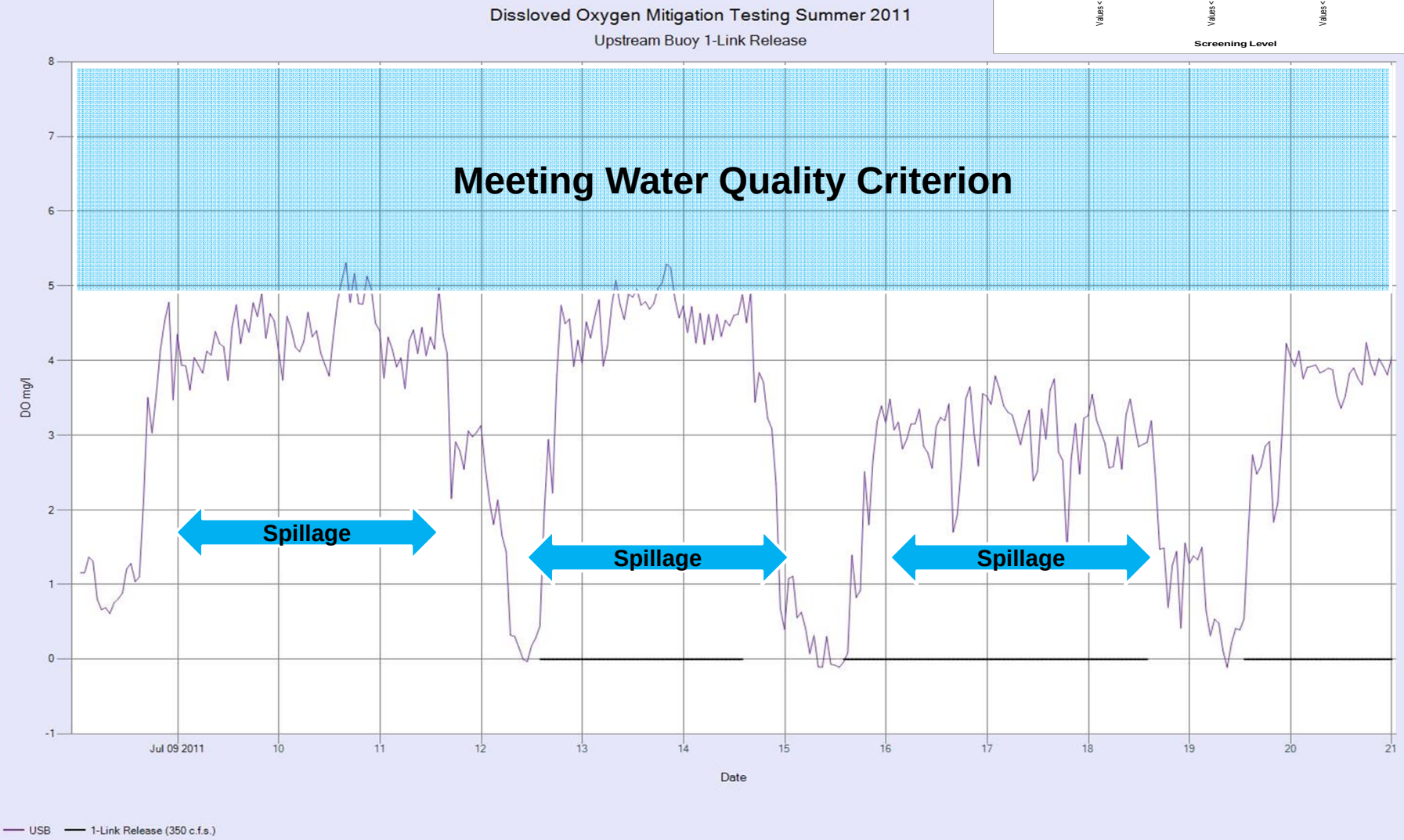


Kerr General Conclusions

Two water quality management scenarios

1. Acute DO toxicity
2. Water Quality Criterion

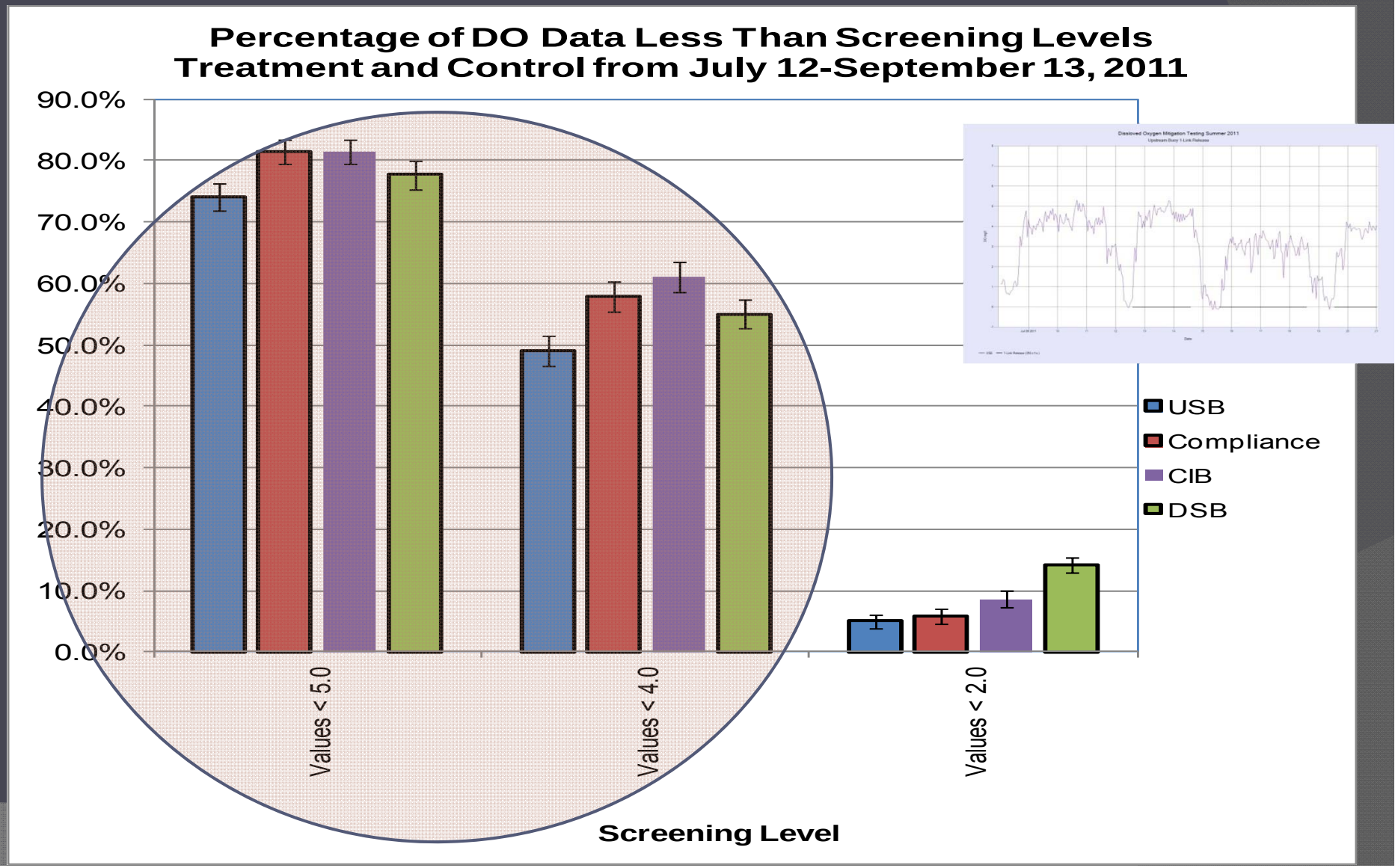




Kerr General Conclusions

Two water quality management scenarios

1. Acute DO toxicity
2. Water Quality Criterion



Kerr Adaptive Management Scenario

The following implementation schedule **will be implemented on June 1, 2012**.

"**Between the months of June 1 through September 30, a one chain link release from the spillway will be used to mitigate acute and nuisance DO conditions. When either median daily DO values fall below 5ppm for a 48 time period or when greater than 4 15-minute samples fall below 3ppm in any 24 hour period, the mitigation release be used continuously until 90% of samples are above 5ppm and no values are below 2ppm over a consecutive 7-day period, or until Hudson Lake falls below the regulatory rule curve. If any single value is less than 1ppm, the mitigation scenario will be implemented and continue until the afore-mentioned conditions are met. The Compliance stations will be used jointly to provide data for use in managing implementation (Figure 68). Testing will continue to document variance in DO concentrations during the continuous release periods. The 24 and 48 hour time periods run from 0600 to 0600 hours over two consecutive days**."

In an effort to facilitate the response process, an **e-mail alert system** will be set up to notify both operators and interested parties. When any individual compliance probe indicates a DO mg/L reading below any of the action limits, the NexSens iChart 6.0 (NexSens, 2012) environmental software housed at the OWRB offices will send out an alert email to all necessary personnel at GRDA, FERC, ODWC, USFWS, and the OWRB. This email will indicate the most recently measured DO concentration and will state the appropriate response according to the mitigation plan. The program will reset the alert email as soon as measurements rise above the action limit.

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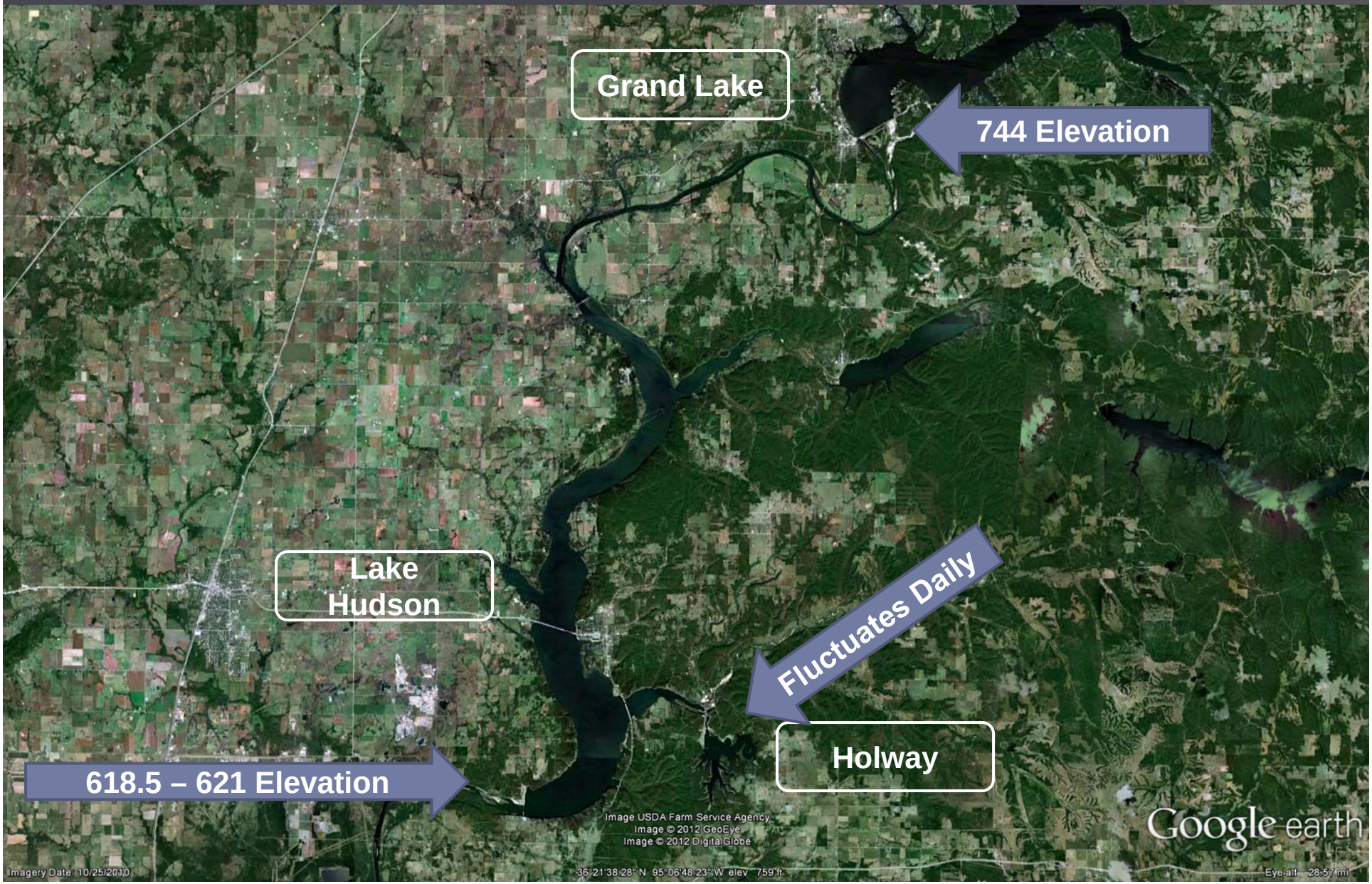
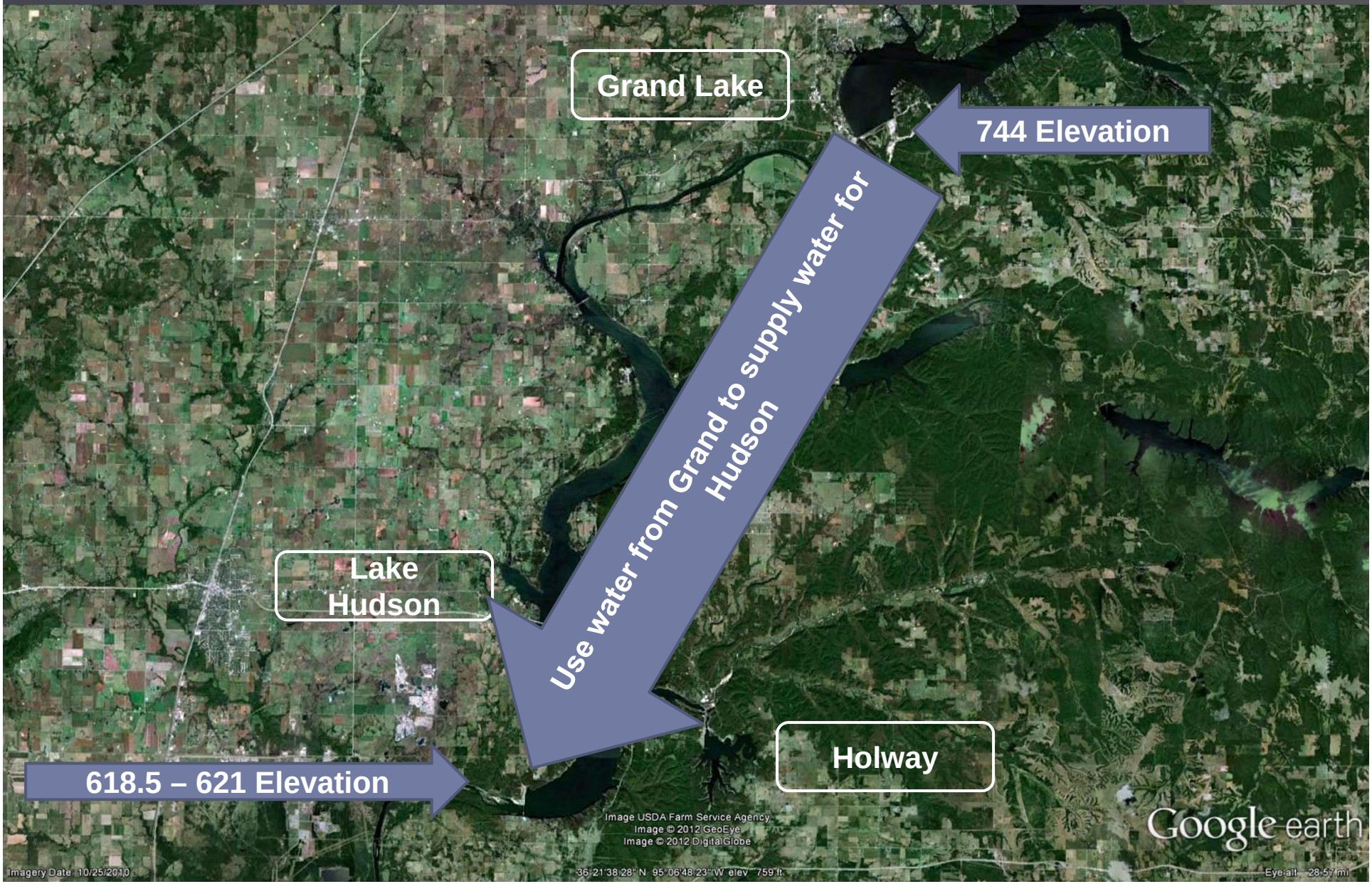
Holistic Watershed Management



Holistic Watershed Management



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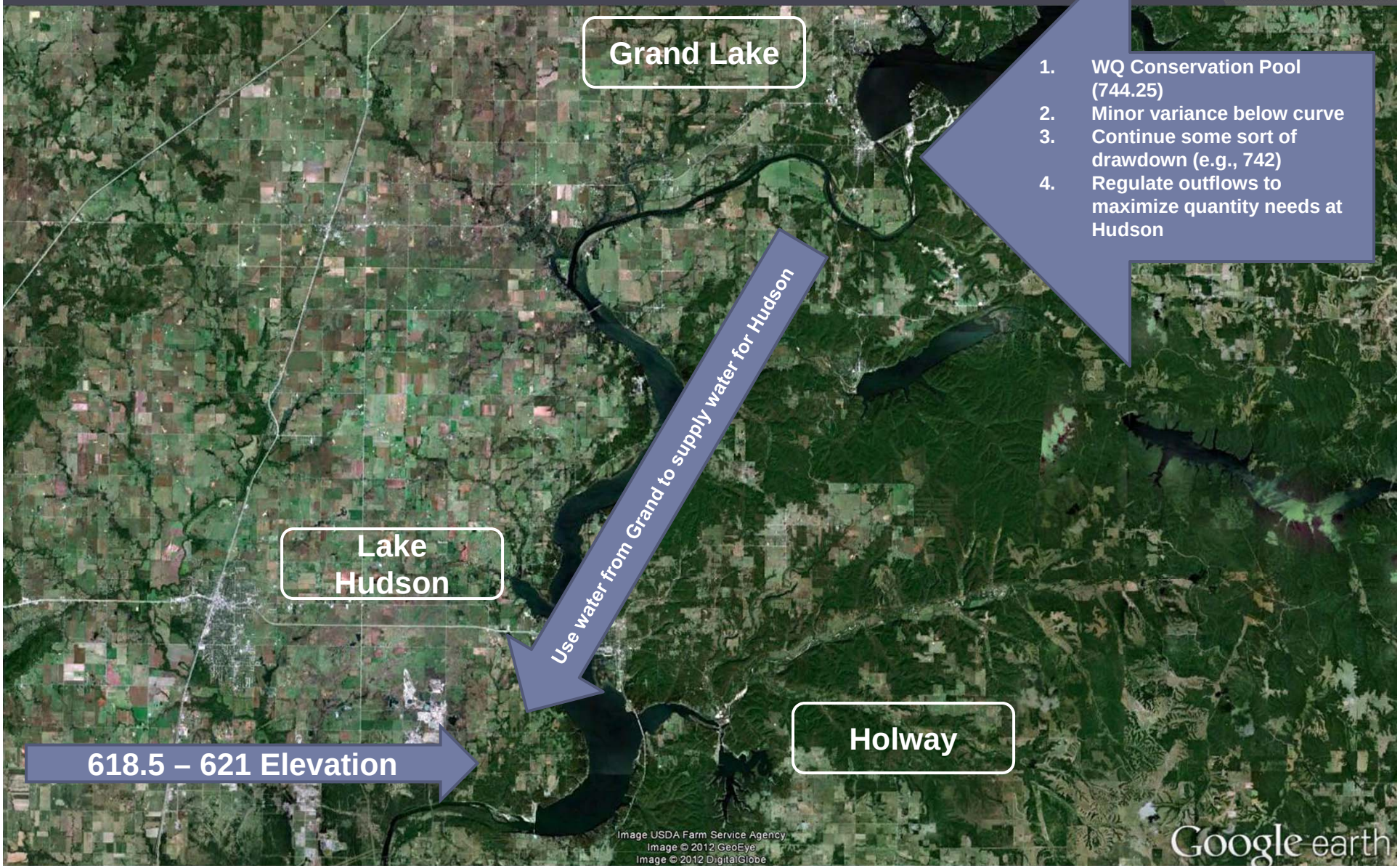
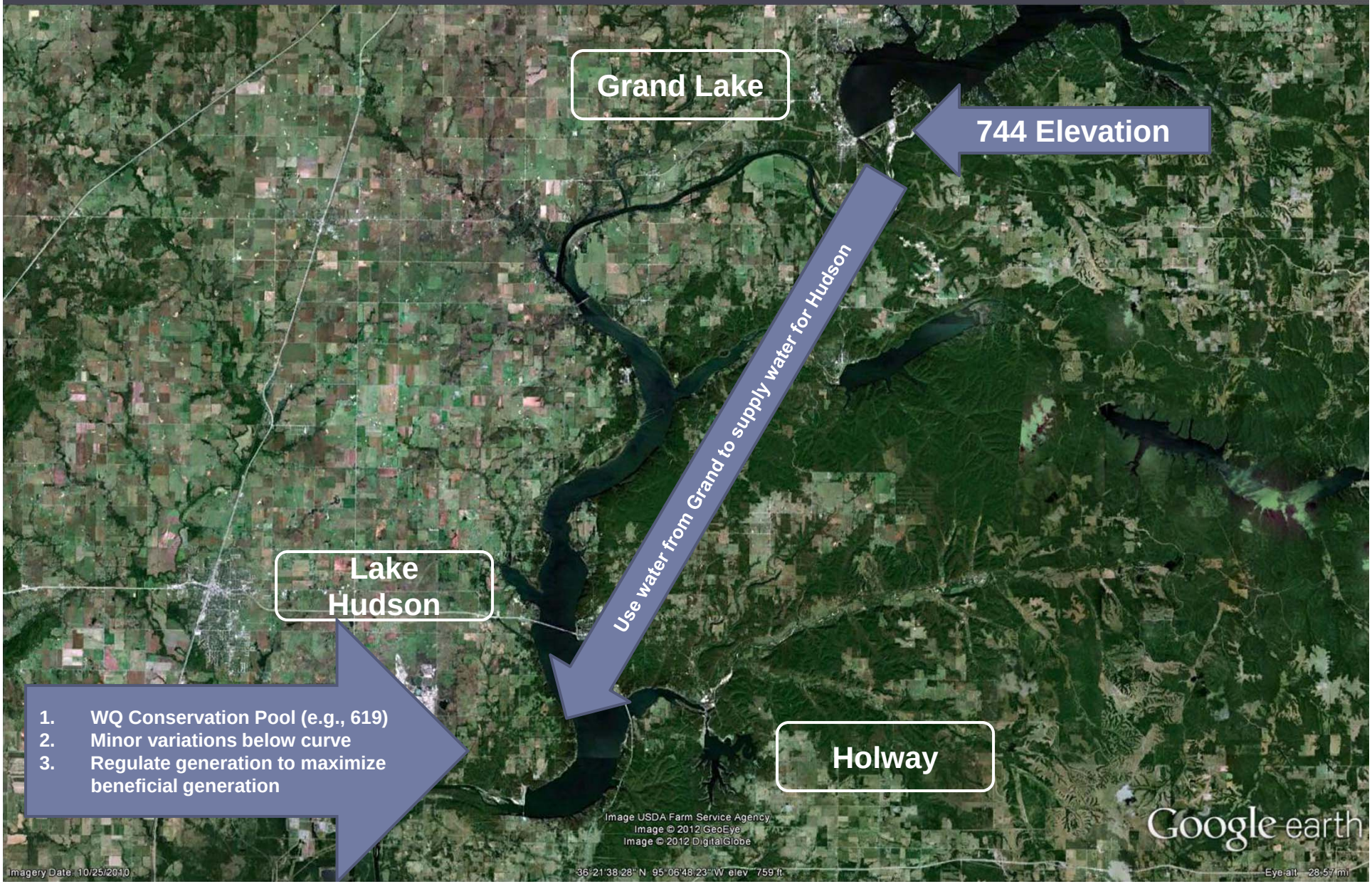
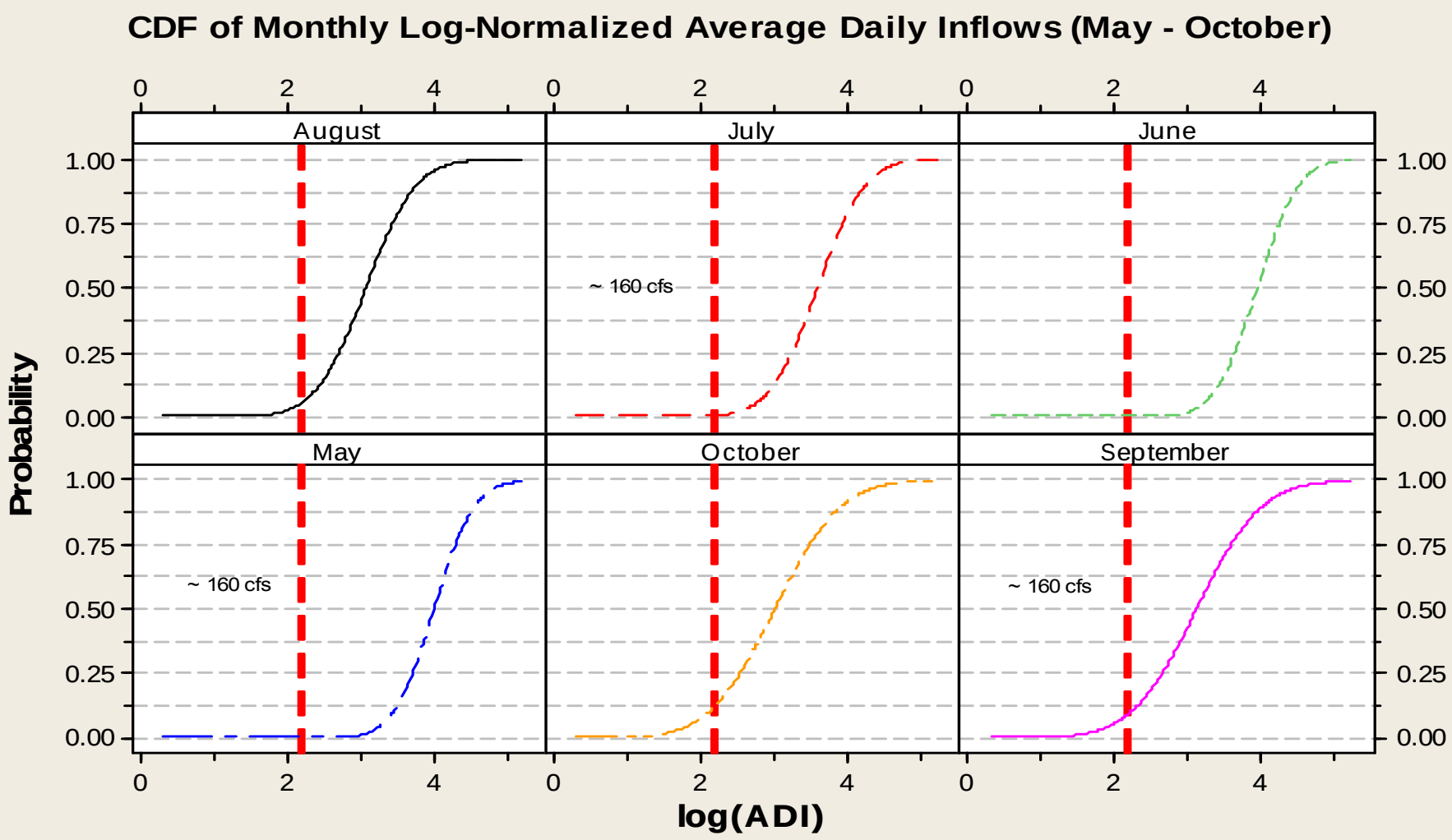


Holistic Watershed Management



Do we have enough water??

Cumulative distribution functions (CDF) representing probability of Monthly Log-Normalized Average Daily Inflows (ADI) from May – October at Pensacola Dam. The vertical dashed line represents logADI value of 2.2, which is roughly equivalent to 160 cfs.



Future Plans

- Continued refinement of mitigation plan at Pensacola Dam
  - Data collection/Early warning system
    - Alert emails notifying GRDA personnel to implement the appropriate mitigation scenario
  - Additional testing to make the mitigation plan more efficient
  - DO mapping to determine the extent of DO enhancements
  - Determine the relationship of lake elevations and available water between Grand Lake and Lake Hudson
  - Installed a vertical profiler in lake just above the dam
- Continued Testing Below Kerr Dam
  - Additional testing of flood gate releases 1 gate at 1 chain link opening vs. 2 gates at 1 chain link opening
    - Additional DO mapping to determine the extent of DO enhancements
  - Installed a vertical profiler in lake just above the dam
- Begin Modeling System as a whole