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TO: **Choctawhatchee Basin Alliance of Okaloosa Walton College**

SUBJECT: **Summary report for Project "Hydrology of coastal dune lakes in Walton County, FL"**

DATE: **April 2009**

Project dates	2/14/2007 to 4/14/2009
Dates covered by this report	2/14/2007 to 4/14/2009

Project Tasks

The first year of this two-year project involves three tasks

1. Review and assimilate water budget and water quality data for all coastal dune lakes for which the CBA has available data. Determine appropriate field locations for field instrumentation. CBA will secure permission and access.
2. Instrument for water budget characterization three target lakes: Draper Lake, and 2 of the following 4: Campbell, Camp Creek, or Eastern. UF staff will install wells and stage recorders at each lake.
3. Coordinate monitoring and data collection for water budget characterization. CBA staff and volunteers will be relied upon to conduct the majority of on-site data collection.

The second year comprises two tasks:

1. Continue monitoring of water budget at target lakes.
2. Perform preliminary contaminant budgets for target lakes. Note that the budget currently available for this task is not sufficient for full-scale research effort. Thus, this analysis will be a preliminary assessment aimed at identifying relative contributions of various sources of contaminants entering the lakes. Both groundwater and surface water quality samples will be collected and analyzed. If CBA staff and volunteers are available, sampling will be monthly. If UF personnel are required, sampling will be seasonal.

Project Results Summary

Water level recorders were first placed in Campbell Lake (CL) and Draper Lake (DL) on 30 April 2007. The first instrument was placed in Camp Creek Lake (CCL) on 29 October 2007. The initial transducers were simple units, capable of recording water level only. On 2 May 2008, more sophisticated transducers, which record water temperature and conductivity as well, were installed in CCL and DL. This analysis examines the three lakes from the dates listed above until 3 October 2008, the date of the most recent site visit. In addition to data collected by our transducers, supplemental external datasets were retrieved including a record of Gulf tides at Panama City from National Oceanographic and

Aeronautical Administration (NOAA), barometry at Bob Sikes Airport in Clearview from the National Weather Service (NWS) and a record of rainfall in Niceville from NOAA.

The dynamics of these lakes can be best understood when the water level record is corroborated by additional datasets, specifically conductivity. As a result, the period following 2 May 2008, when the conductivity and temperature datasets are available, received the bulk of our attention. Four periods of time were identified between 2 May 2008 and 3 October 2008, each of which contains a significant event for at least one of the lakes (**Figures 1-3**). By examining each of these segments individually, we should be able to understand how a single event (for example, a hurricane) affects each lake differently.

Period A: 2 May 2008 – 28 June 2008

Period A was selected to capture the significant increase and then sudden decline of the water level in CCL. Most of the water level changes may be explained by rainfall. For example, the rapid increase in early May corresponds to a number of rain events during the same time period. Likewise, the lake level is almost unchanging over the end of May and the beginning of June, a period of little recoded rainfall (**Figures 1 and 2**). It is the sudden drop in water level on June 13th, 30 cm in 30 hours, that makes Period A interesting. We hypothesize that several days of recorded rain on the apparently "brimming" lake, caused the plug of sand at the dune to give way (this process is termed blow-out), allowing the lake to drain rapidly into the Gulf. Interestingly, neither the conductivity nor temperature records reflect this event (**Figures 4-7**).

Period A reveals another interesting feature of the dune lakes when water level fluctuations are compared across the three lakes. The behavior of each of these lakes is driven as much by their individual morphologies as by regional weather events. While CCL "filled up" and overflowed during Period A, the water level in CL steadily declined (**Figure 1**). DL's water level showed a response to rainfall similar to CCL's response, but apparently never forced open the channel to the gulf (**Figure 3**). Finally, despite the lack of response in CCL's conductivity record (**Figure 4**; which indicates almost pure freshwater for Periods A, B and C), the conductivity in DL declined steadily, almost linearly over Period A (**Figure 5**). This may indicate dilution of saltwater from a previous breaching event by rainfall over this period, or a thickening of the freshwater lens over a salt wedge, forcing the salt layer deeper below the transducer. *The saltwater mixing and dilution mechanisms are still unknown and to be resolved with further study.*

Period B: 28 June 2008 – 1 August 2008

Period B was selected to capture apparent blow-out events in CCL and DL. CCL behaved much the same as it did in Period A, with a filling-up of the lake and the giving-way of the sand plug following a few days of relatively small rain events. One noticeable difference is the elevation of the water immediately prior to the blow-out. The CCL water was about 15 cm lower preceding the Period B blow-out than it was before the Period A blow-out. This suggests that the formation and destruction of the sand plug in the channel through the dunes is very dynamic and the plug may not regenerate to its previous size and shape following a blow-out event. Once again, despite an apparent breach of the sand plug, the conductivity in CCL does not respond to the event, indicating either that the elevation of the channel was higher than the high tide or that the transducer was submerged above the salt layer.

DL also experienced a blow-out during Period B. The lake lost more than a meter of water in about 4 hours. The drawdown was significant enough such that the water level fell below the transducer (recorded by the transducer as ~3 cm of water). The channel connecting DL to the Gulf was deep enough to convey salt water into the lake each high tide. This influx of tidal water left a distinct signature on the water level, conductivity and water temperature records (**Figures 8 and 9**). The water level record shows a periodic resubmergence of the transducer which is in phase with the high tides measured by NOAA (**Figure 10**). The conductivity drops to 0 during the exposed periods and spikes to some fraction of full Gulf salinity during each high tide. Even more interesting, the salinity climbs higher with each subsequent high tide, possibly indicating some level of mixing as the lake water that did not drain out immediately following the blow-out was fractionally replaced by Gulf water over each tidal cycle. At the end of the 5-day opening event, salinity in the lake was almost equal to salinity in the Gulf. The water temperature record shows that the temperature of the Gulf water was approximately equal to the temperature of the lake water prior to the blow-out, but it also captures the air temperature between high tides. Because the low tides [and presumed exposures] were occurring at night (**Figure 10**), the temperature drops quite dramatically between each high tide (**Figure 9**). After 5 days or so, the channel is replugged, the lake begins to refill (presumably with rain water) and the conductivity begins to decline steadily. As seen for Period A, CL water level shows almost no reaction to the recorded rainfall, and appears never to experience a blow-out event.

Period C: 1 August 2008 – 21 August 2008

The behavior of all three lakes is very similar from Period B to Period C. Both CCL and DL went through a filling and blow-out cycle, with the blow-outs occurring nearly simultaneously. The CL water level trended slightly upward at the same time that the CCL and DL water levels increased to the point of forcing blow-outs. Curiously, the rainfall record does not indicate a particularly rainy mid-August so the increasing water levels in all three lakes are somewhat unexplained. Period C is distinguished from Period B in that the DL blow-out occurs during a neap tide cycle, such that the high tides do not raise the water level enough to resubmerge the transducer until the channel is plugged. Once again, CCL's conductivity remains unresponsive and DL's conductivity approaches that of sea water when the opening event concludes.

Period D: 21 August 2008 – 20 September 2008

Period D is fairly unique among the four periods. During this period, the lakes were impacted by 3 tropical cyclones: Tropical Storm Fay (23 August), Hurricane Gustav (1 Septenber) and Hurricane Ike (11 September). Interestingly, none of these storms resulted in significant rainfall events, as measured at the Niceville NOAA station, including TS Fay which passed directly over the Florida Panhandle.
Both DL and CCL show significant increases in water level (60cm and 20 cm respectively), coincident with TS Fay. In CCL the change is temporary, resulting in a spike that recedes over a few days, suggesting that the channel was still open. In DL however, the water level remains elevated, perhaps because the channel may have closed. On September 1st, Hurricane Gustav passed over New Orleans, LA. With it came a storm surge 35 cm higher than typical high tides (**Figure 11**). This surge was enough to introduce saline water into both DL and CCL, and this is the first remarkable event in the CCL conductivity record. The water level in both lakes remained elevated following Gustav, possibly due to rainfall. During the event, conductivity in CCL rose briefly, approaching the conductivity of sea water, but dropped precipitously after a few days (**Figure 4**). DL conductivity was already elevated from the previous opening event and only showed a slight increase to the Gustav storm surge, but subsequently remained elevated (**Figure 5**). Ten days later, on September 11th, another extraordinarily high tide was recorded (**Figure 11**), presumably a result of Hurricane Ike, which was still many miles off shore. Again, the water level in CCL and DL rose, and was maintained elevated despite Ike being

out in the middle of the Gulf and probably not delivering much rain. A spike and recession of conductivity was recorded in CCL, similar to the signature left during Gustav. Conductivity in DL was about 90% of sea water immediately prior to the surge, so the event did not significantly influence the conductivity of DL.

As of the end of the period of record analyzed in this report, water levels in both CCL and DL were higher than they had been at any other point in the record. Water level in CL appears to have still been falling following a POR-high in March 2008. Conductivity in CCL was at about 20% of sea water and apparently holding fairly steady. In DL, conductivity was falling somewhat, probably due to dilution, from a peak of 100% of sea water on 1 September 2008.

Proposed Future Tasks

- We are continuing to monitor the hydrology of these lakes. We plan to maintain our instruments and build on both our existing data and our understanding. We hope to continue to collaborate with CBA staff to eventually disseminate our understanding of the hydrologic functioning of the lakes.
- Still unknown are the saltwater mixing and dilution mechanisms within the lakes. We remain interested in resolving these through future study.
- Also still unknown are the mechanisms controlling more than one daily diurnal signal in water level. Our current hypothesis is based on wind-driven seiches forming in the lakes. Again, future study is required to resolve.
- Finally, further data collection may provide a better foundation for characterizing expected frequency and durations of blow-out events for different lakes. Also desirable for such a generalized conceptual model would be a description of the expected changes in temperature and conductivity regimes in the lakes.

Water Level Records for Campbell, Camp Creek and Draper Lakes

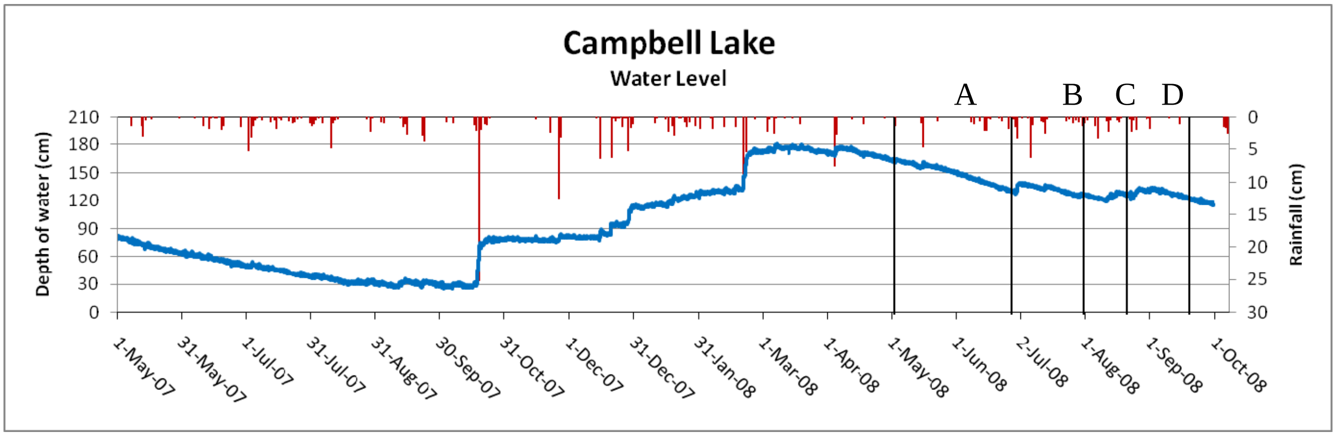

Figure 1. Water level in Campbell Lake from May 2007 to October 2008 and rainfall at Destin Airport for the same period. Values expressed as cm of water above the transducer. Water level record is artificially continuous; it is the combination of several recording instruments which may have had different absolute elevations.

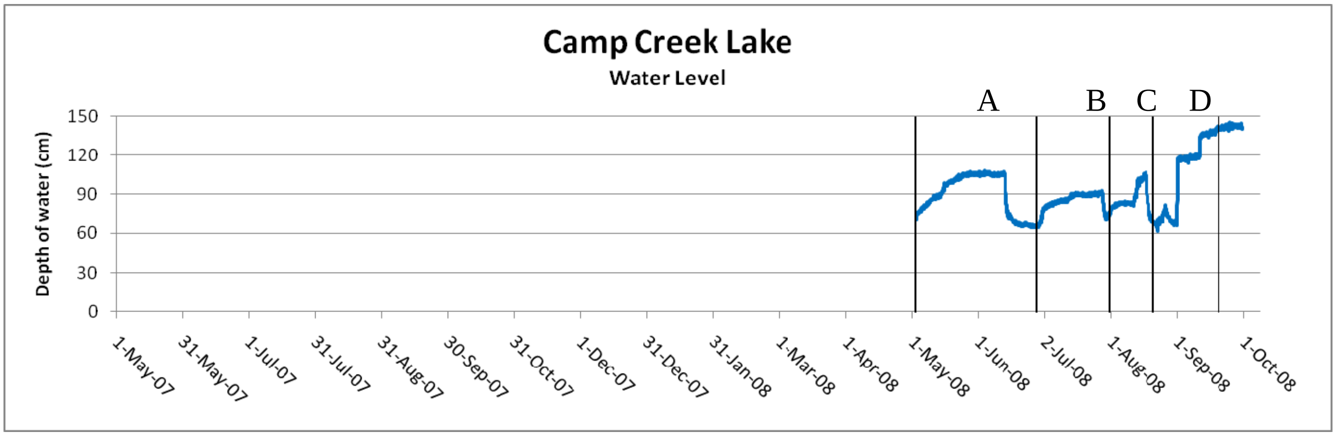

Figure 2. Water level in Camp Creek Lake from May 2008 to October 2008. Values expressed as cm of water above the transducer. Water level record was recorded by a single transducer.

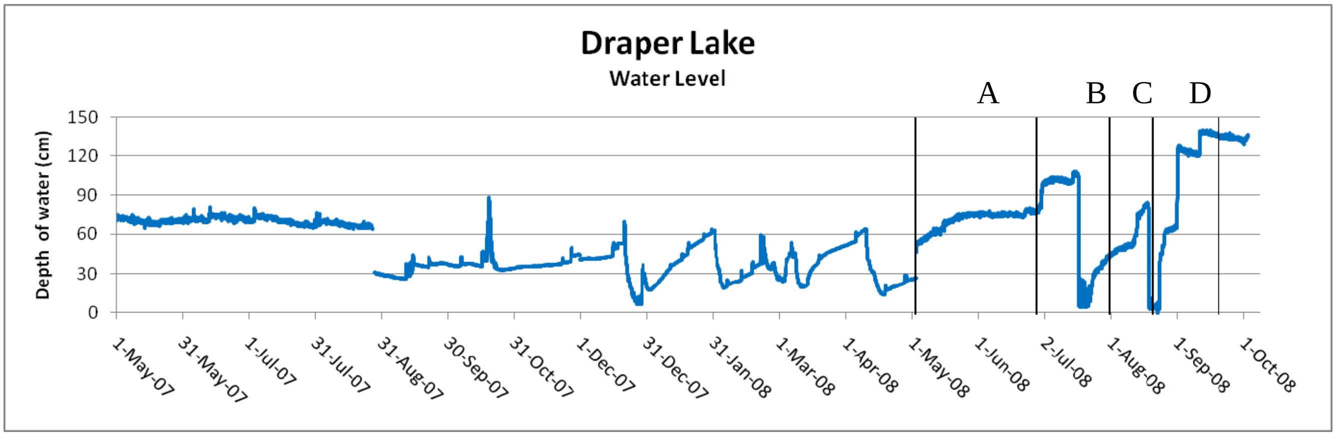

Figure 3. Water level in Draper lake from May 2007 to October 2008. Values expressed as cm of water above the transducer. Full record is assembled from three different transducers.

Conductivity Records for Camp Creek and Draper Lakes

No conductivity record exists for Campbell Lake

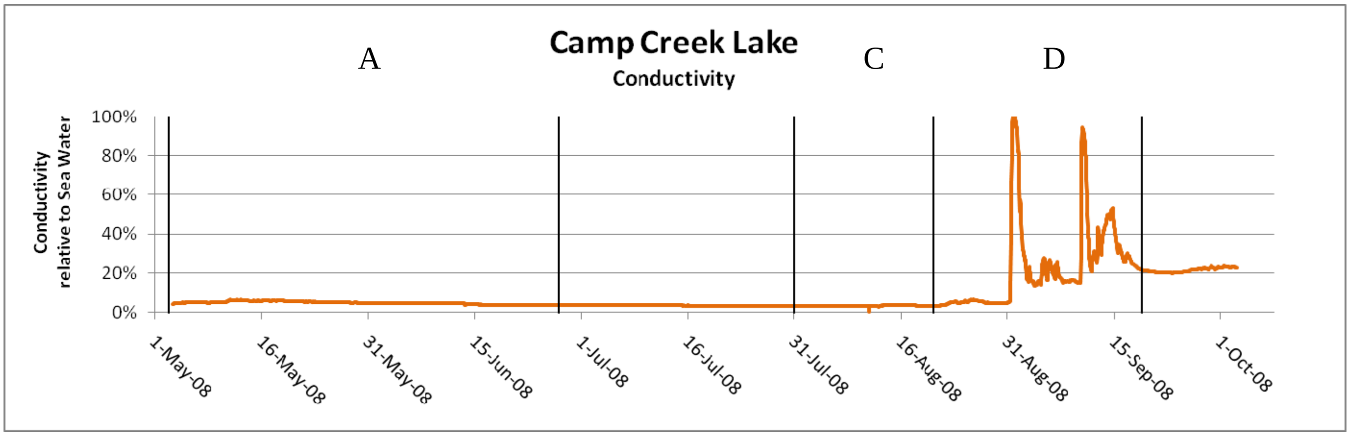

Figure 4. Conductivity record for Camp Creek Lake. Values expressed relative to maximum conductivity for the POR, which was approximately equal to the conductivity of sea water.

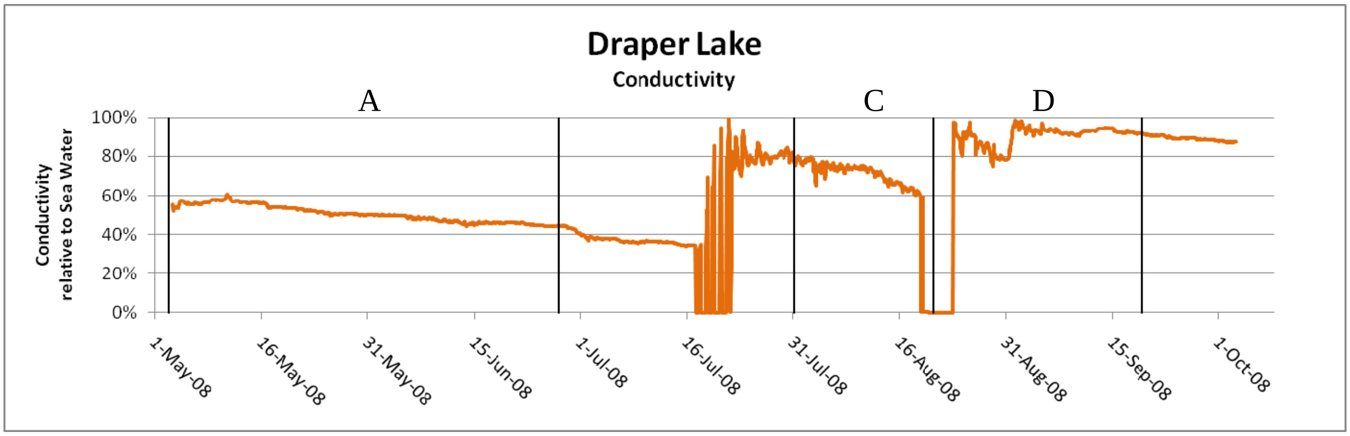

Figure 5. Conductivity record for Draper Lake. Values expressed relative to maximum conductivity for the POR, which was approximately equal to the conductivity sea water.

Temperature Records for Camp Creek and Draper Lakes
No temperature record exists for Campbell Lake

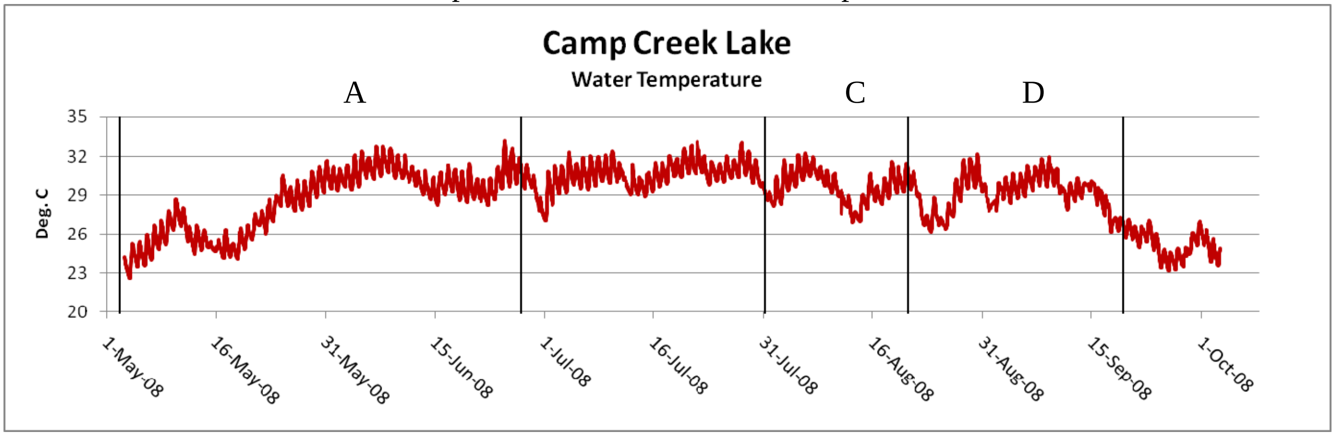

Figure 6. Water temperature for Camp Creek Lake. Values expressed as degrees Celsius.

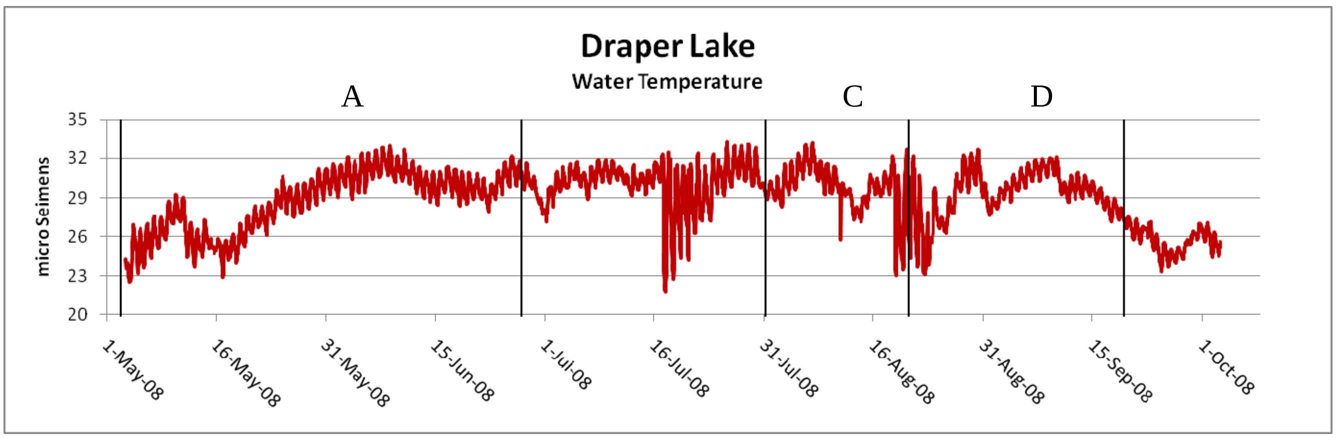

Figure 7. Water temperature for Draper Lake. Values expressed as degrees Celsius.

Draper Lake During July 2008 Blow-Out

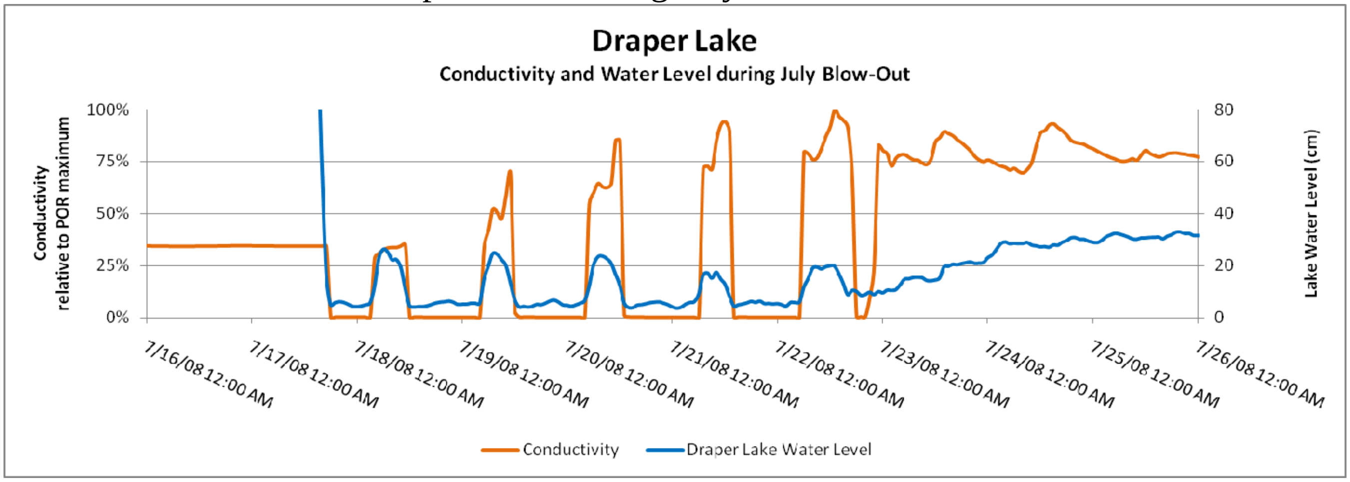

Figure 8. Lake water level and relative conductivity for ten days during the July blow-out of Draper Lake. Conductivity values are expressed as percentage of POR maximum and lake water level values are expressed in cm.

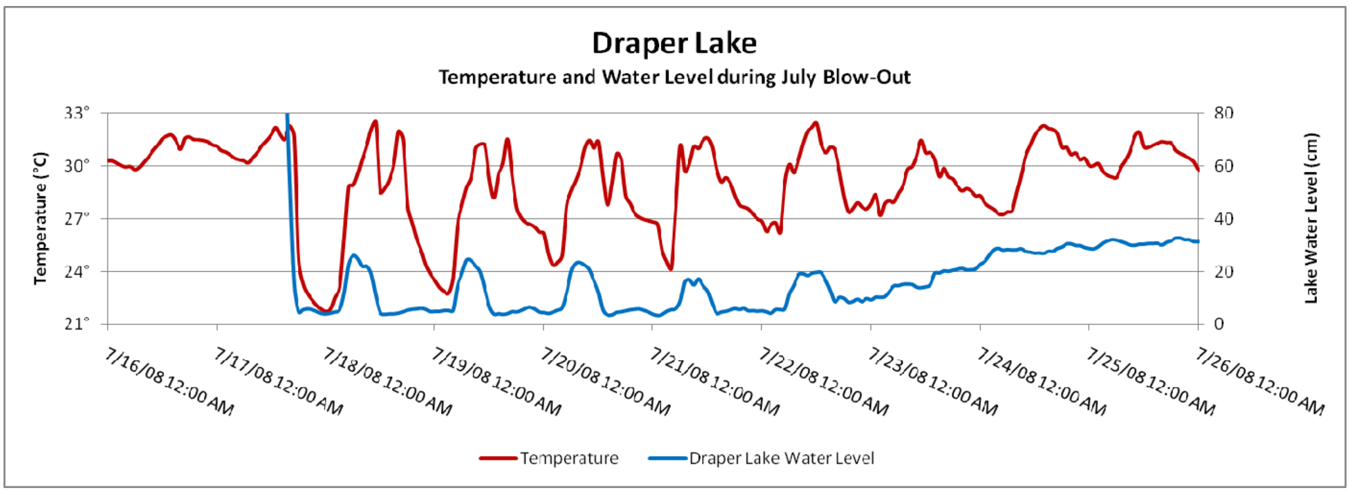

Figure 9. Lake water level and temperature for ten days during the July blow-out of Draper Lake. Temperature values are expressed in °C and lake water level values are expressed in cm.

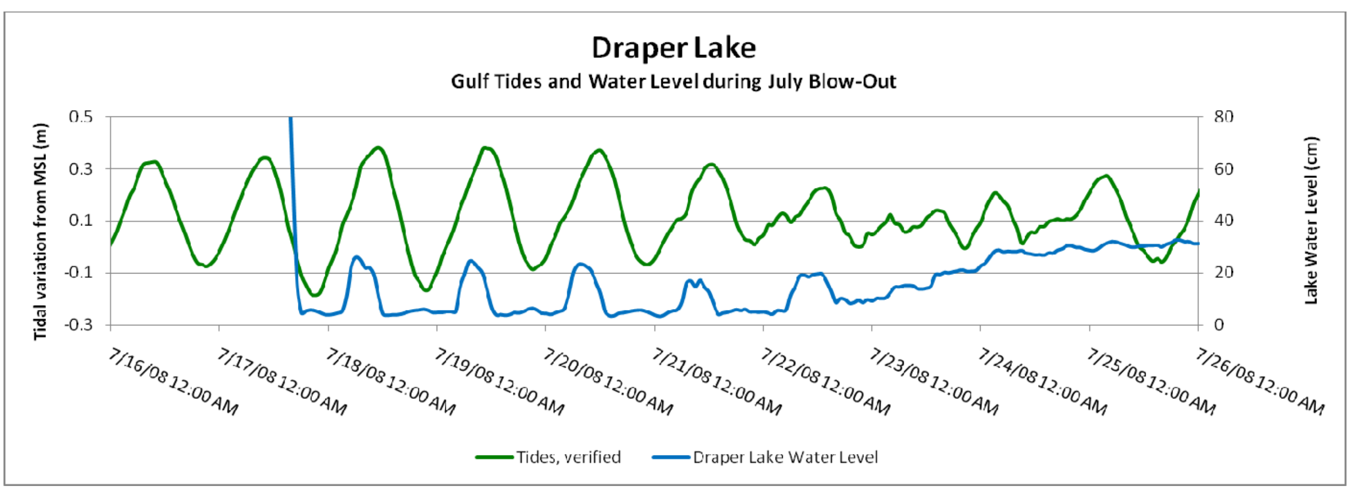

Figure 10. Lake water level and Gulf tides for ten days during the July blow-out of Draper Lake. Tidal values are expressed in meters difference from mean sea level (MSL) and lake water level values are expressed in cm.

Additional Figures Descriptive of the Dune Lakes

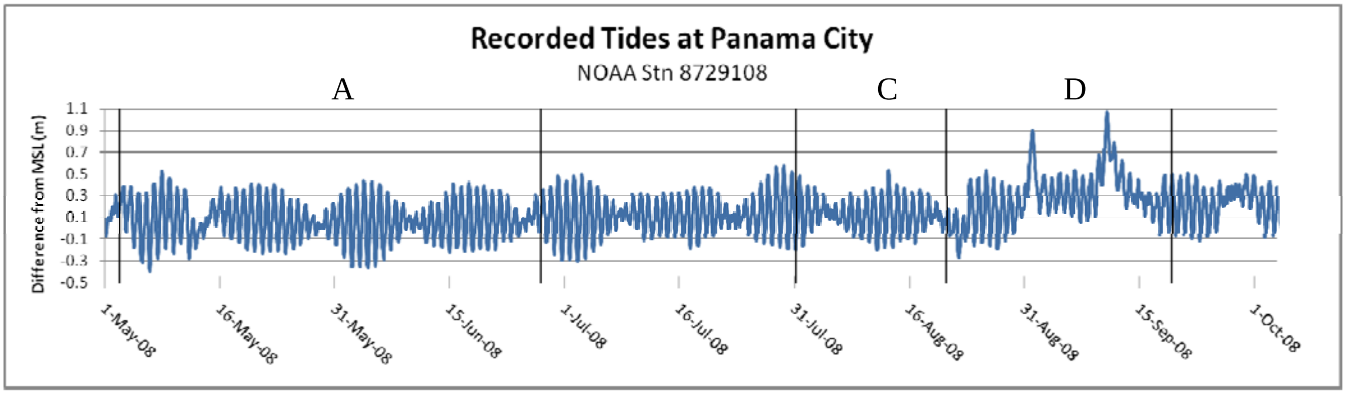

Figure 11. Tides recorded in the Gulf of Mexico at Panama City, FL. Values expressed in meters of variation from mean sea level (MSL).

A map might be nice somewhere in this production, but I don't think Google Earth is the right application for the job; the lakes are too small relative to the distance between them.

Progress Previous Invoice/Reports (Q1, Q2, Q3, Q4, Q5, Q6)

- Two field trips in August and October to maintain instruments and download data.
- Re-installed well 4 at Campbell Lake due to bailer lodged in well by volunteer staff.
- October - reinstalled transducer in Campbell Lake (closer to shore).
- Initiated US EPA funded project titled "A sustainable approach to preserve the Choctawhatchee Coastal Dune Lakes of Florida". This $10,000 one-year project is part of the EPA People, Prosperity, and the Planet program (http://es.epa.gov/ncer/p3/) which is a student design competition. Further activities from this joint project are described below.
- Our group created a new graduate course at UF: SOS 6932 Perspectives in Florida Lake Management that used the coastal dune lakes as a capstone element. Nine students enrolled in the course in Fall 2007 and student groups used the coastal dune lakes for final projects.
- Our class, including two instructors, took a field trip to the coastal dune lakes 28-29 October 2007. With the assistance of CBA staff the students toured the following lakes Campbell, Draper, Eastern, Western, Oyster, Camp Creek, and Powell. The students learned about the hydrology and ecology of the lakes, talked to citizens, and collected sediment samples and salinity data.
- Using historic aerial photos, we created land-use change maps in a GIS format. We have these in digital form and will deliver to CBA staff once we can convert them to an appropriate media (the files are multiple gigabytes).
- The student design team is collaborating with Lakewatch to create an educational component of the lake management plan as their final design for the US EPA. This will be presented in Washington, DC in April 2008.
- Initiated review of existing data
- Two trips to install field instruments – 29 April 2007 and 27 August 2007

- 29 April - installed 3 wells at Draper Lake, 3 wells at Campbell Lake, 2 wells at Camp Creek Lake (site access had not been secured to install a third well at Camp Creek Lake); also installed data-logging pressure transducers in Draper and Campbell Lakes and in wells at these lakes
- CBA-Lakewatch volunteers have collected monthly water quality samples from the wells we installed. There is a multiple-month lag time for analysis after sample collection
- 27 August – site access had now been secured from the third site at Camp Creek Lake, and we installed the third well as well as a transducer in this lake; also downloaded data from previously installed instruments (data shown below).
- Completed final design for US EPA project. Our final report to US EPA is appended to this invoice.
- May and June trips to install in Campbell, Draper, and Camp Creek lakes data-logging salinity probes for continuous recording. Campbell Lake probe could not be installed because of high water levels.
- UF team traveled to Washington DC 20-22 April 2008 to present results of US EPA project, emphasizing project for integrated education campaign in the Coastal Dune Lakes area. Also presented a summary of this project, and data to date at Florida Lake Management Society Meeting in Sandestin, FL.